MINISTRY OF AGRICULTURE

Guide to Agriculture Production and Natural Resources Management in Malawi

Guide to Agriculture Production and Natural Resources Management in Malawi

Revised in 2020

Published by
Agriculture Communication Branch,
Department of Agriculture Extension Services
Ministry of Agriculture
P.O. Box 30145
Lilongwe, MALAWI

Printed with financial support from
Food and Agriculture Organization of the United Nations (FAO)

ISBN999-34-00-9

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMNS AND ABBREVIATIONS

ABMD	-	Aphids Borne Mosaic Disease
ADD	-	Agriculture Development Division
ADMARC	-	Agriculture Development and Marketing Corporation
ARET	-	Agriculture Research and Extension Trust
ASSMAG	-	Association of Smallholder Seed Multiplication Action Groups
ATC	-	Agriculture Trading Company
BBTV	-	Banana Bunchy Top Virus
CAN	-	Calcium Ammonium Nitrate
CBD	-	Coffee Berry Disease
CBSD	-	Cassava Brown Streak Disease
DAES	-	Director of Agriculture Extension Services
DAES	-	Department of Agriculture Extension Services
DAHLD	-	Director of Animal Health and Livestock Development
DAHLD	-	Department of Animal Health and Livestock Development
DARS	-	Director of Agriculture Research Services
DAO	-	District Agriculture Officer
DCP	-	Director of Crop Production
DCP	-	Department of Crop production
DVO	-	Divisional Veterinary Officer
EC	-	Emulsifiable Concentrate
FCV	-	Flue Cured Virginia
FRIM	-	Forestry Research Institute of Malawi
g	-	Gram
GAPNRM	-	Guide to Agriculture Production and Natural Resource Management
GOT	-	Ginning Out Tum
Ha	-	Hectare
IEC	-	Information, Education and Communication
Kg	-	Kilogram
LD	-	Long Duration
LFMA	-	Local Fisheries Management Authorities
m	-	Metre

MAFE	-	Malawi Agroforestry Extension Project
MASL	-	Metre Above Sea Level
MD	-	Medium Duration
mm	-	Milimetre
MOP	-	Muriate of Potash
MPT	-	Multipurpose trees
NDDF	-	Northern Division Dark Fired
PFM	-	Participatory Fisheries management
Pop	-	Population
POSAM	-	Pesticide Suppliers of Malawi
PROSCARP	-	Promotion of Soil Conservation and Rural Production
SCFT	-	Smallholder Coffee Trust
SD	-	Short Duration
spp	-	Species
SSP	-	Single Super Phosphate
SPD	-	Sweet Potato Virus Disease
TMD	-	Tobacco Mosaic Virus Disease
ULV	-	Ultra Low Volume
VFA	-	Village Forest Areas
WP	-	Wettable Powder

FOREWORD

HON. LOBIN CLARKE LOWE, MP
Minister of Agriculture

Malawi's economy remains predominantly agro-based despite development of other economic sectors. With a population of about 16 million, 85% of which is estimated to be employed in the agriculture sector, agriculture development needs special attention. Most farmers, especially in the smallholder sector operate under diverse and challenging conditions that include increased and unstable prices of basic farm inputs such as improved seeds and fertilizers. Effects of climate change which manifest in droughts, prolonged dry spells and flooding, and marketing of farm produce remain critical challenges of the whole agriculture sector. Despite all these challenges, the country has since 2006 managed to produce sufficient food for the nation and record surpluses. The success stories are a result of innovative strategies coupled with use of improved and appropriate technologies by stakeholders in the agriculture sector.

Recognizing the important role to Malawi's overall development, the government from time to time devises strategies to ensure that the country's road to economic growth is properly managed amidst natural and economic challenges. These are implemented through special projects managed by the Ministry of Agriculture and stakeholders in the public and private sector.

To implement the projects and programmes, the Ministry relies on a network of Frontline Extension Workers operating countrywide. These work in partnership with stakeholders in the agriculture sector from the public, civil society as well as the private sector. Farming communities access extension services covering different technologies in crops, livestock, fisheries, irrigation, marketing and environmental management that enable them improve productivity and production of different enterprises. This guide contains important technical information on the following:

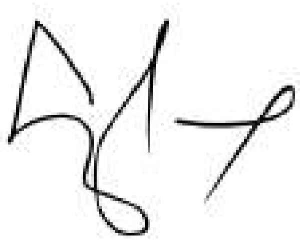
1. **Good Agriculture Practices:** Following recommended agriculture practices is important as it enables farmers to realize optimum results with available resources. This requires timeliness in carrying out required farm operations. Extension staff should provide advice at appropriate times and methods.
2. **Improved Seeds:** Good seed is the basis for optimum yield. The guide provides names and potential yield levels for improved varieties for common crops grown in Malawi. Some of these crop varieties are for cereals, legumes, pulses, roots and tubers, tobacco, cotton, coffee, fruits and vegetables.
3. **Crops and Crop Varieties:** The guide provides the reader with husbandry practices for growing different crops in different agro ecological zones of the country. These include field crops, tree crops, fruits, and vegetables. This is to encourage farmers to practise crop diversification. Procedure of managing crop pests and diseases using both biological and chemical methods are presented in this guide.
4. **Soil Fertility Improvement:** Most of the soils in the country have been degraded due to poor cultural practices. As such, farmers need advice on soil fertility improvement strategies and practices. The guide therefore contains information on types and application rates for chemical fertilizers, types, and methods of making compost and use of agroforestry trees for improving soil fertility.
5. **Land and Water Management:** Soil erosion is a problem in the country. The guide contains information on recommended technologies of land and water management so that farmers can reduce land degradation and conserve soil and water in the fields.
6. **Diversification:** The guide provides information on agriculture diversification to enable farmers grow and raise different types of crops, livestock and fish. Farmers who practise diversified farming, reduce risks of crop and livestock production failures.
7. **Food and Human Nutrition:** Nutritious food and good eating habits are a basis for good health; the guide contains information of common forms of malnutrition, food budgeting, and the six food groups that should be grown and consumed for good health.
8. **Gender and HIV/AIDS**: Gender is an important issue in agricuture, HIV and AIDS are important gender issues that have negatively impacted on the agriculture sector. It is therefore important that the gender and HIV and AIDS are mainstreamed in all agriculture programmes and projects. The guide provides the reader with information relating to impacts of HIV and AIDS on the agriculture sector and the HIV and AIDS mainstreaming process.
9. **Animal health and Livestock development:** Livestock is important for food and nutrition security and income generation. The guide contains information of different types of livestock that can be raised by all categories of farmers. Other information includes housing, feeding, diseases control and marketing of livestock.
10. **Fisheries and Aquaculture Development:** The country is experiencing dwindling catches of fish from capture fisheries. This has necessitated development of aquaculture. The guide provides important information for farmers interested to engage in fish farming such as pond construction, feeding, fish pond management, and fishing gears.

11. **Crop Authorities:** In order to intensify involvement of smallholder farmers in commercial agriculture, government has put in place institutions to assist in organization and management of farmers. This guide provides detailed information relating to growing crops under the authorities for coffee, tea and sugarcane.
12. **Agriculture Extension and Advisory Services:** Extension and advisory services are crucial to ensuring that stakeholders in agriculture development access information of technologies and techniques of applying them. This guide provides information on extension approaches, system of delivery, channels of accessing information and methods of acquiring knowledge and skills of production and marketing for different enterprises.

This guide is a reference manual for professionals in the agriculture sector and farmers to have easy access to research proven-technologies that can be used in different farming enterprises. The academia will also find this guide useful.

It should be pointed out that this is only a guide and some areas might require additional information. Subject Matter Specialists are therefore encouraged to develop other materials such as leaflets, brochures, and booklets that contain detailed and specific information on the technologies and enterprises. All users are further advised to contact nearest agriculture offices or the Secretary for Agriculture for more information in case of need.

Finally, Malawi's economic strength lies in agriculture until other sectors are fully developed. The onus to develop agriculture to its fullest potential lies with all stakeholders in the sector as espoused in the National Agriculture Policy. This country has potential to produce crops, fish and livestock for export to neighbouring and other countries in different regions such as America, Europe, and Asia. The country is demonstrating that it can feed itself with good agriculture programmes and projects in place. Stakeholders in agriculture should make joint efforts to develop Malawi's agriculture sector, while judiciously managing our natural resources for sustainable development.



Honourable Lobin Clarke Lowe, MP

MINISTER OF AGRICULTURE

ACKNOWLEDGEMENTS

ERICA MAGANGA (MRS)
Secretary for Agriculture

Agriculture is a dynamic sector and it is the mandate of professionals in the agriculture sector to ensure availability of information. Periodically, Subject Matter Specialists and Agriculture Scientists provide up-to- date technical information on their areas of expertise through writing manuals, booklets, brochures, circulars and leaflets. This guide is produced to provide a package of information on important agriculture technologies to field staff and stakeholders. Let me urge all field staff to make reference to the manual and accompanying materials in order to deliver relevant information to the farming clientele.

The Ministry of Agriculture would like to thank the team that authored and reviewed the Guide to Agriculture Production, comprising Agriculture Scientists and Subject Matter Specialists from different agriculture and related backgrounds and with wide experiences within and outside the Ministry of Agriculture. The team comprised the following: Dr. Jerome Chim'gonda- Nkhoma, Mr. Anderson Chikomola, and Mr. Pearson Jasi-Soko from the Department of Agriculture Extension Services; Mr. James L. Banda from the Department of Land Resource Conservation; Dr. Eviness Nyalugwe from the Department of Crop Development; Mr. Sabstone Unyolo, Mr. Alban Pulaizi, and Mr. Andrew Saukani from the Department of Fisheries; Dr. Gilson Njunga from the Department of Animal Health and Livestock; Mr. Kenneth Chaula, and Mrs. Martha Mwale from the Department of Agriculture Extension Services. The Ministry is also indebted to the following people for reviewing this guide: Mr. Benjamin Chisama from the Department of Agriculture Research Services; Mr. Esau Banisi from the Department of Irrigation; Mr. Noel Limbani, Mr. Willard Kapindu, and Mr. Blessings Susuwele from the Department of Agriculture Extension Services.

Special recognition should go to Dr. Jerome Chim'gonda-Nkhoma, Director of Agriculture Extension Services for providing overall direction during the process of reviewing the guide. I am thankful to all directors in the Ministry of Agriculture for the contributions made under their specialties. The Ministry is also grateful to the following dedicated editors: Mr. Maxwell Kupatsa, Ms. Cynthia Mahata and Ms. Tuchitechi Hawonga for editing this guide; Mr. Gerald McLean Mafubza, Ms. Edness Kazembe, Mrs. Cecilia Kanyoma, Mr. Mike Chungu, Mr. James Mwale, Mr. Matsimbe B. Nkambeni, and Mr. Ken R. Ndindi for design and layout; lastly, Ms. Zelpher Chapweteka and Mrs. Ireen Linje for providing secretarial services throughout the process of reviewing this guide.

For further information contact the nearest agriculture office or any of the offices indicated in this guide.

Erica Maganga (Mrs)

SECRETARY FOR AGRICULTURE

AUTHORS

Mr. John J. Mussa, Mrs. Gertrude Kambauwa, Mr. James L. Banda, Mr. Kefasi J. Kamoyo, Mrs. L.M. Mzamu, Dr. Jerome Chim'gonda-Nkhoma, Mr. Kenneth Chaula, Mr. Anderson Chikomola, Mr. Pearson Jasi-Soko, Mrs. Sylvia Mapanje, Mrs. Martha Mwale, Mr. Gibson Jere, Dr. Wilkinson Makumba, Dr. Allan Chilimba Dr. Hendrex W. Kazembe-Phiri, Mr. Benjamin Chisama, Mrs. Hilda Kabuli, Dr. Tenyson Mzengeza, Mr. Wiseman Kanyika, Dr. Lawrent Pungulani, Geckem Dambo, Modester Kachapira, Esnart Yohane, Dr. Pilirani Pamkomera, Kennedy Masamba, Obed Mwenye, Mr. Felix Chipojola, Mr. Ofesi, Jessie Mvula, Mrs. Rose Mkandawire, Mr. Doctor Gondwe, Charles Banda, Sophie Nambuzi, Nathan Kachiguma, R. C. Kumwenda, Mr. Thomson G. Chilanga, C. Malidadi, Mr. Misheck Soko, N. Kachiguma, F. Matawale, P Nyasulu, B. Kaunda, Dr. Eviness Nyalugwe, Mr. Erick M.K. Haraman, Mr. Wilson Chafutsa, Mr. Bartholomew W. Ngauma, Mr. Samuel L. Khosa , Mr. Aone Kumwenda, Mr. Amon Wesley Phiri, Dickson Banda, Mrs. Ida Mwato, Mr. Mathias Nkhoma, Humphrey Nxumalo , Alex Lwesha, Dr. Patrick B. Chikungwa, Dr. G.R. Njunga, Mr. Peter Makhambera, Mr. Suzgo Chapa, Mr. Given Manjawila, Mr. S. Mmodzi, Mr. Sabstone Unyolo, Mr. Alban Pulaizi, Mr. Andrew Saukani, H.Banda, C.N.Nyirenda and Mr. C. Gondwe.

CHAPTER 1

IMPROVING AGRICULTURAL PRODUCTION

Malawi's economy remains predominantly agro-based despite development in other economic sectors.

The agricultural sector contributes about 39% of the country's GDP. It is estimated that Malawi has 4.7 million hectares of arable land which can be cultivated under rain fed and irrigated agriculture. However it is estimated that only 2.5 million hectares are under cultivation. Malawi's agriculture is sub-divided into small-scale and estate sub-sectors with the former cultivating on 70% of the land. Smallholder farmers are important players in the sector as they are involved in production of food crops such as maize, rice, legumes and pulses in addition to cash crops such as tobacco, cotton, tea and coffee.

Recognizing the important role of agriculture to the government, Malawi's economy is committed to intensifying its commercialization through value chain approach. This will be achieved with the support of programmes such as the Agriculture Sector Wide Approach Programme (ASWAp) and the Greenbelt which is an approach to the country's green revolution.

Vision: A nation that enjoys food security and sustainable agricultural growth and development.

Mission: To promote agricultural productivity and sustainable management of land resources to achieve national food security, increased incomes and ensure sustainable socio-economic growth and development.

Policy Goal: To contribute to the attainment of national food security, poverty reduction and national economic development objectives.

Policy objectives:

The National Agriculture Policy provides a framework for development of the agricultural sector so that it effectively contributes to the national development aspirations of turning the country from a predominantly consuming to a producing and exporting nation.

This can be achieved through:

i) Facilitating the creation of a conducive and supportive policy environment for effective development of the agricultural sector throughout all stages of the value chain;

ii) Strengthening the capacity of the stakeholders in the sector in the provision of agricultural services;

iii) Enhancing coordination and collaboration amongst relevant stakeholders operating in different sub-sectors of the sector;

iv) Providing a clear strategic policy direction to all stakeholders involved in sector issues along the value chain stages.

Thematic Areas

Implementation of the National Agriculture Policy is based on the following thematic areas :

1. Inputs use and markets.
2. Agricultural production.
3. Agricultural markets development.
4. Gender, HIV and AIDS and Agricultural development.
5. Climate change and environmental issues.

1.1. Good Crop Husbandry Practices

Good husbandry practices are a prerequisite to achieving increased yields. A combination of the following husbandry practices will result in significant increase in yields with minimum extra cost to farmers:-

1.1.1. Early field preparation

Field preparation should be carried out preferably soon after harvest when the soil is still moist and therefore easy to till. This ensures deep ploughing and good decomposition of the incorporated crop residues. It also improves soil structure and minimizes surface run-off. Where this is not practicable, farmers should aim at having fields ready by the end of September so that they can plant with the first planting rains.

1.1.2. Use of manure

With the ever increasing cost of chemical fertilizers, proper use of manures becomes more important. Manures not only supply plant nutrients to the soil but also improve its structure resulting in higher water and nutrient holding capacity. Where manures are used in combination with chemical fertilizers, crops grow vigorously. Yields and quality are also improved. Farmers should therefore incorporate residues and make use of manures. Extension staff should provide technical advice on how to incorporate crop residues, make and use of different types of manure.

1.1.3. Use of good seed or planting material

It is important that farmers use seed and planting material that would germinate, establish well and grow into a healthy crop. For example in maize, farmers can select good seed from open-pollinated varieties for two to three successive seasons. It is not advisable to select seed from hybrid varieties as performance is reduced with recycled seed.

1.1.4. Early planting

Crops need to be planted early as recommended to take advantage of the full rainy season. With the uncertainty in the rainfall pattern, late planted crops risk moisture stress at critical periods such as increased pest and disease attack, reduced growing period and nutrient uptake. Farmers should therefore plant all crops early as recommended.

1.1.5. Optimum plant population density

Optimum plant population leads to high yields because there are sufficient plants per unit area and there is minimal competition for nutrients, moisture and sunlight. In addition, optimum plant populations suppress weed growth, minimize soil erosion and may in some instances reduce pest severity.

The right plant population is achieved by:-

i) Correct spacing between ridges or planting rows;

ii) Correct spacing between planting stations on the ridge or row; and

iii) Correct number of seeds or seedlings planted or sown per planting station or bed.

1.1.6. Timely weeding

Weeds deprive crops of plant nutrients, moisture and sunlight. They may also harbor pests and diseases causing reduction in yields. To reduce competition, it is important that farmers weed their crops timely and frequently.

1.1.7. Intercropping

By intercropping, more than one crop can be harvested in the same season from the same plot, thereby obtaining maximum benefit from it. In some cases other benefits include moisture retention, crop support, soil fertility improvement, soil erosion controll and pest and disease control. Farmers should be encouraged to intercrop in order to realize these benefits.

1.1.8. Crop rotation

Crop rotation is a practice of growing crops on a piece of land in succession every year. In rotation, deep-rooted crop and crops of the same family should not follow each other. For example maize grown after tobacco, cotton and groundnuts has shown better yields. Growing of the same crop on the same piece of land year after year results in poor yields and quality unless expensive management practices are employed. This is because certain diseases and insect pests build-up in the field and some important plant nutrients get depleted in the soil. For instance continued monocropping in maize fields results in witch-weed infestation. It is therefore important that agriculture staff help farmers to work out rotation plans.

1.1.9. Crop hygiene

Insect pests and diseases can severely reduce yields and lower the quality of produce. The incidence of pests and diseases can be reduced without necessarily using pesticides but, for example, observing the closed season in tobacco and cotton; burning or burying infested materials away from the field and destruction of volunteer crops. Uprooting tomato, tobacco, or cotton plants after harvesting helps to reduce disease incidence such as nematodes infestation.

1.1.10. Farm planning and management

To make proper use of available resources, any farm requires planning. A lot of money can be wasted in employing labour and trying to carry out too many tasks at the same time resulting in inefficiency. Agricultural staff should assist in formulating an appropriate farm plan in agreement with the farmer so that there is efficient use of land, water, labour, time, money and other resources.

1.2. Investing financial resources to improve production

Most farmers invest in agriculture to improve farming operations. However, with rising costs of farming, it is important to ensure that financial investments bring good returns; optimum crop yields and returns. Such investments should be based on principles of good husbandry practices mentioned in 1.1.

Where such practices are not followed properly, money invested will be a waste. Farmers should therefore aim at using the following facilities wisely:

1.2.1. Improved seed and planting material

Research work develop new varieties of crop seed and planting materials to produce varieties which are high-yielding and resistant to pests and disease. To realize the full potential of the improved seed and planting materials, good husbandry practices should be followed.

1.2.2. Fertilizers

To obtain high yields from crops, farmers should apply sufficient amounts of fertilizers. Fertilizers should be purchased and stored properly and applied at the recommended rates. It is advisable to apply manure before chemical fertilizers in order to maximize yields.

1.2.3. Crop protection

Farmers should be aware that high incidences of pests and diseases reduce the yield and quality of crops and should therefore apply various recommended control measures correctly and timely. It is imperative that farmers use pesticides as the last resort when necessary and as recommended. Cultural practices which help to minimize pest problems in the nursery and in the field should be encouraged. Farmers should be encouraged to use the Integrated Pest Management (IPM) approach to pest and disease control.

1.2.4. Farm equipment

The majority of farmers find it very hard to carryout farm operations properly and timely by hand even with hired labour. The use of animal power and animal drawn implements such as tractors, ploughs, ridgers, cultivators and farm carts makes the work easier and faster. Other farm implements such as sprayers, planters and wheelbarrows also help in farm operations. Farmers should aim at acquiring these implements.

1.2.5. Credit

Credit taken to invest in farming is a good idea but farmers need to be assisted by extension staff to calculate gross-margins before getting such credit. This would assist in making decision on the amount of credit to get and how to make the most out of it.

1.3. Crop Diversification

Crop diversification is the growing of more than one crop by a farmer within the same season or year. In recent years, crop failures or damages have been experienced because of droughts, floods, pest and disease out-breaks, and other adverse weather conditions. As a result of these problems, it has become necessary to grow more than one crop in order to reduce risks of crop failure. Where more than one crop is grown in the season, the farmer reduces the risk of total loss of food supply and cash return in the event of some of the crops failing, and also takes care of commodity price fluctuations.

Diversification towards more exportable high value crops such as chillies, tobacco and macadamia also helps farmers realize more cash income, and thus improve their farming while earning foreign exchange into the country. Cropping systems that achieve diversification include:-

1.3.1. Mixed cropping or intercropping

Mixed cropping or intercropping is the growing of more than one crop on the same piece of land. If leguminous crops are also included in this system, soil fertility is improved. Farmers should be encouraged to grow more than one crop in order to harvest more in the same season. For example, in the southern region most farmers practice mixed cropping and intercropping. This should be encouraged and be spread to areas where farmers can benefit from the system.

1.3.2. Strip cropping

Strip cropping is the practice of growing different crops in alternating field blocks. Apart from creating possibilities for rotation, strips can be planted with crops of different pest problems and weather tolerance as a safeguard against crop failure. Strip cropping also reduces erosion and pest damage.

1.3.3. Relay cropping

This is growing of a seasonal crop before the first crop is harvested. This is important where land is limiting and residual moisture exists. Apart from realizing two crop harvests in the same season, total labour requirement for the two crops is reduced. A legume such as chick peas or beans undersown to maize improves soil structure and fertility.

1.3.4. Agroforestry

Agroforestry is a collective term for farming system where trees crops and animals are managed on the same piece of land. The widespread existence of trees together with crops suggests that agroforestry is an old practice. The inclusion of tree such as leucaena *(Tephrosia vogelli)* and msangu *(Faidhebia albida)* in the farming system is an important part of integrated land use. Trees can meet a variety of farmer's needs as well as contribute directly to the improvement of soil and micro-climatic conditions on the farm. There are many benefits to a farmer who practices agroforestry. These include:-

i) Developing a farming system that is sustainable and acceptable;

ii) Increasing the production of fuel wood, wood, fodder, poles, timber, medicinal plants, fruits and shade.

iii) Increasing the production of fruit trees, annual crops and livestock on the farm

iv) Minimizing the use of chemical fertilizers; and

v) Controlling soil erosion to improve water infiltration and reduce surface runoff.

Extension staff should encourage farmers to adopt agroforestry in order to realize the benefits of this farming practice.

1.4. Improving Livestock Production

Livestock is an important sub-sector in the agricultural sector in Malawi. This is because it is an important source of income, food and rural materials to farmers and the private companies who use livestock and livestock products for processing and manufacturing of various products.

The policy of the government is to increase livestock production to become self-sufficient in all livestock and their products in order to meet the following objectives:

i) To improve availability of animal protein especially to the rural population;

ii) To market livestock and livestock products profitably for cash income;

iii) To increase production of livestock and livestock products for export in order to earn foreign exchange;

iv) To provide draught animal power.

v) To provide khola manure.

vi) The most common classes of domesticated stock available in Malawi are cattle, pigs, goats, rabbits, sheep, donkeys and poultry. Production of the various classes can be increased once management practices are improved. There are a number of factors to be considered in order to improve livestock productivity and production in Malawi. These include use of improved breeds, good housing, good feeding and good pest and disease control and management.

1.4.1. Breeds and Types of Livestock

Both local and exotic breeds are suited and survive in Malawi. The local breeds are suited and survive in Malawi's environmental conditions but production levels are below those of exotic breeds. The latter are sensitive to insufficient and poor quality feeds and diseases. However, crossbred animals and poultry perform better than local breeds, but below those of exotic breeds. Smallholder farmers are encouraged to keep local and cross-breeds because exotic breeds require high levels of management. The large-scale farmer can afford to keep exotic animals.

1.4.2. Good Livestock Husbandry

Livestock husbandry takes into account a number of practices: These include housing, feeding, pest and disease control and management. Practicing good livestock husbandry is a pre-requisite for increased productivity of livestock. The details and recommendations for housing, feeding and management are presented under the section on animal health and livestock development in this guide.

1.4.3. Disease Control

Different classes of livestock suffer from a number of diseases in various parts of the country, which reduce their productivity. Some diseases affect specific classes while other affects different species of livestock. Some of the livestock diseases can be transmitted to and infect human beings. These are called zoonotic diseases. Zoonotic diseases include rabies, brucellosis, stomach intestinal worms, tuberculosis and fungal infections. In general, diseased livestock do not eat well, lose body condition and die. Disease incidences can be minimized through dipping, vaccinations, treatments, good pasture grazing management, meat inspection and restriction in movement of livestock. These measures will reduce the risk of contracting specific diseases for both livestock and human beings. These measures are explained further in this guide under the sections on Animal Health and Animal Production.

1.4.4. Livestock Marketing

Livestock are an important source of cash income. Farmers are encouraged to improve the quality of their livestock through good management. They are also encouraged to identify markets, which can give them the best returns from their investment in livestock.

1.5. Land Husbandry

Sustainable agricultural production in Malawi depends on the rational use of the natural resources in particular soil and water. Any deterioration in the land resources poses serious consequences for Malawi's future economic growth. Poor soil and water management in agriculture results in poor growth and yield for a number of crop enterprises. This results in low food production, food insecurity and slow economic growth. Farmers should be encouraged to manage water and soils and as an important resources in agriculture as a livelihood strategy for the present and future generations.

1.6. Irrigation

Where there is potential for irrigation, efforts should be made to utilize irrigable land. In addition to increasing crop yields, irrigation helps reduce the risk of crop failure because of drought and prolonged spells. It also presents opportunities for more than one growing season per year. Irrigation also assists in livestock production through provision of supplementary water for pasture production as well as drinking water for animals. It also provides water for fish farming for smallholder farmers. Farmers can organize themselves into groups and construct irrigation facilities on a self-help basis. Proper water management is complementary to good husbandry practices and farmers should be encouraged to manage their water in order to realize increased yields.

CHAPTER 2

AGRICULTURE SERVICES

The Ministry of Agriculture, provides a number of services that support agriculture production and utilization of the produce by providing extension staff and farmers with the necessary information and facilities in order to improve agricultural production. Some of these services are as follows:

2.1. Land Husbandry and Natural Resources Management and Climate Change

Malawi's agricultural production is currently threatened by an increasing demand on its natural resource base due to expanding human population. This has resulted into land degradation thereby reducing agricultural productivity.

Soil erosion and declining soil fertility under continuous cultivation are increasingly becoming serious land degradation problems in the country. Current farming systems are characterized by continuous growing of crops on the same piece of land, cultivation of unsuitable areas such as steep slopes and river banks, making of ridges along the slopes, overgrazing and burning of crop residues. These inappropriate land use and management practices result in increased surface run-off, soil erosion and destruction of catchment areas. On average the country is losing about 29 tonnes of soil per hectare per year, which has negative impact on the crop yields.

This has several implications on how the land is being taken care of in the country. It is therefore recommended to refer to this soil rate because it supports government efforts in developing the requisite control measures.

Recommended crop and animal husbandry practices supported by properly designed, constructed and maintained physical conservation structures are the most effective means of minimizing land degradation caused by soil erosion.

Climate change is any change in climate over time, whether due to natural variability or as a result of human activity (IPCC AR4, 2007). Malawi's economy is agro-based and majority of Malawians who depend on rain-fed agriculture are adversely affected by climate change. For the agriculture sector in Malawi, it is the changes in rainfall regimes that will be a dominant climate factor affecting agricultural production. The changes in rainfall patterns will have great consequences on soil surface run-off, soil erosion, soil-water availability, floods, droughts, groundwater recharge and storage, water quality, water demands for irrigation, crop and domestic uses and a whole range of other environmental and economic activities. A number of responses to these changes have already been identified and are being implemented and these include development of policies and strategies to address climate change, development of programmes and projects to respond to the problems of climate change, commissioned studies for in-depth understanding of the impacts of climate change on agriculture and identification of interventions to address the impacts, increased participation in and to climate change related, increased awareness/sensitization/ campaigns on climate change and mitigation measures and implementation of activities to adapt/mitigate impacts of climate change.

Sustainable land and water management technologies which fall under the land husbandry and natural resources management are important to climate change adaptation and mitigation.

Agriculture is one of the more sensitive sectors to climate change. There is therefore need to adapt agriculture to the effects of climate change. To adapt to increasing weather variability and climate change, farmers will have to change their management practices in a number of ways – for example, how they grow their crops, manage soils and water. These are some of the climate smart agriculture interventions which have been identified for sustainable land and water management. Guidelines on Climate Smart Agriculture (CSA) as well as specific climate smart agriculture interventions like conservation agriculture and rainwater harvesting have been developed to assist land users in implementation in order to achieve high productivity as well conserve the natural resources upon which agriculture depends. It is therefore recommended that the Guidelines are also used as reference materials.

In addition to addressing the impacts of climate change on agriculture, the other components of land husbandry and natural resources management include the deliberate incorporation of Environmental and Social Safeguards (ESS) in the implementation of all agricultural activities a realisation that the environment has a limit beyond which it can support human development and hence the focus is on minimizing negative impacts and enhancing positive impacts.

Environmental and Social Safeguards are important in that they guide the land users in identification of potential impacts of their activities to the environment as well as developing mitigation measures which are outlined in an Environmental and Social Management Plan (ESMP). The ESMP clearly shows the linkages between the predicted environmental and social impacts and recommended mitigation and enhancement measures. It also shows the link between the recommended mitigation measures, the targets/ goals/dates, the stakeholders responsible for implementation of the measures and the estimated cost. The purpose of an ESMP is to provide practical solutions to the impacts identified, and to identify what monitoring activities need to be undertaken in the short and long-term. There is also need to come up with environmental and social monitoring plan which provides for monitoring and checking implementation of the mitigation measures proposed in the ESMP. It gives monitoring indicators, means of their verification, frequency of monitoring and the stakeholders responsible for monitoring. The environmental and social monitoring plan helps to verify the magnitude, duration and scope of the predicted impacts during and after implementing the mitigation measures. It also helps to detect any unforeseen impacts at an early stage so that corrective measures can be taken, before significant damage takes place on society or the environment.

2.1.1. National aims

The National Land Resources Management Policy and Strategy aims at promoting the efficient, diversified and sustainable use of land based resources both for agriculture and other uses in order to avoid sectoral land use conflicts and ensure socio-economic development. The Department of Land Resources Conservation provides guidance and creates awareness to farmers and the general public to appreciate the scarcity and vulnerability of the land resources in the country; and the need to value and conserve them. This is achieved by providing relevant knowledge and skills in all aspects of land use and environmental conservation to Ministry's staff and the general public.

2.1.2. Land husbandry concept

In order to understand how best the land can be utilized, it is necessary to identify its physical, biological and chemical characteristics.

These characteristics give an indication of the limitations as well as capabilities of the land to support a particular land use. This will enable appropriate land use planning which essentially involves matching the land characteristics and land utilization type requirements in order to reduce land degradation. It is advisable to compliment recommended crop and animal husbandry practices with appropriate physical conservation measures.

Most of the recommended crop husbandry practices fall under biological conservation measures. These include early garden preparation, timely planting, correct plant population, intercropping and relay cropping, crop rotation, application of organic and inorganic fertilizers and use of crop residues. Other biological measures are afforestation, control of bush fires, rotational grazing, vetiver planting, and live fencing.

Physical conservation measures include bunds, waterways, terraces, storm water drains, contour marker ridges, planting ridges, infiltration pits, swales and box ridges. These structures control surface run-off thereby reducing soil erosion.

The Land Resources Conservation Department promotes communal catchment conservation and integrated approach to land use; whereby farmers produce crops, trees and livestock on the same piece of land.

Efforts in catchment conservation are made against a number of challenges which include overgrazing, indiscriminate felling of trees, uncontrolled bush fires, the practice of slash and burn (visoso) and cultivation of stream banks and must be discouraged in all areas. These practices destroy ground cover, and endanger our water and soil resources.

Special care must be taken in the use of marginal areas such as steep slopes, with poor and shallow soils and stream banks. These areas are suitable for afforestation and may be sources of firewood, timber and poles. Forest reserves and game parks have been instituted to protect some of these areas which have an important role of preserving our natural heritage. These areas should be protected because of their importance as water catchments.

2.1.3. Recommended practices

In order to achieve sustainable land and water management, it is recommended that a number of practices be adopted by farmers in the country. These are soil and water conservation, soil fertility improvement and agroforestry, conservation agriculture, and rainwater harvesting.

2.1.3.1. Soil and water conservation

Soil and water conservation means the protection, maintenance, rehabilitation, restoration and enhancement of soil and water resources. Soil erosion is one of the common problems faced by farmers due to poor soil and water conservation practices. Soil erosion is the detachment and movement of soil particles from one place to another by raindrop impact, surface run-off, wind and landslides. Soil and water conservation includes management and use of such resources to ensure sustainability. These practices at farm level have the following benefits:-

i) Reduction of run-off and soil erosion
ii) Conservation of soil moisture for plant growth
iii) Improved crop and pasture yields
iv) Increased ground water supplies
v) Reduced siltation and flooding

The broad categories of soil and water conservation practices are biological and physical.

2.1.3.1.1. Biological conservation practices

Biological conservation practices aim at maintaining good ground cover in order to protect the land from rain-drop impact and run-off, and build up soil organic matter for soil structure improvement.

i) Ground cover

Maintenance of good ground cover on gardens through recommended crop husbandry practices and preservation of grasses, trees and litter on uncultivated land, should be promoted.

ii) Soil organic matter

Manure and crop residues should be used to improve soil fertility, structure and water holding capacity.

iii) Agroforestry

Integration of trees/shrubs with crops and or livestock enhances conservation of soil and water resources through root binding of soil particles, improved canopy and leaf biomass fall that increases soil organic matter.

iv) **Contour Buffer Strip Cropping** is one of the recommended ways of minimizing soil loss. The grass strips should be planted with suitable trees such as Gliricidia, fruit trees and crops such as bananas and pigeon peas that provide good ground cover and are beneficial to farmers.

Detailed information on Agroforestry interventions is provided in chapter 4 of this guide.

2.1.3.1.2. Physical conservation practices

All land with a slope of 2% and above requires physical conservation measures. These should be properly constructed and regularly maintained. Some of the recommended physical conservation practices are contour ridging, tied/ box ridging, gully reclamation, raised footpaths, field boundaries, stream-bank protection and contour vegetation strips.

2.1.3.1.2.1. Contour ridging

Contour ridging is the practice of making ridges and realigning them along areas of similar height(contour) in a field. Contour ridging should be promoted in order to enhance water retention and contour marker ridges should be used in aligning planting ridges.

Annual ridging by hand-hoe is the common method of land preparation in Malawi. Since few farmers cultivate on the contour, ridges tend to channel water out of the fields in an uncontrolled manner, which aggravates surface run-off and erosion. Contour ridging is a simple practice to reduce such impacts. To do this, peg and construct contour marker ridges as guides to re-align planting ridges. Marker ridges are best made during the dry season (soon after harvest).

2.1.3.1.2.2. Instruments and Tools for marking contour lines

Several instruments are used in marking contour lines. The low cost instruments are the A-Frame, line level and Phiri-Lino Frame. These instruments are simple to use and therefore should be promoted. Other instruments such as dumpy, quickset and Abney levels require advanced skills. For more information on these contact the nearest Land Resource Conservation Specialist. The low cost technologies are described below:-

The line level

The line level is a relatively cheap, quick and accurate tool in marking contour lines. It consists of a miniature spirit level that hangs from a taut string between two poles. Details of its materials, construction and use are as follows:-

Materials

i) 1 line level.
ii) 5m of string.
iii) 2 sturdy sticks, 1.6-2.0m long with flat ends.
iv) 1 knife.
v) Pegs to mark contour lines (about 100 pegs/ ha for flat and gentle slopes; 150 pegs/ha for medium slopes; and 200 pegs/ ha for steep slopes).
vi) 1 hammer or anything to drive pegs into the ground.

Note:

2 people to hold the sticks, and a leader to read the line level. They will be referred to as A, B and C, respectively.

Equipment setup and testing

1. Trim the ends of the sticks to make them flat. Then place them upright on level ground, preferably the floor of a building. Cut a groove around each stick at exactly the same height (about1.2 to 1.6 morchest level to make reading easy).
2. Hang the line level centrally on the string and tie a note on each end of the level to stop it from sliding.
3. Tie the string ends in the groove of each stick.
4. Set the 2 sticks upright on a level surface (e.g., floor) with the string tight. Mark their exact positions on the floor and read the line level. Then switch the positions of the sticks and read the level again.
5. If the bubble on the level is not perfectly centered both times, check that:
   a) The floor is level.
   b) The groove heights of both sticks are identical, and;
   c) The level is hanging properly.

Correct any problems when they arise.

Using the line level

1. Start pegging at the top of the field about 20m below the upper corner.

Fig. 1: Farmers using a Line level

2. C instructs A to insert a peg by his stick to locate the starting point. Avoid placing the sticks on rocks, ridges and termite mounds, or in holes and depressions. If a large anthill is encountered, stop pegging at its base, then continue from the other side. Ridges can also be made in concentric circles up the anthill to reduce heavy runoff.
3. B then instructs C to move 5m along an estimated contour line with the string tight *(Refer to Fig. 1.)*.
4. B reads the position of the bubble. He/she instructs C to move up or down the slope until the bubble is precisely centered. C inserts another peg at the precise location of his/her stick.
5. Leaving C in place, A moves past B to locate the next peg. B instructs A to move up or down the slope while reading the line level.
6. Follow Step 4. When the bubble is perfectly centered, insert another peg at A's stick.
7. Repeat steps 2 - 6 above, inserting pegs at each point till the end of the field is reached.
8. The team then moves down slope from the first contour line. The interval depends on the slope of the field, i.e. 20m apart for gentle slopes, 15m for medium slopes and 10m steep slopes. Pegging of contour lines should cover the whole field.

The A-frame

The A-frame, shaped like the letter A, is a simple, low- cost tool for marking contour lines. Details of its construction are as follows:

Materials to use

i) 2 m of string
ii) Three 3 m poles
iii) 1 stone
iv) 3 nails or string to tie the frame together
v) 1 panga knife

vi) Pegs to mark contour lines (about 165 pegs/ ha for gentle slopes; 250pegs/ha for medium slopes; and 330pegs/ha for steep slopes)

vii) 1 hammer or anything to drive pegs into the ground

Note: Two people are required.

Equipment setup and testing

1. Trim ends of the two 3m sticks to make them flat and tie or nail their tops together. Then tie or nail the crossbar to the upright sticks 1m from the bottom to form an A shape. Ensure that the bottom ends of the upright sticks are as far apart as possible to increase the inter-peg distance.
2. Hang a string from the top of the two upright sticks with a stone tied to the end so that it hangs 5-10cm below the crossbar.
3. Place the A-frame on a level surface (e.g. floor). Let the string settle, then mark the exact spot where it crosses the horizontal stick. Mark the exact positions of the 2 upright sticks on the floor. Then switch the positions of the frame legs. If the calibration is correct, the string will hang precisely over the centre point. The A-frame is perfectly level when the string hangs precisely over this center point.
4. If the string is not perfectly centred both times, check that:-
   a) the floor is level, and
   b) the frame is tied securely. Adjust the set up as needed.

Using the A-frame

Choose calm days for using the A-frame as wind affects the position of the hanging stone.

5. Start pegging the field about 20m below the upper corner.
6. Insert a peg at the starting point of the line, and position one leg of the A-frame next to it. Avoid holes and depressions or stones, ridges and humps. Handle anthills as described before under the line level.
7. Holding this leg in place, move the other one up or down slope until the string hangs precisely over the mark on the cross pole. Insert a peg at this point of the leg.
8. While holding the second leg in place, pivot the first one round and move it up or down slope until the string hangs exactly over the mark again. Drive another peg into the soil at this point. The pivoting process is important because it evens out errors if the A-Frame is not calibrated properly.
9. Continue pivoting across the slope until you reach the end of the field, pegging the position of the legs as you go *(Refer to Fig 2).*
10. Move down the slope to the next contour line. The interval of which depends on the slope of the field (see "Using the level in the field" under The Line Level and its use). Repeat steps 2 to 5 until the whole field is covered with contour lines.

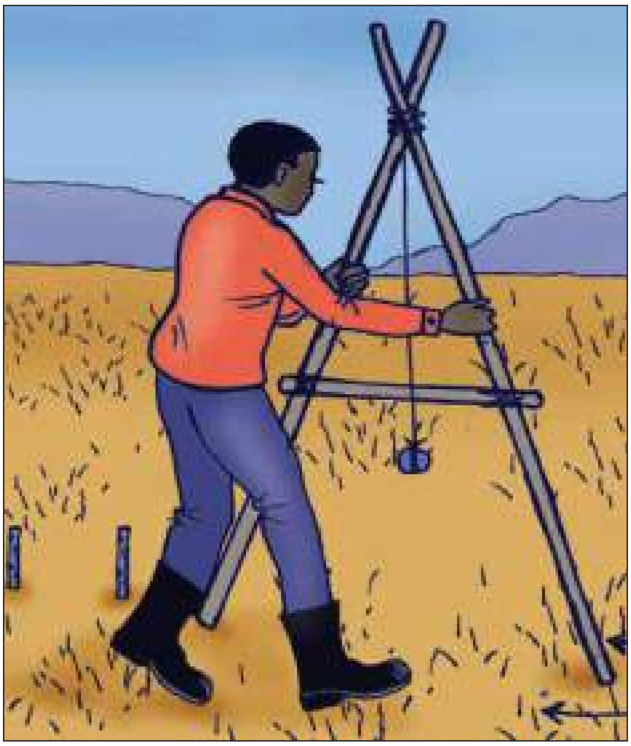


Fig. 2: A man using an A-Frame

The Phiri-Lino frame

The Phiri-Lino frame was designed by a Malawian farmer, Mr Jeremiya Phiri of Chijere Village, Nkhata Bay District, in Mzuzu ADD. It is similar to an A- frame except that it uses a line level superimposed on a string tied to both legs of the frame instead of a pendulum. Its main strength is that it combines the advantages of the line level and A-frame, which makes it simpler and faster to use. Details of its materials, construction and use is as follows:

Materials

i) Line level.
ii) 2.5m of strong string.
iii) 4 Wooden poles with flat ends (two 3m long, one 2.5m long and the other one 2m long.
iv) 1 Panga knife.
v) Pegs to mark contour lines about 165pegs/ha for flat and gentle slopes; 250pegs/ha for medium slopes; and 330pegs/ha for steep slopes.
vi) 1 hammer, rock, or large stake for driving pegs into the ground.

Note: Two people are required to do the exercise.

Equipment setup and testing

1. Trim the ends of the two 3m poles to make them flat and tie or nail their tops together. Tie the 2.5m poles across the other 2 poles about 1m from the bottom to form an A shape. Above it tie the 2m cross stick parallel to the other one to make the frame strong. Ensure that the bottom ends of the uprights are as far apart as possible to increase the inter-peg distance.
2. Cut a groove around each of the 3m sticks at exactly the same height above the ground halfway between the 2 cross sticks.
3. Tie the ends of the string in each groove.
4. Hang the level between 2 knots in the center of the string to stop it from sliding.
5. Test the operation of the equipment by following the steps for the line level.

Using the Phiri-Lino frame

The Phiri-Lino frame (Fig. 3) is used in the same way as the A- frame but readings are made on the spirit level on a string fixed to the frame. This allows use even on windy days, and eliminates the need to stretch the string when repositioning the frame as needed for the line level.

Fig. 3: A woman using a Phiri- Lino frame

Smoothing contour lines

Pegged contour lines may be smoothed out to reduce sharp angles between pegs. This simplifies building marke ridges and re-aligning planting ridges.

When and how to smooth the contour line

Smooth pegged lines only on uniform terrain by moving certain pegs as follows:

1. 3 people each stand by the first 3 pegs in the line. Move the middle peg (no.2) so that all 3 pegs are in a straight line.
2. All 3 people then move two pegs forward i.e., to pegs 3, 4 and 5. Move the middle peg (no. 4) so that pegs 3, 4 and 5 are in a straight line. Repeat this till the line is finished. The line will now follow the gradual curves of the contour. Repeat steps 1 and 2 for all pegged lines until the whole field is covered.

When not to smooth the contour line

Do not smooth contour lines on irregular terrain as it could cause runoff problems. When pegging across paths, gullies, anthills and streams shorten the string with the line level to half of its length (about 2.5m) to reduce the pegging interval for accuracy. This is not necessary for the A and Phiri Lino frames since both already have a shorter pegging interval.

Building marker ridges

Build the pegged contour line into a ridge. The marked ridges simply serve as guides to re-align planting ridges, and need not be bigger than other ridges if they are clearly marked.

Re-aligning crop ridges

After marker ridges are built, align planting ridges parallel to them. Use two marker ridges to align the area between them. Align the top half of the area to the top marker ridge, and the bottom half to the lower marker ridge. This allows half ridges or wedges to be in the middle.

2.1.3.1.2.3. Tied/Box Ridging

In areas of low rainfall and where erratic rains are experienced, box ridging should be practised to to catch and conserve rain water so as to ensure adequate soil moisture for crops.

Build tied/box ridges across planting ridges to create "micro catchments" to increase water infiltration and to reduce erosion. Tied/box ridges are best suited on land with contour ridges. They are also effective where ridges have not been re-aligned.

Building tied/box ridges

1. Construct tied/box ridges across the entire furrow perpendicular to planting ridges, but slightly lower to allow spill over. Space them 1-3m apart depending on the terrain and rate of water flow within the field.
2. When the terrain is steep the box ridges should be closer.
3. Move to the next furrow and repeat step 1 but locate the tied/box ridges halfway between those in the previous furrow.
4. Repeat steps 1 and 2 until the whole field is covered.

2.1.3.1.2.4. Gully reclamation

Gullies are among the most severe forms of erosion in Malawi. They affect not only farmland, but also settlements, grazing land, streams/rivers, wetlands, roads, and bridges. Gully formation is aggravated by cultivating steep slopes and stream banks, ridging off contour, use of unraised footpaths and field boundaries, overgrazing around water points and dip tanks, land clearing and deforestation, poorly constructed roads, dam spillways and physical conservation measures. Gully problems become more acute when waterdrains in from surrounding lands.

Prevention of gully formation

The best way to prevent gully formation is to promote appropriate land use practices that increase water infiltration and reduce run-off. Recommended measures include contour and tied/box ridges, raised footpaths and field boundaries, vegetative barriers on contour and tree planting.

Simple techniques for reclaiming gullies

Identify the cause (s) of the gully, then take proper remedial action before the problem worsens. The following techniques may be used to reclaim small gullies on farmland.

Check dams

(a) Brushwood/bamboo checkdams

Check dams of brushwood and bamboo are temporary structures that are easy to construct. They provide the first line of defense before planted vegetation becomes fully established.

Materials required

i) Line level Small diameter poles long enough to be placed across the gully and extending beyond the gully walls;

ii) Stakes to hold the cross poles in place;

iii) String/nails to tie cross poles to the stakes;

iv) 2-3 anchors to attach to the stakes;

v) Hammer/stone for driving in the stakes.

Constructing check dams

1. Drive pairs of stakes into the bed of the gully, with a gap between them wide enough to fit the cross poles. Insert the stakes across the width of the gully up to the top of the walls, and spaced close enough to each other for strength. 3-4 pairs of stakes are sufficient for smallgullies.
2. Lay small poles between the stakes from the bed to the wall of the gully. Make sure the centre is lower than the ends to act as a spillway so that the sides of the gully are not undercut.
3. Nail or tie cross small poles to the stakes, which can be anchored for strength.
4. An alternative method of construction is to weave freshly cut cross small poles in between single stakes from the base to the top of the gully in the same manner as done in making fish traps, basket or granaries.
5. Space check dams along the bed of the gully gradient (for example, 5-10 meters); narrow the interval for gullies with steeper gradients.

(b) Stone check dams

Where abundant, stones may be used to build check dams by pitching. Stonepitchingextends to the gully walls, with the centre lower than the ends to serve as a spillway in the manner described for brush wood dams.

Note: Construct all types of check dams before onset of the rains to allow silt to build up behind the dam with the first runoff.

(c) Vegetative barriers

Vetiver grass and trees may be established as permanent vegetative barriers in the bed of the gully to slow down runoff. They also trap sediment and organic matter, which enhances regeneration of vegetation and terrace formation within the gully.

Establishing vetiver grass

1. Construct a check dam of brushwood/ bamboos or stones in the gully (see section on check dams).
2. Plant vetiver in dense hedges across the entire width of the gully and above the check dam to make use of sediment deposits (for methods to plant vetiver see Contour vegetation strips). Space hedges according to the gradient of the gully (i.e.,5-10 m) starting above the head of the gully. Plant with the first rains to allow early establishment.
3. Trim the grasses regularly to promote dense tillering and fast growth. The grass will develop as a permanent barrier, reducing water flow into gullies.

Reducing water flow into gullies

Reduce water flow into gullies to prevent increase in size by:

1. Constructing tied/box ridges in fields on the upper sides of the gully.
2. Where possible, leave a strip of uncultivated land along the gully to prevent the walls collapsing.

Note: To reclaim big gullies, consult your local Land Resources and Conservation Specialist and the Land Husbandry Manual.

2.1.3.1.2.5. Raised footpaths and boundaries

Footpaths and field boundaries can aggravate erosion leading to rills and gullies. Raising them above the level of the surrounding fields is a basic soil conservation practice to reduce run off and erosion. The practice is best suited to fields with contour ridges, and it can also be effective where this has not been done.

Steps to raise footpaths and boundaries

1. Mark designated footpaths and boundaries with pegs from top to bottom.
2. Construct a path 50cm wide along the pegged line slightly above the planting ridges. Do this by collecting soil from the furrows between ridges without creating localized depressions.
3. Maintain raised paths and boundaries to prevent any channeling.

2.1.3.1.2.6. Stream bank protection

Stream banks are the most vulnerable land areas in Malawi. They have long been cultivated due to fertility from sediments deposited by regular flooding. Land pressure is also aggravating the problem. Despite this, stream bank soils typically have low cohesion and hence are prone to degradation.

Protection is vital to stabilize stream flow and to reduce the risk of flooding, siltation, landslides and loss of arable land.

Stabilizing stream banks

Prevention is the simplest and best form of protection. Ideally, stream banks should not be cultivated but left to natural vegetation, which provides more permanent and reliable protection than physical structures. Planted grasses and trees are good alternatives where vegetation has been cleared for cultivation or other reasons.

Ways on how to establish vegetation along stream banks are as follows:

1. Demarcate a strip along the stream channel to cover the banks about 5m wide either side for small streams and 10-20 m for big rivers.
2. Planting grasses: Plant vetiver, Napier or bamboo along the strips. Vetiver grass can be planted in strips along the banks at a spacing of 0.45m x 0.2 m and bamboo at 1 m x 1 m.
3. Planting shrubs: Sesbania sesban is ideal at a spacing of 0.45 m x 0.45 m.
4. Planting trees: Several species are recommended in strips at 2 m x 2 m: *Acacia galpini, A. polycantha, A. siberana, Faidherbia albida, Ficus natalensis, F. capensis, F. Tycomorus, Khaya nyasica, Parkia filicoidea, Rauvolfia caffra, Syzygium cordatum, S. guineense, Trichilia emetica, Ziziphus abyssinica, Z. mauritiana and Z. mucronata. (For local names of some of these species refer to table 74).*

Note: Where trees and shrubs are used, leave a 1 m strip from the channel on either side for grass to regenerate to increase surface roughness for reducing water runoff and erosion.

Calendar of key activities for soil and water conservation

July - August

1. Select the tool of choice for marking contour lines and set it up for correct use in the field. Then mark/peg and ridge all contour lines at intervals based on the slope of the field.
2. Organize production of nursery seedlings for planned stream bank protection.

September - October

1. Re-align planting ridges to the marker ridges
2. Build tied/box ridges and raise footpaths and boundaries where needed.
3. Identify gullies that need reclamation, and construct the check dams.

November - January

1. Collect vetiver material for planting along tied ridges and gully banks, as well as on the insides of check dams to re-enforce their effectiveness.
2. Plant selected tree seedlings and grasses in identified areas to protect stream banks.

2.1.3.1.2.7. Contour vegetation strips

Erosion and runoff from deforestation, overgrazing, bushfires, and poor cultural practices are serious threats to the environment and agricultural production. Planting perennial bunch grasses on the contour provides a good barrier against erosion and run-off. With proper spacing and management, natural terraces form between the contour hedges through soil accumulation on the upper side of the hedge. Contour hedges also slow down and retain water that would otherwise be lost through surface run-off. Multi-purpose trees or shrubs may be planted above the hedges.

Recommended species

Two types of grasses commonly used are vetiver *(Vetiveria zizanioides and V. nigritana)*, and napier grass *(Pennisetum purpureum).* Vetiver is a fast growing, deep-rooted perennial grass well adapted to all agro-ecological zones in Malawi. It is not competitive with crops and is not known to host pests and diseases of concern to agriculture. Vetiver seed has low viability, so there is little chance of it becoming a weed. It is easy to establish and maintain, and it makes good thatching, mulch, and bedding material for livestock. *V. zizanioides* is preferred because it grows faster and forms a denser and leafier hedge than *V. nigritana.* It is also less susceptible to termite attack.

Napier grass is a tall, thick-stemmed bunch-type perennial growing to 4m in height. It is also widely adaptable, but grows best in areas with rainfall over 1,000 mm/annum. Napier is commonly used as a fodder for cattle. It grows taller than vetiver but is not as effective for soil conservation. Napier tends to spread and compete more with crops, so it requires more trimming.

Source of planting material

Two spp of vetiver grass are found in Malawi, *V. nigritana* is in abundance in the shire valley and has been planted around farmers' fields. The other, *V. zizanoides* is now available in many parts of Malawi and may be obtained from the Agricultural Development Divisions (ADDs), some Non Governmental Organizations (NGOs) and estates. Vetiver can also be collected from nurseries established for this purpose (refer to section on vetiver nurseries). Material may also be collected from the edges and sides of well established hedgerows, but make sure the hedgerow is left intact with no gaps to allow full recovery.

Vetiver nurseries

Due to short supply of planting material, communities and individuals are encouraged to establish local vetiver nurseries near planting sites before establishing hedges in fields. Small nurseries are easier to manage and maintain, and should be based on farmer demands to avoid confusing value of vetiver with monetary or other incentives.

Establishing Vetiver nurseries

1. Dambos are the best nursery sites as moisture will be readily available. Sites on upland areas should be close to permanent water source for easy watering. Alternatively nurseries can be established under rainfed conditions.
2. Collect enough clumps for the planned nursery. A fully loaded 7tone truck will plant 0.5 ha.
3. Plant slips 45 cm x 45 cm apart and press the soil firmly around each; if farmers wish to intercrop beans or cowpeas on the ridges, plant slips in the furrow 90 cm x 45 cm. Competition will be minimal because the vetiver is newly planted or regenerating.
4. Trim vetiver to 30 cm tall in May/June and again at the start of the next season in December or January to promote tillering and fast growth.
5. Early planting in suitable sites such as dambos allows material to be ready for collection after one season.

Note: Grass hedges are used to reduce runoff and erosion, not to stabilize marker ridges which are guides to realign planting ridges.

Preparing vetiver slips for planting

1. Plan to collect planting material after the rains start, and plant within 48 hours.
2. Select healthy, well established clumps.
3. Trim the grass to 30 cm before digging up.
4. Make vertical cuts to dig out clumps with roots but leave 30-50% of each clump for nursery regeneration.
5. Keep clumps upright in shade and away from wind to reduce drying out until planted. If planting is delayed, water collected material does not dry out.
6. On the day of planting, trim leaves of collected clumps to 15 cm to reduce transpiration and to encourage tillering; then divide them into slips each with 3-4 tillers and 5-10 cm long roots. The slips are now ready for planting in nurseries or along contour lines to establish dense hedges.

Planting Contour Vetiver Hedges

1. Plant vetiver on the contour at 5 m intervals on steep slopes, 10 m on medium slopes and 15 m on gentle slopes. Note: Hedges need not coincide with marker ridges which are used only to guide ridge re-alignment.
2. Plant slips in the furrows. Space each slip a hand width apart (10 cm) in wet soil after the rains start. Press firmly around each slip with its flat side perpendicular to the slope (facing downwards) to encourage dense lateral growth which minimizes gaps in the hedge.
3. Fill any gaps early in the season (refer to the section on Plugging Gaps).
4. Fruit and multi-purpose trees or shrubs (i.e.Msangu, Mthethe, Nkunkhu, guava, peaches, mango, *Sesbania, Tephrosia* or pigeon peas) may be planted 1 m-2 m above and parallel to vetiver hedges (refer the section on Contour tree lines).
5. After good establishment, trim hedges to 30cm in May/June and again at the start of the next season in December/January to encourage tillering for a denser hedge.

Note: Trimmings may be used for thatching, mulch or bedding for livestock.

Plugging gaps in Vetiver Hedgerows

Gaps in hedgerows are a common problem after establishment. Fill in these gaps as soon as possible to prevent water from channeling through them which may cause serious erosion damage. Do this by following the steps below:

1. Prepare enough planting slips and fill gaps on a wet day.
2. Trim the vetiver edges of the gap, then dig a trench 20 cm deep across the entire gap.
3. Plant the slips in the trench 10 cm apart beginning at the edges of the gap.
4. Firm the soil around the slips, and mulch to ensure moisture retention for good establishment.

Planting Napier Grass

Napier is established from stem or root cuttings as it produces little viable seed. The main varieties are Gold Coast, Cameroon, and Congo. All are established as follows:

1. Collect fresh material by digging up healthy plants as done for vetiver grass. Cuttings should be 20 - 30 cm long with 4-5 nodes.
2. Push stem cuttings into the soil at a 45- degree angle with at least 2 nodes buried. Space them 20 cm apart in contour lines.
3. Plant root cuttings to a depth of 8 cm-10 cm and compact the soil around the roots. Use the same spacing as for stem cuttings.
4. Fill any gaps early in the season.
5. After good establishment, trim the grass to 40cm to encourage tillering. If the plants are not well established, wait until the onsert of the next rainy season. Napier grass needs to be trimmed regularly to avoid shading and competition. The trimmed material may be used as fodder.

Contour tree lines

Farmers may choose whether trees or shrubs are preferable for their contour strips. Fruit trees provide fruits which are important for human nutrition and income generation for farm households' valuable nutrition or income. Leguminous shrubs provide fuelwood, green manure and/or fodder. For fruit trees, plant varieties that are resistant to common diseases. Consult local extension staff on available planting material. If bananas are used, plant 90 cm above and parallel to the grass strip, with plants 2 m apart. Other fruit trees may be planted at 4m intervals along the upper side of the contour ridge. This may be done along each strip or along alternate strips.

If trees are preferred, use *Senna siamea, S.spectabilis, Gliricidia sepium* and *Leucaena diversifolia*, depending on the environment. *T. vogelii* and *Sesbania sesban* may also be planted at a closer inter-row spacing of 45 cm, but these are short-lived species which need replanting after 2 to 5 years.

Management of tree lines

Prune tree lines to reduce competition with crops, and to provide green manure, fuelwood or fodder. Prune at the start of the second growing season if trees are greater than 1 m so that they are big enough to recover from pruning. Prune branches with a clean, upward slanting cut at a height of 40 cm for Senna, Gliricidia and Leucaena, and 75 cm for Cajanas, Sesbania, and Tephrosia. During the growing season, prune trees whenever shading or competition becomes a risk. Distribute these prunings along the crop ridges to help reduce weeds and to increase available nutrients for the crops. Alternatively, prunings from Sesbania, Gliricidia and Leucaena may be used for animal feed. Collect branches for fuelwood.

At crop harvest, prune the trees again for green manure, wood or fodder. For green manure, lay fresh prunings along the crop ridges. When the leaves are dry enough to shake off, cover them with soil. The branches may again be collected for fuelwood or other uses.

Availability of planting material

For sources of tree planting materials refer to the chapter on Agroforestry or contact your local Agricultural or Forestry Extension agent.

Calendar of Key Activities for Management of Contour Hedgerows

November - January

1. Identify the size and location of planting sites for nurseries and contour hedgerows.
2. Collect sufficient planting material from identified sources, then prepare it for immediate planting in the selected sites, or to fill any gaps in existing hedgerows.
3. Trim established hedgerows to a height of 30 cm to promote tillering for a denser hedge.

February - March

If the owner has no intention of using or selling the cut grass for thatching or other purposes, trim hedges again to 30 cm tall to reduce shading effects on near-by crops and to promote further tillering.

May - June

Trim hedges after the crop harvest for thatching, mulch or other uses.

All aspects of conservation measures should be integrated in the farming systems.

2.1.4. Soil fertility improvement

Soil fertility improvement or enhancement and appropriate soil management is important in order to maintain or improve soil productivity. Soil fertility enhancement includes use of both organic and inorganic fertilizers which are complementary to each other. Use of chemical fertilizers only causes the soils to become unproductive in the long term and would not sustain crop yields. It is thus important to combine the use of inorganic fertilizers with organic manures such as composts and biomass from agroforestry. Detailed information on Agroforestry interventions is provided in chapter 4 of this guide.

2.1.4.1 Recommended Practices

The most cost effective or economical way of replenishing soil fertility is through the maintenance of soil organic matter. Soil organic matter can be improved through the incorporation and at the same time conservation of crop residues. An integrated approach which uses inorganic, organic and biological sources of crop nutrients is to be promoted.

2.1.4.1.1. Manures

Manures are fully decomposed organic matter. They supply plant nutrients in forms that can be easily taken up; improve structure of the top soil through supply of organic matter which improves root penetration, permeability, water retention capacity, aeration and resistance to erosion; reduces leaching of soil nutrients and improve soil microbial activity. Different types of manure can be classified into the following:

- Compost manure;
- Khola/animalmanure;
- Green manure;
- Farm yard manure; and,
- Liquid manure.

2.1.4.1.1.1. Compost Manure

Compost manure is a prepared mixture of well decomposed organic matter that supplies plant nutrients.The following are the four common methods of making compost:

- Chimato
- Changu (Chinese)
- Pit
- Wooden Frame

2.1.4.1.1.1.1. Chimato method

Chimato is a form of compost that is made as a heap on the ground. When the heap is complete, it is smeared on the outside with mud. The heap does not require turning and in most cases there is no need for additional water.

The best site for a Chimato compost heap is:

- Near a garden where the compost will be applied so as to minimize labour and time in transportation. If it is made in the garden, it is better to site the heap on the edge of the garden in order not to disrupt the cultivation operations in the garden.
- Under shade in order to maintain moisture in the heap.
- On fairly flat ground to help the even distribution of organic material and water.
- Near to the source of the materials and water.
- Away from dwelling houses where chickens and goats as these normally tear apart the compost heap. However, covering the heap with thorny tree branches deters them.

Avoid sites that are exposed to strong winds because the air movement will evaporate water quickly from the compost. Construct a shade or use existing windbreaks where it is windy.

Materials

- Composting materials can consist of grass, crop residues, maize stover and leaves of various plants.

- A booster with high Nitrogen content can consist of Khola manure or previously made compost manure, green fresh matter and leguminous leaves or top soil. The booster provides microbes that are required to speed up the decomposition process of the composting materials.
- Water
- Equipment and tools; these consist of bricks, stones or logs, poles, hoes, a measuring stick and a bucket or pail.

Procedure for making Chimato Compost

- The standard size of Chimato is a 1.5m cube i.e. length of 1.5m, width of 1.5m and height of 1.5 m
- Arrange the logs, bricks, stones in pairs at 10cm apart creating a gap for air vents
- Set three air vents at 60cm apart
- Lay down the maize stover or twigs on logs to create a bed
- Fix a pole in the middle of the created bed. When the compost heap has been completed, the pole will be removed leaving a hole which will be the air vent for aeration in the compost heap
- Chop the composting materials to less than 10cm length to increase surface area which is necessary for rapid decomposition. Pile the chopped composting materials in a layer 20 - 30cm thick.
- Water the layer adequately until it just oozes when the composting materials are squeezed
- Add a booster on top to a height of 3 - 5cm thick
- Water again on top of the booster till it is saturated
- Repeat the above process of a 20 - 30cm layer of watered composting materials topped by a 3 - 5cm layer of booster materials up to a height of 1.5m
- As the heap grows rotate the pole to ensure that there is an open hole
- Smear the outside with mud leaving the air vents open
- Cover the heap with grass or plastic paper to retain the moisture in the heap
- After one day remove the ventilation pole fixed in the middle
- After 2 to 3 days close the top vent to retain warmth in the heap.

A Chimato compost heap takes 40-60 days to mature depending on the type of composting materials used. The softer and greener the material the faster it will compost.

2.1.4.1.1.1.2. Changu (Chinese) Method

The organic materials decompose relatively fast, hence the name Changu.

The process of site selection for Changu (Chinese) compost heap is the same as that for Chimato compost (See the selection criteria listed above for Chimato compost).

Materials

The materials required are similar to those formaking Chimato compost (see the materials list above for Chimato compost). The only extraitem of equipment required is a 2m length of string.

Procedure for making Changu (Chinese) compost heap

- Measure a 1.5m to 2m diameter circle by using a peg and the string;
- Heap 20 - 30cm thick layer of composting material over the area marked. This will form the base of the compost heap;
- Water the heap adequately until it just oozes out when the materials are squeezed, to induce decomposition;
- Add a booster on top to a height of 3 to 5cm thick;
- Water the booster layer adequately;

- Repeat the above process with the diameter of each subsequent layer reducing until the heap is 1.5m high, thereby achieving a conical shape;
- Cover the heap with grass to reduce evaporation.

After 2-3 days the heap will have formed three distinctive layers. Insert a stick into the compost heap to check if decomposition has started. If the stick is warm then is shows that there is microbial activity and decomposition has started. If it is not warm, dismantle the heap and start the process again.

Where decomposition has started, turn the heap after 3-4 days and thereafter every 4-5 days to speed up decomposition. You will need to turn the heap 4-5 times to achieve complete decomposition. During the turning process, remove the outer layer (A) from the heap and separate the middle layer (B) from the inner layer (C).

In the process of rebuilding the heap:

- put layer A at the bottom;
- water adequately;
- put layer C in the middle;
- water adequately;
- lastly put layer B on top/outside the heap; and,
- water and cover the heap with grass.

Normally, the heap will mature within 30-40 days depending upon the nature of composting materials used. The softer and greener the material the faster it will compost.

2.1.4.1.1.1.3. Pit Method

As the name implies this compost is made in a pit in the ground. This process is not recommended during the rainy season unless an overhead roof is constructed. Excessive water draining into the pit will stop the decomposition process.

Materials

The details for both site selection and compositing materials are the same as detailed for making Chimato compost.

Procedure for making Pit compost

- Measure out a square of 1.5m by 1.5m. The length may be extended to any convenient distance in multiples of 1.5m.
- Dig a pit to the depth of not more than 1.0m. Deeper than this microbes may not be able to actively decompose the bulk of composting materials. Separate top soil from the sub soil since top soil may be reused when filling the pit.
- Put manure to a depth of 3 to 5cm at the bottom of the pit to provide nitrogen to microbes in the pit.
- Water the manure until it is completely saturated.
- Fill with composting materials up to 20 -30cm in thickness.
- Water adequately to induce the decomposition process.
- Repeat the above process till the pit is full.
- Cover the heap with top soil (about 8cm thick) and then grass to reduce evaporation.
- After 1 to 2 weeks check for warmth by inserting a stick to see if decomposition has started.

The manure will be ready after 2-3 months depending upon the composting materials used.

2.1.4.1.1.1.4. Wooden Frame Method

In this method, compost is made on the ground inside a framework constructed of poles and twigs. The composting materials are placed inside the frame.

Materials

The details for both site selection and composting materials are the same as detailed for making Chimato compost.

Procedure for making Wooden Frame compost heap.

- Measure out a square of 1.5m by 1.5m.
- Construct the frame at 1.5m in length by 1.5m in width by 1.5m high.
- Pile the composting materials to 20 - 30cm high to provide the bulk of the compost.
- Water adequately to induce decomposition process.
- Spread the booster over the top in a layer 3 to 5cm thick.
- Water adequately to encourage the evapo-sition process.
- Repeat the above process until the heap is 1.5m high.
- Apply water at regular intervals (twice a week) to keep the materials moist.
- After 1-2 weeks check for warmth by inserting a stick to check if decomposition has started to take place.
- Turn the materials every month.
- Cover the heap with about 8cm thick of soil to reduce evaporation by closing the top of the frame.

The composted materials will be ready between 2 to 3 months.

2.1.4.1.1.5 Windrow Composting Method

Windrow composting consists of placing the mixture of raw materials in long narrow piles called wind-rows that are agitated or turned on regular basis. Windrow method produces more manure at once than the methods described above. The compost heap if properly made will mature in 3-4 week time. Two heaps of windrow will be enough to apply on 0.4 ha (1acre) piece of land.

Locally available materials for Windrow composts are suggested as listed below:

Table 1: Suggested locally available materials for Windrow composts

Category	Ingredients for Windrow Composting (Typical Examples)
Basal materials	• Dry stalks and leaves of maize • Dry stalks and leaves of legume crops (soybean, groundnuts, other beans, etc.) • Fresh or dry grasses, tree leaves could be available
Booster materials	• Livestock manure (Khola, cattle dung, goat dung, chicken dropping, etc.) (as source of Nitrogen and to assist breakdown of the dry material) • Virgin soils (uncultivated soils) from forests or dambo areas • [- to introduce microorganisms to breakdown the dry material.] • Anthill soils[- to increase mineral nutrients.] • Wood ash [to help neutralize soil pH]
Water	Adequate amount of water is required in the decomposing process.

Table 2: Approximate amount of materials required for making a heap of Windrow (1 m width x 5 m length x 1 m height)

Materials	Volume (unit)	Weight (kg)
1) Dry stalks and leaves of Maize (chopped)	40 - 50 (x 50kg sack)	200 - 250
2) Soya or/and Groundnuts residues (chopped)	10 - 15 (x 50kg sack)	80 - 100
3) Khola/Cattle/Goat dung or Chicken manure	40 - 50 (x shovel)	100 - 150
4) Virgin soils	40 - 50 (x shovel)	50 - 100
5) Wood ash	20 - 30 (x shovel)	25 - 50

The following are the procedures to make a Windrow compost heap.

- Collect all the materials to be used in the compost heap.
- Chop the fibrous materials (maize stalks, legume residues) into smaller pieces with a Panga knife. The pieces should be from 5 cm to 10 cm long
- Collect soil from virgin land or anti hill that has never been planted to any crop before but has a good plant-ground cover (e.g. dambo or forest soils) or from orchard (e.g. under banana trees).
- Level the ground and measure 1 m width and 5 m length. Then mark the lines with long firm sticks in the corner of the heap. Dig around the measured area to allow water drain easily.
- If the ground is dry, water the base using 3-5 watering cans. Water facilitates activities of micro-organisms below the laid materials. Lay some chopped tree branches or grasses. This will form the base of the heap.
- Heap 20 cm thick layer of composting materials (crop residues and grasses) over the laid branches
- Water the layer adequately until just it oozes out when the materials are squeezed, to induce the decomposition process.
- Add layer of booster materials (khola/cattle manure, virgin /anthill soils and ash) on top to a height of 3 cm to 5 cm thick. Water the booster layer adequately.
- Repeat the above process until the heap has reached around 1 m to 1.5 m high (usually 3 to 4 layers).
- Monitoring decomposition process in windrow. After finishing making the Windrow heaps, there is need to monitor moisture and temperature levels. Moisture level is monitored by Check the water content of the heaps by holding the materials and letting them loose. As a rule of thumb, the materials are too wet if water can be squeezed out of a handful and too dry if the handful does not feel moist to the touch. Temperature is monitored by using a long, sharp, pointed stick and drive it into the pile at an angle. The stick, when removed, will be warm which indicates microbial activity and decomposition has started. If the stick is not warm then something must be wrong.

  The stick also helps you to check on the condition of the compost from time to time. It will show if the heap is wet or dry.

2.1.4.1.1.2. Animal (Khola) Manure

This is animal waste that accumulates in animal Kholas. The quantity and may be quality is increased by using large volumes of bedding materials(litter) in animal houses (Khola).

Animal manures are high in organic matter and so are beneficial to the soil structure. They also, contain large amounts of available nitrogen and phosphorus. These are good for plant establishment and vegetative growth.

However, if khola manure is applied fresh to the soil, the following problems arise:

- the heat from fermentation damages the roots of the young plants;
- there is competition for nitrogen created between crops and microorganisms during the process of decomposition;

- pests and diseases are introduced into the field;
- large numbers of weed seeds are introduced to the fields from the khola manure.

Curing

With the prevalence of the above problems, there is need to cure the animal dung before applying in the fields. This is a process where the manure is collected from the khola and heaped to release heat and to allow thorough fermentation to take place before its application in the farm. This process will:

- reduce the heat of the manure when applied to the fields;
- kill the pests, diseases and weed seeds. An appropriate curing site has the following characteristics:
- fairly flat so as to ensure equal moisture distribution when watering;
- be under shelter to avoid evaporation; and,
- close to the garden for easy transportation.

Materials

- ready supply of fresh khola manure
- water
- grass
- relevant tools i.e. hoe, pail/bucket, measuring stick

Procedure for curing Animal Manure

- Clear the ground for easy marking.
- Dig a pit of a minimum size of 1.0m deep and 1.0m wide. The length will depend on the availability of fresh manure. The objective is to construct a pit that has just the capacity to take the available manure.
- Take manure from the khola and mix it with water just to a friable condition but not to a slurry.
- Put the mixture in the pit until it is full. The top of the manure heap should be conical in shape so any water that may accumulate on top will drain away. The water will suppress decomposition.
- Cover the pit with top soil and grass to avoid moisture loss and evaporation (preferably grass without any viable seed).
- Check the decomposition after 2 to 3 days by inserting a stick in the heap. The stick should be warm if decomposition is taking place.

The fully cured manure will be ready after 30-40 days and is then ready for storage or application to the fields. Cured manure should be stored in a well ventilated place under shade and should not be exposed to strong sunlight, wind or rain.

Application of Manures

Once the compost or manure is prepared it is important to apply it in the right volume in the correctplace in the field. Application rate of manure varies with the type of soil, but also the quantity of manure available. Light soils such as sand requires larger quantities of manure compared to heavy soils such as clay.

The following table, shows as a general rule of thumb quantities that should be applied.

Table 3: Estimated application rates of compost

Type of Compost	Rate per 0.4ha
1. *Chimato*	10 heaps
2. *Changu* (Chinese)	15 heaps
3. Pit	10 pits
4. Wooden frame	10 heaps
5. Windrow	2 heaps
6. Farmyard Manure	0.8 to 2 tons
7. Liquid manure	20 litres per 8 metre or for every ten paces

Application methods

There are different methods of applying manure:

- localised i.e placing on the planting station;
- placing in furrows;
- bunding on the ridge; and,
- broadcasting.

Within Malawi, the traditional blanket recommendation for compost or manure is two handfuls per planting station for all cereals. The two handfuls weigh about 250g. At this rate, the amount of manure applied is 3.5 tonne per hectare. If farmers have additional manure they can spread this in the furrows between the rows. The recommended amount is one 20 litre tin/ bucket spread along 8m of furrow. The current application rate practised in fields planted at the recommended spacing of planting one-one is:

- bunding on the ridge at two handfuls per 3 planting stations, over a distance of 75cm; or
- one handful to each planting station which are 25cm apart.

2.1.4.1.1.3. Liquid Manure

Liquid manures are fast becoming an alternative to compost manures due to their simplicity in process of making. They are in all aspects similar to compost manures except for their being in liquid form. The liquid manures have a number of attributes which include the following:

- have short maturing period of maximum 14 days
- are fast reacting and crops respond quickly once applied
- are easily made from green vegetative material and animal manure e.g. goat droppings, chicken manures and sometimes khola manure
- less bulky as compared to other forms

Materials

- herbaceous nitrogen rich vegetative material such as Triphonia (Deliya), belekete (bonongwe), kabata (chisoso), mtetezga and others
- droppings from animals: from poultry or goats
- water
- hessian sacks
- 200 litre drum or brick and cement reinforced mixing tanks
- locally made earthen pots
- strings
- three supporting poles
- 2m stick

Procedure for making Liquid Manure Vegetative material

- Crash the vegetative matter in a mortar or in a sack
- Soak in water
- Keep the container air tight
- Stir after seven days
- After 14 days, sieve the solution from the residue
- Store the liquid in containers
- Before applying to the crop dilute in the ratio of 1 part to 10 parts

Application

- Apply on both sides crop just as fertilizer is applied under one-one method of maize planting
- Apply 50ml on each side of the crop
- Apply to maize 21 days after planting
- On vegetables, application can be after 14 days
- The residues can also be applied into the field or used as composting material

Animal droppings

- Fill the 50kg bag half full with animal droppings and tie the bag
- Soak the filled bag in a three quarter full 200 litre drum of water while suspended with a pole
- Shake the bag regularly to allow effective dissolvingofnutrients
- Remove the bag after 21 days

OR

- Fill the drum to a half full mark with animal dung
- Top the drum to the level mark of 200 litres with water and thoroughly stir for 10 minutes
- After 2 days stir once a day, early in the morning for 19 days
- Cover the drum for stocking

Application is as in vegetative material

Note: Dilution ratio of the fertilizer to water is as follows:

1:1 for cow dung

1:3 for chicken droppings

Use a small tea cup (100ml) to apply the fertilizer per station as a top dressing.

Dig 10cm by stick and pour the liquid fertilizer (wait 10 to 15 minutes to allow the liquid to infiltrate and cover the hole with the soil)

For detailed information on types of manure, consult the Land Resources Conservation Specialist in your area.

2.1.4.1.1.4.Pelletized Tobacco Wastes (PTW)

Pelletized tobacco waste is an organic fertilizer released for use in maize production systems in Malawi. It is made from waste tobacco dust, stems and leaves regarded as by-products from tobacco processing. The pellets are rich in: Nitrogen, Magnesium, Calcium, Copper and among others for plant development pest and disease tolerance. This low polyphenol compounds that are found in the product facilitate improved uptake of other essential nutrients.

Most smallholder farmers are unable to access inorganic fertilizers that have been advocated for many years to replenish the depleted nutrients in the soils due to high costs. Alternative cheap organic fertilizer technologies have been introduced such as animal manure, farmyard manure, green manure, compost manure and tobacco wastes. However, these organic sources have low nutrient content to support high production of crops such as maize. Supplementing inorganic fertilizer with manure is an alternative which helps to improve soil health and crop productivity.

Importance of PTW

Pelletized tobacco wastes are beneficial to the crops for the following reasons:

- Improve soil conditions by providing nutrients, reducing soil pH and increasing organic matter.
- Improve soil water retention that helps in mitigating dry spells and drought.
- Reduces environmental pollution through recycling of tobacco wastes
- Nutrients are easily accessed by plants due to rapid mineralization.
- In some cases it reduces incidences of field pests and diseases

Product Description

The product comes in two forms of packaging, 50Kg and 25Kg bags to suit farmers' financial stand. From laboratory results, each bag contains the following proportions of nutrients: Nitrogen (14.3 %), Phosphorous (16.17), Calcium (23.2%), Magnesium (1.67%), Copper (25.9%).

Application of tobacco pellets

- Apply 7-10 cm from the maize-planting station to avoid scorching.
- Use a table spoonful (20g) per hole where 1X1 maize planting method is used at basal and the same measure at top dressing.
- Do not crush it to smaller pieces because it easily dissolves in the soil.

Mode of Application

The tobacco pellets can be used for both rain-fed and irrigated farming.

A) **Sole Application:** Where only tobacco pellets are used;

  - Use the pellets for basal dressing as well as top dressing.
  - At basal dressing apply five (25kg) bags per acre and
  - Another five (25kg) bags per acre for top dressing.
  - A total of ten (25kg) bags must be used per acre.
  - A total of twenty five (25kg) bags must be used per hactare.
  - one table spoonful (20g) per hole where 1X1 maize planting method is used.

B) **Supplementation (Optional):** Where tobacco pellets are used in combination with chemical (inorganic) fertilizer

- Basal dress with NPK on recommended rate
- Top dress with five (25kg) bags per acre.
- Use one table spoonful (20g) per hole where 1X1 maize planting method is used.

Time of Application

- Split application is recommended to reduce nutrient losses and enhance synchrony between nutrient availability in top soil as demanded by the crop.
- Basal dressing: Apply 7 days after planting or when the crop has three to four leaves.
- Top dressing: 21 days from planting.

Other Agronomic Practices

Follow other recommended agronomic practices such as, timely planting, weeding, pest and disease control, harvesting and post harvesting management to achieve optimal returns.

CAUTION

1. Do not apply pellets on the same spot where maize is planted
2. Make sure the expiry of PTW is clearly indicated on the bag.
3. Make sure the product is packed in a well labelled bag.
4. Use protective clothing in handling the product i.e. Mouth masks, gloves etc.
5. Do not store in dwelling.

2.1.5 Conservation Agriculture

Conservation agriculture is a farming pratice that combines three basic principles of minimum soil disturbance, permanent soil cover and crop rotations. Conservation Agriculture aims to produce high crop yields while reducing production costs, maintaining the soil fertility and conserving water. It is a way to achieve sustainable agriculture and improve livelihoods.

Conservation agriculture helps farmers to achieve greater farm profitability and food security through:

- moisture retention in the soil
- reduced soil and soil nutrient loss through run-off
- improved soil structure and fertility
- eventual decrease in weeds
- reliable yields in dry years
- reduced labour, animal traction or fuel costs
- increased area cultivated as less time is needed per hectare
- Carbon Sequestration: CA sequesters carbon in soil and vegetation while reducing carbon gas (CG) emissions from oxidation caused by soil disturbance and from the common practice of burning crop residues and weeds

There are a number of complimentary practices depending on the local farm situation in which all the three principles can be applied in combination such as:

- Use of inorganic and organic fertilisers
- Planting methods and tools
- Application of herbicides
- Fodder and cover crops
- Improved seeds
- Agroforestry and natural regeneration
- Soil and water conservation measures

Good crop management practices besides the three key principles are needed to fully realize the benefits of CA such as:

- Use of improved crop varieties
- Timely planting
- Recommended plant spacing
- Recommended fertilizer use
- Optimum weed, pest and disease control

Note: Old ridges flatten out or disappear within one or two seasons

Good soil cover during the growing season is best achieved by optimizing plant spacing within and between rows for different crops to minimize bare ground. Spacing depends on the crop, soils, rainfall, and levels of chemical or organic fertilizers used. After the crop harvest, crop residues and other biomass should be distributed across the ground surface and protected against burning. It is critical NOT to import biomass from adjacent fields which exposes these areas to the elements and limits the area under CA.

The maintenance of a good soil cover of dead or living plant material is at the heart of conservation agriculture. This may mean a total change of cropping system as well as livestock management.

2.1.5.1 Minimum soil disturbance

This is the basis of CA and is non-negotiable. It entails:

- No ploughing, ridging, tillage or heavy weeding by manual or mechanical means.
- Direct seeding into a) small planting holes on the flat or tops of old ridges using a dibble stick, hoe, or other suitable tool (mimics the age-old method of planting in Malawi before the introduction of ridging, or b) rip lines using animal or mechanical drawn rippers.

Converting to conservation agriculture from conventional farming is a slow process and requires patience in order to recognize these benefits since it may take several years.

Maximum benefits of minimum tillage can best be realized if integrated with soil cover, crop rotations and other interventions such as application of compost manure and planting of agro - forestry trees are promoted.

2.1.5.2. Good soil cover

The aim is to achieve good soil cover during the growing season as well as the dry season. The benefits of this practice include: to protect the soil from the elements; to maximize the capture of rainfall while minimizing runoff and loss of top soil; to improve the structure of the soil and its water holding capacity; to help suppress weeds; to increase beneficial activities of termites, earthworms and other organisms and to increase the effectiveness of fertilizers by reducing nutrient losses from volatilization and leaching (see more benefits under the section on benefits of soil cover).

Types and sources of soil cover

- Living or dead plant material applied as mulch.
- Green manure, cover and forage crops
- Crop residues
- Fallow vegetation e.g. Tephrosia

Benefits of soil cover

The source of cover available whether as mulch, cover crop or incorporated in the soil, has a number of benefits to the soil. These benefits include:

- Protection against impact of rain drops - less surface sealing and crusting
- Reduced run off
- Increased water infiltration
- Reduced evaporation, thus conserves soil moisture.
- Protection against soil erosion by water and wind
- Prevention of overheating of soil surface
- Reduced diurnal variations of temperature
- Controls the multiplication of weeds
- Source of soil organic matter build up
- Carbon sequestration
- Cover crops reduce requirement for labour in weeding as they have been proven to suppress weeds.
- When a legume is used, it can be eaten as protein supplement and/or sold for income.

Challenges of soil covering

There are a number of challenges to soil covering that includes:

- Short growing season in the semi-arid limits the growth of green manures and cover crops.
- Crops may also compete with food crops for the limited amount of water available.
- Need to feed crop residues to livestock during the dry season.
- Uncontrolled burning.
- Mulching may retard humification especially where water may limit microbial activity for the decomposition of the mulch.
- Research has shown that crop residues lower crop yields on sites where soil fertility was low and no additional fertilizers were applied.

Crop residues

Mulching or incorporation of the residues helps the farmer to make manure in-situ. In most parts of the southern Africa region, and indeed in Malawi, crop residues are used for compost manure making. Farmers have been faced with the challenge of moving crop residues from the field; to homesteads; and bring them back as compost manure. This has the advantage that if combined with animal dung, there is an added value to the residue. The residue is also protected from grazing animals as well as un controlled fires.

The challenge however has been that farmers will make the compost manure, but not apply it in the field because they have no transport to carry the manure. Labour constraints may also limit the application of the manure.

2.1.5.3. Crop rotation, Intercropping or Relay Cropping

Crop rotations and/or associations/intercrops are critical for maintaining soil health, suppressing weeds, controlling pests and diseases, including Striga, and providing a more diverse base to improve household diets and incomes. Although crops grown will depend on market demands and the interests, needs and resources of the farmer, the inclusion of legumes is encouraged for the following reasons:

- To reduce the demands on the soil and the use of expensive fertilizers,
- To increase opportunities to improve the diet and nutrition of the farm family,
- To increase income from the higher yields under CA by reducing the row spacing to increase the plant density to the optimum (which is not possible with ridges or basins).

Crop rotations increase crop yields, add organic matter to the soil and improve soil fertility. Crops differ in the quantity and quality of the residues they produce, and thus in the effect on soil management.

For example, leguminous crops and oil crops produce fewer residues that decompose faster, have a lower Carbon/Nitrogen ratio and are easier to manage during direct sowing than grain crops.

Crop rotations can include commercial crops and cover crops. The most ideal rotation in a conservation agriculture system is one in which gramineas are diversified with legumes, cruciferas, malvaceas or others. This kind of rotation will:

- Break pest and disease cycles
- Produce different quantities and types of residue
- Facilitate residue management
- Improve the nutrient cycles

The conventional crop rotation cycle incorporates a fallow in the fourth or fifth year of the cycle. This is done to rest the land. The bare fallow however has the disadvantage that it does not necessarily rest as it has weeds growing on it. Conservation agriculture advocates that this should be an improved fallow, preferably planted with legumes or any other soil fertility shrub. This will not only restore fertility, but will also help control weed infestation. Tephrosia vogellii has gained ground in recent years in soil fertility improvement. Because of its characteristics, it is one of the most ideal species for improved fallows in a particular rotation cycle. Rotations of legumes are also ideal as well as with tree crops.

For more information on conservation agriculture, consult the Land Resources Conservation Specialist in your area as well as the National Conservation Agriculture Guidelines.

The National Conservation Agriculture Guidelines start by outlining the foundational farming practices which are the basic soil and water conservation principles with the aim of grounding the CA practice in the wider sustainable land resources conservation context so that conservation agriculture is sustainable. In addition, the Guidelines provide the rationale for conservation agriculture in the country in relation to the global land degradation problems and the basis for which conservation agriculture has the high potential to sustainably conserve the land resources. Furthermore, the Guidelines then provide the details of the conservation agriculture systems which are suitable for Malawi with reference to research findings and lessons learnt in implementing conservation agriculture in the country. The step by step guide for the farmer to implement conservation agriculture is also included so that there is a uniform application of techniques in the implementation of conservation agriculture in order to meet the principles of conservation agriculture.

In ensuring sustainable land management, other complementary practices which should be implemented alongside conservation agriculture are also presented in the Guidelines. Some practices such as use of **herbicides** and **pit planting** have been associated and let alone be mistaken as part of CA while in actual sense they are **NOT** but that such practices are just complimentary.

2.1.6. Rainwater harvesting

Rainwater harvesting is the process of collecting and storing water from an area that has been prepared to increase precipitation runoff. Water collection can be from direct rainfall, runoff and underground water sources.

One of the most widespread and directly accessible sources of water is rainfall. When rain falls the following may happen:

- Direct evaporation,
- Interception by vegetation and other natural or artificial structures,
- Infiltration into the soil where it can provide water for vegetation as well as recharge ground water sources,
- Run-off from the surface into rivers, which take the water to lakes, the sea or ocean.

Rain water harvesting therefore seeks to reduce evaporation losses, runoff and deep percolation of the water by harnessing and storing it in storage structures or in the field for direct use by crops.

Harvested rainwater can be used for the following purposes

- Domestic usages,
- Satisfying crop requirements through impro- vement of soil moisture,
- Controlling and mitigating drought
- Conserving land resource including erosion control,
- Recharging ground water resources
- Watering livestock and for wildlife
- Forestry support
- Industrial use and
- Fire fighting (putting out fire)

2.1.6.1. Rainwater harvesting technologies and systems

The rainwater harvesting techniques are categorized into micro catchments, small external catchments, in-siturain water conservation, and macro catchments techniques.

Micro-catchment techniques

They are normally within cropped land, which generate small quantities of runoff for a single crop, group of crops or row of crops. The techniques include; negarims, infiltration pits, planting pits, stone bunds, contour ridging, box ridging, semi-circular bunds and large half moons.

Small external catchments techniques

Small external catchments include techniques that collect runoff from road drainage and adjacent fields before being diverted into cropland such as road/ footpath run off harvesting.

In situ rainwater conservation techniques

In situ rainwater conservation technologies are distinct from runoff farming systems in that they do not include a runoff generation area, but instead aims at conserving the rainfall where it falls in the cropped area. The techniques include; agroforestry, grass strips/hedgerows along contours, compost manure making and application, mulching and crop residue management, terrace catchments, and gully reclamation for crop production.

Permanent planting pits

Permanent planting pits or basins are small pits in the ground used for planting many types of crops. They are about 30cm wide, 30cm long and 20cm deep, about the size of a man's foot. They are best suited to areas with less than1,000mm of rain a year. Correctly constructed planting pits may be used for various crops for many years. The table shows the summary of the dimensions:

Table 4: Pit dimension and spacing

Spacing between pits	70 cm
Spacing between rows	90 cm
Depth	20 cm
Length	30 cm
Width	30 cm

Materials

- A hand hoe
- Pick
- Pegs to mark the rows and pits
- A string to measure off the correct distance between pits and ensure that the rows are parallel

Procedure for preparation, use and management of permanent planting pits

Step 1: Preparation of pits (immediately after harvest)

- Remove stumps, wood and roots if it is on virgin land. The stump holes should be covered by hand and leveled off. Do not plough.
- In a field that was previously cropped, leave up to 30% crop residue. The residue will decompose, add organic matter and improve soil structure.
- Mark pit position using the rope following a contour line i.e the pits should be dug across the slope.
- As the pits will be permanent, precision is important in construction of these pits. At the spacing given in the table number there will be 15,850 pits per hectare.
- If there is high degree of moisture stress, the pits can be made deeper and wider to make maximum use of rain water. Spread mulch within and around the pits.

Step 2 : Applying fertilizer and manure.

It is recommended to apply 2 handfuls of manure in a pit with above specified dimension. If basal fertilizer is available, it can also be applied at the same time. When manure has been applied, they should be covered with soil. A shallow depression should still remain on top.

Step 3 : Planting

The pit can be planted to the following crops as outlined in table 5.

Table 5: Plant population of some crops

Crop	Seed/pit	Plants/ha.
Maize	4	57,000
Pearl Millet	1pinch	125-150,000
Cotton	Fuzzy 6-8, Delinted 2-3	63,000
Groundnuts	8-10 seed	
Sunflower	4-6	36-44,000

Step 4: Weed control

Keep pits free of weeds at all times. Weed as soon as the weeds appear and just before harvesting. This will reduce the amount of weeds in the next season.

Step 5 : Top dressing

Top dressing fertilizer to maize must be applied after 21days. Use the area specific fertilizer recommended rates as indicated in Chapter 3 in this guide.

Step 6 : Harvesting

At harvest, remove the crop by cutting plants at base. Stems and leaves should be left on the surface of the soil. The roots should not be uprooted; they should be left to decompose within the pit.

In order to increase the efficiency of the pits, it is important to realize that the use of these pits alone will not produce the highest yields. Therefore, to obtain the best results:

- Always incorporate crop residues; leave a minimum of 30% crop residue on the field.
- Agro-forestry trees and cover crops can also be integrated into the pits.
- Apply manure generously.
- Protect crops from weeds, pests and diseases.
- Always plant with first planting rains.
- Grow crops in rotation, at least 30% of the cropped land should be planted to legumes.

Note: When using planting pits:

- Remember that the pits are permanent and can be used for three successive seasons. So it is important to take care of them.
- Family members should be trained to make the pits and should understand the ideas of conservation agriculture.
- Do not plant in a pit which is not nearly filled with soil - the crops will drown.
- Do not dig pits during the rainy season. Hard pans are best dealt with in the dry season.

Macro catchment techniques

These comprise large external catchments producing massive runoff (floods) which is diverted from gullies and ephemeral streams and spread into crop land. Because these techniques handle large amounts of water, designing and constructing them need special skills. The following are the most important macro catchment techniques; flood diversion and spreading, and permeable rock dams.

2.1.6.2. Rainwater storage systems

Storage systems offer the land user a tool for water stress control and dry spell mitigation. Due to the intermittent nature of rainfall, storing rain water allows use of the water at a convenient time as required by an individual or communities. Storage systems are needed to;

- Make water potable and easy to utilize,
- Harvest rainwater when it is plenty and use it later,
- Reduce the distance to watering points and
- Increase the water head/pressure so that it can be used for gravity fed irrigation.

Storage systems include; earth dams, rock catchment, sand dams, farm ponds and water storage tanks.

2.1.7. Other recommended land husbandry practices

i) Farm planning should be encouraged to derive maximum benefit from available resources on a sustainable basis. For details on farm planning refer to the section on farm management in this guide. In addition, consult agricultural staff.

ii) Agropastoral systems such as planting of improved pastures, growing of fodder crops and use of crop residues for animal feed and bedding should be undertaken in all suitable areas.

iii) Implementation of simple gully control measures such as use of brushwood, check dams, planting of suitable vegetative materials such as vetiver, napier and bananas, should be encouraged. For details refer to section under gully control in soil and water conservation section

Herbicide application

The use of herbicides in conservation agriculture is well known and documented. The correct application of herbicides is important in minimizing soil disturbance, but also in reducing the overall production costs, notably reduction of labour demand for weeding.

It is critical that one should have proper knowledge and expertise in the handling of herbicides before deciding to use them. The following will have to be understood about herbicides:

- Herbicides require clean, debris free water. Dirty water may turn the application of herbicides to be costly due to constant break down of sprayers.
- Repeated use of a particular herbicide on a mono-cropping plot can easily lead to resistance. Integrating the use of herbicides with crop rotations will assist in breaking cycles.

2.2. Irrigation

Malawi has abundant water resources and potential irrigable land is under utilized. The role of irrigation in increasing agricultural production is evident from the existing irrigation activities throughout the country.

Irrigation in Malawi is very important as it assists in addressing the challenges of food insecurity and poverty. These challenges have largely been brought about due to erratic rainfall distribution which has resulted into prolonged dry spells, droughts and floods whose occurrence has increased due to climate change effects. These effects have negatively affected rain-fed agriculture. In addition, food demand in Malawi has been increasing steadily due to absolute increase in population which is estimated at an annual growth rate of 2.8%.

Potential irrigable area in Malawi is estimated at 407,000 hectares. Present total irrigated area is estimated at about 104,600 hectares, of which 54,284 hectares are irrigated by smallholder farmers.

2.2.1. National aims

The overall goal of Irrigation Policy is to contribute to sustainable national economic growth and development through enhanced irrigated agriculture production and productivity. This is provided under organized smallholder and estate management institutions.

The policy objectives of irrigation in Malawi are:

i) Increase land under sustainable irrigation farming;

ii) Facilitate crop diversification and intensification;

iii) Create an enabling environment for irrigated agriculture;

iv) Optimize investment in irrigation development taking into account climate change;

v) Enhance capacity for irrigated agriculture;

vi) Promote a business culture in the small-scale irrigated agriculture sector

2.2.2. Policy Priority Areas

In order to achieve the overall goal, the policy focuses on three priority areas namely, Sustainable Irrigation Development, Sustainable Irrigation Management and Capacity Development.

a) Sustainable Irrigation Development. It entails construction of new irrigation infrastructure to put more land under irrigation. The policy, therefore, aims at addressing issues such as inadequate financial resource mobilisation, high development costs (i.e. US$ 9,000 to 15,000 per hectare), unharmonised irrigation development initiatives, environmental degradation, customary land disputes and limited participation of stakeholders.

b) Sustainable Irrigation Management. The developed areas of irrigated schemes should be well managed to sustain productivity. The beneficiary community should operate and maintain the infrastructure so that the designed capacities are maintained to support desired crop production levels. The policy, therefore, aims at addressing issues such as degradation of catchment areas which is affecting availability of water resources; beneficiary community unwillingness or capacity limitations to operate and maintain the systems; marketing challenges; land tenure issues and inadequate irrigation extension services which cause loss of systems capacity.

c) Capacity Development. The development and management of irrigation schemes require adequate technical and administrative capacity among others. The technical competence within the public and private sectors including training institutions and beneficiary communities is critical for sustainable irrigation development and management.

2.2.3. Site selection for irrigation development

There are three factors to be considered when choosing a site for irrigation development. These are physical, economic and social factors.

Physical factors include:

a) Reliability and closeness to the water supply;

b) Land slope and soil characteristics;

c) Risk of flooding;

d) Protection of the crop and equipment from theft and damage by livestock.

Economic factors include:

a) Ease of vehicle access if surveying and engineering work is required;

b) Ease of access to markets for supply of inputs and sale of produce.

Social factors include:

a) Farmer organisation

b) Land tenure issues;

c) Water rights issues.

Each of these factors must be checked and found to be suitable before serious efforts are made to promote or encourage irrigated farming.

2.2.4. Irrigation methods

The following are common methods of irrigating crops.

2.2.4.1. Watering can/bucket irrigation

Watering can or bucket irrigation is widely used by smallholder farmers. This method is best for small plots of land which are close to the water source; particularly where the water source is limited or where open wells re-fill slowly.

Water should not be poured directly from the bucket because if the crop is young, the plants may be damaged.

2.2.4.2. Basin irrigation

A basin is a levelled area of land, surrounded by earth embankments, which is totally flooded during irrigation. Basins can be flat, either sunken or raised, or ridged. In all cases good basin irrigation requires the ground surface to be level.

Basin irrigation is suitable for many crops. The advantages are:

a) The right amount of water can be given with a minimum amount of labour if the beds are well levelled.

b) Water losses can be kept low by minimal run-off.

c) Basins last for a long time once they are constructed.

Prolonged ponding and crop damage can occur in poorly managed flat beds. There is also a risk of soil erosion in the supply channel as a result of high speed of water.

2.2.4.3. Furrow irrigation

Furrows are generally used on farms with large uniform fields where long furrows can be formed. They are not appropriate in plots which are of irregular shapes.

Water is gradually absorbed into the bottom and sides of the long furrow wetting the soil. The length of the furrow is normally greater than 50 m but depends on the type of soil and the land slope. It is important to use the right shape of furrow, furrow spacing and length.

If managed well, furrow irrigation has the following advantages:

a) Moderate to high irrigation efficiency.

b) Less danger of leaching nutrients from the soil than with basin methods.

c) Crop stems are not wetted

d) Even soils which form a surface crust when flooded, can be irrigated as water moves laterally from the furrow into the ridge below the level of plant growth.

The disadvantages of furrow irrigation are:

a) Erosion can occur if the slope is too steep.
b) Labour requirements may be high as the streams must be carefully regulated to achieve uniform water distribution.
c) Salts from the soil or water supply may concentrate on top of the ridge and eventually cause damage to young crops.
d) Lateral spread of water in coarse textured soils may not be enough to wet the soil between the furrows.

Note: Careful land levelling is required for uniform furrow slope and shape.

2.2.4.4. Sprinkler irrigation

Sprinkler irrigation is a way of applying irrigation water to the soil that is similar to natural rainfall. It can be used on many crops, soils and geographic conditions. The system can be used on a land slope of up to 12%. A small sprinkler system can be used where the water supply (flow rate) is limited. Advantages of sprinkler irrigation include the following:

a) Can be used on steep slopes and uneven ground.
b) Can be used on a wide variety of crops.
c) The labour requirement is low.
d) Water is spread evenly over the irrigation plot resulting in high efficiency, if managed properly.

The disadvantages of a sprinkler irrigation system are:

a) High capital cost of the equipment.
b) High operational and maintenance costs for the pump and field equipment.
c) Irrigation is affected by high winds.
d) Evaporation losses can be high.
e) Sprinkler nozzles are easily blocked if sediment-laden water is used.

2.2.4.5. Micro (drip) irrigation

Micro irrigation includes a number of technologies where water is only applied to part of the field surface. It can save on water and improve crop yield. It can also be used for fertigation; a process where fertilizers are applied through irrigation water. With such a system there is even distribution of nutrients and actual crop nutrient requirements can be met since incremental supply of nutrients is possible. In drip irrigation water is given more frequently than with other irrigation methods and this provides a high moisture level in the soil. However the costs of purchasing, operating and maintaining the equipment are high.

2.2.4.6. Sub-surface irrigation

Water is supplied to the plants from below the surface by controlling the level of naturally occurring shallow ground water. Water is made to flow through capillary action that carries it to the surface. Regular drawing down of water is essential to avoid water logging of the plots and crop damage.

2.2.5. Guidelines for selecting an appropriate irrigation method

The following factors should be looked into when considering irrigation:

a) Natural conditions: soil type, slope, climate and water supply.
b) Type of crops to be grown.
c) Type of technology: this will directly affect the amount of labour and skills required for operation and maintenance.
d) Previous experience with irrigation and levels of training.
e) Costs and benefits; capital costs, operational costs and expected benefits.

The selection of an irrigation method must take into account all the above-mentioned factors. It must not be based only on physical or technical criteria.

(i) Natural conditions

(a) Soil type

Sandy soils need frequent but small irrigation applications because little water is stored and the water enters quickly (high infiltration rate). Sprinkler may be better than surface irrigation. All methods – surface or overhead can be used on loamy and clay soils. Clay soils, with low infiltration rates, are ideally suited to surface irrigation. Other human and technical factors will decide the best method.

(b) Land slope

Where the land slope is uneven or steeply sloping, up to 12%, sprinkler or drip irrigation may be better than surface methods as they require little or no land levelling. Surface irrigation is recommended for a land slope of up to 5%. Any slope above 5% encourages soil erosion. However, the expense and operational costs of these methods must be fully understood before any decision is taken to use them. If surface irrigation is chosen the farmers must understand the amount of work required for land levelling and bed preparation.

(c) Weather conditions

Where high winds are common during the dry season, it is better to use surface or micro irrigation methods. Sprinkler irrigation should not be selected in an area where there are frequent periods of high wind during the dry season.

(d) Water resources

Water is applied more efficiently with sprinkler and drip irrigation than with surface irrigation. It is better to use these methods when water is very limited. However, these methods will only be efficient if they are correctly used and maintained by the farmers as they cost more to run due to use of motorized pumps.

Table 6: Types of water source that may be used for irrigation

Water source	Method of irrigation
Small dam	(i) Maintains a high water table immediately downstream of the dam where farmers can use shallow wells. (ii) Where the reservoir contains sufficient water, use treadle pumps, solar-powered pumps or motorized pumps.
Stream	(i) Manual lifting by bucket or can. (ii) Diversion into a canal system using the natural ground slope. (iii) Treadle pump, solar-powered pump or motorized pump if the stream is adequate.
Lake or pool	(i) Manual lifting by bucket or watering can. (ii) Treadle pump, solar powered pump or motorized pump.
Shallow well-waters less than 5m below the surface	(i) Manual lifting by bucket or watering can. (ii) Treadle pump.
Deep well water more than 7m below the surface	(i) Manual lifting with rope and bucket. (ii) Submersible tubewell pump.

(e) Water quality

If the water source contains too much sediment it is better to choose surface irrigation, since the sediments may clog drip or sprinkler irrigation systems. If the water has a high level of dissolved salts it is better not to develop irrigated cropping as yields may be reduced and the soil structure may be damaged over time. Where this is the case, whitish stuff and hard pans will be noted in the soil surface. However, alkalinity has similar visual signs, and alkalinity test is used to distinguish the two conditions.

(ii) Type of crop

Surface irrigation methods can be used for all types of crops. The type of surface method (flat basins or ridged, furrows or micro basins around a tree) will depend on the crop.

As they are expensive to install per hectare, sprinkler and drip irrigation methods are mostly used for high value crops. Drip irrigation is best for individual plants such as trees or widely spaced row crops like vegetables. It is not suitable for close growing crops such as maize since density of pipes on the field will be high and therefore the cost will be very high.

(iii) Type of technology

It is better to consider more advanced technologies where there is a good reason to reject surface irrigation. The high cost of purchasing and maintaining high technology equipment, and the difficulty of finding spare parts and training users to operate and maintain equipment correctly may make them unsuitable. Small-scale surface irrigation systems usually need less sophisticated equipment for both construction and maintenance, except in the case of pump purchase and installation. The equipment is often cheap and easy to maintain.

(iv) Previous experience

The choice of an irrigation method should take into account of any irrigation traditions within the target area.

(iv) Costs and benefits

In selecting irrigation method both the start up and the running costs must be calculated to see the long-term benefits. A method can have high start up costs (high investment) but with low running costs and the opposite is true. Therefore it is important to calculate properly all these costs. Labour and energy requirements must also be considered when selecting an irrigation system.

2.2.6. Water Abstraction technologies

There are two broad based categories of technologies that are used for abstraction of irrigation water and these are river diversion and pumping.

2.2.6.1. River diversion

This technology takes advantage of gravity. Where the water source is at a higher elevation than the field, water is let to flow by gravity. The water is diverted from a stream or reservoir and conveyed to the field through canals or pipes. Schemes that make use of gravity are attractive because of their lower operating costs and ease of use. Where the difference in elevation between the water source and the field is very big, sprinkler systems can also be operated by gravity.

2.2.6.2. Pumping

There are many types of water pumps being used for irrigation. Each pump type has different characteristics and capabilities. The most common pumps for small-scale irrigation in Malawi are:

2.2.6.2.1. Manual pumps

Manual water pumps may vary in their performance and suitability for use in the field. Some pumps are heavier than others. The effort required to operate the pump also varies between different models and designs. Manual pumps cost less than electric, petrol or diesel powered pumps, but the quantity of water (discharge) they produce is many times lower. For a farmer wanting to irrigate a small area (less than 0.2 ha per day from a shallow well water source less than 4 m below the surface) a manual pump can be a good choice because of its low purchase and operating costs. An example of the manual pump available in Malawi is a treadle pump. The average discharge from a treadle irrigation pump can vary between 0.4 to 1.2 litres per second depending on the person operating it and depth from which they are pumping water. The potential irrigated area for treadle pump is 0.3 of a hectare, but for the small Money Maker pump, it is 0.2 of a hectare.

2.2.6.2.2. Motorized pumps

Motorized pumps are water lifting devices that are propelled by diesel engines, petrol engines, electricity, solar power or wind power. Wind-powered pumps have been demonstrated in Malawi on a small-scale. At present, they do not provide enough power to pump the volume of water required for irrigation. They are more appropriate for pumping water for domestic supply or for livestock.

An example of a motorized pump is radial flow pump commonly known as centrifugal pump. These are often described by the diameter of the delivery connection pipe, where the delivery hose is connected, for example 50 mm pump. In Malawi, these are found in two common sizes; small motorized of 5hp which can irrigate 3ha and 10hp for 6ha. Most of them are diesel operated.

A centrifugal pump can be used where pressure is required for example with sprinklers or drip. The operator should ensure that the pressure and discharge of the pump are matched to the requirements of a pressurized irrigation system to avoid wasteful use of fuel.

Petrol engines

These are generally small-sized engines operated by petrol and are portable because of low weight.

The advantages of using petrol engines include:

a) Easy to move from one place to another because of low weight
b) They are cheaper compared to diesel engines

The disadvantages include:

a) They require more regular maintenance hence not long lasting as compared to diesel engines of similar sizes.
b) They are designed to be operated for few hours (two to four hours) per a day hence restricted to small fields.

Diesel engines

These are generally heavy built and robust engines operated by diesel. The advantages of using diesel engines include:

a) They are long lasting compared to petrol engines.
b) They can operate for many hours a day hence suitable for irrigating large fields.

Disadvantages of diesel engines:

a) They are heavy hence not easy to move from one place to another.
b) They are expensive compared to petrol engines.

Electrical Power

Where a reliable source of electricity supply is available, an electric motor is normally the most reliable source of power for pumping. However, in Malawi, this option has proven to be a challenge for most smallholder farmers as they are unable to operate the pumps due to high electricity tariffs.

Solar Power

Solar-powered pumps have been demonstrated in Malawi on a small-scale. So far, they have proven to provide enough power to pump the volume of water required for irrigation with a discharge rate of up to 15 litres/sec. However, this discharge depends on the number of solar panels installed and the water depth. So far potential areas where solar-powered pumps can be installed for irrigation are those along the lakeshore and the Shire Valley basin where the water table is high.

The main advantage of using solar-powered pumps is that once installed, there are no operation costs as compared to other motorised pumps which require fuel or electricity to operate. The challenge is high installation costs for the panels and farmers have to provide adequate security against theft of the solar panels and pump accessories.

2.2.7. Other issues to consider for irrigation development

2.2.7.1. Capacity Building

To ensure that there is a sustainable irrigation development it is important to consider developing the capacity in the irrigation sub sector. This involves the public sector, the private sector and the farmers themselves. Irrigation service providers need to be equipped with knowledge and skills on modern methods of irrigation.

2.2.7.2. Environmental Protection

To protect the environment from impacts of unplanned irrigation development the following measures should be taken:

i) Drainage of irrigated lands should be well planned during the initial phase of irrigation development.

ii) Encourage developers to conduct Environmental Impact Assessment on their irrigation development projects.

iii) Encourage developers to mitigate adverse impacts of irrigation.

iv) Preservation and conservation of the catchment area to the irrigation systems for instance through afforestation and construction of soil conservation structures.

Development of irrigation infrastructure influences soil erosion, as such government recommends that cultivation along rivers should be done 30m away from river banks. The lower part of the developed area should be managed as indicated under river bank protection in chapter one of this manual.

2.2.7.3. Beneficiary empowerment

For the irrigation projects to be sustainable over time it is important that the beneficiaries should be empowered. This can be done through group mobilization and development. Beneficiaries should take part in all the stages of setting up the irrigation development. Contributions towards the costs of putting up structures should be sourced from the beneficiaries and this can be in kind like provision of labour and other materials. In doing this the beneficiaries will be self reliant and take full responsibility of ownership of the project and they will not want to see it fail.

Advisory services on irrigation may be sourced from the nearest staff of Ministry of Agriculture, Non Governmental Organisations, Private companies or Farmer organisations wherever appropriate.

2.3. Farm Mechanization

Farm work drudgery is common among smallholder farmers. The majority of farmers use hand tools such as hoes for agricultural cultivation. Agricultural mechanization is required to reduce the drudgery in order to improve productivity and production. Agricultural operations such as land preparation, planting, irrigation, weed control, harvesting, transportation and post-harvest processing can be improved with agricultural mechanization.

2.3.1. National aims

The national aim is to increase number of farmers using agricultural mechanization equipment in order to improve productivity and production.

To achieve the national aim, the following strategies are pursued:

1. Provision of tractor and draught animal power services for hire at subsidized rate in order to reduce drudgery of farm operations and improve agricultural productivity
2. Training staff and farmers in management and utilization of agricultural machinery and draught animals.
3. Promoting appropriate technologies with emphasis on both manually-operated and animal-powered machinery in order to encourage development of agro-industries in rural areas, such as fruit juice and oil extracting machines
4. Reduce post-harvest losses through improved agro-processing technologies.

2.3.2. Increasing Farm Power Availability and utilization

In order to increase farm power availability, government has been running farm mechanization schemes since 1999. These are the tractor hire and oxenization schemes. The purpose of the schemes is to increase access to farm mechanization services by smallholder and medium scale farmers.

(a) Tractor Hire Scheme

The scheme is operated with the view of ensuring tractor services availability, adaptability, affordability and accessibility to all eligible farmers. It operates throughout the country at ADD and District Agriculture Offices as hiring centres. The scheme mostly targets those that have no access to motorized mechanization.

(b) Oxenization Scheme

The scheme was established to serve smallholder farmers with small and fragmented fields. It provides land preparation and transportation services to smallholder farmers. The scheme is operational at EPA level.

Tractor Hire Scheme

Field Operation and maintenance of tractors and farm machinery

The tractor is a prime-mover which can be used for carrying out farm operations such as ploughing, harrowing, seeding, inter-cultivation, harvesting, transportation, land levelling and operating stationary machines (irrigation pumps, threshers, chaff cutters, cane crusher etc.). All the machines require periodical servicing, maintenance and repairs for efficient and economical performance throughout working life. Although, most of the tractor manufacturers have appointed their dealers to provide operational know how, after sales services of their products, they are inadequate as such many machines are not properly maintained and are subjected to abnormal break downs, wear and tear thereby reducing the effective life of the machines. Due to improper maintenance and servicing of the tractors, it has been found that many tractors have been rendered unserviceable within a short period of time, 5000 tractor hours or even less. Seizures of engine due to lack of oil in the sump and overheating of engine due to inadequate water in the radiator are common troubles. Damage of front wheel bearings and other moving parts due to improper lubrication and adjustments have also been noted. A typical 4-wheel general purpose tractor is shown in Fig. 4.

Fig. 4: View of a typical 4-wheel general purpose tractor

There is need to familiarize ourselves with different controls of common tractor for us to operate, service and maintain them.

1. Tractor Assembly & Controls:

1.1 Power Trains: The power trains consist of engine, clutch, transmission (gear box), differential, final drives, axle shafts, wheels or tracks, steering & brakes.

1.2 Power outlets: The tractor power is made available for use through hydraulic lift, drawbar hitch, belt pulley & PTO shaft. (Fig. 5.)

PTO driven rotavator

Single point hitch

Three point hitch

Use of drawbar

Fig. 5: Views of power outlets in tractor

1.3 Instruments and gauges: Most of the tractors are equipped with gauges and meters such as fuel pressure gauge, oil pressure gauge, water temperature gauge, hour meter, hydraulic pressure gauge and temperature gauge to indicate their operating conditions. Starter switch, light switch, horn button, fuel cut off controls is also fixed on many tractors.

1.4 Levers and controls: The tractor is also provided with throttle or accelerator lever/ pedal, clutch pedal/ lever, brake pedal/ lever, gear shift lever (main & auxiliary), steering wheel/ lever, hydraulic control, PTO pulley lever, differential lock/ pedal/ lever etc. to exercise control on different operations.

Daily, starting and safety checks in tractor:

Daily check points for starting and safety in tractor are:

1. Check fuel in fuel tank
2. Check coolant/water level in the radiator, or inspect cooling fans on air cooled models of tractor.
3. Check tire inflation pressure and conditions of the tyres, cuts, cracks and buckling
4. Check the battery, cables and terminals and electrolyte level.
5. Check the transmission and hydraulic oil levels.
6. Check air filter elements, or the oil level in an oil bath type air cleaner.
7. Check operator's seat. Be sure that it is clear of spilled fuel, oil, grease, crop residue, or loose objects.
8. Check the lighting system and ensure "Slow Moving Vehicle Emblem "is placed.

Tractor operation safety precautions

a) General Points:

1. Run and maintain the tractor according to the operator's Manual of Tractor provided by the tractor manufacturer.
2. Be alert and alert to drive it safely.
3. Always park the tractor with gear shift lever in the neutral position and with parking brake applied.
4. Drive slowly in difficult conditions.
5. Attend immediately to oil and fuel leakages.
6. Listen to the noise or sound in the engine, power transmission, etc., if any abnormal noise is noticed stop the tractor and investigate the causes.
7. When stopped put the tractor out of gear, set brakes firmly.
8. Refuel the tractor only when the engine is cool, don't spill fuel and never smoke while refuelling.
9. Hitch implements only to drawbar or specified hitch points of the tractor.
10. Never drive after taking alcohol drink or drugs.
11. Don't permit unauthorised persons to ride the tractor unnecessarily.
12. Do not keep foot (ride) on the clutch and brake pedals while the tractor is running.
13. Do not sit or stand on the implement when the tractor is in motion.
14. Avoid overloading of the tractor during operations.
15. Do not get off or on the tractor when it is in motion.
16. Never leave the key in the starting switch.

b) Points to be considered for safety on the Farm

1. Set the wheels as wide as required for the job. Use wider wheel track on slopes for stability.
2. Add weights on rear or front, as the case may be, for proper traction.
3. Keep P.T.O. and belt pulley shields in proper place.

4. Do not hook load at a point above the drawbar.
5. Reverse the tractor in low gear.
6. Driver tractor in low gears while overcoming obstacles like small bunds and ditches.
7. Draft control should not be used for raising or lowering the implements at the end of trip/ row.
8. Do not ride the drawbar of tractor during operation.

Periodical service schedule

It is uneconomical to manufacture a tractor with materials which will run for the designed service life. There are some engines in developed countries which can be used for 0.2-0.4 million km without changing lubrication oil with pre-greased, sealed bearings that have lubrication enough for the designed lives. However, at present the materials used in manufacturing of tractors wear off very fast if not properly lubricated, run at desired temperature and clean environment. There are many components that are not designed to run for entire service life of the tractor and these must be serviced and replaced on routine basis probably after 250 to 350 hours of engine operation. If machines are just inspected for any loose nuts and bolts, clearances and deflections thus what is done in short service or first service of tractor. It is essential to maintain lubrication, desired temperature, tightness of bolts & nuts, clean environment inside the tractor engine and other housing besides maintaining deflection of components of tractor for achieving desired service life.

Clean environment inside the engine is achieved by maintaining intake system, i.e.

1) By cleaning pre cleaner periodically,
2) By maintaining correct level of right grade of oil in air cleaner and changing it as and when required
3) By cleaning the dry filter element periodically and changing it as and when required
4) By changing different filter elements at periodic service intervals.

Desired temperature can be maintained by maintaining cooling system. This is accomplished by keeping correct level of water or coolant in radiator or dispenser bowl, by keeping radiator or fans clean.

Desired level of lubrication is simply maintained by changing lubrication oils in different assemblies of tractor periodically along with filter elements.

Certain procedure has been laid down that will produce best results on tractor performance if followed. These services needs have been classified into hours ranging from ten to several hundred hours of tractor use.

10 hours or first service schedule:

1. Clean the tractor, if the tractor worked under dusty conditions & wash it with a swift jet of water to remove the dirt and wipe off with a dry cloth.
2. Inspect the tractor critically for leakage at any point, take correct steps with the help of authorised service provider if need be.
3. Check all the nuts and bolts and tighten them properly on different parts of the tractor and replace the broken ones, if any.
4. Top up the fuel level in the fuel tank at the end of each days operation avoid condensation of water at the bottom of tank or in the fuel line.
5. Check and top up mobile oil. The oil level should be in the middle of these two marks.
6. Check air cleaner oil level and if this level is less than the indicated mark or cut hole then top it.

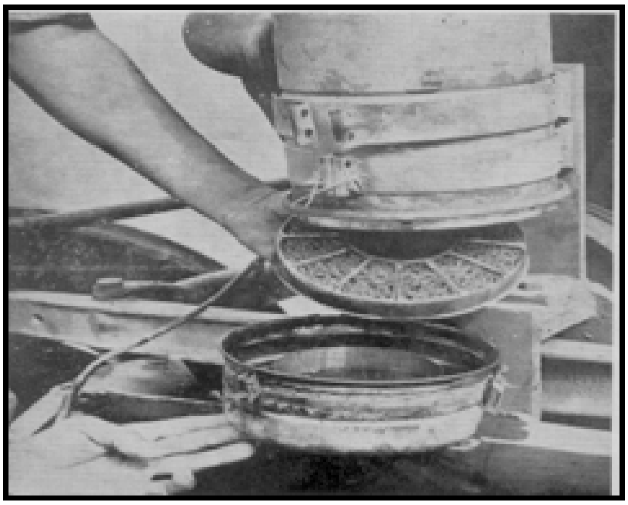


Fig. 6: View of oil bath type air cleaner (Courtesy: Tractor manual Department of FPM, CCSHAU)

7. Check up the water/coolant level in the radiator/ dispenser bowl and top if necessary. Do not allow water level to go below the minimum level.
8. Check the belt pulley gear-box oil level when the pulley is in use and refill it to the plug level with transmission oil.
9. Check the front and rear type-pressure. In general, the pressure for front tyres should be nearly 2 kg/cm2 and that for rear tyres about 1 kg/cm2".

50-60 hours service schedule

1. Repeat the 10 hour service schedule or first service.
2. Maintenance of Tractor Battery: -Inspect the battery for loose terminals and electrolyte level. Wash the battery top with washing soda using warm water and grease the terminals with petroleum jelly to prevent corrosion.
3. Check the fan-belt tension and adjust it if required
4. Clean and service air cleaner
5. Servicing of fuel supply system: This includes
   a) Check the fuel line for any leakage and clean it.
   b) Clean the sediment bowl and the screen.
6. Check and adjust the brakes for proper operation:
7. Check and adjust the engine clutch:
8. Lubricate the following: Fan-hub bearing, throttle-control lever, engine-clutch-release bearing, and alternator bearing
9. Check the water-pump (water body) for leakage and tighten or replace the packing, if required.
10. Loosen the vent plug and the drain-tap of the primary fuel filter and run off a small quantity of fuel in order to remove any water which might have accumulated.

125 hours service schedule

The 125-hour service and maintenance generally includes the following:

1. Repeating the activities carried out in 50h maintenance schedule
2. Changing crankcase oil
3. Replacing the oil filter
4. Servicing the crankcase breather
5. Maintenance of tractor tyres
6. Checking and servicing other parts of the tractor

Note: For any service and maintenance of tractor after this 125hours of operation, follow the guidelines in operators manual

Operation, maintenance and servicing of implements

1. **Mould board plough- Adjustment, operation and maintenance**

Mould board plough is one of the oldest of the all agricultural implements and is generally considered to be the most important tillage implement. It is equipped with heavy-duty box frame specially designed for deep ploughing / land preparation of rough soil. It is designed to work in all types of soils for soil breaking, soil raising and soil turning. Satisfactory operations, economic and long lasting use of the implement depends on the compliance with manufacturer's instructions.

Fig.7: View of M.B Plough attached with tractor three point linkages

a) Tractor preparations for M.B plough operations:

1. The horsepower of tractor selected should match the implement.
2. Adjust the front and rear wheel track width.
3. Provide adequate front end ballast for tractor stability.
4. Select load and depth control setting according to tractor operators manual.

b) M.B. Plough Adjustments:

In order to get better results from M.B. Ploughing, the following adjustments are necessary:

1. Leveling the plough: - The level of the plough is controlled by the tractor top link. You lengthen or shorten the top link if rear end of the plough beam is lower than the front end or vice versa. Lateral leveling is controlled by adjusting the length of the tractor right lower link. These adjustments must be made with the plough prior to operation.
2. Draft of the M B plough: The type of the soil is the greatest external factor that determines the draft of any plough. Draft is also affected by the depth and width of cut per bottom for complete plough in addition to speed. In very hard ground, it is often necessary to add weight to the wheels to force the plough into the soil.
3. Adjustment for deeper ploughing: Apart from positioning the draft control levers of the tractor hydraulic system, the depth of the plough can be obtained by:
   - Adding extra weight to the plough.
4. Warning for driver

i. Don't plough on stony soil.
ii. Tractor should be in high first gear.
iii. If soil is hard then ploughing the field at least twice.
iv. Ploughing works best when the right wheel of the tractor is inside the previously ploughed furrow.

c). Maintenance of M.B. Plough:

Working on stony land increases maintenance and these rules must be followed to get best results:

1. If M.B. plough is new then after first two hours of working tightened all nut bolts.
2. Check the plough adjustments if the steering is hard.
3. After every fifty hours tighten all nuts and bolts.
4. Sharpen the Bar Point and shares if dull. Blunt shares increase the draft.
5. Wash the M.B. plough after work
6. Replace the worn out nuts and bolts.
7. If plough has to remain unused for long time then clean it & apply a layer of used oil for rust prevention.

2. Disc plough – Adjustment, operation and maintenance

A Disc plow consists of a series of individually mounted, inclined disk blades on a frame supported by furrow wheel. Disc ploughs are most suitable for conditions under which mould board plows do not work satisfactory, such as in hard, dry soils, in sticky soils where a mould board plow will not scour, and in loose, push-type soils such as peat lands.

Fig. 8: View of disc plough having scrappers on

a) Adjustments

- Cutting Angle Adjustment: - Discs must be set at an angle. Provision is made for adjustment of the horizontal disc angle and vertical tilt angle to obtain optimum disc operation indifferent soil conditions.
- Width of cut adjustment: - Disc plough has a particular width of cut ranging from 18-25 cm depending on the diameter of the blade. The front disc can be adjusted with the help of cross shaft to suit various draft and penetration requirements
- Leveling the plough: - The level of the plough is controlled by the tractor top link by lengthening or shortening it. Lateral leveling is controlled by adjusting the length of the tractor right lower link.
- Scrapper adjustments: - Scrappers are set low enough to catch and turn the furrow slice before it falls away from the disc. For deeper ploughing, set the scrapper a little higher.

b) Draft of the disc plough

The type of the soil & moisture content are the greatest external factors that determine the draft of plough. In very hard ground, add weights to the wheels frame to force the plough into the soil.

Draft is also affected by the depth and width of cut. Speed is also another factor which increases the draft, doubling the speed increases the draft by about 20%-25%.

i) Adjustments for deeper ploughing

The depth of the plough can be adjusted by the position of draft control levers of the tractor hydraulic system. However more depth can be obtained by:

1. Adding extra weight to the plough
2. Reducing the tilt angle.
3. Tractor should be in high first gear.
4. If the soil is hard then plough the field at least twice.
5. Make sure that the shocker spring is tight.

c) Maintenance of disc plough:

Working on stony land increases maintenance and for best results follow these rules:

- For new disc plough tightening all nuts & bolts after first two hours of working.
- Check the plough adjustments if the steering is hard.
- Check the scrapper adjustments frequently.
- If the soil has entered in grease nipple, then change the nipple.
- After every fifty hours grease all greasing points and tighten all nuts and bolts.
- After 300 hours of operation, open the hub of disc plough, clean it, put in new grease & replace its seal.
- Sharpen the disc if the blades are dull. Blunt blades increase the draft considerably.
- Replace the discs when 22"(550 mm) in diameter
- Keep the bearings lubricated as per the instructions given in the manual.
- Coat the disc blades for rust prevention with the used oil in slack season.

d) Storage of machine after work

1. Wash the disc plough after work.
2. If disc plough has to remain unused for long time then clean it & apply a layer of used oil for rust prevention.
3. Adjustment and maintenance of disk harrows

Disc harrow is secondary tillage equipment designed for breaking the clods and partially inverting the soil / land preparation of rough soil (finer operation).

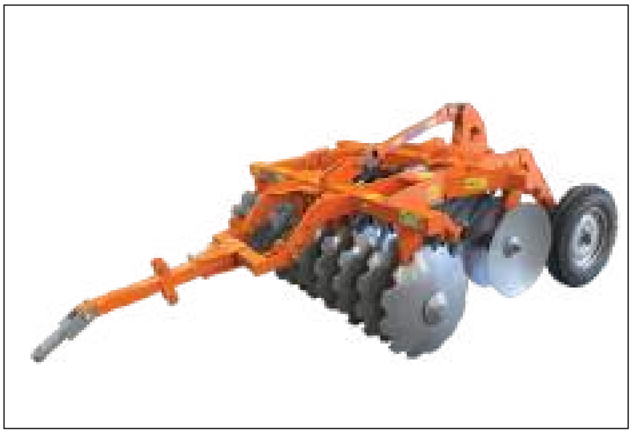


Fig. 9: View of compact mounted type model of disc harrow

a) Adjustments in disc harrow

Before mounting of disc harrow make sure that all nuts & bolts are properly tightened. Determine soil and trash conditions of the field and make these adjustments:

- Disc gang angle adjustment: - Gang angle can be increased for better penetration in dry soil while it should be reduced to avoid plugging in wet soil.
- Disc harrow leveling: - To eliminate uneven penetration and side draft, leveling is done by means of top link & bottom adjustable link.
- Scrapper adjustment: - The scrapper can be adjusted by loosening the bolts at the scrappers clamp.
- Depth control: - The depth of the implement is controlled hydraulically by the left control lever.

Disc harrow penetration depends on:-

- Angle of the gangs
- Weight of the harrow
- Disc diameter
- Disc sharpness (Blunt disc increases the draft considerably)
- Angle of hitch

b) Attaching the harrow to the tractor

- Place the harrow duly leveled on the flat piece of land.
- Reverse the tractor to the harrow (Do not drag the harrow up the tractor).
- Attach the left arm of the tractor to the harrow first.
- Attach the central top link/ arm to the harrow.
- Attach the lower right arm;
- After attaching the harrow, lift it and adjust the control arm parallel to the ground, all the discs should touch the ground uniformly.

Fig.10: View of hitching of harrow

C) Operational guidelines for disc harrow

- Lift the harrow on turning.
- Adjust internal/ external check chains to obtain implement swing range of 50 mm (2")
- Always maintain the correct tyre pressure to avoid wheel slippage.

- Add wheel weights/water ballasting or combination of both when excessive rear wheel slippage.
- Always set hydraulic levers correctly for draft and position control operation.
- Never turn the tractor to the right or left when the harrow is engaged in the soil.
- Never reverse the tractor when the harrow is engaged in the soil.
- To get good results, a disc should be replaced when its diameter is reduced by 5" (125mm) from its original size.

d) Maintenance of disc harrow

Maintenance of disc harrow increases if is used in the stony land.

- If the soil has entered the grease nipple, then change the nipple.
- Tighten all nuts & bolts if disc harrow is new after first two hour initial working.
- After every 50 hours of use, grease all greasing points and tighten all nuts & bolts.
- After fifty hours of use, open the bracket spool of disc harrow & clean with diesel oil & pump in new grease.

e) Storage of machine after work

- Wash the disc harrow after work.
- If the disc harrow has to remain unused for long time then clean it & apply a layer of used oil for rust prevention.

4. Adjustment, operation and maintenance of spraying equipment

Spraying equipment or sprayer: Sprayer is a machine which is used to atomise the liquid chemical and spray at the plant uniformly. In agriculture, a sprayer is a piece of equipment that is used to apply herbicides, pesticides and fertilizers to agricultural crops. Sprayers range in size from man-portable units (typically backpack and spray guns) to trailed sprayers that are connected to a tractor, to self-propelled units.

1. Adjustments in sprayers:

Boom sprayers:

For optimal results, make minor adjustments before each application to account for changes in the crop (size, shape and canopy density), weather conditions (relative humidity, wind speed and wind direction), the nature of the pest and the product chemistry.

a) Sprayer output (Nozzle discharge rate):

Adjust sprayer output and distribution at least twice a year to ensure that the sprayer will uniformly cover the target with the optimal volume. The first adjustment should take place during calibration at the beginning of the season; the second when the target crop has grown and the canopy filled to such an extent that it requires different sprayer settings to achieve good coverage.

b) Spray droplet size:

Spray droplet size depends on nozzle type and setting. A good sprayer should be able to produce droplets of uniform size. Uniform droplet size is highly important for efficient and effective utilization of pesticides. Select optimum droplet size (mmd) for selected type of nozzle to be used which usually vary from coarse sprays (more than 400µm) to Aerosols (<50µm).

Fig.11: View of manually operated sprayer (left) and jet type sprayer (right)

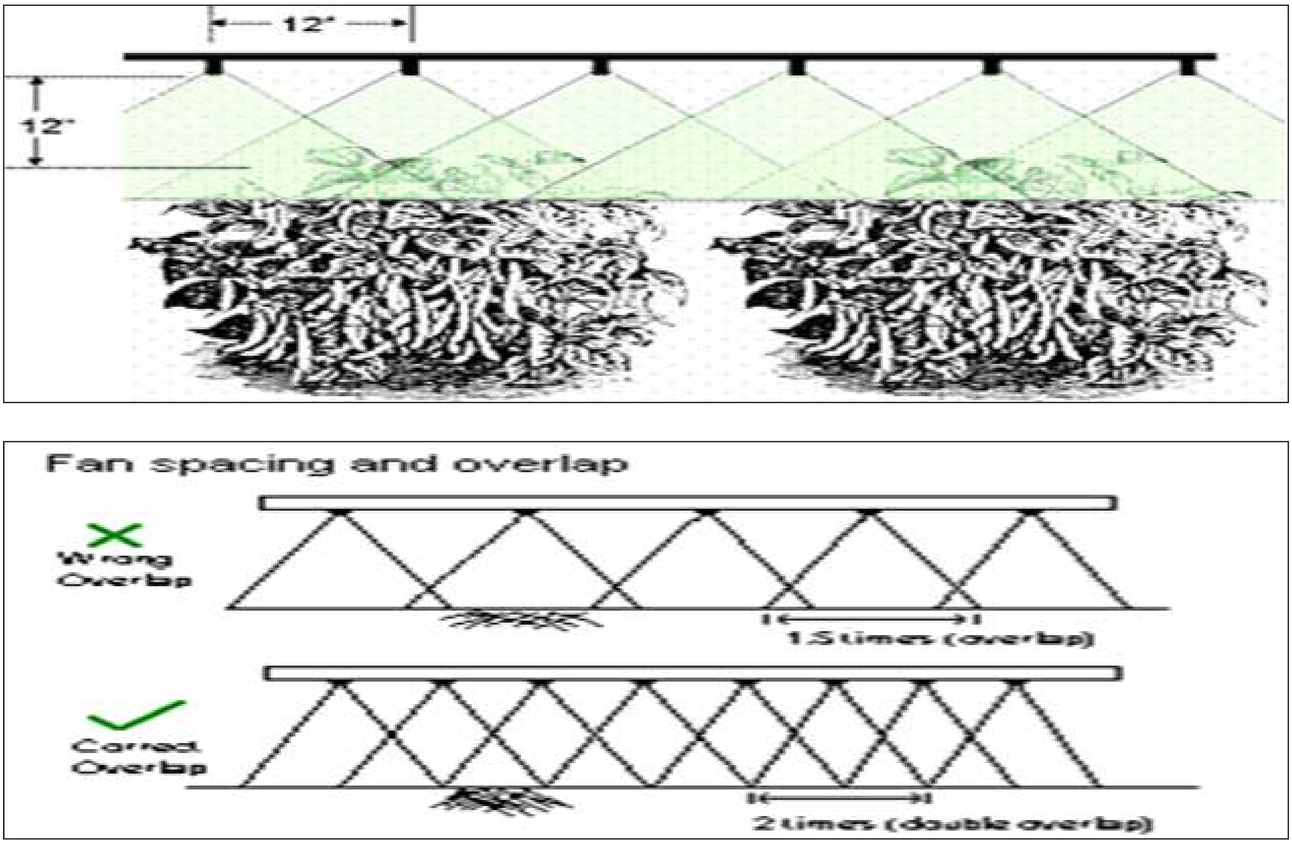


Fig. 12: Fan spacing and overlap

c) Uniformity of spray application:-

Uniformity of spray application on plants depends on:

- Spray boom/ lance height
- Spray angle and
- Degree of overlap

2. Calibration of sprayers:

a) Calibration

To apply a specified rate of chemical to the target surface (e.g. plant, soil, pest); one need to measure the total spray output of the machine, the travel speed and the swath width And then calculate the application rate.

b) Total sprayer output (L/min)

The aim here is to measure the total liquid sprayed from the spray machine in one minute.

- First, set the pressure at the correct level for spraying. The correct pressure is specified by the manufacturer and determined by the type of nozzles used.
- Fill the spray tank with clean water.
- Place a measuring jug under one nozzle to collect the water that comes from that nozzle.
- Run the sprayer for one minute at the correct pressure with all nozzles operating.
- Measure the quantity of water collected in the jug which has to be compared to the output specified by the manufacturer using the correct pressure.

NOTE: Nozzle output should not vary by more than 10%. If it does, should be replaced, it could be worn out or damaged.

c) Travel speed (km/h)

The normal speed for spraying with any sprayer depends on ground conditions. The slower one travels the higher is the application rate.

- Measure out and mark a distance of 100 meters on the ground to be sprayed
- Select the right walking speed/gear and engine revolutions for spraying.
- Measure the time in seconds it takes to travel 100 meters with half full sprayer.
- Calculate sprayer travel speed by inserting the time in seconds into the following formula:

$$\text{Travel speed (km/h)} = \frac{100\text{ (m)} \times 3.6}{\text{Time (seconds)}}$$

d) To calculate spray application rate (L/ha)

- First, measure swath/spray width (in meters). For boom/jet type of spraying, the swath width is equal to the number of nozzles multiplied by the nozzle spacing. For band spraying the swath width is equal to the total of all the band widths
- Calculate the application rate using the following formula:

$$\text{Application rate (L/ha)} = \frac{600 \times \text{total sprayer output (L/min)}}{\text{Swath width (m)} \times \text{travel speed (km/h)}}$$

For example: If total sprayer output is 5 L/min, & operating speed is 10 km/h, and the swath width is 5m, then application rate is:

$$= \frac{600 \times 5}{5 \times 10} = \frac{3000}{50} = 60 \text{ L/ha}$$

e) Benefits of calibration

By calibrating the spraying machine one can find out the spray application rate. This information is necessary whenever the uses of chemicals are specified in amounts per hectare. It also helps to work out how many spray tanks are needed for a particular spraying job/area.

The spray application rate varies for different crops, different row spacing and the age, height and density of crops.

Precautions during spraying

1. Take only sufficient pesticide for the day's application.
2. Do not transfer pesticides from original container into the containers.
3. Make sure pesticides are mixed in the correct quantities
4. Wear appropriate clothing.
5. Avoid contamination of the skin especially eyes and mouth.
6. Liquid formulation should be poured carefully to avoid splashing.

7. Do not spray in high wind, high temperature and rain.
8. Avoid drift by selecting proper direction of spraying and also holding nozzle and boom at a proper height.
9. Never eat, drink or smoke when mixing or applying pesticides. Never blow out clogged nozzles or hoses with mouth.
10. Follow correct spray technique. Spray plant crop thoroughly by operating sprayer at correct speed and correct pressure.
11. Never allow children or other unauthorized persons to be nearby during mixing.

Precautions after spraying

1. Remaining pesticides left in the tank after spraying should be disposed correctly
2. Never empty the tank into irrigation canals or ponds.
3. Do not use empty pesticide containers for any purpose, destroy them-burying/burning.
4. Clean buckets, sticks, measuring jars, etc. used in preparing the spray solution.
5. Wash protective clothing and yourself well and put on clean clothing.
6. Prevent persons from entering treated areas until it is safe to do so.
7. Mark the sprayed plots with a flag.

3. Maintaining the sprayer:

Observe the start-up steps before using the sprayer as it will prevent unnecessary and costly breakdowns and improper application, and may increase the lifespan of the spray equipment.

Step1. Pump maintenance

Before the first spray application, pump clean water through the system until the discharge is clear of dirt, sludge or scale that might be present in the tank, pump, hoses, filters and nozzles. Flush the pump with a solution that will chemically neutralize the liquid pumped.

- Check all diaphragms and check valves for corrosion and wear as well as for water or oil leaks. For a piston pump, inspect check valves, valve seats, O-rings, seals, plunger cups and cylinders. Change the diaphragms and oil every 500 hours of spraying or every 3 months.
- For centrifugal pumps, check for correct operating pressure and leaks. At the end of the season, clean the pump and flush it with a 50% solution (half water) of permanent-type automobile antifreeze containing a rust inhibitor.

Step 2. Hoses

Examine all hoses and connections for cracks or leaks. Hoses and fittings on the pressure side of the pump must be able to handle the maximum pressure from the pump and withstand pressure surges. An air leak in the suction hose would seriously interfere with the operation of the pump and pressure gauge. The size of the hoses and their fittings affect the system capacity and under-sized hoses and fittings can severely reduce the capacity of any pump.

Step 3. Strainers

Strainers (or filters) are installed in the tank opening, between the tank and the pump, after the pump, and in the nozzle bodies. Some farmers do not use nozzle strainers because they feel they contribute to plugged nozzles but they might be using too small a nozzle strainer. Nozzle strainers capture debris before it damages nozzles and should be installed.

Clean the tank and lines thoroughly. Remove the nozzle strainers and scrub them with a bristled brush; flushing will not clear them. Replace all cracked or poorly fitting strainers.

Step 4. Regulator

Sprayer regulators with stem packing should be inspected annually. Tight packing restricts stem movement and could lead to fluctuations or dangerously high pressures. Loose packing may lead to leakage. Certain makes of airblast sprayer may not have adjustable regulators, and may use bypass valves for minor pressure adjustments.

Step 5. Agitator:

Most spray materials do not mix well with water and this may cause uneven application as such mechanical agitators are fitted in the sprayers. For mechanical agitators, check for propeller wear, and ensure that the paddles are secure on the agitator shaft. Lubricate the shaft bearing and adjust seals to prevent leakage. For hydraulic return agitators, ensure the pump capacity is sufficient to handle both the agitation system and the total nozzle output on the booms.

Step 6. Nozzles:

Nozzles are often neglected for fear of damaging the tip. Tip damage has a direct impact on product effectiveness and cost and its performance must be monitored regularly. To clean the delicate edges of the tip orifices, use a soft-bristled brush or a can of compressed air. Some operators use a wire to clean plugged nozzles, but even a wooden toothpick can distort plastic or chip ceramic. Test the nozzle performance during each calibration (at least before and mid-way through the season). New nozzles vary considerably in actual output (by as much as 15%), so never assume new nozzles are operating correctly.

Testing of sprayer nozzles:

1. Use a length of hose to direct nozzle output into a graduated container and measure the discharge of clean water over a 1-minute interval.
2. Compare the volume collected in the jar to the rate listed in the manufacturer's catalogue (in litres/min). Alternately, compare the nozzle output rate from the used tip to that of a known tip of the same size and shape.

   A maximum of 5% variation in nozzle output is acceptable. If the nozzle output is 10% more or less than the ideal output, remove, clean and retest the nozzle. If the nozzle is still not giving desired output, replace it. Nozzle wear is a function of the chemical sprayed, the operating pressure and duration of use. Generally, a nozzle set should be replaced once a year or at the first signs of deterioration.

4. Cleaning the sprayer

Before cleaning a sprayer, read the equipment manufacturer's directions and consult the pesticide label for any special instructions. Ideally, clean sprayers at the end of each day (even if the same pesticide will be sprayed the next day) and before switching products.

a) Triple rinsing: Sprayers retain several litres of spray solution after an application, even when the tank appears empty. Add clean water to 10% tank capacity and circulate it through the entire sprayer for 10 minutes. Open and close any control valves during this process. Clean the sprayer 3 times.

Cleaning when changing products or storing the sprayer: Perform a triple-rinse, as described previously. Refill the tank with clean water and any detergent recommended by the pesticide manufacturer. If tank-cleaning information is not provided, use a specially formulated low-foaming detergent or alkaline cleaner and rinse thoroughly. Reinstall nozzle strainers and nozzle tips. If winterizing the sprayer, store the nozzle strainers and tips or dispose of them in anticipation of a new set.

5. Adjustment, operation and maintenance of threshing equipment

Threshing is an operation of detaching the grains from the ear heads, cobs and pods. Thresher is a machine that separate grains from the harvested crop and provide clean grain without much loss and damage. Grain loss in terms of broken grain, un-threshed grain, blown grain, spilled grain etc. should be minimum (not more than 5%, in which broken grain should be less than 2%).

Fig.13: View of power thresher

- Threshing of crops by traditional method involves drudgery and takes more time to obtain required quality of produce. Due to these, mechanical threshers are widely accepted by the farmers.

a) Component of a thresher and operational principle:

A mechanical crop thresher mainly consists of:

- Feeding device (chute/tray/trough/hopper/conveyor)
- Threshing cylinder (hammers/spikes/rasp-bars/wire-loops/syndicator)
- Concave (woven-wire mesh/punched sheet/welded square bars)
- Blower/aspirator
- Sieve-shaker/straw-walker.

Working Principle of thresher:

The crop is fed from the feeding tray into the threshing cylinder. The threshing cylinder is fitted with spikes/bars/hammers or wire-loops around its periphery according to the type of thresher. During operation, the crop material is slightly pushed into the threshing cylinder through the feeding chute, which gets into the working slit (space between the circumference of the revolving drum with spikes and the upper casing) where the materials are struck several times by the spikes against the ribs. From the lower concave, the entire or a portion of threshed material falls on to top sieve of the cleaning system. In case of spike tooth thresher, an aspirator blower sucks out the lighter material from the top sieve and throws it out from blower outlet. The sieves help in further cleaning of the grain by allowing heavier straw to overflow.

Note: In case of wheat, if farmers want not only clean grain but also fine quality of straw (bhusa) for cattle feed drummy type, hammer mill type and syndicator type threshers are suitable for threshing wheat crops.

b) Factors affecting thresher performance

The factors which affect the quality and efficiency of threshing are broadly classified in following three groups:

i. Crop factors:
   - Type of crop
   - Variety of crop,
   - Moisture in crop material

ii. Machine factors:
   - Feeding chute angle,
   - Cylinder type,
   - Cylinder diameter,
   - Spike shape, size, and number
   - Concave size, shape and clearance

iii. Operational factors:
   - Cylinder speed,
   - Feed rate, method of feeding,
   - Machine adjustments.

c) Adjustments in threshers:

Various adjustments are required before starting threshing operation. The machine has to be put on clean level ground and set according to crop and crop conditions. The adjustments necessary to get best performance from the machine are

(i) concave clearance, (ii) sieve clearance, (iii) sieve slope, (iv) stroke length and (v) blower suction opening. Besides these, cylinder concave grate, top sieve hole size and cylinder speeds for threshing different crops are important for a multi crop thresher. At all times, consult the user's manual that is provided by the manufacturer.

Adjustments before operating a thresher:

1. Position the thresher on a level area close to the crop stack to minimize losses.
2. Spread cloth, canvas, or mat underneath the thresher to collect spilled grain
3. Install the cylinder, cover, and feed tray if dismantled during field transport.
4. Position the thresher so that the straw is thrown in the direction of the wind to avoid blowing of straw, chaff, and dust back toward the operator and the threshed grain.
5. Check each belt's alignment and tension. Adjust the idler pulley on the blower/cylinder belt to correct tension. Improper alignment and tension are the major causes of premature belt failure.
6. Open the cover and check all pegs on the threshing cylinder for tightness. Loose pegs will damage the machine and can be dangerous to the operators.
7. Rotate the threshing cylinder manually at least five revolutions to ensure that there are no obstructions or interferences.
8. Lubricate all bearings with good quality grease but not the belt idler and oscillating screen eccentric bearings which are lubricated for life.
9. Start the engine and allow it to warm up.
10. Feed the thresher with the crop to be threshed for performance checking. Increase cylinder speed if excessive amounts of unthreshed and unseparated grain are observed with the straw.

d) Operating the thresher:

1. Start the engine.
2. Three to four persons are required to operate the machine. One or two men load and the other feed the machine. Another person bags the threshed grain while the other person insures that the cleaning screen is kept free of clinging straw especially when threshing wet material. Use a stick to remove clinging straw from the oscillating screen to protect hands from possible injury.
3. Harvested crops must be placed on the feed tray with the panicle away from the operator, so it is fed panicle first into the thresher.
4. Feed the crop at a maximum and uniform rate without overloading the engine. Adjust the feed rate to match the condition of the material being threshed.
5. For higher threshing efficiency, briefly hold the crop bundles at the feed opening for partial threshing when the material is longer than 40-50 cm. Long material will reduce machine output and may result in poor threshing and clogging of the machine. Short, panicle-harvested materials may result in high unthreshed losses because the panicles move fast through the thresher without receiving sufficient threshing. Recycling the straw is necessary in this case.
6. Adjust blower openings (shutters) to give the air flow needed for winnowing. Open slowly to provide more air for a cleaner output until a small amount of mature grain flows over the wind board.
7. Reduce feeding rate when threshing wet or partially decomposed materials to avoid overloading.
8. Open the cylinder cover periodically to remove straw and chaff accumulation at the lower concave.

e) Safety precautions in threshing operation:

1. Leave all guards and shields in place when operating the machine
2. Before cleaning, servicing, or repairing the machine, disconnect the power to the unit.
3. Keep hands out of threshing belt entry area.
4. Do not wear loose clothing when operating this machine. Clothing can be grabbed by chain drives or rotating shafts and severe injury can result.
5. Keep hands and feet away from chain drives and v-belts when machine is running.

f) Guide lines for maintenance of a crop thresher:

1. Lubricate cylinder and fan bearings with good-quality general purpose grease every 25 hours of operation and also apply a small amount of oil to all hinge points.
2. Inspect the machine regularly for loose, worn, or damaged peg teeth, concave bars, cylinder, discharge paddles and other parts, and tighten, repair, or replace them immediately.
3. Reduce belt tensions by loosening the idler pulley and engine mounting bolts when the machine will not be used for an extended period to minimize deterioration.
4. Check engine crankcase oil level at least every 4 operating hours and follow the engine manufacturer's recommendations for oil change intervals and oil grade.
5. Service the air cleaner, fuel filter, fuel line, carburetor, and spark plug regularly according to engine manufacturer's instructions.

g) Guide lines for storage of a threshing machine

1. Clean the machine thoroughly.
2. Remove belts and store in a dry place.
3. Store the machine in a clean, dry location and cover to reduce damage from dust.
4. Paint parts that need repainting.
5. Clean and apply oil to exposed metal surfaces to prevent rusting.
6. Follow the manufacturer's recommendations on engine storage.

Oxenisation Farm equipment

There are different types of equipment used on the farm. These are used for different operations such as land preparation, weeding, pest and disease control, transportation, and processing.

2.3.3. Land preparation

Some of the implements used for land preparation are as follows:

a) Plough

A plough (Fig.14) is a farm implement for loosening the soil to make it suitable for crop development. It cuts the soil, turns it to bury residues and weeds from the soil surface in order to enhance decomposition. Before use the plough should be set accordingly to achieve the required depth and width of the furrow.It is important that settings should be made regularly as required. Farm machinery and extension staff should train farmers on setting of the plough.

(i) Breast-plate

The breast-plate holds the wings and shares to the beam. Wear of the breast- plate is caused by the abrasive action of the soil moving over it. When the center of the breast-plate and the area around the lower hinges wear to the extent that the hinges come loose or break off, then the breast- plate should be replaced.

(ii) Mouldboard

The mouldboard separate the soil after being cut by the share. It wears out fast along the bottom edge towards the tips.

(iii) Rudder

The function of the rudder is to stabilize the plough as it is being pulled along. The rudder is set to cut through the soil. When the rudder does not penetrate into the soil when it is set even at its lowest position. It should therefore be replaced.

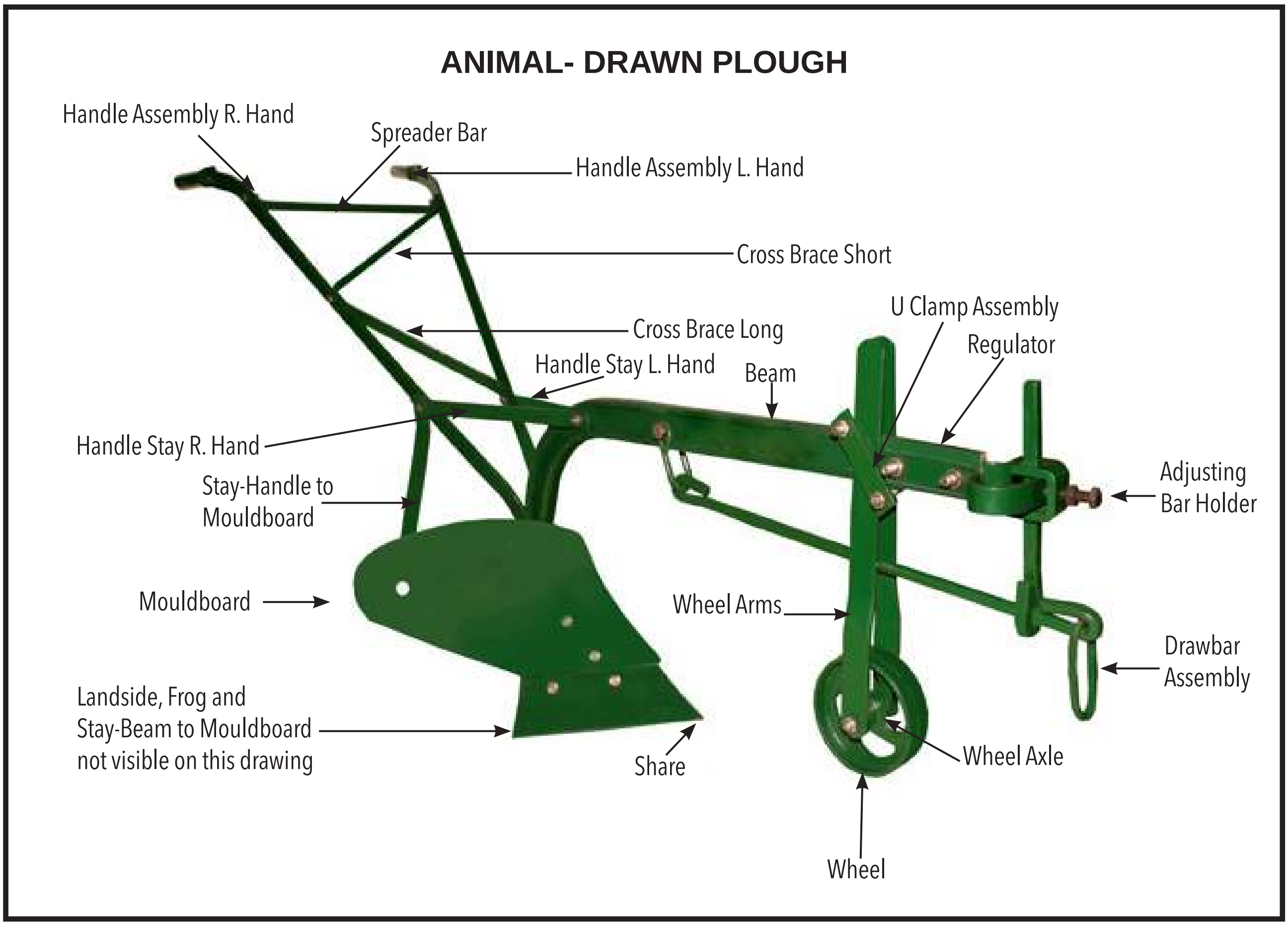


Fig. 14: Animal-drawn plough

(iv) Share

The share for both the plough and ridger should be replaced when worn out. This will be noticed when the share bolts touch the ground (if the ridger or plough is put on a flat surface). Another check on the wear of the share is when the plough is put on a straight edge across the bottom surface of the share between the two wings across the share point. If the share bolts touch the straight edge, then the share should be replaced.

Store the plough in a safe and dry place.

b) Ridger

The ridger (Fig.15) is an implement with a wedge-winged body which throws equal amounts of soil to the right and left of a central furrow. The main use of this implement is to make planting ridges. The ridger has same parts as a plough except that it has two wings Ridger maintenance

Fig. 15: Animal-drawn ridger

c) Cultivator

The wearing parts of the ridger are the share, breast- plate, wings and the rudder which should be maintained regularly and replaced when worn out. The ridger should be properly lubricated with oil if it will not be used within five days but for long term storage, painting with oil based paint is recommended. A cultivator (Fig.16.) is normally used to remove weeds between rows and not between planting stations. It can also be used in seedbed preparation to cut, break and loosen the soil. Parts of a cultivator include wheel and axle, hillers, sweeps and tines. There are two types of cultivators; adjustable cultivators and rigid cultivators. Adjustable cultivators can be set to suit the width of plant rows while in the process of cultivating crops. Rigid cultivators cannot be adjusted during cultivation. The tines can be set to suit the row spacing but the working width of the cultivator cannot be altered during the process of cultivation.

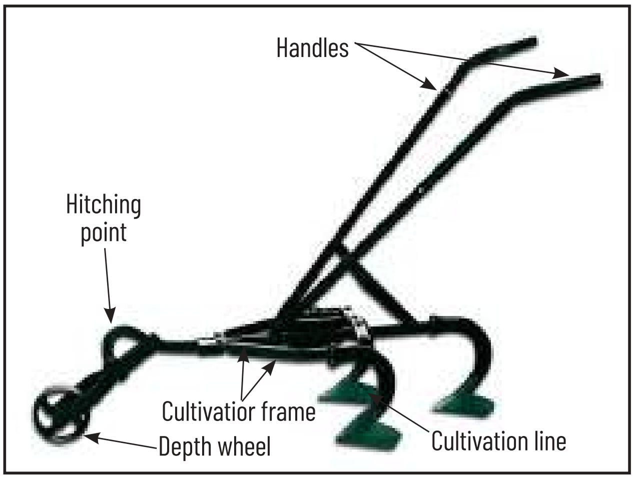


Fig. 16: Animal-drawn cultivator

Cultivator maintenance

The wearing parts of the cultivator are the wheel axle, the sweeps, the hillers and the tines.

(i) Wheel and axle

The wheel helps to control the depth of an operation and mobility. Replace the wheel and axle when broken or worn out. The wheel and axle may break or wear out after several years of farm operations.

(ii) Sweeps

The sweeps hold the tines in position.

The sweeps are worn out if the tine arms touch the ground when the cultivator is placed on flat surface. The sweeps should consequently be replaced.

(iii) Hillers and Tines

Hillers and tines are double-sided. When one side is worn out, the other side is used by turning the other way down.

Hillers and tines are worn out if the arms touch the ground when the cultivator is placed on a flat surface.

The cultivator should be well lubricated with oil if it will not be used within five days.

2.3.4. Farm transport

(a) Farm-cart

The farm-cart is important to a farmer as a means of transport. When using farm- carts, farmers should be advised on the following:

i) Not to overload, and
ii) To keep the load upfront on the cart and not on the rear. If the load is on the rear, the dissel boom will tilt the cart upwards and the straps will choke the animals.

Maintenance of the farm-cart

- Tyre pressure should be checked every day. Make sure tyres are well inflated.
- Check and make sure that bolts and nuts are tight before work.
- Clean the hubs annually. Wash the bearings in petrol, diesel, or paraffin and when reassembling make sure there is grease in the hubs. If grease is not available use Petroleum Jelly.
- Check the wobbling of the wheels and tighten the castle nut.
- When the cart is not in use for a period of one month or more, place blocks under the axle so that the wheels are off the ground.
- Replace parts before they are too worn out or when they are broken.

Yokes

Yokes play an important role in the use of various farm implements. Farmers must have different lengths of yokes for farm implements such as ploughs, ridgers and farm-carts.

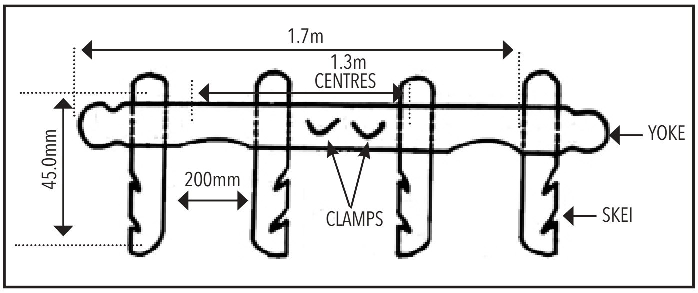


Fig. 17a: Transport yoke

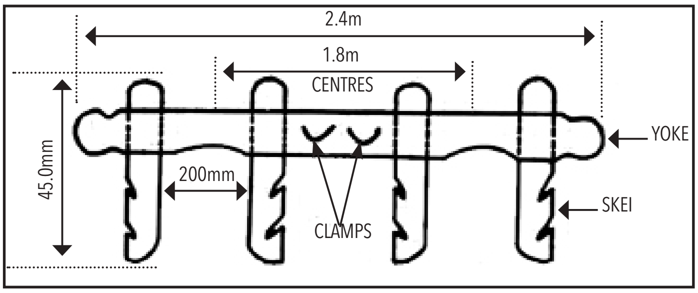


Fig.17b: Ridging yoke

Note: Transport farm implements on a farmcart to and from the field to avoid unnecessary damage.

Acquisition, management and training of draught animals

Farmers can acquire animals from government farms, fellow farmers and own sources. Farmers are therefore encouraged to breed their own

Cultivators use the same yoke as ridgers. To ensure proper upkeep and prolonged use, yokes should be properly stored in a shed to avoid damage.

Yoke lengths

The most important measurements are those between the centers of two pairs of skeis on the yoke shaft. To accommodate activities on the farm which use the draught animals, the following yoke sizes are recommended:-

(i) Ploughing yoke:

Total yoke length should be 150 cm. The space between 2pairs of skeis on the yoke shaft should be 90cm.

(ii) Ridging yoke:

Any ridge spacing will have its own yoke size. Correct ridge spacing can be obtained with correct yoke length for the intended ridge spacing.

Ridge spacing of 75 cm: total length of the yoke shaft should be 210cm and the space between 2 pairs of skeis should be 150cm.

Ridge spacing of 90 cm: Total length of the yoke shaft should be 240 cm and the space between 2 pairs of skeis should be 180 cm.

Ridge spacing of 120 cm: Total length of the yoke shaft should be 300 cm and the space between 2 pairs of skeis should be 240 cm.

(iii) Transport or cart yoke:

Total length of the yoke should be 170 cm and the space between 2 pairs of skeis should be 110cm. animals for use and for sale. The work oxen have to be adequately fed to increase their capacity to work in addition to keeping them healthy. Government has ox-trainers who can assist farmers to train work oxen, however farmers should participate in training their own oxen.

Management of draught animals

i) To get the best results from draught animals on the farm, they must be provided with rain proof housing and must be properly constructed and maintained.

ii) As a guide, housing for 2 animals should be 8 m long and 4 m wide. The height of supporting posts should be 2 m, whereas the center roof-post height should be 3m. The roof should be properly thatched.

iii) Draught animals have less grazing time as they spend part of the day working. Farmers should be encouraged to carry feeds for working animals so that they can be given to animals during work breaks. After working, the animals should be given some maize bran and water to drink, thereafter, the animals should be allowed to graze. Two to three kilograms of concentrate per day are essential for energy production. These can be maize or rice bran, cereals, cotton and groundnut cake.

iv) Draught animals should work for a maximum of 4 hours in the morning and 3 hours in the afternoon. Thereafter they should be allowed to graze and rest. Animals should preferably be used very early in the morning or late in the afternoon to enable them work during cool periods.

v) Farmers should dip animals regularly. They should also be encouraged to purchase and stock animal drugs in groups.

2.3.5. Agro-Processing technologies: Hand Operated Fruit Juice Extracting Machines

A large portion of fruits produced by smallholder farmers is lost through poor postharvest handling. This has necessitated development and fabrication of simple fruit processing machines. Some of the recommended fruit processing machines are Mfinyazipatso Owerama (Horizontal fruit juice extractor) and Mfinyazipatso Oyimilira (Vertical fruit juice extractor).

The two machines extract juices from the pulp of indigenous and exotic fruits that can be made into fruit juices, jams and purees. The main characteristics of these are briefly described below.

a) Mfinyazipatso Owerama (Horizontal Fruit Juice Extractor) contains a tapped horizontal screw outside of which is a barrel that squeezes the fruit pulp or juice using horizontal and side compressive forces. The machine is designed in such a way that one end is bigger (16 cm in diameter) than the other end (9.5cmindiameter) giving a compression ratio of 1.6:1. This machine has been performance tested on a wide range of fruits and has a pulp fruit juice extraction rate of 11-15 L/ hr, an extraction efficiency of 75 85% and a stone/seed breakage of zero.

Fig. 18: Mfinyazipatso Owerama (Horizontal Fruit Juice Extractor) (left) Mfinyazipatso Oyimilira (Vertical Fruit juice Extractor) (right)

b) Mfinyazipatso Oyimilira (Vertical Fruit Extractor) has similar design features as the Mfinyazipatso Owerama (Horizontal Juice Extractor). The main difference is that it is positioned vertically upwards. This machine has a pulp fruit juice rate of 50-60 L/hr, an extraction efficiency of 78-86% and a seed stone-breakage of zero.

2.4 Seed Services

Seed is one of the essential inputs in crop production. Good quality seed of any crop variety gives yields. Problems experienced by farmers include use of poor quality seed due to inadequate availability of certified seed or planting material of most crop such us beans, rice, groundnuts, pigeon peas, open pollinated maize, wheat, soya beans, vegetables, cassava and sweet potatoes. The provision of good quality seed of improved crop varieties to smallholder farmers is essential for increased crop production in Malawi's agriculture. Efforts to improve smallholder agriculture in the country will be fruitless unless the fundamental problems of seed supply to smallholder farmers are addressed.

The government's policy is to open the market allowing seed companies to produce and sell seed introduce new varieties for all crops in the market.

The Government's main goal is to alleviate poverty and ensure food security in the country. The goal is being achieved through:-

i) Diversifying exports of agricultural products.
ii) Raising farm incomes and promote economic growth while conserving the natural resources base.
iii) This is achieved through the available supply of certified seeds of improved varieties of crops by the seed industry to reach farmers through an expanded network of seed distributors.
iv) In order to improve the availability of seeds of food crops, the following changes have been made:-
v) Improvement of Information systems in the seed value chain.
vi) Removal of restriction on seed imports and exports except for phytosanitory regulations.
vii) Harmonization of seed rules and regulations to facilitate seed movement in the SADC and COMESA Regions and the entriee outside world.
viii) Promotion of new regulations to encourage the participation of NGOs and ordinary farmers in the seed sector.
ix) Review of seed classes in Malawi.
x) Inclusion of Plantation and Vegetatative propagated materials in the Seed Act.
xi) Biotechnology experiemenst are underway to improve the food and economic situation
xii) Efforts to supply affordable seeds.
xiii) Institutional, regulatory and legal frameworks have been strengthened
xiv) Institutional and operational linkages have been strengthened.

Seed Certification and Quality Control

The Seed Services Unit (SSU) in the Department of Agricultural Research Services (DARS) has the responsibility of certifying seed and monitoring its production, processing, marketing and storage throughout the country to ensure that farmers have access to good quality seed. Internationally accepted standards are applied for seed certification and quality control. There are six classes of seed of all crop varieties recognized in Malawi and these have different requirements that meet international standards for certification. These classes are:-

(i) Breeders' seed

This is of a particular generation of an in bred line or variety which is produced under the supervision of the breeder or institution that developed the variety in conjuction with the seed Services Unit. It is the source of seed for the production of pre-basic/ pre-foundation seed.

(ii) Pre-basic seed

This class comes from Breeders' seed. It is handled in a such way that it mantians its genetic indentyi and purity is maninted to ensure quality

(iii) Basic or foundation seed

This class of seed production from basic seed. It is handled in such a way that its genetic identity and purity is maintained to ensure quality.

(iv) Certified seed I

Certified seed is produced from basic seed but it can also be produced from a higher class of seed such as pre-basic seed. Production of certified seed should also conform to prescribed standards to maintain genetic identity and purity.

(v) Certified seed II

In cases of shorstage of basis seed, another seed is produced from Certified Seed and this is called certified seed II. But in cases of enough basic seed then onlt certified I is produced and marketed following the regulations.

(vi) Quality declared Seed (QDS)

Previously this was called Declared seed. This class is produced following the requireements such as registration, inspections, sampling and testing. The only diference is the intensity of field inspection. The World Food Organization (FAO) defines QDS as seed that only ten percent of it has been inspected. So this requirement is met worldwide including in Malawi.

2.4.1. Good quality seed for planting

2.4.1.1. Certified seed (CS)

Certified seed of some of the crop varieties such as hybrid maize, tobacco and sunflower can be obtained from seed companies, Agriculture Input Suppliers, Agrodealers, ARET and other shopping chain stores or retail shops in the country.

Other seed crops like open pollinated varieties can be obtained from individual farmers, farmers asso ciation, seed companies, Agrodealers, International Agriculture Research Centres, University and NGOs.

2.4.2. Seed production

Commercial Seed Companies, farmer associations, NGOs and individual farmers are actively involved in the production of certified seed. Such seed is rigorously inspected by government seed inspectors. SSU sample and test all seed for purity, germination and moisture content in the laboratory prior to distribution or marketing to farmers.

For farmers wishing to participate in this programme, it is important that the following guidelines are adhered to in order that good quality seed is produced.

2.4.2.1. Planning

The demand estimate should be accurate to avoid over production. Seed producers should be ready to meet the costs of seed certification and quality control.

2.4.2.2. Selection of seed producers

The fields should be located close together to minimize supervision and inspection costs. The area should be accessible at all times, especially during the rainy season in order for inspections to be conducted adequately.

2.4.2.3. Standard for seed production

Seed crops have to be grown according to specific standards stipulated by the Seed Services Unit. The aim is to produce good quality seed. Major components of the standards include:-

(i) Registration/Application

Seed grower registration is the first activity that the farmer is required to do for the seed to be certified. This is done before the end of December of each year for rain fed seed production and just a month before planting of or irrigated seed production. Registration helps SSU to update seed data, easily locate the field or seed by the inspection team, and easily direct buyers to where the required seed is located. It is important for the country to know seed quantities available to avoid emergency importation. Any field that is not regisered is not inspected even if the producer gets the seed from the right sources. Applicable registration fees are charged upon registration.

Table 7: Field Requirements and Laboratory Tests Results

CROP		FIELD REQUIREMENTS				LABORATORY TESTS					
Botanic Name	Common	Minimum isolation distance		Maximum % of off-types		Minimum number of inspec-tions		Mini-mum ger-mina-tion		Mini-mum % pure seed	
		BS	CS	BS	CS	BS	CS	BS	CS	BS	CS
		(B)	(C)	(B)	(C)	(B)	(C)	(B)	(C)	(B)	(C)
Arachis hypogoaeo	Groundnut	10	5	0.2	0.2	3	3	75	75	98.0	98.0
Cajanus cajan L.	Pigeon pea	400	200	0.1	0.3	3	3	75	80	99.0	98.0
Glycine max L.	Soyabean	10	5	0.2	0.5	3	3	70	70	99.0	99.0
Gossypium Hirsutum	Cotton (H)	500	400	0.2	0.3	3	3	70	75	99.0	98.0
Gossypium Hirsutum	Cotton (OP)	100	100	0.2	0.3	3	3	70	75	99.0	98.0
Helianthus annus L.	Sunflower	1000	800	0.2	0.5	3	3	75	85	98.0	98.0
Helianthus annus L.	Sunflower (H)	3000	1500	0.2	0.5	5	3	80	80	98.0	98.0
Nicotiana tabacum L.	Tobacco	800	400	0.2	0.5	3	3	85	85	99.0	99.0
Oryza sativa L.	Rice	5	5	0.2	0.3	3	3	80	80	98.0	98.0
Pennisetum glaucum	Pearl millet	400	200	0.5	0.5	3	3	75	80	98.0	98.0
Phaseolus vulgaris L.	Beans	10	5	0.1	0.2	3	3	70	75	99.0	99.0
Sorghum bicolor	Sorghum (OP)	400	350	0.2	0.5	3	3	80	80	99.0	98.0
Sorghum bicolor	Sorghum (H)	750	500	0.2	0.5	5	3	80	80	99.0	98.0
Triticum aestivum L. emend	Wheat	10	5	0.1	0.3	3	3	85	85	99.0	99.0
Vigna unguiculaya L.	Cowpea	10	5	0.2	0.5	3	5	75	75	99.0	98.0
Zea mays L.	Maize (OP)	400	200	0.5	1.0	3	3	90	90	99.0	99.0
Zea mays L.	Maize (H)	400	360	0.1	0.3	5	5	70	70	99.0	99.0

Table 8: Cereal and legume seed production standards

Crop	Grade of parent seed to be sown	Isolation* requirement	Land history	Varietal purity (plants)	Laboratory standards	
					Purity (seed)	Germination
Maize (Hybrid)	Breeder	360	No maize the previous season	99.0%	99.0%	90.0%
Maize (Open pollinated)	Basic	200	No maize the previous season	99.0%	99.0%	90.0%
Sorghum	Basic	200	No sorghum the previous season	99.6%	97.0%	75.0%
Wheat	Basic	3	No wheat the previous season	99.9%	98.0%	85.0%
Rice	Basic	5	No rice the previous season	99.9%	98.0%	75.0%
Groundnuts	Basic	3	No maize the previous season	99.9%	98.0%	80.0%
Beans	Basic	5	No beans the previous season	99.0%	99.0%	80.0%
Pigeon peas	Basic	100	No pigeon peas the previous season	99.8%	98.0%	75.0%
Cow peas	Basic	5	No cow peas the previous season	99.5%	98.0%	75.0%
Soyabeans	Basic	5	No soyabeans the previous season	99.5%	98.0%	75.0%
Sunflower	Basic	100	No sunflower the previous season	95.0%	98.0%	75.0%

* Is the distance to be maintained between the seed crop and another crop of the same species which is not intended for seed production

Table 9: Vegetative propagated crop standards

Crop	Registartion time	No of inspections	Land History	Number of generations	Sampling size	Offtypes %	Sampling technique	Isolation distance	Zero percentage diseases at harvest
Cassa-va	Before or at planting or 2 months after ratooning	3	2 years	7	100 plants/ha	0.05	Zigzag or diagonal	5 m	Cassava mosaic Bacterial blight Brown streak
Yams	Before planting	3	Free from volunteer plants and avoid swampy and shaded areas	7	Not specified	0.01%	Zigzag or diagonal	5 m	Tuber infected with scales
Potato	Before planting	4	3 years without solanecea crop 60 m from a diseased crop	7	Not specified	0.01	Zigzag or diagonal	10m basic and 5 m certified	bacterial wilt Fusarium wilt Black leg verticilum wilt ring rot wart disease potato spindle Golden nematodes Andean potato mottle virus Andean potato latent virus dry and soft rot in storage
Sweet Potato	Before planting	4	two sea-sons	7	Not specified	0.5	Sample 100 plants per 1m X 20m	10 m	Sweet potato virus com-plex disease Alternaria, weevils

(ii) Seed Source

Seed should be procured from a reliable source such as from breeders in different institutions. The Seed Services Unit (SSU) provides information of where the right class of seed can be sourced from in case farmers do not have any knowledge/ information of the source of seed. Information for seed source is required during registration.

(iii) Land verification

Land verification cheks the history of the field to be grown to seed. It ensures that same crops do not follow each other consecutive to avoid contamination, mixtures and prevalence of pests and diseases.

(iv) Isolation

Seed crop field must be isolated (separated) from any other variety of the same crop to avoid cross contamination. Different crops have different isolation distance depending on their mode of pollination.

(v) Field Standard

Poor stands, lack of vigor or uniformity, weed growth, or conditions which may hinder accurate inspections are cause for rejection. A field for seed production should generally be weed free to prevent admixture. A weed free field is also important as it aids easy movement during field inspection. Offtypes (plant or seed that deviates in one or more attributees from the breeder's description) should be roughed off before pollination takes place.

(vi) Seed sampling and testing

Seed has to be tested for germination and putity prior to selling. Government seed samplers will draw official samples for laboratory testing after the seed has been graded and packed in standardized bags. Only seed that has passed laboratory standards can be accepted and sold.

Laboratory test results are valid for twelve months thereafter the seed has to be re-tested.

(vii) Seed Monitoring

Seed quality deteriorates during storage/ distribution. SSU conducts routine seed monitoring in all seed companies and seed distributors to ensure that farmers do not access substandard seed. During the market seed monitoring the seed inspectors check if the seed is being handled correctly during sales, if the seed is correctly labeled and if any fake seed is being sold in the market.

2.4.2.4. Training

SSU provides training technical assistance advice in seed certification and quality control to all stakeholders in the seed value chain.

2.4.2.5. Seed prices and marketing

Knowledge in gross margin analysis is important as farmers have to come up with their own seed prices and find their own markets.

2.4.2.6. Seed storage

Seed is a living entity as such it is important that all precautionary measure are taken to reduce deterioration during storage.

2.4.3. Liaison amongst different Institutions

The success of the seed industry depends on collaborative efforts of different Departments in the Ministry, commercial seed companies and other sectors of the economy involved in the seed industry. that is why Institutional and operational linkages have been strengthened with a view of providing are efficient seed delivery system to farmers. SSU offices at Chitedze , Bvumbwe, Lifuwu and Lunyangwa Research stations can be contacted for more information on Seed certification and Quality Control issues.

2.5. Crop Protection

One of the challenges facing the agricultural sector in Malawi is low crop production and quality as a result of pest infestation and disease attack. The Ministry of Agriculture aims at minimizing losses in quantity and quality of crop produce through proper crop disease and pest management.

There are several methods of reducing pest and disease incidences. These include cultural, biological, mechanical, physical control measures, use of resistant crop varieties, sanitation, plant quarantine and application of pesticides. The emphasis is to promote the use of these methods in the form of Integrated Pest and Disease Management (IPDM). This approach employs a combination of two or more of the control methods and places emphasis on environmental protection and preservation of beneficial organisms. By using IPDM the use of pesticides is minimized hence the cost is reduced and the environment is protected.

2.5.1. Cultural control

The way crops are managed may affect pests and diseases that live in the crop environment. Time of planting, weeding, uprooting of infested plants and harvesting practices which may destroy these pests are cultural pest control methods. For instance, early planting will reduce bushy top in tobacco, stalk borers, maize streak and other diseases. Removal of tomato plants after harvest will reduce nematode populations in the soil. Weeds can habour pests that attack crops and reduce yield, therefore, timely weeding is important. If harvesting is delayed, maize, millets and other crops may be damaged by rodents, weevils, birds and other pests. Farmers should, therefore, be encouraged to carry out cultural practices timely and as recommended. Following proper crop rotation, removal of volunteer plants and other crop hygiene practices will reduce the build-up of weeds, insect pests, nematodes and diseases.

2.5.2. Biological control

Biological control results from the manipulation of populations of parasitoids, predators and pathogens in reducing the abundance of pest species and maintaining its population at a level lower than it would have been in the absence of these organisms. It may also involve the release of a pest's natural enemies in an area. Examples of natural enemies are *Trichogramma spp.* and *Apanteles spp.* parasitizing eggs and larvae of stalk borers, *Epidinocarsis lopezi* parasitizing cassava mealy bug, predators such as ladybirds *(Coccinellids spp.)* feeding on aphids, and birds feeding on army worms. *Teretrius nigrescens* (Tn) is a natural enemy of Larger Grain Borer *(Prostephanus truncatus)*. Some pathogens such as fungi, bacteria and viruses also contribute to reduction of populations of insect pests and the spread of diseases. Where possible, conditions should be created to enhance their effectiveness. For this reason, chemical pesticides should be applied judiciously to maintain populations of these natural enemies.

2.5.3. Mechanical control

There are other methods of reducing pest problems that are just as effective. These include setting up traps and barriers which disrupt pests moving in a particular area. Control may also be achieved by hand picking and crushing. These methods need to be encouraged as they are cheaper.

2.5.4. Physical control

Changing the availability of water, relative humidity, temperature and light conditions especially in storage can make living conditions unfavourable for pests. Cool and dry grain will have fewer pest problems than warm and moist grain. Sterilization of nursery beds by burning is another example of physical control. Farmers should therefore be encouraged to dry their produce thoroughly before storage and sterilize nursery beds before sowing.

2.5.5. Use of Tolerant varieties

Some varieties of crops are more tolerant to pest and disease attacks than others. They suffer less damage and are not easily destroyed. These are called tolerant varieties. Planting them reduces crop damage. For instance, planting hairy cotton varieties reduces jassid population on the leaf thereby minimizing damage. Flint maize suffer less pest damage in storage compared to dent maize.

2.5.6. Sanitation

Sanitation is the removal and disposal of infected or infested plant or plant parts and wastes; and keeping crop fields and storage facilities as clean as possible as these would be sources of infection or infestation. Removal of volunteer crops deprives a pest or a host on which it would harbor over winter. Rouging and destruction of infected or infested plants in the nursery and field reduce sources of pests. For example, destruction of infested tomato plants with spider mite will reduce population of the pest for next growing season. Removal of weeds will reduce pest and disease incidences in crop fields. Some rodents such as rats and mice thrive on food wastes that are not properly disposed of. Removal of such wastes reduces chances of rodent problem developing. Other storage pests such as weevils may remain in storage structures and bags. Cleaning of such storage structures before putting in new harvests would therefore reduce pest load in storage.

2.5.7. Plant quarantine and other regulatory control measures

Plant quarantine is the holding of imported plant material in isolation for a prescribed period to ensure freedom from diseases and insect pests. Pests which are non- existent in Malawi can be introduced from other countries through imported plant material. Plant quarantine is used to control the spread of insect pests and diseases between countries. It is therefore the responsibility of every importer and traveler to obtain an import permit from the Ministry of Agriculture before importing such materials.

Within the country, the most important regulatory control measure is restricting movement of plant material from infected areas to clean areas. Field staff should advise farmers not to transfer infected plant material from one area to another.

2.5.8. Use of pesticides

Pesticides offer quickest pest control solution. However, they should be used to supplements other methods of pest control. They should therefore, be used only when necessary as they cannot solve all pest problems encountered and besides they may be harmful to the environment, expensive and scarce at times. The use of pesticides is only recommended where it is difficult to control pests through use of other methods. Farmers should however, be advised to use recommended pesticides for each type of pest and strictly follow instructions. It is strongly recommended that farmers buy pesticides from registered dealers and agents only. Farmers should buy pesticides enough for the season as surpluses may deteriorate, and cause storage and disposal problems. Farmers should be encouraged to read the label before buying and using pesticides.

2.5.8.1. Storage of pesticides

Pesticides should be stored safely and properly to avoid poisoning, accidents and enhanced deterioration. All types of pesticides should be stored in their original containers under lock and key, away from children and livestock. Pesticides should be stored under dry conditions and away from direct sunlight. They should not be stored or transported together with food, clothing and furniture. If in doubt, contact the Pesticide Control Board.

2.5.8.2. Choice of applicators or spraying machines

There are various pesticides applicators available for use by farmers. Farmers are advised to carefully choose their applicators because failure to do so may result in poor pest control leading to economic loss. The choice of a sprayer should be based on crop type, area to be covered, pests to be controlled, terrain of the area to be sprayed and initial capital. Ultra Low Volume (ULV) and knapsack sprayers are recommended for spraying small crops and bushes including vegetables. Mist blowers can be used for spraying any crop including large trees.

2.5.8.3. Safety when handling pesticides

All pesticides are dangerous. To prevent accidental poisoning, all pesticides should be properly stored in original labelled containers and be kept away from children. Containers which are not clearly labelled or have no labels should not be used. Decanting of pesticides and reuse of containers is totally discouraged as this would also cause accidental poisoning. Safety periods between application and harvesting of food crops have to be strictly observed.

All pesticides users should be trained to handle pesticides with utmost care. The general practice by farmers of spraying without protective clothing should be discouraged as it exposes a large area of the body to the pesticide. Farmers should be advised to cover as much of their body as possible. Protective clothing should be used and for these purpose overalls, gloves, gum boots and masks are recommended. Where farmers can not afford overalls and gum boots, they should improvise with plastic bags or any other plastic materials; and where they cannot afford masks, they should improvise with pieces of cloth. Sprayers that are leaking should be repaired before use.

Disposal of unused pesticides and empty containers

i) To avoid disposal problems of left over pesticides, farmers should be advised to mix just enough quantity of pesticide for the crop area to be treated. If however, a small quantity of a pesticide remains in the sprayer tank or mixing bucket this should quickly be sprayed over the crop or another crop specified on the label until all is used up.

ii) It is recommended that sprayers and mixing buckets should be rinsed at least three times with clean water. Rinsing water should not be disposed of on grazing areas, in open water masses (ponds, streams, rivers and lakes), or sites draining into open water masses as most of them are toxic to human beings, animals, fish and other aquatic organisms. Rinsing water should be buried in a small pit in the field. Paper and polythene packs should be burned in a pit in open air. The burning has to be done in an open space with plenty of air since some pesticides can produce fumes that are dangerous. Alternatively burn in an incinerator. Metal container should be perforated and flattened, plastic containers cut and glass containers broken before being buried in a pit.

Wherever possible farmers should buy pesticides in small quantities just enough for the season and mixing just enough for that day's spraying to avoid storage and disposal problems.

2.5.8.4. Use of natural plant (botanicals)

Little is known about the use of natural products such as fish bean (Tephrosia vogelii), neem, dema etc. but small-scale farmers may be using these to control pests. Use of such natural plant products on a commercial scale is not allowed without prior permission from the Ministry of Agriculture.

2.5.8.5. Dealing with accidental contamination

When a person handling a pesticide is contaminated with splashes or spillage, contaminated clothes should be removed and the skin washed with plenty of clean water and soap. Contaminated eyes should be rinsed with clean water for at least 15 minutes. In case of poisoning, medical attention should be sought. Where possible, first aid as stated on the label can be given before the patient reaches the hospital. Make sure to bring to the hospital the pesticide container so that the doctor is able to check specifications on the label.

2.6.0. Plant pest diagnostic and advisory services

The Department of Agricultural Research Services runs several plant laboratory clinics for pest diagnostic services such as plant disease and insect pest identification. After the pest has been identified, its identity and control options are communicated to the farmer if necessary. Upon getting reports about pest incidences, field visits are made to establish the severity of the problem. Farmers and field staff are therefore requested to make use of these services.

2.6. Agricultural Farm Inputs

Most aften increased productivity heavily relies on use of recommended inputs. The inputs required vary according to the type of enterprise the farmer is engaged in.

Farm inputs are therefore an essential prerequisite for increased production. They should be sourced and secured on time in order to ensure timely undertaking of agricultural operations. The different types of farm inputs include manure, chemical fertilizer, seed pesticides and farm implements.

2.6.1. National aims

Use of recommended farm inputs especially improved seed and fertilizers by smallholder farmers is low. The government policy is therefore to improve access to as well as and increase the adoption of recommended farm inputs.

2.6.2. Types of Farm Inputs

Price increases are making it more difficult for smallholder farmers to afford the chemical fertilizers and this trend is expected to continue. It is therefore recommended that farmers make much more use of manures such as khola, compost and buried crop residues. Simultaneous use of organic and chemical fertilizers increases yield.

2.6.2.1. Manures

Manure is fully decomposed organic matter applied to soil to supply plant nutrients . Manures provide a number of benefits to crops. They supply plant nutrients in forms that can be easily taken up; improve structure of the top soil through supply of organic matter which improves root penetration, permeability, water retention capacity, aeration and resistance to erosion; reduces leaching of soil nutrients and improve soil microbial activity. Different types of manure can be classified into the following:

- Compost manure;
- Khola/animalmanure;
- Green manure;
- Farm yard manure; and,
- Liquidmanure.

2.6.2.2. Chemical fertilizer

Deficiencies in soil nutrients in different parts of the country affects crop production negatively. This is addressed through use of fertilizers. Chemical fertilisers improve crop yields tremendously, especially in maize, tobacco, rice and horticultural crops. They also contribute towards quality improvement for the produce especially when balanced plant nutrients are provided.

Fertilizers give best results when crop husbandry practices are of high standard. Failure to observe these fundamental principles of good farming will only result in a waste of money spent on fertilizers. There are two groups of chemical fertilizers currently on the market namely:-

2.6.2.3. High analysis (concentrated fertilizers

High analysis fertilizers are those which contain a total of 45% or more of nitrogen, phosphorus and potash combined. The objective of introducing the high analysis fertilizers is to reduce the cost of fertilizers both to the farmers and to the nation. Concentrated fertilizers contain more plant nutrients per unit weight than conventional fertilizers, hence reduced quantity and transport cost. Urea is an example of high analysis fertilizers. Urea is a nitrogenous fertilizer for topdressing. It contains 46% nitrogen (N). When used instead of Calcium Ammonium Nitrate (CAN), only about 2/3 of the normal amount is applied. When used in place of Sulphate of Ammonia (SA), only ½ the usual quantity is used. The ordinary prilled (small shiny balls) form of Urea absorbs moisture very rapidly under humid conditions after the bag has been opened, and when kept for a long time it may deteriorate to a wet granular and coated formulation which does not absorb moisture easily.

2.6.2.4. Low analysis (conventional) fertilizers

Low analysis fertilizers are those that have less than 45% nitrogen, phosphorus and potash altogether. These include:-

i) 23:21:0+4S

This fertilizer is used as a basal dressing which has replaced 20:20:0. A part from nitrogen and phosphate it also contains 4% Sulphate.

ii) 23:10:5+6S+1.0Zn

This is a basal fertiliser which composed Nitrogen, Phosphorus, Potassium Sulphur and Zinc. The fertilizer has reduced amount of phosphorus, it has more potassium and added zinc as compared to 23:21:0+4S

iii) Sulphate of Ammonia

Sulphate of Ammonia is a top dressing fertilizer that is used on rice, tea, sugarcane and in areas with alkaline soils. It contains 21% nitrogen (N) and 24% sulphur (S)

iv) Calcium Ammonia Nitrate (CAN)

This is a top dressing fertilizer which is currently manufactured in 3 distinct grades, namely, 26, 27 and 28% nitrogen. It is a recommended low analysis nitrogen fertilizer for upland and plateau areas where soils are neutral to acidic. Fertilizers will normally be available in 50 kg bags.

2.6.2.5. Fertilizer sales

The bulk of smallholder farmers' fertilizer is procured by the Smallholder Farmer Fertilizer Revolving Fund of Malawi (SFFRFM). They are distributed through ADMARC outlets;SFFRFM and other agents at present for SFFRFM fertilizers. Fertilizers are also procured and distributed by private dealers.

Farmers are encouraged to buy fertilizers during the peak period crop produce selling period. Purchases on cash are cheaper than those on credit as there is no further financial commitment to farmers since there is no credit service charge. Extension staff should therefore continue encouraging farmers to purchase fertilizer on cash basis.

2.6.3. Seed

Use of improved seed is vital in crop production. It is the government's policy that farmers must use good quality seed which ensure high germination percentage and good crop establishment. Farmers are encourage to source from reputable sources such as Seed companies, ADMARC and agrodealers. Farmers have to check for packaging dates to ensure that they do not plant carry over seed.

2.6.4. Pesticides

When crops are infested with pests, the yield and quality are reduced. It is therefore important that farmers control pests both in the field and in storage. Pesticides should only be used if the level of the pest/ disease is at or exceeds the economic threshold level (value of crop saved crop exceeds the cost of control. Some of the common pesticides available are Cypemethrins (Ripcord, Cymbush, Sherpa) for the control of insect pests; Chlorothalonil (Daconil) for the control of fungal diseases in the field; Pirimiphosmethyl(Actellic)for the control of storage pests and Clorothenvinphos for the control of ticks in cattle. Extension workers and farmers are encouraged to check for specific pesticide types under respective enterprises in this Guide.

2.6.5. Farm animals and implements

Farm implements and draught animals facilitate tillage operations, transport, and proper application of pesticides. These include ploughs, ridgers, cultivators, tool bars and treck chains for tillage, farm carts and wheelbarrows for transport. Other inputs provided are dairy cows, milking equipment, draught animals, stall feeders and poultry. Inputs for livestock production include dairy cows, draught animals, breeding stock, poultry, milking equipment, feeds, drugs and pesticides (read chapter 6 on Animal production). The animals can sourced from Government farms and other farmers. Feeds, feeders, drinkers can be sourced from agro-dealers, drugs, pesticides and vaccines can be sourced from veterinary pharmacies. To ensure adequate supply of farm inputs, estimates should be made in line with demand. Staff should closely monitor their availability, distribution, purchase and use.

2.7. Soils and Soil Testing

Soil is a medium for plant growth and is a crucial asset of importance in agricultural production. Unfortunately soils in Malawi have a serious problem of nutrient deficiency which is caused by a number of factors.

Continous cultivation on the same piece of land with no crop residue incorporation and lack of or inadequate application of chemical fertilizer, has greatly affected soil crop productivity. Most of Malawi soils are depleted of their nutrients and organic matter. Loss of soil cations has reduced soil pH, thus increasing soil acidity. The low pH has led to high exchangeable aluminium.

High aluminium saturation in soils has been reported to occur in Mulanje, Nkhata-Bay, Mzimba and Dedza. Aluminium toxicity may be controlled by liming the soil.

The pressure to produce more from the soil is growing proportionally with the rapid increase in population. Smallholder farmers traditionally practised shifting cultivation, with soil fertility being rejuvenated by long fallow periods. However, pressure from rapidly increasing population has led to reduced-fallow periods and little or no rotation, poor land and soil management practices under smallholder agriculture causes a serious increase in soil erosion, surface runoff and nutrient depletion. Declining soil fertility, especially nutrient deficiencies and poor soil physical conditions are among the most significant factors constraining crop production in Malawi.

The soil's inherent capacity to supply available soil nutrients in adequate amounts and suitable proportions decreases with continued cropping with little or no nutrient added. Continous cropping without proper management of external nutrients exacebate the mining of nutrients from the soils. To ensure a sustainable increase in crop production, application of fertilizers and manure is very important. The use of fertilizers without first testing the soil for its nutrient status is like taking medicine without first consulting a medical doctor to establish the problem. Soil nutrient deficiencies should be identified through soil testing to benefit from fertilizer application. Recently, the cost of chemical fertilizer has more than doubled, and fertilizer use should be restricted to sites of real nutrient deficiencies to reduce the cost of production.

2.7.1. National aims

Soil testing is essential as the first step in obtaining high yield and maximum returns from the money invested in fertilizer. Efficient use of fertilizer is a major factor in any programme designed to bring about high economic returns in agricultural production, and this can be achieved only when the application of fertilizer is based on information derived from a soil test. Each recommendation based on a soil test takes into account the values obtained from soil analysis, the research work so far conducted on the crop in the particular soil area,and the management practices of the concerned farmer.

The national aim therefore is to provide soil testing services which would be a guide to the expected contribution of particular soil nutrients and making a judicious fertilizer recommendation for profitable agriculture production.

2.7.2. Major Soil Type

The location of Malawi shows that it has tropical and sub-tropical environments. These are aggressive soil-forming environments. Consequently, soils formed have low inherent fertility because their clay components are predominantly 1:1 (kaolinite) as opposed to 2:1 (iron oxides), both of which are inactive materials: and low content of rock minerals which can release nutrients when they break down. That is why soil organic matter is the major determinant of the fertility of these soils. The major soil types of Malawi and their distribution are given in Table 10.

The most prevalent soils in the country are the red soils (i.e. Ferrisols, Ferruginous soils and Ferralitic soils) which occur on the highlands and medium plateau physiographic units. They are highly weathered and hence have low inherent soil fertility. Natural ecosystems have in-built recuperative mechanisms so that the decline is usually not beyond repair.

Table 10: Occurrence, chemical characteristics and the fertility status of major soil types in Malawi

Soil group	Occurrence	pH	%BS	CEC me%	Clay	Fertility
Ferruginous (Lixisols and Luvisols)	Ekwendeni, Lilongwe Plain, Shire High- lands, Namwera, Ntchisi-Dowa Hills and Kirk Range	5.0-5.9 Acid to moderately acid	50-60	4-10	1:1 Kaolinite and halloysite, Fe and Aloxides, some 2:	Moderate to high fertility
Ferruginous (Acrisols and Ferr alsols)	Mulanje, Nkha- ta-Bay and and Thyolo	4.0-5.5 strong- ly acid to acid	20-80	2-6	1:1 Kao- linites and halloysite, 2:1 illites Fe and A1 oxides	Low fertility
Calciumorphic alluvials (Fluvisols)	South west Mzimba and Kasungu Plains, Mchinji, Central Dedza, Kawinga Plain parts of Shire Highlands	4.5-5.7 strong- ly to moderately acid	30-80	3-8	1:1 Kaolin- ite and halloysite Fe and A1 oxides	Low fertility

	Lower Shire Valley, Phalombe, Bwanje and Lakeshore Plains	6.5-8.5 almost neutral to alkaline	90-100	10-25	2:1 minerals, mica	Moderate to high fertility
Hydrommorphic soils (Gleysols)	Dambo throughout the country	6.0-7.5 moderately acid to slightly alkaline	80-100	13-20	2:1 illites and micas	High fertility, but with poor site drainage
Soil group	Occurrence	pH	%BS	CEC me%	Clay	Fertility
Lithosols (Leptosols	High altitude hills, mountain and scarp zones	4.0-5.5 strongly acid to acid	70-90	4-10	1:1 Kaolinites and halloysite, 2:1 illites and Fe and A1 oxides	Low fertility, shallow and stony
Vertisols	Lower Shire Valley, Phalombe Plain	4.0-5.7 strongly to moderately acid	100	25-40	2:1	High fertility,but intractable montimo rillo nitic clays

Note: Soil pH- soil reaction, Bs- base saturation, CEC- cation exchange capacity

Therefore, response to added fertilizer must be crop specific and related to site-specific situations. Soil testing is becoming important in crop production in the country. Soil fertility trials have revealed localized deficiencies of potassium (K), Sulphur (S), Zinc (Zn) and boron (B) and there are many sites in Malawi that have adequate levels of phosphorus (P). Table 11 indicate deficient levels of analysed soil nutrients across the ADDs.

Therefore, the past blanket fertilizer recommendation of 92 kg of nitrogen per ha and the current area specific fertilizer recommendation to hybrid maize for the country need to be used with the knowledge that real site specific fertilizer recommendation can be achieved through soil testing. Efficient use of fertilizer is a major factor in achieving economic increase in agricultural production and this can be attained when fertilizer application is based on information derived from a soil test.

2.7.3. Soil testing services

The Malawi Government recognizes the fact that soil testing is a proven, practical method for evaluating the fertility status of soils and for providing a sound basis for making recommendations in respect of fertilizer application and soil amendments to laboratories at Chitedze and Bvumbwe Agricultural Research Stations for analysis. The soil database is being updated and soil fertility maps are being developed to assist in formulation of fertilizer recommendation to farmers. It has thus invested in the establishments of soil and plant analysis laboratories at both Chitedze and Bvumbwe Agricultural Research Stations.

Following the recognition of soil testing services as being a vital part of the expanding fertilizer use, extension personnel should be encouraged to take soils in farmer's field and submit the soil samples to laboratories at Chitedze and Bvumbwe Agricultural Research Stations for analysis. The soil database is being updated and soil fertility maps are being developed to assist in formulation of fertilizer recommendation.

2.7.4. Role of extension services in soil testing

The actual analysis of the soil sample and the making out of the fertilizer recommendation is only part of the soil testing services. The efficiency of this services, to a large extent, depends upon the care and effort put forth by extension workers and farmers in the collection and dispatch of soil samples to the laboratory. The effectiveness of soil testing service also depends upon the proper adoption of the fertilizer recommendations, including the establishment of result demonstration on farmer fields to induce the farmers to follow the fertiliser recommendations.

Table 11: Soil sampling sites showing percentage deficient level of nutrients

ADD	RDP	Zn	Cu	Ca	Mg	K	P
MZADD	Mzimba: Central South	 65 87	 4 9	 42 69	 59 51	 20 43	 50 59
	Nkhatabay Rumphi N.	54 63	2 8	42 58	24 37	14 21	64 66
SVADD	Nsanje Chikwawa	31 58	0 0	23 0	0 0	8 4	23 33
MADD	Mangochi Zomba Machinga	40 63 27	16 14 5	26 45 0	3 10 0	3 16 5	18 47 55
	Balaka	30	5	0	5	5	45
	Namwera	59	0	37	9	11	20
KADD		46	4	6	12	18	58
KRADD	Karonga Chitipa	45 49	4 7	14 7	11 9	19 16	54 54
BLADD	Mulanje	20	0	0	0	10	40
	BT/Shire	58	28	25	3	2	36
	Phalombe	3	6	0	0	0	80
SLADD		41	0	11	6	0	28
National mean		49	6	24	14	13	44

2.7.5. Soil Sampling

A useful soil testing service starts with collection of representative soil samples. A fertilizer recommendation made after analyzing the soil can only be as good as the sample on which it is based. One field can be treated as a simple sampling unit only the soil is relatively uniform and does not exceed two hectares. Variations in slope, colour, texture, management, and crop pattern should be taken into account and separate composite samples should be collected for each area. To obtain a composite soil sample adequately representing the field, follow the procedure given below:

i) Sample each field separately. However, where the areas within a field differ distinctively in crop growth, appearance of the soil, or in elevation, or are known to have been cropped or fertilised and manure applied differently, divide the field and sample each area separately.

ii) Take a composite sample for each area.Scrape away surface litter, then take a small sample from the surface to plough depth (20cm) from a number of plots in the field (20 to 30 per hectare). Collect these samples in a clean bucket or a wide container.

iii) Where crops have been planted in lines (rows), sample between the lines.

iv) Do not sample unusual areas. Avoid areas recently fertilised, old bunds, marshy spots, near trees, compost piles, or other non representative locations.

v) Use proper sampling tools. Satisfactory samples can be taken with a soil tube, auger, spade, trowel or pick-axe.

vi) Take a uniformity thick sample from the surface to plough depth. If a spade or trow are used, dig a V-shaped hole, then cut out a uniformly thick (2cm) slice of soil from the bottom to the top of the exposed soil face. Collect the sample on the blade or in your hand and place it in the bucket.

vii) Pour soil from the bucket on a piece of clean cloth or paper and mix thoroughly. Discard by quartering all but 500g to 1 kg of soil. Quartering may be done by mixing the remaining two portions; again dividing into four parts and discarding two opposite quarters, and so on. The sample should be dried in the shade for an hour or two before it is put in a cloth bag container.

viii) Each cloth bag should be large enough to hold 500g or 1kg of soil and should be properly marked to identify the sample

ix) Fill out soil sample information sheet for each sample. ADDs can obtain these forms from Chitedze and Bvumbwe Agricutural Research Stations. These forms may be sent separately to the laboratory or enclosed with the soil sample.

x) Address the samples to the station Manager at either Bvumbwe or Chitedze Research Station.

xi) Keep a record of the areas sampled and simple sketch map for reference when you get the soil test and fertilizer recommendation report from the soil testing laboratory. As indicated, soil testing should be used as a basis for fertilizer application in order to obtain better economic returns from the money invested in the purchase of fertilizers. Extension workers are strongly urged to encourage smallholder farmers to submit soil samples to Bvumbwe or Chitedze Research Station for analysis. In taking such Samples field staff should help farmers in order to obtain more reliable recommendation. If for some reason a farmer fails to have his or her soils analysed, the blanket fertilizer recommendation may be used as a basis for fertilizer application with the clear knowledge that he/she may be applying quantities of fertilizers that may not bring about an economic increase in crop production.

Soil sampling should at most be conducted once in 3 to 5 years, depending on crop performance. Such exercise should also be carried out to monitor soil fertility changes under continous cultivation. After collecting the soil samples send them to Chitedze or Bvumbwe Research Station for analysis.

There is a minimum charge for this service for commercial farmers, but for smallholder farmers the service is free of charge.

2.8. Agribusiness Extension

The process of democratisation, decentralization, privatisation and market liberalisation is forcing farmers to adjust farming practices. In order to address these new challenges, farmers have to move from subsistence farming to commercial farming. In commercial farming, farm planning and management with an understanding of the changing market-systems is of increasing importance to farmers. Hence farmers and extension staff need to be well conversant in planning, production and marketing methods in order to make sound decisions and ensure that there is efficient and sustainable use of the available resources.

However, the prevailing small landholding size of farmers makes it impossible to utilize economies of size and scale. Especially when it comes to growing commodities for the export market, farmers have to face stiff competition on international markets. This calls for well organized farmers' organisations in order to produce efficiently, market profitably and get access to quality extension services.

2.8.1. National aims

The aim of the Agribusiness extension is to promote commercialization of agriculture especially among smallholder farmers for food security and income generations. The national aim will be achieved through the following policy objectives:

1. To increase farm-income by effective, efficient and sustainable use of the production resources such as land, labour, capital and management.
2. To promote farmer organizations such as associations, cooperatives, companies and trusts to link them effectively to service providers such as input suppliers, commodity markets and extension services.
3. To encourage market oriented production in order to move from subsistence to commercial farming. To achieve the objectives, farmers need to have adequate resources for production. These factors are described below.

2.8.2. Factors of production

Successful farming business requires efficient utilization of factors of production which are:

2.8.2.1. Land

Land in Malawi is one of the most limiting factors of production. Farmers must therefore aim at obtaining the highest marginal returns from it.

2.8.2.2. Labour

Labour is another scarce resource. It is important therefore that farmers should spread their labour requirement throughout the year by avoiding choice of enterprises that compete for labour during peak periods. Farmers should also ensure that labour is not idle during certain periods of the year. Those enterprises which give highest gross margins per person-day should be adopted if labour is the most limiting factor on the farm.

2.8.2.3. Capital

Capital refers to assets and money invested in farming business. Examples of assets include fertilizer, chemicals, machinery and tools. Capital is one of the most limiting resources among smallholder farmers and should be used where it will add the most profit to the farm enterprise.

2.8.2.4. Management

Management involves decision making on the effective combination of the above mentioned factors of production. Good farm-management results in higher profits than poor management using the same quantities of land, labour and capital. Farmers have to acquire knowledge and skills in farm planning in order to make right decisions as to what, when, where and how farm resources should be used in order to derive maximum benefits.

2.8.3. Farm planning

Farm planning is the systematic organization of activities and resources to be used in the farming enterprises. There are a number of techniques which farmers can use in farm planning in order to assess the profitability and viability of the farm enterprise.

Some of these are:

1. Record Keeping
2. Gross Margin Analysis
3. Budgeting
4. Cash Flow Plan
5. Income Statement

2.8.3.1. Farm records

Keeping of records is a prerequisite of sound decision making as well as meaningful business planning, budgeting, and evaluation.

Farm records are grouped into three:-

1. **Physical records:**

   These are items and materials used in the farm business such as stores records, inventories, field operations and membership lists in case of farmer organisations.

2. **Financial records:**

   Information related to all monetary transactions and plans, for example receipts, cashbook, invoices, cash flow plans and income statements.

3. **Human resource:**

   This information related to staff and employees such as contracts of employment and application letters.

2.8.3.2. Gross margin analysis

A gross margin is the gross income from an enterprise less the variable cost incurred in achieving it. A farm business is usually composed of several enterprises. A farmer could grow tobacco on one field, maize on another and cabbage on a different field. This means that he has three enterprises on his farm namely tobacco, maize and cabbage.

In order to decide if he/she should grow more tobacco, maize or cabbage to maximise his/ her profit, he/she will have to calculate which enterprise is giving him/her a higher return. Depending on his/ her most limiting production factor, he/she will be interested either in the highest return per area (ha), per labour (hour or person-day) or per capital. The appropriate tool to assess this is the Gross Margin Analysis.

Gross Margin Analysis enables a farmer to compare the relative profitability of growing different crops (refer to Table 12). However, you can also compare the profitability of using different production technologies, like growing hybrid maize with intensive fertilizer application or growing OPV maize with manure application.

In order to calculate gross margin, the "gross income" and the "variable costs" are needed. It should be noted that the Gross Margin Analysis is usually based on farm-gate prices. This holds true for the produce-prices as well as for the input-prices. Otherwise the Gross Margin from one enterprise could not be compared to the Gross Margin of another.

(i) Gross income

This is the price per unit of the crop you have received at farm-gate times the amount of units you have harvested per ha. This includes both produced consumed or sold.

(ii) Variable costs

These are costs directly linked to production of a specified enterprise. They may also be called production costs and change according to level of production. Variable costs mainly consist of costs incurred from land preparation up to harvesting, for example: planting material, fertilizer, pesticides, labour, hire of machinery and water.

(iii) Fixed costs

These are costs incurred regardless of whether or not output is produced. They are also called "common costs" or "overhead costs". These costs are difficult to estimate per enterprise since they need to be allocated to the various enterprises produced on the farm. Examples of these costs may include buildings machinery, taxes, insurance permanent labour cost, depreciation and interests paid on loans. Since they remain fixed they are not considered in the Gross Margin Analysis, but they are used for other budgeting purposes.

2.8.3.2.1. Uses of gross margin

Some of the uses of gross margins include:

a) The Calculating return per area: This is calculated by dividing the gross margin by the area used for calculating the revenue and the costs, which in most cases is 1 hectare or 1 acre. This method is used when land is the most limitingfactor.

b) Calculating return on labour: Is calculated by dividing the gross margin by the person-days. Family labour should not be included in the calculation of gross margin itself.

c) This method is used when labour is the most limiting factor.

d) Calculating return on capital: This is calculated by dividing gross margin by variable costs. This will tell you the return for the capital invested. This method is used when capital is the most limiting factor.

e) Break even yield is calculated by dividing variable costs by price of commodity. This will give you the level of yield to be achieved in order to just cover the expenses.

f) Break even price is calculated by dividing variable costs by yield. This will give you the price where you neither have a profit nor a loss.

2.8.3.2.2. Points to note when using gross margin analysis

Though gross margin analysis is an excellent tool to make informed decisions there are some key points to be remembered:

i) Gross margins are not net profits, since they do not contain the fixed costs.

ii) Compare only farm enterprises using similar resources (it is not easy to compare livestock and cropping enterprises).

iii) Consider your capital requirements for different production methods (like use of an irrigation system).

iv) Consider your skills and knowledge needed for certain enterprises (like using a greenhouse for horticultural off-season production).

v) Consider your managerial capacity (like growing many different horticultural crops at the same time).

vi) Consider the risks involved in some special enterprises (like growing strawberries only).

vii) Consider that it will take a learning process to successfully apply a new production method until you get the full returns.

Table 12: Calculation of Gross Margin

	Unit	Quantity	Price/Unit	Total Value
Product Revenues	1)	2)	3)	4)
Variable Costs				
Planting Material (seeds)				(a)
Fertilizer			5)	
Manure	oxcarts			
Type 1	bags			
Type 2	bags			
Total Fertilizer				(b)
Pesticides			5)	
Type 1	litres			
Type 2	litres			
Total Pesticides				(c)
Other Inputs				
Irrigation water	litres			
Paid machinery services				
Other				
Total Inputs				(d)
Labour	6)			
Hired labour	hours or day			
Farming labour other forms of labour	hours or day		7)	
Total Labour				(e)
TOTAL VARIABLE COSTS				8)
GROSS MARGIN				9)

Basic explanation of Table 12

1. "Unit" will mean kg; in case the commodity is usually measured in heads, baskets or the like you can use these as units as well.
2. Insert estimated production per hectare based on experience or research; use the same units of measurement as under (1).
3. Insert the farm-gate price per unit. If you do not know the farm-gate price take a market price and deduct all the costs involved to bring one unit of the produce to the market where you are supposed to get that price.
4. Multiply quantity of units with adjusted price per unit to get the total gross revenue or total value of the commodity at your farm-gate.

Gross Income

1. This is the cost of fertilizer or pesticide at farm-gate. Therefore you have to take the prices at the shops and add all costs involved to bring that fertilizer/pesticide to your farm gate.
2. This includes land preparation, planting, fertilizing, weeding, spraying, harvesting, cleaning, grading and packaging.
3. These are the opportunity costs of family labour (money which the farmer could have earned otherwise by engaging in for example casual (ganyu) labour, small business instead of farming.
4. (a) Sum up the total costs of planting material (b) fertilizers (c) pesticides inputs (d)other (e) and (f) labour in order to get the TOTALVARIABLE COSTS.
5. Deduct the TOTAL VARIABLE COSTS (8) from PRODUCT REVENUES (4) inorder to get the Gross Margin.

2.8.3.3. Budgeting

Budgeting is a detailed quantitative statement of a farm plan and a forecast of its financial result. It sets out physical aspects of the plan, what to produce, how much and the resources required, the expected costs and returns, and therefore profit. Budgeting therefore is used for formulation of plans for efficient allocation of resources.

Two types of budgets are commonly used in farm business management; these are partial budget and complete or whole farm budget.

2.8.3.3.1. Partial Budgets

In general, partial budgeting is concerned with evaluating the consequences of changes in a farm enterprise or farm enterprise mix that affect only a part rather than the whole farm. The objective is to assess the expected marginal returns (profits) as a result of that change.

There are two main situations where partial budgeting may be applied:

1. **Change in the combination of enterprises**

   Example: growing tobacco instead of maize.

2. **Change in production method**

   Example: using a plough instead of hand hoes.

Information required for Partial budget:
A partial budget asks four questions about the effect of the proposed change on costs and returns:

If the total costs of the change exceed the total income realized from the change, the proposed change is not advisable.

2.8.3.3.2. Complete budget

Complete budgets look at the whole farm system and not only on one or two enterprises of that farm. Complete budgeting will therefore include all expenses and receipts incurred in the farm system. This is the main difference to marginal costing techniques like gross margin or partial budgeting.

Complete budgeting is used when:

i) Starting a new farm-enterprise

ii) Comparing the financial effects of a proposed large change with the present system. Complete budget involves in general terms a critical review of resource structure and expected profit.

2.8.3.4. Cash flow plan

A cash flow budget is a summary of all cash transactions affecting the business during a certain period of time (month, quarter, year). It is a useful financial planning tool to avoid times of cash shortages. Smallholder farmers usually do not plan their cash flows for the next growing season which results in cash shortages during the farming period. This in turn affects farming operations and leads to sub-optimal production. For any business to operate successfully it is important that it has sufficient funds to meet its financial obligations at all times.

Table 13 is an example of a Cash Flow Plan. It shows different categories of cash In and Out flows of a farmers' organization operating an input supply shop as well as handling the marketing of its members' produce. Categories for CASH IN and CASH OUT can be customized in order to fit a single farm or another type of farm business organization.

Table 13: Completion of a cash flow plan

COST	RETURNS
What new costs are involved?	What former costs are saved?
What former income is lost	What new income is obtained?
Total Costs of Change	Total Income from Change

2.8.3.4.1. Uses of a cash flow plan

A Cash Flow Plan enables the farmer to foresee if at any time during the year he/she will encounter a financial crisis. This will be indicated by a negative CLOSING BALANCE. In case the CLOSING BALANCE is negative the farm enterprise and/ or its financing mechanisms have to be adjusted until the CLOSING BALANCE indicates a positive value throughout the concerned period.

2.8.3.5. Income statement

An Income Statement shows the results of all business transactions of a farm-business or a farmers' organisation that occurred during a specific period, such as month, quarter or year. It gives the total revenue of the business, the total expenses, and the resulting net income of the whole enterprise. In an Income Statement, fixed as well as variable costs are included. A typical Income Statement of a farmers' organisation may look like sample in Table 14.

Note:

a) In an Income Statement you have to include the depreciation although it does not represent an actual payment or expense in form of cash. Depreciation is the loss of market value over a period of time, usually one year. To calculate the rate of depreciation for one year, deduct the estimated scrap value of the equipment from its original cost and divide the result by number of years the equipment will last before it is replaced with a new one. The number of years must be estimated according to your experience with such an equipment.

b) The receipt of a loan nor the payback of the loan-principal is not supposed to be included. However the payment of the interest has to be entered as it represents the "cost of capital" money used in the business of farming.

Smallholder farmers usually experienced shortage of initial capital to start businesses as individuals and cannot negotiate competitively for prices on the market. One way of addressing the problem is to encourage farmers to establish farmer organizations. Farmer organizations are either formal or informal. Farmers' organizations operating like a business entity need a certain organizational form in order to function effectively, efficiently and in accordance with the laws. The laws of Malawi provide different options for setting up a business. Some of the criteria used to differentiate these organizational forms are:

i) Who owns the business?

ii) Who controls the business?

iii) Who profits from the business?

iv) Who uses the services offered by the business?

v) Who is liable for debts of the businaess and to what extent?

2.8.3.5.1. Sole trader

A sole trader is an individual who is self employed, operates his/her business alone and who has sole responsibility for its management. It is suitable for persons who want to have absolute control over the business and for businesses which need only a limited amount of capital investment inorder to get started. There is no specific law on a sole trader as long as he/she adheres to all laws that may affect his/ her business. Most of the smallholder farmers in Malawi are operating as sole traders. Advantages and disadvantages of a Sole Trader:

Advantages

i) Quick decision making in farm management

ii) Full authority of the owner

iii) Easy to control

iv) Owner receives all profit

v) Direct contact with customers (markets)

vi) Legal arrangements are simple

vii) Easy to dissolve the business

Disadvantages

i) The business has no separate entity other than the owners

ii) Owner is personally responsible for all losses (unlimitedliability)

iii) Difficult to raise large capital for investments

iv) Difficult to utilize economies of scale (when using machinery, transport facilities, labour force and buildings)

v) Inability to capture certain market opportunities because of small production volume

vi) Owner is tied to business and may be unable to be away without closing it

vii) Death disability of the owner may end the business

2.8.3.5.2. Partnership

A partnership is an agreement between two or more (not more than 20) people to run a business jointly with an aim to make and share the profit. The other purpose of forming a partnership is to share the running costs of the business. A partnership is also known as a firm. Capital in a partnership is contributed based on agreement. For example, a partnership can be on a 50/50, 60/40, 20/20/60 percent basis.

Advantages

i) Legal arrangements are relatively simple.

ii) Larger amounts of capital can be raised than in sole trading.

iii) Decision making is fairly quick

iv) Tasks in running the business are shared among the partners.

v) Quite easy to control when partners are few.

vi) Easy to dissolve the business when partners agree.

vii) Partners may bring different special skills into the business.

Disadvantages

i) The business has no separate entity other than the partners (unincorporated).

ii) Partners are personally responsible for all losses(unlimited liability).

iii) Profit is divided between partners according to agreement.

iv) Difficult to utilize economies of scale when partners are few.

v) Inability to capture certain market opportunities because of small production volume when partners are few.

vi) Potential of growth is limited since number of partners is usually limited by law.

vii) Requires good cooperation and trust between partners.

viii) Death or withdrawal of one partner may end the business.

Table 14: Income statement

Income statement for the period of.....................	
REVENUE	
Agricultural inputs sale	
Agricultural produce sales	
Charges for services	
Total Revenue	
COSTS	
Purchase of agricultural inputs	
Purchase of members produce	
Cost of transport	
Salaries and wages	
Casual labour	
Office expenses	
Travel expenses	
Interest paid on loan	
Utilities (electricity and water)	
Maintenance costs	
Depreciation	
Total Costs	
NET INCOME(= Total Revenue - Total Costs)	

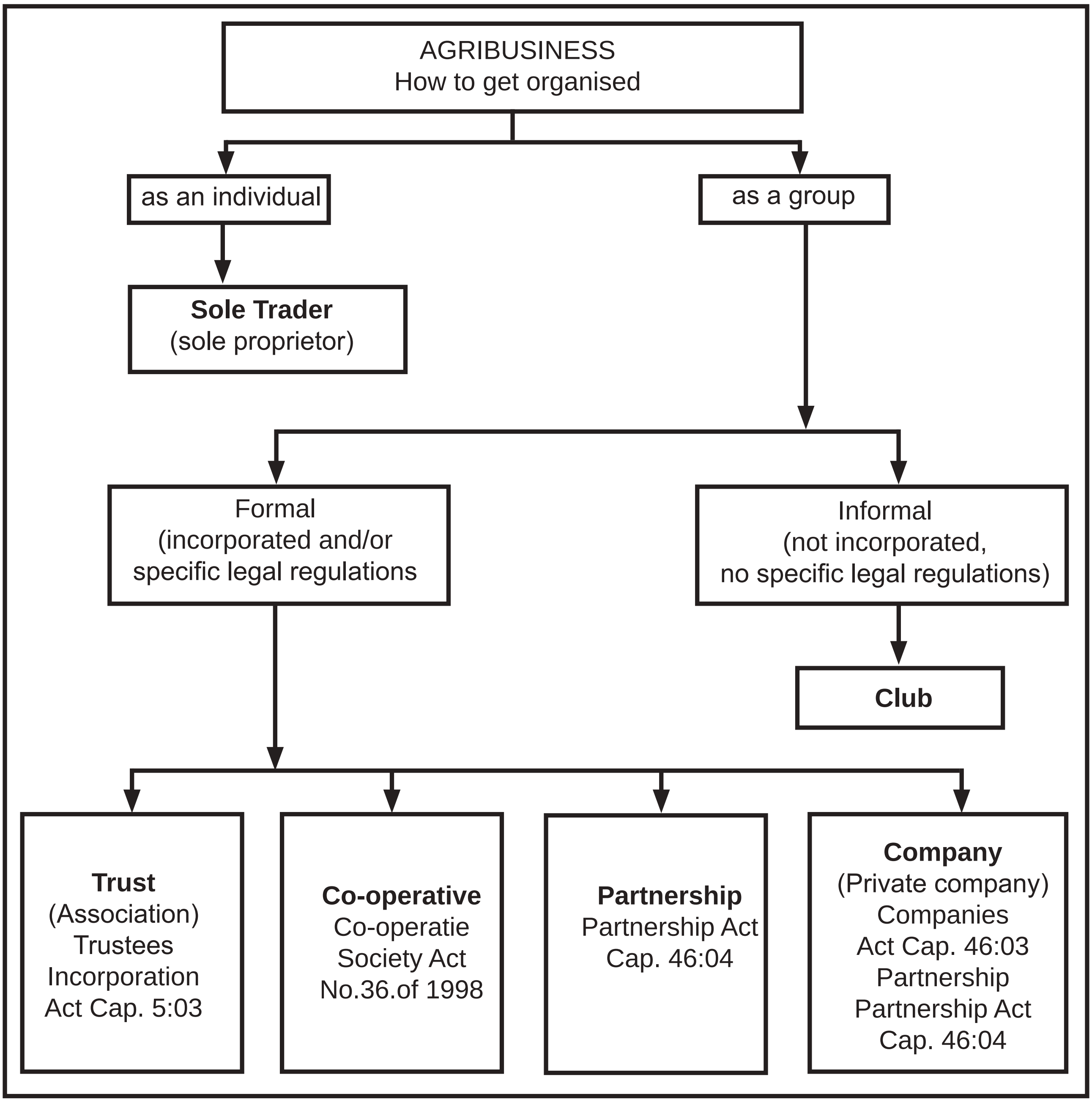


Fig. 19: Common Business Organizations

2.8.3.5.3. Corporation (Parastatal, Company, Co-operative, Trust)

A corporation is an organization which has "lawful authority of incorporation" and is regarded as an artificial person or "legal entity. This means a corporation has the same rights and obligations as a real human being. Thus it can have a name, is able to sue and be sued, can borrow or lend money, can own property and land. It has an identity separate and distinct from the members who compose it.

Corporations in Malawi are generally created by an Act of Parliament. Parliament may create corporations in three ways:

1. by a private (or local) Act
2. by a (special) public Act, or
3. by a (general) public Act, by registration in compliance with statutory requirements.

Companies created under the Private (Local) Act or under the (Special) Public Act are generally known as statutory corporations or as "parastatals". Companies created under the (General) Public Act are known as private or public companies.

2.8.3.5.4. Company

Companies registered under the Companies Act are either public or private companies. The owners of a company are called shareholders because they have invested a certain amount of money any formal of resource into the company by buying shares from the company's share capital. Management is done by a board of directors who may be shareholders or professional employees. The company's profit is distributed to the shareholders in form of dividends according to the shares held by the members.

A company is usually regarded as something big or unachievable by many people, but in reality this is not the case. In the commercially oriented farming community (especially estates and farmer organisations) the option of forming a company is increasingly becoming popular. The head of the household can be the director and the main shareholder of the company. Even a family farm could be run as a company. In that case the husband/wife and the sons/daughters could be additional shareholders and directors.

Business-oriented farmer organisations intending to get incorporated other than a cooperative, the "private company limited by shares" is a viable option. However, the maximum number of 50 shareholders in case of smallholder farmers negatively affects the potential of growth in terms of commodity turnover.

An example of a Corporation created under the Companies Act and dealing in Agribusiness is NASCOMEX (owned by NASFAM). NASCOMEX is a limited liability company with a share capital. It is a profit making company. The purpose of NASCOMEX is trading in agricultural commodities.

Advantages and Disadvantages of a Private Company limited by share

(a) Advantages

i) The business has a separate identity other than the shareholders.

ii) The shareholders have limited liability (in a private company with limited liability).

iii) The business continues even when share- holders die or sell their shares.

iv) Larger amounts of capital can be made available.

v) In cases where most of the shareholders are farmers themselves, thecompany can utilize economies of scale.

vi) In cases where most of the shareholders are farmers themselves, the company can capture certain market opportunities because of bigger production volume.

(b) Disadvantages

i) Must follow more legal requirements

ii) Complex organization (depending on size, decision-making might be slower than with a sole trader or partnership).

iii) Owners (shareholders) have limited control of the business unless they are the directors themselves.

iv) Membership restricted to 50 shareholders

2.8.3.5.5. Association (Trust)

In farming we are mainly concerned with associations of people who have their trustees registered under the Trustees Incorporation Act. These corporations are then called Trusts or Trust Companies, but in everyday language they are just knownn as “Farmers Associations”. They are either created for a ch-aritable purpose or for purpose which are of the beneffit of the inhabitants of Malawi (and this is dependent on the opinion of the Minister). Their aim is primarily not to make profits by running a business but to provide services.

The purpose of these corporations is to look after what they have been created for. They usually do not make money. Profits made are usually reinvested into the corporation and used for the betterment of what they are looking after. Since there is no distribution of profits in terms of dividends and the like, these corporations do not offer shares to their members or to the public.

From the explanations above, trusts were not meant for conducting agribusiness as such. Their aims are more on the educational, social and charitable side. However, it is worthy noting that most of the currently existing farmer associations are actually following co-operative principles and practices.

Examples of organizations created under the Trustees Incorporation Act are the “National Smallholder Farmers Association of Malawi” (NASFAM) and the “Smallholder Coffee Farmers Trust”

2.8.3.5.6. Cooperative

Though a cooperative is also a corporation it is mentioned here as a separate category. The reason being that despite being an independent legal entity. a co-operative might experience more governmental influence through the Registrar’s office unlike a Trust under the “Trustees Incorporation Act” or a Private Company. However, one has to keep in mind that most of the powers given to the Registrar are meant to promote the co-operative’s business aand to protect it’s members from unlawful or fraudulent actions of it’s directors. One might classify this particular feature as an advantage or disadvantage depending on how it is implemented by the people in charge.

The purpose of a farmers’ co-operative is to improve the economic conditions of its members by increasing their profits from farming. This is achieved by offering tailor made from services such as input supply, marketing, education and credit-schemes. Modern cooperatives operate like private business enterprises as far as profit maximization is concerned. However the net profits realizes will be ploughed back to the member-farmers in proportion to their business turnover with the cooperative and to a lesser extent as dividends on the shares held by the individual members.

The special feature of a cooperative is that the members are the financiers, the owners, the users, the controllers and the beneficiaries of the business at the same time.

The law governing cooperative societies is the Cooperative Societies Act Cap. 47:02. “A Guide to the Cooperative Societies Act” in simple English is available at the Department of Cooperatives within the Ministry of Industry and Trade.

Advantages of a cooperative

i) The business has a separate identity other that the members (shareholders).

ii) The members have limited liability.

iii) Management is based on democratic principles

iv) Shares are easily transferable.

v) Legal regulations protect members’ rights (regular audits, financial estimates, members’ right to request an inspection by the Registrar).

vi) The cooperative continues when some members die.

vii) Members must be farmers with a common bond (growing the same crop, living in the same area), thus they can utilize economies of scale.

viii) Can capture certain market opportunities because of bigger production volume.

ix) Profits may be reinvested into the co-operative and/or can be distributed to members according to their business turnover with the cooperative.

x) Property of the cooperative is owned by the members.

xi) Size of membership is not restricted.

Disadvantages

i) Strict legal regulations.

ii) Interference by Registrar (Registrar's power of inspection and inquiry).

iii) Complex organisation (depending on size, decision-making might be slower than with a sole trader or partnership).

iv) Members have limited power over the cooperatives' business unless they are elected as office bearer.

2.8.4. Guidelines to formation of farmers' organisations

In the formation of farmers' organisations agricultural extension staff as well as competent advisors from NGOs and the private sector assume the role of facilitators. Their function is to create awareness among the farming community about the advantages and disadvantages of cooperatives in order to face the new challenges of production and marketing. They assist the farmers in getting the needed information on group organisation and management in order to empower the farmers to make sound decisions. However, it has to be remembered that ultimately group-formation is a bottom-up process which is owned by the farmers themselves.

The following steps of group formation might serve as guidelines for farmers as well as facilitators in order to ensure good organisation and functioning of farmer groups.

Step 1 - Awareness meeting with leading smallholder farmers

This is usually an informal meeting with some of the leading farmers from the area to discuss the problems and needs farmers face and the possibility of forming a farmer organisation to address those needs. It should be mentioned that in some cases farmer organizations can not be used to address some challenges and needs.

Step 2 - First smallholder farmer meeting

This is an exploratory meeting with potential members. In case of a positive decision the Interim Steering Committee should be elected in order to guide the group through the further formation process.

Step 3 - Feasibility study

Feasibility study is designed to provide an overview of the primary issues related to a business idea. It determines whether the business idea would be economically worthwhile or not.

Step 4 - Second smallholder farmer meeting

At this meeting the results of the feasibility study will be presented and discussed. If the feasibility study is indicating a viable business but farmers support is questionable it is advisable to ask farmers to make a token interest investment and sign a pre-membership agreement. Nevertheless, there should be a vote to proceed with formation or not.

Step 5 - Business plan

There is need for a business plan for the group to be prepared. A business-plan gives an opportunity to find weaknesses or hidden problems ahead of time. This aims at assessing potentiality of chosen business.

Step 6 - Constitution and bye laws

Group members need to discuss and formulate the groups constitution and bye laws. They will be used for registration and in day to day activities of the group.

Step 7 - Incorporation of the farmers' Organisations

The legal environment, the kind of services envisaged, the feasibility study as well as the member's preferences will determine which organisational form will be chosen.

Step 8 - Election of office bearers

Before election, farmers need to be sensitized on the office's, responsibilities and duties of office bearers. This will enable them to elect appropriate persons to the positions. Officers should then be elected carefully according to reputation and qualifications needed.

Step 9 - Hire staff, acquire facilities and equipment

Employing staff or other personnel will depend on the type and size of business and qualifications needed to run it. Acquire facilities and equipment that may be required. Ensure that use and maintenance of facilities like storage rooms, office rooms and phones is well stipulated in the bye laws.

Step 10 - Begin operations

Open bank account, arrange for book keeping and record keeping, elect members to subcommittees or task forces, start implementing the business plan.

2.8.4.1. The functions/services of farmers' organizations

The overall objective of a farmers' organization is to increase the farmers' income. This is achieved by offering tailor-made services to its members. Usually a farmers' organization will provide one or more of the following services:

Marketing

i) Through bulking of members' produce, the farmers' bargaining power is improved when dealing with other business-partners.

ii) Wholesale traders are attracted by big quantities and might collect the produce with their own transport facilities, thus reducing the marketing costs of the farmers.

iii) Improved storage facilities can reduce produce losses and enable the Farmers' organizations to speculate on prices.

iv) Communication facilities (which might be too costly for an individual farmer) for identifying attractive buyers and accessing market information.

v) Value adding by grading, simple processing and packaging. Buyers are attracted by assured quality.

vi) Improved facilities and equipment (like scales verified by Malawi Bureau of Standards or by Industry and Trade, Assize Department) in order to diminish fraud.

Input supply

i) Reduced costs of inputs-bulk purchasing reduces price of needed supplies.

ii) Reduced costs of transport-some companies offer free delivery when the ordered amount is big enough.

iii) Supply of specific inputs otherwise not available. Sometimes the private sector is not interested to provide specific inputs in remote areas. Those inputs can be made available by the farmers' organisation.

iv) Timely supply of inputs through self-management.

Finance

i) Organised groups have easy access to credit institutions.

ii) Through provision of services at cost and distribution of the Farmers' Organisations' earnings, the income of the members is improved.

Extension (advisory services)

i) Continued education on production, marketing and organizational issues boosts production and improves members' educational level.

ii) Enables more effective linkages between extension services providers and research.

iii) Encourages farmer to farmer extension services using the Lead Farmer Approach.

Lobbying

Farmers' Organisation represents many voices and is in a much better position to raise its members' concerns in the political arena than an individual farmer.

Other services

Farmers Organisations can address members' needs not taken care of by other institutions and/ or organizations by offering tailor-made services.

2.8.4.2. Farm Business School Methodology

As farmers become more market-oriented, agricultural extension needs are changing and extension workers, farmers, and other stakeholders face new challenges in providing appropriate advice.

Smallholder farmers have to become better managers, more competitive and improve their efficiency and profitability. One methodology envisioned by the service is to build farmer capacity in entrepreneurial and management skills, through a "learning by doing" approach. The Farm Business School (FBS) concept enables farmers to learn and improve their knowledge, change their attitudes and enhance their skills toward improved farm commercialisation.

A Farm Business School is defined as a programme of business-oriented learning designed to help smallholder farmers who are getting involved in producing for the market and need help in making it work profitably. It is a venue that brings farmers together to carry out collective and collaborative enquiry with the purpose of motivating farmers to address business and marketing problems and opportunities.

This learning takes place at village or local level in circumstances that are familiar to the participants. Extension officers and lead farmers are trained as facilitators and then organise seasonal training courses, where farmers work in small groups at their own agreed time and duration using materials that have been specially designed for the schools.

The FBS forum is also regarded as a forum for sharing knowledge between farmers through discussion, practical exercises and self-study. The major focus on FBS is management, marketing, financing and production skill development.

Characteristics

A Farm Business School has four key characteristics. ***Focus on content not the training facility:*** The Farm Business School 'classroom' can be a classroom in a school, a formal training venue, a meeting room in a cooperative, church premises, or even outside under a tree. Equipment is kept to a minimum. A white board or chalk board, markers, chalk, pencils and exercise books make up the majority of the teaching and learning 'equipment'.

Experiential learning (learning by doing): Participants in the Farm Business School learn by doing. This includes exercises in the 'classroom', field trips, market visits, presentations and demonstrations.

Farmer to farmer learning: There are no experts who know everything or have all the right answers. Most of the participants have something to share and something to learn. They draw from their personal experiences. They help one another understand how things work in the real world.

Matching the farm season: The programme is organised to match the activities of the farm season. Planning is done before the land is prepared in case of crops or new livestock is purchased. Marketing is addressed as a part of the planning what to produce, but it is also looked at again before the harvest is due.

All of these factors keep the learning real. They keep the learning in the context of the participants' own experiences and farming set up.

A FBS can be used or implemented by any number of organizations and individuals.This includes farmer organizations, farmer groups, commodity groups and non-government organisations. The FBS can be run as its own programme, or can be incorporated as a part of another programme. The FBS is of particular interest to individuals and agencies that are involved in helping farmers to improve profitability.

On average the FBS runs for a period of one year comprising three terms which are named pre-season, in-season and post-season.

Steps in establishment and management of farm business school:

a) Identification of frontline staff to be facilitators.
b) Staff training in market oriented farm business planning and management.
c) Staff training on establishment and management of Farm Business School.
d) Community sensitisation.
e) Identification of lead farmers to participate in the school.
f) Launching of farm business school
g) Facilitation and participation in FBS for a specified duration depending on type of chosen model enterprise under learning.
h) Graduation of FBS lead farmers.
i) Lead farmers plan to train fellow farmers on market-oriented farm business planning and even establish Farm Business Schools in their areas.

2.9. Food and Nutrition

Malawi has been chronically affected by Malnutrition for decades identified as stunting (short for age) wasting and underweight. Further, micronutrient deficiencies, anemia, iodine deficiency disorders (such as goiter, cretinism and cognitive development) and vitamin A deficiency disorders (night blindness, xerophthalmia) have been a problem too. Poor nutritional status and poor diets with the advent of the HIV pandemic further worsens themalnutrition situation. The Food and Nutrition programme provides advisory services on food and nutrition to ensure that farmers diversify production and diets to ensure good nutrition and health.

2.9.1. National Vision, mission and goal vision

Vision

A well-nourished Malawian population that effectively contributes to the economic growth and prosperity of the country.

Mission

To provide nutrition education for a sustainable and diverse food system that contributes to a well-nourished nation and economic growth.

Goal

To achieve a sustainable and diverse food system that contributes to a well-nourished nation and economic growth.

2.9.2. Food and Nutrition strategies

The food and nutrition programmes mandate is to improve nutritional status of farm households by:

- Promoting production of a variety of high nutritive value foods, emphasizing on alternative staple foods; crops, livestock and fisheries.
- Promoting dietary diversification through encouraging consumption of diversified high nutritive value foods on a regular basis.

- Improving dietary quality for vulnerable groups (the sick, the elderly, pregnant women, lactating mothers, children with special focus on under two years (with special 1000 days) for optimal growth and development, and people living with HIVand AIDS).
- Increasing the consumption of micronutrient rich foods such as fruits, vegetables, small stock, use of vitamin A fortified sugar and use of iodised salt, to reduce Vitamin A, Iron and Iodine deficiencies. Taking into consideration the need for fats and oils in vitamin A and vitamin C in iron absorption respectively.
- Promote proper processing, preservation, storage and utilisation of locally available and home grown foods.
- Intensify Nutrition Education.

Some of the measures to achieve consumption of a variety of micronutrient rich foods at household level is by encouraging households practice Integrated Homestead Farming (IHF).

IHF is the growing of diversified crops and rearing of small stock and or aquaculture around the home for improving food security and nutrition. IHF provides simple food-based approaches to resolving nutrient deficiencies through successful establishment and management of integrated farming at household, institutional and community settings. IHF can be practiced at structures such as model villages, schools and nutrition rehabilitation units (NRUs).

Components of Integrated Homestead Farming (IHF) includes planning food and nutrition education programs for communities, food and nutrition, vegetable and fruits production, small stocks production and aquaculture.

1. **Planning Food and nutrition programs**

   This component is about community mobilization, collaborating with other sectors, communication and facilitation skills

2. **Food and Nutrition**

   The nutrients play various important roles in the body. They provide energy, body building and maintenance

3. **Vegetables and fruits**

   The homestead can include a wide variety of plants and fruit trees that provide five of the six food groups: vegetables, fruits, legumes and nuts, fats and oils which can significantly improve the family's diet.

4. **Small stock and Aquaculture production**

   Some of the small stock animals that can be reared around the homestead include poultry, rabbits/guinea pigs and goats. Where possible fish can be reared around the homestead where there are water sources. These species are prolific, easy to keep, widely adaptable, easy to manage and need less space and labour.

a) Food and Nutrition Education

This is desirable to provide the information needed by communities and families so that they understand their own food and nutrition issues and take appropriate preventative and corrective actions. Nutrition education should be used as a tool to increase household food security, improve the utilization of food in the home so that available food resources result in improved nutrition status.

The following need to be taken into account in implementing nutrition education programmes:-

a) Extension staff (both females and males) should involve both men and women farmers in food and nutrition programmes, and that food and nutrition should be part and parcel of all agricultural programmes and projects.

b) Make sure that diseases are prevented at both household and community levels at all times. The target population should understand the importance of using safe water, sanitation, hygiene, health services, and regular monitoring of growth through under five and antenatal clinics to correct growth failure when it occurs and receive prompt treatment for common infections; and diseases.

c) Extension staff should devise mechanisms to ensure that households grow improved varieties of crops to realize high yields and incomes; grow drought resistant varieties to suit changes in climate, avoid overselling of produce after harvest in order to keep enough to last the family the whole year, households should grow a variety of cereals, root and tubers such as cassava, sweet potato, pulses, oilseeds, fruits and vegetables, and rear small stock such as poultry and rabbits to ensure variety in the diet.

2.9.3. Factors and causes associated with malnutrition in Malawi

Malnutrition is an outcome of various processes and factors. Nutritional requirements of an individual changes throughout the life cycle (from conception to old age). An individual nutritional needs are influenced by age, sex, physiological status and level of activity. Any imbalance between the body's nutrient requirement and intake leads to malnutrition. When the nutrient intake is more than what the body requires, the person gets what is called overnutrition while if the nutrient intake is less than what body requires, the person gets what is called undernutrition. The causes of undernutrition vary from person to person but can be divided into three main categories. These are immediate, underlying and basic causes.

(a) Immediate causes

Immediate causes of malnutrition are inadequate dietary intake and diseases. Inadequate dietary I intake diet may result from:

- insufficient breast milk
- inadequate meals (quantity)
- undiversified foods (lacking in variety)
- low concentration of energy and other nutrients in meals (food that is too watery) and
- infrequent meals. Diseases may cause malnutrition because sick people may not eat much due to:
    - lack of appetite
    - poor absorption of nutrients by the body
    - loss of nutrients from the body and
    - the body using up nutrients more quickly (e.g. during fever)

(b) Underlying causes

These include family food shortages, inadequate care and feeding practices especially of children and women, poor living conditions and poor health services.

(i) Family food shortages may be due to:

- Lack of money for food
- Low production of family food
- Poor food storage and preservation
- Poor food choices and budgeting
- Poor food distribution and marketing outlets
- Poor infrastructure

(ii) Inadequate care and feeding practices. Family food distribution and consumption practices can cause malnutrition in the following ways:

- Over and underfeeding of children
- Poor care for women (especially during pregnancy, child birth and breastfeeding), the sick, old people and those with long term illnesses
- Poor food preparation and level of hygiene in the home
- Inadequate use of health services

(iii) Poor living conditions that may include insufficient water, inadequate sanitation, overcrowded housing and poor health services can facilitate malnutrition.

(c) Basic causes

The underlying causes of malnutrition may arise from the following basic causes:

- wide spread poverty
- high food prices
- inadequate nutrition, health education and other social services
- low status and education for families especially women
- environmental damage
- inadequate mainstreaming of food and nutrition activities in projects and programmes

2.9.4. Essential actions to prevent Malnutrition

- Train extension staff and households in recommended food processing, preservation, storage and utilization technologies.
- Conduct staff and farmer training in food budgeting to ensure that households have adequate food resources to last to the next harvesting season.
- Promote the consumption of diversified high nutritive value foods (including indigenous foods)
- Intensify nutrition education among the farming communities
- Formulate integrated interventions e.g. Integrated Homestead Farming to improve household food and nutrition security especially for those affected with HIV and AIDS
- Conduct multimedia campaigns on the prevention of micronutrient deficiencies.
- Intensify development and dissemination of food and nutrition information through multimedia channels.
- Promote good multi-sectoral collaboration and coordination among stakeholders.

2.9.5. Common forms of malnutrition

Malnutrition presents itself in two forms namely; protein energy malnutrition and micronutrient deficiencies .

(a) Protein Energy Malnutrition (PEM)

This is a condition where there is inadequate intake of protein and energy leading to undernutrition and is common in children under the age of five. It can also be due to intake of too much protein and energy leading to a condition called overnutrition. Overnutrition is associated with risk for non communicable diseases such as hypertension and diabetes.

Undernutrition is characterized by kwashiorkor and marasmus.

(i) Kwashiorkor

This is a result of inadequate protein in the body and may lead to stunted growth.

Signs of Kwashiorkor

- The child fails to grow
- The child cries a lot and is irritable
- The child's hair changes. Although this might not always occur, the hair loses its color and condition, becoming light, thin, straight, fine and soft and can be easily pulled out
- The skin becomes blotchy with darker areas than normal. Sores and ulcers may develop especially on the buttocks, arms and legs
- The child lacks appetite, may vomit and has diarrhoea

Note: the condition may also affect poorly nourished lactating mothers

(ii) Marasmus

This is a result of inadequate energy and all other nutrients in the body

Signs of marasmus

- The child is very thin
- There is loose skin on the body, legs and arms. The bone shape is seen, with poor or no muscle
- The child is alert and looking for any one who has food
- The eyes are sunken and the skin of the face is drawn so that the child looks like a little old man
- The child gives a low sad whimpering sound from time to time

Parents or guardians of children with Kwashorkor and Marasmus should feed them different types of foods from the six food groups at least five times per day (See the six food group chart). The meals should be prepared with energy dense and protein rich foods. Severe cases should be referred to the hospital.

Prevention

This situation can best be avoided by feeding children with adequate and varied balanced diet. Parents should be advised to feed children protein rich and energy dense foods.

(b) Micro nutrient deficiency

Micronutrient deficiency is another form of malnutrition. It is lack of essential vitamins and mineral required in the body. Common ones in Malawi are Iron, Vitamin A, Iodine and Zinc deficiencies.

(i) Iron Deficiency

Iron is needed as a building material, and most of the iron is used to make the red part of the blood called haemoglobin. Deficiency in iron results into Anemia. Anemia is also made worse by malaria, worm infestation, bilharzia which are highly prevalent in the country and can also be caused by heavy bleeding When iron is very little, the blood is not red enough and the person is usually pale. The red part of the blood carries oxygen from the lungs to all parts of the body including the brain. Anaemia affects people of all ages especially children, pregnant and lactating mothers.

Signs of Iron Deficiency

Iron deficiency shows the following clinical signs and symptoms:

- Breathlessness
- Tiredness
- Weakness
- Pale hands, tongue and membrane of the lower eyelids
- Frequent headaches and dizziness

Iron deficiency anaemia is caused by inadequate dietary iron intake

Prevention

- Eating foods that are rich in Iron. These foods include dark green leafy vegetables, pulses and legumes, liver, eggs and meat
- After each meal eat fruits rich in vitamin C such as malambe (baobab), masawu (jujube), lemons and oranges. Vitamin C helps in the absorption of Iron
- Avoid taking food rich in caffeine or tannins such as coffee and tea together with meals as it hinders absorption of iron in the body.

(ii) Vitamin A deficiency

This results from lack of vitamin A in the diet. It is compounded by a lack of fat or oil in the diet. Vitamin A is fat soluble. Fat or oil helps in the proper absorption of Vitamin A. Vitamin A helps in normal functioning of the eyes, immune system, promotes growth, maintain healthy skin, support the production of sperms and prevents other body compounds from damaging reactions with oxygen (it acts as an oxidant).

Signs of vitamin A deficiency

- Night blindness (unable to see in dim light)
- Softening and ulceration of the cornea (the white part of the eye)
- Rough and horny skin
- Total blindness may occur in severe cases
- Weakness in the immune system

Prevention

Eat vitamin A rich foods such as dark green vegetable (bonongwe, kholowa, luni, nkhwani and rape), Yellow and orange fruits (paw-paw, mangoes and carrots), liver, milk,fortified oils, sugar and bio-fortified orange fleshed sweet potato.

Note: This vitamin is fat soluble therefore it is advisable to add some fat or oil to vegetables during preparation to increase its absorption. In the absence of oil use nsinjiro.

(iii) Iodine deficiency

This is caused by lack of iodine in the diet. The condition is common in high altitude areas such as Dedza, Ntcheu, Mzimba, Rumphi and Chitipa because of iodine deficient soils. Iodine is required in the body for the proper functioning of the thyroid gland. It is also necessary for development of the brain and nervous system during pregnancy. Inadequate iodine in the body may result into the following;

- Goitre (swollen neck)
- Poor brain development (cretinism)
- Speech and hearing defects
- Infertility

Prevention

- Use iodized salt when preparing meals all the time.
- Store iodised salt in well covered containers to prevent loosing iodine through vapour.

(vi) Zinc deficiency

Zinc is an important mineral critical for the normal body processes, growth and development. Deficiency in zinc may lead to poor growth and impaired reproductive systems.

Other functions of zinc in the body include;

- Genetic material and protein synthesis
- Strengthens body immunity
- Vitamin A transportation
- Taste and smell perception
- Normal development of foetus
- Production of sperms
- Treats diarrhoea (zinc tablets)

Signs of Zinc deficiencies

- Anaemia.
- Growth retardation
- Slow DNA synthesis, impaired cell and protein synthesis.
- Weak sense of smell and taste
- Impaired function resulting to low production of sperms
- Slow healing of wounds
- Delayed onset of puberty

Prevention

Eat zinc rich foods such as; wheat, whole grain cereals, nuts, legumes, poultry.

Bio-fortifying crops with zinc such zinc beans

2.9.6. The Six Food Groups

The food group chart and poster has classified food into six groups. The grouping is according to type of nutrient content and amounts and not according to their functions as was the case with three food groups. It is felt that this will encourage people to eat a variety of foods in their diet.

The six food groups are:

(a) Staples

These include cereal grains such as sorghum, millet, maize, rice, starchy roots (cassava, potato) and starchy fruits (plantain). They mostly provide carbohydrates. Other nutrients such as protein and minerals depend on how they have been processed.

(b) Legumes and Nuts

This group includes groundnuts, soya beans, beans, cowpeas, peas, ground beans, and pigeon peas. They provide mainly protein and carbohydrates. Soya bean and nuts are also rich in fat in addition to protein and carbohydrates.

(c) Vegetables

This group includes green leafy vegetables such as bonongwe, luni, kholowa, mkhwani, khwanya, chigwada, mpilu, chisoso, mwamunaligone and kamganje. It also includes carrots, tomatoes, pumpkin and mushroom. They provide mostly vitamins, minerals, water and fiber which is necessary for proper digestion.

(d) Animal Foods

All the foods in this group are of animal origin such as meat, eggs, milk and milk products, fish, mbewa, ngumbi, grasshoppers, catapillars (mphalabungu), and birds. They provide protein, fats, vitamins and minerals.

(e) Fruits

This group includes all fruits such as tangerines, lemons, ripe bananas, pineapples, paw-paws, mangoes, masawu, bwemba, malambe, masuku, peaches, apples, guavas, water melons and many available to its members at all times. They are a good source of vitamin C when eaten fresh. They also provide beta carotene and fiber.

(f) Fats and Oils

This group includes oil seeds such as soya beans, groundnuts, sesame and pumpkin seed. Other sources are avocado pear, cooking oil, meat, fish, milk and milk products such as butter, margarine and yoghurt. Members of the community should be advised to consume all six food groups by the end of the day each day.

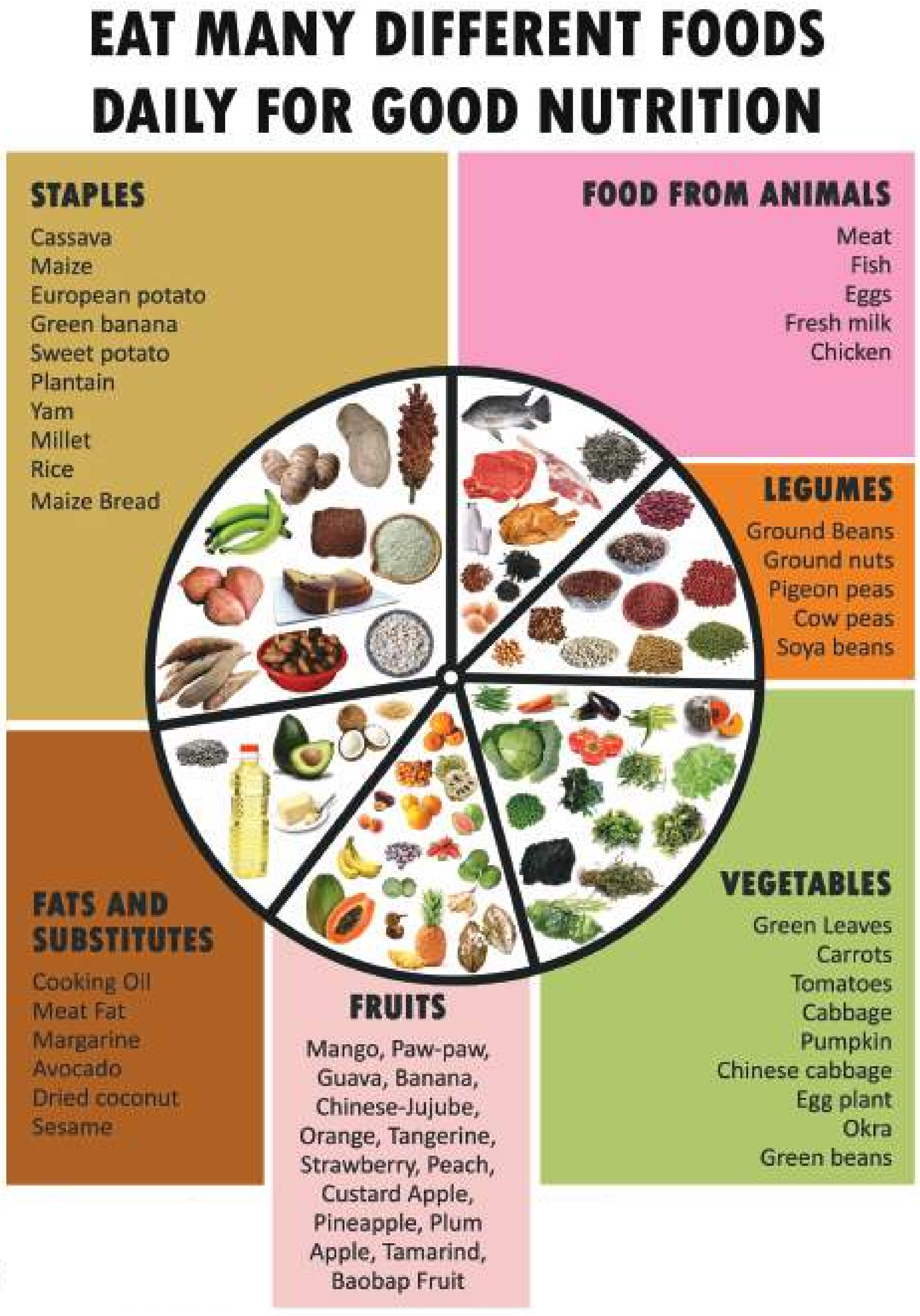


Fig. 20: The six Food Groups

2.9.7. Household food security

Good nutrition starts with good feeding, therefore there is need to ensure that households are food secure. All households should ensure that there is adequate food of a wide variety available to its members at all times. It is therefore recommended that extension staff should:

a) make an effort to reach nutritionally vulnerable households, which include those with small land holdings and female headed households with extension packages aimed at improving diversified production.

b) advise households to avoid overselling farm produce after harvest in order to keep enough to last the family the whole year as follows:

2.9.7.1. Amounts of food and energy required from each food group

A person requires energy and nutrients from all six food groups. Production and consumption of diversified foods is the most ideal means of accessing these nutrients. A normal person requires 1375g of foods per day from all the six groups, equivalent to 2,205 Kilocalories (500gs of this amount should come from staples (grains or tubers or both), 300g from fruits, 300g from vegetables, 150g from legumes and Nuts, 75g from animal foods, 50g from fats and oils). Children below age of 12 require half amount of an adult person. Below is a guide on food and energy requirement for a normal adult person from each food group per day and per year per each group.

Table15: Amount of food and energy requirements per day and per year for a normal adult person

	Adult food needs by food group	Grams/ day	Kg/ year	Kcal	% Kcala
1	Grains	250	91.3	838	38%
	Tubers	250	91.3	240	11%
2	Fruits	300	110	150	7%
3	Vegetables	300	110	96	4%
4	Plant protein	150	55	588	26%
5	Animal protein	75	27	58	3%
6	Fat	50	18	235	11%
Totals		1375	503	2205	100%

Key 1: Staples. 2: Fruits: 3: Vegetables, 4: Legumes and Nuts, 5: Animal foods, 6: Fats and Oils.

(Source: Sustainable Nutrition Manual, WFP, 2015)

Where the household has access to all food groups, it is encouraged to refer to the above table for the amount of food to keep per person per year.

Households that produce cereals/root tubers and legumes should be advised to keep the following amounts;

(i) 300kg of cereal grain or 400kg of fresh cassava or sweet potato per an adult person per year, and half for a child below age of 12.

(ii) Legumes, 30kg per head per year(20kg of beans or other pulses and 10kg of shelled groundnuts per person per year).

Note: In cases where only groundnuts or only beans are grown keep 30kg per person per year.

These are average figures and the estimation includes an allowance for processing losses, visitors, as well as amount used during various ceremonies i.) Farmers should also be encouraged to preserve and store enough fruits and vegetables when they are plentiful for use in times of scarcity.

ii.) Farmers should also be encouraged to keep small stock to improve access to nutrients from animals.

iii.) Those that have source of water or wet lands should be encouraged to practice irrigation and fish farming

2.9.7. Seasonal Food Availability Calendar

A Seasonal Food Availability Calendar is a visual expression of year round food availability expressed in months and or season in a year. It shows periods of the year in which different foods are available and also highlights periods in which households have difficulty accessing certain foods making it challenging to prepare balanced meals. It is a tool for identifying collective measures to overcome food shortages and effectively utilize the available foods.

Process for developing Seasonal Food Availability Calendar

- Draw a chart showing months of the year
- Jointly with the community write the food groups in the first column of the chart
- List the type of foods commonly grown and consumed in the community (second column)
- Depict the availability of each of the foods by months
- Discuss how to prepare nutritious meal in each month
- Discuss how to close the food gaps

Seasonal food gaps can be closed through a number of ways;

- Diversifying production and consumption of foods to include all food groups for example; Integrated Homestead Farming
- Using irrigation facilities to grow food crops during the dry season
- Using improved storage facilities to reduce crop damage and food losses
- Growing crops that mature different times of the year
- Processing and preserving foods that are highly perishable for example roots and tubers, vegetables and fruits.

Fig 21. Food Availability Calendar

Fig 22. Filled Food Availability Calendar

(Source: IHF, MoA/FAO, 2015)

2.9.8. Food and Nutrition Surveillance

Nutrition Surveillance is the monitoring of food and nutrition situation. The purpose is to ensure that nutrition interventions benefit the targeted groups. Monitoring is undertaken at national, ADD, District, EPA and Section levels. Some of the monitoring indicators that can be used in nutrition surveillance by extension workers are:

- Number of malnourished children
- Type of foods eaten
- Number of meals eaten at different times of the year
- Number of households with food and without food at different times of the year

Food and Nutrition Surveillance Tools

- 24-hour diet recall
- Food Frequency Questionnaire (FFQ)
- Food Security Index (FSI) or
- Household Food Insecurity Access Scale (HFIAS)
- Dietary diversity score

For more information on Food and Nutrition refer to available guidelines and manuals in the various Departments, line ministries and other organizations.

2.10. Agricultural Extension Methodologies and Systems

The Extension Methodologies and Systems Branch is a sub programme of the Department of Agriculture Extension Services responsible for design, development and implementation of extension approaches, methodologies and systems used in provision of extension and advisory services to smallholder farmers.

The agriculture sector in Malawi faces many challenges which negatively affect agricultural development. Agricultural Extension facilitates agricultural innovations and adoption process in order to contribute to agricultural development. The history of extension in Malawi dates back to 1903. Througout the year's extension has undergone reforms in approaches and systems. Notable among these include:

- Master Farmer System used progressive farmers and was provided with inputs to demonstrate to fellow farmers on recommended technologies mainly to do with soil and water conservation;
- Modified Master Farmer System (Mchikumbi) used the individual approach which favoured commercial farmers
- Group approach where inputs were provided to farmer clubs on credit
- The Block Extension System (a modified training and visit system) was implemented in Malawi from 1981 to 1999 and the system continued to promote group approach and provision of farm inputs on credit. The section was subdivided into 8 blocks and the Extension Worker used a fixed visitation schedule
- From 2000 the District Agriculture Extension System was introduced to ensure that services are responsive to the demands from the people. Decentralised structures were created to provide forum for interaction with stakeholders. Malawi has experienced changes in social, political and economic environment over the years that have resulted in market liberalization, removal of universal subsidies on agricultural inputs, de-linking of agricultural credit from extension services and the subsequent introduction of microfinance companies which apply market-oriented rates on loans. These changes have created opportunities and challenges for farmers and stakeholders in the agricultural sector. Key challenges facing agricultural extension include:

i) Shrinking public sector resources
ii) Low staff farmer ratio
iii) Poor coordination among stakeholders in provision of agricultural extension services
iv) Decentralization
v) Low literacy levels among farmers
vi) Shrinking production resources

Some of the opportunities noted include:

- Increased number of actors in agricultural extension and advisory services
- Opportunities for farmer involvement in programme planning and implementation
- Availability of diverse sources of information

Changes in the socio-political environment has necessitated extension to provide agricultural extension services to farming communities and agro-based institutions based on demand and need in order to embrace democratic principles.

Vision

The Vision of agricultural extension service is that "all farmers demand and access high quality agricultural extension services."

Mission

The mission is to provide demand driven agricultural extension services in partnership with civic, Non Governmental Organizations (NGO), private and farmers organizations and promote equalization and coordination in service provision in order to achieve food, nutrition and income security at household level there by reducing poverty.

2.10.1. National aims

The aim of the agricultural extension programme is to assist in achieving and maintaining self-sufficiency in food production and income generation through promotion of proven technologies so as to improve agricultural productivity. Extension puts emphasis on assisting farmers to become aware of improved technologies in the production of livestock, fisheries, crops, irrigation, nutrition and natural resources management programmes. It also enables them participate in lucrative and profitable income generation for the improvement of their livelihoods.

The objective is therefore to provide pluralistic and demand-driven agricultural extension services in Malawi. Farmers are encouraged to demand extension and advisory services depending on their needs.

In line with this policy, the agricultural extension programme has the following strategic objectives:-

1. Increasing contact with male and female farmers using appropriate and well-targeted messages through agriculture clusters, farmer groups, clubs, association, cooperatives and trusts.
2. Expanding contact with disadvantaged groups in the community such as women, the youth, people with disabilities, people living with HIV and AIDS and other vulnerable farmer categories.
3. Strengthening Research-Extension-Farmer (REF) linkage mechanisms such as joint field visits, field days, participation in research project meetings, joint extension-research planning meetings, farmer participation in research on-farm trials and adaptive research.
4. Fostering co-operation with NGOs that are involved in agricultural development programmes in order to improve co-ordination and information sharing.
5. Promoting irrigation, food and nutrition, land resource conservation technologies; integration of fish, crops and livestock production in farming systems.
6. Promoting use of innovative participatory development approaches and methods to facilitate agricultural development planning, implementation, monitoring and evaluation.
7. Conduct strategic agricultural extension campaigns, agricultural shows, visits, tours, field days and meetings in order to create awareness among farmers and staff on recommended technologies.
8. Organising, conducting and implementing commodity oriented advisory services.
9. Providing in-service training for extension staff to improve their levels of competence in working with farmers of all gender categories.
10. Providing extension staff with effective message development and communication skills.
11. Undertaking regular farmer training courses to improve farmer knowledge and skills.

2.10.2. Salient features of agricultural extension policy

(a) Pluralistic Extension Services

Pluralism ensures that several players such as public/government, civil/NGOs, and private extension companies play their part in the country's extension endeavours. Pluralism is about providing a conducive environment for different service providers torender services to farmers. This enables farmers to have a greater choice of quality services and develop new skills for market oriented economy. The idea is to streamline services in terms of roles and responsibilities to ensure better quality service for farmers by:-

i) Providing a conducive environment for provision of extension and advisory services along enterprise value chains.

ii) Promoting and strengthening farmer organizations on the obligations of service providers and provision of client-oriented extension services.

iii) Building capacity for public extension worker to coordinate and facilitate work of other players.

(b) Demand Driven Extension Services

Democracy has made Malawian farmers more enlightened about development issues including those affecting the agricultural sector. They have become aware of their rights to demand services from service providers. In addition, a diversity of demand is created through sensitization and exposure to available technologies on the market. The extension services therefore need to respond to farmer demands with consideration to their resource endowment. This requires categorization of farmers into food security, emerging commercial and commercial farmers. As such, there is need to encourage agricultural extension service providers to dialogue with farmers in order to support them with appropriate services so as to enhance learning.

(c) Accountability

A democratization process requires that farmers are not only looked upon as beneficiaries of extension but also as clients, sponsors and stakeholders. This calls for mechanisms for great accountability of extension services to farmers and their representatives to bring high quality and effective eservices. Where extension is of private interest, farmers must be given a chance to choose among extension deliverers especially when the farmers are the ones paying for the services. For public extension services, farmers should have a voice in the way extension services are planned, implemented and evaluated and this will be achieved through political decentralization and strengthening of farmer organization and inclusion of all stakeholders.

(d) Those who benefit pay (Service at cost)

It is not possible for government to provide all the extension services due to changes in macro and micro economic environment. Some extension services promote private interests while others promote public interests. Public funds must be used in the public interest and government must prioritise targets and budgets to extension services which promote national policy objectives of the environment management, poverty reduction and food security. The private sector and farmer organisations must be encouraged to mobilize private finance for extension services that promote private interest and can be done through commercialisation and privatisation of extension services where those who benefit pay for the services. In a case where the services are both in the private and public interest, cost sharing mechanisms could be explored.

(e) Equalisation

While encouraging private sector involvement in extension service delivery, the public sector must make sure that marginalized and vulnerable segments of the society such as women, youths and people with disabilities are not left out of the development process.

(f) Decentralized Services

In line with Malawi Decentralization Policy, Agricultural Extension Policy is implemented through the District Agriculture Extension Services System (DAESS). The DAESS is a mechanism for enabling farmers to identify and organize their agricultural felt needs for approprite action by relevant stakeholders. The system is integrated into the District Council structures through District and Area Stakeholder Panels and District Agriculture Extension Coordination Committee. The village is the entry, planning, and implementation base for all agricultural interventions.

Specific objectives of the DAESS include the following:

- To organize farmer's agricultural needs.
- To pool service providers and related resources in order to address prioritised farmer's agricultural needs.
- To instill sense of ownership and self reliance in agricultural programmes among farmers.
- To foster coordination among stakeholders in service provision.

Main Focal Areas of DAESS

The District Agricultural Extension Services System has four main areas of focus namely:

(i) Organisation of farmers demands:

This is a process of enabling farmers in their wealth categories to identify their agriculture felt needs.

(ii) Organising service provider's response to farmers needs:

This is a process of identifying and engaging service providers that would respond to farmers needs.

(iii) Stakeholders Coordination:

All the stakeholders will have to cooperate, coordinate and plan together at the district level for the system to be effective.

(iv) Funding acquisition:

The district council will have to find ways of financing agricultural extension services from a diverse base of sources. The assemblies have to explore sources of finances (see section on Financing of Services).

STRUCTURES OF THE DAESS

District Agricultural Extension Services System (DAESS)

DAESS platforms (Centre in Blue) are aligned to Ministries of Local Government (MoLG, Left in Grey) and supported by Ministry of Agriculture (MoA, Right in Green)

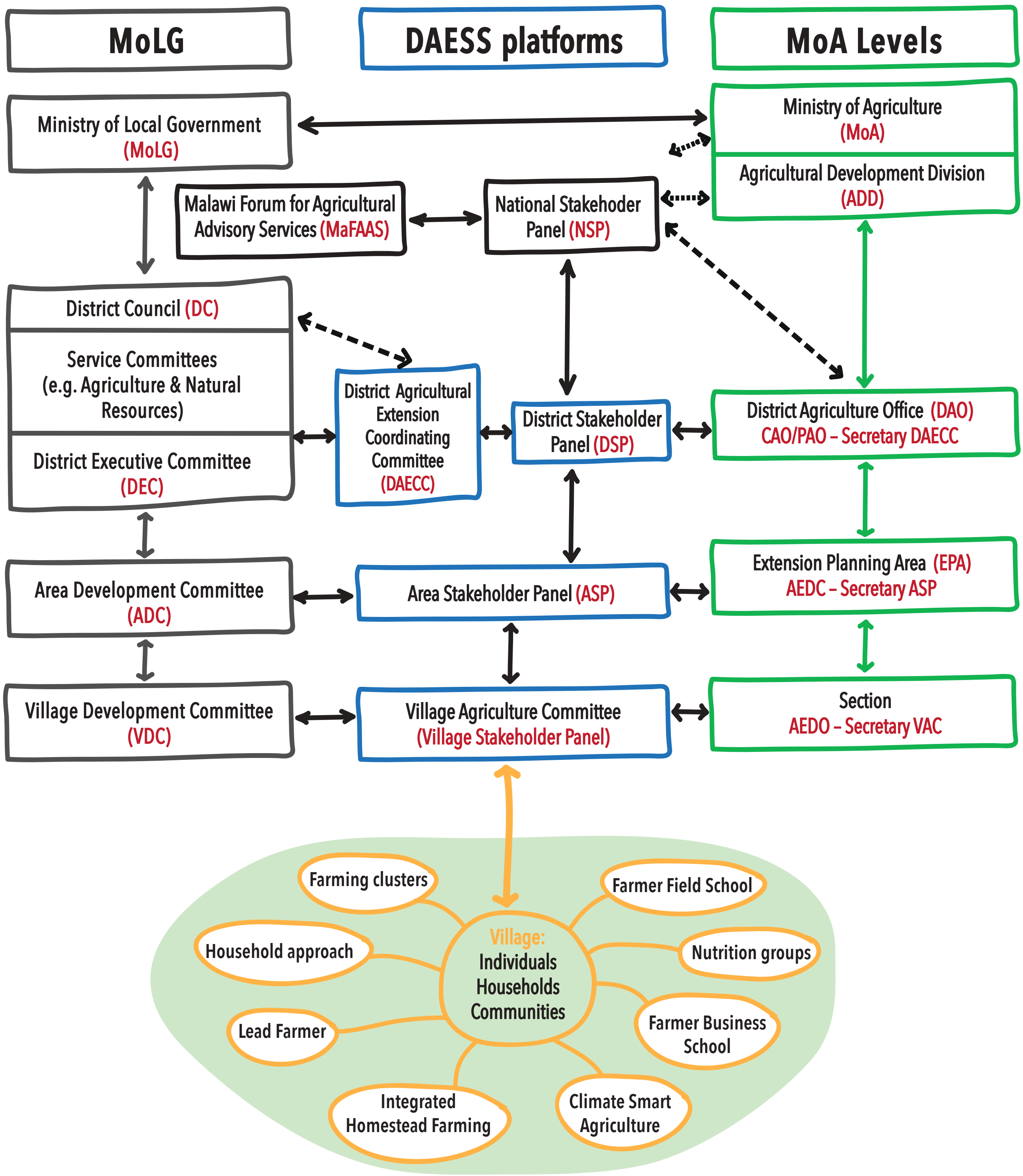


Fig. 23: The DAESS Structure

2.10.3. Extension Approaches

The Agricultural Extension Services use participatory approaches to ensure active involvement and inclusion of stakeholders and farmers of all gender categories in planning and implementation of agricultural interventions. Some of the participatory approaches used are:

(a) Model Village Approach

A Model Village is a village where subjects are committed to working together with various service providers to achieve their vision.

It has well defined development structures, with the village leadership and subjects that are receptive to harmonized integrated development interventions for improved rural livelihoods. The process of establishing a model village is known as the Model Village Approach.

Specific objectives of establishing a model village are to:

i) Empower communities/villages to be responsible for their development destiny.

ii) Improve capacity in production and market related activities.

iii) Improve management of natural resources for sustainable development.

(b) Agricultural Clusters and Ulimi wa M'ndandanda

An Agricultural Cluster is a collection of farmers managing similar agricultural enterprises in the same catchment area or locality. Ulimi wa M'ndandanda is a stretch of well managed fields of different crops.

The objective of establishing agricultural clusters and m'ndandanda is to demonstrate and promote proven technologies in strategic places which are visible and accessible on road sides and villages. Existing community structures such as Village Development Committees and Stakeholder Panels support implementation of agricultural clusters and ulimi wa m'ndandanda. The relationship with the model village is that the concepts are implemented using the village as the entry point learning and organizing base for promoting proven technologies for adoption by farmers of all gender categories. The process of establishing agricultural clusters and ulimi wa m'ndandanda is facilitated by agricultural extension workers and partners from the civil society and private sector. In addition, farmers who are good at specific technologies assist in promoting technologies and they are known as Lead Farmers.

(c) Farmer Field School

Farmer Field School is a participatory extension training methodology that centers on comparative application of both farmers' practices and recommended practices in addressing a technical problem. Farmers in Farmer Field Schools are guided to study in more detail what ought to be done for their production to improve in both quantity and quality. Farmer Field Schools facilitate adoption of technologies by participating farmers.

The process of establishing a Farmer Field School is as follows:

- Conduct baseline survey to identify gaps that exist. The gaps are the differences between farmers' practices on one hand and the recommended practices on the other.
- Data analysis
- Prioritization of gaps
- Development of training agenda for comparative studies from the prioritized gaps
- Documentation of experiences from the studies
- Dissemination and utilization of best-bet practices from the training experience

2.10.4. Strategies for reaching out to farmers

(a) Use of farmer groups

There are basically two approaches for reaching out to farmers with extension services: these are group and individual. The individual approach involves contacting farmers individually with extension services and messages. The group approach emphasizes provision of extension services through groups of farmers. In order to improve farmer coverage the group approach is advocated. The group approach improves learning adoption, ownership and sustainability of technologies.

Types of farmer groups

There are two types of groups used in extension. These are natural and special interest groups. Field extension workers use special interest groups and natural groups to improve coverage of extension services.

i) **Special Interest Groups:** these are groups that are formed with a specific objective. They usually originate from farmers who approach an extension worker or agency with an intention of gaining knowledge and skills on technologies that will help them to benefit in form of increased production, recognition or other types of benefits. Such groups include tobacco, poultry,irrigation, fish and conservation clubs.

ii) **Natural Groups:** these are existing groups in the society pursuing non-agricultural goals and values but can be used for extension purposes. Natural groups include church, village, dancing, youth and clans.

Extension workers are advised to mobilize as many groups as possible in their areas of operation. Field extension workers should possess knowledge and skills of mobilization, group dynamics, training, development, promotion and management in order to effectively mobilize groups.

(b) Lead Farmer

This is a form of a farmer to farmer extension approach. A Lead Farmer is described as a farmer who has mastered a specific technology and is willing to support fellow farmers in the learning and implementation of that particular technology. Agricultural Extension Workers facilitate identification of Lead Farmers in a community to ensure that he/she is accepted by fellow farmers in the community. He/she should be an innovator and model in his/her farming enterprises. Lead Farmers are motivated through training, study tours, recognition and receiving awards for good performance.

This is a participatory approach because farmers get actively involved in provision of extension and advisory services to fellow farmers and the practice provides an opportunity for them to frequently interact and share experiences with agricultural research and extension professionals.

c) Plant Health Clinics

Plant Health Clinic is an innovative platform where farmers take their diseased plants for identification and diagnosis of plant diseases and pest attacks. Importance of Plant Health Clinics are

- Farmers get advice on how to control pests and plant diseases and general information on crop production
- Easy monitoring of plant pest's outbreak and diseases

- Identification of new pests and diseases that have come to the area
- Collection points on pests and diseases data for policy makers and researchers

Plant Health Clinics are managed by extension workers who are trained as plant doctors. Farmer details like name, village, phone number, crops grown and history of the land where the diseased plant was collected is recorded for follow ups. Plant doctors get additional help on information to diagnonise diseases and pests from factsheets and research stations. Location of the clinic and dates for holding the clinic is done by the plant doctor in consultation with the surrounding farmers. At the plant clinic farmers are encouraged to follow good agricultural practices as a way of controlling pests and diseases. Use of chemicals to control pests and diseases is given as a last resort.

2.10.5. Agriculture Extension Methods

In order to increase awareness and adoption of technologies, use of different extension methods is encouraged by the Ministry of Agriculture, the methods include:

(a) Strategic Extension Campaigns

Strategic Extension Campaigns are intensive efforts to pass on a specific message to clients using multi- media channels within a specific period. The goal is to enable the clients change knowledge, attitude and practices. Strategic Extension campaigns need to be arranged annually throughout all Agricultural Development Divisions. They should depict new technologies and attract farmers to try them in their fields. Good campaigns should be based on the principles of development communication therefore they need proper planning and coordination before implementation.

(b) Demonstrations

A demonstration is a training methodology for an extension worker to impart knowledge and skills to the clientele. Demonstrations show how a task is performed. There are two types of demonstrations namely : Method and Result.

Method Demonstration shows participants how to perform a task. Result demonstrations show participants the effect of practicing a particular technology and emphasizes on why a particular technology should be adopted,

Harmonized Demonstrations are those demonstrations with at least 3 technologies which are compatible and are combined for maximum results. These demonstrations are used to address problems that farmers are facing in their farming and are identified in a participatory manner using the engendered Participatory Rural Appraisal toots. Departments and organizations collaborate with each other to come up with a comprehensive package of compatible technologies to be able to address farmer's problems in a holistic manner.

Demonstrations should be conducted by Extension Workers from time to time as way of influencing farmers to adopt modern techniques of farming. Demonstration should be conducted in an interactive or participatory manner to allow for maximum involvement of the clientele.

When carrying out a method demonstration, field staff should follow specific steps in logical sequence before requesting farmers to do the same. Later farmers should be involved in demonstrating the skills to the groups.

(c) Field days, visits and tours

Field days, visits and tours are important to raise awareness of new recommended practices and encouraging farmers to implement them in their own fields. They should be conducted on successful demonstrations and programmes for the benefits of participants and as a way of encouraging the implementers. These should be organized at village, section, district and ADD levels.

(d) Agricultural shows and exhibits

Agricultural shows and exhibits provide farmers, extension workers and stakeholders with an opportunity for interaction on different agricultural programmes and activities. This is important for farmer training and produce marketing. The aim of agriculture shows is to let farmers learn from each other, the production and processing of high quality agricultural products. Local leaders and farmers should participate in preparing and conducting the shows. All farmers should also be encouraged to participate, bring farm produce and learn from others. The organizer and farmers should be encouraged to observe the following aspects:-

i) Type of items for display

ii) selection of items for display

iii) acceptable qualities of items

iv) Uniformity of items

v) Originality of items for display

Agricultural shows and Exhibitions should be held annually in every district. During the agricultural shows and exhibitions, farmers are assisted by extension staff to explain how such items were produced. Ideally agricultural shows should be held from May to August when field crops are being harvested and most vegetables and fruits are available. Both crop and livestock products should be presented in balanced levels at the agricultural shows. Each farmer should be free to bring items, which have been produced or processed at his or her farm. Items that have been purchased should not be allowed to be presented at the display. Items from one agricultural show should not be presented at other shows. If identified at other shows, the items must be disqualified.

There should be some guidelines for judges to follow in determining the quality of displays. Field staff should inform exhibitors before the items are presented for viewing and explain that the main purpose of the show is for them to learn. Prizes are given as an incentive in appreciation for quality items.

2.10.6. Extension Message Development and Communication

Limited knowledge and skills among farmers and frontline extension workers is a challenge in the agriculture sector. This is addressed through regular training of front line extension workers. Development of technical extension message is the prerequisite for farmer and extension staff training. Subject Matter Specialists (SMS) in technical departments of the Ministry of Agriculture facilitate message development in different aspects of agricultural production and development.

The process of message development includes the following steps:

- Situation analysis
- Prioritizing issues
- Identifying themes
- Developing communication objectives
- Deciding channels
- Writing technical messages
- Pre-testing the draft messages
- Refinement of the message by incorporating comments and observations following pre-testing
- Replication of the messages after refining

In order to increase awareness on technologies and adoption levels, a multimedia approach to Message dissemination is advocated. These include mobile van campaigns, demonstrations, field days, exhibits, shows, visits, tours, radio, agricultural fairs, leaflets, posters, newsletters, magazines and television.

2.10.7. Extension training

Planning and conducting training is an important part of extension programme. Staff and farmers' courses are conducted in order to impart new knowledge and skills and change of attitude.

Farmer training should be well planned and scheduled to start in farmer groups, EPA or day training and Residential Training Centers.

Farmer training in the field should be a continuous process going on according to the extension workers programme and scheduled as agreed with farmers in a participatory manner.

EPA training should comprise day courses held at the EPA headquarters with farmers operating from their homes. These should be undertaken in circumstances where the contents can not be covered at field or village level.

Residential Training Center (RTC) courses should be offered at the centers where farmers can be accommodated for a period as determined by the course content. These courses should be designed with more facilities for practical training.

To avoid duplication of efforts, courses at training centers should deal with subjects that cannot be adequately dealt with at community level or farmers' fields due to lack of appropriate facilities, equipment or materials. Women farmers should be encouraged and given increased access to attend agricultural training, Staff training is also a very important component for effective delivery of services. Staff need periodic training in order to be updated. These can also vary from day to long term training done within the country or offshore.

2.10.8. Agriculture Communication Services

Agriculture communication services are provided by professionals who are trained to strategically produce, package and disseminate messages and information using different formats and mediums. Easy access to information by farmers and stakeholders have a positive impact on agriculture production.

Goal

To contribute change in attitude, knowledge and practices on recommended agriculture technologies and successful innovations to enhance their adoption for increased agricultural productivity.

Objective

To increase farmer's, extension worker's, all staff in the ministry of Agriculture and agriculture stakeholder's access to agriculture information and knowledge.

Strategies

Communication Branch (ACB), uses multiple communication strategies including multimedia campaigns, and technical message development and dissemination. To widen the reach of agriculture extension services, the ACB integrates Information Communication Technology in information dissemination.

i. Multimedia campaigns

The strategy uses a combination of communication tools, technics and communication channels to reach as many people as possible. Agriculture messages packaged in different formats are disseminated to the audience using different media channels. These messages could be a combination of print publications, audio, images, animation and video.

ii. Technical Message Development

To accelerate agricultural productivity and to enhance adoption of recommended agricultural practices, the ministry, through the ACB, develops and disseminates agriculture technical messages on various enterprises. The ACB works hand in hand with farmers and subject matter specialists to identify information gaps in farming communities. The branch then works hand in hand with agriculture scientists who are responsible for releasing technologies that are designed to solve farmers' problem. The technologies are simplified into easily understandable messages which are packaged and are disseminated to farmers through various media formats such as publications, radio programs and videos.

The following steps are followed when developing a technical message:

- Situation analysis
- Prioritizing issues
- Identifying themes
- Developing communication objectives
- Deciding channels
- Writing technical messages
- Pre-testing the draft messages
- Refinement of the message by incorporating comments and observations following pretesting
- Mass production (optional)
- Dissemination

iii. Information Communication Technology in Information Dissemination

Information communication technology refers to communication devices or applications that capture, transmit and display information electronically such as radio, television, mobile phones, computers and network hardware and software.

Integrating Information Communication Technology in information dissemination positively contributes to agriculture productivity as it offers a wide range of solutions to challenges such as the increasing population of farmers which has resulted in an increased demand for advisory services.

Traditional forms of ICTs such as radio, television and mobile unit and new ICTs such as mobile phones and the internet are used to disseminate information and messages to farmers and stakeholders.

Using these ICTs increases farmers' and stakeholder's access to agricultural information and advisory services, leading to increased production.

Some ICT based channels such as the mobile phone allows target audience participation and involvement. It is easy for farmers and other stakeholders to provide feedback on topics through text message.

Below are some of the ICT tools that are used to disseminate agriculture information;

Radio

Agricultural radio programmes are produced in different languages and aired on Public, Private and Community radio stations.

The main radio programmes that are produced by the Ministry of Agriculture are "Ulimi wa Lero" and "Zokomera Alimi". Other radio programmes are produced in partnership with other stakeholders. These radio programmes also offer entertainment and general information such as market prices.

In Malawi, radio has a wide reach which makes it one of the ideal channels for disseminating agriculture information and messages. To maximise the efficiency of radio, interaction and participation from listeners is encouraged. This is done by using the mobile phone as a channel for feedback. Listeners are able to send text messages to a given number in response to a program that was aired. This feedback is referred back to subject matter specialists and addressed in subsequent programmes.

Radio program schedules are formulated and distributed to guide farmers. Extension workers should encourage farmers to listen to radio programs through radio listening clubs or as individuals.

Television

Television is a powerful and empowering tool that raises awareness, generate discussion and increase knowledge amongst farmers and stakeholders. It is an important channel for advocacy, for drawing policy makers' attention to issues in agriculture sector.

For farmers, television is effective because it not only 'tells' but 'shows' them. This makes the adoption of new technologies very easy.

Agricultural television programmes and videos are produced on issues of strategic importance in the agriculture sector and these are broadcast on public and private TV stations. Some of the examples of programmes that are featured on TV stations are "Patsogolo ndi Ulimi," and "Tisanthule za Ulimi". However, both private and public television stations produce and broadcast programmes to address farmers' needs.

Videos on specific issues are also shown to farming communities using the mobile Unit. Extension workers may use the video films to supplement and reinforce a point in order to enhance knowledge.

Mobile Unit Services

A mobile unit is a set of equipment consisting of a mobile van, puppets, a Public Address system and a television set. This equipment is used to show agricultural videos to farming communities, puppet theatre and mobilise farmers for important events.

The mobile unit is one of the most effective tools for technology transfer because the same message is shared to the same audience in different formats, through word of mouth, videos and publications. These various channels reinforce each other and combining them allows those farmers who cannot use a particular channel due to reasons such as illiteracy to get the message through the other channels.

The mobile unit services are available at DAES headquarters and in all ADDs (Management Unit).

The role of Extension staff is to process the film/puppet show in order to ensure that farmers understand the message. Extension staff should encourage farmers to attend and participate in mobile unit programmes.

Print

The Ministry, through the ACB, publishes books, leaflets, brochures, posters magazines, flyers, newsletters and other publications on various agricultural technologies aimed at informing and educating farmers and other stakeholders in the agriculture sector.

Print media is an effective tool used in dissemination of agricultural information because they are kept and used as reference material by farmers and other stakeholders when need arises. Certain publications, such as books, offer enough space for a thorough explanation and illustrations and pictures. These make it easy for the target audience to understand the message.

One of the publications that are produced by the Ministry of Agriculture is the bi-monthly "ZaAchikumbi" Magazine.

Most of the publications produced by the Ministry are distributed for free to farmers. Farmers are encouraged to read these publications to increase their knowledge in agriculture.

Mobile Phone

Widespread use of mobile phones amongst farmers and other agricultural stakeholders has created a good platform for information dissemination.

Agricultural tips are easily accessed by extension staff, farmers and partners through SMS.

To effectively access the information, farmers are required to register into the system including the enterprise they are implementing.

Lead farmers should be encouraged to record the messages received in a note book for sharing and reference. Information sharing is done during field days and local village meetings.

Farmers are encouraged to check with extension workers on the clarity of messages. To maintain flow of messages, farmers are encouraged to notify their extension workers whenever they change their phone numbers.

Mobile phones are also used in combination with other ICT tools such as radio and Television to increase listener participation. Farmers use mobile phones to send feedback on radio or television programs that have been aired. Farmers also access agricultural information through other ICT based platforms established by the private sector.

2.11. Gender HIV and AIDS in Agriculture and Natural Resources Management

Gender disparities in Agriculture and Fisheries sectors have emerged as serious constraints to the achievement of agricultural development objectives in Malawi. Gender disparities exist in roles performed by men and women, boys and girls in agriculture and also in the way the different gender groups' access and have control over agricultural resources and benefits. HIV on the other hand has exacerbated existing agricultural development challenges and weakened the institutions that are key in rural development.

2.11.1. Overall objective:

The overall objective is to reduce existing gender disparities, further spread of HIV and mitigate the impacts of AIDS at workplace, household and community level. This is achieved through mainstreaming of gender, and HIV issues in all programs and projects at all levels.

2.11.2. Specific objectives

- To promote quality participation of all gender groups in planning, implementation, monitoring and evaluation of all agricultural programs and projects.
- To promote mainstreaming of gender and HIV issues and interventions in Agricultural Programs and Projects in farming communities and workplaces.
- To facilitate establishment of Income Generating and Special projects for all gender groups in order to reduce gender disparities and empower them socially and economically.

2.11.3. Strategies

In order to address gender and HIV issues in agriculture and fisheries sectors, the following strategies are used:

- Review and develop gender and HIV responsive policies and strategies.
- Build capacity of agriculture sector staff and farmers in gender and HIV mainstreaming in programs and projects through use of engendered participatory tools and household methodologies
- Mainstream gender and HIV in agricultural programmes and projects at community and the workplace
- Promote Income Generating and Special Projects (IGSP) for vulnerable groups.
- Promote gender and HIV responsive monitoring and evaluation.

2.11.4. Gender groups

The agriculture sector comprises various gender groups. These include men, women, boys, girls, male and female youths, elderly, persons with disabilities and people living with HIV.

2.11.5. Links between Gender, HIV and AIDS

It is well recognized that there are strong links between Gender, HIV and AIDS. This is illustrated below.

- Women have limited opportunities for wealth, capital creation and livelihood improvement compared to men, which predisposes them to risky behaviours and HIV infection.
- Deaths of husbands often leave women and children without or with very few assets that predisposes them to high-risk behaviour such as exchanging sex for money, food, and clothes as a means of survival.
- Greater burden of care for AIDS patients is provided by women and girls than men and boys.

- Low income resulting from limited opportunities for wealth and capital creation among women and female youths predisposes them to risky behaviour and HIV infection and limits their livelihood improvement.
- Abrupt change of gender in the event of death of spouse or both dying from AIDS. The vulnerable household heads (Female, Male, Elderly, Child) are ill prepared in handling both productive and reproductive roles.
- There are gender disparities in the way men and women have access to and control over resources asserts and benefits which makes women and girls to be more vulnerable to HIV.

2.11.6. Some Gender, HIV and AIDS Concepts and Terminologies

The following are some important concepts and terminologies often used in gender, and agriculture discourse.

2.11.6.1. Gender

Gender is the socially and culturally constructed roles, responsibilities, privileges, opportunities, power relations, status and expectations ascribed to men women, boys and girls. Gender relations are dynamic, changeable and can vary from culture to culture or place to place.

Sex	Gender
Biological	Cultural
↓	↓
Given by birth	Learned through socialization
↓	↓
Universal	Varies from culture to culture
↓	↓
Therefore **cannot** be changed	Therefore can be changed
Men cannot perform functions that are biologically female, and women cannot perform functions that are biologically male.	Both men and women **can** do or perform equally well in positions and jobs traditionally referred to as women's or men's, given the chance and right environment.

Fig. 24: Differences between sex and gender

2.11.6.1.1. Differences between gender and sex

Gender is often confused to mean **sex**. However the terms **"gender"** and **"sex"** do not refer to the same thing. As defined by the World Health Organization: **"Sex"** – refers to the **biological** and **physiological** characteristics that define males and females. As indicated above, there are fundamental differences between sex and gender. These are illustrated in the following diagram:

2.11.6.2. Gender roles

Refers to "behaviors, tasks and responsibilities that a society considers appropriate for men, women, boys and girls". Culture defines roles and responsibilities to which women and men are socialized to conform. For example, in Chikhwawa it is the role of men to cut grass while in Mzimba this is done by women. Gender roles are also affected by age, class, religion, ethnicity and historic trends, technology, economy, HIV and AIDS, education, and political environment.

The gender roles are categorized into productive, reproductive and community roles.

2.11.6.2.1. Productive roles

These are roles or work that aims at production of goods and services for consumption and trade. This is normally paid work or results in generation of income. Examples are farming and fishing.

Realities of productive work

Women and men perform some different functions and responsibilities due to the gender division of labour. However the women's productive work is often less visible and less valued than men's.

2.11.6.2.2. Reproductive work

These are roles or work that aims at caring and maintenance of the household. The reproductive work contributes to the welfare of individuals, and to the productive activities. Analysis has shown that reproductive work is largely done by females and is rarely mechanized and is usually unpaid work. Examples are cooking, washing dishes, fetching water, constructing a bath shed, making hoe handles, sweeping and caring for children.

Realities of reproductive work

Ignoring reproductive work assumes that women's labour is available in an unlimited manner and its supply is elastic.

2.11.6.2.3. Community roles

These are roles or work that aims at addressing the collective organization of social events and services. Examples include ceremonies and celebrations, participation in groups, organizations and community development activities.

Realities of community work

Both women and men engage in community activities, although a gender division of labour also prevails. This work however is rarely considered in economic analysis of communities. It involves considerable amount of volunteer time and is important for the spiritual and cultural development of communities as well as a vehicle for community organization and self-determination.

2.11.6.3. Gender Issue

It refers to inequality or unfair treatment felt by one gender category in that their needs are not being met. Some examples of gender issues prevailing in agriculture sector are; limited access, ownership and control of assets and benefits by women farmers, limited access to information and technology by women farmers and limited participation of women in agricultural decision-making.

2.11.6.4. Gender Concerns

These are inequalities or unfair treatment which arises from different situations due to one's sex and the one affected does not recognize it as a problem or talk about it.

2.11.6.5. Gender disparity

It refers to the quantitative or qualitative differences between women and men, boys and girls in terms of participation, access to and control over resources and benefits. It is a measure of gender inequality on any social economic indicator like income levels, training and technology adoption.

2.11.6.6. Gender Blindness

It refers to lack of recognition of the different needs of women and men, boys and girls in planning, implementation, monitoring and evaluation of policies, programmes and projects.

2.11.6.7. Gender Bias

It means favouring one gender category over/against the other in terms of decisions, actions, policies and strategies.

2.11.6.8. Gender Stereotype

It refers to accepted beliefs, negative or positive altitudes and perceptions of males and females, which are generally accepted as true based on socially constructed norms. For example, the saying "Mphongo ya chiwala siichepa (a man is never young)" is a positive stereotype for masculinity; "A woman's place is in the kitchen" is a negative stereotype against women.

2.11.6.9. Gender Discrimination

It refers to prejudiced or favored treatment of an individual based on gender based accepted beliefs, negative or positive attitudes and perceptions.

2.11.6. 10. Gender Analysis

Is a systematic way of assessing the extent to which different social or gender groups are involved or included in development initiatives or how the development agenda impacts on them in order to identify the related issues.

It focuses on the following aspects;

- Division of labour between men and women, boys and girls.
- Different needs of men and women, boys and girls.
- Sex based division of access to and control over resources and benefits.
- Opportunities and constraints in development for men, women, boys and girls.

2.11.6.11. Gender disaggregated data

Refers to both quantitative and qualitative information that depict the situation of the various gender categories in a development agenda or society.

2.11.6.12. Gender Balance

It refers to equal representation and power in decision making of men, women, boys and girls in any intervention or development agenda.

2.11.6.13. Practical Gender Needs

These are short term needs of the various gender categories arising from gender roles. They are immediate and material in nature and address basic or welfare requirements for example food, water and health services. It changes the condition of the situation for the affected gender category(ies).

2.11.6.14. Strategic Gender Needs (SGN)

These are long term needs of the various gender categories, which help in changing or improving their positions in a society. SGN can be addressed by consciousness raising, creating self confidence, education and mobilization.

2.11.6.15. Gender Empowerment

The process of building capacities to enable women, men, boys and girls, to exercise control over their own lives. It gives ability to an individual to gain self-confidence and take control of one's life for example the provision of education and training.

2.11.6.16. Gender equity

Means being fair, socially just and impartial through fair distribution of resources and benefits. It is a step towards achieving gender equality.

2.11.6.17. Gender Equality

Refers to having the same status, rights and responsibilities for men and women boys and girls. In this case no individual should be less privileged in opportunities and rights. Underlying causes of discrimination should be identified and removed.

2.11.6.18. Stigma

Refers to a process that goes on inside an individual through which a negative social label of disgrace, shame, prejudice or rejection is attached to self or a person hence it cannot be seen. Stigmatization of a person living with HIV or AIDS means that they are discredited, branded unworthy, reduced in value in peoples' eyes and also in their own eyes.

2.11.6.18.1. Types of stigma

Internal stigma

This is having a feeling of shame, self-doubt, guilt and self blame which can lead to depression and withdrawal. This is manifested through; denial (refusing to accept one's status), self-exclusion (refusal to use services), over compensation (exaggerated behavior to lessen stigma or compensate for illness), revenge anger (wish to harm others) and social withdraw to protect self from discrimination.

Received stigma

This is manifested through behavior that shows fear of contagion through neglect, gossiping, rejection, blaming, abusing and avoiding.

Associated stigma

This target partners, friends, family and health workers. For example, nurses who care for HIV or AIDS patients are called names because they are believed to have the virus.

2.11.6.19. Discrimination

This is arbitrary action against affected persons through restriction, exclusions and denial. For example an infected person being denied to use the same hoe or join a group because of his or her status.

2.11.7. Impact of Gender Disparities on Agriculture

Ultimate goal of Agricultural and Fisheries Programs and Projects is mostly human (people) development through increased food security, improved nutrition status, increased incomes and improved environmental sustainability. However, perpetuating gender disparities or inequalities leads to underachievement on the expected outcomes. Specific impacts of gender disparities on agriculture are as follows:

- Unequal power relations reduces agricultural productivity, food security and income where women have limited access to and control over production resources, farming decisions, markets, wealth creating opportunities and benefits from production and yet they contribute 70% of the agricultural labor.
- Overburdening of women with triple roles (productive, reproductive and community) affect timeliness in implementing some agricultural operations.
- Inadequate knowledge and skills especially for women farmers on recommended production technologies and marketing reduces agricultural productivity and economic empowerment.

2.11.8. Impact of HIV and AIDS on Agriculture

In Agriculture and Fisheries Institutions/ Workplaces, HIV and AIDS pandemic has increased absenteeism and mortality, contributed to the loss of institutional memory and job specific knowledge and skills. Staff members get frequently absent from work because they are sick, caring for the sick relatives or attending funerals. The increased morbidity and mortality reduces efficiency at the work- place and increases vacancies.

In the smallholder and commercial agriculture, HIV and AIDS negatively affects the quality and supply of labour, access to food and income, productivity of farmers and household demographics. This has the following outcomes:

Decreased agricultural productivity which results in food insecurity

Labour shortages contribute to reduction in Agricultural productivity as a result of weak and poor physical condition of the infected. Increased deaths and time spent nursing the sick and visiting the AIDS victims in homes and hospitals also affects labour supply. This results in low agricultural production, and consequential food insecurity.

Reduced income, household assets and social support

A household with a person or persons living with HIV and AIDS opt for less labour demanding crops such as cassava and sweet potatoes at the expense of labour intensive and high cash value crops such as cotton and tobacco.

Livestock, food crops and household assets are sold in order to meet the hospital and funeral expenses instead of investing in agriculture. The increased funeral expenses and illness drain farm resources.

Malnutrition

Food insecurity and limited production of cash crops results in families eating inadequate and non-nutritious foods.

Change in livelihood strategy

Agricultural production is negatively affected through the shift in attention from agricultural activities to other livelihood strategies.

2.11.9. Gender, HIV and AIDS Mainstreaming

Gender, HIV mainstreaming is a process of assessing gender, HIV issues and concerns and integrating them in the design, implementation, monitoring and evaluation of policies, programs, projects, and budgets. HIV and AIDS mainstreaming is a process of identifying the causes and effects of HIV and AIDS at work places, community and household levels and addressing them in an effective and sustainable manner.

2.11.10. Process for Mainstreaming Gender, HIV in Agricultural Policies, Programs and Projects

The process for mainstreaming Gender, HIV in Policies, Programs and Projects at all levels is the same. The following are the steps;

(a) Identification of Issue and Concerns

Identification of Gender and HIV issues and concerns with the various gender groups at the work place, community and household levels in collaboration with relevant stakeholders and partners.

The identification is done by using selected gender, HIV and AIDS responsive participatory appraisal tools like River Code, the Harvard analytical frame- work, Seasonal Calendar, Vision Journey, HIV and AIDS timeline and the Gender Balance tree amongst others. Secondary gender disaggregated data from relevant stakeholders could also be analyzed to identify the issues. It is essential that all gender groups and partners should express and prioritize the issues and concerns affecting them.

(b) Internalization

This step helps various gender groups to own the issues and concerns. Climate setters and tools in form of role plays, case studies, drama and focus group discussions which reflect real life situation or experiences will facilitate this process.

(c) Integration

This means packaging of interventions to address gender, HIV and AIDS issues and concerns in the core business/subject matter with quality participation of all gender groups. This ensures that the policies, programs and projects interventions also address the gender, HIV and AIDS issues. The resulting strategies and actions are translated into a gender, HIV and AIDS responsive action plan or work plan.

The objectives, outputs, activities and indicators in the action or work plans should be phrased in a gender and HIV responsive manner.

The interventions should be accompanied with relevant Information, Education and Communication (IEC) materials.

(d) Institutionalization

It entails setting up mechanisms that will ensure that gender, HIV and AIDS is mainstreamed in policies, programs and projects at work places, communities and households. It is achieved through capacity building; organizing and strengthening support structures such as: Gender, HIV and AIDS committees, Coordinating offices (Desk Officers and Focal Points) to support the mainstreaming. Diagrammatically the mainstreaming process is depicted as follows:

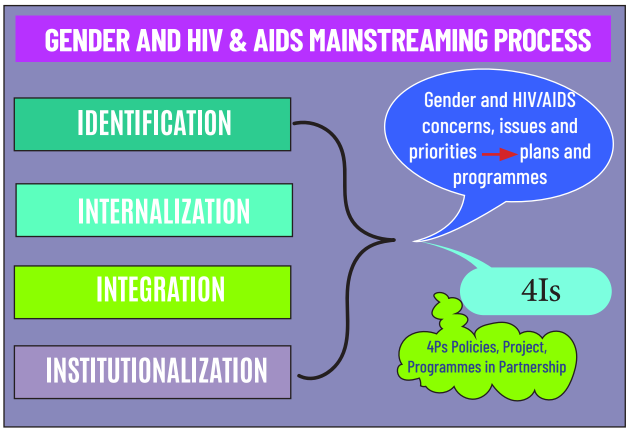


Fig. 25: Gender, HIV and AIDS Mainstreaming

2.11.11. Importance of Gender and HIV Mainstreaming

- To enable policies address the needs of the various gender groups in order to foster equitable development
- To reduce gender disparities for men, women, boys and girls' participation in agriculture interventions.
- To reduce gender disparities in access to and control over agricultural resources and benefits.
- To assist programmes and projects not to perpetuate or introduce gender disparities.
- To prevent HIV infections for men, women, boys and girls involved in agriculture
- To minimize the effects and impacts of HIV and AIDS on men, women, boys and girls or affected households in programs and projects.
- To ensure proper and focused targeting of programs and activities according to the existing gender disparities, effects and impacts of HIV and AIDS.

Characteristics of Gender, HIV And AIDS Responsive Project And Programme

- Activities are analyzed from a Gender, HIV and AIDS perspective.
- Data is disaggregated by Gender
- Gender, HIV and AIDS analysis of a project or programme is done on a routine basis and the project or program is adjusted according to findings.
- Projects and programmes are continuously monitored for impact on Gender, HIV and AIDS.

2.11.12. The Household Approach

The Household Approach is an extension methodology that promotes power relations among adult and youth household members in order to promote equitable access to and control over resources, assets and benefits. It also enables household members to identify and address HIV issues which results in improved livelihood of all household members.

2.11.12.1. Process of implementing the Household Approach

The household approach is implemented following a set of steps described below:

Step 1: Training of extension workers and subject matter specialists

The training is aimed at building the capacity of staff in the implementation of the approach. The training covers overview of the approach, tools for identifying household issues, challenges and opportunities, monitoring and evaluation and record keeping.

Step 2: Awareness meetings

This involves raising awareness about the approach to service providers and local leaders

Step 3: Identification of special interest groups

This involves identification of group of farmers to participate in the Household Approach. The interest group consists of a group of farmers engaged in a similar agricultural enterprise.

Step 4: Awareness meetings for farmers

This involves creating awareness about the approach within the interest group.

Step 5: Identification of local facilitators

This involves selection of local facilitators from the interest groups who interface with individual households implementing the approach.

Step 6: Orientation of local facilitators

This involves orienting the local facilitators about the approach. At this step the local facilitators also selects peer households to work with.

Step 7: Orientation of selected peer households

Orientation of peer households is done by the local facilitators with support from the extension worker. This also includes development of meeting schedules with the participating households.

Step 8: Training of local facilitators

The local facilitators are trained on the implementation of the approach. The training covers basic data collection, orientation on the tool used to identify household gender and HIV issues, action planning and monitoring and evaluation.

Step 9: Collection of baseline data

Baseline data is collected after orienting the household on the approach and developing a working schedule. Baseline data provides information on the status of the household situation before participating in the Household Approach.

Step 10: Vision setting

The extension worker and local facilitators should facilitate setting up of household vision using "vision tool."

Step 11: Identification of issues at household level

This involves the identification of household gender, HIV issues using Gender, HIV responsive tools such as the Gender Balance tree, and HIV timeline.

Step 12: Consolidation and prioritization of issues for action planning

This involves consolidation of issues identified at step 11 above.

Step 13: Household action planning

This involves development of a household action plan using the gender, HIV responsive action planning tool. The action plan includes activities addressing priority enterprises, needs and problems as derived from needs assessment.

Some examples of Gender, HIV Responsive Participatory Appraisal Tools for identification of issues

1. VISION JOURNEY

What is a Vision?

- It is an articulation of a desirable future state that is better and successful than the present towards which an individual/Household/ group/community should aim.

Objectives of Visioning

- To help individuals/household/group/ community articulate their visions of what constitutes a 'happy life'
- To identify similarities and differences in visions of women, men, male and female youths.
- To build consensus on the different aspirations for individuals
- To help individuals/household/group/ community to produce a plan that will help them work towards their vision
- To instill ownership by individuals/ household/group/community of the desired change processes from the start
- To introduce and reinforce a culture of planning, tracking, reflexive learning and participation of individuals/household/ group/community

Steps in developing a Vision road/ journey

There are five steps in developing a vision. These are;

Step 1. Drawing First circle - Current Situation
Step 2. Drawing of the Second Circle – Future
Step 3. Listing Opportunities and Constraints
Step 4. Developing Milestones and Targets
Step 5. Developing Proposed Actions

Step 1. Drawing First circle - Current Situation

Draw a large circle at the bottom left hand corner of the notebook page or flipchart. This represents the current situation. With the aid of drawings write the current situation focusing on the assets and property that you have this may include the status of house, farm enterprises, household assets, farm equipment, education and other things that might be available at the homestead.

Step 2. Drawing of the Second Circle – Future

- Draw a large circle at the top right hand corner of a notebook page or flipchart
- With the aid of drawings write your desired future situation focusing on the assets and property that you aspire to have
- This may include the status of houses, farm enterprises, household assets, farm equipment, education and other things that might be available at the homestead
- This represents the future
- It is a large circle at the top because it is like a sun and you are reaching for the sky.
- It is a vision which will inspire households to pick themselves up, and continue to move forward even if they fall and stumble on the rocks along the road
- Draw two straight lines to link both circles representing your road from the current (bottom) to the future (top)
- The road is straight and upwards, because this is how you hope you will reach up to your vision.

Step 3. Listing Opportunities and Constraints

- On the upper side of the road, list opportunities that will help individuals and households to achieve their vision
- Opportunities are a set of activities or circumstances that make it possible to achieve your aspirations or needs.
- The more opportunities individuals can think of, the easier it will be to advance and achieve their goals.
- On the lower side of the road, list constraints that can make individuals and households fail or limit them to achieve their vision.
- It is important to foresee and avoid them if possible.
- The opportunities and constraints which are under their control should be written near the road.
- The ones they cannot control should be written further from the road.

Step 4. Developing Milestones and Targets

- Every journey starts with small steps.
- The vision is a long term dream and within the journey one is supposed to set milestones and target that show progress towards attainment of the set vision. These milestones can be set for a year or for some years.
- The individuals and households need to plan realistically how they are going to move within the existing opportunities and constraints.
- Let individuals and household draw a circle after the current situation and indicate the milestones that will enable them move towards the vision.
- In the same way draw two additional circles at key points where you expect to have something to show as measurable milestones along the road with the final circle touching the vision circle.
- Individual and households should leave space in between the milestones where they will indicate the actions.

Developing Proposed Actions

- In between each milestone indicate the actions needed to move from one to the next
- Revise the milestones and target if necessary
- Individual and households can use this vision journey to track their progress over time, and adjust where necessary

Outputs of the visioning exercise

- Individual and household vision journeys with milestones and actions for the next 36 months in a notebook and flipchart.
- These are tracked during periodic review meetings.

Tips for the facilitator

- Make sure you have good samples of vision journeys from previous exercises to serve as an example to the participants where necessary
- Familiarize yourself with the tool by drawing your individual or household vision journey
- Continually observe principles of inclusion, equity and respect right from the start
- It is important not to impose anything at this stage but inspire people to think of a better future including improved relationships. *An example of Vision Journey is shown next page:*

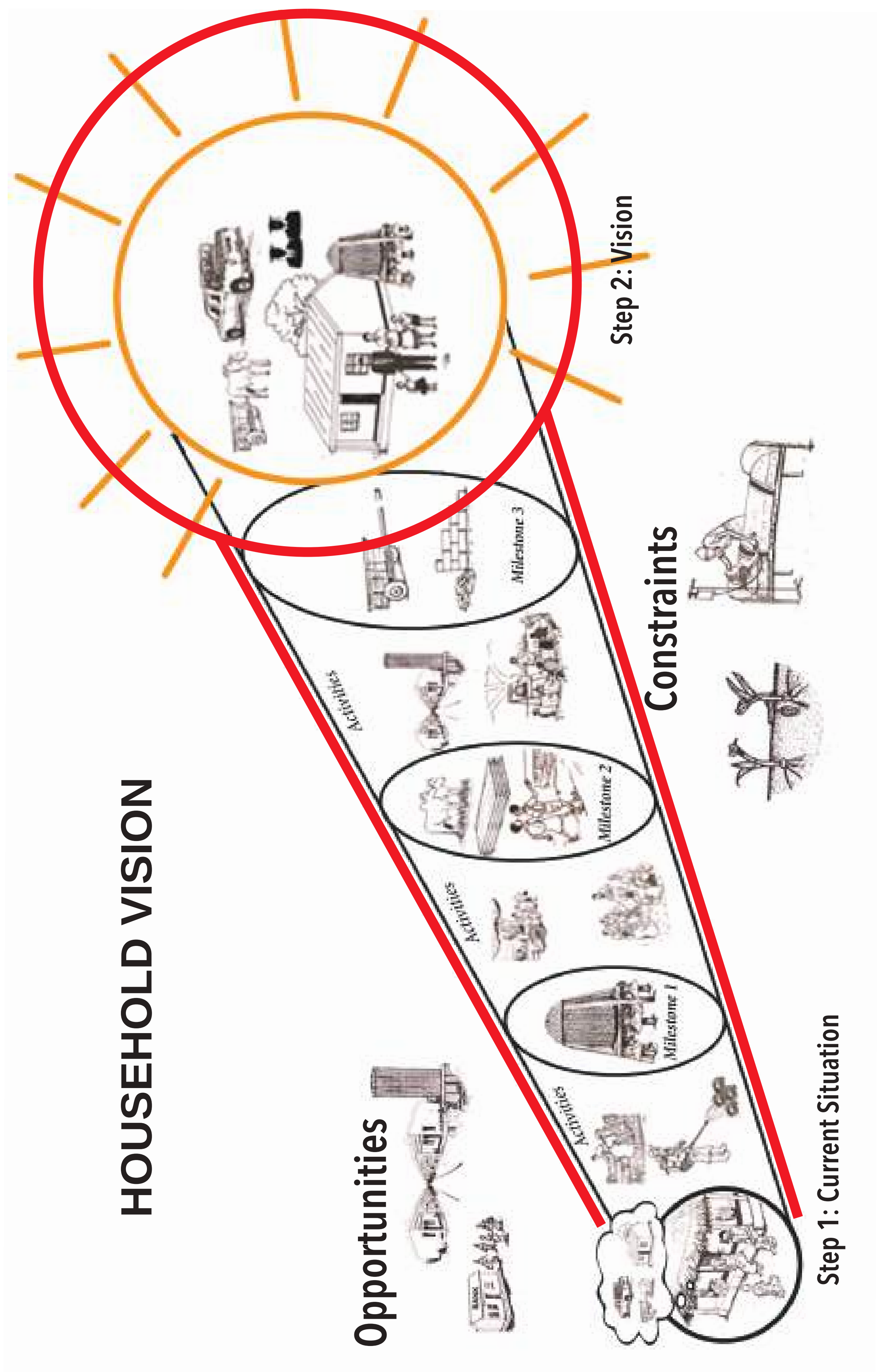


Fig. 26: Diagram of household vision

2. HIV TIME LINE

HIV timeline is a diagrammatic representation of the significant changes of HIV as it progresses from infection to the period after death if no medical attention is sought. The purpose of the tool is to enable identification of the effects and impacts of HIV on the various gender categories as it progresses from infection to time after death and also assists in the development of related interventions for each phase in order to address the situation. The timeline is presented as follows and is also simulated to a river coarse:

HIV PHASES

HIV negative

When a person is not infected by the virus. This is only verified through HIV Testing. This requires addressing the predisposing factors in the interventions.

Infection

The initial contraction of the HIV: e.g. through contact with HIV contaminated blood or other body fluids. This stage is very risky for the spread of the virus because an infected person can pass on the virus to others without their knowledge. Good nutrition through agricultural enterprise and dietary diversification and medical treatment can slow down the rate at which HIV weakens the immune system.

Asymptomatic period

Is a period when HIV infected person is showing no apparent signs or symptoms of the disease.

Symptomatic period

When an HIV infected person is showing the symptoms and signs of being infected with HIV because HIV is damaging the immune system such as unintentional weight loss of 10 kilograms in a month. The person may get opportunistic infections which arise due to severely damaged and weakened immune system e.g chronic diarrhoea, pulmonary Tuberculosis.

Death:

When the HIV person passes on due to opportunistic infections. There are diseases that arise due to weak immune system of an HIV positive person such as chronic diarrhea, extra pulmonary Tuberculosis and Kaposi's sarcoma. At this point the immune system is severely damaged and weakened and cannot cope.

Impact on bereavement:

These include orphanage, loss of labour, knowledge and skills, reduced production and income. In some cases, there is loss of property as a result of property grabbing. This requires interventions that will address the issues including the predisposing factors.

THE HIV TIMELINE

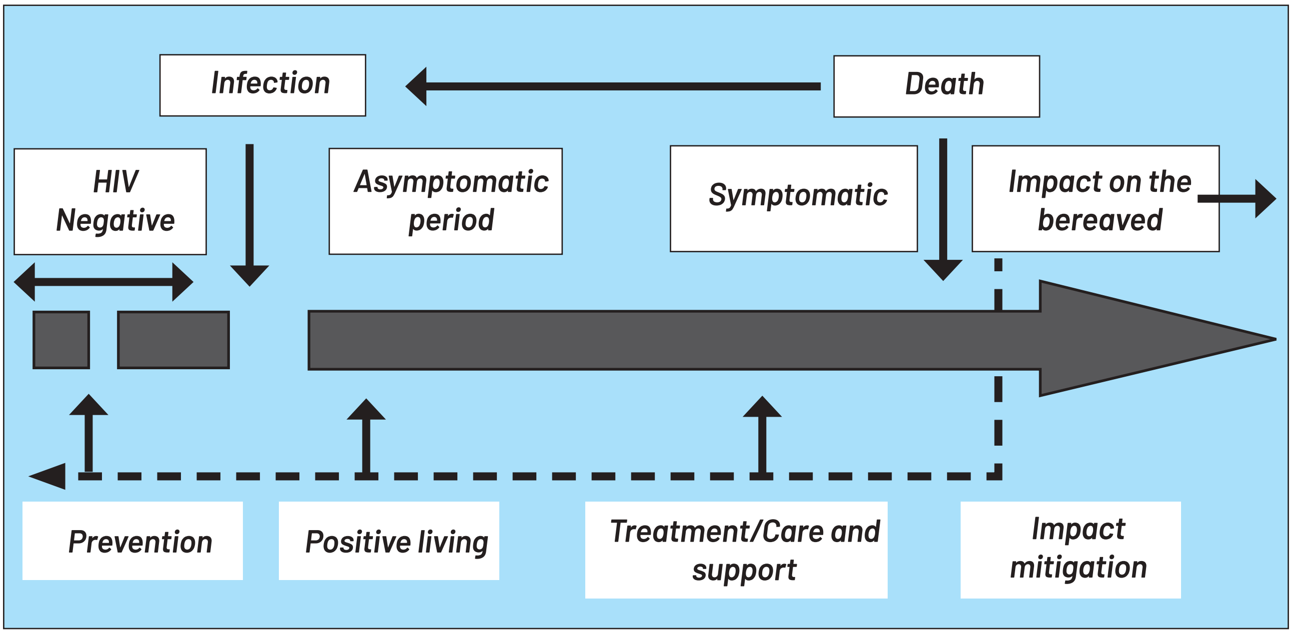


Fig.27: HIV Timeline

3. GENDER BALANCE TREE

This tool helps household members in identifying and analyzing gender issues at household level hence creating awareness on the existing situation on gender relations. It is also used to identify immediate and longer term action commitments by the household in order to improve the gender balance and increase everybody's wellbeing. The tool symbolizes a tree. It has a trunk, primary and secondary roots, branches and fruits.

Specific Objectives of the tool

- Identify who contributes most work to the household
- Identify who spends most income for the household
- Identify who benefits most from household income
- Identify who uses most of the household produce
- Identify inequalities in ownership of assets and decision-making
- Decide priority areas for improving the gender relations and inequalities

Steps in using the Tool

Step 1: Drawing the Trunk

It involves drawing of two lines in the middle of the paper representing the trunk in which composition of the household will be reflected. Draw symbols of the woman and other female members of the household inside the left side of the trunk. Dependents should be drawn beneath the woman symbol

Symbols for the man and other male members should be drawn inside the right side of the trunk.

Step 2: Drawing Roots

These indicate who contributes what work (paid and unpaid) to the household.

This step involves drawing of five roots that represents activities done by the various members of the household.

Two roots on the left side represents a woman and other productive female members of the household while the other two roots on the right side represent activities performed by the man and other productive male members of the household. It is recommended that separate colour should be used for the different sides of the roots.

The outer root represents income earning activities performed by males and females whilst the inner roots represent activities that bring food and reproductive activities for males and females.

A central root is drawn to show joint activities performed by all gender groups in a household.

Draw a black circle around activities that take the most time performed by men, women male and female dependents.

Put in a square for the activities that bring most income for the various gender categories.

Step 3: Drawing Branches and Fruits Symbolizes expenditure by gender categories

This step involves drawing five branches that represents benefits and expenditure by the various members of the household.

Two branches on the left represents self and household expenditure for the women and other productive female members of the household whilst the ones to the right corresponds to men and other productive male members of the household. The central branch represents for joint household expenses.

On the outside branches on left and right sides, draw items or symbols on personal expenditures that is expenditures for personal benefits for man, woman, male and female dependents. Draw a circle around the items with largest personal expenditure(s) in black for the various gender categories.

On the inner branches, draw items that each gender category spends for the household. Draw a circle around the items with largest personal expenditure(s) in black for each of the gender categories.

In the central branch draw items that male and female gender categories spend jointly for the household. Draw a circle around the items with largest joint expenditure(s) in black.

Draw a triangle around all expenditures classified as necessary by the household. Put a cross items that the gender groups and household would like to change and a tick on all those they would want to retain.

Step 4: Control over assets and decision-making (Pushers of the tree)

This step shows assets that are controlled by the various gender groups in a household and the decision maker (s) on household income, produce and products. The step involves

Indication of symbols for property that is owned or controlled by each gender category e.g. land, livestock, house, kitchen equipment. Asset owned by women are symbolized on the left, men on the right and both in the center of the trunk.

Using symbols indicate the decisions that are made by the man or woman.

An example of a gender balance tree is presented on the next page:

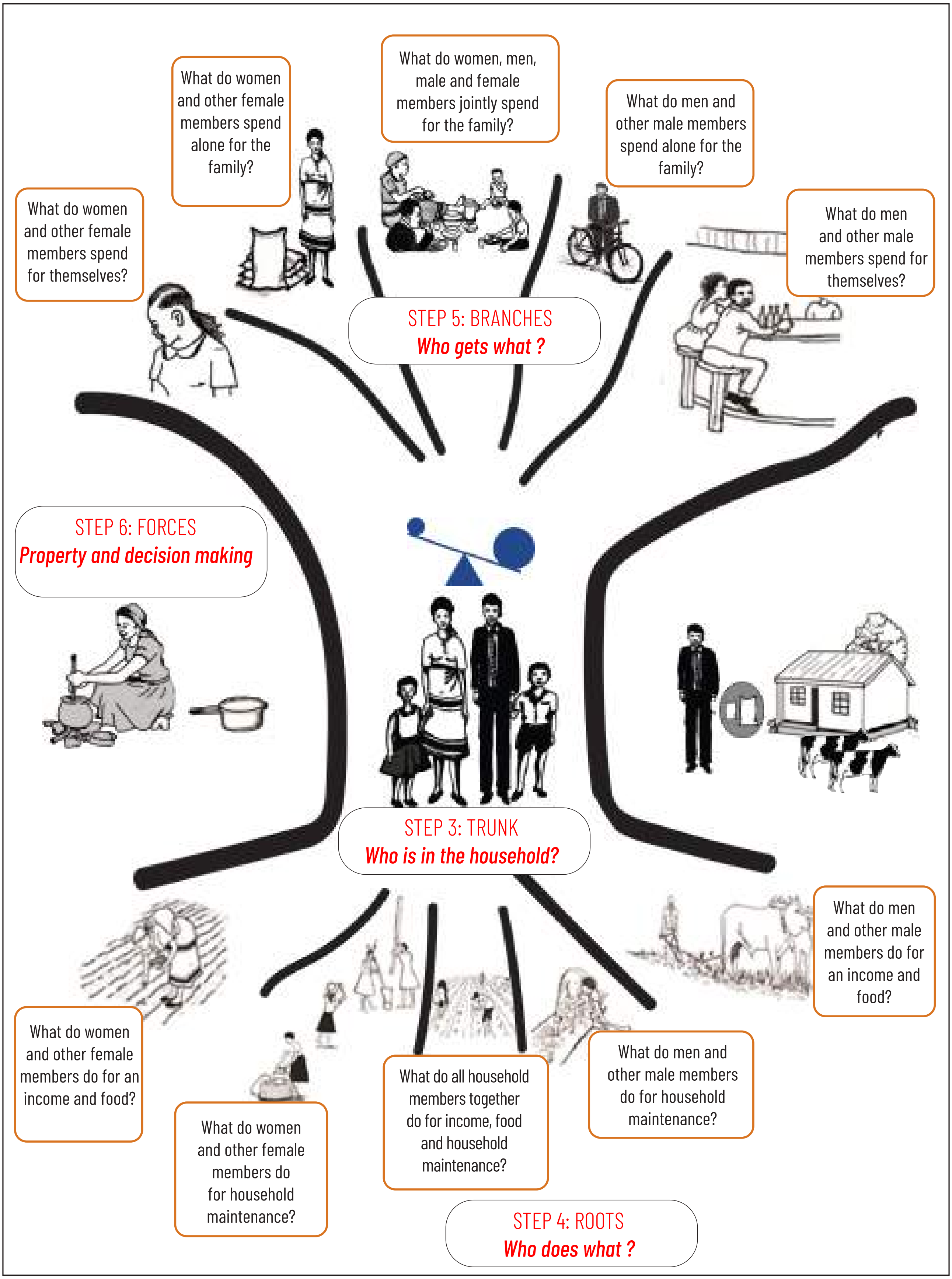


Fig.: 28 Gender Balance Tree

Step 5: Status of the Tree

Draw a symbol (balance or see saw) that will represent the side the tree will lean towards if balanced on a scale. This is determined by the responses to the following questions:

- Who is doing most of the work for activities that generate income?
- Who is doing most of the work for activities that generate or produce food and promote welfare of the household?
- Who owns most of the property?
- Who controls the household income and property?
- Who spends most of the income?

Step 6: Household Change Commitments

This step involves discussion on how the tree can balance. It indicates the strategies that the different gender categories will use to balance the tree based on the issues identified on step 5. Strategies are developed on how to address the identified issues on division of work, ownership of property, control and expenditure of income, and decision making. It is important to indicate tasks that should be done jointly, which expenditures should be cut, what property should be shared in ownership and which income earning activities can income be increased or time decreased. The gender groups and household should identify 5 action commitments from the tree that require increase or reduction that will make the tree balance.

CHAPTER 3

CROPS

3.1. Cereals

Cereal crops such as maize, rice, sorghum and millets form the basis of our staple food in the country. It is, therefore, important that their production be increased to ensure sustainable availability of food and income after the sale of surplus produce. The above mentioned cereal crops are discussed in the following subsections:

3.1.1. MAIZE *(Zea mays)*

Maize is grown throughout the country under rainfed, irrigated or residual moisture by smallholder, commercial and estate farmers. It is the main staple food crop for the country as such farmers are encouraged to make informed decisions and use their expertise to improve productivity. However, maize productivity remains low due to low adoption of improved technologies, low soil fertility, erratic rainfall and pest and diseases among others.

3.1.1.1. National aims

The aim is to attain and maintain self-sufficiency in maize requirements at household and national level. The objective is to increase production per unit area. Farmers are encouraged to grow high yielding varieties, apply inorganic and organic fertilizers if the country is to sustain food self-sufficiency in the face of increasing population.

At present, average yields range from 2,000 to 3,000 kg per hectare for hybrids, 1,400 to 2,400 kg per hectare for open pollinated varieties (OPVs) and 880 to 1,300 kg per hectare for unimproved maize cultivars. However, there is much scope for increasing yield under suitable agro-ecological zones with good agricultural practices. On average, yields of more than 10,000 kg per hectare for hybrids and 5,000 kg per hectare for OPVs can be attained with good management.

3.1.1.2. Classification of areas for maize production

Maize production areas in Malawi are classified as shown in figure 29 below:

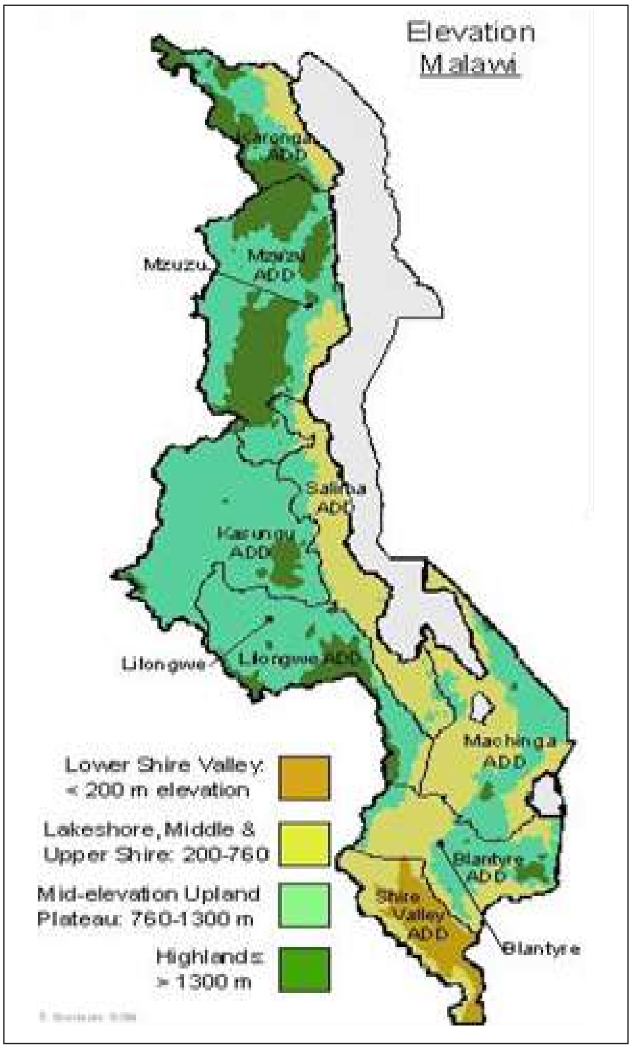


Fig. 29: Classification of areas for maize production in Malawi.

a) **Low-Altitude Areas**

The low-altitude maize growing areas are less than 600m above sea level (masl). These areas are characterized by high summer temperatures of about 30oC or more, relatively flat and have a generally short rainy season of between 3 to 4 months long.

The average rainfall is between 700 to 800 mm per annum. These areas are also called marginal maize growing areas associated with erratic rains and frequent droughts. Examples are the Shire Valley, Phalombe Plain, Lakeshore Plain and Upper Shire Valley from Kapichira Falls to Mangochi and Nkhamanga plain in Rumphi district. Short duration maturing varieties are best suited for these areas.

b) **Medium-Altitude Areas**

These are main maize growing areas which comprise about 60% of the total cultivated area. Altitude ranges from 600m to 1,300m above sea level. These areas are characterized by moderate temperatures and a fairly long rainy season of between 4 to 5 months, with an average rainfall of about 875mm per annum. Examples of such areas include the Lilongwe- Kasungu plain, Upper South Rukuru Valley, Shire Highlands, and Chitipa plain.

c) **High Altitude Areas**

These are areas above 1,300m above sea level and are characterized by cool temperatures and overcast conditions. Maize takes long to mature because of low temperatures. Examples of such areas are Viphya and Nyika Plateaus, Kirk Range, Dedza Hills, Dowa Hills and Misuku hills.

3.1.1.3. Improving yields

Increased production per unit area will enable the farmer to adequately feed the family from a small piece of land. This will also enable the family to have surplus maize for sale and release some land for other crops. Commercial farmers are also encouraged to use approved recommended technologies to increase productivity.

In order to achieve the potential yields the following husbandry practices are recommended:

3.1.1.3.1. Early planting

Early field preparation is essential to facilitate planting with the first planting rains capable of wetting the soil to a depth of 15 cm between October and December. Farmers in some areas dry plant maize one to two weeks before the onset of rains as a way of reducing labour requirements. This is a good practice and should be encouraged where possible. One to two weeks delay in planting may cause up to 25% yield loss. All maize varieties should be planted early.

3.1.1.3.2.Recommended plant population for all maize varieties

Optimum plant population is achieved by proper ridge and plant spacing, and number of plants per station.

Table 16: Plant population density with ridges spaced at 75 cm

Plant spacing	No. of plants	Plant population per hectare
75cm	3	53,333
50cm	2	53,333
25cm	1	53,333

Maize ridges should be spaced 75cm apart; 75cm between maize stations within the ridge and 3plants per station or 75cm x 50cm x2 plants or 75cm x 25cm x 1plant per station to achieve a plant population of 53,333 plants.

Farmers who intercrop maize with legumes or any other crop should plant maize at 75 cm between ridges and 75 cm between planting stations and 3 plants per station.

Stations with less than 2 or 3 plants should be filled immediately after emergence to ensure correct population and an even stand.

3.1.1.3.3. Use of quality improved seed

a) **Hybrid Maize**

Hybrid maize seed should be bought every season. There are several varieties that have been released and recommended in this country. The recommended hybrid maize varieties that are currently in use are included in Table 17a.

b) **Open Pollinated Maize Varieties**

Most OPVs range from semi flint to flint and therefore have good poundability and storage characteristics. Certified seeds can be purchased from recommended agrodealers and Seed Companies. After three seasons new seed should be acquired. The recommended and released Open pollinated varieties which are currently in use are presented in Table 17b.

Table 17a: Some recommended Hybrid Maize and their characteristics

Variety	Originator	Type	Grain Colour	Grain Texture	Ecology (Altitude)	Days to Maturity	Potential Yield
MH 18	DARS	Hybrid	110-120	White	Low/Mid Alt	110-120	5t/ha
MH 26, MH 27, MH 28, MH 30, MH 31, MH 32, MH 33, MH 34, MH 35, MH 36, MH 37 and MH 38	DARS	Hybrids	120-130	White	Mid/Low Alt.	120-130	8-11t/ha
MH 39A, MH 40A, MH 42A, MH 43A, MH 44 A	DARS	Pro-vit A Hybrids	120-130	Orange	Mid/Low Alt.	120-130	5-7.5t/ha
SC 301, SC 403	SEEDCO	Hybrids	90-110	White	Low Altitude	90-110	5-7t/ha
SC 537	SEEDCO	Hybrids	120-130	White	Mid Altitude	120-130	7-13t/ha
SC 627, SC 719	SEEDCO	Hybrids	140-150	White	Mid/High Altitude	140-150	11-13t/ha
PHB 30 G19-6, P3812W, PHB30D79	PIONEER	Hybrids	135-140	White	Mid/Low Alt.	135-140	7-12t/ha
PAN 12,	PANNAR	Hybrid	110-120	Yellow	Mid Altitude	110-120	7-10t/ha
PAN 53, PAN 63, PAN 67, PAN 3M-01, PAN 4M-21, PAN 4M-19, PAN 4M-23	PANNAR	Hybrids	120-130	White	Mid/Low Altitude	120-130	7-10t/ha
PAN 6777, PAN 7M-83, PAN 5M-35, PAN 7M-81, PAN 8M-93, PAN 7M-89, PAN 77	PANNAR	Hybrids	130-140	White	Mid/High Altitude	130-140	10-12 t/ha
DK-777, DKC- 8033, DKC-8053	BAYER	Hybrids	110-1102	White	Low /Mid Altitude	110-1102	7-10t/ha
DKC 9089	BAYER	Hybrids	120-130	White	Mid/Low Altitude	120-130	10t/-13t/ha
MRI 455, MRI 514	SYGENTA	Hybrids	120-130	White	Low/Mid Alt.	120-130	8-11 t/ha
MRI 614, MRI 624, MRI 634, MRI 744	SYGENTA	Hybrids	130-140	White	Mid/High Alt.	130-140	10-11 t/ha
Peacock 10, CAP 9001	Peacock Seeds	Hybrids	130-140	White	Mid/High Altitude	130-140	7-10t/ha

Table17b: Some recommended OPV Maize varieties in use and their characteristics

Variety	Originator	Type	Grain Colour	Grain Texture	Ecology (Altitude)	Days to Maturity	Potential Yield
ZM 309	DARS/CIMMYT	OPV	White	Flint	Low Altitude	110-120	5t/ha
Chitedze 2 QPM	DARS	OPV	White	Semi-Flint	Mid Alt.	110-120	5t/ha
ZM 523	DARS/CIMMYT	OPV	White	Flint	Mid/Low Alt.	110-120	6/ha
ZM 621, ZM 623	DARS/CIMMYT	OPVs	White	Flint	Mid/High Alt.	130-140	7t/h
ZM 721	DARS/CIMMYT	OPV	White	Flint	Mid/High Alt.	130-140	8t/ha

3.1.1.3.4. Manure and fertilizer application

3.1.1.3.4.1 Manure application

Farmers are encouraged to use manure especially with the increasing cost of chemical fertilizers. Manure improves soil structure as well as supplying nutrients to plants. Manure should be applied not less than a month before planting maize and the commended rate is 12.5 tonnes per hectare. As a guide, this can be achieved by using a 20 liter tin of manure applied every 8 meters (8steps) along the furrow. Where manure is not adequate farmers should apply 2 handfuls per planting station and mix with soil before planting. Farmers should be encouraged to make compost manure from house hold decomposable refuse and crop residues.

3.1.1.3.4.2. Fertilizer application

To obtain high yields and maximum returns from the money invested in fertilizers, farmers are strongly advised to base fertilizer application on soil test results. There specific fertilizer recommendations given in this and subsequent Sections that should be followed and will help farmers reliably produce sufficient maize to meet their own needs and to contribute to the food security of the nation.

There are two recommendations in one area depending on whether the maize is produced for home use or for sale. Refer to Table 18 for details on area specific fertilizer rates.

3.1.1.3.4.3. Rates and time of fertilizer application

Timely application of both basal and top dressing fertilizers is important for high yield. Apply fertilizers as follows:

Either

Apply 105kg of 23:10:5+6S+1.0Zn per hectare. The fertilizer should be applied 10cm away from the planting station and 10 cm deep. Use cup number 5, ¾ full on each side of the planting station.

a) Apply at planting or soon after seedling emergence. Twenty one days after basal dressing, follow it up with 150 kg of Urea at the same depth and distance from the plant.

or

b) Apply 100 kg of 23:10:5+6S+1.0Zn per hectare. The fertilizer should be applied 10 cm away from the planting station and 10 cm deep. Use cup 5, ¾ full on each side of the planting station. Apply at planting or soon after seedling emergence. Follow it up with 100 kg of Urea at the same depth and distance from the plant, using cup 5 almost full or level on each side of the planting station.

or

c) Apply 50 kg of 23:10:5+6S+1.0Zn per hectare. The fertilizer should be applied 10 cm away from the planting station and 10 cm deep. Use cup 2, level on each side of the planting station. Apply at planting or soon after seedling emergence. Follow it up with top dressing150 kg of Urea, 21 days after basal dressing, at the same depth and distance from the plant, using cup 2 full on each side of the plant.

Note that cup number 5 is two and half times the volume of cup number 2 and that a Coca cola bottletop when heaped contains the same amount of fertilizer as cup number 5 level full.

- Numbers refer to kg per hectare of nitrogen: (N) phosphate: (P) potassium (K) +sulfur (S) +Zinc (Zn).
- The recommendations are based on the available fertilizers like Urea (46%N) and 23:10:5+6S+1.0Zn
- 35:10:0+2S=1 bag of 23:10:5+6S+1.0Zn and 1 bag of Urea per hectare (50kg bags).
- 69:21:0+4S=2 bags of 23:10:5+6S+1.0Zn and
- 92:21:0+4S=2 bags of 23:10:5+6S+1.0Zn and 3 bags of Urea per hectare 3(50kg bags).

3.1.1.3.4.4. Lime application

An application of 2,000 kg/ha lime to maize grown on acidic soil is effective at increasing grain and dry matter yields. Acid soils are mainly in areas characterized by high total rain fall (>900 mm per year) and low soil pH levels (<5.5) such as on vast areas on Mulanje, Dedza, Misuku and Viphya plateaus. Agricultural lime needs to be applied on newly prepared ridges, which have been split in the middle. The lime is incorporated into the ridge and maize is planted at the recommended plant density and following all the recommended agronomic and crop husbandry practices as outlined. The best source of local agricultural lime in Malawi is near Chuzi in Chikhwawa district and Uliwa (Chilumba) in Karonga district. Other lime deposits are found in many parts of Malawi especially in Ntcheu and Balaka districts.

Table18: Area Specific fertilizer recommendation rates for maize

ADD	Districts and EPAs	Production for Home Consumption	Production for Market Sale
Karonga	Chitipa District All EPAs except Misuku	69:21:0+4S	35:10:0+2S
	Misuku	69:21:0+4S	nil
	KarongaDistrict	35:10:0+2S	nil
Mzuzu	Rumphi / North Mzimba		
	Mpherembe, Bwengu, Zombwe and Bolero EPAs	92:21:0+4S	35:10:0+2S
	Muhuju and Phoka / Nchenachena	69:21:0:+4S	nil
	Central Mzimba	92:21:0+4S	35:10:0+2S
	South Mzimba	92:21:0+4S	35:10:0+2S
	NkhataBay		
	All EPAs except Mpamba	69:21:0+4S	Nil
	Mpamba	35:10:0+2S	Nil
Kasungu	ALL Districts	92:21:0+4S	35:10:0+2S
Lilongwe	ALL Districts	92:21:0+4S	35:10:0+2S
Salima	SalimaDistrict	92:21:0+4S	35:10:0+2S
	NkhotakotaDistrict		
	Nkhunga and Linga EPAs	69:21:0+4S	Nil
	Zidyana and Mwansambo	92:21:0+4S	35:10:0+2S
	Bwanje RDP	92:21:0+4S	35:10:0+2S

Table18: Area Specific fertilizer recommendation rates for maize (cont.)

ADD	Districts and EPAs	Production for Home Consumption	Production for Market Sale
Machinga	Mangochi	69:21:0+4S	35:10:0+2S
	Namwera District	69:21:0+4S	35:10:0+2S
	Balaka District		
	Ulongwe and Mpilisi	69:21:0+4S	35:10:0+2S
	Bazale and Phalula EPA s and Rivi-Rivi Settlement Scheme	92:21:0+4S	35:10:0+2S
	Machinga District	69:21:0+4S	35:10:0+2S
	Zomba District		
	All EPAs except Mtubwi and Chingale	92:21:0+4S	35:10:0+2S
	Mtubwi and Chingale	69:21:0+4S	35:10:0+2S
Blantyre	Shire Highlands Districts	92:21:0+4S	35:10:0+2S
	All except Lirangwe EPA	92:21:0+4S	35:10:0+2S
	Lirangwe	69:21:0+4S	35:10:0+2S
	Thyolo District	92:21:0+4S	35:10:0+2S
	Mulanje District	92:21:0+4S	35:10:0+2S
	Phalombe District	92:21:0+4S	35:10:0+2S
	Mwanza District	69:21:0+4S	35:10:0+2S
ShireValley	Chikhwawa and Nsanje Districts	35:10:0+4S	Nil

If you are growing maize for sale, grow hybrids to maximize profits

Table19: Fertilizer application rates

Fertilizer rate per hectare	Basal Dresing 23:10:5+6S+1.0 Zn23:10:5+6S+1 .0Zn) Fertilizer cup	Top dressing UREA Fertilizer cup
35:10:0+2S	No. 2 half full	No. 2 half full
69:21:0:+4S	No. 2 almost full	No. 2 half full
92:21:0+4S	No. 2 almost full	No. 5¾ half full

3.1.1.3.4.5. Pests and their control

Maize pests are categorized into weeds and insect pests. Notifiable pests should be reported to the nearest agricultural office as soon as they are noticed. Any pest out breaks should be controlled to prevent damage and spread to other areas.

3.1.1.3.4.5.1 Weeds and their control

Maize suffers most from weed competition during the first six weeks after germination. The crop should be weed-free during this period. The smaller the crop the less it is able to survive competition. At least two weedings are necessary for effective weed control. Herbicides can also be used for weed control.

There are pre and post-emergence herbicides. A pre-emergence herbicide is the one that may be applied before the targeted crop has emerged.

Post-emergence herbicides are applied after the weeds and the crop emerge. This is because of the selective nature of the herbicides and it is important to avoid drift so that the herbicide does not fall onto an unintended crop. For pre- emergence and post-emergence herbicides it is important to do the application when the soil is still wet.

All herbicides have labels indicating application rates and type of weeds they control. It is important to check the labels as application rates can change even with the same product depending on concentration and soil type.

Some of herbicides, in particular, an application of Dual Magnum, a pre- emergence herbicide, into the soil at the rate of 2.2litres/ha before planting maize is effective in suppressing witch weed. At this rate Dual Magnum controls weeds and suppresses the emergence of witch weed.

Witch weed *(Striga asiatica)* is becoming an increasingly serious problem in areas where maize is monocropped with poor management. Adequate manure and fertilizer application will help the crop with stand the effect of witch weed. Uprooting the weed before it flowers will help to reduce its population in succeeding seasons. Crop rotation with catch crops such as sun flower and cotton should be practiced where land permits.

Other weeds of economic importance are:-

a) Common grass weeds such as wild finger millet *(Eleusine indica)*, kapinga which is Bermuda grass *(Cynodon dactylon)* and wild oat *(Avena fatua)*.
b) Common broad leaf weeds such as Nicarndra physalodes, Bidens pilosa, black jack, *(chisoso)* and Amarathus *(bonongwe)*.
c) Sedges such as Cyperus rotundus (highland nutsedge) and cyperus (yellow nutsedge).

Control of these weeds is by frequent weeding and use of systemic herbicides such as glyphosate which kill underground root system.

3.1.1.3.4.5.2. Important insect pests

(i) **Fall armyworm**

Fall armyworms are very destructive caterpillars of certain nocturnal moths which feed mostly on crops of the grass family such as maize, millet, sorghum, rice, and sugarcane. They also feed on non-grass family crops such as soya beans, tobacco, groundnuts, cowpeas, potatoes, amaranthus, including pastures, among others. If not controlled, can cause up to 100% yield loss.

Description of fall armyworm

Eggs

Fall armyworm eggs are laid in masses or in layers covered with greyish scales and hatch within 2 -3 days.

Larva

The larvae closely resemble that of the African armyworm. At early stages larvae are pale green with black heads and changes to orange brown at later stages. Fully grown larvae are about 4 cm long and are pale green or almost black with a reddish-brown head. They are very active early in the morning and late in the afternoon.

Fig. 30: Fall armyworm notorious larvae stage

It differs with Army worm due to its inverted "Y" and upper body black tubercles from which hairs arise.

Pupa

The FAW normally pupates in the soil at the depth 2 to 8 cm. The larva constructs a loose cocoon by tying together particles of soil with silk.The cocoon is oval in shape and 20 to 30 mm in length. If the soil is too hard, larvae may web together leaf debris and other material to form a cocoon on ths soil surface. The pupa is reddish brown in colour measuring 14 to 18 mm in length and about 8 to 9 days during the summer, but reaches 20 to 30 days during cooler weather.

Moth

The moths which lay eggs are similar in shape and size to other moths in the Lepidoptera family, grayish in colour and about 4cm long. The front wings of the male are grayish in color with white markings near the wing tips. The front wings of the female are similar but the markings are less distinct.

Management of Fall Armyworm

Sex pheromone traps have been installed in all EPAs country wide for forecasting possible Fall armyworm outbreaks. A rise in moth catches in these traps is an indication of potential outbreaks. Extension staff should, therefore, advise farmers to inspect their fields regularly.

Fall armyworm is controlled by use of Integrated Pest Management (IPM) strategies including cultural, physical, biological, botanical (natural plant products) and chemical control methods simultaneously as discussed in section 2.5. In case of pestcides use, refer to the table below.

(ii) **African Armyworm** *(Spodoptera exempta)*

African Armyworm is a serious notifiable pest of cereals which is very destructive particularly to maize, rice, wheat, sorghum, millets and pastures. African Armyworm is an endemic pest and the attack may be sudden. Quite often out breaks occur right after the first rains. Early detection and reporting of the pest is important for effective control to minimize damage.

There are sex pheromone traps set up in all EPAs country wide for forecasting possible African armyworm outbreaks. A rise in moth catches in these traps is an indication of potential outbreaks. Extension staff should, therefore, advise farmers to inspect their fields regularly.

The caterpillars occur in large numbers, march in one direction, aggressively feeding on all grass in their way. They may also occur as scattered populations which may lead to larger outbreaks later. They prefer young tender plants which they chew to the ground while old ones are left as bares talks with mid ribs only.

The African Armyworm can be controlled using pesticides listed in the table below.

Table 20: Recommended pesticides for Fall Armyworm and African Armyworm.

INSECTICIDE (TRADE NAME)	ACTIVE INGREDIENT(S)	RECOMMENDED DILUTION RATE	AMOUNT TO DILUTE IN A 16-LITRE SPRAYER	AMOUNT TO DILUTE IN A 20-LITRE SPRAYER
Steward 150 EC	Indoxcarb	1ml/litre	16ml	20 ml
Belt 480 SC	Flubendiamide	0.3ml/litre	5ml	6 ml
Proclaim Fit	Lufenuron & Emamectin benzoate	0.5g/litre	8g	10 g
Chlorpyrifos 480 EC	Chlorpyrifos	1ml/litre	16ml	20 ml
Decis Forte	Deltamethrin	0.2ml/litre	3.2ml	4 ml
Deltanex 25 EC	Deltamethrin	0.8ml/litre	12.8ml	16 ml
Ecoterex 0.5 GR	Deltamethrin & Pirimiphos methyl	0.1g/whorl of maize plant	Not applicable	Not applicable
Snowcron 500 EC	Profenofos	0.5ml/litre	8ml	10ml
Snowmectin 1.6 EC	Abamectin	1ml/litre	16ml	20ml
Nimbecidine	Neem oil (Azadirachtin)	3ml/litre	48ml	60ml
WormAtak EC	Teflubenzuron & Cypermethrin	1ml/litre	16ml	20 ml
Dettamax 25 EC	Deltamethrin	0.8ml/litre	12.8ml	16 ml
Antario	Abamectin	3g	48g	60g

(iii) **Red locust** *(Nomadacris septemfasciata)*

This is a notifiable pest and is potentially the most destructive in Malawi because of the extensive damage it can cause within a short period of time. The leaves are eaten from the margin in wards. The breeding areas are known and frequent surveys are made in the breeding areas in Lake Chilwa/ Chiuta plains, Elephant, Ndindi and Vwaza Marshes, Mpatsanjoka dambo and Kuseri-kumvenji Estate to monitor any unusual population build-up. The eggs are laid in the wet season (November to April) and hatch after 30 days. Since there are also breeding areas in neighbouring countries, everyone is advised to report immediately to the nearest agricultural or government office any swarms spotted. Control of the pest is coordinated by the International Red Locust Control Organization for Central and Southern Africa (IRLCO-CSA) in conjunction with the Ministry of Agriculture. Spraying chemicals such as Fenitrothion ,Green muscle and Carbaryl can be used to control the locust hoppers.

(iv) **Large short-horned Grasshoppers** *(Ornithacris spp. and Cyrthacanthacris spp.)* **and Crickets** *(Acanthoplus spp.)*

The insect pest is sometimes reported as red locust; however, it is less damaging. Crickets have also been known to damage the maize crop at the milky stage. Control for insect pests is as for Red locust.

(v) **Maize Stalk Borer** *(Busseola fusca, Chilo partellus)*

These are the most important stalk borer spp. that attack maize in Malawi. Busseola fusca is commonly found in high altitude areas of above 800 m above sea level. This is one of the serious pests on maize causing considerable damage in high altitude areas and to the late planted crop. Chilo partellus is most important in low altitude areas below 800m above sea level. The larvae hatch from eggs laid in the leaf sheath feeding on the folded leaves as they burrow into the main stem.

Pupae over winter inside the stalks. Farmers are, therefore, advised to feed the stalks to livestock or bury infested crop residues after harvesting. Maize stalk borer also attacks sorghum and sugar cane. Some wild grasses are alternative hosts.

Scout your fields regularly to inspect for infestations of Stalk borer and take quick action when you identify a problem. Apply Ecoterex 0.5 GR in the funnel at a rate of 0.1g per whorl of maize. The insect pest can be controlled by spraying with pyrethroids.

(vi) **Leaf roller** *(Cnaphalocrocis medinalis)*

Leaf roller is a pest of economic importance. The adult belongs to a group of moths. The larvae infest the leaves, rolling them longitudinally together and live inside the rolled leaf. Leaves are sometimes not actually rolled, but the tips are fastened to the basal part giving the rolled appearance. With heavy infestations, plants appear scorched and weakened. High infestation levels may cause severe yield losses. Late planted crops are mostly attacked.

Control is either by keeping the area free from weeds and thus prevent a build-up of this pest on alternative hosts (Gramineae), or applying insecticides only when the infestation is heavy. The leaf roller caterpillars can easily be controlled by such pesticides as Fenitrothion or Carbaryl (Sevin). The rates for leaf roller control areas for army worm. In small areas with low infestation, clipping of infested leaves and destroying them may help control the pest.

(vii) **Earworm** *(Helicoverpa armigera)*

The insect pest is also called African boll worm or tobacco bud worm depending on the crop it has attacked. In maize the insect pest causes damage by feeding on the silk sand soft grains of the cob. There is no economic control measure recommended for earworm. Hand picking is most practical and should be encouraged.

(viii) **White grubs**

White grubs can usually be found in the soil around the base of damaged plants. Scraping the surface exposes white C shaped grubs 3mm to 3cm long with brown heads, 3 pairs of legs and abdomen with shiny tips. They become swollen and semitransparent with maturity. Pupae are soft and white and are found within cells in the soil. Adult beetles (chafers) are nocturnal and pale yellow to dark brown. White grubs destroy seedlings by feeding on roots of the crops. The wilted or dead seedling are seen early in the season, while patchy maize stands of poor and tilted plants are evidence later. Surviving plants are deformed with reduced cobs.

Economic importance

Entire field may require total replanting following infestation.

Management options

- Hand-pick white grubs from the base of the plant and destroy them
- Seed-dress with Gaucho, Monceren GT

3.1.1.3.4.6. Storage pests

(i) **Larger Grain Borer** *(Prostephanu struncatus)*

This is a grain storage insect pest which causes heavy losses in maize. Infestation is more severe in cob maize than in shelled maize. The adult larger grain borer starts by boring into the cob cores. The early symptoms of attack are holes on the stalk end of the cob. Larger Grain Borer can also gain access through the tip of the cob. Direct boring through the sheath is also possible. Under severe damage, weight losses as high as 40% in maize can be observed after only 3 to 6 months of storage. It produces a lot of dust as it tunnels through the grains and dried cassava. Larger Grain Borer can be controlled using integrated post-harvest management approach which involves a combination of several control methods.

These include:

Cultural control practices

i. Harvesting as soon as the maize is dry.
ii. Separating damaged cobs from good ones.
iii. Maintaining and thoroughly cleaning storage stores and burning crop residues.
iv. Drying produce thoroughly before storing.
v. Boiling sacks in water and thoroughly drying them before putting in produce.
vi. Dehusking and shelling the maize.

Apply Actellic Superior Bifelthrin (Super Grain Dust), Wivokil super dust at the rate of 25g of chemical dust per bag of 50 kgs shelled maize and mix thoroughly before storage or 1 bottle of Actellic Super dust which weighs 200g is enough for 8 bags of 50kgs shelled maize.

Biological control- The government through the Department of Agricultural Research Services has released and will continuously be releasing Teretrius nigrescens (Tn), a biological control agent which feeds on and reduces the population of the Large Grain Borer.

(ii) **Weevils and Moths**

Maize may be damaged in storage by different types of weevils and moths. Hard grains of OPV, unimproved and flint grained hybrid varieties suffer less weevil damage. Storage pests can be controlled by applying recommended pesticides such as Actellic Super Dust, Super Grain Dust, Super Guard Dust, Wivokil and Shumba Super at the rate of one sachet (25g) to 50kg of shelled grain. For unshelled maize apply 50g. The pesticide can be obtained from recommended pesticide suppliers.

(iii) **Rodents**

Rodents such as rats and mice can be controlled by using rat guards in maize cribs (nkhokwe), bait, traps and keeping storage surroundings clean.

3.1.1.3.4.7. Diseases and their control

(i) **Turcicum leaf blight** *(Exerohilium turcicum)*

This is the most widely spread disease of maize in Malawi. The incidence ranges from 16 to 25% and can be severe. Higher incidences occur in areas where improved varieties are extensively cultivated. However, Malawi varieties are tolerant. The disease occurs late in the season when maize is almost mature. Control is by growing tolerant varieties.

(ii) **Maize streak virus**

This disease is wide spread in low altitude areas with a warm humid environment. It also occurs in high altitude areas when maize is planted late.

The vectors transmitting the virus are leaf hoppers *(Cicadulina spp)*. Maize planted during off season in dimbas using residual moisture acts as a reservoir of both leaf hoppers and the virus. The disease can be controlled by planting early so that the crop passes the vulnerable stage before the population of the vectors grows. Use of tolerant varieties and seed dressing by Gaucho is recommended. Apply Gaucho 70 WS 500 gin 2 litres of water for 100kg maize seed.

(iii) **Cob rot** *(Fusarium spp and Diplodiamaydis)*

This disease can cause 5 to 13% losses in some seasons depending on time of planting and amount of rainfall. Cob rots can be reduced by planting tolerant varieties which have good tip cover, timely harvesting and proper drying of grains before storage.

(iv) **Gray Leaf Spot (GLS)**

This disease is caused by a pathogen called Cercosporazeae maydis which is a fungus and is carried from season to season in diseased maize residues. Dissemination is mostly by wind borne spores (wind dispersed), with infected fields acting as initial sources of inoculum. Symptoms first appear on the lower leaves moving upwards. Under warm, foggy, or humid conditions, the disease quickly affects the whole plant giving it scorched appearance, hence the name Chiwawu. The disease manifests itself mostly at tasselling. Temperatures above 20oC favour maximum disease development. The disease continues to spread in most Agricultural Development Divisions (ADDs), with some ADDs recording severe outbreaks. With early outbreaks, the maize crop fails to reach physiological maturity, resulting in low yields and poor-quality maize. The disease can be controlled through an integrated pest management approach, which includes the following:

a) Observing good crop husbandry practices such as early land preparation, early planting, burying all diseased plants and others.
b) Ensuring that crop residues are fully decomposed before planting.
c) Rotating maize with non-cereal crops, which are immune to GLS such as soyabeans where possible.
d) Burning severely attacked plants.
e) Planting maize varieties that are tolerant to GLS as described in Table 21.

(v) **Downy mildew**

Downy mildew is caused by a watermould, Peronoschlespora sorghi which also attacks sorghum. The disease can be very devastating and cause very serious losses in maize. It can also spread very fast through various means. It is very important that the disease be controlled whenever it is observed. Use of recommended cultural practices such as use of certified seed and destruction of crop residues, would significantly reduce the incidence of the disease.

The disease was first observed in Mwanza in 1991/92. It became serious in Mulanje in 2003. The disease has now spread to Thyolo, Chiradzulu, Zomba and Blantyre districts.

Symptoms

The most conspicuous symptoms include:

- Stuntedness.
- Yellowing and striping of leaves where by the strips are not delimited by the veins as is the case with maize streak virus disease.

- In severe cases you get crazy top. The inflorescence is replaced by a mass of narrow twisted leaves.
- Sterility of the plants. This is the case with systemically infected plants (seed-borne).

Mode of spread

The disease can be spread by wind, use of infected seed, soil, crop residues where the pathogen can over-winter and rain/water splashes.

Effects

The disease causes yield losses of up to 100%, where infected seed has been used. In situations where farmers are producing seed maize, there is total loss, as the seed from those areas cannot be used as seed.

Control Measures

- Roguing and destruction by burning of infected plants. This helps to reduce spread and also reduces nutrient and water deprivation for the neighboring healthy plant
- Avoid Mono-cropping. This is to reduce inoculum (spore-load) for the next crop. Use of crop rotation with non-host crops is greatly recommended
- Early planting. This will help the plants to escape the high pressure of the disease at the vulnerable young stage of growth
- Use certified seed. Usually seed that has been certified is clean as the crop is subjected to rigorous inspections
- Use tolerant seed especially in areas where the disease has been noted
- Use resistant varieties, where available
- Destruction through burning of residues in areas where the disease has been noted.
- Winter crop production of maize disease was prevalent.
- Staff was also trained in the control of Downy mildew.

(vi) **Maize Lethal Necrosis (MLN)**

This is a serious new disease of maize that can devastate maize crops. The disease is caused by a combination of two viruses. Maize chlorotic mottle virus and Sugarcane mosaic virus that are difficult to differentiate individually based on visual symptoms. The insects (leaf hoppers) that transmit the disease causing viruses may be carried by wind over long distances. Infected plants are frequently barren; ears formed may be small or deformed and set little or no seed which may lead to total crop loss in the field.

What are the typical symptoms?

- Mild to severe mottling on the leaves, usually starting from the base of young leaves in the whorl and extending upwards toward the leaf tips.
- Stunting and premature aging of the plants.
- Dying (known as "necrosis") of the leaf margins that progresses to the mid-rib and eventually the entire leaf

Necrosis of young leaves in the whorl before expansion, leading to a symptom known as "dead heart" and eventually plant death

How can farmers prevent MLN in their fields?

- MLN does not occur on crops other than maize, so crop rotation is advised.
- Weed fields regularly to eliminate alternate hosts for insect vectors.
- Use maize varieties that are resistant to MLN.

Fig 31: Maize Lethal Necrosis diseased maize plants

Table 21: Maize varieties with disease resistance

Name of varieties	Days to maturity	Potential yield (kg ha-1)	Specific attributes
PAN 33	138 – 146	7,000	Tolerant to MSV and good resistance to cob rot, GLS and Northern Leaf Blight
PAN 77	136 – 144	6,500	Tolerant to MSV and good resistance to cob rot, GLS and Northern Leaf Blight
PAN57 533	135 – 144	6,000	Resistant to GLS, NLB, MSV and Cob rot
PAN 63 MH26	139 – 146	6,000	Resistant to GLS, NLB, MSV and Cob rot
SC 715	152 140	11,000	Tolerant to Cob rot, GLS and MSV, but very good tolerance to ear rots
SC 717 627 727	152 140	13,000	Moderately resistant to MSV and good tolerance to cob rot
PHB 30G19	140	7,000	Tolerant to GLS, MSV and NLB
PHB 30V33	140	7,000	Tolerant to GLS, MSV and NLB
DKC8033	120 – 130	12,000	Tolerant to MSV, GLS, TLB and cob rot
DKC 80 - 73 90 - 89	130 – 140	10,000	Good husk cover

3.1.1.3.4.8 Harvesting

Harvesting should be done as soon as the maize is dry. Stooking is recommended to complete drying, facilitate harvesting and enable farmers to plough their land while the soil is still moist. To avoid damage by rodents, termites and weevils in the field, maize should be harvested and stored soon after stooking. However, this should not

destruct farmers from incorporating maize stover into the soil after they have completed harvesting.

3.1.1.3.4.9. Marketing

Ensure that maize is well dried before it is taken to the market. Rotten or moist maize is not accepted for sale at any agro produce markets.

3.1.1.3.4.10 Storage

Maize should be stored in dry ventilated structures. This controls most pests and diseases especially those that cause rotting. Farmers are encouraged to use improved storage structures such as concrete and metallic silos. Cribs (Nkhokwes) should be made rat proof by the use of rat-guards and they should be properly thatched to prevent leaking. If bags are used for storage ensure that they are clean. Farmers should dry grains thoroughly and maize should be kept in a dry place for storage.

Estimated maize production for the past ten seasons is presented in Table 22.

Table 22: Estimated maize hectarage and production (mt) for the past ten seasons

Year	Area (Ha)	Yield (Kg/Ha)	Production (MT)
2010/11	1,732,371	2,248	3,895,181
2011/12	1,733,692	2,090	3,623,924
2012/13	1,676,758	2,171	3,639,866
2013/14	1,704,528	2,334	3,978,123
2014/15	1,676,213	1,656	2,776,277
2015/16	1,674,076	1,415	2,369,493
2016/17	1,534,192	1,937	2,971,967
2017/18	1,685,347	1,601	2,697,959
2018/19	1,470,641	1,468	2,158,231
2019/20	1,496,805	1,800	2,693,561
Average	**1,638,462**	**1,880**	**3,080,458**

3.1.2. RICE *(Oryza sativa)*

Rice is one of the cereals grown along the Lakeshore, Phalombe plain, the Shire Valley and areas around Lake Chilwa either in irrigated rice schemes or in rain fed low land areas. The crop is either grown in irrigation schemes, low land or rainfed. The schemes are underutilized due to various reasons such as low patronage and labour constraints. However, it is an important cash earner where it is grown and forms part of the staple food in the urban centers.

3.1.2.1. National aims

The national aim is to increase paddy yields in irrigated rice schemes and also increase both area and yield of rain fed rice to meet both the domestic and export demand.

The present low yields of 1,000 to 1,500 kg per hectare rice cultivars under rain fed conditions should be increased to 3,500 to 4,000 kg per hectare. The present cultivated rain fed area of 30,000 hectares should be increased to the potentially available area of 70,000 hectares. These improvements should result into a significant increase in rice production.

For irrigated rice average yields are low and are at 4,000kg per hectare. Potential yields for improved rice varieties are 6,000 to 7,000 kg per hectare. Upland rice varieties are NERICA 3 and NERICA 4.

3.1.2.2. Improving yields

In order to achieve the potential yields, the following husbandry practices are recommended:-

3.1.2.3. Use of Improved varieties

3.1.2.3.1 Improved varieties

3.1.2.3.1.1. Irrigated and low land rice varieties

a) Mpeta (IR10L121) is a recently released Indica type of rice for irrigated low land cultivation. It matures in 110 days and yields 7.0 ton. It has a good seed shape, aroma, taste and cooking time. It is tolerant to rice blast and highly resistant to Gray Beetles.

b) Nazolo (IR13N144) is a recently released Indica type of rice for irrigated and low land cultivation. It matures in 110 days and yields 7.0 ton. It has a good seed shape, aroma, taste and cooking time. It is tolerant to rice blast and highly resistant to Gray Beetles)

c) Nunkile (Pusa33) is recommended for low land irrigated cultivation. Two crops can be grown in a year because it takes 112 days to mature in the wet season and 140 days in the dry season. The variety has moderate susceptibility to blast (Pyriculareae oryzae). For this reason, Nunkile is not recommended for blast–prone areas such as Limphasa or mid– altitude (above 500 masl) ecologies. Nunkile matures two weeks earlier than other irrigated varieties and therefore bird scaring should start early to avoid yield loss. The variety is also attractive to field mice because of its strong scent.

d) Kayanjamalo variety is recommended for lowland rainfed and irrigated conditions, and matures in 105 days. It has yield potential of 6.5 t/ha and is resistant to major rice diseases and pests. Mpatsa variety is recommended for lowland rainfed and irrigated conditions, and matures in 100 days. It has yield potential of 5.8 t/ha and is resistant to major rice diseases and pests.

e) Mtupatupa (TC G10) is recommended for low land irrigated cultivation. It matures in130 days in the wet season while in the dry season it takes 155days. It can be double cropped only when sown early enough. The name refers to the variety's grain that expands when cooked. It is moderately scented.

f) Vyawo (ITA 302) is recommended for low land cultivation under rainfed or irrigated conditions. Vyawo is tolerant to blast. The variety takes 130 days to mature in the wet season and 150 days in dry season.

g) Senga (IET 4094) is a recommended variety for irrigated low land cultivation. It matures in 116 days in the wet season and 143 days in the dry season.

h) Changu (IRI 1561-250-2-2) is a recommended variety for irrigated schemes. It has a short to medium maturity period of 119 days during the wet season and 145 days during the dry season.

3.1.2.3.1.2. Rain fed upland rice varieties

a) Nerica 3 is a dwarf non-aromatic variety (<92cm) with grains measuring 7.2mm and 2.2mm in length and width, respectively; and has a milling yield of 75%. It also has a good cooking quality. It is a photoperiod insensitive variety with days to maturity of 95 to 120. It has potential yields of 4,500kg/ ha. This variety is suited to upland conditions such as Mchinji, Mbawa (Mzimba) and Meru(Chitipa)

b) Nerica 4 is a dwarf non-aromatic variety (<92cm) with grains measuring 7.2mm and 2.5mm in length and width respectively; and has a milling yield of 74%. It has a good cooking quality. It is a photoperiod insensitive variety with days to maturity of 100 to 120. It has potential yields of 5,000 kg ha. This variety is suited to upland conditions such as in Mchinji, Mbawa (Mzimba) and Meru (Chitipa). Unlike Nerica 3, Nerica 4 can tolerate late season drought better than Nerica 3.

c) Wambone (FRX 92-14) is a recommended variety for rain fed lowland areas. It takes 128 days from seedling emergence to maturity. Its yield potential is 4600 kg per hectare and is scented.

d) Faya14-M-49 is a recommended variety for low land rain fed cultivation. It matures in 150 to 155 days and its photo period sensitivity makes it unsuitable for a planting in the dry season. The variety is preferred by consumers because it is scented. Mice attack the crop because of its strong scent.

e) Katete variety is recommended for lowland rainfed and irrigated conditions. The variety matures in 94 days. It has yield potential of 6 t/ha and is resistant to major rice diseases and pests.

f) Lifuwu (FRX 78-12) is a recommended variety for rain fed low land areas. It takes 142 days from seedling emergence to maturity. Its yield potential is 3800 kg per hectare and is scented.

g) Mpatsa variety is recommended for lowland rainfed and irrigated conditions, and matures in 100 days. It has yield potential of 5.8 t/ha and is resistant to major rice diseases and pests.

3.1.2.3.1.1 Upland Dambos rice

a) Kameme (IRAT170) i s re c om m e n d e d for upland dambos in the mid to high altitude areas. It takes 132 days from seedling emergence to maturity. Its yield potential is 3,700 per hectare.

Table 23: Rice varieties and their production ecologies

Ecology	Varieties
Irrigated	Changu, Senga,Vyawo, Mtupatupa, Nunkile, Kayanjamalo, Mpatsa and Katete, Mpeta, and Nazolo
Rainfed	Wambone, Lifuwu, Faya 14-M-49, Nerica 3, Nerica 4, Kayanjamalo, Mpatsa and Katete.
Upland dambos (mid high altitude areas)	Kameme,

Farmers should be encouraged to purchase rice varieties from registered rice seed growers.

3.1.2.3.2. Unimproved varieties

Where farmers are using unimproved varieties such as Singano, Kilombero, Kalulu and Mwasungo, they should be encouraged to select their own seed in the field and store it properly.

3.1.2.4. Nursery preparation and sowing

Preparation of a good seed-bed for seed sowing and transplanting is important for good establishment, crop growth and weed control. Farmers should, be encouraged to prepare their seed-beds early to enable timely sowing and transplanting. Sowing should be done between mid- December and mid - January during the dry season. A seed rate of 63kg for the rain fed Faya 14-M-69 and other local cultivars, and 75 kg for all irrigated varieties is required for one hectare. Rice should be sown on flat beds 20m long, 1m wide and 5cm high. This is commonly done in the irrigation schemes. Twenty such seed beds will produce enough seedlings for one hectare.

3.1.2.4.1. Land Preparation

Fields should be ploughed to facilitate root development and plant growth. This should be done soon after harvesting while the soil is still moist. It should be followed by breaking of clods, leveling, bunding and pudding.

3.1.2.4.2. Planting

3.1.2.4.2.1. Growing rice using the System of Rice Intensification (SRI)

The System of Rice Intensification (SRI) is a method of growing rice that increases rice production by addressing the constraints such as poor water management, low soil fertility, lack of proper weed control methods and poor crop husbandry. SRI improves productivity of land, water, labour and other farm inputs invested in rice farming. It is most suitable on irrigated rice but can be used on rain fed lowland rice.

It has been found to improve rice production from 2 tons/ha to over 7 tons/ha.

Components of System of Rice Intensification

SRI has 6 pillars of cultural practices that are implemented as a package.

1. Transplanting young seedlings 10 days after seedling emergence
2. Transplanting one seedling per hill
3. Square transplanting at 23 cm x 23 cm
4. Applying 12 kg 23:10:5+6S+1.0Zn and 4.3 kg urea per 0.1 ha plot or 1600 kg well decomposed organic manure
5. Use of intermittent flooding and not continuous flooding
6. Use of cono weeder for controlling weed

3.1.2.4.2.2. Growing rice using old Methods (Dribbling or Broadcasting)

3.1.2.4.2.2.1. Rain fed Rice

Depending on when planting rain comes, unimproved varieties should be sown directly in the field either by dibbling or broadcasting. When sown by dibbling, plant 6 seeds per station at spacing of 23 cm x 23cm with the first planting rains. The farmer can also dry plant before first planting rains. Thin or supply to 4seedlings per station at 15 to 20 days after seedlings emergence.

3.1.2.4.2.2.2. Irrigated Rice

Irrigated rice should be transplanted. Transplanting ensures a vigorous initial plant growth. In the wet season, 15 to 25 day-old seedlings should be transplanted between mid-January and mid-February and 20 to 30days–old seedlings between mid-July and mid-August in the dry season. Transplant 3 to 4 seedlings per station at 23cm x 15cm spacing.

3.1.2.4.3. Water control and management

Water control and management is vital for optimum crop growth and productivity. This ensures that the required amount of water is available throughout the crop growth period. Water management practices such as leveling, bunding, making canals, siting inlets and outlets properly, are vital to ensuring efficient water supply and distribution. These, however, vary between irrigated and rain fed rice.

3.1.2.4.3.1. Rain fed Rice

Water availability to rain fed rice is markedly improved by dividing the field into several small plots and making bunds around them. Bunds assist in controlling the movement and distribution of rain water. Farmers growing rain fed rice should therefore be encouraged to make bunds in their fields.

3.1.2.4.3.2. Irrigated Rice

The irrigation schemes should have adequate water for irrigated rice from transplanting time to physiological maturity period. A permanently flooded field during this period ensures less nitrogen losses due to denitrification compared to fields that are intermittently flooded. Farmers should, therefore, be encouraged to flood their rice fields continuously to a depth of 5 to10cm up to 7 to 10 days before harvesting this ensures reduction in loss of nitrogen through denitrification as compared to the fields which are always flooded.

3.1.2.4. Fertilizer application

The recommended nitrogen source for rice in Malawi has been 23:10:5+6S+1.0 Zn and UREA. However, research has shown that farmers can obtain the same high yields by using Urea fertilizer. This will reduce the cost of production because farmers will buy half the number of bags of Urea as compared to the number of bags of Sulphate of Ammonia to meet the recommended rates.

3.1.2.4.1. Faya14M-69 and other cultivars

a) Faya14-M-69, Kilombero and other cultivars require an application rate of 60kg nitrogen and 25kg Phosphate (P205) per hectare. These are achieved with application of 100kg23:10:5+6S+1.0Zn twenty (20) days after seedling emergence and 50kg Urea at 60 days after seedling emergence. This is the most profitable regime. Alternatively apply 120kg 23:10:5+6S+1.0Zn and 15kg UREA per hectare 3 weeks after seedling emergency, followed by 145kg UREA per hectare 9 to 10 weeks after seedling emergence.

b) Senga (IET 4094), Changu (IR1 561-250-2-2), Nunkile (Pusa 33), Mtupatupa (TaichungSen 10) and Vyawo (ITA 302), require an application of 80kg nitrogen and 25Kg Phosphate (P2O5) per hectare. Recent research has shown that farmers can substantially increase yield of Nunkile, Vyawo and Mtupatupa by applying 240kg nitrogen at Lifuwu and Domasi, 120kg nitrogen at Nkhate and Muona and 160kg nitrogen at Limphasa, Hara, Lufilya schemes. An application of 25kg Phosphate (P2O5) per hectare should also be done. The higher nitrogen rates depict declining soil fertility in irrigation schemes.

   These rates will be achieved by applying 100kg of 23:10:5+6S+1.0 Zn and 5Kg Urea at the time of transplanting. Each fertilizer is applied separately to achieve good distribution in the field. This is followed by an application of 100kg of Urea per hectare at 40 days after transplanting for all varieties except Nunkile which should be top dressed at 25 days after seedling emergence. This is the most profitable regime. Alternatively 120kg 23:10:5+6S+1.0Zn and 60kg of UREA at the time of transplanting. This should be followed by 200 kg of UREA per hectare four to six weeks after transplanting.

   The higher nitrogen rates (240,160,120) can be achieved by applying 119kg 23:10:5+6S+1.0Zn and 200kg Urea at transplanting at Lifuwu and Domasi followed by 260kg Urea at 40days after transplanting. At Nkhate and Muona, 119kg 23:10:5+6S+1.0 Zn and 71kg Urea should be applied at transplanting following by 130 kg urea at 40 days after transplanting. Farmers at irrigation schemes applied at of Limphasa, Hara, Lufilya and Wovwe should apply 119kg 23:10:5+6S+1.0Zn and 114kg Urea followed by 174kg Urea at 40 days after seedling emergence.

3.1.2.4.5. Pest control

3.1.2.4.5.1. Weed control

Ploughing immediately after harvest helps reduce weed population. Puddling helps further in the initial weed control operations. After broadcasting or dibbling, hand weeding is the only recommended method of weed control in rainfed rice. Hand weeding should be done at 2, 4 and 6 weeks after seedling emergence. In irrigated schemes, hand weeding and use of chemicals are recommended. The herbicide, Ronstar 25EC should be applied at the rate of 3 liters in 300 liters of water per hectare using a sprayer. The application should be done soon after transplanting within 3 days, on moist soil. Irrigation water should be applied after 3 days. Proper water control helps to reduce weeds that do not withstand submergence.

Nadanga weed *(Echinochloa crusgalli)*

This weed is a serious problem in rice fields. It is not easy to distinguish the weed from rice until flowering. Control is therefore very difficult and always late. Farmers in schemes affected by this weed gaining experience in identifying it and they should be advised to frequently check their fields in order to clean their plots of the weed. Transplanting in rows assists in easy identification of the weed.

The uprooted weeds should be taken far away from the plots and destroyed either by burning or deep burying. Where there is a heavy infestation of the weed, maize should be grown after the rice crop to enable easy identification so that it can be controlled.

3.1.2.4.5.2. Bird control

Birds are the most important pest of rice and substantially reduce yields. These should be controlled by scaring. The most common are Quelea quelea and other Weaver birds.

3.1.2.4.5.3. Insect pest control

(i) Green grasshoppers *(Ruspolia differens)* this insect pest locally known as *Bwanoni* can be a serious pest in rice. Sorghum, millets and wheat may also be attacked. In rice fields, yield losses maybe up to 80%. They prefer feeding on the grain at milky stage. Control is by spraying 50EC at a dilution rate of 136ml in 14 liters of water for knapsack sprayer or 1 liter of water for ULV sprayer, or Carbaryl 85WP, 85g in 14 liters of water for knapsack sprayer or 1 liter of water for ULV sprayer.

(ii) Shootfly *(Diopsis oryzae)* and African Army worm (*Spodoptera exempta)*. Where these are a problem, control is by spraying Carbaryl 85WP at the rate of 85g in 14 liters of water for knapsack sprayer or 1 liter of water for ULV sprayer at seedling emergence and 9 to 10 weeks after transplanting.Alternatively spray a pyrethroid of Deltamethrin 10mb/l using either ULV or knapsack sprayer should also be sprayed to control stalk eyed shoot flies, other flies and moths at seedling emergence in dibbled rice, and at 3 weeks and 6 weeks after transplanting. Army worm should be controlled as it appears.

3.1.2.4.5.4. Disease control

Diseases of economic importance are Leaf blast caused by *Pyricularia oryzae* and brown spot caused by *Helpminthosporium oryzae*. The control measure for both diseases is good crop husbandry such as correct plant spacing, fertilizer application, water control and use of certified seed. Burning of infected crop residues also reduces incidences of the diseases. In 2014, Rice Yellow Mottle Virus was confirmed to occur in Malawi, work is in progress to identify the strain of the virus and search for mitigation measures.

3.1.2.4.5.5. Harvesting

Paddy is ready for harvesting when the grains on the panicles are golden brown (straw coloured) and when three quarters of the panicles in the field are at this stage. Rice reaches maturity about

30 days after 50 % flowering time. To obtain the best whole grain rice yields, harvest rice at 8 to12 days after maturity date in wet season and 4 to 8 days after maturity in dry season. Where moisture meters are available, the rice should be at 20 to 30% moisture content. Water should be drained 7 to 10 days before the expected date of harvesting to ensure uniformity of maturity and to enable the farmer to harvest in drier fields.

3.1.2.4.5.6. Threshing and winnowing

Rice should be cut using sickles at 5 to 10 cm above the ground and threshed on the same day. This is because rice does not dry fast on straw laid down on ground. Threshing should be done on mats or black plastic paper by beating with sticks or a handful of rice on straw to release the grains. Threshed rice should be winnowed using flat basket, move chaffs, broken straws, unfilled grains and other foreign matter from the well filled grains.

3.1.2.4.5.7. Drying

The winnowed rice should be dried by spreading it on mats for two sunny days to enable it reach 14% moisture content which is safe for storage. High whole grain percentage is obtained when it is taken for milling soon after drying period. If stored for a longer period, dry it in the sun for a day before milling.

3.1.2.4.5.8. Storing

Proper storage facilities include sacks and cribs (nkhokwe). Well dried paddy should be stored in moisture-proof, well aerated structures and guarded against insects and rodents. Dusting with Actellic Super (Bifelthrin) and Super Grain Dust at the rate of one sachet (40 g) to a bag (75 kg) of paddy controls rice weevil (Sitophilus oryzae) attack. Farmers should be encouraged to use rat guards in nkhokwes to control rats.

3.1.2.4.5.9. Marketing

Paddy which is ready for sale should be free of chaff, stones, dirt and any other foreign materials and be dried to14% grain moisture content. Some buyers can, however, purchase paddy at 16 to 20% grain moisture content. The main buyers are ADMARC, NASFAM and other Private Traders.

Usually buyers accept two grades of paddy. Grade one paddy is well winnowed and free of foreign material and diseased grains, and is bought at a premium price, otherwise it is down-graded to grade two and bought at an inferior price.

Besides marketing paddy, individuals in the country mill their paddy at maize mills or rice mills in irrigation schemes and sell the milled product at prices which vary between areas and individuals. This value adding should be encouraged in all the rice growing areas.

3.1.2.4.5.10. Rice production

Estimated rice production for the past ten seasons is as shown in Table 24.

Table 24: Estimated rice hectarage and production (mt) for the past ten seasons

Year	Area (Ha)	Yield (Kg/ Ha)	Pro-duction (MT)
2010/11	61,559	1,913	117,733
2011/12	60,132	1,836	110,405
2012/13	65,275	1,917	125,156
2013/14	67,400	1,958	132,002
2014/15	65,761	1,695	111,437
2015/16	53,676	1,560	83,757
2016/17	49,880	1,414	70,536
2017/18	60,848	1,744	106,128
2018/19	59,665	1,624	96,891
2019/20	66,062	1,759	116,227
Average	**61,026**	**1,754**	**107,027**

3.1.3. SORGHUM
(Sorghum bicolor)

Sorghum is an important staple food in the Shire Valley and a food security crop in other marginal rain fall areas. It can also be an alternative cash crop. Sorghum is drought tolerant than maize. This makes the crop more suitable to these areas.

3.1.3.1. National aims

The objective is therefore to increase yields to meet food requirements and surplus for sale in the marginal rainfall areas. Smallholder farmers sorghum average yield is about 600kg per hectare. There is scope to increase yields up to 2,500kg per hectare with improved varieties under good management.

3.1.3.2. Improving yields

In order to achieve high yields, the following husbandry practices are recommended:-

3.1.3.2.1. Varieties

3.1.3.2.1.1. Use of Improved varieties

The following improved varieties are recommended:-

Pilira 1(SPV 351)

The variety is recommended for Karonga, Salima, Bwanje Valley, Rivirivi and Mpilisi. It matures between 100 and 115 days with a plant height of 1.4 to 1.7 meters. It has a spindle-shaped, well exerted and semi-compact panicle with hard and corneous white grain. It has a threshing value of 52.1% and a yield potential of 3,400kg per hectare.

Pilira 2 (SPV 475)

The variety is currently only recommended for the Shire Valley. It matures between 110 and 120 days with a plant height of 1.5 to 1.8 metres. It has an elliptic-shaped exerted and semi compact panicle with hard cream coloured grain. It has a yield potential of 3,000kg per hectare and threshing value of 48.2%.

Farmers can obtain seed of Pilira 1 and Pilira 2 from growers and breeders. This seed can be used for two successive seasons. Farmers should rogue off types, in the field and remove any diseased small sized and off coloured seed.

3.1.3.2.1.2. Unimproved varieties

Farmers can also use the tall unimproved sorghum varieties like Thengalamanga, Kasonthe, Masotong'o, Dikwa, Kawaladzuwa, Gwiramtima, Sinakhomo, PN3, Kayera, Acc 967, and Makolokoto.

Gwiramtima

This is a high yielding (2,400 - 3,500kg/ha), tall (33 - 400cm) and very early maturing (100 - 105 days) sorghum variety that is disease, insect pest and drought tolerant. It is photoperiod insensitive, and has an intermediate, hard creamy white medium- sized grain type that is highly nutritious and greatly favoured by consumers because of its excellent food quality and palatable taste. Gwiramtima (meaning eating with satisfaction in the Sena language) is especially recommended for the Shire Valley.

Makolokoto

This is a high yielding (2,100-3,700kg/ha), tall (338-360 cm), late maturing (130-140 days) sorghum variety that is disease and insect pest tolerant, drought tolerant and photoperiod insensitive. It has an intermediate, hard creamy white medium- sized grain that is highly nutritious and favoured by consumers. It has an excellent polished grain quality that has excellent food qualities with a palatable taste. Makolokoto (meaning completely satisfied in the Sena language) is recommended for the Shire Valley.

Sinakhomo

This sorghum variety has a yield potential of up to 3,000 kg/ha, is tall (338-360 cm) and is early maturing (100-112 days) sorghum variety that is disease and insect pest tolerant, drought tolerant and photoperiod insensitive. It has an intermediate, hard creamy white medium-sized grain that is highly nutritious and favoured by farmers and consumers. It has an excellent polished grain quality with good food quality and taste. Sinankhomo (meaning eating without end in Sena) is recommended for the Shire Valley as well.

PN3

This is a short maturity (90days) sorghum variety that is adapted to low and medium altitude areas (60-1000masl), and is tolerant to drought. This variety is ready for harvesting by mid to end March when planted in mid to end December. PN3 is a short-sheathed inter-node sorghum variety that grows to a height of 130 cm at maturity. The stem base is thick, light green in colour and produces no tillers. It takes 59 days to reach 50% flowering and 90 days to physiological maturity (when a black layer is formed on the grain) with 12 to 15 functional leaves remaining on the plant. Its potential yield is 3,000kg/ha on soils of moderate fertility, but yield can be greatly reduced when dry spell occurs during panicle development or flowering stage 30 to 60 days after emergency, or at temperatures above 30oC.

Kayera

This is a high yielding (2,100-3,000kg/ha), tall (342-355cm) and early maturing (115-121days) variety tolerant to disease and insect pests, drought and photoperiod insensitive. It has an intermediate, hard creamy white medium-sized grain that is highly nutritious and preferred by farmers and consumers. It has an excellent polished grain quality, good flour and palatability. Kayera (meaning white-grained in the Sena) is recommended for sorghum growing areas in Machinga, Salima and Karonga districts.

Acc 967

This is a high yielding (2,000-3,500kg/ha), tall (290-314 cm), early maturing (115-121 days) sorghum variety that is disease and insect pest tolerant, drought tolerant and photoperiod insensitive. It has an intermediate, hard creamy white medium- sized grain that is highly nutritious and favoured by farmers and consumers. It has an excellent polished grain quality, good flour quality and good food palatability taste. Acc 967 is also recommended for sorghum growing areas in Machinga, Salima and Karonga districts.

3.1.3.2.2. Field preparation

Early land preparation is recommended. In the Shire Valley and other marginal rainfall areas, soil moisture can be retained for longer periods by ridging and box ridging. Remove all weeds, shrubs and stumps. Loosen the soil, break clods and smoothen out. Prepare ridges at 75cm apart for the short varieties and 90cm apart for the tall varieties. Avoid clods to ensure good seedling emergence and establishment.

3.1.3.2.3. Planting and plant population

Plant with the first planting rains of 25mm or wetting to a soil depth of 15cm in order to take full advantage of the rainy season. Split each ridge 2.5cm deep and plant 5 seeds into the groove every 30cm and cover the ridge. Thin to 2 seedlings per station when plants are15cm high. The seed rate is 5kg per hectare. Plant unimproved varieties at 90cm apart between ridges and 45cm apart between plants.

3.1.3.2.4. Fertilizer application

Fertilizer is only recommended for improved varieties as follows:

(i) **Basal Fertilizer application:**

Split each ridge to a palm's depth. Sprinkle 1m ridge length with 18g of 23:10:5+6S+1.0Zn fertilizer or use two and a half capfuls of cup No 8 and cover before planting.

(ii) **Top dressing**

Top dress sorghum after thinning. Make 2.5cm deep groove on the side of the ridge (10cm) away from the plants. Apply 4.5g of Urea per 1m ridge length using one heaped cup No 5 or 7 g for CAN per 1m ridge length using one cupful of No.8.

3.1.3.2.5. Pest control

3.1.3.2.5.1. Weed control

Timely weeding during the first 6 to 8 weeks should be followed by banking.

3.1.3.2.5.2. Bird control

The most important pests of sorghum are birds and should be scared right from head formation to harvesting.

3.1.3.2.5.3. Insect pest control

The most important insect pests of sorghum are Shoot fly (Atherigona soccata) and Stem borer (Chilo partellus). Stem borers will mostly attack late planted sorghum. Control is by planting early. Gaucho seed treatment is required at planting to control Shoot flies systematically. Ecoterex 0.5 GR can be placed in plant whorls (funnels) at a rate of 0.1 g per whorl to control stem borer.

3.1.3.2.5.4. Disease control

Experience in the shire valley is such that the recommended varieties are generally resistant to most disease of economic importance. Leaf blight (Helminthosporium turcicum) has been observed but this normally occurs in the crop later in the season when improved varieties have formed grain.

The improved varieties of Pilira 1 and 2 are tolerant to both Downy Mildew (Sclerospora sorghi) and Sooty Stripe (Ramulispora sorghi) where as they occur in the unimproved varieties. They can therefore be controlled by timely sowing and growing of improved varieties.

There are two types of grain moulds namely; Fusarium spp and Culvularia spp which are fungal diseases. These are normally experienced when harvesting is delayed. Farmers are therefore advised to harvest as soon as physiological maturity occurs where this disease is prevalent, particularly where rains are continuous.

3.1.3.2.6. Harvesting and threshing

Harvesting should be done as soon as the crop has reached physiological maturity. This may be 3 months after planting. At this stage the grain has 25% to 30% moisture content and forms a black layer at the hilum region. Timely harvesting minimizes weevil attack in the field, bird damage and shattering. Cut the dried heads and put them in a bag. When threshing beat the bag to loosen the grain from the heads.

3.1.3.2.7. Storing

Dry the grain well to about 12.5% moisture content and store in dry structures. Treat the grain with Actellic Super Grain Dust or Wivokill superdust at the rate of 25g per 50kg bag of sorghum and store in a dry clean place. The grain may also be stored into a crib (nkhokwe). Put into the crib (nkhokwe) treated grain. Before starting to fill the crib (nkhokwe) clean and remove all old grains. Sprinkle evenly some Actellic Super or Super Grain Dust on the side and floor of the crib (nkhokwe) roughly at the rate of one sachet (40g) for every sq.m.

Table 25: Estimated sorghum production (mt) for the past ten seasons

Season	Cultivated Area (Ha)	Yield (Kg/ha)	Production(mt)
2010/11	89,602	818	73,330
2011/12	79,782	854	68,111
2012/13	89,399	965	86,242
2013/14	92,093	1,012	93,187
2014/15	93,858	845	79,327
2015/16	98,853	589	58,192
2016/17	98,846	589	58,186
2017/18	103,912	870	90,361
2018/19	106,242	780	82,852
2019/20	114,130	1167	133,212
Average	**96,672**	**851**	**82,300**

3.1.4. PEARL MILLET
(Pennisetum glaucum L. Leeke)

Pearl millet is an important food crop mostly grown in the Shire Valley. Farmers should be encouraged to grow grow pearl millet due to its tolerance to drought.

3.1.4.1. National aims

The aim is to increase production of this crop in marginal rainfall areas. Pearl millet yield on average is 600 kg per hectare but there is potential to increase yield to 2,000kg per hectare using improved varieties. The objective is therefore to increase yield to this level.

3.1.4.2. Improving yields

In order to improve yields, the following husbandry practices should be followed:-

3.1.4.2.1. Use of recommended varieties

Farmers should be encouraged to grow improved varieties which are high yielding.

Nyankhombo (Okashana–1)

This variety is currently recommended for the Shire Valley. It matures very early (75 to 80 days) and has a plant height of 1.9 to 2.3m. It has a large candle shaped panicle that measures 20 to 26cm long. The grains are large and global, soft to intermediate in hardiness and grey in colour. It has a yield potential of 2,500kg per hectare.

Tupatupa (SDMV 89005)

It is intermediate maturing and grows 2.3 to 2.9 meters in plant height. It matures in 90 to 100 days and has a yield potential of 3,500kg per hectare. Panicles are cylindrical shaped, 26 to 32cm long. It has oval medium sized grains which are grey white in colour and intermediate hardiness.

SDMV 90031

This is a high yielding variety, yielding above 2800 kgha-1. It has a large seed size of about 11.4g. with grayish grain colour. It grows tall (177-194cm) and matures very early. It is resistant to drought, diseases and insect pests such as Stem borer. Seeds of these varieties can be obtained from registered growers and breeders. Since pearl millet is an out crossing crop, farmers must use fresh seed each season. Farmers can also use unimproved pearl millet varieties grown in their areas.

3.1.4.2.2. Field preparation

Early land preparation is recommended both in Shire valley and other marginal rainfall areas. Soil moisture can be retained for longer periods by ridging and box ridging. All weeds, shrubs and stumps must be removed and soil clods broken and smoothened out. Ridges for improved varieties should be prepared at 75 cm and 90 cm for those unimproved. Alternatively pearl millet can also be grown on the flat at 75 cm between rows and 90 cm apart between rows for improved and unimproved varieties respectively.

3.1.4.2.3. Planting and plant population

Pearl millet must be planted with first planting rains when 25mm rainfall has fallen. Split the ridge 2.5cm deep and plant 5 seeds into the grove every 40cm and cover the ridge. Thin to 2 seedlings per station when plants are 15cm high. Pearl millet maybe planted in furrows or side of the ridge to give better crop establishment in marginal rainfall areas. The seed rate is 4kg per hectare.

3.1.4.2.4. Fertilizer application

Fertilizer application is recommended as follows:-

Either use 200kg of 23:10:5+6S+1Zn per hectare at the time of planting. Apply using drilling method 18g per meter of ridge using two and half cupfuls of cup No.8.

Or

100kg of 23:10:5+6S+1.0Zn at the time of planting or soon after seedling emergence. Apply 9g per meter of ridge length using two cup full of cup No.5. This should be followed by 50kg of Urea per hectare. Apply 4.5g per meter of ridge length using one heaped cup No.5;

There are no significant responses to fertilizer in heavy and alluvial soils such as those in some parts of Shire and Bwanje Valleys.

3.1.4.2.5. Pest control

3.1.4.2.5.1. Weed control

Timely weeding during the first 6 weeks is recommended and should be followed by banking.

3.1.4.2.5.2. Bird control

Birds are most important pests of pearl millet and they should be scared right from head formation to harvesting.

3.1.4.2.5.3. Disease Control

The Disease of economic importance is Downy mildew and can be controlled by use of improved varieties and early planting.

3.1.4.2.6. Harvesting

Harvesting should be done as soon as the crop has reached physiological maturity. At this stage the grain has 25 to 30% moisture content. Timely harvesting minimises weevil attack in the field, grain damage and shattering.

3.1.4.2.7. Storing

Dry the grain well to about 12.5% moisture content and store the crop in dry structures. Treat the grain with Wivokil Super Dust or Actelic Super Grain Dust at the rate of 25g per 50kg bag. Before starting to fill the crib (nkhokwe),Clean and remove all old grains before filling the crib (nkhokwe. Sprinkle evenly some Grain Dust on the side and floor of the nkhokwe roughly at the rate of one sachet (40g) for every 3sqm.

Farmers are also encouraged to use hermatic bags for storage without use of pesticides.

Table 26: Estimated Pearl Millet production (mt) for the past ten seasons

Year	Area (Ha)	Yield (Kg/Ha)	Production (MT)
2010/11	992	439	435
2011/12	12,418	832	10,333
2012/13	1,031	464	478
2013/14	1,011	481	486
2014/15	967	442	427
2015/16	972	396	385
2016/17	972	396	385
2017/18	19361	553	10699
2018/19	27579	432	11912
2019/20	17977	863	15510
Average	**8,328**	**613**	**5,105**

3.1.5. FINGER MILLET
(Eleusine coracana)

Finger millet is an important food and cash crop in the plateau areas in the Northern Region. The slash and burn (Visoso) as practiced in Chitipa and Karonga and Mzimba destroys vegetation and land productivity and should therefore be discouraged.

3.1.5.1. National aims

The aim is to increase yield per unit area through better production practices. Present yields range from 500 to 800kg per hectare but the crop can yield up to 2,000 kg per hectare. The goal is to increase production through improving yields and not expanding hectarage.

3.1.5.2. Improving yields

In order to improve yields of finger millet the following husbandry practices are recommended:-

3.1.5.2.1. Improved cultivars

Plant improved cultivars such as Dopalopa and Mavoli which are red and white grained.

3.1.5.2.2. Field preparation and spacing

Plant 2 to 4 weeks after first rains to allow Rapoko grass (Eleusine indica), a weed which looks like millet to emerge so that it can be controlled before millet is sown.

Plant by drilling in rows 30cm apart on flat with well-built contour bunds, or drill on flat ridges 90cm apart with 2 rows per ridge spaced at 30 cm and thin to allow not more than 5cm between plants. The seed rate is 7 kg per hectare.

3.1.5.2.3. Fertilizer application

For all finger millet cultivars apply 200kg of 23:10:5+6S+1.0Zn per hectare. Apply 6g per meter on the flat using one and half cup full of cup No.5, or 18g per meter on ridges using two and half cupfuls of cup No.8.

3.1.5.2.4. Weed control

The crop should be free from weeds during the first 6 to 8 weeks as this is the period when the crop is least able to stand competition.

3.1.5.2.5. Disease control

The most important disease of finger millet is Head blast which causes premature drying of fingers. It can be controlled by using tolerant cultivars namely Dopalopa and Mavoli.

3.1.5.2.6. Harvesting and storage

Harvest the crop when the heads are dry and store whole heads in dry structures such as nkhokwes. Farmers are encouraged to store their produce in hermatic bags without application of pesticides.

Table 27: Estimated Finger Millet production (mt) for the past ten seasons

Year	Area (Ha)	Yield (Kg/Ha)	Production (MT)
2010/11	45,359	716	32,476
2011/12	32,740	698	22,865
2012/13	47,725	813	38,784
2013/14	48,587	859	41,716
2014/15	49,420	669	33,065
2015/16	50,706	377	19,125
2016/17	50,705	377	19,125
2017/18	36,031	678	24,422
2018/19	26,651	728	19,403
2019/20	37,550	750	28,176
Average	**42,547**	**656**	**27,916**

3.1.6. WHEAT
(Triticum aestivum L.)

Wheat is an important cereal crop which is grown both for cash and food. It is mostly grown under residual moisture in Tsangano, Neno, Dedza, Mchinji, Ntchisi Hills, Phoka Hills, Viphya plateau and Misuku Hills. There is a high demand for wheat in the country. The current production is estimated at 2000 tonnes per annum which is only about 5% of the total grain requirement of over 100,000 metric tonnes. The country imports the difference to meet the short fall. There is need therefore to increase production in order to meet national demand.

3.1.6.1. National aim

Government aim is to increase production through improving yields and fully utilizing suitable areas to meet domestic demand and reduce dependence on imports.

Current yields range from 400 to 900kg per hectare but there is potential to increase yields to 3,500kg per hectare.

The strategy is to promote wheat production under irrigation and residual moisture in the high altitude areas.

3.1.6.2. Improving yields

In order to improve yields the following husbandry practices are recommended:-

3.1.6.2.1. Use of improved varieties

Kenya Nyati: This variety is recommended to be grown in the rainy season and is well adapted to high altitude area of 1,000m above sea level or more. It performs well in these areas when the main rains are tailing off and the cool season is setting in. It is tall (90 to100cm) with medium to late maturity (140 to 150 days). It has a yield potential of 3,500kg per hectare and has good baking qualities. It is susceptible to leaf rust and stem rust. All the recommended irrigated varieties do well under rainfed condition.

Irrigated

Torim73: It is a semi-dwarf variety with a mean height of 83cm and a yield potential of around

6,000kg per hectare and it matures in 90 to 120days

Limpopo

It is a dwarf variety (60cm) and of early to medium maturity (90 to 120 days). It has good baking qualities with a yield potential of 3,400kg per hectare. It is adapted to different altitudes and tolerant to leaf rust, stem rust and powdery mildew.

Jupateco 73

It is a semi-dwarf wheat variety adapted for production under irrigation in upland areas and matures in 90 to 120 days. It grows to a height of 80cm and has a yield potential of about 3,500kg per hectare.

Loerie

It is semi–dwarf variety (75 to 100cm) which is recommended for production under irrigation in medium to upland areas. It matures in about 120days. It has a yield potential of 4,500kg per hectare or more.

Gamtoos

It is a semi–dwarf wheat variety which is about 75–100cm and matures in about 120days. It has a yield potential of 3,500kg per hectare and better baking qualities.

Other released wheat varieties include SC Nduna, SC Smart and SC Stallion.

3.1.6.2.2. Field preparation

Make a fine tilt seedbed to ensure good seedling emergence and establishment.

3.1.6.2.3. planting

Rainfed wheat should be planted just after the heavy rains have tailed off and drizzles have started. For Tsangano, Neno and Ntchisi Hills, this time is between early March and early

April. In Phoka Hills, Viphya plateau and Misuku Hills, wheat planting should start from mid-April to mid-May. For the irrigated crop, planting should be done from end April to mid-June.

3.1.6.2.4. Method of planting

Drill seed in rows 30cm apart and 5cm deep. This requires a seed rate of 80kg per hectare for the crop grown under residual moisture and 100 kg per hectare for the irrigated crop.

3.1.6.2.5. Fertilizer application

All types of fertilizers applied in wheat should be drilled 10cm deep and 10cm away from the rows.

3.1.6.2.5.1. Rainfed wheat

Apply 100kg of 23:10:5+6S+1.0Zn and 100kg of UREA per hectare. Apply 12g per 4 meters of row length using 3 cup full of cup No.5 for each type of fertilizer.

3.1.6.2.5.2. Irrigated wheat

For basal dressing apply 200kg of 23:10:5+6S+1.0Zn per hectare. Apply 12g per 2 meters of row length using 3 cup full of cup No.5. For top dressing, or 100kg Urea per hectare. Apply 12g per 2 meters of row length using 3 cup full of cup No.5. Apply the fertilizer 3 weeks after planting.

Irrigation

Irrigate to field capacity at time of sowing for good emergence and establishment. Irrigate at 14 to17 days after emergence to stimulate rooting and tillering. Irrigate when the wheat plants show signs of water stress. Irrigation should be stopped when the majority of ears and flag leaves are yellowing.

3.1.6.3. Pest control

3.1.6.3.1. Weed control

It is recommended to keep the crop weed free as much as possible, particularly during the first 3 weeks after emergence.

3.1.6.3.2. Bird control

Birds are the most important pests of wheat especially Quelea spp(mpheta) and should be controlled by scaring from grain setting period to harvesting.

3.1.6.4. Disease control

Common diseases of wheat are leaf rust (Puccinia recondita), stem rust (Puccinia graminis), powdery mildew (Erysiphe graminis), loose smut(Ustilago nuda), leafblotch (Helminthosporium spp.) and stem blotch (Septoria spp.). Rust is favoured by a humid environment when temperatures begin warming in August. Severe infections reduce kernel weight, test weight and kernel quality.

Control is by growing tolerant varieties namely Kenya Nyati, Limpopo, Torim73, Jupateco, Loerie and Gamtoos.

3.1.6.5. Seed selection and storage

Seed of the improved varieties is not available and farmers should be encouraged to select and keep their own seed. The purity of the variety should be maintained by rogueing off types in the field at time of physiological maturity (yellowing stage). Any off type, rotten and diseased seed should be discarded at time of processing. Enough seed should be kept for planting.

3.1.6.6. Harvesting

Cut and stook the crop as soon as it has reached physiological maturity. The grain will be dry and flinty at this stage. Threshing should be done on clean surfaces to avoid grain mixing with sand, stones and trash.

3.1.6.7. Marketing

Farmers should only sell clean and dry wheat (12.5% moisture content). All shriveled and off type seed, stones and any trash should be removed

3.1.6.8. Storage

Store the crop in clean packaging materials such as bags and should be put on a dunnage (raised platform). An application of Grain Dust at the rate of 25g per 50kg bag of grain will prevent weevil attack.

3.1.6.9. Wheat production

Estimated wheat hectarage and production for the past ten seasons is shown in table 28.

Table 28: Estimated wheat hectarage and production for the past ten seasons

Year	Area (Ha)	Yield (Kg/ Ha)	Produc-tion (MT)
2010/11	1,216	1,521	1,850
2011/12	1,291	1,473	1,901
2012/13	1,269	1,406	1,784
2013/14	946	1,226	1,160
2014/15	921	1,279	1,178
2015/16	717	1,112	797
2016/17	717	1,112	797
2017/18	607	1,227	745
2018/19	583	1,209	705
2019/20	557	1,233	687
Average	**882**	**1,315**	**1,160**

3.2. Grain Legumes

Grain legumes are an important source of vegetable protein. Farmers should therefore be en-couraged to grow them for their own consumption, to improve their nutritional status and for cash. Where landholdings are small, grain legumes should be interplanted with maize, cassa-va, sorghum and other crops Groundnuts, phaseolus beans, soyabeans, pigeonpeas, cowpeas, groundbeans, chickpeas, fieldpeas, guarbeans, grams, velvet beans and dolicus beans are Grain legumes commonly grown in Malawi.

3.2.1. National aim

The policy aim is to increase production of grain legumes for local consumption to improve the nutritional status of the rural and urban communities and surplus for cash.

3.2.2. PHASEOLUS BEANS *(Phaseolus vulgaris)*

Beans are a good source of protein and income. The green leaves are valuable vegetables. The crop is grown throughout the country mostly in cool plateau areas. Beans can also be grown in low altitude areas during winter months of April to July under residual moisture.

The bean yields for both pure stand and interplanted are around 300kg to 800kg per hectare. However the potential yields are 2000kg/ha for large seeded varieties and 2,500kg per hectare for small seeded varieties. The objective therefore is to increase production by improving yields while ensuring that varieties of desirable cooking characteristics and highly market demanded varieties are promoted. Where it is not possible for farmers to plant beans in pure stands, they should be interplanted with other crops such as maize or grown as a relay crop thereby maximizing production from the same piece of land.

Improving yields

In order to improve yields, the following cultural practices are recommended:

3.2.2.1. Use of recommended improved varieties

Farmers should be encouraged to use improved varieties. There are several improved varieties recommended and they include PAN 148, PAN 9249, VTTT 924/10-4, Cim-Dwarf-01-12-2, NUA 35, Nasaka, Bwenzilaana, Sapelekedwa, Kamtsilo, Napilira, Maluwa, Nagaga, Mkhalira, Kambidzi, Kalima, Sapatsika, Chimbamba, BCMV-B2, BCMV-B4, BC-D/O(19), Kholophethe, Kabalabala, NUA 45, NUA 59 and VTT 924/4-4 which are determinate (dwarf) and Kanzama, Bunda 93 and Namajengo which are in determinate (climbing varieties). Seed descriptions for these varieties are presented in Table 29a.

In irrigation schemes farmers should be advised to plant as soon as the summer crop has been harvested. The dimba crop should be planted when the climate is favourable. In the Lake Shore, the crop can be planted in May to June while in upland, planting should be done in July to August when temperatures have warmed up.

Table 29a Phaseolus bean seed description

Name	Growth Habit	Day To Maturity	Potential Yield/ ha (Kg)	100 seed weight (g)	Seed coat Color
Kholophethe	Bush	95	2500	55	Sugar-cream/red speckled
PAN 148	Bush	100	2100	42	Burge/white-/red speckled
PAN 9249	Bush	110	2500	58	Burge /white-Red Speckled
VTTT 924/10-4	Bush	75-80	3000	45	Red
VTTT924/4-4	Bush	70	2500	41	Sugar-cream/red speckled
Cim-Dwarf-01-12-2	Bush	85	3000	45	Red mottled
NUA 35	Bush	70	2500	52	Red mottled
NUA 45	Bush	70	1300	45	Red mottled
NUA 59	Bush	70	2000	50	Red mottled
Nyambitila	Bush	70	2500	48	Red
Namtupa	Bush	70	2500	48	Red
Chitedze Bean 1 (CB1)	Bush	70	2500	42	Red
Chitedze Bean 2 (CB2)	Bush	70	2500	48	Red
Chitedze Bean 3 (CB3)	Bush	70	2500	54	Red
Chitedze Bean 4 (CB4)	Bush	72	2500	45	Red Kidney
Chitedze Bean 5 (CB5)	Bush	75	2500	45	Red Kidney
Namajengo	Climber	90	1200	23	Red
Saperekedwa	Bush	90	1500	36	Red
Kanzama	Climber	95	1500	35	Red mottled
Kalimtsiro	Climber	90	1200	31	Black
Nasaka	Bush	80	1200	45	Khaki
Bwenzilaana	Bush	85	1500	49	Yellow
Kalima	Bush	90	1500	51	Red mottled
Bunda 93	Climber	90	2000	37	Red mottled
Chimbamba	Climber	90	1500	43	Red
BCMV-B2	Climber	80-90	2500	19	Brown
BC-D/O (19)	Bush	80-90	2000	37	Sugar-Cream/red speckled
BCMV-B4	Climber	90	2000	39	Sugar-Cream/red speckled
Kambidzi	Bush	85	2500	22	Cranbery
Maluwa	Bush	85	2000	41	Red mottled
Mkhalira	Bush	85	2500	24	Khaki
Napilira	Bush	90	2000	42	Red mottled
Sapatsika	Bush	90	2000	46	Red
Nagaga	Bush	90	2000	54	Khaki
Kabalabala	Indeterminate	90	2800	27	Navy

3.2.2.2. Field preparation

Field for the crop should be ready before the onset of the first planting rains.

3.2.2.3. Time of planting

For the interplanted crop, planting should be done soon after planting the main crop or as soon as the main crop has emerged. For the pure stands, planting should be done at onset of the first planting rains. In relay cropping, planting should be when the main crop has reached physiological maturity.

In irrigation schemes farmers should be advised to plant as soon as the summer crop has been harvested. The dimba crop should be planted when the weather is favourable.

3.2.2.4. Plant population

To achieve high yields optimum plant population should be observed.

a) **Pure Stands and Relay Crop (Rainfed)**

Dwarf beans should be planted in 2 rows spaced at 30cm on the ridge. Plant 1 seed per station 10 cm apart along each row. The ridges should be 75cm or 90cm apart. This requires a seed rate of 80 to 70 per hectare respectively.

Climbing beans should be planted on 1 row, 1seed per planting station spaced at 15cm. This requires a seed rate of 75 to 90kg per hectare. To maximize podding and assist plants escape disease infestation climbing beans should be properly staked.

b) **Interplanted Crop**

Where maize is planted at 3 seeds per planting station, plant 4 bean seeds between maize planting stations. For dwarf varieties the interplanted crop requires the same spacing as in pure stands. Seed rate for both types is the same, 50 to 60kg/ha.

c) **Dimba Crop**

Beans should be planted on the flat as this assist in moisture conservation. Plant dwarf varieties in rows, 45cm apart, 1 seed per planting station spaced at 20cm. The seed rate is 40 to 50kg per hectare. Climbing varieties should be planted in rows 45cm apart 1 seed per planting station spaced at 30cm and they should be staked. The seed rate is 35 to 45kg per hectare.

d) **Irrigated Crop**

When planting beans under irrigation follow recommendations under pure stand and interplanted crop as described under rainfed conditions.

3.2.2.5. Fertilizer application

Fertilizer is essential particularly at the initial stages of bean growth. Where fertilizer is not available farmers are encouraged to apply manure. The fertilizer is needed for root development.

Use 23:10:5+6S+1.0Zn fertilizer at the rate of 100kg per hectare. Apply 18g per 2 metres of ridge length using two and half cupfuls of cup No.8.

3.2.2.6. Pest control

a) **Weed Control**

The crop should be kept free of weeds during the first 6 to 8 weeks after planting. Weeding after flowering, should not be practiced to avoid flower shedding. However, hand weeding where weeds are observed can be done as long as care is taken.

b) **Disease Control**

Use disease tolerant varieties. The new improved varieties such as Napilira, Maluwa, Sapatsika, Nagaga, Kambidzi and Mkhalira are moderately tolerant to major bean diseases in Malawi.

(i) **Anthracnose** *(Colletotrichum Undemuthianum)*

Anthracnose is a fungal disease which produces brown spots on the leaves, stem sand pods. Yield loss can go up to 100%. It can be controlled by spraying the crop with Mancozeb (Dithane M45) 80WP at the rate of 10g to 15g per 10 liters of water or chlorothalonil (Daconil–278W–75) 35g in 10 litres of water. Spraying should be done at fortnightly intervals using a knapsack sprayer. It can also be controlled by using a 3 year crop rotation with cereals, removal or burying crop residues, use of tolerant varieties and intercropping.

(ii) **Angular leaf spot** *(Phaeiosariopsis griseola)*

This is the most important disease in beans as it occurs annually in all bean growing areas. Yield losses can go up to 80%. Symptoms occur on all aerial plant parts, developing usually at flowering. The symptoms are initially grey spots which later become dark brown.

Control is by spraying Daconil at the same rate as for Anthracnose. Spray at 2 weekly intervals. Seed, wind, rain and soil are the principal means of spread. Therefore use of clean seed, burial of infected debris and rotation can decrease diseases severity.

(iii) **Web blight** *(Rhizoctonia solani)*

This disease is sporadic and when it attacks will affect the plant severely. Damage may be of up to 100%. Small necrotic spots first appear on primary leaves which later merge to affect the whole leaf, forming a web over the plant and leading to defoliation. Therefore cultural practices such as mulching can be highly effective in suppressing the disease.

(iv) **Halo blight** *(Pseudomonas syringae)*

The disease is caused by bacteria. It is a common disease in beans and can cause losses of up to 46%. It is characterized by small water soaked lesions which appear on the leaves and quickly develop greenish yellow halos. Plants may sometimes produce white exudates.

Control by use of tolerant varieties such as Nagaga, Napilira, Maluwa, Sapatsika, Kambidzi and Mkhalira and or by spraying copper oxychloride and as well as copper based fungicide.

(v) **Bean common mosaic virus** *(BCMV)*

The outstanding symptoms are dark green sectors on a lighter green background usually accompanied by downward curling of the leaf margins. This disease is transmitted by aphids and the control of aphids can hold the spread of the disease. The aphids can be controlled by spraying with Dimethoate 20WP or 40EC, 34g or 17ml in 14litres of water respectively sprayed at fortnightly intervals.

(vi) **Common bacterial blight** *(Xanthomonas camppestris pv phaseoli)*

This is a bacterial disease and can cause losses of up to 70%. The initial symptoms appear as water soaked spots on the lower side of the leaf. As the spots enlarge, the centers become necrotic and irregular. CBB may also occur on and inside seed which may bear pale yellow lesions and become wrinkled. Lesions may also develop on stems which may easily break under windy conditions.

Control is by use of tolerant varieties, and use of disease free seed as well as crop rotation.

3.2.2.7. Insect pest control

a) **Bean Stem Maggot** *(Ophiomyiaspp)*

This is an insect pest which attacks beans throughout the year. There are 3 species of the bean fly: Ophomyia phaseoli, O. Centrosematis and O. Spencerella. Attacked seedlings die or develop into weakened and stunted plants. Stems become dry or swollen and split with a cankerous growth. Pupae and Larvae may be lodged under the e p i d e r m i s . Total crop loss may be experienced when maggot densities are high. Infestation may be high in relay and late planted beans. There is no complete control for bean stem maggot, however, farmers are advised to adjust time of planting and practice good water management in irrigated crops as well as ensure good soil fertility management. Partial control may be achieved by seed dressing with AMIGO. Adjusted time of sowing, by planting early in cool wet and high altitude areas such as Misuku, Nyika, Viphya, Ntchisi, Dedza, Ntcheu and Shire Highlands and late planting in medium altitude areas such as Zomba, Kasungu-Lilongwe plain, Rumphi, Mzimba and Chiradzulu plains. Seed dressing with (Gaucho) Imidacloprid 70WP and spraying with carbary l85WP at the rate of 85grams in 14litres of water will also help. For the already infested crop, farmers are advised to earth up ridges in order to enable plants regenerate more roots below the base of the first roots.

b) **Bean Beetle**

(Ootheca Mutabilis and O. benning)

This is an insect which feeds on leaves of young plants making interveinal holes and damage is severe on plants in the primary leaf stage and may extend to upper leaves. The relay, dimba/ winter and the irrigated crops are not infested. It can be controlled by spraying Carbaryl 85WP at the r a t e o f 8 5 g i n 14 litres of water for knapsack or 1litre of water for ULV sprayer. Spraying should only be done when infestation is likely to cause economic damage.

Delayed planting where practicable may allow the crop to escape the damage from high colonizing populations at the beginning of the rains.

c) **Bean Aphids**

The black bean aphid *(Aphis fubae)* is the principal aphid that causes direct damage to beans in most areas while in lowland areas the cowpea aphid, Aphis craccivora may colonise and damage bean plants. Aphis spp is dull black with a pair of elongated process (cornicles) located near the tip of the abdomen and tail (cauda). Adults often have powdery white secretions on the abdominal segments. Winged forms disperse to colonise new fields or plants and may invade bean fields soon after emergence. Aphis craccivora is shiny black and lacks white secretion. Aphid populations usually build up during dry weather.

With severe infestations, production of honey dew and later sooty mould is easily noticeable. The plants lose their greenness and therefore look black. Under these conditions they will eventually not be able to effectively photosynthesize. They suck sap from plants and cause seedlings to wilt and die. Older plants may be stunted as a result of the attack. Apart from the above direct damage, aphids also transmit Bean Common Mosaic Virus.

Control

Control for both Bean aphid and Cowpea aphid is by spraying with Dimethoate (WP or EC) and Pirimab.

3.2.2.8. Harvesting

Harvest when most of the pods on the plant have started drying. Start harvesting in the morning when dew has evaporated. Do not harvest late when the pods are too dry to avoid loss of beans through shattering. Continue sun drying before threshing.

Actellic Super Dust and Wivokill to 50kg of grain to prevent Bruchid (Callosobruchus spp.) attack whose appearance can be mistaken for weevils.

Table 29b: Estimated bean production for the past ten seasons

Season	Area (Ha)	Yield (Kg/ha)	Production (mt)
2010/11	268,688	494	132,689
2011/12	310,978	537	182,596
2012/13	307,158	617	189,417
2013/14	316,686	616	195,048
2014/15	329,959	572	188,745
2015/16	328,339	481	157,769
2016/17	260,812	390	101,605
2017/18	265,372	509	135,031
2018/19	273,897	431	118,080
2019/20	360,457	598	215,547
Average	**331,091**	**534**	**176,893**

3.2.3. GROUNDNUT
(Arachis hypogaea)

Groundnut is one of the most important food and cash crops in Malawi. It is a good source of protein, vitamins and vegetable oils. However, in recent years production has not been satisfactory, as a result, Malawi has been importing substantial amounts of vegetable oils. It is therefore important to increase production of groundnut especially oil rich nuts as this would play an important role in import substitution. Like other legumes, groundnut is capable of fixing atmospheric nitrogen. When grown in rotation with other crops such as maize or tobacco, it improves soil fertility. Groundnut haulms also provide a good source of animal feed, especially in the dry season when feedstock becomes scarce.

3.2.3.1. National aim

The aim is to improve the yield and quality of both confectionery and oilnuts to meet the local and export demand, and provide raw materials to the domestic oil industry. Production of groundnut has not significantly increased. Malawi currently promotes two botanical or market types of groundnut, namely: Virginia types in the mid altitude agro-ecology and Spanish types in the lowland agro-ecology. The Virginia types take between 120 to 150 days to mature while the Spanish types take between 90 to 120 days to mature. Currently, six varieties are being promoted, and these are: Virginia types - CG 7, CG 8, CG 9, CG 10, CG 11, Chalimbana 2005,Nsinjiro, and Spanish types - CG 12, CG 13, CG 14, Chitala, Kakoma and Baka. These groundnut types combine high yield, disease resistance and other preferred market traits. The major objective is to increase yield per unit area and expand areas under groundnut cultivation.

Improving yields

In order to improve yields, the following good agronomic practices are recommended:-

3.2.3.2. Use of recommended improved varieties

Farmers should always use good quality/certified seed for higher yields. Groundnut seed like the other legumes can be recycled up to a maximum of 3 seasons. Such seed should be kept in shell until shortly before planting. After three years of recycling, fresh seed should be obtained from known and registered seed sources.

Farmers may obtain seed from reputable seed suppliers , The recommended varieties which fall on two groups of either Virginia or Spanish based on growth habit are:-

(i) **CG 7 (ICGV-SM 83708)**

Confectionery nut with medium seed size. It is recommended for production in all groundnut growing areas of the country. It has a bunch growth habit and tolerates drought. It matures in 130 to 150 days. The seeds are red, uniform and contain 48 % oil. It has a yield potential of 2500 kg per hectare. It is a Virginia runner in growth habit.

(ii) **Nsinjiro (ICGV-SM 90704)**

Nsinjiro is a confectionery nut recommended for production in all plateau areas of Malawi, within the altitude range of 1000-1500m above sea level. It matures between 120 to 140 days after sowing. The yield potential is close to CG7 but has the advantage of being tolerant to groundnut rosette. The seeds are tan in colour, 45 % oil. Nsinjiro has a potential yield of 2000 kg per hectare. The variety has spreading bunch growth habit.

(iii) **Chalimbana 2005 (CML 851/7)**

Chalimbana 2005 is a confectionery nut recommended for all plateau areas of the country within the altitude range of 1000 to 1500m above sea level. The variety was bred by the national programme and released for cultivation in 2005. Chalimbana 2005 is a Virginia bunch variety with a tan seed coat, and matures in 130 to 140 days. It contains 45% oil and has a yield potential of 2000-2500 kg per hectare. Additional attributes include moderate resistance to both rosette and early leaf spot diseases.

(iv) **Kakoma (JL 24)**

Kakoma is a confectionery nut recommended for production in all the low–lying areas within an attitude range of 200-500m above sea level such as the Shire Valley, Lakeshore Areas and also for off-season (dimba) cultivation. It matures in 90 to 120 days after sowing, has no seed dormancy and it should therefore be harvested as soon as it matures. The seeds are small, pale tan in colour and contain 48% oil. Kakoma has a potential yield of 1500 kg per hectare. It has erect bunch growth habit.

(v) **Baka (ICG 129991)**

Baka is a confectionery nut recommended for production in all the low–lying areas within an attitude range of 200-500m above sea level such as the Shire Valley, Lakeshore Areas and also for off-season (dimba) cultivation under residual moisture. Like Kakoma, it matures in 90 to 120 days after sowing, has no seed dormancy. The seeds are pale tan in colour and contain 48 % oil but are slightly smaller than Kakoma. However, Baka has an added advantage in that it is rosette tolerant. It has erect bunch growth habit.

(vi) **Chitala (ICGV-SM 99568)**

Chitala is a Spanish bunch confectionary nut grown within an attitude range of 200-500m above sea level such as the Shire Valley and other lakeshore areas. The variety can also be grown during the off-season under dimba cultivation using residual moisture or irrigation. Chitala has a seed yield potential of 1500kg/ha, matures in 90 to 100 days after sowing, and has no seed dormancy. The seeds are tan in colour, medium sized (41g/100 seeds) and contain48 % oil. An additional attribute of Chitala is resistance to rosette.

(vii) **CG 8 (ICGV-SM 08501)** include oil content for all the varieties

CG 8 is a newly released medium duration, Virginia type groundnut variety. It is recommended to be grown in mid-altitude areas. It has a yield potential of 2500 kg/ha. It is decumbent in growth, has dark-green leaves, orange- yellow flowers and reaches 50% flowering in about 40 days. It has a deep pod constriction produces 2 medium to large seeds per pod, red in colour and has a shelling percentage of ≥70%. It takes 120 to 130 days to reach maturity. It is resistant to groundnut rosette disease.

(viii) **CG 9 (ICGV-SM 08503)**

CG 9 is a newly released medium duration, Virginia type groundnut variety. It is recommended to be grown in mid-altitude areas. It has a yield potential of 2500 kg/ha. It is decumbent in growth and has green leaves, orange- yellow flowers, reaching 50% flowering in about 40 days. It has a very deep pod constriction, produces 2 medium to large seeds per pod, red in colour and has a shelling percentage of ≥70%. It takes 120 to 130 days to reach maturity. It is resistant to Groundnut Rosette Disease.

(ix) **CG 10 (ICGV-SM 01724)**

CG 10 is a newly released medium duration, Virginia type groundnut variety. It is recommended to be grown in mid-altitude areas. It has a yield potential of 2000 kg/ ha. It is decumbent in growth, has green leaves, orange-yellow flowers and it reaches 50% flowering in about 40 days. It has a deep pod constriction, produces 2 medium to large seeds per pod, light red in colour and has a shelling percentage of ≥69%. It takes 120 to 130 days to reach maturity. It is resistant to groundnut rosette disease.

(x) **CG 11 (ICGV-SM 01731)**

CG 11 is a newly released medium duration, Virginia type groundnut variety. It is recommended to be grown in mid-altitude areas. It has a yield potential of 2500 kg/ha. It is decumbent in growth, has green leaves, orange-yellow flowers and reaches 50% flowering in about 39 days. It has a moderate pod constriction, produces 2 medium to large seeds per pod, tan in colour and has a shelling percentage of ≥65%. It takes 120 to 130 days to reach maturity. It is resistant to groundnut rosette disease.

(xi) **CG 12 (ICGV- SM 01514)**

CG 12 is a newly released short duration, Spanish type groundnut variety. It is recommended to be grown in low- altitude areas. It has a yield potential of 1500 kg/ ha. It is erect in growth, has light green leaves and yellow flowers. It reaches 50% flowering in about 34 days. It has a deep pod constriction, produces 2 small to medium seeds per pod, very pale tan in colour and has a shelling percentage of ≥80%. It takes 90 to 100 days to reach maturity. It is tolerant to drought and groundnut rosette disease.

(xii) **CG 13 (ICGV-SM 99551)**

CG 13 is a newly released short duration, Spanish type groundnut variety. It is recommended to be grown in low- altitude areas. It has a yield potential of 2000 kg/ ha. It is erect in growth, has light green leaves, orange-yellow flowers. It reaches 50% flowering in about 32 days. It has a slight pod constriction, produces 2 small to medium seeds per pod, pale tan in colour and has a shelling percentage of ≥67%. It takes 100 to 110 days to reach maturity. It is resistant to rosette and tolerant to drought.

(xiv) **CG 14 (ICGV-SM 99556)**

CG 14 is a newly released short duration, Spanish type groundnut variety. It is recommended to be grown in low- altitude areas. It has a yield potential of 2000 kg/ha. It is erect in growth, has light green leaves, orange-yellow flowers. It reaches 50% flowering in about 33 days. It has no pod constriction, produces 2 small to medium seeds per pod, very pale tan in colour and has a shelling percentage of ≥74%. It takes 100 to 110 days to reach maturity. It is tolerant to drought.

3.2.3.3. Field preparation

Select deep, well-drained sandy loam soils that are well supplied with calcium and moderate amounts of organic matter. Land should be prepared early enough before the onset of rains in order to sow with the effective early rains. All debris should be ploughed under thoroughly.

3.2.3.4. Time of planting

Groundnuts should be planted with the first effective rains(approximately 25-30mm) Delayed groundnut planting will result into high buildup of aphids.

Table 30: Seed rate and spacing for recommended groundnut varieties

Botanical / market group	Varieties	Row and hill spacing (cm)	Seed rate (Kg/ha)
Virginia Bunch	CG 7, CG 8 , CG 9, CG 10 and CG 11, Chalimbana 2005, Nsinjiro	75cm x 15cm x 1 seed	80-100
Spanish Bunch	CG 12, CG 13, and CG 14, Kakoma, Chitala, Baka	75cm x 10cm x 1 seed	50-60

3.2.3.5. Plant population

To ensure optimum plant population, plant at correct ridge or row and plant spacing. To achieve this, use the recommended seed rate and spacing as indicated in Table 30.

However, note that higher yields can be obtained on ridges spaced at 60cm and 75cm depending on the variety used. Supplying should be done if necessary within one week of seedling emergence. At planting, place the seed5-6cm deep into the soil and cover it with soil thoroughly.

3.2.3.6. Pest control

3.2.3.6.1. Weed control

Weeds cause severe damage to the groundnut crop during the first 45 days of its growth. This is the most critical period of weed competition. Therefore weeding at least twice during this critical period is imperative, thus within 20 and 45 days after sowing. Thorough weed control prior to pegging is extremely important. During pegging, only hand weeding should be done to avoid damage to developing pods. Chemical weed control can also be done using herbicides such as Dual Magnum, Roundup and Harness. However, whenever herbicides are used, farmers should as much as possible use appropriate types, following instructions on time of application, application rates and safety precautions provided on the label.

3.2.3.6.2. Disease control

(i) **Early Leaf spot**

Early leaf spot (Cercospora arachidicola) may attack the crop soon after emergence. The disease causes defoliation and has a potential of reducing yields by up to 50%. However, it is more serious on the Plateau areas of Lilongwe- Mchinji to Kasungu Plain. Early leaf spot lesions are roughly circular, dark brown on the upper leaf surface and a lighter shade of brown on the bottom leaf surface. Infected groundnut debris act as the source of inoculum.

(ii) **Late leaf spot**

This disease occurs later in the season than early leaf spot. The lesions are nearly circular rough and darker on the lower leaf surface. The disease is more serious in the low altitude areas along the Lake shore and in the Shire Valley. Severe attacks result in heavy defoliation leading to 15to 25% yield losses.

(iii) **Rust**

The disease usually occurs at the same time as late leaf spot. The symptoms are orange coloured pustules on the lower surface of the leaflets. The pustules rupture to release reddish brown spores and the leaves become reddish then dry up. Yield losses due to this disease are usually up to 10% or less and are lower than those caused by early and late leaf spot. All these three foliar fungal diseases can be controlled using Daconil sprays at fortnightly intervals. However, at the current groundnut producer prices, chemical control is not economical. It is therefore important to follow good agronomic practices such as early planting, crop rotation, burial of crop residues and removal of volunteer plants in order to reduce the primary source of inoculum.

(iv) **Groundnut Rosette**

Groundnut rosette is caused by a virus whose vector is an aphid. It can be serious in fields that are planted late and when the field is gappy, or has low plant populations. Infected plants are chlorotic and stunted. If the disease occurs in epidemic proportions, yield losses can approach100%. Early planting at the recommended spacing will help to control the disease. Use of tolerant varieties such as the new varieties CG 8, CG 9, CG 10, CG 11, CG 12, Nsinjiro, Chitala and Baka is an ideal control option.

3.2.3.7. Insect pest control

(i) **Soil-inhabiting pests**

Several species of termites, white grubs and Hilda patruelis are the most important pests of groundnuts. Damage by termites and Hilda is parabolic but common in high soils and especially during dry spells. The affected plants wither and die. Avoid growing groundnuts in fields that have a history of termites or termite mounds. For Hilda, since the damage starts from the edges of fields, maintaining a clean surrounding grasses of the field reduces the pest incidence.

(ii) **Aphids**

Aphids infest the groundnut plants at all stages of growth if conditions are favourable. Their feeding causes leaves to curl and growth to be stunted. Aphids are particularly important because they transmit the virus that causes groundnut rosette disease. Early planting at correct spacing will help to control the spreading of aphids. Use rosette resistant varieties such as CG 8, CG 9, CG 10, CG 11, CG 12, Nsinjiro, Chalimbana 2005, Chitala and Baka in rosette endemic areas.

3.2.3.8. Fertilizer application

Groundnuts do not usually respond to direct application of mineral fertilizers. Generally, groundnuts perform well following a well fertilized maize crop, so long as phosphorus, calcium and sulphur-containing fertilizers such as 23:10:5+6S+1.0Zn were applied. Calcium is the most limiting nutrient in sandy soils and where medium-large-seeded varieties particularly of Virginia type are grown.

Groundnut can be basal dressed with 100 kg/ha of single superphosphate (SSP) fertilizer to provide 7% phosphorus, 19.5% calcium, and 12.5% sulphur. The fertilizer should be applied in a band on the ridge, or broadcast onto the soil and ploughed under before sowing or soon after emergence.

Top dressing with Gypsum at the rate of 200-400 kg/ha directly at the base of the plant when 30% of the plants have flowered will help to correct Calcium deficiency and reduce groundnut pops.

3.2.3.8. Harvesting

Timely harvesting of groundnuts is essential to avoid discoloration of nuts, germination and pods remaining in the ground at harvesting . Check by lifting a few pods and examining the inside of the shell. The nuts are mature when the inside of the shell is spotted pale brown. The fall of leaves is not necessarily a sign of maturity. Delayed harvesting also predisposes the nuts to infection by aspergillus and aflatoxin contamination.

3.2.3.10. Drying and storage

After lifting, the groundnut should be quickly and thoroughly dried before storage. Store groundnuts in dry containers, Storage under wet conditions will enhance the development of a fungus (Aspergillus flavus) which leads to aflatoxin contamination. If the pods are to be stored longer, put in gunny bags and dust them with Actellic Super Dust or Wivokil to protect the pods from various storage pests.

3.2.3.11. Shelling and marketing

It is bad practice to wet pods to make shelling easier since wet nuts are not accepted at the markets. After shelling, the nuts should be graded carefully. All mouldy nuts should be discarded and not fed to livestock as they are toxic because of a high concentration of aflatoxin. Shriveled and broken nuts should be separated. Only clean whole nuts will fetch a high price at the markets. Farmers should winnow and grade the pods to ensure that only properly filled pods are presented at the markets.

Table 31: The groundnut production trend for the past ten seasons

Season	Area (Ha)	Yield (kg/ha)	Production (mt)
2010/11	308,094	1,056	325,215
2011/12	353,190	1,042	368,081
2012/13	362,824	1,050	380,800
2013/14	375,991	1,057	397,503
2014/15	373,925	793	296,498
2015/16	369,987	743	275,070
2016/17	359,410	742	266,689
2017/18	380,121	987	375,014
2018/19	394,400	848	334,328
2019/20	413,250	1011	417,990
Average	**369,119**	**931**	**343,719**

3.2.4. SOYABEAN
(Glycine max)

Soya bean is a very important and versatile grain legume because it can be put to many uses. It provides high quality vegetable protein of around 37% CP and oil for humans and livestock consumption. It is used in the production of various other recipes at household and industrial levels such as the production of Likuni Phala, soya milk and soy meat. It is also used in the production of feeds for poultry and other livestock. The crop is also a good nitrogen fixer and it therefore improves soil fertility. It is grown as alternative food and cash crop in areas where groundnut pops are a problem.

The crop can be grown under a wide range of climatic conditions ranging from warm to hot low lying areas of the Shire Valley with marginal rainfall of less than 700mm to the highlands of Nyika and Vipya Plateaus with more than 2,000mm rainfall; and soil types ranging from sandy loams to heavy clay soils with sufficient drainage.

Overall production has increased over the past ten years, however, the actual production level tend to fluctuate due to several factors including low and fluctuating farm-gate prices, inadequate availability seeds suppliers of improved seed varieties, poor crop husbandry practices, short-lived seed viability of soybeans and lack of awareness on processing and utilization technologies for the crop. However, there is need and potential to increase production further to meet both the domestic and export markets. Currently average farmers' yields are very low ranging from 400 to 1,000kg per hectare. Yield of up to 4,500kg per hectare can be obtained with good crop management.

3.2.4.1. National aim

The objective is to encourage the growing and utilization of the crop and increase yields towards the potential in order to meet the prevailing high demand in both domestic and export markets.

Improving yields

In order to improve yields the following husbandry practices are recommended:-

3.2.4.2. Use of improved varieties

Farmers should be advised to select the right varieties depending on location and climatic conditions.

Soybean varieties can be divided into two; indeterminate and determinate.

3.2.4.2.1. Ocepara 4

Ocepara 4 is an indeterminate variety which has a very high yield potential of over 4,000kg per ha.

It is adapted for cultivation in medium plateau to upland areas characterized by a prolonged rainfall season. The variety requires a full growing season for best yields. It is a very tall plant, with broad leaves, medium to late maturing. A well grown crop produces a lot of green canopy. An additional characteristic is that Ocepara 4 is resistant to root knot nematode (Meloidogyn spp) hence is most suitable for cultivation in root knot nematode prone sandy loamy soils hence can be grown as a rotational crop in tobacco fields. This variety has white flowers and grey hairs. It is big seeded (22g per 100 seeds) and has a small light grey hilum. The variety takes about 23 days from maturity to shatter and its logging resistance is very strong. The normal colour at maturity is light grey.

3.2.4.2.2. Nasoko (427/5/7)

Nasoko is a determinate variety. It takes 120-130 days to maturity. The yield potential; is 3,500 kg/ha. It is widely adapted to most agro ecologies in Malawi. It is a fairly tall plant, with broad leaves, late maturing with light cream round seeds which have a colorless hilum a characteristic most preferred by the agro-processors. The variety has pink flowers and grey hairs. It is big seeded (22g per 100 seeds). It takes about 23 days from maturity to shatter. The variety has good logging resistance and its colour at maturity is light grey.

3.2.4.2.3. Makwacha (747/6/8)

Makwacha is an indeterminate variety. It takes 120-130 days to maturity. The yield potential is 3,500 kg/ha. It is widely adapted to most agro ecologies in Malawi. The variety has very strong logging and shattering resistance. It is medium maturing with large spherical flattened bright cream seeds.

3.2.4.2.7. Soprano

It is a medium to late maturing variety (120-140 days). It is recommended for medium to high altitude areas. It is large seeded variety with cream color and brown hilum. The yield potential is 3000 kg/ha.

3.2.4.2.8. PAN 1867

It is a determinate variety. It matures earlier (120 days). The variety is recommended to medium-high altitude areas. It is large seeded (23g/100 seeds). It is a short variety. The yield potential is 2500 kg/ha.

3.2.4.2.9. Solitaire

It is a medium to late maturity variety widely adapted to most agroecological zones. The variety is large seeded, tolerant to frogeye disease and yields up to 3000kg/ha.

3.2.4.2.10. SC Serenade

It is an early to medium maturing (110-120 days) grown in low to medium altitude areas. Large seeded, exhibits indeterminate growth and yields up to 3000kg/ha.

3.2.4.2.12. SC Squire

It is a medium to late maturity (120-140 days) grown in medium to high altitude areas. The variety I medium seeded, yellow seeded with yellow helium, tolerant to Soya Bean Rust, matures in 127 days and yields up to 3000 kg/ha.

3.2.4.2.13. SC Sequel

It is a medium to late maturity (120-140 days) grown in medium to high altitude areas. High yielding, yellow seeded with black helium, tolerant to Soya Bean Rust, matures in 123 days and yields up to 3000 kg/ha.

3.2.4.2.14. Tikolore

Tikolore is another indeterminate variety. It is an early to medium maturing variety. It does well in low, medium and high altitude areas. The variety is susceptible to rust but can escape, small seeded, promiscuous (may not require inoculant), Tolerant to frog eye disease with potential yield of 2500kg/ha.

Table 32: Description for recommended varieties for soya bean production in Malawi

Variety	Source of material	Maturity period	Recommended agro-ecologies	Special varietal attributes
Ocepara-4	DARS	Medium to late maturity (120-140 days)	Medium altitude areas	Large seeded with brown helum, produce white flowers and grey hair, exhibits indeterminate growth, resistant to root-knot nematodes and yields up to 2500kg/ha.
Nasoko	DARS	Medium to late maturity (120-140 days)	Medium to high altitude areas	Large seeded with cream colour, white helum, produce white flower and grey hairs, exhibit indeterminate growth and yields up to 3000kg/ha.
Makwacha	DARS	Medium to late maturity (120-140 days)	Medium to high altitude areas	Large seeded with light cream colour, white helium, produce white flowers and grey hairs, exhibits indeterminate growth and yields up to 3000kg/ha.
Solitaire	SeedCo	Medium to late maturity (120-140 days)	Widely adapted to most agroecological zones	Large seeded, tolerant to frogeye disease and yields up to 3000kg/ha
Soprano	SeedCo	Early to medium mature (110-120days)	Medium to high altitude areas	Large seeded, tolerant to frogeye disease and yields up to 3000kg/ha
Tikolore	DARS /IITA	Early maturity (90-110 days)	Low to medium altitude areas	Small seeded, brown helum, promiscuous (may not require inoculation), tolerant to frogeye disease, susceptible to rust and yields up to 2500kg/ha
SC Serenade	SeedCo	Early to medium maturing (110-120 days)	Low to medium altitude areas	Large seeded, exhibits indeterminate growth and yields up to 3000kg/ha
PAN 1867	Pannar Seeds	Early Maturing (110-120 days)	Low to medium to high altitude areas	Large seeded, exhibit indeterminate growth, yields up to 2500kg/ha
SC Squire	SeedCo	Medium to late maturity (120-140 days)	Medium to high altitude areas	Medium seeded, yellow seeded with yellow helium, tolerant to Soya Bean Rust, matures in 127 days and yields up to 3000 kg/ha
SC Sequel	SeedCo	Medium to late maturity (120-140 days)	Medium to high altitude areas	High yielding, yellow seeded with black helium, tolerant to Soya Bean Rust, matures in 123 days and yields up to 3000 kg/ha

3.2.4.3. Field preparation

Field preparation should be done before the first planting rains. Prepare ridges at 75cm or 90cm apart. Fields should be properly tilled to conserve soil and water.

3.2.4.4. Seed inoculation

Seed should be inoculated with Rhizobium for high grain yield such as Nitrofix, Biofix and Histick. Nitrofix is applied by inoculating seed prepare 200ml of a 5% sugar solution (discouraged due to ants attack) by dissolving one match box full of sugar into water contained in a bottle of fanta. Mix one sachet of inoculants (50g) into this solution to form a slurry. Pour this slurry over 25kg of seed and mix until all the seed is evenly coated. Leave it to dry in the shed for 30 minutes. Plant seed within 24 hours of inoculation. Inoculum does not have to be stored in are frigerator, it can be stored at room temperature. For Biofix and Histick farmers are encouraged to mix the product with right quantity of water and seeds.

3.2.4.5. Seed dressing

All seeds should be dressed with a fungicide such as Thiram before planting in order to control seed-borne and soil borne diseases.

3.2.4.6. Time of planting and seed rate

3.2.4.6.1. Rainfed crop

Soya beans should be planted with the first planting rains Medium to late maturing varieties of soya bean require 100 days of good rainfall for good development of the crop. Planting in narrow row widths produces more yield than wide spacing. Planting on the ridge should be done on two rows spaced on each side of ridge at approximately 30cm apart and placing one seed per planting station 5cm apart and 2.5cm deep. Flat planting should be done on rows spaced at 45cm apart and 5cm between stations. In both cases the required seed rate is 60 to110 kg per hectare depending on seed size.

3.2.4.6.2. Irrigated crop

Soya beans can be grown under residual moisture or irrigation. Normal ridge and planting spacing and seed rates should be followed. Water logged conditions should be avoided.

3.2.4.7. Fertilizer recommendations

There are three options. In the first place the farmer can choose to apply only Rhizobium inoculants for a certain yield target. Secondly, a farmer can choose to apply fertilizer only without the inoculum. In this option nitrogenous fertilizers can be applied in place of rhizobium inoculants to achieve more or less the same yield target depending on the soil fertility status. Thirdly the farmer can choose to apply both rhizobium inoculants and nitrogenous fertilizer to the crop in order to achieve a very high yield target. For very high grain yield targets above 3,000 to 4,000kg per hectare, apply both rhizobium and fertilizers at the rate of 200 kg of 23:10:5+6S+1.0Zn per hectare (50kg per hectare N) by applying 18g of fertilizer by banding per meter length of ridge using 2 cupfuls of cup No.5 soon after planting or at seedling emergence.

3.2.4.8. Pest control

3.2.4.8.1. Weed control

The field should be kept weed free especially in the initial stages of crop development.

3.2.4.8.2. Insect pest control

The important insect pests of soya bean are semi loopers, flower and pod borers and pod sucking bugs. These insect pests can be controlled by spraying the crop with Carbaryl 85WP (Sevin) at the rate of 85g in 14 litters of water using a knapsack sprayer. If a ULV sprayer is used, mix 85g of Carbaryl in one liter of water and spray.

3.2.4.8.3. Nematode control

Root knot nematodes (Melodogyne spp.). Growing of resistant variety such as Ocepara 4 is recommended to control nematodes. The crop should not be grown in rotation with crops that are alternative hosts to nematodes, for example after or before tobacco.

3.2.4.9. Harvesting

The crop is mature when pods turn brown or gray in colour depending on variety. Harvesting should be done when pods rattle when shaken.

Table 33: Estimated soya bean production for the past ten seasons

Season	Area (Ha)	Yield (kg/ha)	Production (mt)
2010/11	75,839	998	75,665
2011/12	102,647	1,009	103,617
2012/13	114,369	1,023	116,977
2013/14	121,913	1,084	132,185
2014/15	139,005	870	120,952
2015/16	153,834	890	136,910
2016/17	149,689	885	132,417
2017/18	184,187	1,099	202,502
2018/19	173,558	977	169,564
2019/20	196,909	1,093	215,183
Average	**141,195**	**996**	**140,597**

3.2.5. PIGEON PEA
(Cajanus cajan)

Pigeon pea is an important pulse in the country particularly in the Southern Region. It can be grown in almost all types of free draining soils either in pure or mixed stand with other crops such as maize and cassava. Pigeon pea is a valuable source of vegetable protein and farmers grow it either for food or cash. Pigeon pea improves soil fertility through leaf litter and nitrogen fixation. It can be grown either as an annual or as a perennial crop.

Present average yields range from 400 to 800kg per hectare. Potential yields of up to 2,500 kg per hectare can be obtained in a pure stand. The objective therefore is to improve yields.

3.2.5.1. National aim

The objective is to increase production and increase yields towards the potential in order to meet the prevailing high demand in both domestic and international markets.

Improving yields

In order to improve yields the following agronomic practices are recommended:-

3.2.5.2. Use of recommended improved varieties

There are 3 maturity groups or types of pigeon peas available for cultivation in Malawi and these include:

a) Maturity groups

(i) **Short Duration (SD) (Early maturing) pigeon peas**

Short Duration (SD) pigeon pea varieties mature in about 120 to150 days depending on date of sowing and location. The SD pigeon pea varieties are relatively insensitive to day length and can therefore be grown in a wide range of climatic and soil conditions including dry (700mm mean annual rainfall) low lying (60m above sea level), warm to hot areas to the high plateaus (>1,500m above sea level) which are characterized by cool temperatures and continuous rainfall (2,000mm mean annual rainfall). Currently there are no varieties amongst the SD pigeon pea with resistance to the soil borne disease Fusarium wilt and Cercospora leaf spot diseases and insect pests such as pod borers and pod sucking bugs. Therefore, an SD crop has to be protected against pests.

This category of pigeon peas offers an unlimited opportunity for extending the production of pigeon peas to non- traditional pigeon pea growing areas in Malawi such as the medium to high altitude areas with cool temperatures in the Central and Northern Regions of Malawi. Adapted varieties in this category are available for cultivation.

(ii) **Medium (intermediate) duration (MD) pigeon peas**

Medium duration (MD) varieties mature in about 160 to 180 days after sowing depending on time of sowing and location. The MD varieties are best suited for cultivation in areas characterized by an average rainfall season such as the medium altitude plateaus in Lilongwe, Kasungu and in areas with short rainfall seasons. Generally the MD varieties will do well where the long duration (late maturing) varieties are grown. These varieties can be grown either as pure stands or as an intercrop with cereals such as maize or other crops such as cassava and cotton.

For optimum yields for both maize and pigeon pea, MD pigeon pea plants are sown on the same ridge with maize, 3 maize plants at each station spaced at 90cm apart and 3 plants of MD pigeon pea placed between the maize stations. Any maize variety can be intercropped with pigeon peas without reducing grain yields of pigeon peas.

(iii) **Late maturing (long duration) (LD)**

Late maturing (long duration) (LD) varieties mature in about 210 to 270 days after sowing depending on time of sowing and location. These varieties are traditionally grown in most parts of Southern Region and in certain parts of the Central and Northern regions too, where they form a major component in the farming systems. Farmers should select and plant good seed of the recommended varieties in LD category which include Sauma (ICP9145) and Kachangu (ICEAP 00040). The 2 varieties are also suitable for intercropping with cereals such maize or other crops such as cassava and cotton.

b) Varieties

(i) **Sauma (ICP9145)**

Sauma is an indeterminate variety which flowers between 160 to 180 days, and matures between 220 to 270 days after sowing depending on time of sowing and location. This variety has strong resistance to the soil borne Fusarium wilt disease and leaf spots Cercospora spp. Which are among the major factors which constrain pigeon pea productivity in the country. Sauma produces many spreading branches which are capable of growing taller than 2 m in a December sowing. The stems are woody and green in colour; the leaves are dark green and its flowers are bright-yellow and the pods are green. Its seeds are large (15g per 100 seeds) oval shaped and white in colour with white hilum. It has a yield potential of 2,500kg per hectare.

(ii) **Kachangu (ICEAP00040)**

Kachangu is an indeterminate variety which flowers between140 to180 days, and matures between 190 to 240 days after sowing depending on time of sowing and location. This variety has some considerable degree of resistance to Fusarium wilt disease. Like Sauma, this variety also produces many spreading branches which are capable of growing taller than 2 m in a December sowing. The stems are also woody and green in colour; the leaves are green and its flowers are ivory creamy, the pods are green and seeds are creamy white. The seed is much larger (22g per100 seeds) than that of Sauma, and the seed coat is much easier to remove during Dhal processing as compared to Sauma. This variety is preferred by the agro-industry.

(iii) **ICPL 87015**

ICPL87015 is a nearly maturing and high yielding (up 2,500kg/ha) variety that has stable seed and grain yields. It is adapted to a wide range of environments with a high market potential. It grows to a height of 130cm, matures in 126 days and has large cream seeds with a seed size of 17 g/100 seeds. Because of its earliness in maturity, it tends to escape the Fusarium wilt disease. However, for high yields, there is need to spray at flowering and pod filling. Because of its early maturity.

(iv) **ICPL 93026**

ICPL93026 is a nearly maturing and high yielding (up 2,500kg/ha) variety that has stable seed and grain yields. It is adapted to a wide range of environments with high market potential. It grows to a height of 137cm, matures in 127days and has large cream seeds with seed size of 17g/100seeds. Because of its earliness in maturity, it tends to escape the Fusarium wilt disease.

However, to attain high yields, three sprays of pesticides are required during the flowering and pod filling stages.

(v) **Chitedze Pigeon peas 1 (ICEAP 01514/15)**

The stem is green while the leaves are green and medium in size. It flowers and matures in about 120 days and 190 days, respectively. It is non determinate and semi-spreading in growth habit (Under intercropping, the plants remain tall and compact but when grown under low population additional branches develop giving a semi-spreading appearance). The base flower colour is red. The immature pods are green with light stripes, long and sickle-shaped. Each pod contains 6-7 seeds. Seeds are large white/ cream with 100-seed mass of 14-17g. Plant height is significantly influenced by temperature. Under warm environments, the plants grow tall but shorter under cool environments. It has yield potential up to 2.5 tonnes per hectare. The variety is susceptible to Fusarium wilt but tolerant to most leaf diseases.

(vi) **Chitedze Pigeon pea 2 (ICEAP 1485/3)**

This medium duration pigeon pea variety was developed from a cross between ICPL 87091 and ICEAP 00040 and was officially released in Malawi in 2014. The variety matures between 150-180 days depending on location and time of planting. The immature and mature pods have black stripes. One hundred (100) seed mass weighs 14-17g.

(vii) **Mwaiwathu alimi (ICEAP 00557)**

ICEAP 00557 is a distinct, stable and uniform variety. The stem colour is green. At optimum temperature for growth, it flowers and matures in about 130 days and 180 days, respectively. It is non-determinate and semi-spreading in growth habit.The open flower is yellow in colour with dense streaks.

The immature pods are green with light to dense stripes, long and sickle-shaped. Each pod contains 6-7 seeds. Seeds are large white/ cream with 100-seed mass of 17-19 g. It has the potential yield up to 2.5 tonnes per hectare. It is tolerant to fusarium wilt and most common leaf diseases.

3.2.5.2.1. Field preparation

Field preparation should be done before the first planting rains. Prepare ridges at 75cm or 90cm apart. Fields should be properly tilled to conserve soil and water.

3.2.5.2.2. Time of planting

To achieve higher yields, planting should be done with the first planting rains or soon after the main crop has emerged where interplanting is practiced.

3.2.5.2.3. Seed dressing

All seeds should be treated with a fungicide seed dressing before planting such as Thiram in order to control seed-borne and soil-borne diseases.

3.2.5.2.4. Plant population

3.2.5.2.4.1. Pure stand

(i) Short Duration (SD) pigeon peas SD pigeon peas are best produced as sole crop. Plant on the ridges which are spaced at between 75 or 90cm apart on double or single row. Planting on single row requires 2 plants per station, 20cm apart.

Planting on double rows which are spaced at 30cm apart requires one plant per station, 10cm apart, in either case, 75cm ridges pacing gives a plant population of 133,330 plants per ha and a seed rate of 20 to 30kg per ha whereas 90cm ridge spacing gives a plant population of 111,110 plants per hectare and a seed rate of 16 to 25kg per ha. Seed yields of the SD pigeon pea varieties are reduced when intercropped with maize on the same ridge due to shading by the maize plants.

The only way to intercrop SD pigeon peas with maize is where the maize and the SD pigeon pea are planted on alternative ridges or in strips of 2 or more ridges.

(ii) Medium Duration (MD) and Long Duration (LD) pigeon peas

Plant 2 seeds per station spaced at 60cm on ridges of either 75 or 90 cm apart. This requires a seed rate of 6kg per hectare and the expected plant population is 37,000 and 44,444 per hectare at 90cm and 75cm ridge spacing respectively.

3.2.5.2.4.2. Interplanted crop

Medium duration (MD) and Long Duration (LD) Pigeon peas

Plant 3 seeds per station spaced at 90cm or 75cm apart in between the main component crop. This requires a seed rate of 6kg per hectare and the expected plant population is 37,000 and 44,444 plants per hectare at 90cm and 75cm ridge spacing respectively.

3.2.5.3. Pest control

3.2.5.3.1. Weed control

The field should be weed free especially in the initial stages of establishment.

3.2.5.3.2. Insect pest control

Without exceptional pigeon peas have to be sprayed twice between 50% and full flowering and twice between 50% and full pod to control insect pests.

Lepidopteran larvae including cutworms *(Agrotis spp.)*, whitegrubs *(Lanchosterna spp.)*, elegant grasshopper *(Zonocerus elegans)* and aphids *(Aphis craccivora)* feed on young seedlings. Thrips *(Megaluro thipusitatus)*, spotted larvae of Maruca testulalis and larvae of Helicoverpa armigera, feed on flowers and pods and are capable of causing yield losses of more than 70%. Flower beetles or blister beetles *(mylabris pustulata)* cause serious damage to flowers. Physical destruction is recommended.

Aphids can be controlled by spraying Dimethoate20WP which should be applied at the rate of 34g per 14litre of water using ULV sprayer alternatively apply dimethoate 40EC at the rate of 17 ml in 14 litres of water using knapsack sprayer or 17ml of water for ULV sprayer. Cutworms and grubs can be controlled by drenching with Carbary l85WP at the rate of 85g per 14 litres of water for knapsack sprayer or 85g in 1litre of water for ULV sprayer. Flower eaters, leaf eaters, elegant grasshoppers, pod borers, jassids, thrips, and flower beetles can be controlled by spraying with Carbary l85WP at the rate of 85g per 14litres of water for knapsack sprayer or 85g in 1litre of water for ULV sprayer.

Pod sucking insects: Clavigralla Spp. And Nezara virdula feed on pigeon pea pods. The seeds on the attacked pods become shriveled and useless and such losses may be close to 100% if attack comes in at the beginning of podding stage. Control by spraying dimethoate 40EC at the rate of 17ml in 14 liters of water using knapsack sprayer or 17ml of water for ULV sprayer.

3.2.5.4. Disease control

The only major disease is the Fusarium wilt *(Fusarium udum)*. The disease can only be controlled by use of resistant varieties.

In this case use Sauma or Kachangu which are resistant to Fusarium. Use of these varieties can help to contain the spread of the disease.

3.2.5.5. Harvesting and storage

Harvest the dry pods and stack them to complete drying. Thresh and clean the grain. Dust the grain with Actellic Super at the rate of 25g to 50kg of grain or Grain Super Dust at the rate of 25g to 50kg of grain. Grain may be put in bags or other clean containers. Store them on a clean and cool dry place.

Table 34: Estimated pigeon pea production for the past ten seasons

Season	Area (Ha)	Yield (kg/ha)	Production (mt)
2010/11	196,552	1,119	220,017
2011/12	203,400	1,167	237,351
2012/13	217,068	1,327	287,983
2013/14	223,207	1,429	318,885
2014/15	228,817	1,465	335,165
2015/16	246,362	1,506	371,114
2016/17	246,245	1,507	370,976
2017/18	270,246	1,731	467,912
2018/19	249,472	1,743	434,756
2019/20	248,400	1,624	403,466
Average	**232,977**	**1,480**	**344,763**

3.2.6. COW PEA
(Vigna unguiculata)

Cowpea is an important legume crop that is grown all over the country particularly in warm areas with low rainfall like the Shire valley, Bwanje Valley, Lakeshore and Phalombe Plains, as well as other dry areas. The crop will tolerate heat and relatively dry weather conditions. The pea contains good quality protein that will complement the protein present in cereal grains. Leaves are valuable vegetables (Mtambe) that will provide essential vitamins and minerals.

3.2.6.1. National aims

The objective is to increase production by improving yields. Average yields for both pure and mixed cropping range from 300kg to 600kg per hectare. There is potential to achieve yields of up to 2,000kg per hectare in pure stand. The objective is to increase production by improving yields.

3.2.6.2. Improving yields

In order to improve yields the following husbandry practices are recommended:-

3.2.6.2.1. Use of improved varieties

Improved cultivar Sudan 1 (Nseula) and variety IT82E-16 and Nkanakaufiti are recommended. Farmers should be advised to select and plant good seed.

3.2.6.2.2. Time of planting

For pure stand, farmers in the Lakeshore areas and Shire Valley should plant with the first planting rains. In medium and high altitude areas where there is need to escape excessive damage by disease and insect pests, farmers should plant in January and early February. For mixed stand, plant soon after planting the main crop or when the main crop has emerged.

3.2.6.2.3. Plant population

a) Pure crop

(i) Indeterminate and semi-determinate *(Khobwe)* types, plant one seed at 20cm apart, on ridges spaced at 75cm or 90cm apart.

(ii) Determinate *(Nseula)* types, plant 2 seeds per station spaced at 20cm apart on ridges spaced at 75cm or 90cm apart.

The seed rate for all cowpea types under pure stand is 10 to16kg per hectare.

b) Interplanted crop

Plant 3 seeds per station spaced at either 75 or 90cm apart, on ridges spaced at 75cm or 90cm in between the main crop for both determinate *(Nseula)* and indeterminate *(Khobwe)* types.

3.2.6.2.4. Pest control

3.2.6.2.4.1. Weed control

The field should be free of weeds during the first 3 weeks for good and early establishment

3.2.6.2.4.2. Insect pest control

Foliage beetles *(Ootheca mutabilis),* foliage thrips *(Sericothrips occipitalis)*, leafhoppers *(Empoassca dolichi)* and aphids *(Aphis craccivora)* can start attacking the crop at seedling stage and can cause losses of 70 to 80%. Flower thrips (*Taemothrips sjostedti)* attack at flower bud initiation stage and can cause up to 100% damage. Flower and pod borers *(Maruca testulalis)* and pod sucking bugs *(Anoplcnemis curvipes)* if present can cause losses of up to 100%.

Aphids, foliage thrips and sucking bugs can be controlled by spraying Dimethoate (Rogor) 20WP at the rate of 34g for 14litres of water for knapsack sprayer or 34g for 1litre of water for ULV sprayer;

or Dimethoate 40EC at the rate of 17 ml for 14litres of water for knapsack sprayer or 17ml for 1litre of water for ULV sprayer.

Flower, pod borers, leaf eaters can be controlled by spraying Carbary l85WP at the rate of 85g for 14 litres of water for knapsack sprayer or 85g for ULV sprayer.

3.2.6.2.5. Disease control

The major cowpea diseases are Ascochyta blight *(Ascochyta phaseolorum)*, which causes up to 100% yield loss. Scab *(Elsinoe phaseoli)* which causes up to 80% yield loss. Cercospora leafspots *(Cercospora spp.)* which causes up to 40 to 60% yield loss and aphid borne mosaic virus disease (ABMD) which causes up to 80% yield loss.

Ascochyta blight can be controlled by spraying Mancozeb (Dithane M45) 80WP at the rate of 15g for 10litres of water for knapsack sprayer or 15g for 1litre of water for ULV sprayer or Chlorothalonil (Daconil 278W-75), 35g for 10litres of water for knapsack sprayer or 35g for liters of water for ULV sprayer. Spraying should be done at fortnightly intervals. Planting cowpea in between maize planting stations reduces Ascochyta blight pressure on cowpea crop.

Scab, ABMD and Cercospora leafspots can be controlled by use of resistant varieties. IT82E-16 variety is resistant to both diseases. Intercropping cowpea with maize reduces pressure of these diseases. In addition, Cowpea Yellow Mosaic Virus Disease (CYMD) can also attack the crop. This can be controlled by resistant varieties such as IT82E-16 and Sudan I.

3.2.6.2.6. Harvesting

Harvest the pods as soon as they start drying and continue drying them to complete the process. For determinate types *(Nseula)* , uproot the whole plant as soon as the pods start drying, as pods dry at almost the same time.

3.2.6.2.7. Storage

Seeds should be thoroughly dry as fungal pathogens and insects can easily attack fresh seeds. Before storage treat the seeds by applying Actellic Super Grain dust at the recommended rate If ash is used to treat cowpea grain, apply 25% ash to the volume of the grains. Cowpeas may be packaged in bags. However treat the bags by putting them in boiled water so that insect pest eggs can be killed. Store in a cool dry place. Place the bags on dunnage (on a raised platform).

Table 35: Estimated Cowpea production (mt) and hectarage for the past ten seasons

Season	Area (Ha)	Yield (kg/ha)	Production (mt)
2010/11	70,599	452	31,928
2011/12	70,588	429	30,279
2012/13	75,504	478	36,119
2013/14	78,472	490	38,445
2014/15	81,753	439	35,903
2015/16	85,787	341	29,266
2016/17	78,960	335	26,471
2017/18	92,119	473	43,601
2018/19	87,181	434	37,816
2019/20	86,889	503	43,717
Average	**80,785**	**438**	**35,354**

3.2.7. BAMBARA NUT OR GROUND BEANS *(Vigna sub terranean)*

Bambara nut is grown in throughout the countryis either grown in pure stand or intercropped with maize, cassava, groundnuts and other crops. Farmers should be encouraged to grow the crop as it is a good source of carbohydrates (59%), crude protein (19%), and fat (7%) by weight. The grain is boiled and eaten or prepared as side dish taken with a staple meal.

3.2.7.1. National aim

To encourage improved production of the crop in all areas where it is grown. Average yields range from 500 to 800kg per hectare. In pure stand with good husbandry practices, higher yields up to 3,000kg per hectare can be obtained.

3.2.7.2. Improving yields

In order to improve yields, the crop should be grown in suitable areas with good crop husbandry practices as follows:-

3.2.7.2.1. Use of good seed

Select and plant good seed of high yielding local cultivars. A number of farmers are currently selecting and multiplying seed of high yielding local cultivars in their areas. The Department of Research has made a number of selections and has come up with the following local cultivars:-

1. **Kayera**

   Kayera yields an average of about 880kg/ ha. It is adapted to a wide range of environments in Malawi, including marginal rainfall areas, and those with poor soil fertility. It has the following characteristics:

   (i) 84g for a100 seed weight
   (ii) 65 pods per plant
   (iii) 1 seed per pod
   (iv) 60% shelling percentage, and
   (v) 10 stems per plant. It takes 53days to attain 50% flowering. This variety is susceptible to Anthracnose and Mosaic disease.

2. **Makata**

   Makata gives a high average yield of 1,160kg/ ha. This variety is adapted to a wide range of environments in Malawi, including marginal rainfall areas characterized by poor soilfertility.It has the following distinguishing characteristics:

   (i) 92g for a 100 seed weight
   (ii) 38 pods per plant
   (iii) 1 seed per pod
   (iv) 60% shelling percentage
   (v) 7 stems per plant, and
   (vi) 5cm canopy spread. It takes 55days to attain 50% flowering. It is susceptible to Anthracnose and Mosaic diseases.

3. **Kadziunde**

   Kadziunde gives an average of about 900kg/ ha. This variety is also adapted to a wide range of environments in Malawi, including marginal rainfall areas, and those characterized by poor soil fertility. Some of the distinguished characteristics include:

   (i) 42g for a 100 seed weight,
   (ii) 31pods per plant,
   (iii) 1seed per pod
   (iv) 60% shelling percentage,
   (v) 5cm canopy spread.
   (vi) It takes 55 days to attain a total of 55 leaves and 50% flowering. This variety has the special attribute that its pods bury themselves in the ground so that it does not require any banking at all. This variety is also susceptible to Anthrocnose and Mosaic diseases.

3.2.7.2.2. Suitable soils and climate

Bambara nut will grow on a variety of soils especially light and sandy loams but it also does well on heavier soils. The ideal rainfall is between 900 mm and 1,200 mm which should be well distributed during the growing season. However,the crop will also yield with a well distributed rainfall ranging from 600 to 700mm.The crop tolerates dry spells better than groundnuts and phaseolus beans.

In Malawi, suitable areas for growing Bambara nut are therefore the lower and upper Shire Valley, Mulanje, Phalombe, Lake Chilwa, Bwanje Valley and lakeshore plains. Other suitable areas are Lilongwe, Chitipa plains, Namwera plains and Blantyre Shire Highlands.

3.2.7.2.3. Time of planting

The crop should be planted with the first planting rains for high yields.

3.2.7.2.4 Plant population

Space ridges at 90cm or 75cm apart. Plant one seed per station spaced at 15cm apart on the ridge. Where planting on flat is necessary, space planting rows 45cm apart and plant one seed per planting station spaced at 15cm on each row. The 45 x 15cm spacing gives higher yield than the 90 x 15 cm or 75 x 15cm. Seed rate is 100 to110kg per hectare.

3.2.7.2.5. Fertilizer requirement

Currently there are no fertilizer recommendations for ground bean.

3.2.7.2.6. Pest control

3.2.7.2.6.1. Weed control

Keep the field weed–free Earth up ridge or rows to facilitate pegging and development of pods. Care should be taken not to damage pegs and developing pods when weeding.

3.2.7.2.6.2. Insect pest control

The following insect pests cause some yield losses and can be controlled when need arises.

(i) **Aphids and other sucking insect pests**

Control these insect pests with Dimethoate 20WP at the rate of 35g in 14 liters of water using a knapsack sprayer or 35g in 1 liter of water if using a ULV sprayer.

(ii) **Leaf and flower eating insects**

These should be controlled with Carbaryl (Sevin) 85WP at the rate of 85g in 14 litres of water if using a knapsack sprayer or 85g in 1 liter of water using an ULVsprayer.

3.2.7.2.6.3 Disease control

(i) **Wilt Sclerotium blight** *(Sclerotium rolfsii)*

Infection occurs at or just below the soil surface. Light brown lesions occur which quickly darken and enlarge until the hypocotyls or stem is girdled. Yellowing or wilting of plants is usually the first symptom. Leaves of infected plants turn brown, dry and cling to the dead stem. The most characteristic sign of the fungus is a white mat of fungal mycelia forming on stem bases, leaf debris and soil surface around infected plants. The disease can be controlled by alternating bambara nut with a non-host crop such as maize.

(ii) **Leafspot** *(Cercospora canescens)*

Rotation with non-host crops is the main control measure as chemical control spraying may prove un economical.

3.2.7.3. Harvesting

Bambara nut will mature at 140 to 170 days after sowing depending on climate variety. Pods are mature and ready when the inside layer of the pods show brown patches. At this stage the haulm swill start yellowing. Lift the crop using a hand hoe or a plough. Dry the lifted pods in the sun. Gleaning is necessary to recover pods remaining in the soil.

When dry, strip the pods from the haulms and continue drying in the sun until they are thoroughly dried before shelling or storing. Pods are thoroughly dry when they make a rattling sound if shaken.

3.2.7.4. Storage

Bambara nut is best stored in the pod at household level. This practice reduces damage by storage insect pest. Store in cool or well-ventilated structures.

3.2.7.5. Shelling and marketing

Bambara nuts can be sold shelled or unshelled but most buyers accept shelled bambara nuts. Shell nuts using a mortar and pestle. Winnow to remove trash and stones. Select and store separately clean whole grain from damaged ones. Present for marketing shelled, clean whole grain; free of trash, stones and discoloured grain.

Table 36: Estimated Bambara nut production (mt) and hectarage for the past ten seasons

Season	Area (Ha)	Yield (kg/ ha)	Production(mt)
2010/11	13,224	718	9,492
2011/12	13,284	692	9,198
2012/13	12,953	690	8,939
2013/14	13,249	704	9,322
2014/15	12,545	609	7,639
2015/16	11,539	553	6,378
2016/17	0		0
2017/18	0		0
2018/19	0		0
2019/20	0		0
Average	**12,799**	**664**	**8,495**

3.2.8. CHICKPEA *(Cicer arientinum)*

Chickpea is an important cash crop grown mostly in the Shire Highlands. The crop requires less moisture than most crops, therefore it can be grown under residual moisture as a relay crop to maize. It is also important because it improves soil fertility

Average yields range from 200 to 600 kg per hectare. Potential yields of 2,000kg per hectare can be achieved. The objective therefore is to improve yields.

3.2.8.1. Improving yields

To improve yields the following husbandry practices are recommended: -

3.2.8.1.1. Use of good seed

There are no recommended variety at present. Farmers should therefore select and plant good seed from unimproved cultivars.

3.2.8.1.2. Field preparation

For a relay crop, prepare ridges when maize has reached physiological maturity. Prune most of the maize leaves into the furrow and bury them in the new ridge. For a pure crop, prepare land by ploughing and ridging by February. Ridges should be 90cm apart with a flat top.

3.2.8.1.3. Time of planting

For the relay crop, plant after the buried maize leaves have decomposed. For a pure crop, plant as soon as ridges are made provided there is enough moisture.

3.2.8.1.4. Plant population

Plant on double rows spaced at 30cm on the ridge. Plant one seed per station spaced 10cm apart. This requires a seed rate of 8 to 10kg per hectare.

3.2.8.2. Pest control

3.2.8.2.1. Weed control

Keep the field weed free o to avoid competition for nutrients, moisture and sunlight.

3.2.8.2.2. Insect pest control

To avoid caterpillar infestation which normally damage the pods, plant the crop after the main rains. Pests can be controlled by using carbarly (Sevin) 85WP at the rate of 85 g in 1 liter of water for spinning disc (ULV); Fenvalerate (Sumicidin) 20EC at the rate of 13ml in 14 liters of water for knapsack sprayer or 13ml in 1 litre of water for ULV and Fenitrothion (Sumithion) 50EC at the rate of 36ml in14 litre of water for knapsack sprayer or 136ml in 1 liter of water for ULV sprayer. Pesticides can be obtained from the nearest Agro-dealers. Application rates per hectare are 200 liters for knapsack and 6 litres for ULV sprayer.

3.2.8.2.3. Disease Control

The major disease of chickpea is the Ascochyta blight or Zonate losses. The disease can be controlled by spraying Mancozeb (DithaneM45) 80WP at the rate of 21g per 10litres of water for ULV sprayer. Orchlorothalonil (Daconil278W), 49g in 10 liters of water for knapsack sprayer or 49g in 1 liter of water for ULV sprayer. Spraying should be done at fortnightly intervals.

3.2.8.2.4. Harvesting and storage

Harvesting should be done when the pods are dry. Uproot the plant, dry and thresh. Store the grain in a cool dry place. If chickpeas are to be kept for long periods apply Actellic Super Dust and Wivokil at the rate of 25g per 50 kg of grain to reduce Bruchid damage. Alternatively, you can also use Super Grain Dust at the rate of 28g per 50kg of grain.

3.2.8.2.5. Chickpea production

The estimated production of chickpea for the past ten seasons is as tabulated in Table 37.

Table 37: Estimated hectarage and production (mt) of chickpea for the past ten seasons

Season	Area (Ha)	Yield (Kg/ha)	Production (mt)
2010/11	2,157	748	1,614
2011/12	2,259	788	1,779
2012/13	2,390	824	1,970
2013/14	2,295	837	1,920
2014/15	2,314	797	1,844
2015/16	2,223	744	1,655
2016/17	2,223	744	1,655
2017/18	2,218	833	1,847
2018/19	2,166	825	1,786
2019/20	2,193	954	2,093
Average	**2,244**	**809**	**1,816**

3.2.9. FIELD PEA
(Pisum sativum)

Field pea is commonly grown in most parts of the country mainly in the high altitude areas both as a pulse and a vegetable. Dry seeds (pulse) are a good source of protein and fresh seeds are good source of vitamins and minerals in addition to proteins. Field peas can be grown as a pure stand crop in the field or in dimbas or as a relay crop to maize.

3.2.9.1. National aim

To increase production of the crop so that it assists in the provision of proteins, vitamins and minerals. There is scope to increase production in all suitable areas. The objective therefore is to increase production through relay cropping, improved husbandry practices, and use of improved seed. Extension staff should encourage farmers to grow the crop both for food and cash.

3.2.9.2. Improving yields

In order to improve yields the following husbandry practices are recommended:-

3.2.9.2.1. Use of recommended varieties

Farmers should be encouraged to plant recommended varieties such as Earlicrop and W.F. Massey for early season and Alderman for the late season They should select good seed for planting.

3.2.9.2.2. Field preparation

Field pea should be planted after main rains are over For continuous supply planting should be done at 2 weeks intervals.

3.2.9.2.3. Plant population

Sow the seeds on double rows spaced at 30 cm on ridges 90 cm apart. Sow 2 seeds per station spaced at 7.5 cm apart 2.5 cm deep. Seed rate ranges from 65 to 95kg per hectare.

3.2.9.2.4. Staking

For tall varieties it is important to stake.

3.2.9.3. Pest control

3.2.9.3.1. Weed control

Keep the field weed free after planting.

3.2.9.3.2. Disease control

Powdery mildew (Erysiphepisi) is the only disease of economic importance and can be controlled by spraying Dinocap (Karathane) at the rate of 10g in15 liters of water using a knapsack sprayer or 9g in 1 liter of water for ULV sprayer. Alternatively, apply sulphur 80WP at the rate of 30g per 10 liters of water for knapsack sprayer or 42g for 1 liter of water for ULV sprayer: or use sulphur dust at 7 to10 day interval.

3.2.9.3.3. Insect pest control

Cut worms (Agrotis spp): These can be controlled by hand picking or drenching with Carbaryl 85WP at the rate of 85g in 14 liters of water for knapsack sprayer or 85g in 1-liter water for ULV sprayer.

3.2.9.4. Harvesting

a) **Vegetable crop**

Field pea will reach physiological maturity 60 to 95 days after planting. Pods should be harvested regularly when they are dark green and well filled. Harvest the pods before they become yellow and dry.

b) **Pulse crop (dry peas)**

Harvest the pods as they dry before they shatter.

3.2.9.5 Storage

For the pulse crop, apply Actellic Super Dust or Wivokil at the rate of 25g per 50Kg of grain. Store in a cool and dry place.

3.2.9.6. Estimated Field Pea production for the past ten season

Field pea production is on the rise. Refer to Table 38 for production trends over the last ten seasons.

Table 38: Estimated Field Pea hectarage and production (mt) for the past ten seasons

Season	Area (Ha)	Yield (Kg/ha)	Production (mt)
2010/11	4,247	617	2,619
2011/12	4,349	637	2,771
2012/13	4,473	697	3,118
2013/14	4,596	683	3,139
2014/15	4,727	700	3,307
2015/16	4,249	619	2,630
2016/17	3,581	583	2,087
2017/18	3,692	703	2,594
2018/19	3,772	703	2,651
2019/20	4,002	818	3,275
Average	**4,169**	**676**	**2,819**

3.2.10. GRAMS: Green grams *(Vigna aureus)* and Black grams *(Vigna mungo)*

Green and Black grams are commonly grown in the Shire Valley and Bwanje Valley, Phalombe Plain,Mulanje, Lake shore areas and in other warm plateau areas with similar climatic conditions. Grams are a source of protein that will complement the protein present in cereal root and tuber crops. Gram is prepared as a side dish taken with staple meal. Immature pods of some gram cultivars are prepared as a vegetable dish.

Average yield range from 300 to 700kg per hectare. The crop can yield up to 1,500kg per hectare in pure stands. Farmers should be encouraged to grow the crop as a complement to staple food and in rotation with other crops or as an intercrop to improve soil fertility.

3.2.10.1. Improving yields

In order to improve yields the following crop husbandry practices are recommended

3.2.10.1.1. Suitable soils and climate

The crop will grow well on drained clay loam or sandy loam soils. A hot weather with a defined rainy season is preferred to enable the grain to mature and dry towards the end of rains. Contineous rainfall at maturity stage of crop growth encourages fungal diseases and rotting of mature pods.

3.2.10.1.2. Time of planting

Grams can be intercropped, relay cropped, grown in pure stand or as green manure crop.

It should be planted in December as first or as a green manure crop; and in February as a relay crop so that the pods mature and dry towards the end of the rains to avoid rotting of mature pods.

3.2.10.1.3. Plant population

Plant grams 2 rows spaced at 30cm on ridges 90cm or 75cm apart. Plant 1 seed per planting station spaced at 10cm on each row. When intercropped, number of seed to be planted will depend on the spacing of any other major crop. Seedrate is 6 to 10kg per hectare. A green manure crop will require a higher seedrate because a dense vegetation is required.

3.2.10.1.4. Fertilizer application

Currently there are no fertilizer recommendations for the crop.

3.2.10.2. Pest control

3.2.10.2.1. Weed control

Keep the field weed-free from emergency to maturity

3.2.10.2.2. Insect pest control

Not much is known on insect pest of economic importance for grams in Malawi. The following can cause yield losses;

(i) **Leaf and flower eating insects**

These can be controlled by spraying Carbaryl (Sevin) 85WP at the rate of 85g in 14 litres of water if using knapsack sprayer or 85g in one litre of water if using a ULV sprayer.

(ii) **Aphids**

Control aphids with Dimethoate 20WP at the rate of 34g in 14 litres of water if using knapsack sprayer or 35g in 1 litre of water using ULV sprayer. Spray whenever there is aphid infestation.

(iii) **Cut worms and grubs**

These can be controlled by drenching the base of seedlings with Carbarly 85WP. Mix 85g in 14 litres of water and drench using a watering cane.

3.2.10.3. Disease control

Information on diseases of economic importance in grams is not currently available, as there is no research undertaken on the crop.

3.2.10.4. Harvesting and threshing

Pods are ready for harvesting when they are black or brown in colour. Pick mature pods in the morning to avoid loss of grain by shattering. Harvesting should be done as soon as pods start drying to avoid shattering.

Thresh dried pods by beating the pods with a stick on the mat or using a mortar and pestle. Winnow to remove trash, stones and immature grains.

3.2.10.5. Storage

Store well dried grain in clean and dry containers or bags. Grams are very susceptible to insect pest damage in store. It is therefore important to apply Actellic Super Dust and Wivokil 25g per 50kgs of grain. Store in a cool dry place.

3.2.10.6. Marketing

Sell dry and clean grain, free of trash, stones and immature or discoloured grain.

Table 39: Estimated gram production for the past ten seasons

Season	Area (Ha)	Yield (kg/ha)	Production (mt)
2010/11	1,812	648	1,174
2011/12	1,828	598	1,094
2012/13	1,849	645	1,193
2013/14	1,806	643	1,161
2014/15	1,806	906	1,636
2015/16	1,275	607	774
2016/17	1,206	832	1,003
2017/18	0		0
2018/19	0		0
2019/20	0		0
Average	**1,655**	**694**	**1,148**

3.2.11. GUAR or CLUSTER BEAN *(Cyamopsis tetragonoloba)*

The crop is currently grown in some parts of Shire Valley, Blantyre and Machinga ADDs. Farmers grow the crop solely for cash and nitrogen fixing in the soil. It grows well on well drained sandy loams. The crop is mostly for industrial use (additives: baked goods, cheese, ice cream, and fried bean, papers and textile) and as cattle feed although some farmers use the leaf as a vegetable.

Average yields of guar beans range from 400 to 1,000kg hectare. The potential yield is 2,000 kg per hectare. The objective therefore is to increase production through improving yields and expanding production to other ADDs.

3.2.11.1. Improving yields and quality

To improve yields the following husbandry practices are recommended:

3.2.11.1.1. Use of recommended varieties

Khanpur Local is the variety being grown at the moment.

3.2.11.1.2. Time of planting

The appropriate time to sow guar beans is from mid to end January. However in abnormal wet seasons planting can be extended to the second week of February.

3.2.11.1.3. Plant population

Plant guar beans on ridges spaced at 90cm or 75cm apart. Sow 4 seeds per planting station spaced at 20cm. Thin to 2 plants when they are 10cm high. The seed rate is 6kg per hectare.

3.2.11.1.4. Fertilizer application

Fertilizer is not recommended.

3.2.11.1.5. Pest control

3.2.11.1.5.1. Weed Control

It is important to keep the field weed free until wadequate canopy coverage is attained.

3.2.11.1.5.2. Insect pest control

No pests of economic importance have been reported. Mild leaf blight attack can be a problem under warm conditions.

3.2.11.2. Harvesting

The crop should be harvested when pods and stems have turned brown. When harvesting up-root plants to avoid pod shattering. Threshing should be done on hard clean ground or on a mat free from sand and stones.

3.2.11.3. Storage

Store guar beans at 8 to 10% moisture content. Given good average weather conditions in the store, the guar beans resists storage pests and can be kept for several years without deterioration.

3.3. Oil seeds

Oil seeds are useful for both food and cash. They are important as a concentrated source of energy in the diet. The present production of edible oils in Malawi is not satisfying the existing demand thus necessitating importation. Increased domestic production of oil seeds will improve the supply of raw materials for the production of these oils there by reducing the need for importation. The major edible oil seed crops grown in Malawi are sunflower and sesame in addition to groundnuts and cotton.

Castor seed is a source of industrial oil.

3.3.1. National aim

The aim is to attain self sufficiency in edible oils. The existing yields and hectarage for oil seeds are very low. The objective is to increase production through improving yield and expanding hectarage in suitable areas.

3.3.2. SUNFLOWER *(Helianthus annuus)*

Sunflower oil is one of the top quality edible oils and the cake is used in the production of livestock feed. It is therefore important to encourage increased production of sunflower in all suitable areas. A warm, fairly dry climate is considered optimal for sunflower production. The drier warmer areas with an annual rainfall of 650mm to 850mm and a low relative humidity are suitable for the growth of the crop. However, 500 to 650mm annual rainfall is sufficient for the shorter early maturing types. Generally sunflower is not very selective to soil types provided the soils are well drained. The crop will produce high yields when grown on deep and well drained sandy loam soils.

A pH between 5.2 and 6.1 is optimum and sunflower can be grown on soils with PH range of 5.7 to over 8.0. Cool moist weather conditions are favourable for the development of rust disease (Puccinia helianthi), wilt disease (Sclerotinia spp.), and head rots (Septoria spp., Fusarium spp., Diplodia spp.) On the other hand, very hot dry conditions are favourable for the development of charcoal rot disease (Macrophomina phaseoli). Sunflower is commonly grown in areas such as South Mzimba, Kasungu North, Lilongwe to Mchinji plateau areas, Balaka and Phalombe as well as Lake Chilwa plain.

Average yields of unimproved varieties are 400 to 500kg per hectare but there is potential to increase yields up to 2,500 kg per hectare. Improved varieties can yield up to 3,000kg to 5000kg per hectare. The aim is to encourage farmers to grow the crop and expand hectarage in suitable areas and improve yields to satisfy raw material requirement for edible oils.

3.3.2.1. Improving yields

In order to improve yields the following husbandry practices are recommended:-

3.3.2.2. Use of improved varieties

Farmers should be encouraged to use improved varieties. The recommended varieties are:-

PAN 7351

Recently released variety well adapted to mid-altitude. Potential yield of 5000kg /ha and with oil content of 43. Tolerant to PM and SLM fungal diseases.

PAN 7049

Adapted to mid-altitude. Potential yield of 5000kg /ha and with oil content of 43%. Tolerant to PM and SLM fungal diseases.

PAN 7232

It is a nearly maturing variety. Matures in 90 to 100 days. It has a yield potential of 4,000kg per hectare with an oil content of 43%. The seed colour is black.

SO 323

It is a nearly maturing variety. Matures in 90 to 100 days. It has a yield potential of 3,500kg per hectare with an oil content of 43%. The colour of the seed is black.

Super 430

It is a medium maturing variety. Matures in 100 to 125 days. It has a yield potential of 3,000kg per hectare with an oil content of 41to 45% and the seed colour is striped.

Super 530

It is a medium maturing variety. Matures in 112 to 131 days. It has a yield potential of 3,000kg per hectare with an oil content of 42 to 45% and the seed is striped yields are obtained.

The following are the potential hybrid sunflower varieties Agsun 51, Agsun 57 and HV3037. Seed for improved varieties is obtainable from ADMARC and other suppliers.

3.3.2.3. Time of planting

Seed rate for unimproved cultivars is 8 kg per hectare and 3.5kg per hectare for improved varieties. Planting sunflower 4 to 6 weeks after the onset of effective planting rains produces the best yields. This is because the flowering and early grain filling stages coincide with the period when good rains occur. This will also let the crop escape diseases, since physiological maturity stage will occur under conditions of low relative humidity after the rainy season.

Ridges should be spaced at 75cm or 90cm apart and planting stations should be 50cm apart. Plant 2 seeds per station for improved varieties. For unimproved varieties, plant 4 seeds per station and thin to 2 seedlings 2 weeks after emergence.

Higher yields can be obtained when ridges are spaced at 75cm.

3.3.2.4. Fertilizer application

An application of 40kg per hectare P_2O_5 and 40kg/ ha N is recommended to obtain the best sunflower yields. This is equivalent to about 4 (four) 50kg bags of 23:10:5+6S+1.0Zn plus one 50kg bag of Urea or CAN. The two should be mixed and applied at once 2 weeks after sowing the seed using one heaped cup No.8. Fertilizer should be applied soon after thinning and placed at 10cm away from the plant.

3.3.2.5. Pest and disease control

3.3.2.5.1. Weed control

Weeding during the first 5 weeks after emergence is crucial. However it is important to keep the field weed free throughout the growing season. Sunflower is an important catch crop for witchweed (Striga asiatica),It should be used in rotation with maize to reduce witchweed infestation.

3.3.2.5.2. Insect pest control

It may be necessary to spray sunflower against cutting beetles such as dusty surface beetles, harpalus beetles, black maize beetles, cutworms and false wireworms during the early stages of plant growth. These can be controlled by spraying the plants with sevin (carbary l85%WP) at the rate of 1 sachet of 50g dissolved in 14litres of water using knapsack sprayer or 50g for 1 liter of water using ULV sprayer.

3.3.2.5.3. Disease control

Following all the recommended cultural practices for cultivating sunflower will reduce the incidence of diseases such as Alternaria leaf spots, septoria leaf blotch, rust and heat rot.

3.3.2.5.4. Nematode control

Sunflower is a host for root knot nematodes. It should therefore neither follow nor precede tobacco, soybeans, potatoes (kachewere), chillies or other Solanaceous spp in rotation.

3.3.2.6. Harvesting, drying and threshing

The sunflower crop is physiologically mature when the back of the head has turned from green to yellow and the bracts have turned brown. Harvesting should start as soon as the seeds are mature. The heads should be cut and dried near the homestead for ease of bird scaring. When dry, the heads should be beaten at the back pointing into a container. The seeds are then winnowed to remove chaff and other debris.

3.3.2.7. Marketing

Buyers and processors of sunflower seed are available in the country. Black seeded varieties fetch a higher price on the local market and it is advisable to grade the seed properly prior to marketing. Sell only clean winnowed seed.

3.3.2.8. Sunflower production

Estimated sunflower production for the past ten seasons is as shown in Table 40.

Table 40: Estimated sunflower production (tonnes) and hectarage for the past ten seasons

Season	Cultivated Area (Ha)	Yield (Kg/ha)	Production (mt)
2010/11	12,437	854	10,621
2011/12	14,094	882	12,429
2012/13	14,394	958	13,795
2013/14	14,909	1,024	15,273
2014/15	15,045	930	13,994
2015/16	16,156	974	15,736
2016/17	16,135	975	15,726
2017/18	19,320	1108	21,414
2018/19	19,202	1058	20,312
2019/20	17,860	1158	20,680
Average	**15,955**	**1003**	**15,998**

3.3.3. SESAME
(Sesamum indicum)

Sesame (Chitowe) is grown in Malawi either for food or cash. It is tolerant to drought and grown where other crops fail. The seed can be pounded into a cake (Sesame candy) which is eaten as a confectionery or sesame flour (nsinjiro) for seasoning side dishes. Sesame oil extracted from seeds is used for cooking and soap making. The processed oil is odourless and has a long shelf life. Sesame is also used in bakeries for drappings on bread. The crop does well along the Lakeshore, Phalombe and Shire Valley Plains. It can also grow in Lilongwe, Mzimba, Rumphi and Chitipa.

Sesame is interplanted with cereals and grain legumes. The major problems of sesame production in Malawi include poor cultural practices, insect pests and diseases.

Average yields range from 300 to 400 kg per hectare. Potential yields of up to 1,000 kg per hectare can be achieved in pure stands. The objective is therefore to improve yields towards the potential by following good cultural practices.

3.3.3.1. Improving yields

In order to improve yields the following crop husbandry practices are recommended:-

3.3.3.1.1. Use of improved varieties

The farmers should be encouraged to use improved varieties. Recommended varieties are Acc Mw 323, Acc Mw 431, Burkina 32-75 and Sebu.

3.3.3.1.2. Soil requirements

Sesame thrives best on soils which are well drained. It is extremely susceptible, even for a short period, to water logging at any stage of growth. Soils with a pH range of 5.5 to 8.0 are suitable.

3.3.3.1.3. Time of planting

Planting should be done between mid-January to mid-February so that the crop matures under dry days. Sesame will produce an excellent crop with a rainfall of 500 to 650mm. Heavy rains at flowering will drastically reduce yields and cloudy conditions are undesirable.

3.3.3.1.4. Plant population

Plant 2 seeds per planting station, 15cm apart on ridges spaced at 90cm. This will give a plant population of 150,000 plants per hectare. The seed rate is 3kg per hectare. A ridge spacing of 75 cm increases yields.

3.3.3.1.5. Pest control

3.3.3.1.5.1. Weed control

Early weeding protects the crop from intensive competition with weeds until the crop produces sufficient canopy to suppress further weed growth. The critical period is within the first 4 to 6 weeks of crop establishment. During this period, competition between the crop and weeds for nutrients, moisture and sunlight is high.

3.3.3.1.5.2. Insect pest control

The green peach aphid (Myzus persicae) is the most serious pest and is usually controlled by spraying with Dimethoate 20WP at the rate of 34g per 14litres of water for knapsack sprayer or 34g in one liter of water for ULV sprayer.

3.3.3.1.5.3. Disease control

Bacterial blight is the most serious disease when the crop is planted early. Leafspot is a serious problem in sesame as it causes premature defoliation of the leaves. To escape this disease, planting should be delayed until mid-January.

3.3.3.2. Harvesting, drying and threshing

Sesame is ready for harvest when one third to two thirds of the lower plant parts turn yellow. Cut the plants and tie into bundles. Stook the bundles upright to dry. When completely dry, thresh by gently and carefully beating the bundles turned upside down into a container. The process of beating should be done periodically until no seed comes out from the capsules in the bundles.

3.3.3.3. Sesame production

Estimated sesame production for the past ten seasons is as shown in Table 41.

Table 41: Estimated sesame production (mt) and hectarage for the past ten seasons

Season	Area (Ha)	Yield (Kg/ha)	Production (mt)
2010/11	2,155	370	798
2011/12	2,093	384	804
2012/13	2,662	312	831
2013/14	3,207	360	1,153
2014/15	3,592	376	1,352
2015/16	7,704	199	1,534
2016/17	7,704	199	1,534
2017/18	9,924	274	2,721
2018/19	9,329	314	2,932
2019/20	10,377	477	4,949
Average	**5,875**	**317**	**1861**

3.3.4. CASTOR SEED
(Ricinus communis)

Castor seed is an important source of oil for household and industrial uses (lubricants, medicines, paints and rubber). Suitable areas for castor growing are the Shire Valley, Phalombe Plain, Lakeshore Plain in Lilongwe and Chitipa

Average yields range from 150 to 400 kg per hectare. Potential yields of up to 2,000 kg per hectare are achievable. The objective is therefore to improve yields towards the potential by following good cultural practices.

3.3.4.1. Improving yields

In order to improve yields, the following cultural practices are recommended:

3.3.4.1.1. Use of good seed

The local giant variety grown by smallholder farmers is the only available planting material.

3.3.4.1.2. Weather Conditions

Castor requires moderately high temperatures of 200 to 260C with low humidity throughout the growing season to produce maximum yields. Rainfall between 600 to 700mm is optimum for high yields. Castor is fairly drought tolerant and can give fairly high yields when grown in areas with a rainfall of 375 to 500mm, provided it is well distributed throughout the growing season. Moisture stress at flowering or continuous rains at this period will reduce yields.

3.3.4.1.3. Suitable soils

Castor will grow and produce a crop in almost any soil type provided it is well drained. However, high fertile soils favour production of excessive vegetative growth resulting in low seed yield and therefore such soils should be avoided. Soils with a slightly acidic reaction of pH 5.0 to 6.5 are preferred.

3.3.4.1.4. Time of planting

To achieve high yields, plant with the first rains in areas such as the Shire Valley, Phalombe Plain and the Lakeshore Plain to allow the fruit to mature as the rains tail off. In medium altitude areas (500m to 900m above sea level), plant the crop in mid- December.

3.3.4.1.5. Plant population

Plant castor on ridges spaced at 75cm or 90cm. Sow one seed at 60cm between planting stations on the ridge. The seed rate is 10 to 12kg per hectare.

3.3.4.1.6. Pest control

3.3.4.1.6.1. Weed control

Keep the field weed free throughout the growing season.

3.3.4.1.6.2. Insect pest control

The most common insect pests are leaf eaters and flower moths.

3.3.4.1.7. Disease control

The most common disease of castor is Botritis mould–Recem (Botrytis cinerea). It is not economical to control the disease with fungicide.

3.3.4.1.8. Harvesting and shelling

The pods are ready for harvesting when they turn grey and the pods shows cracks. Harvest by hand picking only mature pods. The giant local variety produces the first ripe pods suitable for picking approximately 140 days after planting.

Dry the pods on a clean dry ground in the sun for a few days before shelling. Shell using a mortar and pestle.

3.4. Root and Tuber Crops

Root and tuber crops are important as a source of food, cash and raw materials for industrial uses. Even in areas where maize is a staple food, root and tuber crops are important food supplement. They are particularly important as food security crops in seasons of drought and survive relatively well in marginal soils.

3.4.1. National aims

In view of the importance of root and tuber crops, the objective is to improve production in areas where they are a staple food and encourage every farmer to grow them as food and cash crops. Farmers should be advised to grow root and tuber crops as any other important crop rather than resorting to growing them in incidences of eminent drought. The important root and tuber crops are as follows:

3.4.2. CASSAVA *(Manihot esculenta)*

Cassava is a staple food crop in the lake shore areas of Nkhotakota, Nkhata bay, Rumphi and Karonga. In some districts of Malawi such as Mzimba, Kasungu, Lilongwe, Dedza, Dowa, Machinga and Mulanje cassava is becoming a major cash crop.

It is also grown in other parts of the country as a security crop, eaten as a snack and also sold as dry cassava chips. The leaves are also used as relish (ndiwo). Cassava is also used as livestock feed. In addition cassava is becoming a significant industrial crop as it is used as a binder in the timber industry, starch in the textile industry and in confectionary industry. The main advantages of growing cassava are its drought tolerance, ability to yield well on marginal soils, tolerance to some pests and diseases, minimal labour requirement and that yields fluctuate less compared to grain crops.

3.4.2.1. National aims

The policy is to increase production in all areas. The national average yields range from 8,000kg to 20,000kg fresh weight per hectare. The potential yields of up to 45,000kg per hectare fresh weight (depending on the variety) can be achieved. The objective is therefore, to increase yields towards the potential.

3.4.2.2. Improving yields

To obtain high yields the following husbandry practices should be followed.

3.4.2.2.1. Use of improved varieties

There are currently 17 recommended varieties, fourteen of which are improved and the other three are local. The sweet varieties includes: Chamandanda, Chinangwa 1, Chinangwa 2, Mpale, Kalawe, and Mbundumali/Manyokola. The bitter varieties includes: Gomani, Chitembwere, Silira, Maunjiri, Mkondezi, Sauti, Yizaso, Phoso, Mulola, Sagonja, and Chiombola. Each variety has different yield potential as indicated in Table 42.

Table 42: Improved varieties of cassava

Variety	Taste	Special attribute	Maturity period (months)	Potential yield (tonnes/ha root fresh weight basis)
Chamandanda	Sweet	Yellow colour	12-15	26
Chinangwa 1	Sweet	White	12-18	37
Chinangwa 2	Sweet	White	12-15	38
Mpale	Sweet	White	12-15	30
Kalawe	Sweet	White	12-15	28
Mbundumali/ Manyokola	Sweet	White	9-15	25
Gomani	Bitter	White	9-15	25
Chitembwere	Bitter	White	9-18	18
Silira	Bitter	White	9-15	25
Maunjili	Bitter	White	9-12	35
Mkondezi	Bitter	White	9-15	40
Sauti	Bitter	White	12-15	25
Yizaso	Bitter	White	12-15	25
Phoso	Bitter	White	12-15	35
Mulola	Bitter	White	12-15	40
Sagonja	Bitter	White	9-12	35
Chiombola	Bitter	White	9-12	45

Farmers should be encouraged to use these varieties to obtain good yields per unit area.

3.4.2.2.2. Land preparation

Make ridges at 90cm apart and 30cm high.

3.4.2.2.3. Planting material

Cassava stem storage technique is encouraged among smallholder farmers who store the harvested cassava stems until there is enough rains for planning in the next season. Planting material should be free from insect pests such as cassava mealy bug and cassava scales; and diseases such as the cassava mosaic disease (CMD), cassava brown streak disease (CBSD) and cassava bacterial blight (CBB). Cuttings should be obtained from the base to the middle portions of well matured plants of older than 9 months. For plants that are 12 months or more the base should not be used for growing as it will have been lignified. Cuttings to be planted should be 25 to 30 cm long.

3.4.2.2.4. Seed rate

About 65 to 80 bundles of 50 one meter long stems are required to plant one hectare of cassava for root production.

3.4.2.2.5. Time of planting

Plant with the first planting rains. Farmers should not plant cassava late. Cassava does well on well drained soils.

3.4.2.2.6. Plant population

To obtain optimum plant population, plant cassava on ridges at 90cm apart and 90cm between plants where cassava is grown to be processed into Kondowole. This gives plant population of about 12,000 plants per hectare. For slender roots to be sold fresh on the market, a spacing of 90cm x 75cm or 90cm x 60cm can be used and will give plant population of about 15,000 and 18,000 plants per hectare respectively. Cuttings should be planted at about 45 degrees angle and two thirds of the cutting should be inserted into the soil. Cassava planted in dambos should be planted on high and big ridges spaced at 120cm for good drainage.

3.4.2.3. Pest control

3.4.2.3.1. Weed control

Weed early particularly during the critical first 3 months of the establishment of the crop. Delay in weeding results in low yields.

3.4.2.3.2. Insect pest control

(i) **Cassava mealy bug** *(Phenacoccus manihot).*

This is a serious cassava insect pest in the country. Symptoms of infestation include: leaf curl, shortened internodes, bunchy tops, stunted growth and complete defoliation. The plants should be checked for the presence of an insect which is covered by a waxy mealy-like substance, hence the name mealy bug.

No chemical control measures are advocated at the moment. The impact of the mealy bug on cassava is reduced by use of clean planting materials, early planting, restricting movement of cuttings from affected areas and biological control. Early planting will enable the crop to establish and form roots by the onset of the dry season before the cassava mealy bug population starts increasing and causing significant damage. It should be noted that biological control is a slow method of containing the pest and results may take some time to be effective. Farmers, therefore, are encouraged to strictly follow the recommended cultural practices.

(ii) **White flies** *(Bemisia spp)*

These are sucking insects and their feeding habit is not very destructive. They are important because they transmit the cassava mosaic and brown streak virus diseases. Control is aimed at the disease and not the insect pest. Use of clean planting materials is advocated.

(iii) **Cassavas Scales** *(Aonidomytilus albus)*

These are sucking insect pests. Their feeding activity results into yellowing and defoliation of leaves. They occur on the stem and leaves. Yields are reduced substantially. Control is by using clean planting materials and early planting.

(iv) **Cassava green mite (CGM)***(Mononychellus tanajoa Bondar)*

This is another serious pest of cassava. It is more prevalent during the dry season. Cassava green mite feeds on young leaves and tender shoots. Damage symptoms include yellow speckles, leaf size reduction and plant defoliation which may be followed by shoot dieback giving a candle stick appearance. Economic loss include damage to leaves which are used as a vegetable and root yield reduction. Control is by planting early, use of tolerant varieties and clean planting materials.

3.4.2.3.3. Disease control

(i) **Cassava Mosaic Disease (CMD)**

This disease is caused by cassava mosaic virus. It is characterized by mottled and curled leaves and transmitted by white flies. Control is by use of clean planting materials; and by uprooting infected plants in the field. The uprooted plants should be buried.

(ii) **Cassava Bacterial Blight** *(Xanthomonas campestris pv. Manhot)*

The disease is characterized by wilting tips and eventually appears as die back. Control is by burying or burning infected plants, use of clean planting materials and crop rotation.

(iii) **Cassava Brown Streak Disease (CBSD)**

Cassava Brown Streak Disease is caused by a virus and transmitted by White flies. Damage symptoms appear on the leaves, stems and roots. On the leaves the disease appears as patches of yellow areas mixed with normal green colour. The damaged leaves do not become distorted in shape as in cassava mosaic disease.

The symptoms are more prominent on mature leaves than on young leaves. On stems, the disease appears as dark streaks with dead spots. These streaks are more prominent on upper, green portions of the stems. On roots the disease causes discoloration and necrosis. It also causes root distortion/constriction. Control is by exercising good seed selection, rouging infected plants and use of CBSD tolerant varieties such as Sagonja, Chamandanda and Mpale.

Farmers should be advised to be on the lookout for any insect pest and disease outbreaks. Any outbreaks should be reported to the nearest agricultural office or any other government office.

3.4.2.4. Cassava processing

After the cassava crop has reached maturity, the quality of roots of most varieties often deteriorates after 15 months of growth. They should therefore be harvested on time. Processing cassava roots and leaves leads to a reduction in cyanide toxicity, improvement of palatability, conversion of the perishable roots and leaves into stable products, which can store for an extended period of time.

Farmers using sweet varieties should process their cassava roots using the cassava chip (makaka) methods if the end product is to be used for human consumption.

For bitter varieties farmers should process cassava using either heap fermentation as is done in Mulanje or submerged fermentation as is done in Nkhotakota and Nkhata Bay. For Industrial use such as in timber and textile industry, use cassava chips (makaka) for both bitter and sweet varieties.

Farmers are encouraged to store the cassava in flour or chip form.

3.4.2.5. Cassava storage

Cassava roots are highly perishable once harvested hence they are best left in the field and harvested as required. It is recommended that the cassava roots once harvested should be stored in a processed form.

Farmers should store cassava chips (makaka) in cool dry places after packing them in gunny bags. Cassava chips (makaka) should be stored in mudded nkhokwes.

To avoid weevil damage apply 25 g of Actellic Super Dust to 50kg makaka or 25g of Super grain dust to 50kg of makaka.

3.4.2.6. Marketing

Cassava can be sold as fresh roots, chips and flour. Farmers can also make money by selling cassava stems as planting materials.

Table 43: Estimated Cassava production (mt) fresh wt. for the past ten seasons

Season	Area (ha)	Yield (kg/ha)	Production (mt)
2010/11	200,139	21,567	4,316,373
2011/12	209,583	22,164	4,645,218
2012/13	211,089	22,804	4,813,699
2013/14	216,405	23,579	5,102,692
2014/15	220,500	22,485	4,957,879
2015/16	228,283	21,889	4,996,843
2016/17	231,657	21,413	4,960,556
2017/18	236110	22694	4897673
2018/19	240390	23490	5358163
2019/20	242454	23543	5708032
Average	**223,661**	**22,247**	**4,975,713**

3.4.3. SWEETPOTATO *(Ipomoea batatas)*

Sweetpotato is widely grown in the country as a food security and cash crop. It is mainly eaten as a snack. Orange fleshed varieties are a good source of vitamin A. Leaves of Sweetpotato are used as relish (ndiwo) and are good source of vitamin A.

3.4.3.1. National aims

The policy is to promote production throughout the country as food supplement and for cash. Present yields range from 7,000kg to 12,000kg per hectare fresh weight but there is scope to increase yields up to 40000kg fresh weight per hectare with improved varieties. The objective, therefore, is to increase yields towards the potential.

Table 44: Research recommended Sweetpotato varieties in Malawi.

Proposed name	Colour	Yield t/ha	Special attributes	Maturity (Months after planting)	% Dry matter
Kenya	Pale yellow	30	High dry matter	5	38
Semusa	Cream	40	Semi - erect growth habit	5	35
Mugamba	Cream	40	Semi erect growth habit	5	35
Zondeni	Orange	8-16	Deep orange	5	32
Sakananthaka	White	20-30	High dry matter	5	35
Salera	White	35	Very sweet and fast cooking	5	32
Kakoma	White	30	Very sweet and fast cooking	5	30
Nyamoyo	Cream	35	Cream, smooth roots for commercial	5	33
Sungani	Cream	35	Cream, high yielding	5	32
Anaakwanire	Deep Orange	25	Deep orange flesh, more roots(6 to 8 roots per plant	6	30
Mathuthu	Orange	25	Orange, soft (29% dry matter good for children	5	29
Kaphulira	Orange	35	Orange, very early maturity to allow for piece meal harvesting during lean times	3.5	30
Chipika	Orange	35	Orange, High yielding	5	30
Kadyaubwelere	Deep Orange	30	Deep orange flesh, sweet taste	5	31
Msungabanja	Deep orange	30	High yielding, betacarotene, moderate tolerance to SPVD	4.5	31
Royal choice	Orange	35	High yielding,moderate tolerance to SPVD	3.5	31
Mthetsanjala	Deep orange	30	High yielding, and betacarotene	4.5	32

3.4.3.2. Use of recommended varieties

Use clean and virus free vines.

1. The vine should be cut 10-15 cm away from the base to reduce incidence of sweetpotato weevil.
2. Where there is adequate soil moisture, experience has shown that cuttings from the shoot ends sprout and establish quickly.

Farmers should be encouraged to establish nurseries in dambos and near any other water sources in order to raise adequate plant material for early planting. Cuttings should be 25 to 30cm long.

3.4.3.2.1. Planting and plant population

For root production, the ridges should be spaced at 90cm and planting stations at 30cm. This gives a plant population of 38,000 plants per hectare. Place two thirds of the cutting deep in the soil on ridges. Where white grubs are a problem, do not plant on soils rich in organic matter. Soils which are water logged should be avoided. For seed production, beds are recommended. Standard bed is 20m x 1m. The bed will require 5 bundles (1 bundle 100 cuttings of 30 cm long). In 1 ha there are about 333 standard beds.

3.4.3.2.2. Seed rate

About 370 bundles of sweetpotato vines are required to plant one hectare. Each bundle contains 100 cuttings of 30 cm long of vines. This is for root production. However for seed production; 1650 bundles are required per hectare; and the 30 cm long vine is cut further into 2 or 3 pieces (10 cms each) depending upon variety.

3.4.3.2.3. Time of planting

Sweetpotato should be planted with the first planting rains. Where rainfall is not reliable, planting should be completed by mid-January. This enables the crop to establish while there is still adequate moisture in the soil.

Farmers who plant their Sweetpotatoes in dimba gardens like in the Shire Valley flood plain should plant their crop as soon as water has receded. This ensures enough residual moisture for the crop to establish well.

3.4.3.3. Pest control

3.4.3.3.1. Weed control

Weed early particularly during the first 6 weeks of establishment. Weeding may not be necessary where the crop is fully established and has covered the whole ground. Where the crop cover is poor, hand weeding should continue as required.

3.4.3.3.2. Insect pest control

(i) **Sweetpotato weevil** *(Cylas formicarius)*

This is the most destructive insect pest of Sweetpotato. Even very low populations reduce quality of the tubers. In response to weevil feeding, the crop produces bitter testing and toxic substance which render stored roots unfit for human consumption. The problem is more prevalent during the dry season. Control is by practicing crop rotation, use of resistant varieties namely: Yoyera, Babache, Kenya, Kakoma, Semusa, Mugamba, Tainoni, filling cracks when the roots start bulking, and timely harvesting. Part of the vine 10-15 cm above the base is ok.

(ii) **White grubs**

White grubs cause serious damage to roots and tubers of Sweetpotato. Where they are a problem do not plant on soils rich in organic matter.

3.4.3.3.3. Disease control

3.4.3.4.1.Sweetpotato Virus Disease (SPVD)

This is caused by Sweetpotato viruses. The disease is characterized by mottled and curled leaves and is transmitted by aphids and white flies. Control is by use of Sweetpotato Virus Disease (SPVD) clean planting material, rouging of infested plants and use of torelant varieties namely Yoyera, Babache, Lunyangwa, Kakoma, Semusa, Mugamba, and Royal Choice.

3.4.3.4.2. Harvesting

Harvesting should be done when the crop is fully mature. Never leave the crop in the field for a longer time otherwise the sweetpotato weevils will heavily attack the tubers hence reducing the quality and quantity of usable tubers. Care should be exercised not to bruise or cut the tubers to avoid storage problems.

Table 45: Estimated Sweetpotato production (mt) (fresh weight) and hectarage for the past ten seasons

Season	Area (Ha)	Yield (kg/ha)	Production (mt) fresh weight
2010/11	188,705	17,081	3,223,263
2011/12	121,166	16,936	2,052,047
2012/13	210,002	18,002	3,780,512
2013/14	224,259	18,772	4,209,699
2014/15	172,454	17,865	3,080,859
2015/16	185,116	17,401	3,221,232
2016/17	271,449	20,159	5,472,073
2017/18	204,187	19,721	4,026,730
2018/19	209,681	21,258	4,457,421
2019/20	290,183	21,950	6,369,543
Average	**207,720**	**19,205**	**3,989,338**

3.4.4. POTATO *(Solanum tuberosum)*

Potatoes locally known as Kachewere grow successfully in areas of high altitude, which have a cool climate and adequate rainfall. These areas include Tsangano, Neno, Dedza, Shire Highlands, Viphya Plateau, Ntchisi, Mchinji, Phoka and Misuku Hills. In these areas it is an important cash and food crop. The bulk of the crop is consumed in urban and semi urban areas where it is an important component of the diet.

3.4.4.1. National aims

The policy is to increase production to meet domestic demand. Present average yields of 7,500 to 10,000kg per hectare fresh weight can be increased to between 15,000kg and 20,000kg per hectare. The objective therefore is, to improve yields in order to improve farmers' income and food security.

3.4.4.2. Improving yields

In order to achieve high yields the following husbandry practices are recommended:

3.4.4.2.1. Use of recommended varieties

The following are recommended varieties: Rosita, Cardinal, Holland, Desiree, Pimpernel, Roslin Bvumbwe, Roslin Tsangano, Violet, Chuma, Thandizo, Njuri, Bembeke, Mwai, Mpatsa, Mtukulapakhomo, Kaso, Ufulu and lady rosetta.

3.4.4.2.2. Site selection and field preparation

Soils should be free-draining, deep and rich in organic matter with soil acidity of pH5.0 to 6.5. Avoid rocky soils, which deform developing tubers. Plough deeply and break soil clods to make a fine tilth. Make ridges between 75cm to 90cm apart.

Table 46: Recommended potato varieties in Malawi

Variety	Yield Potential (Tons/Ha)	Utilization	Tuber Dormancy	Dry Matter	Maturity
Rosita	18-25	Chips Crisp Table potato	Short dormancy	21%	Early Maturing (90 Days)
Violet	25-30	Chips Table Potato	Short Dormancy	22%	Medium Maturity (120 Days)
Mwai	35-40	Chips Table Potato	Long Dormancy	21%	Early-Medium Maturity (90-120 Days)
Chuma	35-40	Chips Table Potato	Long Dormancy	21%	Late Maturing (over 120 Days)
Zikomo	35	Table Potato Chips	Long Dormancy	18%	Medium Maturity (120 Days)
Njuli	35	Crisp Chips Table potato	Medium to Late Dormancy	23%	Early –Medium Maturity (90-120 Days)
Thandizo	35-40	Table Potato Chips	Short Dormancy	23%	Early Maturing (90 Days)
Mpatsa	36	Chips Table Potato	Short Dormancy	20	Early maturity (90 – 110 days)
Mtukulakhomo	30	Chips Table Potato	Medium Dormancy	22	Early maturity (90 – 110 days)
Kaso	30	Chips Table Potato	Medium Dormancy	22	Early maturity (90 – 110 days)
Ufulu	32	Chips Table Potato	Short Dormancy	22	Early maturing (90 – 110 days)

3.4.4.2.3. Planting

Before planting loosen the soil in the furrow sand apply fertilizer and manure as recommended.

Plant spacing should be 30 cm apart and ridges placed at 90cm apart for table production. While potato for seed, plant spacing 25cm apart and 75 cm ridge spacing. This gives a plant population of 38,000 to 54,000 plants per hectare, respectively. Plant well sprouted tubers. The seed rate ranges from 2,000 to 3,000kg per hectare depending on the size of seed potatoes. After planting, tubers should be covered with about 6 to 10cm of soil depending on soil moisture. In dry soil seed tubers should be planted deeper. Manure and fertilizer application

After ridging make grooves on top of ridges 15cm deep. Apply between 12.5 and 25 tonnes of compost or khola manure per hectare using one to two 20 liters tins for every 8 metres (8 steps) along the grooves. Apply 200kg of D compound per hectare. Apply the fertilizer in the grooves and cover the fertilizer and manure with about 5 cm of soil. Three to four weeks after crop emergence, top dress with 200kg of CAN per hectare. Apply 20g per meter of ridge length using 5 cupfuls of cup No.5. Top dressing is done by applying the fertilizer along the plant rows on the ridge and working it into the soil.

3.4.4.3. Pest control

3.4.4.3.1. Weed control

A potato field should be weeded twice during the growing season. When the crop is crowding occasional weeds should be uprooted by hand. Hoe weeding later in the growing season is not economical and moving in the field when the crop is very dense assists in spreading viruses. Earth up to cover developing tubers and to prevent tuber moth infestation.

3.4.4.3.2. Insect pest control

(i) **Aphids** *(Myzus persicae)*

Aphids are controlled by spraying with Malathion 25WP or Dimethoate 20WP. If applying Malathion, use 14g in 14 litres of water for knapsack sprayer or 14g in 1 liter of water for ULV sprayer. If using Dimethoate, apply 34g in 14 liters of water for knapsack sprayer or 34g in 1 liter of water for ULV sprayer.

(ii) **Tuber Moth** *(Phthothorimaea operculella)*

Tuber Moth damage can be avoided by earthing up. Chemical control in the field can be achieved by spraying Dipterex 50WP or Lebaycid 50WP at the rate of one fertilizer cup. No.16 per 15 litres of water for both chemicals; starting when plants are 23cm high that is approximately one month old. This should be done repeatedly at intervals of 10 to 14 days. Seed tubers should further be protected by dusting them with one sachet (40g) of Pirimiphos- methyl (Actellic) per 90kg sack of potatoes.

3.4.4.3.3. Disease control

(i) **Late Blight** *(Phytophthora infestans)*

This is the most serious fungal disease of potatoes in Malawi. Late Blight is controlled through the use of resistant or tolerant potato varieties such as Rosita and Cardinal among the recommended varieties. The diseases can also be controlled by spraying with fungicides as Mancozeb (Dithane M45) 80WP at the rate of 20g per 10 liters of water or Chlorothalonil (Daconil 2787W-75) at about the same rate. The disease attacks the crop early in the season, planting out of the main rainy season helps to prevent the disease as it does not cause problems during hot or dry weather.

(ii) **Early Blight** *(Altenaria solani)*

This is also a fungal disease that attacks potato and damage the foliage.

Fortunately this disease in Malawi attacks the crop later in the season than Late Blight. So a crop that is planted with first rains is usually not badly affected. Control measures are the same as those for Late Blight

(iii) **Bacterial Wilt** *(Ralstonia solanacearum)*

This is a very destructive bacterial disease of potatoes. The bacterial multiplies in the vascular system of the plant and blocks the flow of water from the roots to the above ground plants. The sprout wilts due to a lack of moisture. This occurs despite the fact that there is no water stress visible in other plants, and the soil is moist. If the plants are infected in the later stages of development, when tubers are developing, the bacteria will get into the tubers and survive there. Typical symptoms of bacterial wilt in tubers include: Oozing eyes, soil sticking to the eyes, vascular browning, and ooze coming from the vascular ring and rotting of tubers.

There is no chemical control measure. Bacterial Wilt is avoided or controlled by use of crop rotation and disease-free fields. Rouging of diseased plants in an infected crop reduces the spread of the disease. There are no tolerant varieties to bacteria wilt in Malawi.

(iv) **Potato Viruses Y, X and Potato Leaf Roll Virus (PLRV)**

There are many viruses that attack potatoes and cause yield losses of up to 80 to 90%.The viruses common in Malawi are Potato Virus Y, X and Potato Leaf Roll Virus (PLRV). Viruses do not have chemical control. They are transmitted by insects such as aphids and whiteflies and mechanically as farmers move in the crop. The recommendation is to use clean seed, use tolerant potato varieties, and control the aphid population. Most of the newly recommended varieties i.e. Violet, Chuma, Thandizo, Njuri, Bembeke, Mwai are tolerant to viruses.

Primary symptoms for PLRV are:-

Rolling of upper leaves especially leaflet bases. Leaves tend to be upright and are generally pale yellow.

Secondary symptoms for PLRV are:-

Rolling of basal leaves, stunting, upright growth and paleness.

Control of PLRV

Chemical control of PLRV is aimed at controlling aphids in order to reduce spread of the virus within a field. Apply insecticides from early to mid-season if aphids and PLRV are present. The following chemicals are recommended to farmers for control of green peach aphids; Cypermethrin, Deltamethrin, Apha-cypemethrin, Dimethoate, Chloropyrifos, Acetamiprid, Imidacloprid. Application rates must be as per manufacturer's recommendations. Since the virus also spreads through seed, farmers are recommended to use clean seed only.

(v) **Nematodes** *(Meloidogyne spp)*

The potato nematode of economic importance in Malawi is root knot nematode (Meloidogyne spp.) It is best controlled through crop rotation and use of chemical Nematicides such as Furadan. Use recommendations on the label.

3.4.4.4. Harvesting

The potato crop is mature when leaves turn naturally yellow or the top dies off. If the crop must be harvested before it fully matures, the tops should be cut off at least 2 weeks before harvest. This allows tuber skins to harden so that they are not damaged during harvesting. When harvesting tubers they should be dug from the sides of the ridges not from above to avoid tuber damage. After harvesting avoid exposing the tubers to rain or any moist conditions.

3.4.4.5. Potato storage

3.4.4.5.1. Ware potatoes

Potatoes meant for consumption are termed ware potato. Potato for consumption should be stored in darkness (dark store or dark containers). This is to avoid greening of tubers. Green tubers are not good for consumption because they contain a toxic substance. Storage does not improve quality of the potatoes therefore best quality crop should be stored from the start. Potatoes are usually 80% water and keeping potato means keeping water in tubers. The shelf life of potatoes for consumption can be prolonged by keeping them at low temperatures less than 90C. The use of modified potato storage structures is practically recommended under Malawi conditions. Under smallholder storage systems, these are double walled nkhokwes.

3.4.4.5.2. Seed potato storage

Storage of seed potato is different from that of ware potato. Good seed storage practices should aim at retaining seed potato tubers' vigour, health and other good planting materials attributes. Potato tubers for seed should be stored in Diffused Light Store so that when they start sprouting ('germinating'), the sprouts will grow slowly, vigorously and will be stronger. A barn-like structure 8m x 4m x 3m with open sides and a low-hanging roof that allows in diffused light is used for the storage of seed potatoes. The walls are made of split bamboo to allow some light in. Once green and under cool conditions, seed potato can store for 3 months. Varieties own dormancy assist in lengthening the life span of the tubers. The structures can be seen at Bembeke Research Station in Dedza.

Table 47: Estimated potato production (mt) for the past ten seasons

Season	Area (Ha)	Yield (kg/ha)	Production (mt)
2010/11	52,689	17,631	928,941
2011/12	24,206	15,439	373,708
2012/13	54,207	16,917	917,027
2013/14	58,604	17,473	1,023,981
2014/15	37,009	16,276	602,351
2015/16	37,958	15,321	581,548
2016/17	66,604	18,416	1,226,603
2017/18	41,061	15,216	624,798
2018/19	42,007	12,602	529,369
2019/20	70,310	15,831	1,113,077
Average	**48,466**	**16,344**	**792,140**

3.5. Tobacco
(Nicotiana Tabacum)

Tobacco is one of the most important export crops for Malawi. It is a major foreign exchange earner to the country's economy and a source of cash income for both smallholder and estate tobacco sub sectors.

Despite pressure from the anti-smoking lobbyists, the demand for tobacco still exists. The sustainability of tobacco industry will however be assured only if farmers produce high quality tobacco.

Extension officers and other parties interested in ensuring the long term sustainability of the tobacco industry should make farmers appreciate that prices offered for the crop will decrease considerably with production of low quality tobacco. Tobacco production should be within the national production targets as determined from requirements indicated by tobacco buyers. It has been observed that some people wrongly regard the granting of land lease as an automatic license to grow tobacco. After obtaining lease hold land, they proceed to have employees and to buy agricultural inputs such as fertilizer before obtaining an authority to grow tobacco. Prospective tobacco growers are therefore strongly advised to obtain a license before buying inputs and recruiting employees for tobacco production.

Countries which import tobacco from Malawi are very strict with residual levels of pesticides in tobacco. It is, therefore, essential that pesticides are only used on tobacco nurseries and in the field as recommended. Agricultural chemicals not normally used on tobacco should never be allowed to come in contact with tobacco during production, curing or in storage. Farmers are advised not to store any chemicals in tobacco barns and holding sheds.

National average yields per hectare are 1000kg for Dark tobacco (Northern Division Dark Fire-cured (NDDF), Southern Division Fire-Cured (SDF), Sun-Air Cured or Dark Air Cured (DAC) tobacco), 500kg for Oriental tobacco, and 1,500kg for Burley tobacco and 1,800kg for Flue Cured or Virginia (FCV) tobacco. These yields are very low compared to potential yields of 2,500kg per hectare for Dark tobacco, 1,000kg for Oriental tobacco, 3,000kg for Flue Cured or Virginia tobacco and 4,000kg for Burley.

3.5.1. National aims

The policy is to increase yield and improve quality of tobacco which in turn will translate into high earnings and poverty reduction for farmers. It is Government policy to regulate production as well as the pricing of tobacco on the market through provision of grade minimum prices.

It is government objective to ensure sustainable production of tobacco using practices that protect and improve the environment in which tobacco is grown.

TOBACCO PRODUCTION SYSTEMS

Production

Tobacco in Malawi is produced under two main systems; Integrated Production System (IPS) and non-IPS system. The IPS refers to tobacco that is produced under contract with the buying company. Within the IPS, there are two categories; sponsored and non-sponsored, where the former's production is supported through loans on production inputs and the latter only agrees to sell to the contracting company.

Tobacco is produced in two farmer sectors; smallholder and estate sectors.

The smallholder sector produces over 90% of burley, 30% of flue cured and 100% of dark tobacco in Malawi. Farmers operating under this sector mainly do so in clubs of at least ten farmers each. Individually, they have land holdings of as little as 0.5ha.

The estate sector produces the rest of the tobacco volumes. This sector mainly produces flue cured tobacco under large and leased estates.

TYPES OF TOBACCO GROWN IN MALAWI

Malawi grows different types and varieties of tobacco. The choice of tobacco type and/or variety depends on trade requirement, farmer preference and prevailing climatic and soil conditions.

BURLEY VARIETIES

Several varieties of Burley tobacco are recommended for production in Malawi. These include locally-developed and introduced varieties that have been tested and approved for use under Malawi conditions.

Recommended locally-developed Burley varieties include: ABH12, ABH31 and ABH43, all of which are male sterile and compliant to trade requirements on seed integrity and traceability.

Growers who are interested to use introduced varieties should follow appropriate procedures for importation.

FLUE CURED VARIETIES

Currently recommended locally bred Flue cured tobacco varieties in Malawi are AFH1, AFH2, AFH3, AFH4, AFH5 and AFH6. Farmers also have a choice to grow tested and registered introduced varieties from reputable international tobacco research institutions.

DARK TOBACCO VARIETIES

Dark tobacco is one of the most important tobacco types grown in Malawi. Recommended varieties include: ADFC1, ADFC2, ADFC3 and ADFC4. Other varieties include Malawi Western, MW86-57, AWL10 and AWL28.

3.5.2. Improving yield and leaf quality

3.5.2.1. Nursery management

i) Different approaches are recommended for tobacco seedling production. These include: conventional seedbeds, motherbed, polypot and float tray systems. In general, the nursery site should be located on a piece of land that has good surface and internal drainage. The site should be away from curing and grading facilities. Soils suitable for tobacco nurseries include: fertile sands, loamy sands and light sandy loams, which are easy to manage and work with.

ii) The sites should be tilled deeply, as early as possible while soils are still moist. Large clods should be broken down, but avoid working the soil unnecessarily. It is recommended that the length of seed beds should be 30m or any convenient length and 1m wide. The beds should be raised to 15cm high and the top should be slightly convex above the level of surrounding path to provide good drainage or rather cumbered beds. Equivalent bed space to raise enough seedlings for 1 hectare is 3 beds of 30m long by 1m width. Nursery sites should be properly fenced to ensure protection from stray animals and other pests, strong wind and airborne diseases. Avoid smoking near and in the nursery. Soap and water should be made available for hand washing and a footbath provided for disinfecting the feet at the entrance of the nursery. These measures will prevent spread of diseases;

a) Nematodes should be controlled by using recommended pesticides such as Basamid or by burning. Basamid, a chemical in a form of white granules, is applied at the rate of 1.5kg for a standard seed bed of 30m x 1m. Before applying the chemical, water the seed beds for 12 days to activate organisms. Leave seedbeds for 2 days for the soil to reach field capacity. On the14th day, apply the chemical using the above rate and thoroughly mix with soil to a depth of 20cm.The seed beds should immediately be covered with a plastic sheet and should remain in place for 7 days. On the 21st day plastic should be aerated in order to release some toxic gases that may injure the seed. The second aeration should be done on the 26th day and 2 days thereafter, sowing can be done. Basamid does not leave any harmful residues after breaking down making it an ozone friendly chemical.

If burning using maize stalks is employed, 1m of maize stalks are piled and burnt for the purpose of controlling nematodes in the seedbeds meant for raising tobacco seedlings. Water is applied for 12 days before piling the stalks to activate soil organisms after which actual burning is done. As much as possible ash should be removed from the seedbed to reduce chances of seedling damage from excess salts.

b) Alternatively, nematodes can be controlled by using the float tray system. The method uses soil less media to raise seedlings with the aim of preventing soil borne pathogens and nematodes. Pine bark is the common substrate used in float tray tobacco seedling production.

3.5.2.2. Field management

Farmers should aim at transplanting tobacco with the first planting rains so as to complete the operation before Christmas except for Oriental tobacco which can be transplanted in January in areas where this type of tobacco recommended for production. Transplanting tobacco after December is not recommended because farmers run a high risk of the crop catching bushy top disease.

In case farmers transplant in January, a routine spray of Acetamiprid at a rate of 3g mixed with 10 litres of water after transplanting and depending on scouting.

Where resources permit, famers should apply recommended pesticides (CPAs) such as Confidor 70WG against aphids, Velum 400SC for control of nematodes and other transplanting and post-transplanting CPAs guided by ARET's yearly list of pesticides recommended for use on tobacco in Malawi to improve crop performance. To maximize yield, tobacco should be water planted. This refers to a procedure where tobacco seedlings are transplanted 2-3 weeks prior to the rains by applying 5 to10litres of water in the transplanting hole followed by proper covering with dry soil. The amount of water applied also depends on the soil moisture content at the transplanting time and prevalent climatic conditions.

Farmers should follow a minimum rotation of 4 years to avoid build- up of pests and diseases, particularly nematodes. Soybeans are an alternative host for root knot nematodes and other aerial pathogens of tobacco. Soybeans should therefore not be grown next to tobacco or immediately before tobacco in a rotation.

3.5.2.2.1. Tobacco and cotton

In areas where both tobacco and cotton are grown, great care is required to avoid insecticides used on cotton drifting onto tobacco. If traces of pesticides not recommended for tobacco but used on cotton are found on tobacco, the good reputation of Malawi tobacco on the international market would be jeopardized.

It is therefore essential that tobacco should not be planted within 100m radius of any cotton crop. Great care should also be taken to ensure that no insecticides used in cotton are stored or prepared for spraying in buildings used for curing or handling tobacco as this would also lead to contamination of the tobacco.

3.5.2.2.2. Tobacco hygiene

The tobacco free period known as closed season should be strictly observed to reduce the build-up and incidence of pests and diseases including tobacco bushy top and nematodes which threatens the industry. Tobacco bushy top virus is transmitted by aphids *(Myzus persicae)*.

Alternative hosts such as *Kasiyabwinja (Nicandra physaloides)* and *Chambwinja (Datura stamonium)* should not be allowed in or near tobacco fields. All tobacco stalks should be uprooted and burned as soon as the last reaping is completed.

Usually by 1st May and 15th May farmers must have uprooted their tobacco stalks from their fields in the Southern and Central regions respectively. In the Northern region, stalk uprooting should have been completed by 30th May each year.

Stalk uprooting should be strictly adhered to regrowth of tobacco and alternate hosts for aphids and nematodes such as potatoes, tomatoes, sunflower, chilies and eggplant should not be allowed to grow in or near tobacco fields during the tobacco free period.

Tobacco nurseries should be well cleared and seedlings destroyed for hygienic purposes. This should not exceed 31st December in the Southern and Central regions. In the Northern region, nursery destruction should be done before 1st January of each year.

3.5.2.2.3 Tobacco Insect Pest and Disease Management

3.5.2.2.3.1 Pests

The most common pests of tobacco are as follows:

1. **Ants** *(Monomorium minimum)*

   Symptoms of ant damage are their observed presence in large numbers on the seedbeds and reduced seed germination because they carry the tiny newly sown seed off the seedbed.

   Control is by drenches of imidacloprid, Decis Forte and Lambda-Cyhalothrin.

2. **Aphids**

   (Myzus persicae, M. nicotianeae)

   The tobacco aphid also known as the green peach aphid is the most severe insect pest of tobacco in Malawi. They settle down on the tobacco plant, particularly on the underside of leaves and form colonies on tender shoots, sucking the sap. They transmit viral diseases such as bushy top. Aphids also exude sticky substances called honeydew which encourage growth of fungi that becomes black in appearance.

   Chemical control of aphids must be preventive, both in the seedbeds and in the lands. In seedbeds, Imidacloprid, Thiamethoxam, Acetamiprid and etc can be used. In the field drenches of Imidacloprid, Thiamethoxam at transplanting will control aphids at recommended rates.

3. **Budworms** *(Heliothis spp)*

   The first generation larvae are almost black but older larvae may appear brown or green to almost black with pale undersides. The larvae grow to reach 3-4 cm in length and appear at any time in the season. They are mainly attracted to young leaves, especially at the bud where they feed causing many holes in the tiny developing leaves. As these leaves increase in size, the feeding holes increase proportionally, giving the leaves a raged distorted appearance. Tobacco plants are sometimes topped by budworms, results into early sucker growth that can cause stunting and the need for extra labor to remove the suckers.

   Control is by hand picking under light infestations and chemical sprays of Steward 150 EC, Aryna 46EC, Belt Expert 480 SC etc.

4. **Cutworms** *(Agrotis sp)*

   These are brownish-grey, soft bodied hairless caterpillars about 2-4 cm long. They are most active and prefer feeding at night, cutting stems of seedlings in seedbeds, or newly transplants at ground level or just below ground level. They can be found below ground 2-5 cm away from newly damaged plants. The insect will curl up into a small thick lot when disturbed. Cutworms are active at night.

Control is by early ploughing of seedbeds and lands to decompose plant material, chemical control in seed beds with drenches of lambda-Cyhalothrin, Belt Expert 480 SC and Deltamethrin will provide effective control in the nursery only. In the field, lambda-Cyhalothrin drench at the base of the plant soon after transplanting will control cutworms. Apply the chemicals at recommended rates.

5. Grasshoppers *(Zonocerus elegans)*

These include the common grasshoppers, green grasshoppers and elegant grasshoppers. Damage is mostly through feeding on the stems, leaves of young seedlings, transplants and chewing of the leaves of older plants.

Control of cutworms and budworms in the seedbeds and lands will also control grasshoppers.

6. False wireworms *(Trachynotus spp Wand Psammdes spp)*

Wireworms, the larval stage of click beetles are hard, yellowish-brown grubs that live in the soil and tunnel the roots and piths of young tobacco plants during the first months after transplanting. The lifecycle of a wireworm takes about a year to complete and ranges from 1-3 years.

Control is by early ploughing to allow complete decomposition of the plant residues. Drenches of Karate 5EC in the lands provide effective control.

7. Termites *(Odontotermis spp)*

Termites can be observed both in nurseries and in the lands, especially where there is lack of decomposed organic material during hot and dry weather. Seedlings or young transplants are eaten just at the base of the stem.

In seedbeds, drenches for control of ants, aphids and cutworms will also deter termites. Often the drench of Confidor will control the termites for sometime.

8. Stink bugs *(Nezara spp)*

These are green or brown colored insects, shield shaped on the back of wings damage is caused by the insect sucking sap, particularly on young, tender leaves. Leaves wilt very rapidly and droop, but usually recover to normal. Under hot, dry conditions, the leaves may become scorched.

Control recommendations for tobacco aphids will also be effective for stink bugs.

9. Tobacco Beetle *(Lasioderma serricorne)*

Tobacco beetle or cigarette beetle, is a storage insect pest, which thrives and multiplies in dirty bulking and grading sheds and tobacco burns. At the end of the season, these buildings should be cleared of tobacco, tobacco scraps, and tobacco dust, and washed with water and detergent and sprayed with Fendona or Cislin. The walls should be plastered and white washed. Particular attention should be paid to corners and crevices where tobacco dust may accumulate. Cured tobacco should not be stored in the same room as other stored crops such as maize. Cured tobacco should not be kept from one season to another to avoid tobacco beetle.

To ensure tobacco hygiene during storage with respect to this pest, farmers are required by law to have their tobacco holding shed and storage structures checked from time to time by produce inspectors. If tobacco is infested by the beetle it should be fumigated using Phostoxin 56% and a certificate issued from government inspectors before sale.

Note: This chemical must applied by registered fumigators only

Other tobacco pests include: - crickets, stem borer, leaf miners, white grubs, white flies and laceworms. Sprays recommended for tobacco aphids and budworms will also control the aforementioned pests.

3.5.2.2.3.2 Diseases

Common tobacco diseases in Malawi are as follows:-

1. Damping Off *(Pythium spp)*

Damping off is probably the most common seedbeds disease and often responsible for more seedbed failures than any other disease. The disease affects tobacco at any stage of growth in the seedbeds and can also develop on newly transplanted tobacco. Damping off occur mostly, under cool wet weather conditions though over watering or excessive runs and undecomposed organic manure used in seedbeds can also increase severity.

Symptoms first appear on the lower stem of the seedling as brown to black rot. The decay extends up the stem and causes seedlings to collapse. Seedlings wilt and appear yellow and stunted in patches.

Control is by seedbed treatment with basamid or burning, reduced watering in seedbeds and seedbed drenches with copper compounds (copper Oxychloride) for damping off.

2. Root Knot Nematodes *(Meloidogyne spp.)*

Nematodes (also called eelworms) are by far the most serious pest problem of tobacco in Malawi as in many parts of the world. The most serious ones affecting tobacco are the Meloidogyne spp. This type of nematodes favours light sandy solids. It is spread by practices which move soil form infected lands to clean lands, such as by cultivations and tillage implements, erosive running water and strong winds which can blow eggs in dust for long distances. Continuous cropping of tobacco or rotations with susceptible crops in the same land will aggravate the attack to serious proportions.

Symptoms of attack are stunting and yellowing of leaves, occurring in patches in the land. If the plants are uprooted and examined, galls will be noticed on the roots, usually accompanied by reduced production of fibrous roots.

Control of nematodes

a) Use of resistant or tolerant varieties

b) Rotations with other crops which do not encourage build-up of the rootknot nematodes.

c) Rotations with grasses such as weeping love grass *(Eragrostis Curvula, Ermelo Strain)* in nursery sites or Katamran Rhodes Grass *(Chlorisguyana)* in the lands.

d) Removal of tobacco volunteer plants during the off season and keeping fields free of weeds.

e) Chemical control of nematodes.

If there is any doubt about the presence of nematodes in tobacco lands, ARET can analyze suspected soils for nematodes.

3. Alternaria Brown Spot *(Alternaria Alternata)*

Alternaria can be seed borne or can originate from old tobacco scraps, stalks and alternate hosts particularly solanaccous plant. It is spread by wind. Frequent rainfall and high humidity favour further development of the disease. Excessive nitrogen increases susceptibility of the crop. The disease appears first on the older leaves as circular, brown spots with sharply defined margins. As the leaves approach maturity, a yellowish 'halo" of varying width often forms around the lesion. The disease severity depends much on the weather, the overall health of the plant, varietal tolerance and harvest rate.

The control of the disease can be achieved in several ways such as use certified, disease – free seed treated with silver nitrate, particularly of the resistant varieties, rotation of nurseries and tobacco lands, treat seed beds with Basamid in the nursery and Velum 400SC in the field and plant early to escape infection etc.

4. Angular Leaf Spot and Wild Fire *(Pseudomonas syringae pv tabaci)*

Angular leaf spot and wildfire are both devastating diseases of tobacco caused by different strains of the same bacterial pathogen. Both diseases develop and spread rapidly under high humidity and wet leaf soaking conditions. Driving rains and sand blasting can enhance development of the diseases. Under dry conditions, the diseases do not develop as rapidly. Unbalanced fertilizers, particularly high nitrogen coupled with low potassium will increase susceptibility of the crop to the diseases. The disease can occur in the seed bed or field.

Angular leaf spots are circular to angular bounded by leaf veins. Spots are dark brown to black in colour. The spots coalesce forming irregular dead areas. The centres of spots fall out leaving large holes.

Control is by use of clean, disease free treated tobacco seed, rotation of nursery sites and tobacco lands, early ploughing of both nurseries and tobacco land to decompose plant materials, general hygiene practices and restrict unauthorized entry into nurseries, seedbeds to be treated with Basamid and or burning, use clean, disease free seedlings for transplanting, preventive sprays of copper oxychloride in the seedbeds. It should be noted that copper sprays in the lands are not approved for reasons of residues. In the event that the disease appears in the lands, topping high and reaping earlier than normal may help to salvage the crop. Hygiene in the lands. When working in the lands e.g. during weeding, topping, suckering or reaping, always start with the clean lands or plants end up with diseased lands or plants. Destruction of tobacco stalks and crop residues in the lands and at the farmstead will eliminated the source of infection for the ensuring season

5. Fusarium Wilt *(FusariumOxysporum)*

Fusarium wilt is a serious problem mainly in old tobacco estates especially in the central region. The disease is enhanced by nematode infection.

The affected side does not develop as the rest of the plant so that unequal growth is observed and the stem, including the bud, is tipped towards the infected side of the plant. Leaves on that side turn yellow. Field identification of the disease can be made when a strip of the bark is peeled from the stem and a brownish discoloration will be seen rather than the normal white colour.

Control is by rotation with non-susceptible crops, use of resistant varieties, use of certified seed and destruction of alternate hosts such as weeds.

6. Granville Wilt *(Pseudomonas syringae pv Solanaecearum)*

It attacks plants mainly through wounds in roots incurred at uprooting and transplanting or through wounds inflicted by soil nematodes. The disease also spreads by transplanting diseased seedlings into clean lands.

Development of the diseases and severity of damage is enhanced by high soil moisture and high soil temperature.

Wilting of the leaves beginning with lower leaves is a manifestation of the disease. The stems of the tobacco plant develop a light tan to yellowish discolouration and appear dirty. White yellowish slimy viscous beads may appear on the cut surface. In advanced stages the plant is stunted, wilts and eventually dies.

Control is by Crop rotations, general sanitary practices at uprooting seedlings, at transplanting, topping and desuckering, growing of varieties resistant/tolerant to nematodes and other oil borne diseases. Use of basamid to control nematodes in seedbeds.

7 Bushy Top Rosette *(Bushy Top Virus, BTV)*

Bushy top is probably the most commonly found disease of tobacco in Malawi. It is a viral disease and it is spread by the tobacco aphid. Infection often starts in the seedbeds but symptoms are rarely observed at that stage, but manifest themselves in the lands. The damage is most severe in late planted crops.

Affected plants are stunted, internodes at the top part of the plant are shortened, midribs of young leaves are distorted and newly formed leaves do not develop significantly. Excessive axillary buds may also develop with many small leaves. The earlier the disease sets in the more severe the symptoms appear. These symptoms together develop into a bushy appearance at the top of the plant, hence the name bushy top.

Early planting, chemical drenches or sprays of imidacloprid in the seedbeds and lands will control aphids. Destruction of seedlings in nurseries soon after transplanting is completed, control of suckers since aphids prefer tender shoots as tobacco matures and elimination of weeds hosts and tobacco plant regrowths in the lands help to control the aphids which transmit the disease.

8 Tobacco Mosaic Virus *(TMV)*

Symptoms are light and dark green areas on the leaf and sometimes, burning and scalding types of symptoms may occur if attacked by more virulent strains of the virus. The virus is spread by poor hygiene and also from infected trash.

Control is by use resistant varieties, avoid unnecessary handling of seedlings and plants, control of aphids and other insects in the nursery and field, early weed control, avoid smoking and snuffing tobacco in nurseries and fields and uprooting and destroying tobacco plants soon after harvest.

9 Frog Eye *(Cercospora nicotianae)*

Brown, tan or gray spots with white centres appear on tobacco leaves. The disease starts from lower mature leaves and moves up the plant, as nitrogen supply in the leaf is depleted and as upper leaves progressively mature.

The disease is considered desirable in burley tobacco because it is an indication of proper leaf maturity at harvest. It is not normally advised to implement control measures in burley unless the disease is so severe so as to affect yield and quality. In flue cured tobacco, the disease is of economic importance because infection continues in the barn and can lead to leaf degradation and loss of yield and quality.

Control is by use of certified and disease free seed, rotation of seed beds and tobacco lands, spray recommended chemicals such as Bion 50 WG in the nursery and the field at early plant growth and destruction of infected trash.

Other economic important diseases of tobacco include: - Anthracnose, White mold, Algae, Wildfire, Black shank, Hallow stalk, Potato Virus Y and Cucumber Mosaic Virus.

For more on tobacco pests and diseases, consult ARET Extension Agents (EAs) or Agricultural Extension Development Officers (AEDO), government extension workers, in your areas.

3.5.3 Post Harvest Handling and Presentation

Harvesting or reaping, curing, bulking and preliminary pre-sale (farm) grading constitute some of the important aspects of post-harvest technology of tobacco.

a) Reaping

Reap only two ripe leaf per plant per reaping, and load the leaf into the barn on the same day it is reaped in the same barn and ensure it is fully loaded in case of barns that uses fuel. Avoid exposing the fresh leaf to the suns heat and avoid bruising it. Tie it in twos onto a stick, manuclips or talita clips and load it into the barn according to specifications for each type of tobacco.

During reaping, the midrib of the leaf should be broken off as close to the stalk of the plant as possible, with a sharp downward movement, without leaving any part of the leaf butt.

b) Tobacco Curing

This process of drying is conducted in such a way as to produce certain well-defined and desirable qualities in different types of tobacco. Perfect curing will unveil the quality of the leaf but not enhancing it while poor curing destroys reduces quality and quantity of the harvest.

Depending on the type of the tobacco, four principal methods of curing can be distinguished, namely, i) flue-curing, ii) air-curing, iii) fire curing and iv) sun-curing.

c) Storage and bulking

Properly conditioned and graded tobacco will fetch high prices at the market. Bulk the tobacco for at least 2 weeks before grading. Bulking improves quality of tobacco and helps to remove green tinges on the leaf.

i) Conditioning

This is the softening of the leaf for easy handling by moistening it humid air created naturally or artificially. A well conditioned tobacco should not crack or break and when left will spring back and should snap at about 90^{o} when bent.

Methods includes natural method which uses natural moisture in the air, watering the barn floor, using humidifiers, using steam from boiling water in a drum, using vapor from underground floor of a pit and use of vapors from non-wet green grass.

ii) Leaf Storage and bulking

From the barn leaf is transferred to storage sheds. The tobacco has to be placed on a wooden platform 60cm away from walls to prevent moisture from the floor migrating into the tobacco. The leaf can be packed as Rough bales or on Slat packs or Bulks (doughnut or rectangular shaped). It should be left there for at least two weeks for good quality leaf.

iii) Tobacco storage pests

Tobacco beetle or cigarette beetle (Lasioderma serricorne), is a storage insect pest that thrives and multiplies in dirty bulking and grading sheds and tobacco barns. At the end of each season, buildings should be cleared of all tobacco, tobacco scraps, and tobacco dust, and washed with water and detergent and sprayed with Fendona or Cislin 2.5 SC (Deltametthrin). The walls should be plastered and white washed. Particular attention should be paid to corners and crevices where tobacco dust may accumulate. Cured tobacco should not be stored in the same room as other stored crops such as maize. Cured tobacco should not be kept from one season to another to avoid tobacco beetle.

To ensure tobacco hygiene during storage with respect to this pest, farmers are required by law to have their tobacco holding shed and storage structures checked from time to time by produce inspectors. If tobacco is infested by the beetle it should be fumigated and a certificate issued by government inspectors before sale.

d) Grading

This is the sorting out or separation of cured leaf into uniform lots according to leaf plant position, leaf color, leaf body appearance and length. High graded leaf is easily classified at the market.

The process of classifying tobacco in order to give its grade are explained in sections for each tobacco bellow. Agricultural practices that ensures uniform crops are encouraged in order to have few but high quality grades of leaf.

Note that tobacco grades are subject to change and therefore always be in contact with ARET and other agricultural staff for up to date information.

Grading is subjective, hence it should be done by more than one person and should be carefully done and expert advice should be sought from ARET or other agricultural staff.

e) Presentation

This involves proper tying, baling and grouping of bales.

Tobacco leaves of same grade are tied together bailed together and sold together.

Bail weight should be between 25kg to 120kgs of cuboids shape with 90cm x 60cm x 60cm or 75cm x 75cm x 60cm wrapped in hessian.

Grouping is the arrangement of tobacco bales in such an order that bales of similar quality are sold together in runs of declining order of value.

Avoid non- tobacco related materials (NTRM) which are any foreign matter found in graded and baled tobacco either at the auction floors or in the tobacco processing factories. Examples of NTRM are: plastic strands from woven polypropylene bags used to pack fertilizers, maize, or salt; feathers, metal objects, eggs, stones, bricks, strings, wooden material, grass etc. therefore avoid use of these materials near tobacco.

Again avoid nesting which is a deliberate placement of NTRM, substandard cured tobacco hands or scraps in graded and baled tobacco with an intention of obtaining more weight for a small amount of quality tobacco.

3.5.4. Tobacco Marketing

Tobacco is mainly sold through licensed Tobacco Selling Floors in Malawi for all the tobaccos.

Two systems of selling tobacco operate concurrently. These are contract and open auction.

All the tobacco produced under the IPS is sold through the contract system where only the contracting company is allowed to offer a price for the tobacco. The non-IPS tobacco is offered on the alternative selling platform where all buying companies are free to bid and the highest bidder gets the tobacco. Only properly graded and presented tobacco is bought on the selling floors. Table 48a depicts statistics of tobacco sales from 2010 to 2019.

Table 48a: Tobacco sales through the auction floors

	BURLEY	FLUECURED	SDDF	NDDF	SUN/AIR
YEAR	Volume(Kg)	Volume(Kg)	Volume(Kg)	Volume(Kg)	Volume(Kg)
2010	193,238,632	24,320,730	64,112	2,545,848	28,749
2011	208,324,837	23,856,100	373,339	4,617,184	
2012	64,676,433	12,628,175	219,377	2,298,529	124
2013	144,796,667	19,747,037	286,749	3,837,148	-
2014	159,385,912	31,065,782	206,138	1,309,709	-
2015	168,248,234	23,060,068	78,432	1,293,034	-
2016	174,902,046	17,558,178	167,972	2,496,798	-
2017	81,446,593	20,812,593	378,065	3,899,564	-
2018	163,973,708	32,279,725	851,730	4,900,197	-
2019	138,957,754	22,662,132	687,237	3,363,710	12,912

Table 48b: Farmer registration per tobacco type

YEAR	Burley	Flue cured	NDDF	SDF
2010	72,614	1,332	875	18
2011	10,533	411	390	57
2012	55,730	2,531	1,479	65
2013	54,011	2,347	1,344	118
2014	46,957	4,021	617	95
2015	41,590	2,849	474	40

3.5.5 DARK TOBACCO

Dark also known as Western tobacco is the third most important of the types grown for cash mainly on customary land. Export market prospects for this crop remain good provided Malawi is able to maintain high quality leaf at steady level of production.

Varieties recommended for this crop include ADFC1, ADFC2, ADFC3 and ADFC4. Other varieties include Malawi Western, MW86-57, AWL10 and AWL28.

There are three types of Dark tobacco as classified on the Malawi market:

3.5.5.1 Northern Division Dark Fire-cured Tobacco (NDDF)

This type of tobacco is traditionally cured in barns constructed from either bricks or mud. Curing is done using smoky fires made in open or partly covered fire pits using semi-dry firewood during lamina curing and very hot fires at midrib drying using dry firewood. The final product is dark brown in colour, giving rise to the name dark fire-cured tobacco.

Recommended areas for Northern Division Dark Fire-cured tobacco production are parts of Lilongwe, Dowa, Ntchisi, Dedza, Kasungu, Mzimba, Rumphi and Chitipa.

3.5.5.1.1 Improving leaf yields

In order to improve cured leaf yields and quality of dark tobacco recommended cultural practices should be followed.

3.5.5.1.2 Cultural practices

(a) Seedbeds

Seedling production and nursery management is done in the same way for all tobacco types grown by smallholder farmers as well as estates.

i) Site selection for nursery is important. The ideal site should have deep fertile sandy clay loam soils, near a reliable water source, away from sheds and barns. Ensure that clean water is used. Borehole water is best. If stream water is used, ensure that it is not drawn from the stream edges. A nursery site should be sown to tobacco at most once in 4years

ii) Farmers should only use certified seed from Agricultural Research and Extension Trust (ARET) or contracting merchant, which is pure and free from diseases. Under good management certified seed will produce the best quality leaf. The use of farm saved seed is strictly prohibited in the tobacco industry because the resultant leaf is not considered compliant to seed integrity and traceability requirements by the trade. Seed recycling also spreads serious diseases such as wildfire which results in yield reduction and poor quality tobacco.

iii) In the nursery, "S" mixture (6:18:6) fertilizer is recommended and should be applied before sowing at the rate of 1kg per seedbed of 15m x 1m. If "S" mixture is not available, other compound fertilizers may be applied upon guidance of the extension officer or contracting merchant.

iv) Tobacco seed should be sown at the rate of 1.5-2.0g per standard seedbed of 30m x 1m. For one seedbed of 15m x 1m, use 1.0g or one half Fanta or coca-cola bottle top of seed with inner cork intact. Put the seed in a 14 litre watering can filled to three quarters full of water. Six such beds will produce enough seedlings for a hectare. Growers should ensure that nurseries are not sown thickly. A seedling density of 45 to 50 seedlings per 30cm x 30cm quadrant is ideal.

Farmers can also raise seedlings using the Mother bed system to save labour and water.

Growers should aim at achieving 2 sowings staggered at 2 week intervals so as to ensure that suitable seedlings are available for planting even if the onset of rains is delayed.

Frequent watering is necessary between sowing and seedling emergence (6 to 7 days) to keep the surface of the seedbeds continuously moist but not too wet to wash away seed. Three waterings per day are usually recommended from sowing to emergence, but in conditions of extreme heat and wind, more waterings are required. Four waterings per day should be given in hot areas such as Shire Valley and lake shore plains.

When seedling emergence is completed, the frequency of watering should be reduced to twice per day but maintaining the same amount of water. Two weeks after all seedlings have emerged, watering frequency should be reduced further to once per day depending on prevailing climatic conditions.

Towards transplanting time, less frequent watering is necessary to harden seedlings for at least 2-3 weeks in readiness for field conditions.

Nitrate of soda at the rate of 10g per square meter should be applied as a drench to yellow stunted seedlings when the first two leaves are 1.5 to 2cm in diameter. Farmers should aim at making the first transplanting by the end of November to the beginning of December and finishing by Christmas. An ideal seedling for transplanting should have a height of 15 to 20cm, of standard pencil thickness with not more than 8 to 10 leaves below the bud. It should be well hardened with a strong vigorous root system and clean of diseases and nematodes.

*At this rate of application there is no need to top dress with CAN. Animal manure can also be applied at 500 grams per plant before transplanting followed by top dressing with 200kg/ha of CAN as indicated in Table 51.

Note: The nitrogen content of manure should not be less than 1.5%.

i) In areas where anthracnose disease is serious, spray nurseries with copper oxychloride 85WP every fortnight beginning four weeks after germination. Farmers from the same location should be encouraged to locate their nurseries at the same site or within the same location in order to facilitate anthracnose disease control. Farmers are advised to report any suspected infection of seedlings by anthracnose to the nearest agricultural office.

Farmers should know that the success of the tobacco crop is largely dependent upon the production of good seedlings in the nursery.

(b) Field Preparation

i) Tobacco fields should be prepared (from July to September) so that transplanting can start in November and be completed in December.

ii) Both ridges and plants should be spaced at 90cm.

(c) Fertilizer and manure application

It is recommended that farmers should use both inorganic fertilizer and manure.

(d) Weed control

Farmers should keep the fields free of weeds to reduce competition for soil moisture, nutrients and solar radiation (sunlight). For good root development banking is necessary at 3 to 4 weeks after transplanting.

(e) Topping and de suckering

Plants should be topped early at the extended bud stage. It is important that this operation is done when 10 to 20% of plants have reached the extended bud stage. Farmers should leave 12 to 15 leaves per plant depending on guidance from the extension officer or contracting merchant. Farmers should prime 4 to 5 lower leaves in order to attain well expanded stretchy and oily cured leaves. Suckers should be removed at least once every week or before they are 3cm long when the suckers can easily be handled. Use of chemical suckercides such as Fabulin forte 305 EC, Antak Tabamex among others to ensures early and suppression of suckers.

(f) Reaping

Western tobacco usually ripens two weeks after topping or some 7-8 weeks after transplanting. Ripe leaf is thick, pale green.

3.5.5.1.3 Curing

This type of tobacco requires heat and smoke to cure.

(a) Prerequisites before curing

i. Adequate barn space

Barn size should be in such a way that one reaping day should lead to full capacity of at least one barn. One hector requires twelve barns of 3.6m x 2.4m x 2.4m (for small scale farmers) or six barns of 3.6m x 3.6m x 4 tiers (for medium scale farmers) or four barns of 4.8m x 4.8m x 4 tiers for large scale farmers.

ii. Adequate fuel wood

One hector of western tobacco requires 11.6m³ to 18m³ depending on type and efficiency of the curing structure and methods and/or leaf conditions.

(b) The curing process

It is done in in rooms that have fire pits inside or outside and it takes about 12 to 15 days. The process has three stages. Vents are normally closed and are opened only when excessive humidity is observed. It has three phases as explained bellow;

i. Yellowing

Use no firewood unless temperature falls below 65ºF and it takes about 5-7 days.

ii. Smoking or colouring or browning

Use dry fire wood plus fresh wood or green leaves to create smoke and heat. Temperatures should be 85-95ºF and it takes 3 to 4 days.

iii. Leaf drying

Use dry wood only. Temperatures should be 100-120ºF.The stage takes about 3 to 5 days.

(c) Cured leaf Faults

Can be the result of field stress or curing inefficiencies (curing faults).

i. Green leaf:

Avoid reaping immature leaf, bruising, sunburn and avoid too high temperatures in the barn.

ii. Moldy leaf:

Avoid exposure of dried leaf to high humidity or exposure to water.

iii. Sooty leaf:

Avoid over smocking or restricted air flow in the barn.

(d) Grading

Sort out or separate the cured leaf into uniform lots according to leaf plant position (family or group), body appearance, color, length and special factors.

At the auction the leaf will be classified as follows.

i. Plant positions; First symbol

L – Lower Leaf
M – Main leaf

ii. Quality; Second symbol

1=Fine quality; oily (Wrapper) Main Leaf

1=Good Quality; oily Lower Leaf

2=Good quality; up to 10 % torn Main Leaf

2=Medium; up to 10% torn, slightly oily Lower Leaf

3=Off coloured; up to 50% off coloured

4=Greenish filler; of up to 50% greenish cast and up to 10% torn

5=Sooty tobacco; 50% soot and up to 10% torn Filler.

6=Diseased tobacco; up to 50% diseased
7= Mouldy tobacco: up to 50% mould

iii. Length: Third symbol length.

Table 49: Length symbols in leaf classification

LENGTH SYMBOL	QUALITIES 1 & 2	QUALITIES 3, 4 & 5	QUALITIES 6 &7
A	> 48 cm	> 48 cm	> 48 cm
B	> 40 to 48 cm	>30 to 48 cm	23 to 48 cm
C	> 30 to 40 cm	23 to 30 cm	
D	23 to 30 cm		

iv. Colour: Fourth symbol

B=Brown colour, thin to medium bodied leaf (Lower or Main Leaf) D=Dark brown, heavy bodied leaf (Main Leaf)

An example of an NDDF grade

L2CB- lower leaf (L), Medium quality; fully ripe slightly oily, without disease and up to 10 % torn (2), over 30 cm to 40 cm in length (C) brown in colour (B)

There are 56 NDDF or SDDF tobacco grades. A good harvest should have the smallest number of grades as possible.

3.5.5.2 Southern Division Fire-cured Tobacco (SDF)

This is a form of Dark tobacco presented as lightly fired and lighter in colour than the Northern Division Dark Fire-cured tobacco. It has milder flavour and aroma.

Recommended areas for Southern Division Fire-cured tobacco production are parts of Blantyre, Chiradzulu, Phalombe, Mulanje, Zomba and Mangochi. However, the crop can also be grown in Mwanza and Shire Valley.

3.5.5.2.1 Improving yields

In order to improve yields and quality of Southern Division Dark Fire-cured tobacco, recommended same cultural practices should be followed.

(a) Cultural practices

Use cultural practices recommended for Northen Division Dark Fire-cured tobacco except for curing.

(b) Curing

Only dry wood should be used with the aim dry wood should be used with the aim of producing heat and little smoke which is required to flavour the leaf without necessarily making it dark brown. SDF is lightly fired for a lightly coloured leaf. Heavy smoky fires must therefore be avoided. After 3 to 6 days of firing depending on weather conditions, the fires should be drawn for the last time. The cured leaf should be hung in the shed for the final drying stage of the midribs with tobacco sticks placed at least 22.5cm apart on tiers to allow adequate air circulation. While drying, midribs should be checked frequently dations are followed.

to avoid rotting. It may be necessary to thin out some grass from the sides of the shed to allow more air circulation. This will hasten the drying process and arrest rotting of midribs.

3.5.5.3 Sun-Air Cured Tobacco

This is Dark tobacco whose lamina and midribs are dried with the help of the sun and air circulating through the leaf in open sided sheds with adequate thatch to prevent leaking. Recommended areas for sun-air cured tobacco production are Mchinji, Kasungu and parts of Ntcheu. Other areas can also grow sun-air cured tobacco provided that proper curing recommendations are followed.

3.5.5.3.1 Improving yield and quality

In order to improve yield and quality of sun-air cured tobacco recommended cultural practices should be followed.

(a) Cultural practices

All recommendations given for Northern Division Dark Fire-cured Tobacco apply except for curing.

(b) Curing sheds

Curing sheds should be 55m long comprising 2 bays with 2 tiers each of 75cm wide maintaining the bottom tier at 90cm from the ground. The shed should be constructed along the direction of prevailing winds with the wind ward side cladded. The roof should be leak proof with thatch extending over the side of the shed to prevent rain blowing in to the leaf.

Wilting, yellowing, browning, colour fixing and midrib drying

Wilting and yellowing should take place in a wilting and yellowing barn in the same manner as NDDF tobacco. When wilting and yellowing is completed, the leaf should be hanged on tiers in a sun-air shed. After about 3days the leaf will turn brown. At this stage the leaf should be put on open air racks for sunning after which it should be returned to the shed in the evening. The top of the racks should be lightly covered with grass to prevent direct sunlight from scorching the leaf. The process should be repeated until the brown colour is fixed in the leaf. Midrib drying should take place in the shed and not on racks.

Note: Choose a fine sunny day for to dry leaf

A light grass cover should be laid on top of the racks to prevent direct sunlight from premature drying of the leaf. Leaf should be removed from outside racks whenever rain signs are noticed. Leaf must be immediately put in the sun to dry should moulds set in.

For choice of Dark tobacco varieties (NDDF, SDF, Sun-air and Dark-air cured) and their agronomic characteristics, please refer to Table (50).

Table 50: Characteristics of Some Dark Tobacco Varieties in Malawi

VARIETY	ADFC1	ADFC2	ADFC3	ADFC4	Malawi Western	MW86-57	AWL28	AWL10
Yield potential*	High	High	High	High	Low	High	High	High
Leaves at topping	12-15	12-15	12-15	12-15	12-15	12-15	12-15	12-15
Ripening rate	Medium	Medium	Medium	Medium	Fast	Medium	Fast	Fast
Colour in field	Green	Green	Green	Green	Green	Green	Light green	Light green
Colour of cured leaf	Brown	Brown	Brown	Brown	Dark	Brown	Brown	Brown
Disease resistance								
Nematodes (M. javanica)	Moderate	Moderate	Moderate	Moderate	Susceptible	Susceptible	Susceptible	Susceptible
Fusarium wilt	Moderate	Moderate	Moderate to High	Moderate to High	Susceptible	Low	Low	Low
Angular leaf spot	Low	Low	Low	Low	Susceptible	Susceptible	Susceptible	Susceptible
Alternaria brown spot	Low	Low	Low	Low	Low	Susceptible	Susceptible	Susceptible
White mould	-	-	-	-	Susceptible	Susceptible	Susceptible	Susceptible

*: Above 2500 kg/ha = High; 1500 to 2500 kg/ha = Medium; Below 1500 kg/ha = Low

Table 51: Types and rates of fertilizers for Dark Tobacco

Fertilizer type	Basal dressing rate				Top dressing rate			
	Kg/ha	50 Kg bags	Cup no.	Remarks	Kg/ha	50 Kg bags	Cup no	Remarks
Super C (8:24:20)	150	3	8	1.5 cups/ plant	-	-		
Compound C (6:18:15)	200	4	8 or 16	1cup/ plant 2cups/ plant	-	-		
Animal Manure*		500 grams	-	-	-	-		
CAN					200	4	8 or 16	2 cups/ plant 1 cup/ plant

Note: Recommended nitrogen rate for Dark fire cured tobacco is 68 Kg N/ha. For other fertilizer formulations proper calibration is required.

Grading

Sun air cured tobacco should be graded in the same manner as NDDF.

3.5.5.4. Oriental tobacco

This type of tobacco is also known as Turkish or Aromatic Tobacco. Some varieties are known for their characteristic aroma of the cured leaf. Generally the plants are small with short internodes and small leaves resulting in a large number of leaves per plant. It is sun-air cured.

Unfortunately, demand for this tobacco has dwindled and for the past 10 years no commercial Oriental tobacco has been produced in Malawi. The tobacco had potential for production in parts of Mzimba, Lilongwe, Machinga, Zomba, Blantyre, Chikwawa, Chitipa and Rumphi.

3.5.5.4.1. Improving yield and quality

Recommended cultural practices should be followed in order to improve yields and quality.

3.5.3.3.4.2. Use of recommended varieties

Samsun is the oldest Oriental variety to have been grown in Malawi. This is a neutral variety with yield potential of 1,000kg per hectare.

Elsoma is another variety recommended for production in Malawi. It has yield potential of 1,500kg per hectare.

3.5.5.4.3. Seedbeds and sowing

Nursery preparation and sowing is the same as for Dark tobacco except that 8 beds of 15m x 1m are required to plant a hectare.

Nursery management is the same as for other tobacco types grown by small holder farmers as well as estates.

i) Site selection is important. The ideal site should have deep fertile sandy clay loam soils, near a reliable water source, away from shades and barns. Ensure that clean water is used. Borehole water is best. If stream water is used, ensure that it is not drawn from the water's edges. A site should be sown to tobacco atleast once in 4 years.

ii) Farmers should only use certified seed from ARET, which is pure and free from diseases. Under good management use of certified seed will result in attainment of high yield and good quality leaf.

iii) Growers who use farm saved seed are a danger to themselves due to non-compliance to trade requirements. They also pose a risk to other growers and the entire tobacco industry by acting as a source of spread of serious diseases such as wildfire that reduce yield and result in poor leaf quality.

iv) In the nursery "S" mixture (6:18:6) fertilizer is recommended and should be applied before sowing at the rate of 1kg per seedbed of 15m x 1m. If "S" mixture is not available, other compound fertilizers may be applied upon guidance of the extension officer or contracting merchant.

v) Oriental seed should be sown at the rate of 1.5-2.0g per standard seedbed of 30m x 1m. For one seedbed of 15m x 1m, use 1.0g or one half Fanta or coca-cola bottle top of seed with inner cork intact. Put the seed in a 14 litre watering can filled to three quarters full of water.

Oriental is grown at a higher plant population per hectare, 25,000, to achieve optimum yield. This requires more nursery beds (five standard beds) to produce enough seedlings for a hectare. Growers should ensure that nurseries are not sown thickly. A seedling density of 45 to 50 seedlings per 30cm x 30cm quadrant is ideal.

Frequent watering is necessary between sowing and seedling emergence (6 to 7 days) to keep the surface of the seedbeds continuously moist but not too wet to wash away seed. Three waterings per day are usually recommended from sowing to emergence, but in conditions of extreme heat and wind, more waterings are required. Four waterings per day should be given in hot areas such as Shire Valley and lake shore plains.

When seedling emergence is completed, the frequency of watering should be reduced to twice per day but maintaining the same amount of water. Two weeks after all seedlings have emerged, watering frequency should be reduced further to once per day depending on prevailing climatic conditions.

Nitrate of soda at the rate of 10g per square metre should be applied as a drench to yellow stunted seedlings when the first two leaves are 1.5 to 2cm in diameter. Oriental tobacco grown under some level of stress gives best leaf quality. Farmers should aim at transplanting seedlings from January. An ideal seedling for transplanting should have a height of 15 to 20cm, of standard pencil thickness with not more than 8 to 10 leaves below the bud. It should be well hardened with a strong vigorous root system and clean of diseases and nematodes.

*At this rate of application there is no need to top dress with CAN. Animal manure can also be applied at 500 grams per plant before transplanting followed by top dressing with 200kg/ha of CAN as indicated in Table 51.

Note: The nitrogen content of manure should not be less than 1.5%.

i) In areas where anthracnose disease is serious, tobacco nurseries should be sprayed with Mancozeb (Dithane M45). Farmers from the same location should be encouraged to locate their nurseries at the same site or within the same location in order to facilitate anthracnose disease control. Farmers are advised to report any suspected infection of seedlings by anthracnose to the nearest agricultural office.

Farmers should know that the success of a tobacco crop is largely dependent upon the production of good seedlings.

3.5.5.4.4. Field preparation

i) Clearing and preparing gardens should be done in good time so that planting can be completed by mid-January. This enables reaping to be completed before the onset of the dry cold weather which makes curing difficult. Ridges should be made 90cm apart with broad surface for double row planting of 12 to 15cm between plants and 25cm between rows.

3.5.5.4.5. Fertilizer application

Either Use "B" compound(4:18:15) fertilizer at the rate of 200kg per hectare using 2 cupful's of cup Number 8 per metre of ridge length at transplanting;

Or

Super "B" Compound (5:33:24:20) fertilizer at the rate of 150kg per hectare using 3 cupful's of cup Number8 per 2 metres of ridge length at the time of transplanting.

High nitrogen levels are undesirable as they would produce poor quality leaf which is difficult to cure. A well-managed crop should not exceed 1.5m in height.

3.5.5.4.6. Reaping

Reaping should be done at the correct stage of leaf ripeness, just when the leaf starts turning yellow (mellow yellow). Nursery leaves should be primed and buried so that tent space is reserved for the main leaf. Farmers should not reap over- ripe leaf as it will cure papery with yellow margins and unripe leaf will always cure green.

3.5.5.4.7. Curing space

Proper curing structures and adequate curing space are as essential as is the attention to the curing process at all stages. Curing tents have shown to give more superior results than the use of racks. However, in addition to curing tents farmers should have holding sheds in which to store the cured leaf. A tent measuring 8m long and 4m wide, should be erected in the east-west direction to allow direct sunlight into the entire length of the tent. One tent of the above dimensions can cure tobacco from 8 standard plots (27.5m x 10m).

When the tent is loaded with reaped leaf, tobacco should not be disturbed until it is fully cured in 20 to 25 days depending on weather conditions. The tent should always be closed at night, in windy conditions and when it rains. However, in dry and calm weather conditions, the tent should be kept open during the day. If the tent is completely covered, severe heat may build up resulting in faster than normal curing with a lot of fixed green patches.

3.5.5.4.8. Grading

Oriental tobacco should be graded by string as grading by leaf would be rather tedious. If leaves of the same size and ripeness is sewn to the same string at reaping then grading becomes a straightforward operation. The graded leaf should be baled separately according to grade. When putting tobacco in the baling box, butts should face outward touching the surface of the box. Clearly labeled bales should be stored in cool dry conditions ready for dispatch to the market.

The following are grades for oriental tobacco:-

Grade	Description of leaf
A	Special thin, well textured whole clean leaf with lemon colour and good elasticity
B	As above with light yellow colour
K	Slightly diseased and slightly perished leaf
KK	Heavily diseased, heavily torn, green leaf of poor quality

3.5.6. FLUE CURED TOBACCO

Flue-cured tobacco is mainly a crop recommended for medium to high altitude areas. This type of tobacco is normally cured in brick or mud barns in which hot air conducted through metal pipes (flues) heats up the barn. Smoke does not come in contact with the tobacco. The cured leaf is lemon (yellow), orange or mahogany (brown) in colour.

Market prospects for Malawi Flue-Cured tobacco are not that limited. However, this type of tobacco is highly capital intensive and growers are advised to ensure high management to realise good returns. Currently recommended Flue cured tobacco varieties in Malawi include: AFH1, AFH2, AFH3, AFH4, AFH5 and AFH6.

Farmers can also grow introduced varieties of their choice from other countries following appropriate guidelines for importation.

3.5.6.1. Improving yields

In order to improve yields and quality the following agronomic practices are recommended:

1. **Use of recommended varieties**
   Choice of variety or varieties to be grown on the farm is the first step towards increasing yields.

2. **Use of certified seed.**
   Use only certified seed from reputable institutions.

The information in Tables 52 and 53 provides guidance in choosing a suitable flue cured tobacco variety for production in Malawi.

Table 52: Agronomic characteristics of Flue Cured Tobacco varieties available from ARET

Variety	Topping height (No. of leaves)	Yield potential*	Ripening rate	Leaf Colour	
				Field	Cured
AFH1	18-20	High	Medium	Green	Lemon / Orange
AFH2	18-20	High	Medium	Green	Lemon / Orange
AFH3	18-20	High	Medium	Green	Lemon / Orange
AFH4	18-20	High	Medium	Green	Lemon / Orange
AFH5	18-20	High	Medium	Green	Lemon / Orange
AFH6	18-20	High	Medium	Green	Lemon / Orange
KRK26R	18-20	High	Medium to slow	Dark Green	Lemon / Orange
KRK66	18-20	High	Medium to slow	Dark Green	Lemon / Orange
KRK72	18-20	High	Slow	Dark Green	Lemon / Orange
PVH2110	18-20	High	Fast to medium	Light green	Lemon
PVH2259	18-20	High	Fast to medium	Light green	Lemon
PVH2291	18-20	High	Fast to medium	Light green	Lemon

*: Above 2500 kg/ha = High; 1500 to 2500 kg/ha = Medium; Below 1500 kg/ha = Low

Table 53: Disease reaction of Flue cured tobacco varieties

Disease	VARIETY								
	AFH1	**AFH2**	**AFH3**	**AFH4**	**AFH5**	**AFH6**	**KRK26R**	**KRK66**	**PVH2291**
Root knot	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant
Bacterial / Granville wilt	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant
Fusarium wilt	-	-	-	-	-	-	-	-	Susceptible
Angular leaf spot	Susceptible	Susceptible	Susceptible	Susceptible	Susceptible	Susceptible	Resistant	Resistant	Resistant
Alternaria brown	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Susceptible	Resistant	Resistant
Tobacco mosaic virus (TMV)	Susceptible	Susceptible	Susceptible	Susceptible	Susceptible	Susceptible	Resistant	Resistant	Susceptible
Potato virus Y (PVY)	Susceptible	Susceptible	Susceptible	Susceptible	Susceptible	Susceptible	Resistant	Resistant	Susceptible
Wildfire	Susceptible	Susceptible	Susceptible	Susceptible	Susceptible	Susceptible	Resistant	Resistant	Resistant
White Mould	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant
Black shank	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	-	Resistant	Susceptible

(-) = Disease not assessed (due to either low pathogen pressure for reasonable classification or completely not available during evaluation).

3.5.6.2. Seedbeds

i) Nursery site should be ploughed early, fenced and treated (sterilized).

ii) Adequate clean water should always be available nearby for watering seedbeds.

iii) Seedbeds should be of convenient size for ease of management. A seedbed measuring 30m by 1m is recommended. Three of these are adequate for one hectare.

iv) Prior to sowing, broadcast and incorporate 3.0 to 4.5kg of 'S – Mixture' (6:18:6) fertilizer on the seedbed. Use 1.5 – 2.0g of seed on a 30m x 1m seedbed and sow the same way as other tobacco varieties. Beds should be evenly mulched using love grass or any fine non-leafy combed grass such as 'Katsichi' or 'Wanje'. Top dress the nursery and those yellow and stunted seedlings with a drench of Nitrate of Soda at 10g per square metre (300g per 30 square bed) when the first 2 leaves are 1.5cm in diameter.

v) Adequate watering is essential for seedling growth. Seedlings should be hardened by watering less frequently before transplanting to prepare them for field conditions.

vi) Smoking cigarettes or snuffing near the nursery is prohibited.

vii) Diseases and pests are a major challenge in tobacco seedling production. For recommended pesticides and proper management farmers should seek advice from Extension Officers in their respective areas.

3.5.6.3. Field management

i) The field should be deeply ploughed and properly ridged to allow for good drainage and good root development. Second year reverted lands should be fumigated with appropriate pesticides to control nematodes, weeds and other pests.

ii) Ridges should be made 105 to 120cm apart and plants should be transplanted at 45 to 60cm apart depending on varieties and merchants requirement.

iii) Flue cured tobacco can either be grown entirely under irrigation, partially irrigated (water planted before rains) or rain planted. Farmers are encouraged to dry plant (water transplanting before rains) in order to achieve high yields.

iv) Control of nitrogen is particularly important to achieve a high quality Flue cured tobacco crop. Too little nitrogen could produce low yields whilst too much has an adverse effect on quality and may increase the incidence of insect pests and diseases. Growers should make an effort to know the soil nutrient status of their fields before applying fertilizer. When in doubt, growers should seek advice from the nearest Extension Office.

As a guide, fertilizer application in Flue cured tobacco should supply about 72 kg nitrogen; 108 kg phosphate (P_2O_5) and 90 kg potash (K_2O) per hectare. Higher or lower rates should be considered after soil analysis results of the field.

There are different formulations of fertilizer for application in tobacco including; ordinary compounds, Super Compounds and straight fertilizers (Table 54). Straight fertilizers may only be used in case of need to supplement specific nutrient elements such as nitrogen or potassium.

v) Topping and desuckering should be done early enough. Chemical desuckering using Antak, Fabulin Forte 305 EC and Tabamex 360EC among others is very effective.

vi) Reaping should be done when leaves are mature and ripe, just when they start turning yellow (mellow yellow). Over-ripe leaves are light and so will reduce yield whereas unripe or immature leaves cure green or black and will drastically reduce cured leaf quality.

Table 54: Some commonly used fertilizers in tobacco and their nutrient composition

Fertilizer Type	Nitrogen %	P2O5 %	K2O%	Sulphur %	Boron %
Compound A	2	18	15	4	0.1
Compound B	4	18	15	4	0.1
Compound C	6	18	15	4	0.1
Compound D	8	18	15	4	0.1
Compound S	6	18	6		
Super B	5.33	24	20	6	0.15
Super C	8	24	20	6	0.15
Super D	10.5	24	20	6	0.15
Calcium Ammonium Nitrate (CAN)	27	-	-	-	-
Nitrate of soda	16	-	-	-	-
Ammonium Nitrate	34.5	-	-	-	-
Urea	46	-	-	-	-

3.5.6.4. Reaping

Reaping flue cured tobacco usually commences two weeks after topping, some 7-8 weeks after transplanting. Ripe leaf is thick, mottled yellow and green, veins break with a cracking sound when squeezed inwards and Leaf tends to bend away from the stem. Take a sample and place it in a kitchen, lower leaves will color in about 60-72 hours and middle to upper leaves 36-48 hours.

Always remove the lowest two leaves and Always break the midrib right at the stalk. An average reaping interval is around 5 days.

After reaping the leaves are tied using MT2 or MT9 string in twos onto sticks or stuck on to talita clips or manuclips at 5cm apart ready for curing. The sticks are placed on the tiers in the barn at 22.5cm apart.

3.5.6.5. Curing

Flue cured tobacco is done by heating the air in the barn using hot pipes winding in the barn. The air then absorbs the moisture from the leaves.

Because this book is about good agricultural practices, the full engineering aspects of construction of tobacco curing barns will not be tackled. Consult ARET and other agricultural staff for full details.

a. Prerequisites for curing

i. Adequate curing space

The barn sizes should tally with farm size to ensure that at least one barn is filled per each reaping.

As a rule of thumb, one hector requires approximately two barns that curies 256 sticks and measuring 3.6m by 4.8m by 4 tiers taking 7 days turn round and reaping interval as 5 days.

ARET's flue cured tobacco manual has formulas and charts for calculating different barn sizes and hectarage.

ii. Adequate fire wood

Venturi furnace barns requires 10 to 14m³ / ton of cured leaf while Rocket barn will require 5.7 to 8.6 m3 /ton. It is proper to start with small fires.

b. The curing process

It is done in rooms that have flue pipes to heat the air inside. This has three phases as follows;

i. Yellowing or colouring

The flue should not become too hot to keep a hand on. and allow the barn to warm up until colouring is complete. Vents should be opened as soon as the tips of the leaves colour, and full vent must be given as soon as temperatures go beyond 95ºF

ii. Lamina drying

It is done as fast as possible for about one day. Temperature should be raised from 110ºF to140ºF.

iii. Midrib drying

Rise temperature to 140ºF-160ºF. Vents have to be closed in order to conserve both time and fuel.

c. Alternative Curing Fuel

Nowadays in Malawi fire wood is scares. However, tobacco is a main stay for Malawi. Hence alternative curing sources needs to be explored.

At present, coal is a viable substitute although its use is hampered by high transportation costs. It can be used with modifications to the furnace as advised by ARET or other agricultural staff.

Charcoal is also another alternative because 1 kg of wood converted to charcoal yields more heat than 1 kg of wood not converted to charcoal according to research.

3.5.6.6. Handling and Presentation

a. Grading

Grading of flue cured tobacco puts the leaf in uniform lots of leaf plant position, body appearance or quality, leaf color and then special factors. Never mix grades.

b. Classification

Then the graded leaf is classified and finally given grades by using symbols that stands for separation criteria at grading as follows;

i. Leaf plant position or families or groups (first symbol)

- **X**-Lugs: bottom leaves, rounded tip and thin
- C-Cutters: middle section leaves and oblate tip
- **M**-Thin or smoking Leaf: leaves above middle section. Midrib is prominent
- L- Leaf: Upper section leaves, have pointed tips and prominent midrib

ii. Leaf quality (second symbol)

This is the overall soundness of the tobacco leaf determined by its body appearance

Table 55: Leaf quality symbols

Quality Symbol	Definition	%blemish or injury	% waste
1	Fine	Up to 5	Nil
2	Good	10	5
3	Fair	30	15
4	Low	50	30
5	Poor	80	60
NG	Very poor	Over 80	Over 60

iii. Leaf color (third symbol)

There are L-Lemon, O-Orange and R-Mahogany.

It is a function of leaf plant position, weather, nutrition, soil, curing process, etc.

iv. Body appearance or special factor (fourth symbol)

This includes style factor such as texture and maturity differences (F, standard and K) and extra factors such as degree of blemish, injury and waste (J, G, V, MD, Q, Y etc.),

They reduce or increases quality as follows:

F- High maturity/spotted	1st to 3rd quality
J-Discoloured/stained	2nd to 5th quality
K-Substandard/ close grained	3rd to 5th quality
V-Greenish tinge	2nd to 4th quality
Y - Guinea fowl spot	4th to 5th quality
Q -Scorched/Dappled red	3rd to 4th quality
G -Set/fixed green	5th quality
LD-Mouldy tobacco	5th quality
MD-Mixed /Split tobacco	3rd to 5th quality

A1-Strip (two thirds of the midrib torn)

A2-Scrap (Portions of the lamina)

Note that some special factors are specific to leaf families. For example, 'Y' is found in lower leaf only.

Below is an example of flue cured tobacco grade and its description:

L2OJ: Leaf of good quality and orange color but has moderate water stains. If the degree of the water stain was severe then the grade of this tobacco would be L3OJ etc.

There are 121 flue cured tobacco grades. A good harvest should have the smallest number of grades as possible.

3.5.7. BURLEY TOBACCO

This is one of air cured tobacco types. It is cured in open barns which can either be roofed using iron sheets roofed or grass thatch. The cured leaf is predominantly buff to tan.

Burley is currently grown by both estate and smallholder sub sectors. It is grown in all areas where other tobacco types are produced in the country.

3.5.7.1. Improving leaf yield and quality

In order to improve yields and quality, the following recommended agronomic practices must be followed:

1. **Use of recommended varieties**
   Choice of variety or varieties to be grown on the farm is the first step towards increasing yields.

2. **Use of certified seed.**
   Use only certified seed from reputable institution

The information in Tables 56 and 57 provides guidance in choosing a suitable burley tobacco variety for production in Malawi.

Table 56: Agronomic characteristics of some recommended burley tobacco varieties from ARET

Variety	Topping height (No. of leaves)	Yield potential*	Ripening rate	Leaf Colour	
				Field	Cured
ABH12	24-26	High	Medium	Light Green	Tan to red
ABH31	24-26	High	Medium	Light Green	Tan
ABH43	24-26	High	Medium	Light Green	Tan
BRK1	24-26	High	Medium	Green	Tan to Red
BRK5	24-26	High	Medium to Fast	Green	Tan to Red
BRK2	24-26	High	Slow	Green	Tan to Red
BRK4	24-26	High	Slow	Dark Green	Tan to Red
DDV7	24-26	High	Medium to Slow	Dark Green	Tan to Red
HB4151P	22-24	High	Fast		Tan to Red
CCB812G	22-24	High	Medium to Fast	Light green	Tan to Red

*: Above 2500 kg/ha = High; 1500 to 2500 kg/ha = Medium; Below 1500 kg/ha = Low

Table 57: Disease reaction of some recommended burley tobacco varieties in Malawi

Disease	VARIETY									
	ABH12	**ABH31**	**ABH43**	**BRK1**	**BRK5**	**BRK2**	**BRK4**	**HB4151P**	**DDV7**	**CCB812G**
Root knot	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant
Fusarium wilt	Susceptible	Resistant	Resistant	Susceptible	Susceptible	Resistant	Susceptible	Resistant		Resistant
Angular leaf spot	Susceptible	Susceptible	Susceptible	Susceptible	Susceptible	Susceptible	Resistant	Susceptible	Resistant	Susceptible
Alternaria brown	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Susceptible	Resistant	Resistant	Resistant
Tobacco mosaic virus (TMV)	Resistant	Susceptible	Susceptible	Resistant	Resistant	Resistant	Resistant	Susceptible	Resistant	Susceptible
Potato virus Y (PVY)	Susceptible	Susceptible	Susceptible	Susceptible	Susceptible	Susceptible	Resistant	Susceptible	Susceptible	Susceptible
Wildfire	Susceptible	Susceptible	Susceptible	Resistant	Resistant (0)	Resistant	Resistant (0,1)	-	Resistan	-
White Mould	-	-	-	Susceptible	Susceptible	Susceptible	Susceptible	-	-	-
Black shank	-	-	-	-	-	-	-	-	-	-

(-) = Disease not assessed (due to either low pathogen pressure for reasonable classification or completely not available during evaluation).

Seedbeds

General management of Burley tobacco nurseries is the same as that of Flue-cured tobacco and other tobacco types. It is recommended to sow seeds as early as May of each year if a fully irrigated crop is to be produced, August for a partially irrigated and by mid-September in case of a rain-fed tobacco crop.

3.5.7.2 Field preparation

Burley tobacco grows best on sandy clay loams or heavier soil types. The field should be early ploughed and ridged. For a good burley crop, a four year rotation is recommended. However, wherever this is not possible due to land limitations, second year and reverted lands should be treated with appropriate pesticides especially nematicides to control nematodes.

(a) Transplanting

Transplanting should be done with the first planting rains and ensure it is completed with the shortest period possible. Delayed planting risks higher bushy top disease attack, resulting into yield loss.

Transplant burley tobacco on ridges spaced at 120cm between ridges, at 60cm between plants and one plant per station. This will give a density of 13889 plants per hectare. However higher densities can also be used depending on the merchants' trade requirements. To maximize yield, burley tobacco should be water planted at least 2-3 weeks prior to the rains by applying at least 10 litres of water in the transplanting hole followed by proper covering with dry soil. The amount of water applied also depends on soil moisture content at transplanting time and prevalent climatic conditions.

Crop Rotation

In pursuit of crop diversification, farmers should follow a minimum rotation of 4 years with an appropriate crop mix to avoid build-up of pests and diseases, particularly nematodes.

Soybeans are an alternative host for root knot nematodes and other aerial pathogens of tobacco. Soybeans should therefore not be grown next to tobacco or immediately before tobacco in a rotation.

(b) Fertilizer application

Nitrogen requirement for Burley tobacco is higher than that of Flue-cured or other tobacco types. At the time of transplanting basal dress with:-

Either

Super "D" fertilizer at the rate of 450kg per hectare, applying 32.4g per planting station using 2 x cup No.16 or one full cup No.30 applied at half cup on each side of the plant;

Or

"D" Compound fertilizer at the rate of 600kg per hectare, applying 43g per planting station using 2 x cup No.22 applied at one cup on each side of the plant.

Top dress the burley crop with 400kg of CAN per hectare. Split the application at two weeks interval. Apply 200kg CAN using one full cup No.16 per planting station three weeks after transplanting, and the second application of 200kg CAN per hectare should be done 2weeks after the first top dressing using the same specifications.

Specific details are presented in Tables 58 and 59.

Table 58: Type and rates of fertilizers for burley tobacco

Type	Basal Dressing				First top dressing				Second top dressing			
	Rate	50 Kg bags/ha	Cup No.	Remarks	Rate	50 Kg bags/ha	Cup No.	Remarks	Rate	50 Kg bags/ha	Cup No.	Remarks
Super D	450	9	16 or 30	Twice cup#16, one on each side or Cup#30, half on each side of the plant								
Compound D	600	12	22	2 x cup#22, one on each side of the plant								
CAN					200	4	8 or 16	Half cup on each side (16) or 1 cup on each side(8)	200	4	8 or 16	Half cup on each side (16) or 1 cup on each side(8)
AN					162	3.5	5	1 cup on each side	162	3.5	5	1 cup on each side
UREA					122	2.5	8	Half cup on each side	-	-	-	-
CN					-	-	-	-	360	7.5	22	Half cup on each side

*: CAN = Calcium Ammonium Nitrate (27%N); AN = Ammonium Nitrate (34.5%N); CN = Calcium Nitrate (15.5%N).

Table 59: Choice of Top dressing fertilizers

Type	Form of N	Availability	Effect on soil pH	Leaching potential	Time of application
CAN	NH_4^+ NO_3	Immediate	No change	Moderate	At 2-3 weeks and 5 weeks after transplanting
UREA	NH_4^+	Slow	Lower pH	Low	At basal, and no later than 2 weeks after transplanting
AN	NH_4^+ NO_3	Immediate	Lower pH	Moderate	At2-3 weeks and 5 weeks after transplanting
CN	NO_3	Immediate	No change	High	At 5 weeks after transplanting

*Note: Urea should only be used as a first top dressing nitrogen source applied together with basal or no later than 2 weeks after transplanting

(c) Topping

Topping should be done at the extended bud stage leaving 24 to 26 leaves per plant or as guided by the extension officer or contracting merchant. Hand desuckering may be used but use of chemical suckercides ensures earlier and complete sucker suppression thereby increasing yields.

3.5.7.3 Reaping

Under normal weather conditions burley tobacco is ready for reaping some 8-9 weeks after transplanting, the reaping process itself lasting another eight weeks or so. Ripe leaves are creamy yellow with green tinges on the veins.

3.5.7.4 Curing

Burley tobacco curing is done in open barns and relies on natural weather conditions for the curing and drying process. As a result, the process takes longer, sometimes up to 5-6 weeks if the weather is very humid.

(a) Prerequisites

i. Enough barn space

One hector of burley tobacco requires proximately 1000m of tier length. This can be made into a barn length of 250m with 2bay tier dimensions or a 60m barn of 4bay 4 tier. Must be strong.

Usually, the number of leaves per stick is 80, tied into hands of two leaves back to back, and spaced 3cm apart. The stick spacing varies anywhere between 22.5cm to 30 cm as determined by the leaf size. During very wet conditions the distance may increase to 50cm while during hot and dry weather the sticks are squeezed together as practically as possible. Again once yellowing is achieved, sticks can be moved closer for midrib drying. This will also help to create barn space for more tobacco, thus making the most efficient use of available barn space. The tobacco sticks should always be stagger packed.

(b) The curing process

As with the other tobacco types, burley too undergoes the stages of yellowing, lamina drying and midrib drying.

Leaf should take about two weeks to turn from green to yellow (yellowing) to uniform brown (laminar drying). The rate at which these stages will proceed will eventually influence quality.

Midrib drying may take 3 – 4 weeks depending on weather.

(c) Factors Affecting Drying Rate

Relative Humidity (RH): It affects the rate of moisture removal from the leaves. Optimum RH is between 70% 80%.

Temperature: It influences the moisture holding capacity of the air. Optimum is between 15-30oC.

Air Speed: It influences the drying rate.

The aim of burley curing in open sheds is therefore to manipulate the barn environment in order to achieve high quality cures.

(d) Common Curing Faults

These are unwanted characteristics of the leaf caused by curing inefficiencies or field stress such as nutrition, water and weeds.

i. Mouldy Leaf

Avoid prolonged exposure of already dried leaf to very wet conditions.

ii. Mottled Leaf

Avoid curing the leaf too fast drying (yellow mottling) or too slow drying gray mottling.

iii. Water Stained Leaf

Avoid contact of already dried leaf with water.

iv. Green Cured Leaf

Avoid premature reaping, bruising and sun burn.

v. Barn Rot

Avoid over packing of tobacco sticks, which effectively blocks air movement.

(e) Other Curing Methods

i. Stalk Curing

This is the curing of the whole tobacco stalk with an aim to save labour cost.

ii. Use of Flue Barns

Where flue cured tobacco barns are available; they can be used to finish off midrib drying thereby freezing the burley barn to take up more leaf.

iii. Live barns

These are barns that are constructed on trees that still intact in soil and are alive (not cut). This reduces deforestation and money spent on buying of poles. They are durable.

3.5.7.5 Leaf Handling and presenta- tion

a. Grading

Grading of flue cured tobacco puts the leaf in uniform lots of leaf plant position, body appearance or quality, leaf color and then special factors. Never mix grades.

b. Classification

Then the graded leaf is classified and finally given grades by using symbols that stands for separation criteria at grading as follows;

i. Plant Position (First Symbol)

X-Lugs; **C**-Cutter, **M** -Thin Leaf and **L** -Leaf

ii. Quality (Second symbol)

This is the overall soundness of the leaf. It is increases or decreased by degree of special factors (style and extra factors) of the leaf. It is denoted by symbols 1 to 5 as follows;

1= Fine: 5% blemish/injury, no waste
2=Good: 10% blemish/injury, 5% waste

3=Fair: 30% blemish/injury, 15% waste
4=Low: 50% blemish/injury, 30% waste
5=Poor: 80% blemish/injury, 60% waste
NG=None descript: over 80% blemish/injury, over 60% waste

iii. Colour (Third symbol)

L – Buff, **O** –Tan and **R** - Red

iv. Special factors (fourth symbol)

Special factors are the style or nature (F) of the leaf and extra factor due to blemishes and waste and reduces quality (the second symbol) as follows.

F — High maturity: 1st to 3rd quality
J — Discolored/stained: 3rd quality and below
K —Greyish/yellow mottled: 3rd quality and below

G —Slight /crude green: 4th quality and below

LD – Mouldy: 3rd quality and below

MD –Mixed tobacco: 3rd quality and below

Below is an example of a burley tobacco grade and its translation;

C3LK: Fair quality, mottled, buff, cutter. The grade could be reduced to C4LK or C5LK depending on severity of in this case, the mottling (i.e. the K).

There are 65 burley tobacco grades. A good harvest should have the smallest number of grades as possible.

Note that tobacco grades are subject to change and therefore always be in contact with ARET and other agricultural staff for up to date information.

Grading is subjective, hence it should be done by more than one person and should be carefully done and expert advice should be sought from ARET or other agricultural staff.

Table 60: Annual Tobacco sales data

	BURLEY			FLUE CURED			SDDF			NDDF			SUN/AIR			ALL TYPES TOBACCO		
YEAR	Volume (Kg)	Realisation (U.S$)	Av. Price (US$/ Kg)	Volume (Kg)	Realisation (U.S$)	Av. Price (US$/ Kg)	Volume (Kg)	Realisation (U.S$)	Av. Price (US$/ Kg)	Volume (Kg)	Realisation (U.S$)	Av. Price (US$/ Kg)	Volume (Kg)	Realisation (U.S$)	Av. Price (US$/ Kg)	Volume (Kg)	Realisation (U.S$)	Av. Price (US$/ Kg)
2010	193,238,632	342,971,867.07	1.77	24,320,730	66,869,257.00	2.75	64,112	172,256,19	2.69	2,545,848	6,371,560.46	2.50	28,749	41,501.61	1.44	220,198,081	416,426,442.33	1.89
2011	208,324,837	235,564,660.03	1.13	23,856,100	50,451,690.11	2.11	373,339	613,474.11	1.64	4,617,184	7,108,515.41	1.54				237,171,460	293,738,339.66	1.24
2012	64,676,433	132,123,718.98	2.04	12,628,175	40,337,630.46	3.19	219,377	542,136.46	2.47	2,298,529	4,806,639.60	2.09	124	124.00	1.00	79,822,638	177,819,249.50	2.23
2013	144,796,667	292,111,857.85	2.02	19,747,037	61,213,389.48	3.10	286,749	593,623.65	2.07	3,837,148	7,918,457.91	2.06				168,667,601	361,837,328.89	2.15
2014	159,385,912	282,957,859.05	1.78	31,065,782	75,640,005.69	2.43	206,138	356,313.50	1.73	1,309,709	2,610,294.50	1.99				191,967,541	361,564,472.74	1.88
2015	168,248,234	280,209,951.28	1.67	23,060,068	54,199,988.82	2.35	78,432	174,425.61	2.22	1,293,034	2,796,853.32	2.16				192,679,768	337,381,218.73	1.75
2016	174,902,046	226,215,286.30	1.29	17,558,178	44,858,974.37	2.55	167,972	358,746.50	2.14	2,496,798	4,956,949.79	1.99				195,124,994	276,389,956.96	1.42
2017	81,446,593	144,242,299.84	1.77	20,812,593	60,756,984.96	2.92	378,065	678,215.10	1.79	3,899,564	6,839,562.79	1.75				106,536,815	212,514,062.69	1.99
2018	163,973,708	255,499,036.61	1.56	32,279,725	72,682,033.69	2.25	851,730	1,469,890.24	1.73	4,900,197	7,849,286.62	1.60				202,005,360	337,500,247.16	1.67
2019	138,957,754	181,768,642.80	1.31	22,662,132	49,513,371.59	2.18	687,237	1,017,843.63	1.48	3,363,710	4,704,831.93	1.40	12,912	42,996.60	3.33	165,683,745	237,047,686.55	1.43

3.6. Cotton
(Gossypium hirsutum)

Cotton is avaluable cash crop grown in the Shire Valley, Mwanza/Neno, Phalombe Plain, Zomba West, Machinga, Mangochi West and Lake shore, Bwanje Valley, the lakeshore areas of Dedza, Salima, Nkhotakota, Ntchisi, Dowa East and Karonga including the Henga Valley and Nkhamanga Plain in Rumphi District. The other potential cotton production areas include Lilongwe West, Mchinji, Dowa, West Mzimba and Kasungu.

Apart from providing cash incomes to farmers, processed cotton seed provides valuable raw material for the manufacturing of cooking oil and livestock feeds.

3.6.1. National aims

The aim is to increase production and improve quality to meet local demand and export any surpluses. Average seed cotton yields range from 700 to 800 kg per hectare but with good management yields of between 2,500 kg and 3,000 kg per hectare can be obtained. The objective therefore is to increase production by improving yield towards the potential and expanding hectarage in all suitable areas.

3.6.2. Improving yield

In order to obtain high yields of good quality, the following cultural practices are recommended.

3.6.2.1. Use of recommended varieties

New cotton varieties have been developed for specific ecological zones in the country. The new varieties have higher yield potential and are more adaptable to areas that are being recommended for production.

These improved varieties are:

Hybrid cotton varieties

MAHYCO C 567

The main features include hairy leaves and semi erect growth habit. Its average height is about 131 cm and flowers about 61 days after emergence. It is medium maturing. It produces bolls which mature and start opening at about 119 days after crop emergence. It has high seed cotton yield potential above 3500 Kg/ha. The hybrid gives 32 % more seed cotton yield than Makoka 2000; 69 % over RASAM 17 and 25 % over IRM 81. The average boll size is 5.7 g. Its ginning out turn is around 35.00 %. It is tolerant to sucking pests such as jassids and aphids. It is also tolerant to major diseases under field conditions such as bacterial blight. It has fibre length of 30.5 – 31.0 mm; fibre strength of 30.0 – 31.0 g/ tex and fibre fineness (micronaire) of 4.0 – 4.2. This hybrid is suitable for cultivation in the lakeshore areas.

MAHYCO C 569

The main features include slightly hairy leaves and semi erect growth habit. Its average hieght is about 125 cm and flowers about 60 days after emergence. It is medium maturing. It produces bolls which mature and start opening at about 117 days after crop emergence. It has high seed cotton yield potential above 3500 Kg/ha. It gives 18 % more seed cotton yield than Makoka 2000; 74 % over RASAM 17 and 24 % over IRM 81. Hybrid 569 produces large boll sizes averaging 5.9 g. Its ginning out turn is around 35.00 %. It is tolerant to sucking pests such as jassids and aphids. It is also tolerant to major diseases under field conditions such as bacterial blight. It has fibre length of 30.5 mm; fibre strength of 30.0 – 31.0 g/ tex and fibre fineness (micronaire) of 4.2–4.4. This hybrid is suitable for all ecological zones.

MAHYCO C 571

The main features include slightly hairy leaves and erect growth habit. Its average height is about 121 cm and flowers about 58 days after emergence. It is medium maturing. It produces bolls which mature and start opening at about 116 days after crop emergence. It has higher seed cotton yield above 3500 Kg/ha. It gives 37 % more seed cotton yield than Makoka 2000, 86 % over RASAM 17 and 29 % over IRM 81. Hybrid 571 produces large boll sizes averaging 5.9 g. Its ginning out turn is around 35.00 %. It is tolerant to sucking pests such as jassids and aphids. It is also tolerant to major diseases under field conditions such as bacterial blight. It has fibre length of 30.5 – 31.5 mm; fibre strength of 31.0 – 31.5 g/ tex and fibre fineness (micronaire) of 4.3– 4.4. This hybrid would be suitable for all ecological zones.

MAHYCO C 577

The main features include slightly hairy leaves and semi erect growth habit. Its average height is about 126 cm and flowers about 57 days after emergence. It is medium maturing. Under Malawi conditions, it produces bolls which mature and start opening at about 113 days after crop emergence. It has high seed cotton yield potential over 3500 Kg/ha. It gives 22 % more seed cotton yield than Makoka 2000, 78 % over RASAM 17 and 18 % over IRM 81. Hybrid 577 produces boll sizes averaging 5.4 g. Its ginning out turn is 37.00 %. It is tolerant to sucking pests such as jassids and aphids. It is also tolerant to major diseases under field conditions such as bacterial blight. It has fibre length of 30.5 – 31.0 mm; fibre strength of 30.0 – 31.0 g/ textile and fibre fineness (micronaire) of 4.2 – 4.3. This hybrid would be suitable for Shire valley areas.

MAHYCO C 579

The main features include slightly hairy leaves and semi erect growth habit. Its average height in Malawi is about 126 cm and flowers about 56 days after emergence. It is medium maturing. Under Malawi conditions, it produces bolls which mature and start opening at about 108 days after crop emergence. It has high seed cotton yield potential over 3500 Kg/ha. It gives 25 % more seed cotton yield than Makoka 2000, 35 % over RASAM 17 and 14 % over IRM 81. It produces boll sizes averaging 5.7 g. Its ginning out turn is 38.37 %. It is tolerant to sucking pests such as jassids and aphids. It is also tolerant to major diseases under field conditions such as bacterial blight. It has fibre length of 31.0 – 31.5 mm; fibre strength of 30.5 – 31.0 g/ tex and fibre fineness (micronaire) of 4.3 – 4.5. This hybrid is suitable for all ecological zones.

MAHYCO C 570

The main features include slightly hairy leaves and semi erect growth habit. Its average height in Malawi is about 133 cm and flowers about 57 days after emergence. It is medium maturing. Under Malawi conditions, it produces bolls which mature and start opening at about 111 days after crop emergence. It has high seed cotton yield potential over 3500 Kg/ha. It gives 16 % more seed cotton yield than Makoka 2000, 38 % over RASAM 17 and 21 % over IRM 81. It produces boll sizes averaging 6.3 g. Its ginning out turn is 35.00 %. It is tolerant to sucking pests such as jassids and aphids. It is also tolerant to major diseases under field conditions such as bacterial blight. It has fibre length of 31.0 – 31.5 mm; fibre strength of 30.5 – 31.0 g/ tex and fibre fineness (micronaire) of 4.2 – 4.3. MAHYCO C570 is suitable for wide adaptation in Shire valley and medium altitude areas.

MAHYCO C 608

The main features include slightly hairy leaves and semi erect growth habit. Its average height in Malawi is about 129 cm and flowers about 56 days after emergence. It is early maturing. Under Malawi conditions, it produces bolls which mature and start opening at about 109 days after crop emergence. It has high seed cotton yield potential over 3500 Kg/ha. It gives 24 % more seed cotton yield than Makoka 2000, 69 % over RASAM 17 and 19 % over IRM 81. It produces boll sizes averaging 5.5 g. Its ginning out turn is 36.00 %. It is tolerant to sucking pests such as jassids and aphids. It is also tolerant to major diseases under field conditions such as bacterial blight. It has fibre length of 30.5 – 31.0 mm; fibre strength of 30.0 – 31.0 g/ tex and fibre fineness (micronaire) of 4.2 – 4.3. This hybrid is suitable for all ecological zones.

OPV cotton varieties

QM 302 (QUT 127)

The main features include hairy leaves and erect growth habit. Its average height in Malawi is about 104 cm and flowers about 71 days after emergence. It is medium to long maturing. It produces bolls which mature and start opening at about 142 days after crop emergence. It has high seed cotton yield potential above 3000 Kg/ha. The variety gives 6 % more seed cotton than Makoka 2000, 19 % over RASAM 17 and 8 % over IRM 81. The average boll size is 5.3 g. Its ginning out turn is around 41.00 - 42.00 %. It is tolerant to sucking pests such as jassids and aphids. It is also tolerant to major diseases under field conditions such as bacterial blight. It has fibre length of 31.0 – 31.5 mm; fibre strength of 32.5 – 33.5 g/ tex and fibre fineness (micronaire) of 4.3 – 4.5. It is suitable for lakeshore areas.

QM 303 (QUT 128)

The main features include slightly hairy leaves and semi erect growth habit. Its average height in Malawi is about 106 cm and flowers about 73 days after emergence. It is medium to long maturing. It produces bolls which mature and start opening at about 142 days after crop emergence. It has high seed cotton yield potential above 3000 Kg/ha. The average size of the boll is 5.6 g. Its ginning out turn is around 41.50 %. It is tolerant to sucking pests such as jassids and aphids. It is also tolerant to major diseases under field conditions such as bacterial blight. It has fibre length of 30.5 – 31.0 mm; fibre strength of 32.5 – 33.0 g/ tex and fibre fineness (micronaire) of 4.4 – 4.5. It is suitable for Shire valley areas.

QM 201 (QUT 129)

The main features include hairy leaves and semi erect growth habit. Its average height is about 98 cm and flowers about 71 days after emergence. It is medium maturing. It produces bolls which mature and start opening at about 139 days after crop emergence. It has high seed cotton yield potential above 3000 Kg/ha. The average boll size is 5.4 g. It's ginning out turn is around 41.00 – 42.00 %. It is tolerant to sucking pests such as jassids and aphids. It is also tolerant to major diseases under field conditions such as bacterial blight. It has fibre length of 28.5 – 29.5 mm; fibre strength of 29.5 – 31.0 g/ tex and fibre fineness (micronaire) of 4.4 – 4.6. It is suitable for Shire valley areas.

MAKOKA 2000

This variety has a compact growth habit with an open canopy that facilitates effective ground canopy spraying. It is tolerant to bacterial blight *(Xanthomonas campestris pv. malvacearum)* and jassid *(Jacobiella fasciallis)* damage. The average number of days between sowing and flowering and boll opening (maturity) are 53 and 44 days, respectively. It has a seed cotton yield potential of over 3,000kg per hectare and an improved ginning out turn (GOT) of 38.9%. Its average fiber characteristics are 28.5mm span length and 0.9 maturity ratio. It is recommended for the lower Shire valley.

RASAM 17

This variety is recommended for all lakeshore areas, such as Mangochi West, Salima, and Karonga. It is tolerant to bacterial blight disease and Jassid damage. Average number of days between sowing and flowering, and between flowering and boll opening are 66 and 55 days, respectively. It has a yield potential of 3,000kg/ha. It has a high ginning out turn of 37.8 % and produces mature fibres with an average maturity ratio of 0.53 and a span length of 18.4 mm.

IRM 81

This variety is well adapted to areas between 500 and 1,000 metres (medium altitude) above sea level, such as Phalombe plain, Balaka, Mwanza / Neno areas, Machinga and Henga Valley. Other potential areas for this variety include the Lilongwe plain through to Mchinji, Dowa West and Kasungu. It has an average flowering period of 68 days, and 50 days from flowering to boll maturation. The potential yield is 3,500kg per hectare and has an average ginning out turn of 38.7 %. It produces good quality fibre with an average maturity ratio of 0.85 % and a span length of 29.6 mm.

FQ902

It is recommended for medium to high altitude areas under high levels of management. It has erect and compact growth habit with pale green, lobed and hairy leaves as well as plant surface. The average number of days between sowing and flowering and flowering and boll opening (maturity) are 53 and 44 days. It has a potential seed cotton yield of over 3000 kg/ha and an improved ginning out turn of 41.4 %. It is tolerant to jassid attack, and has similar fibre quality characteristics as other recommended varieties.

SZ 9314

It has a compact growth habit with an open canopy that facilitates easy pesticide application. It takes 75 days to flower and 71 days to boll opening. It has a high yield potential (3,500 kg/ha). It has a boll size of 5.6 g and an improved ginning out turn of 43 %. It is highly suitable for large scale commercial production.

Chureza

It was released for commercial production in all areas outside the Shire Valley. The main botanical characteristics of Chureza include: erect and compact growth habit with pale green, lobed, and hairy leaves. The stems are green and hairy. It flowers between 60 and 70 days after crop emergence. The bolls mature between 120 and 130 days after crop emergence. It has a potential seed cotton yield of over 3000 kg/ha. It has an average ginning out turn of 41.75 %. Chureza has similar fibre quality characteristics as the recommended varieties in various ecological areas where cotton is grown in Malawi.

DP 485

The main botanical characteristics include closed growth habit with pale green, palmate hairly leaves. The stems are brown and hairy. Its average height in Malawi is about 120 cm and flowers between 72 to 75 days after emergence. It is medium maturing. It produces bolls which mature between 130 and 140 days after crop emergence. The bolls are generally small. It has high ginning out turn which is around 41%. It is tolerant to red spider mite and jassid insect attack. It is recommended for production in the eastern bank of the Shire valley away from Makoka 2000.

DP 486 (QM 301)

Its botanical characteristics include, open in the top half of the plant but the bottom half can become closed by basal monopodia under good management. It has pale green, palmate hairy leaves. The stems are brown and hairy. Its average height in Malawi is 126 cm and flowers between 72 to 74 days after emergence. It is late maturing. It produces larger bolls which mature between 130 and 140 days after crop emergence. It has high ginning out turn which is around 41%. It is also tolerant to Jassid and red spidermite attack. It is recommended for lakeshore areas.

Bt cotton hybrid varieties

MAHYCO C 567 BG II

With good management the variety can yield 4000 - 5000 Kg per hectare. It matures in 170-180 days. It is suitable all cotton growing areas of Malawi. The main features include slightly hairy leaves and semi erect growth habit. Its average height is about 123 cm and flowers about 52 days after emergence. It is medium maturing. It produces bolls which mature and start opening at about 100 days after crop emergence. The average boll size is 5.1 g. Its ginning out turn is around 35.88 %. It has excellent bollworm resistance. It is tolerant to sucking pests such as jassids and aphids. It is also tolerant to major diseases such as bacterial blight. It is easy to pick. It has fibre length of 31.8 mm; fibre strength of 26.9 g/ tex and fibre fineness (micronaire) of 4.3. It is tolerant to drought.

MAHYCO C 569 BG II

It is medium maturing variety, about 170-180 days after crop emergence. On average it takes about 56 days to flower and 108 days to start boll opening. Under good management the yield can go up to 4000 – 5000 Kg per hectare. It is suitable for cultivation in all cotton growing areas of Malawi. Its main features include slightly hairy leaves and semi erect growth habit. Its average height is about 126 cm and flowers about 56 days after emergence. The average boll size is 5.7 g. Its ginning out turn is around 39.00 %. It has excellent bollworm resistance. It is tolerant to sucking pests such as jassids and aphids. It is also tolerant to major diseases such as bacterial blight. It is easy to pick. It has fibre length of 31.0 – 31.5 mm; fibre strength of 30.5 – 31.0g/ tex and fibre fineness (micronaire) of 4.3 – 4.5. It is tolerant to drought.

MAHYCO C 570 BGII

The variety has a potential to yield 4000 – 5000 Kg per hectare. It matures in 170- 180 days. It is suitable for cultivation in all cotton growing areas of Malawi. The main features include slightly hairy leaves and semi erect growth habit. Its average height is about 116 cm and flowers about 51 days after emergence. It is medium maturing. It produces bolls which mature and start opening at about 100 days after crop emergence. The average boll size is 6.0g. Its ginning out turn is around 32.00 %. It has excellent bollworm resistance and is tolerant to sucking pests such as jassids and aphids. It is also tolerant to major diseases such as bacterial blight. It is easy to pick. It has fibre length of 31.5 mm; fibre strength of 28.0g / tex and fibre fineness (micronaire) of 4.0. It is tolerant to drought.

MAHYCO C 571 BG II

This variety can yield 4000 – 5000 kg per hectare with a ginning out turn of 33.83 % under good management. It matures in 170- 180 days and is suitable for cultivation in all cotton growing areas of Malawi. The main features include slightly hairy leaves and semi erect growth habit. Its average height is about 118 cm and flowers about 51 days after emergence. It is medium maturing. It produces bolls which mature and start opening at about 100 days after crop emergence. The average boll size is 5.4 g. makes it easy to pick. It is tolerant to sucking pests such as jassids and aphids. It is also tolerant to major diseases such as bacterial blight. It has fibre length of 31.0 mm; fibre strength of 27.6 g / tex and fibre fineness (micronaire) of 4.0. It is tolerant to drought.

3.6.2.2. Field preparation

Cotton fields should be deeply ploughed as early as possible so that sowing may be done in good time. Ridges should be made either 75cm or 90cm apart and cross-tied especially in areas of low rainfall such as Shire Valley. Cross ties may however, be removed if signs of water-logging appear. Fine tilth is required for early seedling emergence and growth.

3.6.2.3. Time of planting

Cotton should be sown at the onset of first effective planting rains which is normally 50 mm and capable of wetting the soil to a depth of at least 15cm. Where a farmer is faced with shortage of labour he may dry plant, if adequate rains are anticipated within one to two weeks of sowing. In a normal season sowing may continue up to the first week of January in all cotton growing areas except for Karonga where planting may continue up to the end of January. However, a delay of 4 weeks in planting can account for up to 30% loss in yield.

3.6.2.4. Plant population

Whether the ridge is spaced at 75 cm or 90 cm, planting stations should be 60 cm apart within the ridge. For delinted seed, plant 5 seeds per hole giving a seed rate of 15 kg per hectare. If using fuzzy seed, plant 8 to 10 seeds per hole. This gives a seed rate of 25 kg per hectare. If sowing is done by machine, plant spacing can be reduced to 30 cm within the row without much drudgery. The seed should be sown at 20 mm depth in wet soil. When dry planting, seed may be sown at a depth of 25 mm to 32 mm so that the seed does not germinate with light rains insufficient to maintain subsequent seedling growth. Farmers are advised to follow planting instructions printed on the seed pack for hybrid and Bt cotton varieties.

3.6.2.5. Supplying and thinning

Supplying or filling of gaps should be done within 2 to 3 days of emergence to ensure uniform growth. It is only recommended when 2 consecutive stations have less than 2 plants each About 3 weeks after emergence when plants should be thinned to 3 best plants per station for 60cm spacing and to one for 20 to 30cm spacing. Thinning should be done when the soil is moist to avoid damaging roots of adjacent plants. If the soil is dry, thinning should be done by cutting the unwanted plants using a knife or a pair of scissors. A delay in thinning will result in plants severely competing for nutrients, sunlight and moisture. This in turn will result in substantial yield losses.

3.6.2.6. Fertilizer application

Cotton responds to fertilizer especially on light sandy soils. Farmers should be encouraged to apply fertilizers to their cotton if early crop establishment shows stunted growth. Fertilizer recommendation for cotton is 34 kg N, 45 kg P205 and 22 kg Sulphur per hectare where the crop is stunted because of nutrient deficiency. Farmers should be advised not to apply fertilizer on fertile soils as this may lead to rank growth (excessive growth at the expense of flower and boll formation).

Fertilizer should be applied as follows:-

Either apply 23:10:5+6S+1.0Zn at the rate of 100 kg per hectare. Apply 5g per planting station using Cup No.5 after thinning. At first flower apply 24 kg of Urea per hectare. Apply 3g per planting station using metric cup No.5.Or

Apply 100 kg of 23:10:5+6S+1.0Zn per hectare. Apply 5g per planting station using Cup No. 5 after thinning. At first flower, apply 52 kg CAN per hectare. Apply 3g per planting station using half of Cup No.5.

Use of Foliar fertilizers can correct N, P, K, B deficiency problems in cotton. Application of FOLIFERT supplement at 2 liters/ha (60 ml/15 liters of water) can boost crop development and yield increase. Spraying should be done 5 times every two weeks starting from 4 weeks after emergence. Spraying should be done early in the morning before 10.00 hours or late in the afternoon after 16.00 hours for best results.

Boron deficiency results in shedding of flowers and bolls. The problem is more prevalent in have their second pair of true leaves, the crop light sandy soils of Karonga ADD, Salima ADD, Machinga ADD, and Shire Valley ADD. To correct the deficiency, boron in the form of Solubor should be dissolved together with insecticides and sprayed with the first 6 sprays. When using knapsack sprayer apply, 71g (12 level metric cup number 16 or 50 grams Vaseline Blue Seal bottle top) in one litre of water. Solubor can be bought from agricultural inputs distributors such as ADMARC and other private companies.

3.6.3. Pest control

3.6.3.1. Weed control

It is extremely important to keep cotton free of weeds between planting and flowering. If weeds are left to compete with the crop during this period, very low yields will be obtained. This is because weeds compete for nutrients, soil moisture and solar radiation (sunlight) which are essential for good growth and high yields. Farmers should not wait for dry spells before weeding because by the time there is a dry spell, weeds may already have overcrowded the small plants. Some weeds which occur later in the season must be removed before bolls open to avoid seeds and trash getting onto the lint.

An application of Harness 90 EC (acetochlor) at the rate of 1.0 litre/ha (range 0.75-1.5litres/ha) for soils with a clay content of 0 - 10%, or 2.0 litres/ha (range 1.0-3.0 litres/ha) for soils with a clay content of 11-30%, is effective in controlling annual grasses and certain broadleaf weeds in cotton for a period of up to 12 weeks after application. Farmers can prepare a formulation that will apply 1.0 or 2.0 litre/ha by adding 50 ml of Harness EC to15 litre knapsack sprayer tank or 170 ml in 5 litre tank of Micron ULV+. Harness 90 EC, whose active ingredient is acetochlor 900 g/litre, controls:

(i) up to eight common grasses that include crab finger grass *(Digitaria sanguinais)*, goose grass *(Eleusine indica)*, herring bone grass *(Urochloa panicoides)* and buffalo grass *(Panicum spp.)*.

(ii) up to thirteen broad leaf weeds, including pigweed *(Amaranthus spp.)*, wandering Jew *(Commelina benghalensis)* apple of Peru *(Nicandra physalodes),* Denje *(Corchorus olitorius)* wild goose berry *(Physalis angulata)* and khaki weed *(Tagetes minuta)*. For effective and optimal weed control, farmers should apply Harness EC within three days after cultivation that is followed by10-15 mm of rain.

(iii) Early weeds in cotton can also be controlled by applying Pendimethalin 500 EC (Dinitroaniline). Pendimethalin should be applied immediately after planting at 2 l/ha (40 mls/15 litre knapsack sprayer) to control annual grasses and broad leaves.

Apply Roundup 360 SL (Glyphosate) where weeds have emerged before planting or after planting but before emergence of cotton seedlings. This is a non-selective contact herbicide which controls all green weeds. It should be used to clean up cotton fields of any existing weeds prior to planting or germination of cotton seedlings. Roundup should be applied at 150 ml in a 15-liter knapsack sprayer tank or 250 ml in a 5 liter spray tank with the Micron ULVA+.

3.6.3.2. Insect pest control

Cotton has the highest insect pest load of all crops grown in Malawi. Consequently, insect pests are the largest single factor limiting cotton production in the country. Insect pests of economic importance to Malawi include African bollworm *(Helicorvepa armigera Hubner)*, spiny bollworm *(Earias biplaga WLk and E. insulana Boisd)*, red bollworm *(Diparopsis castanea Hmps),* and pink bollworm (*Pectinophora gossypiela Saund*), red spider mite *(Tetranychus spp.),* cotton strainers *(Dysdercus spp),* jasssid *(Jacobiella Empopoasca) fascialis Jac),* aphid *(Aphis gossypii Glov)*, harvester termites *(Hodotermes spp.)*, subterranean termites *(Microtermes and Ancistrotermes)*, elegant grasshopper *(Zonocerus elegans Thnb),* cotton psyllid *(Paurocephala gossypii Russel),* Lygus bug *(Taylorilygus vosseleri)*, Cotton semi-looper, *(Anomis flava)* and other general leaf eaters. These can effectively be controlled by planned use of pesticides and cultural practices. To obtain high yields, the crop should be protected from insect pests through the application of recommended insecticides at the correct rates and following crop hygiene practices. In order to effectively control insect pests the following procedures should be observed:-

(i) **Scouting and spraying**

Scouting is the key to pest management on cotton as it is the only way of determining estimates of pest levels in a cotton field. Farmers should be advised not to spray on a routine weekly basis but rather spray only when a weekly scouting has shown that bollworm eggs, damaged squares [squares flare up] and insect pest counts have reached recommended action threshold levels. In this way farmers may save some insecticides and time, besides delaying the onset of pesticide resistance and pest resurgence. It is therefore very important that agricultural staff give guidance to farmers on recommended methods of scouting including the choice and use of various recommended insecticides

In addition, it is highly recommended that when synthetic pyrethroids are used, scouts should check thoroughly the recovery of some insects such as bollworm larvae and cotton stainers. The knock down effect is quick but some larvae may recover. With cotton stainers, actual death may take a long time. Any signs of frequent recovery should be reported to appropriate authorities as this may be a sign of development of resistance. Similarly, build-up of insect pests such as whitefly and red spidermites should be reported. At the moment no scouting technique has been devised for whitefly for use by extension staff but the following technique should be employed:-

Count the number of adults and nymphs on 2 leaves each at the top, middle and bottom of the plant. Turn the leaves gently by holding at the petiole. Such counts should be done on the same plants as for bollworm counts and scouting should preferably be done in the early part of the morning when adult whitefly is less active. Levels of nymphs above 10 per plant should be regarded as very high.

Farmers can use either the knapsack sprayer with a tail boom or the utra low volume (ULV) sprayer to apply the recommended pesticides. Both sprayers and insecticides are available at ADMARC markets and other input suppliers. Farmers are strongly advised to purchase pesticides from registered dealers and agents only. Agricultural field staff should advise farmers on how and where to buy sprayers and pesticides.

(ii) **Recommended pesticides**

The recommended pesticides in Malawi, their target pests and time of application are as presented in Table 61. If red spider mite is observed, spray Dimethoate or acetamiprid as for aphids. Where red spider mite is observed on one plant, only that plant should be sprayed. Cotton packs

The Ministry of Agriculture has approved the use of cotton packs. Cotton packs comprise all cotton pesticides a farmer may require per unit area per growing season. This is recommended to make sure that farmers get their requirement in time and ensure that different pesticides as recommended are provided for use at the right time by farmers and to reduce the workload by extension staff. Staff should therefore encourage farmers where possible to purchase cotton packs. The composition of the packs will vary depending on the type of pyrethroid in the pack.

The pack now commonly available contains the following:

1 x 250ml bottle cypermethrin 20EC; 26 X 85g Carbaryl 85WP for all ADDs. And 10 x 34g Dimethoate 20WP or 1 x 250ml bottle of Dimethoate 40EC. This pack will cover 0.33 hectares of cotton but can be rounded up to 0.4 hectares of cotton.

(iii) **Crop hygiene**

Measures of field crop hygiene are particularly important. Pink and red bollworms and psyllids are partly controlled by observing the closed season. Observing the closed season is particularly important for pink bollworm which is difficult to control with pesticides. Among the regulations governing this is that all cotton stalks should be uprooted by 30th July and burned by 15th August together with trash on the ground except in Karonga where uprooting and burning should be complete by 31st August and15th September respectively. By following this regulation, the pest load is reduced for the next season's crop.

3.6.4. Harvesting and grading

Harvesting should be done when 3 to 5 bolls have opened per plant and should be done every 10 to 14 days on average. Using 2 hands, pick into a cloth bag tied round the waist having separate pockets for clean and stained cotton. Walk between 2 rows picking bolls from sides of adjacent row, and checking for trash before putting the cotton in the bag. Late harvesting results in staining of seed cotton, loss of weight, mice damage and dirtening of lint due to falling on to the ground and collecting dust.

Table 61: Choice of pesticides in relation to pest species and crop growth stage of cotton

Growth rate	Pest species	Action threshold levels	Pesticide	Rate (weight or volume) of pesticide to be mixed with 15 liters or 1 liter for knapsack or ULV respectively
Vegetative* (3-6 weeks after emergence)	Jassid Psyllid Elegant grasshopper Semi loopers Red bollworm Harvester termite	2 nymphs per leaf - When abundant - - When active	Carbaryl 85WP Dimethoate 40EC Acetamiprid	• 85g • 34ml • 5ml
	Aphid Red spider mite	Present on 6 plants out of 24 plants When present		
Squaring to flowering (6-10 weeks after emergence	Red boll worm, Spiny boll worm, Psyllid Jassid	When eggs are found - 2 nymphs	Carbaryl 85WP Profenofos 40EC Triazophos 40ET Thunder 145 O-TEQ Cyclone	• 85g • 40ml • 75ml • 15ml • 30ml
	Aphid Red spider mite	Present on 6 plants out of 24 plants When present	Dimethoate 40EC Triazophos 40EC Acetamiprid	• 34ml • 75ml • 5ml
Peak flowering (10-13 or 12-15 weeks after emergence)	African bollworm**** Red boll worm Spiny bollworm	6 eggs out of 24 plants	• Lamdacyhalothrin 5 EC (Karate) • Cyfluthrin 5EC (Baythroid) • Decis forte • Dettamax 2.5WP • Dettamax 2.5EC • Thunder 145 -OTEQ • Cypersupper 20EC • Cypermethrin 20EC	• 12ml • 13ml • 5ml • 40g • 20ml • 15ml • 10ml • 10ml

Table 61: Choice of pesticides in relation to pest species and crop growth stage of cotton *(Continued)*

Growth rate	Pest species	Action threshold levels	Pesticide	Rate (weight or volume) of pesticide to be mixed with 14 liters or 1 liter for knapsack or ULV respectively
	Aphid Red spider mite	Present on 6 plants out of 24 plants When present	Dimethoate 40EC Triazophos 40EC Acetamiprid	34ml 75ml 5ml
Boll formation to boll maturity (beginning 13 to 15 weeks after emergence	Red bollworm Cotton stainers	When eggs are found When abundant	Carbaryl 85WP, Profenofos 50EC Triazophos 40EC Thunder 145 O-TEQ	85g 40ml 75ml 15ml
	Aphid Red spider mite	Present on 6 plants out of 24 plants When present	Dimethoate 40EC Triazophos 40EC Acetamiprid	34ml 75ml 5ml
Boll opening	Cotton stainers Dusky stainers (*Oxycaremis* spp)	When abundant When present	Carbaryl 85WP Profenofos 50EC Triazophos 40EC Thunder 145 O-TEQ	85g 40ml 75ml 15ml
	Aphid	Present on 6 plants out of 24 plants	Dimethoate 40EC Triazophos 40EC Acetamiprid	17ml 75ml 5ml

Picking should never be done when it is wet. If plants are wet in the morning picking should be delayed until surface of open bolls is dry. After harvesting, the seed cotton should be thoroughly graded before taking it to ADMARC or other registered markets.

There are two grades of cotton, A and B. Grade A is clean cotton without trash while grade B is stained cotton without trash. Grading should be done in the shade as in the sun all the cotton appears clean.

For more information on cotton, interested parties should refer to the publication on Cotton Hand book of Malawi. Enquiries may also be made to Agricultural Development Divisions, Director of Agricultural Research Services, Director of Crop Development and Director of Agricultural Extension Services.

3.6.5. Cotton production

Estimated cotton hectarage and production for the past ten seasons is as shown in Table 62.

Table 62: Cotton production in tonnes and hectarage for the past ten seasons

Season	Hectarage	Yield (Kg/ha)	Production (mt)
2010/11	59,626	880	52,456
2011/12	252,130	917	231,188
2012/13	184,513	861	158,826
2013/14	149,259	887	132,337
2014/15	123,019	645	79,289
2015/16	78,474	401	31,439
2016/17	41,097	719	29,545
2017/18	40,613	529	21489
2018/19	42,652	626	26716
2019/20	42,685	627	26783
Average	**101,407**	**779**	**79,007**

3.7. FRUITS

Malawi has a wide range of climatic conditions and soil types which enable a variety of fruits to be produced. Fruits are valuable sources of vitamins and mineral salts which are essential for body protection against diseases. Some fruits provide proteins, carbohydrates and oils. They are also a source of income. Several factors such as cultural practices, insect pest and disease incidences limit the yield and quality of fruits in the country.

3.7.1. National aims

The aim is to increase fruit production in suitable areas to satisfy domestic demand so as to improve the nutritional status of the rural and urban populations and export where opportunities exist. The objective is, therefore, to encourage farmers to grow fruits of high quality for local consumption.

3.7.1.1. Improving yields

In order to obtain high yields of good quality fruits, the following cultural practices are recommended:-

3.7.1.1.1. Site selection

Site selection should be done carefully considering soil types and climatic conditions for each type of fruit crop. Soils should be deep, fertile and free draining. To prevent Amillaria root rot disease all unwanted trees should be ring-barked and left to die. Those that cannot die by ring-barking must be dug out with as much root system as possible. This should be done 2 years in advance of planting. In areas where there are strong prevailing winds, establish a wind break one year before planting the fruit trees.

3.7.1.1.2. Planting

The time of planting for each type of fruit tree should be followed to achieve successful establishment. All trees should be spaced according to recommendations. The planting holes should be 90cm in diameter and 90cm deep. They should be dug at least 2 months before planting and filled with top soil mixed with 5 to 10kg of well decomposed manure.

3.7.1.1.3. Orchard management

Make basins or box ridges around each tree and mulch. The fruit trees should remain mulched throughout the year to conserve moisture. Irrigate where applicable. Protect the orchard from fire hazards by weeding and making fire breaks of at least 3m wide around it.

Trees should be pruned as recommended. Insect pests, diseases and nematodes should be controlled by using appropriate control methods.

3.7.1.1.4. Manure and fertilizer applications

It is important to apply manure during the period of tree growth and development. Apply 5 to10kg of well decomposed manure per tree at every beginning of the rainy season.

Fertilizer applications should be based on soil and leaf analysis. Apply half of the chemical fertilizer at the beginning of the rainy season and the other half when the rains are tailing off, except for Triple super phosphate which should be applied once at the beginning of the rainy season.

3.7.2. TROPICAL AND SUB-TROPICAL FRUITS

These are fruit trees that are evergreen and prefer warm to hot environment, characteristic of tropical and sub-tropical conditions. They do not withstand frost and are therefore suitable for growing in low medium altitude areas ranging from sea level to 1, 200m above sea level. Tropical and sub-tropical fruits in Malawi include citrus, bananas and plantains, pineapples, mangoes, avocado pears, guavas and pawpaws.

3.7.2.1. CITRUS

Citrus can be grown in many areas depending on species and varieties. Commercial production of most varieties should be in areas below 1,000 m above sea level. Adequate moisture is essential especially during flowering and fruit set from August to November.

3.7.2.1.1. Improving yields

In order to improve yields the following cultural practices are recommended:-

3.7.2.1.2. Use of recommended varieties

(i) Sweet orange *(Citrus sinensis)*: Valencia Late, Washington Navel, Hamlin, Zanzibar, Jaffa and Premier.
(ii) Sour orange *(Citrus aurantium)*: Bitter Seville (for marmalade)
(iii) Tangerine *(Citrus reticulata):* Dancy Mandarine and Local Mwanza, Mandarins
(iv) Grape fruit *(Citrus paradis)*: Marsh Seedless, Red Bush and Duncan.
(v) Lemon *(Citrus limon)*: Eureka and Villa Franca.
(vi) Lime *(Citrus aurantifolia):* Tahiti and West Indian.

Extension staff should, therefore, advise farmers where and how to obtain grafted plants. Table 63 presents fruit tree nurseries registered with National Fruit Trees Association (NAFTNA) where farmers can access quality fruit plants.

Table 63: Some medium scale fruit tree nurseries in the ADDs registered with NAFTNA

Region	ADD	Nursery Name	Types of fruits	Location
North	Mzuzu	Seed & Nursery services	Citrus, Bananas, Peach, Apples, Mango, Guava	Mzuzu city
Centre	Kasungu	Mwai Fruit Nursery	Mango, Citrus, Guava, Pawpaw	Near Dowa turn-off
	Lilongwe	Green World Fruit Nursery	Mango, Citrus, Guava, Passion fruits, Bananas	At Pondamali trading centre along Bunda road
		Horticulture Centre Nursery	Mango, Citrus, Grape vines, pawpaw, Mulberry, Guava	NRC along Likuni river
		Lobi Fruit Nursery	Mango, Citrus, Guava, Peach, Apple, Plum, Banana, Passion fruits	Lobi in Dedza District
	Salima	World Fruits Nursery	Mango, Pawpaw, Passion fruits	Close to the old Bus Depot in Salima
South	Blantyre	Fair View Nursery	Mango, Citrus, Guava, Passion fruit	At Zalewa along the Shire river
		Zipatso Association Nursery	Citrus	Mwanza District
		Bvumbwe Research Nursery	All fruit trees	13 km along Limbe-Thyolo road
	Machinga	Tadala Nursery	Mango, Citrus, pawpaw, Custard apple	Along Mangochi Road
		ICRAF	All fruits/Indegenous	Zomba town
		Matawale Fruit Nursery	Mango, Citrus, pawpaw, Guava, Passion fruit	Airport turn-off
	Shire Valley	Ndilekeni ndipume Fruit Nursery	Mango	Nsanje District

For small scale nurseries details contact your nearest District Horticulture Officer

3.7.2.1.3. Site selection

Soils should be deep, fertile and free draining.

3.7.2.1.4. Spacing and manure application

Planting holes should be made 2 months in advance at the following spacing:-

(i) For orange, grape fruit and lemon 6m x 6m and 7m x 7m under marginal and optimal soil and climatic conditions, respectively.

(ii) For tangerine and lime 5m x 5m and 6m x 6m under marginal and optimal soil and climatic conditions, respectively.

Fill the hole with top soil mixed with 5 to 10kg of well decomposed manure.

3.7.2.1.5. Time of planting

Plant with the first planting rains (rains of 50mm or wetting to a depth of 15cm). Short crops maybe interplanted between rows of fruit trees during the early stages of tree growth.

3.7.2.1.6. Soil moisture conservation

Basins or box ridges should be made 1m in diameter at planting and thereafter to follow canopy diameter around each tree to trap water. Trees should be mulched to maintain moisture and suppress weeds. Keep the mulch 15cm away from fruit tree base. Supplementary watering should be done as required.

3.7.2.1.7. Fertilizer application

Apply fertilizers as recommended based on leaf and soil analysis.

3.7.2.1.8. Pest control

a) Weed control

The basin area should be kept weed free at all time. Weeds outside the basin area should be kept short by slashing.

b) Insect pest control

The important insect pests of citrus are fruit flies, false codling moth, orange dog, aphids, leaf miner and scales.

(i) **Fruit flies** *(Iceratitis capitata)*

Both larvae and adult infestations result in premature ripening and shedding of attacked fruits.

Chemical control of fruit flies is by spraying Fenthion (Lebaycid) 50EC at the rate of 7ml per 14 litres of water for knapsack sprayer or 7ml in 1 litre of water for ULV sprayer, once every week. Alternatively a poison bait of 20g of Trichlorphon (Dipterex) 50WP mixed with 2.4kg of brown sugar in 20 litres of water sprayed to the whole foliage may be used.

(ii) **False codling moth** *(Cryptophlebia leucotreta)*

Infestations can be reduced by removing all damaged fruits on the tree and those on the ground, weekly. These should be buried in a hole, at least 15cm deep, away from the tree.

(iii) **Orange dog** *(Papilio domodocus)*

The caterpillars eat the leaves. Young plants may be defoliated and growing points may be destroyed. Control is by hand picking and crushing of caterpillars.

(iv) **Black Aphid** *(Toxoptera Spp.)*

Aphids attack new shoots causing stunted growth. Chemical control is by spraying with Dimethoate 20WP at the rate of 35g in 14 liters of water for knapsack sprayer or 35g in 1 liter of water for ULV sprayer.

(v) **Leaf Miner**

Polyphagous fly-like pest, cause significant damage to a diverse range of common horticultural crops with many alternative hosts. Biologically avoid use of chemicals to preserve parasites and predators, also do not apply nitrogen fertilizer at times of the year when leaf miner populations are high.

(vi) **Scale insects**

Soft and red scales may be controlled by spraying with Dimethoate 20WP at the rate of 35g in 14 liters of water for knapsack sprayer or 35g in 1 liter of water for ULV sprayer.

3.7.2.1.9. Disease Control

The important diseases of citrus are:-

(i) **Citrus Greening disease**

This is a serious disease affecting almost all citrus growing areas in the country. The disease is characterized by leaf mottling (yellow green or cream green), stunted growth. Leaf fall, twig die back and eventual death of the tree in advanced stages of the disease. The fruit may be malformed and remain green after maturity and tastes bitter. The disease is transmitted either through infected planting material or psylid *(Trioza erytriea)*. The Psyllid vector does not thrive well in hot dry conditions. Control is by planting clean plant material in hot areas and pruning of infected branches. Raise citrus seedlings in hot areas where the vector does not thrive in order to propagate clean plant material.

(ii) **Armillaria root rot** *(Armillaria mellea)*

The disease is characterised by rotting of roots and butts of citrus trees. Thick, creamy white, fan like sheets of mycelium are found under the bark of roots and stem base, and these are frequently flattened, dark brown rhizomorphs. In severe infection the plant dies rapidly, the bark of the roots and stem base are cracked and covered with gum or resin exudates.

The disease occurs in orchards established on recently opened land which had natural trees. To prevent Armillaria root rot disease, all unwanted trees should be ring-barked and left to die. Those that cannot die by ring barking must be dug out with as much root system as possible.

(iii) **Gummosis (Foot Rot)** *(Phytophthora parasitica)*

Foot rot occurs on the crown and larger roots of trees at various stages of growth. Dark spots may appear on the bark which become water soaked and colour the outer bark surface. Advanced stages of the disease result in splitting or shredding of the bark which becomes dry, and often curls or becomes loosened from the wood. Gumming may appear during the early stages of disease development. The end result is a die back. Usually the trunk becomes girdled and the tree finally dies. This disease can be controlled by using tolerant varieties.

(iv) **Citrus woolly whitefly** *(Aleurothixus floccosus)*

The adult flies are tiny about 1mm and yellowish in colour with white powdery wings. They live in colonies on the under side of the leaves where they lay eggs and hatch into larvae in about 10 days. Larvae look like a mass of cotton wool hence the name "woolly whitefly". Damage is caused by the larvae extracting leaf juices when feeding and by development of sooty mould which grows on honey dew (sugary waters) produced by the larvae. On the leaves, sooty moulds interfere with photosynthesis and result in leaf defoliation.On fruits, there is reduction in fruit size and quality.

Control is best achieved by biological control. This method uses the natural enemy of the white fly called cales noaki

-a small parasitic wasp that parasitises and kills young larvae of the white fly. The wasp is released into affected orchards where it multiplies and spreads.

3.7.2.2. BANANAS AND PLANTAINS *(Musa spp)*

Bananas are widely grown in the country. In some parts of Thyolo, Mulanje, Nkhotakota and Nkhatabay bananas are grown as a cash crop. The crop is also grown in other parts of the country for local consumption. In Misuku Hills and Karonga both bananas and plantains are grown as staple food. Most lakeshore districts and plateau areas in Chitipa, Mzimba, Rumphi, Kasungu, Namwera and Phalombe would grow good bananas with irrigation. Currently, banana and plantain production is threatened by occurence of three diseases: Black Sigatoka *(Mycosphaerella fijiensis*) Panama *(F.oxysporum f. spp cubense)* and Banana Bunchy top Disease (BBTD). The BBTD is the most dangerous among the three and it has spread to almost all areas where bananas are grown in Malawi. Farmers should be alerted to avoid planting the infected banana suckers, uproot and destroy the diseased plants by burning or burying.

3.7.2.2.1. Improving yields

In order to obtain high yields of good quality fruit, the following cultural practices are recommended:

3.7.2.2.1.1. Use of recommended varieties

The recommended banana varieties are Dwarf Cavendish (Kabuthu) and Giant Cavendish (Williams). Another Giant Cavendish Mulanje, should be encouraged. Kabuthu yields up to 60,000kg per hectare if well managed.Williams and Mulanje may yield twice as much.

Some of the released varieties include Grand Nain, FHIA 23, FHIA 17, FHIA 25, Saba, Pelipita, and Cardaba. There are several potential local banana cultivars being grown such as Sutene, Katsizi tall, Kholobowa 1 and 2, Kazanda and Zambia which should be promoted by selecting good material. Production of local plantain cultivars such as Ngwewo (Khazanga) and Ndoki (Zeru) should be encouraged. The newly released Giant varieties: TMBX 1378 and SH 3640 are resistant to Black Sigatoka.

3.7.2.2.1.2. Site selection

Bananas and plantains grow best in warm to hot areas with well distributed rainfall of more than 1,200 mm. However in Malawi bananas and plantains are grown even in cool frost free areas. Bananas are more tolerant to moisture stress than plantains. Soils should be deep, free draining and rich in organic matter.

3.7.2.2.1.3. Spacing and time of planting

Plant dwarf varieties at 2m x 2m in poor soils or 2.3m x 2.3m in fertile soils. Plantains and giant bananas should be spaced either at 3m x 3m in poor soils or 3.5m x 3.5m in fertile soils. Holes should be dug 2 months in advance and should be 60cm deep and 60 cm in diameter. Nematode free suckers should be planted with first planting rains to a depth of 30 to 45cm. Plant one sucker per hole. For dwarf varieties 1,890 to 2,500 suckers will be required to plant a hectare; whilst 816 to 1,111suckers will be required for giant bananas and plantains. The higher rates are for poor soils whereas the lower rates are for fertile soils.

3.7.2.2.1.4. Soil moisture conservation

Box ridges or basins should be made around the mat (cluster) to trap water. Plants should remain mulched throughout the year to conserve moisture in the soil. Harvested banana or plantain pseudostems (mother plants trunks), old and dead leaves and pruned suckers should be chopped and used as mulch.

3.7.2.2.1.5. Thinning

Maintain 3 to 4 suckers per mat to get large bunches. These suckers should be well spaced and at various stages of growth; one in fruit, one just bearing, one half grown and other just emerging.

3.7.2.2.1.6. Fertilizer application

Manure is very important in increasing the yield and quality of bananas and plantains. Apply 10kg or more of well decomposed manure per mat at the beginning of the rainy season. Chemical fertilizers can be applied as follows: Either apply 200g CAN, 250g Single super phosphate and 175g Muriate of Potash per mat at the beginning of the rains, followed by 200g CAN per mat in March.

Or 75g Urea, 200g 23:10:5+6S + 1Z and 175g Muriate of Potash per mat at the beginning of the rains, followed by 125g Urea in March. All fertilizers should be sprinkled around the mat and be incorporated into the soil.

3.7.2.2.1.7. Pest control

a) Weed control

Cultivate lightly to avoid root damage.

b) Insect pest control

Banana weevil *(Cosmopolites sordidus)* is a very important insect pest of bananas and attacks corm. The adult weevil is nocturnal and its presence is detected by black tunnels on the corm. In severe attacks the plant dies and falls off. Plantains are generally more susceptible. The pest is most prevalent in old mats which are not weeded. Control is by planting clean material, keeping the plantation weed free and establishing new plantations wherever the insect is severe.

c) Nematode control

Nematodes are a problem in most areas where bananas are grown. Bananas are attacked by various nematodes that cause rotting of the corms. Burrowing nematode *(Radopholus similis)* enters roots and corms, causing damage and also providing entry for the root rot fungus *(Fusarium oxysporum)*. In severe cases the plants die. Also prevalent is the root knot nematode (*Meloidoygyne javanica)*. To control both nematodes and root-rot fungus, plant clean banana suckers. This can be achieved by scraping off all roots from suckers before planting. A five-year rotation should be followed where possible.

d) Disease control

(i) **Black sigatoka** *(Mycosphaerella fijiensis)*

The disease infects leaves. It starts with black streaks parallel to leaf veins which become elongated and muddy brown to black in colour, these join affecting the whole leaf lamina. Infection is most severe in the rainy season and under severe attack plants die. Black Sigatoka disease has been observed in Karonga and is more severe in Nkhata Bay.

This disease may be controlled by restricting movement of bananas, planting material and banana leaves from infected areas to other areas; and burning of infected leaves trash. It can also be controlled by planting tolerant varieties such as TMBX and SH3640.

(ii) **Leaf spot** *(Mycorphaerella musicola)*

The initial stage is characterized by brown spots surrounded by a yellow hallow and in advanced stages the spots join together covering large areas of the leaf surface Severe infections may result in premature fruit ripening. Control measures are the same as of Black Sigatoka.

(iii) **Fusarium wilt** *(F.oxysporumf.spp. Cubense)*

This disease is commonly known as Panama disease and is caused by soil borne fungus. The fungus attacks the rhizome first and spreads to the vascular system of the pseudostem. It blocks the vessels and restricts the movement of water to the entire plant.

The characteristic purple discolouration of the vascular bundles will be observed when pseudostem of the infected plant is cut. The disease attacks bluggoe (Magombo/Harare/Kholobowa 1 and 2) and Zambia varieties.

(iv) **Anthracnose** *(Coletotrichum musae)*

This disease is characterized by black circular spots on the rind (peel) of mature fruits. Infected fruit may eventually rot.

Control is by field hygiene which includes the collection and burning of infected material. Mature uninfected fruit should be harvested and stored in clean curing place. Bruising should be minimized by careful transportation. It can also be controlled by planting tolerant varieties such as Cardaba, Saba and Pelipita.

(v) **Cigar-end rot (***Verticillium theobromae)*

The disease is characterised by blackening of finger tips and in severe cases the whole fruit is blackened. This disease initially infests the tip of the finger and spreads along the whole finger when the disease is prevalent. It is reduced by removing petals from the tips of fingers and removing the flower after fingers are well formed.

(vi) **(Armillaria root rot** *(Armillaria mellea)*

This disease is characterised by severe rotting of the corm and presence of white mycellia. Control is by ring-barking unwanted trees 2 years in advance, leaving them to die and uprooting before establishing the plantation.

(vii) **(vii) Banana Bunchy Top Disease (BBTD)**

This is a very serious disease of bananas reported in 1994 and confirmed in Malawi in1997.It is serious because it affects all banana varieties. The disease is spread by an aphid vector (*Pentalomia nigronervosa)*. Spread is through movement of infected planting material. Infected plants are stunted, with leaves becoming narrow, upright, pointed, and brittle and the plants have a rosette bunchy appearance. Mother plants produce many suckers than normal which may appear clean but are infected. Control of the disease is by practicing field hygiene, use of clean planting material and restricted movement of planting material. In severe cases, uproot and destroy all infected plants, regrowths and suckers.

3.7.2.2.1.8. Harvesting

Fruits should be harvested when fully mature. They are fully mature when fingers on the upper hands are plump and round in shape.

3.7.2.3. PINEAPPLES *(Ananas comosus)*

Pineapples can be grown at altitudes of up to 1,200m above sea level with warm to hot temperatures ranging from 20 to 30°C. The fruits grown above 1,200m above sea level are bitter and fibrous. Optimum rainfall for pineapples is 1,500mm well distributed throughout the year. In areas with less rainfall supplementary watering is required. The potential yield is 75,000kg per hectare. The objective is, therefore, to encourage production in suitable areas such as Mulanje, Thyolo, Nkhatabay, Phoka and Songwe, and encourage farmers to achieve the potential yield by following recommended cultural practices.

3.7.2.3.1. Improving yields

In order to improve yields and quality, the following cultural practices are recommended:

3.7.2.3.1.1. Use of recommended varieties

Use improved high yielding varieties such as Smooth Cayenne and Local Queen. For the main crop, these varieties may yield 75,000kg per hectare while the ratoon crop may yield 50,000kg per hectare with good management.

3.7.2.3.1.2. Site selection

Select sites with soils which are fertile, free draining and rich in organic matter.

3.7.2.3.1.3. Field preparation

If there is need to remove any trees, they should be ring-barked 2 years in advance and left to die. They should then be uprooted together with most of the root system before establishing the plantation. Dig the land deeply and prepare beds 90cm wide and 25cm high with 60cm pathways between them. Incorporate 5 to10kg of well decomposed manure per square metre.

3.7.2.3.1.4. Planting

Pineapples can be established from suckers, slips and tops. Lower scally leaves are removed from the planting materials to expose the root zone. Slips and tops should be left in the sun upside down for 2 weeks to form a callus (protective layer) at the base of top or slip before planting to avoid rotting. At planting time, planting materials should be graded into several groups according to sizes, and each group should be planted separately to ensure uniform stand and maturity in the field. Plant 2 rows on each bed spaced at 60cm and 30cm between plants and 4cm deep with first planting rains. If planted deeper than 4 cm the planting materials may rot.

3.7.2.3.1.5. Fertilizer application

Apply fertilizers as indicated in Table 64 soon after planting and repeat at 3 months interval except for single Super phosphate which has to be applied all at once soon after planting. Similar fertilizer applications should be repeated to the ratoon crop at 3 month interval after the main crop has been harvested for single super phosphate.

All fertilizers should be banded 10cm deep and 10cm away from the plants or broadcast and incorporated into the soil. For the ratoon crop fertilizers should be broadcast between rows. In this case prilled Urea should not be used as it is likely to volatilize. Wherever overlapping is a problem broadcast the fertilizer over plants and irrigate using sprinkler or a watering can. Apply 5 to 10kg of well decomposed manure per square metre at the beginning of each rainy season.

3.7.2.3.1.6. Mulching

Mulching soon after planting to conserve moisture and control weeds.

Table 64: Fertilizer recommendations for Pineapple production

Fertilizer combinations		Kg/ha	Grammes Per metre of row length	Cup size
Either	(a) CAN	380	28	One cup 30
	(b)Single Super phosphate	200	15	One cup16
	(c)Sulphate of Potash	200	15	One cup16
or	(a)23:21:0+4S	300	23	One cup 22
	(b)Muriate of Potash	150	11	One cup16
or	(a)23:21:0+4S	200	18	One cup 16
	(b)Urea	100	8	One cup 8
	(c)Muriate of Potash	150	11	One cup 16

3.7.2.3.2. Harvesting

For the fresh market, pineapples should be harvested when a quarter of the fruit turns yellow. Pineapples for canning should be harvested when half of the fruit has turned yellow.

3.7.2.4. MANGOES

(Mangifera indica)

Mangoes are widely grown in the country. They do well in warm to hot areas with altitudes ranging from 0 to 750m above sea level with well-defined wet and dry seasons.

The yields of mango are low in cool areas because of incidences of powdery mildew. Presently yields of fully grown improved mango trees range from 200 to 500 fruits per tree. Although unimproved cultivars of mangoes may yield more than the above figure, their high fibre content and large stones may exclude them from certain markets. The objective, is therefore, to increase production by improving management of the available local and exotic varieties.

3.7.2.4.1. Improving yields

In order to improve yields and quality, the following cultural practices are recommended:-

3.7.2.4.1.1. Use of recommended varieties

Use improved grafted varieties which have a small stone and fibreless.

These are:

- **Haden –** big oblong fruit in shape, sweet, with a partial purple colour skin which becomes lighter when ripe.
- **Tommy Atkins** – A medium size, oblong fruit, very sweet, with deep purple colour when approaching maturity.
- **Kent** – very big fibreless fruit which weighs close to a kg each with moderate sweetness, green skin colour which breaks into lighter purplish orange close to the pertiole when mature.
- **Keit** – another medium size sweet oval in shape turning red orange from the stalk at maturity.

- **Davis Haden –** medium sized fruit, sweet with orange skin colour when ripe.
- **Irwin –** sweet, small size fruit weighing close to 150 grams each with full deep purple skin colour close to maturity.
- **Boribo –** Medium size with green colour which become lighter when ripe.
- **Ngowe –** Oblong sickle in shape, sweet and orange when ripe.
- Local cultivars such as Boloma and Domasi which are big and sweet, and small mangoes such as Waka, Nthulura and Kapantha that are widely adapted should be encouraged.

3.7.2.4.1.2. Field preparation

Soils should be deep, relatively fertile and free draining. Planting holes should be prepared 2 months in advance. The holes should be 90cm in diameter and 90cm deep. They should be filled with top soil mixed with 5 to 10kg of well decomposed manure. Sub soil should be left for basin making only to guide water to the new plant.

3.7.2.4.1.3. Time of planting and spacing

Plant trees in December or January for successful establishment. Cover the new plant root ball with soil up to the collar mark. Trees should be spaced at 9m x 9m or 10.5m x 10.5m or 12m x 12m depending on variety, soil type and other environmental conditions. Closer spacing is for marginal areas and wider spacing is for optimum areas. Commercial planting in ideal areas start with closer spacing of 2m x 2m then thin out as the canopies close up until standard spacing is reached. Basins should be made around each tree as wide as the canopy and mulched to conserve moisture. During the early stages of fruit tree establishment, low growing crops maybe inter planted.

3.7.2.4.1.4. Manure and fertilizer application

Apply 5 to 10kg of manure at the beginning of each rainy season. Apply fertilizer as recommended after soil and leaf analysis results.

3.7.2.4.1.5. Pest control

a) Weed control

Keep the basin area weed free. The rest of the area outside the basin should be regularly slashed if not interplanted with other crops.

b) Insect pest control

(i) **Mango Stone Weevil** *(Sternochetus mangifera)*

This insect damages the seed. The larva enters the fruit during the early stage of fruit development leaving no external sign of its entry. This may result into premature fruitfall, fruits rotting in storage, in transit and markets. To control the pest collect and bury dropped fruits.

(ii) **Scales** *(Coccus mangiferae and Coccus acuminatus)*

These appear on leaves and fruits and can be controlled by spraying Dimethoate 20WP 85g in 14 litres of water sprayed to full coverage using a mist blower.

(iii) **Fruit Fly** *(Ceratitis capitata)*

The larvae damage the fruit. Control is by regular collecting and burying of all dropped fruits. Chemical control of fruit flies is by weekly spraying of Fenthion (Lebaycid) 50EC at the rate of 1ml per 2 litres of water. Alternatively a poison bait of 20g of Trichlorphon (Dipterex) 50WP mixed with 2.4kg of brown sugar in 20 litres of water sprayed to the whole foliage maybe used. Harvesting mangoes when they are physiologically mature will also control the insect pest.

3.7.2.4.1.6. Disease control

(i) **Anthracnose** (*Glomerella cingulata)*

The disease causes discoloration of young leaves, premature ripening and enhanced rotting of fruits.

(ii) **Powdery Mildew** *(Oidium mangiferae)*

The fungus infects inflorescence in moist conditions and results in shedding of flowers and young fruits.

Both Anthracnose and powdery mildew can be controlled by spraying Benomyl (Benlate) 50WP at the rate of 15g in10 litters of water.

3.7.2.4.2. Harvesting

Fruits of improved mango varieties should be harvested when they are physiologically mature (kuyezuka or kudengula).When harvesting avoid bruises on the fruit. The fruits should not drop to the ground. A fully grown tree may yield 200 to 500 fruits or more per year depending on management, variety and age of tree.

3.7.2.5. AVOCADO PEARS *(Persica americana)*

Avocado pears are important food and cash crop. The crop grows well in cool to warm areas with an average annual rainfall ranging from 750 to 1,800 mm. It is grown in the Shire Highlands, Thyolo, Mulanje, Zomba, Nkhatabay, Songwe, Misuku Hills and other areas with similar climatic conditions. The crop does particularly well in free draining soils.

3.7.2.5.1. Improving yields

In order to improve yields and quality, the following practices are recommended:-

3.7.2.5.1.1. Use of recommended varieties

Use recommended varieties such as Fuerte, Mayapan,Hass, Colinson and Anaheim. The growing of available local cultivars should be encouraged especially where farmers have no access to improved varieties.

3.7.2.5.1.2. Field preparation

All unwanted trees should be ring-barked two years in advance and left to die. Those that cannot die by ring-barking must be dug out with as much root system as possible. Planting holes should be dug 90cm in diameter and 90cm deep. Holes should be filled with top soil mixed with 5 to 10kg of well decomposed manure.

3.7.2.5.1.3. Time of planting and spacing

Trees should be planted with the first planting rains when the soil is warm and moist. They should be spaced at 9m x 9m under marginal conditions or 12m x 12m under optimum conditions. In areas of heavy winds, wind breaks should be planted.

3.7.2.5.1.4. Manure and fertilizer application

Apply 5 to 10kg of well decomposed manure per tree at the beginning of the rainy season. Fertilizer should be applied on the basis of leaf and soil analysis results.

3.7.2.5.1.5. Pest control

a) Weed control

The basin area should be kept free from weeds and the area around basin should be slashed to keep weeds as short as possible.

b) Insect pest control

Insect pests of economic importance are:-

(i) **Fruit flies** *(Ceratitis capitata)*

Fruit flies infest the fruit resulting in premature fruit drop and fruit rots. Control is by collecting and burying of all dropped fruits.

(ii) **Thrips**

Thrips attack fruits causing rusting (blemishes). They may also attack leaves and shoots mainly in dry regions.

To control fruit fly and thrips spray Fenthion (Lebaycid) 50EC fortnightly at a rate of 1ml in 2 litres of water for knapsack sprayer or 1ml in1 liter of water for ULV sprayer.

3.7.2.5.1.6. Disease control

(i) **Foot rot** *(Phytophthora cinnamomi)*

This is a disease of economic importance in avocado pears. It attacks the base of the tree and may eventually affect the root system. The disease can be controlled by dusting captan or copper oxychloride on the root collar.

3.7.2.5.1.6. Harvesting

The fruits should be harvested when they are physiologically mature. At this stage the seed inside the fruit rattles when shaken. If the fruits are to be transported for long distances, harvesting should be done before rattling sound is detected.

3.7.2.6. PAWPAW

(Carica papaya)

Pawpaws are widely grown in the country. They are an important food and cash crop. The crop grows well up to an altitude of 1,000m above sea level and requires an annual rainfall of 1,000 to 2,000mm which should be well distributed.

The optimum temperatures for growth is between 20oC and 30oC. The best soil for papaya production is a well-drained and fertile loamy soil rich in organic matter.

3.7.2.6.1. Improving yields

In order to improve yield and quality, the following practices are recommended:-

3.7.2.6.1.1. Use of recommended varieties

a) Solo

This is a small fruited variety which produces no male plants. It produces female plants with round, shallowly furrowed fruits and bisexual plants with pear shaped fruits in equal proportions.

The fruit weighs 0.5 to 1.0kg and is of excellent quality. When the fruits are fully ripe the skin is orange-yellow and flesh golden-orange and very sweet when grown in warm environment.

b) Waimanalo

This is a Solo selection which is large fruited and firm with a long storage life.

c) Sunrise

This is also a Solo selection which has fruits with a pink flesh.

d) Local collections

There are several local collections which need to be selected and their production encouraged.

3.7.2.6.1.2. Field Preparation

All unwanted trees should be ring-barked 2 years in advance and left to die to reduce the risk of Armillaria infection.

Planting holes should be dug 2 months in advance 90cm in diameter and 90cm in depth. Space them 1.8m x 1.8m to 2.4m x 2.4m. The holes should be filled with top soil mixed with 5 to 10kg of well decomposed manure.

3.7.2.6.1.3. Sowing

Pawpaws are grown from seed. Seeds collected from the fruit should be washed, dried and dusted with fungicide such as Thiram to avoid damping-off disease *(Pythium, Rhizoctonia, Fusarium, Botrytis, Phytophthora spp)*. Sow seeds in nursery beds or pots to raise seedlings. Seedling emergence may take 3 to 5 weeks from the time of planting. Seed may be stored up to 3 years. It should be noted, however, that germination percentages declines with storage period.

3.7.2.6.1.4. Transplanting

Seedlings should be transplanted when 6 weeks old or 30cm tall. Transplanting should be done in the late afternoon or on cloudy, dampy days. Watering should be done every day until the plants are well established.

3.7.2.6.1.5. Mulching

Heavy organic mulching is desirable to conserve moisture, control weeds and keep the soil cool.

3.7.2.6.1.6. Fertilizer application

Apply 5 to 10kg of well decomposed manure per plant annually at the beginning of the rainy season. Chemical fertilizer application should be applied on the basis of leaf and soil analysis results.

3.7.2.6.1.7. Irrigation

Pawpaw is fairly drought-tolerent but irrigation is required after prolonged dry periods.

3.7.2.6.1.8. Pest control and disease control

(i) **Armillaria root rot disease.**
It is characterized by rotting of roots and trunks. In severe infection the plant dies rapidly. To prevent Armillaria root disease, all unwanted trees should be ring barked 2 years in advance and left to die in order to reduce the risk of armillaria infection. Those that cannot die by ring- barking must be dug out with as much root system as possible.

(ii) **Damping off disease** *(Pythium, Rhizoctonia, Fusarium, Botrytis, phytophora spp).*
This disease also attacks pawpaw. Damping off disease should be controlled by dusting with Cullier Benlate, Captan or Thiram. Use chemicals as specified on the label. Also avoid dense sowing and over watering in the nursery.

3.7.2.6.1.9. Harvesting

Pawpaw have potential yields of up to 140kg per tree. The best time to harvest pawpaw is when 80% of the fruit is yellow coloured. Pawpaws for sale at the local market should be picked at the first indication of the yellow colour to facilitate transportation and storage in the market process. The fruit must be handled with great care to avoid scratching.

3.7.2.7. GUAVA

(Psidium guajava)

Guavas are widely grown in the country. They are an important food and cash crop. Guava plants are adapted to a wide range of soil and climatic conditions. They grow well from 500m sea level up to 1,500m above sea level and require an annual rainfall between 1,000 and 2,000mm. The optimum temperature for growth is 20oC.

3.7.2.7.1. Improving yields

In order to improve yield and quantity the following practices are recommended:-

3.7.2.7.1.1. Use of recommended varieties

a) **Apple**

This is a medium size, slightly ovate variety with deep-pink skin, creamy white flesh, and a moderate amount of seed. The variety is good for canning.

b) **Chittidar**

Medium to large, round-ovate, white fleshed, good for canning

c) **Lucknow 49**

Medium to large with pink, thick flesh, few seeds, high pectin and good for jelly and canning.

d) **Safeda**

Medium size, thin skin, thick, white flesh, few seeds, outstanding quality for canning.

e) **Allahabad**

Large, white fleshed, with few medium sized fairly hard seeds.

3.7.2.7.1.2. Field preparation

To prevent Armillaria root rot disease, all unwanted trees should be ring-barked and left to die 2 years in advance. Those trees that cannot die by ring barking should be dug out with as much root system as possible before establishing guava plants. Planting holes should be dug 2 months in advance at 90cm in diameter and 90cm deep. Space them at 6m x 6m apart. Fill holes with top soil mixed with 5 to 10kg of well decomposed manure.

3.7.2.7.1.3. Sowing

Guavas are propagated from seed. Seed collected from fruits should be washed and dried before sowing. Seeds should be sown on nursery beds and potted 2 to 3 weeks after emergence.

3.7.2.7.1.4. Transplanting

Seedlings should be transplanted when 15cm to 30cm high. This should be done at the beginning of the rainy season preferably in the late afternoon during wet weather. Young plants should be irrigated during dry spells.

3.7.2.7.1.5. Mulching

Heavy organic mulching is desirable to conserve moisture, control weeds and keep the soil cool.

3.7.2.7.1.6. Training and pruning

Training of a young guava tree is recommended to develop a strong framework comprising 3 to 4 main branches. Suckers should be removed from the base. Orchards maybe rejuvenated by cutting off the main (Scafford) branches at 60 to 90cm from the branching base.

3.7.2.7.1.7. Fertilizer application

Apply 5 to 10kg of well decomposed manure per tree annually at the beginning of the rainy season. Application of chemical fertilizers should be based on leaf and soil analysis results.

3.7.2.7.1.8. Pest control

a) Weed control

The basin area should be kept weed free. Slash the grass outside the basin area.

b) Insect pest control

(i) **Fruitfly**

Guava is a prime host of the Mediteranean fruitfly *(Ceratitis capitata),* Caribean fruitfly *(Anastrepha suspensa),* and the melon fruitfly (*Dacus cucurbitae)*. Ripe fruit infested with the larvae is rendered totally unusable. To avoid fruitfly damage, fruits must be harvested when fully mature but before they are ripe.

Collect all fruits on the ground and destroy them by burying. The fruitfly may effectively be controlled by spraying Fenthion (Lebaycid), Dipterex, or Carbaryl twice at 10 day intervals using rates specified on the label.

(ii) **Mosquito Bug** *(Helopeltis spp.)*

Mosquito bug attacks young fruit and leaves by piercing and sucking the sap. Attacked leaves are left with brown spots. Fruits get brown spots and they are deformed and may crack later during their development stages.

3.7.2.7.1.9. Harvesting

Guava trees start bearing 2 to 4 years after transplanting. Yields vary with varieties from 700 to 1,500 fruits per tree weighing 50 to 80kg per tree per year. Ripe guavas bruise easily and are highly perishable. For fresh marketing, the fruits must be harvested when fully mature but under ripe and handled with great care. The fruits should also be padded. Tree ripe fruits frequently suffer from bird and fruit fly attack resulting in heavy losses.

3.7.3. DECIDUOUS FRUITS

Apple *(Malus domestica Borkh)*, Peach *(Prunus persica)*, Plum *(Prunus domestica)* Pear *(Pyrus communis)* and Nectarine *(Prunus persica*). Deciduous fruits have a high food and cash value. They grow successfully in high altitude areas only (1,000 to 2,000m above sea level) where chilling temperatures of between 0°C and 7°C occur in winter (June/July). The low temperature is essential for breaking dormancy of the trees.

Most good quality deciduous fresh fruits consumed in Malawi are imported and justifies the need to promote and expand the local production to satisfy the local demand and also for import substitution and farm-income generation. Presently, most farmers grow seedling trees of unknown varieties which produce extremely low yields of poor quality fruits.

3.7.3.1. National aims

The aim is to encourage and promote the growing of high yielding deciduous fruits of good quality in all suitable areas which are mostly of high altitude.

3.7.3.2. Improving yield and quality

In order to improve both yield and quality, vegetatively propagated trees should be used and can be obtained from Agriculture Research Stations, ADD nurseries and other nurseries approved by Ministry of Agriculture staff.

Seedlings should be planted in suitable areas only following the recommended cultural practices.

3.7.3.2.1. Use of recommended varieties

3.7.3.2.1.1. Apple *(Malus domestica corkh)*

Varieties: Anna, Dorsett Golden and Ein Shemer. At least two of these varieties should be planted in the same orchard to enhance cross pollination which is essential for high fruit setting.

Spacing: 3m x 3m.

3.7.3.2.1.2. Peach

Freestone varieties: Flordared, Flordaprince, Flordagrande, Premierand 7-10.

Ringstone varieties: Megro, BR 6 and Torquesa. Spacing: 4m x 5m.

3.7.3.2.1.3. Nectarine *(Pyrus persica)*

Varieties: Sunred

Spacing: 5m x 5m

3.7.3.2.1.4. Plum

Varieties: Satsuma, Reubenel, Royal Beauty, Gaviota and Harry Pickstone.

Spacing: 4m x 4m.

3.7.3.2.1.5. Pear

Varieties: Hood and Flordahome
Spacing: 4m x 4m.

3.7.3.2.2. Suitable areas

Shire Highlands, the Kirk Range (Neno/Ntcheu), Ntcheu, Dedza, Mzuzu, Ntchisi Hills, Vipya Plateau, Phoka and Misuku Hills are the suitable areas for deciduous fruits. All these are at over 1,000m above sea level with adequate rainfall.

3.7.3.2.3. Field preparation

All unwanted trees should be ring-barked 2 years in advance and left to die and uprooted before establishing the plantation. Those trees that cannot die by ring barking should be dug out 2 months in advance. Planting holes should be dug 2 months in advance at 90cm x 90cm in diameter by 90cm deep and filled with top soil mixed with 5 to10kg of well decomposed manure.

3.7.3.2.4. Planting

Plant trees in August or September when they are dormant. Construct a basin at least 1m in diameter around the trees to trap water. Trees should be watered weekly or as required until rains start. Mulching is essential to conserve soil moisture and supress weeds. The basin should be extended each year to the edge of the canopy.

3.7.3.2.5. Training and pruning

In the early stages of plant growth, training should be done to create a desirable framework of the tree. Trees should be pruned annually when they are dormant for maintenance of vigour and high productivity. When pruning, remove dead or broken wood, one of the rubbing branches, water shoots and tall branches. Apple and Pear should be pruned to a centre leader system (pyramid shape), while peach and plum should be pruned to an open v shape (Open centre shape).

3.7.3.2.6. Manure and fertilizer application

Apply 5 to 10kg of well decomposed manure per fruit tree once every year at the beginning of the rainy season.

3.7.3.2.7. Pest control

3.7.3.2.8. Weed control

Keep the basin area free of weeds and the areas outside the basin should be slashed to keep the grass as short as possible.

3.7.3.2.9. Insect pest control

(i) **Aphid** *(Aphis citricola)*
These are controlled by spraying Dimethoate 20WP at the rate of 35g in 14 litres of water for ULV sprayer.

(ii) **Fruitfly** *(Ceratytis spp)*
Larvae of these flies damage the fruit. They are controlled by daily or weekly collecting of dropped fruits and burying, or spraying Fenthion (Lebaycid) 50EC once a week at the rate of 1ml in 2 litres of water for knapsack sprayer or 1 litre of water for ULVsprayer.

(iii) **False codling moth** (*Cryptophlebia leucotreta)*
Damage and control is the same as for fruit flies.

3.7.3.2.10. Disease control

(i) **Armillaria root rot**
To prevent Armillaria root rot, all unwanted trees should be ring-barked well in advance so that they are completely dead by the time of planting deciduous trees. Infected fruit trees should be uprooted with as much root system as possible and burned.

(ii) **Stem canker (Nectria spp)**
Stem canker is an important disease of apples and pears. The symptom of the disease is cankering. The cankers develop around bud scars, wounds and twig stubs. Young cankers appear as circular brown area. When advanced, the cankers become sunken and black, while the edges are raised above the surrounding healthy bark. The tissue under the black bark in the canker is dead, dry and spongy and may flake and fall off. Cut and burn cankered branches or trees where possible. Spraying with Orthodifolotan (Captafol) 80WP at the rate of 25g in10 litres of water immediately after leaf fall helps reduce stem canker infections in fruit trees.

(iii) **Apple Powdery Mildew (Podosphaera leucotricha)**
The disease occurs in the nursery and in the orchard. It infects leaves, flowers, shoots and fruit. On leaves, lesions first appear as whitish patches of fungal mycelium and spores on undersides along the margins. The lesions spread rapidly engulfing the entire leaf. With time the whole leaf is covered with white powdery growth.

Infected leaves are narrower than normal, folded longitudinally and become stiff and brittle with age. Infected blossom buds produce diseased leaves. Losses results from death of vegetative shoots, flower buds, and loss of fruit quality. Control of powdery mildew is through growing tolerant varieties and applying Benomyl (Benlate) 50WP at rate of 11g in 10 litres of water or Thiphanante-methyl (Topsin) 50WP at the rate of 10g in10 litres of water.

3.8. TREE NUT CROPS

The most commonly grown tree nut crops in Malawi are cashew and macademia. Oil palm and coconut are grown to a rather small extent. Tree nut crops offer considerable potential for diversification of Malawi's agricultural sector as foreign exchange earners and as cash crops for smallholder sector. The production of tree nut crops is steadily increasing and there is more potential for expansion.

3.8.1. National aims

The objective is to promote the growing of tree nut crops in all suitable areas in order to widen the economic base of the smallholder farmers; improve family nutrition through use of by-products; and provide raw materials for confectionery and other industrial uses.

3.8.2. CASHEW NUT *(Anacardium occidentale)*

The cashew has many uses; the kernels are eaten raw, roasted or used in confectionery products; the cashew nut shell liquid is used in manufacturing of plastics and paints; and the cashew apple is processed into refreshing drink and wine. It grows in a wide range of soils although water logged conditions should be avoided.. There is great potential in expanding the area under the crop and suitable areas include the lakeshore areas, the Shire Valley, and parts of Phalombe and Mwanza. Current smallholder yields average 4kg per tree. However, individual trees yielding 20 to 40 kg have been identified in orchards.

3.8.3. Improving yields and quality

In order to improve both yields and quality, the following cultural practices are recommended:-

3.8.3.1. Use of improved varieties

There are no available recommended varieties of cashew yet. Farmers are therefore advised to plant high yielding vegetatively propagated local selections obtainable from Bvumbwe Agricultural Research Station and Press Agriculture Limited. The planting of seedlings raised directly from seed should be followed with grafting in situ with scions from the selected high yielding mature trees.

3.8.3.2. Planting and spacing

Plant with the first planting rains. Trees should be spaced at 9m x 9m to 12m x 12m in holes 1m in diameter and 1m deep.

3.8.3.3. Mulching

Trees should be mulched under the canopy area to suppress weeds and conserve moisture.

3.8.3.4. Pruning

When trees are 3 years old, the lower branches up to 90cm above the ground should be pruned to clear the ground for easy nut collection. Prune trees in the dry season only. This will avoid fungal infections. Later prunings should be for broken and dead branches only.

3.8.3.5. Fertilizer and manure application

Chemical fertilizer application on cashew nut is currently not economical. Where fertilizer application is necessary, avoid excessive use of nitrogen which may result in soft trees susceptible to wind damage. Cashew trees in Malawi respond to phosphorus. Farmers should strongly be advised to apply 5 to10kg of well decomposed manure per tree at the beginning of the rainy season.

3.8.3.6. Fire breaks

Cashew trees are susceptible to fire damage. It is, therefore, advisable that fire breaks of 3 to 5m wide be made around cashew plantings to avoid damage by bush fires.

3.8.3.7. Pest control

3.8.3.7.1. Weed control

Keep the basin area free of weeds by light weeding and heavy mulching. The area between the trees should be slashed.

3.8.3.7.2. Insect pest control

Weekly monitoring of the orchard for insect pests and diseases is very important management practice. The following are pests of economic importance:-

(i) **Mosquito bug** *(Helopellis spp.)* causes damage by sucking young shoots, leaves and fruits. The insect pest may cause die back and severe crop loss. In non-tobacco growing areas it should be controlled by spraying either Endosulfan 35EC or 47.5EC at the rate of 21ml and 15ml in 14 litters of water, respectively. In tobacco growing areas use only Fenitrothion 60EC or 50EC at the rate of 23ml and 28ml in 14 litres of water, respectively. Fenitrothion can also be used in non-tobacco areas.

(ii) The following bugs cause damage to young leaves: *Amoplocnemis curvipes, Tupalus fasciats,* (common in the Shire Valley) brown plant hopper *(Hilda patruelis)* and green stink bug *(Nezara viridula)*. Control is as for mosquito bug.

(iii) Aphids *(Aphididae)* suck the growing tissues and the attacked tissue become deformed. Control is as for mosquito bug.

(iv) The cashew stem girdler *(paranaleptes reticulate spp.)* should be controlled by removing the dead girdled branches and burning them to destroy the eggs.

(v) The cashew weevil *(Curculiomidae)* larva makes tunnels in the bark. Control is by collecting and burning dead trees and affected parts.

3.8.3.7.3. Disease control

Powdery mildew *(Odium spp.)* is caused by a fungus. It attacks flowers and new leaf formation. Sprays of Benomyl 50WP at the rate of 14g in 14 litters of water will control the disease. Where powdery mildew and mosquito bug have been observed at the same time, the chemical controls for the two can be combined.

3.8.3.8. Harvesting

Nuts are left to drop on the ground and collected daily in wet weather or weekly in dry weather. The nuts should be removed from the apples and dried in the sun until the kernels rattle inside when shaken. Store the nuts in a well-ventilated area and turn them regularly.

3.8.3. MACADAMIA *(Macadamia integrifolia)*

Macadamia nuts have a variety of uses. They are eaten raw or roasted as dessert nuts. They are also used in the confectionery industry; and for oil extraction for household and cosmetic uses. Currently within Malawi there are approximately 4,508 hectares of macadamia planted, of which only 1,760 hectares are estimated to be under smallholder management. However, there has been an increase in smallholder plantings over the past 8 years following an initiative from Macadamia Smallholder Development Project (MSDP), Support to Smallholder Development Project (SSDP) and Farm Income Diversification Programme (FIDP).

Macadamia is best adapted to areas 600 to 1,700 metres above sea level with well distributed rainfall pattern of not less than 1,000mm per annum. Suitable and potential areas include Misuku Hills, Viphya Hills (Uzumara, Mphompha and Nchenachena), Nkhata Bay and Mzuzu Highlands in the north; the highlands of Ntchisi and Dowa in the centre; and the highlands of Thyolo and Neno in the south. In Malawi, mature trees yield an average of 40kg in shell per tree.

3.8.3.1. Improving yields and quality

In order to improve yields the following cultural practices are recommended:-

3.8.3.1.1. Recommended clones

Plant grafted plants of the recommended clones 246 (Keauhou), 333(Ikaika), 660(Keau), 344(Kau), 741(Mauka), 800(Makai), 508(Kakea) and 788 (Pahala), also newly released varieties 845, 789, 804, 790 and 828. Trees are available at Bvumbwe and Lunyangwa Research Stations, Mphompha EPA in Rumphi, Kalira EPA in Ntchisi, Nachisaka EPA in Dowa and a number of Government and commercial nurseries in macadamia growing areas.

3.8.3.1.2. Site selection

Choose a suitable site. Macadamia prefer a well- drained soil with no heavy clay or rock within a meter of the surface. Areas where summer temperatures often exceed 32°C and winter temperatures go well below 14°C should be avoided. On virgin land, old trees should be ring barked, left to dry and uprooted to prevent Armillaria root disease. Macadamia trees can be interplanted with other crops such as maize and beans. They can be planted around the households to provide shade, they can also be planted on steep slopes along the contour bunds to assist in soil conservation. Do not plant macadamia under other trees or in water logged places.

3.8.3.1.3. Composting

To produce healthy and fast growing trees it is essential to use compost at planting and in subsequent years. Pit compost or special 'quick' compost can be used.

Quick composting: Use grass, macadamia husk, maize stover or dry leaves and manure especially cattle manure. Avoid using chicken manure as it may burn roots of the young trees. Chop up grass or stover, put them in a layer about 20cm thick, 3m long and 3m wide. Put a 20cm thick layer of manure on top, followed by another grass or stover layer and so on until the pile reaches 1m high. Keep watering this compost heap every day. Turn over the heap every week. The compost will be ready in a month.

3.8.3.1.4. Field preparation

Dig holes at least 60cm wide and 60cm deep, 3 weeks before planting. Separate top soil from sub soil. Mix the compost with the top soil and fill in the hole. The sub soil should be used to make the mound and basin for water conservation.

3.8.3.1.5. Planting and spacing

Macadamia trees are best planted with the first planting rains. Keep the plants in a cool place, under shade and water daily. Cut off all the roots growing out of the planting pot. The best time for planting is when the soil has enough moisture and either early in the morning or late in the afternoon to avoid excess heat. Ensure the grafting tape is removed prior to planting. Remove plants from the plastic pots complete with the ball of soil around the roots. Ensure minimum damage to fibrous roots. When planting ensure that the whole root system is covered up to the colar mark and that the graft union is above the ground. Firm up the soil around the plant. Construct a basin around the plant for moisture conservation. The plants need watering in the event of dry weather after planting. Trees of upright clones such as 344 (Kau), 741(Mauka) and 660 (Ikaika) should be planted at 9m x 5m to 10m x 5m. For all other clones plant at 10m x 10m. Macadamia trees are susceptible to strong winds, therefore stakes and wind breaks are required.

3.8.3.1.6. Mulching

Mulch around the basin with grass, dried leaves or maize stover. Where termites are a problem keep the mulch at least 15cm from the trunk. Mulching is essential for moisture and soil conservation, weed suppression and improvement of soil organic matter content.

3.8.3.1.7. Tree training and pruning

Macadamia trees should be trained to a single stem with branches at 60 to 100cm from the ground, and subsequent branches restricted to every 45 to 90cm. All suckers a rising from the rootstock should be removed.

3.8.3.1. 8. Fertilizer application

Both chemical and organic fertilizers are recommended. For smallholder farmers the use of good compost manure coupled with heavy mulch should be stressed. In the absence of soil and leaf analysis results, refer to Table 65.

Apply half the amount of CAN and Muriate of Potash at the beginning of the rainy season and the other half at the end of March. Triple super phosphate should be applied once at the beginning of rains every year.

3.8.3.1.9. Micronutrients

It is often necessary to apply micronutrients to tree crops. These should be applied only when they are deficient in the soil or plant as revealed by soil and plant analysis results. Micronutrients should be dissolved in water and sprayed onto the foliage. The following concentrations are recommended:

3.8.3.1.9.1. Zinc

Zinc oxide at 15 g in 10 litres of water.

3.8.3.1.9.2. Copper

Copper oxychloride (50 WP Copper) at 20 g in 10 litres of water.

3.8.3.1.9.3. Manganese

Manganese Sulphate at 20 g in 10 litres of water.

3.8.3.1.9.4. Boron

Borax or Borex 10 g in 10 litres of water or solubor (11B) at 70 g in 100 litres of water at flowering and again 8 weeks later. Apply all micronurients when the trees are actively growing.

3.8.3.1.10. Pest control

3.8.3.1.10.1. Weeding

The field should be free from weeds by slashing to avoid competition for plant nutrients and facilitate easy nut collection.

3.8.3.1.10.2. Insect pest control

Management of macadamia is based on judicious application of pesticides and reliance on natural enemies. Weekly monitoring during flowering and fruiting is important to determine the presence of insect pest and the type of pesticide required. At altitudes of over 700m above sea level, weekly monitoring throughout the year is recommended because of extended flowering season.

At fruiting formation the following bugs are prevalent; southern green stink bug *(Nezara viridula)*, two spotted bug *(Bathycoelia spp)*, Yellow spotted bug *(B.rhodaini)*, coreid bug *(Leptocaria sordida)*, and mosquito bug *(Heloppeltis spp.)*.

Mosquito bug is a serious insect pest in young macadamia trees. Control is by applying any of the insecticides as detailed in Table 66.

During nut development, nut borers such as macadamia nut borer (Cryptophlebia batrachopa) and false codling moth *(C. leucotreta)* are common. Control is by spraying Cypermethrin at the rate of 5 ml per 10 litres of water, not more than 3 sprays are recommended per season. Control of mealy bug by natural enemies is assisted by use of 5 ml Chlorpyrifos (Dursban) 48 EC per litre as trunk banding. For this to be effective all foliage must be pruned clear of the ground.

3.8.3.1.10.3. Disease control

Flower blights *(Botyrtiscinerea and Cladosporium spp.)* are disease of economic importance in macadamia. They normally occur during high humidity. Control is by spraying fungicides as detailed in Table 66. If flower blight infection occurs at the same time with any of the insect pests prevalent at flowering time, Benomyl 50 EC or Propineb 50 EC can be combined with Endosulfan 35 EC or Endosulfan 47.5 EC.

3.8.3.1.11. Harvesting

Nuts are left to drop on the ground and collected at least weekly in wet weather or fortnightly in dry weather. Nuts can be harvested from the tree once the entire crop is mature, this is determined by the inner husk colour which turns brown when mature. To avoid kernel sweating and mould development, nuts should be dehusked on the day of harvest and dried on racks in layers of a maximum 10cm deep under shade. Suitable racks can be made from chicken wire or bamboo to allow aeration. Nuts should be turned daily during drying and allowed to dry to below 10% moisture which can take 6 weeks during fine weather. When moisture is reduced to10%, the kernel can be heard rattling when shaken. Sorting is required to remove damaged and discoloured nuts before delivery to the factory.

Avoid storing nuts on the farm for longer than 2 months as quality will be reduced.

Table 65: Fertilizer recommendations for macadamia

Age of tree (year)	Option 1			Option 2	
	CAN	Triple super phosphate	Muriate of potash	Compound J (15-5-20)	Muriate of potash
1	100	20	125	185	65
2	200	40	250	370	130
3	300	60	375	555	190
4	400	80	500	740	260
5	500	100	625	925	320
6	600	120	750	1,100	380
7	700	140	875	1,295	450
8	800	160	1,000	1,480	510
9	900	180	1,125	1,665	570
10	1,000	200	1,250	1,850	630
11	1,100	220	1,500	2,035	700
12	1,200	240	1,625	2,220	760
13	1,300	260	1,750	2,405	830
14	1,400	280	1,875	2,590	890
15	1,500	300	2,000	2,775	950
16	1,600	320	2,000	2,960	1,020

Table 66: Pesticide recommendations for macadamia

Part of plant attacked	Pests	Chemicals	Rate of chemicals per 10 litters Of water
Flower	1.Black citrus aphids 2.Broad mite 3.Blue butterfly 4.Loopers 5.Flower blights	Endosulfan 47.5EC Endosulfan 35EC Endosulfan 35EC Endosulfan 35EC Benomyl 50EC Propineb 50EC	10ml 14ml 14ml 14ml 10ml 20ml
Fruits	1.Green stink bug 2.Two spotted bug 3.Yellowspottedbug 4.Mosquito bug 5.Coreid bug	Endosulfan47.5EC Or Endosulfan 35EC Fenitrothion 50EC Or Fenitrothion 60EC	10ml 14ml 20ml 17ml
Nuts	1.Macadamia nut borer 2.False codling moth	*Cypermerthrin 20EC	5ml

*Not more than 3 sprays of Cypermethrin are recommended per season.
For mealy bug control, 5ml of Chlorpyrifos (Dursban) 48EC per litre is recommended as trunk banding.

3.8.4. COCONUT
(Cocos nucifera)

Coconut is an important source of income for some farmers, mostly through the sale of fresh nuts. It has a potential as an industrial oil crop, whereby copra (sun or kiln dried albumen) which has an oil content of up to 75 % is used for oil extraction. Fresh coconuts can also be used for home oil processing. After oil extraction the copra cake can be used for feeding livestock. It has up to 20% protein and 2 to 10% fat.

Coconut grows well in low altitude areas, of 0m to 900m above sea level where warm to hot conditions exist. Growth rate, yield and oil content decrease with increasing altitude. In Malawi best conditions are found along the lakeshore, the Shire Valley, Phalombe Plain, Nkhamanga and Henga Valley. It requires well distributed rainfall of above 1,200mm per annum. Coconut can grow well even in low rainfall areas, especially when ground water conditions are favourable. They require free draining soils, deep enough to allow healthy root development. They cannot withstand water logging conditions, not even for a short period. Yields of between 40 and 60 nuts per tree per year can be achieved from high yielding trees.

3.8.4.1. Improving Yields

To improve yields, the following cultural practices are recommended:-

3.8.4.1.1. Varieties and seed selection

There are no defined varieties that are released in Malawi yet. The only type found in the country is the tall coconut palm. Semi dwarf coconut hybrid variety CR 165 from Sri Lanka is being grown in Malawi. Seed selection should start from the field. The seed nuts should be selected from high yielding trees.

3.8.4.1.2. Nursery preparation and sowing

Seed nuts should be planted in nurseries that should be unshaded and sunny, with adequately drained sandy or loamy soils. Seedbeds should be raised 25cm above ground level. Trenches 15cm deep and 30 cm apart should be made and seed nuts placed horizontally with the largest of their 3 sides upper most and only two thirds of the nuts buried. The seedbed should be mulched and watered daily. Seedlings should emerge within 4 months and those that do not sprout after 5 months should be discarded.

3.8.4.1.3. Field preparation and planting

Unwanted trees on the site should be ring barked and uprooted when completely dead. Planting holes 90cm deep and 90cm wide are required and these should be 7.5m x 9m apart. Seedlings are ready for planting when they have 3 to 4 leaves (6 to 12 month sold). Seedlings should be planted with the nut about 30cm below the soil surface. Cover the plant with soil only up to the base of the shoot. The rest of the hole can gradually be filled up as the stem grows. Lightly compact the soil around the seedling at planting. Young plants should be fenced against goat or cattle damage.

3.8.4.1.4. Manure and fertilizer application

Application of 5 to 10kg per tree every year during the formative years encourages vigorous growth, early bearing and high initial yields. Potash is the predominant nutrient requirement of the palm. Nitrogen is important especially in young plants whereas responses to phosphorous in mature palms only occur where soils are markedly deficient. A typical mixture recommended for palms is 700g CAN, 430g Triple superphosphate and 1,000g Muriate of Potash per tree per year for trees of 3 to 6 years of age. Trees over 7 years of age should receive 1,000g CAN, 650g Triple super phosphate and 1,400g Muriate of Potash per tree. Apply fertilizers in split application at the beginning and end of rains in a band encircling the palm up to1.5 to 2 metres from the trunk.

3.8.4.1.5. Pest control

3.8.4.1.5.1. Weed control

Coconut palm basins should be weed free to reduce weed competition. These basins should increase from 2m in diameter for young coconut palms up to 4m for fully grown trees. Intercropping with annual crops and slashing in the plantation are good management practices, provided basins are kept free of vegetation throughout the year.

3.8.4.1.5.2. Insect pest control

(i) **Rhinoceros Beetle** *(Oryctes monoceros)*

The female lays eggs in khola manure and bare cow dung. Khola manure and cow dung should be avoided when the beetle is evident. The adult attacks growing points particularly in young palms up to an age of 3 years. Once the growing point is eaten, the palm dies.

Adult beetles are controlled by poking a hooked piece of wire in their entry points, which show frass of the beetle thereby hooking them out. To destroy the eggs and grubs, field hygiene should be practiced. Trunks should be split and burned.

(ii) **Coreid bug** *(Pseudotheraptus wayi)*

The Coreid bug punctures very young nuts causing nut dropping or longitudinal scars. Copra production from damaged mature nuts is greatly reduced. Currently, Coreid bug infestation is very minimal. There is no recommended control measure for the pest.

3.8.4.1.6. Disease control

No coconut disease has so far been reported in the country.

3.8.4.2. Harvesting

With good management, tall palms produce nuts 6 to 8 years from planting. It takes a further 5 to 8 years to reach full productivity. Harvesting is done through out the year as flowers are produced all year round. Nuts have to be harvested off the tree.

3.9. SPICES

Spices are high value crops with an export potential. They are widely used in food seasoning and processing, cosmetics, perfumes and other industrial uses. In Malawi these spices include chillies, turmeric, ginger, pepper, coriander, cardamom, paprika and cinnamon. Many ecological areas in Malawi are suitable for production of these spices. These spices, however, are not widely grown except for chillies and paprika.

National aims

The aim is to introduce and encourage spices production in all suitable areas to satisfy local and export demands. The objective therefore is to improve yields to meet local and export demands.

3.9.1. CHILLIES *(Capsicum spp.)*

Chillies are the most important and widely grown spice in the country. Chillies can be grown in altitudes of up to 1,500m above sea level. Distinct wet and dry seasons are essential for good ripening and drying of the fruits. For better growth, soils should be free draining and rich in organic matter.

3.9.1.1. National aims

Present yields range from 200 to 500 kg per hectare dry weight. Yields of up to 2,500 kg per hectare dry weight can be achieved.

3.9.1.2. Improving yields

In order to improve both yields and quality, the following cultural practices are recommended:-

3.9.1.2.1. Use of improved varieties

There are many cultivars, the fruits of which vary in shape, size and pungency. The ones common in Malawi have been grouped into four categories:-

(i) Large and long, with pointed tip, moderately pungent (Red Cayenne).

(ii) Large and long with blunt tip, moderately pungent (Red Cayenne).

(iii) Small and round, very pungent and highly flavoured (Kambuzi).

(iv) Small and slender with a pointed tip, extremely pungent (Bird's Eye or Mphiripiri).

Generally the large cultivars have moderate pungency whereas the small cultivars have a high degree of pungency.

3.9.1.2.2. Nursery management

(i) Nursery beds should be located on new land every year.

(ii) Well drained soils should be used and those soils which cake, pack, or crust should be avoided.

(iii) Beds of 20 to 25 cm high, 1m wide and to any convenient length should be constructed. Beds should be separated by pathways 45 to 60 cm wide. North-south orientation gives more even exposure to sunlight than east-west.

(iv) Well-decomposed organic manure 2 to 5 kg per square metre should be applied and mixed thoroughly with the soil. Add 125g of compound "S" fertilizer per square metre using 4 cupfuls of cup No.30.

(v) Seedbeds should be sterilized by burning maize stalks to control damping off diseases *(Pythium, Fusarium, Phytophthora, Rhizoctonia spp.*) and nematodes. Maize stalks should be stacked about 1m high and burned slowly during calm weather. This should preferably be early in the morning or late afternoon.
As an alternative, the seedbed can be fumigated with Basamid. Agricultural staff should advise farmers on how to fumigate with Basamid.

(vi) Seeds should be sown 2 days after fumigation. About 500g of seed is sufficient for one hectare. Seeds should be sown 0.5 to 1cm deep in rows 15cm apart in September for transplanting in November or December.

(vii) The seedbeds should be mulched lightly with grass after sowing and watered immediately.

(viii) After seedling emergence, the mulch should be thinned gradually over time.

(ix) A 5% solution of Sulphate of Ammonia (50g added to 1 liter of water) should be applied at the time of regular watering when the seedlings are at least 2 weeks old to promote faster growth.

3.9.1.2.3. Field preparation

Fields should be ploughed and harrowed to bring the soil to a fine tilth. Ridges should be made 90cm apart.

3.9.1.2.4. Time of transplanting

Transplanting should be done with the first planting rains when the seedlings are 8 to 10cm high or 4 to 6 weeks old.

3.9.1.2.5. Spacing

For Red Cayenne which is a taller cultivar, transplant one seedling per planting station spaced at 60cm on ridges 90cm apart. For Birds Eye and Kambuzi which are smaller cultivars transplant one seedling per planting station spaced at 45cm on ridges 90cm apart.

3.9.1.2.6. Fertilizer application

Apply 150 to 200kg CAN per hectare at the rate of 8g per plant using cup No.8. Alternatively apply 120kg Urea per hectare at the rate of 5g per plant using one heaped cup No.5. Place fertilizer 10cm away from the plant 2 to 3 weeks after transplanting.

3.9.1.2.7. Crop rotation

A 5 year rotation is recommended. Chillies belong to the same family of crops such as tomato, tobacco, egg plant and potato and they have similar diseases, insect pests and nematode problems. These crops should not follow each other until after 5years. They should follow non host crops such as grasses and brassicas.

Chillies should never be left to ratoon as this increases diseases, insect pest and nematode problems.

3.9.1.2.8. Pest control

3 .9.1.2.8.1. Weed control

Keep the field free of weeds particularly during the first six weeks after transplanting for quick establishing and high yields.

3.9.1.2.8.2. Insect pest control

Cut worms *(Agrotis spp.)* can be controlled by hand picking or by insecticide sprays. Use Carbaryl 85WP at 85g in one litre of water for ULV or in 14 litres of water for knapsack sprayer, or Cypermethrin 20EC at the rate of 10ml in one litre of water using ULV sprayer or 10ml in 14 litres of water using knapsack sprayer.

3.9.1.2.8.3. Disease control

Damping off, leaf spot, Tobacco Mosaic Virus and bushy top are diseases of economic importance. Damping off can be controlled by spraying seedlings with Thiram 75WP soon after emergence following instructions on the label. Other diseases can be reduced by crop rotation.

3.9.1.2.8.4. Nematode control

Nematodes can be controlled by rotation with non-host crops such as maize or other grass crops, and cabbages or other brassicas.

3.9.1.2.9. Harvesting

Pick only ripened fruits which have developed a uniform red colour. Detach fruits talks while picking. Picking should be done weekly under dry conditions to avoid rotting and damage.

In case half ripe fruits have been accidentally included in the harvest, they should be spread thinly under shed on mats and covered with other mats for 3 days. This process allows the fruits to cure to a uniform red colour. Hessian sacks may be used in place of mats. Plastics should not be used because they encourage mould growth which spoils the chillies.

3.9.1.2.10. Drying

The red ripe chillies should be spread in bright sunlight, in raised racks using mats or sacks until the chillies are fully dry. At this stage the fruit will produce a dry rattling sound. This takes 4 to 10 days.

3.9.1.2.11. Grading

Chillies should be graded when they are fully dry. Remove cracked, yellow-coloured and over ripe fruits that have developed deep black colour; and any other discoloured fruits. Grades of chillies are as follows:-

Grade A: Clean, well dried and undamaged chillies with shiny red colour.

Grade B: All remaining chillies fall under this grade.

Dried chillies should be stored in hessian sacks at 10% moisture content in a cool dry room to avoid rotting. Hessian sacks are better for easy air circulation. Occasional re-drying of the bags should be done to maintain quality of the stored crop.

3.9.2. TURMERIC *(Curcuma domestica)*

In Malawi turmeric is grown as an annual crop. The primary product is its cured dried rhizome which is valued mainly for its yellow-orange colouring powder, aroma and flavour. It is used for seasoning and as an important ingredient for curry powder. It is also used as a dyeing agent and in production of cosmetics. Oil may also be extracted from it. Turmeric grows well in altitude of up to 1,200m above sea level with an annual rainfall exceeding 1,000mm. The crop thrives on deep well drained loamy and alluvial soils. Most areas in Malawi are suitable for the production of turmeric.

3.9.2.1. National aims

The aim is to increase production of turmeric to satisfy local and export demand. Potential yields of up to 12,000kg per hectare fresh weight for the rainfed crop and 20,000kg per hectare fresh weight for the irrigated crop can be achieved. The objective is to encourage farmers to grow the crop and improve yields.

3.9.2.2. Improving yields

In order to improve yields and quality, the following cultural practices are recommended:-

3.9.2.2.1. Use of recommended varieties

Currently there are no recommended varieties. Farmers are, however, advised to use local cultivars. Farmers requiring seed should contact their Agricultural Development Divisions.

3.9.2.2.2. Field preparation

Fields should be tilled and clods broken to a fine tilth. The crop can be planted on beds or on ridges. Beds are usually 120cm wide, 20 to 25cm high, and of convenient length. The path between beds should be 50cm wide. Well decomposed organic manure should be incorporated at the rate of 5 to10kg per square metre.

3.9.2.2.3. Planting

Plant using fingers or rhizomes. Seed rate varies from 1,700 to 2,000kg per hectare. Plant with the first rains in rows 30 to 60 cm apart and 25 cm between plants. Wider row spacing are for broad leafed varieties.

3.9.2.2.4. Fertilizer application

Basal dress with 75kg Single Superphosphate per hectare at planting. Apply 4g per meter of row length using 1cupful of cup No.5.

Top dress with either CAN within 40 to 60 days after planting at 75kg per hectare. Apply 4g per meter of row length using one cupful of cup No.5; or 50kg of Urea per hectare, apply 4g per 2 metres of row length using 1 cupful of cup No.5. Both CAN and Urea should be applied along with 50kg of Muriate of Potash per hectare using the same cup for 2m of row length. Three months after planting, a second dose of CAN should be applied at 75kg per hectare.

3.9.2.2.5. Mulching

Turmeric should be kept mulched with grass preferably green grass or easily decomposed organic material.

3.9.2.2.6. Irrigation

Crops under irrigation should be irrigated regularly to keep the soil moist.

3.9.2.2.7. Pest control

3.9.2.2.7.1. Weed control

The crop should be kept weed free.

3.9.2.2.7.2. Insect pest and disease control

Currently there are no insect pests and diseases of economic importance in Malawi.

3.9.2.2.7.3. Nematode control

Nematodes should be controlled by good crop rotation, manure application and treatment of planting material with hot water at 48^{o}C for 20 minutes.

3.9.2.3. Harvesting

The crop is ready for lifting at about 7 to 9 months after planting when the lower leaves turn yellow. When harvesting care should be taken that the rhizomes are not cut or bruised and that the whole clump is lifted. The leafy tops are cut off, all the adhering soil is shaken or rubbed off and the rhizomes washed in water.

3.9.2.4. Seed storage

It is necessary to keep adequate seed rhizomes for planting. Seed rhizomes should be stored in pits covered in sand under shade.

3.9.3. GINGER *(Zingiber officinale)*

Ginger is grown in Malawi as an annual crop. Freshly harvested ginger consists of tangled clumps of inter connected rhizomes known as races or hands and branches known as fingers. Ginger is used mainly for food seasoning, in baking, brewing and in the wine industry.The crop grows in altitude of up to 1,500m above sea level. It thrives under hot and humid conditions. High rainfall of 1,500 to 3,000 mm per year, well distributed over the 8 months growing period is ideal. Ginger grows well in different soil types with free draining characteristics.

3.9.3.1. National aims

The aim is to increase production of ginger to satisfy the domestic demand and export any surplus and introduce ginger growing in suitable areas especially those that do not have reliable cash crops. Potential yields of up to 12,000 kg fresh weight can be achieved. The objective, therefore, is to encourage more farmers to grow the crop and improve yields.

3.9.3.2. Improving yields

In order to improve both yields and quality, the following cultural practices should be followed:-

3.9.3.2.1. Use of selected cultivars

Currently there are no recommended ginger varieties. Farmers are therefore encouraged to grow local cultivars.

3.9.3.2.2. Field preparation

Fields should be dug and large clods broken to provide fine tilth. The crop can be planted on beds or on ridges. Beds are usually 120cm wide, 20 to 25cm high, and of any convenient length. The path between beds should be 50 cm wide. Well decomposed organic manure should be incorporated at the rate of 5 to10kg per square metre of seedbed.

3.9.3.2.3. Planting

Plant ginger using fingers or setts. Seed rate varies from 1,200 to 1,800kg per hectare. Sow with the first rains in rows 30cm apart and 25cm between plants. Planting with the first rains is very important as a delay of one week may result in yield losses of up to 1,000kg per hectare

3.9.3.2.4. Fertilizer application

Apply 75kg single super phosphate per hectare by applying 4.5g per 5m of row length using one cup No.5 at planting 40 to 60 days after planting. Top dress with either CAN at the rate of 60kg per hectare, apply 5.4g per 3m of row length; or 35kg Urea, apply 4.2g per 4m of row length using 1 cupful of cup No.5. Both CAN and Urea should be applied along with 50kg Muriate of Potash per hectare using the same cup for 2m of row length.

Three months after planting, the second dose of CAN should be applied at 60kg per hectare, or Urea at 35kg per hectare.

3.9.3.2.5. Mulching

Ginger should be kept mulched with grass preferably green grass or easily decomposed plant material.

3.9.3.2.6. Irrigation

Ginger is very sensitive to water stress. Crops under irrigation should be irrigated regularly to keep the soil moist.

3.9.3.3. Pest control

3.9.3.3.1. Weed control

The crop should be kept weed free.

3.9.3.3.2. Insect pest control

No insect pests of economic importance have been identified in Malawi.

3.9.3.3.3. Disease control

(i) **Soft rot** *(Pythium spp.)*

The leaves turn yellow and dry up. The shoots fall and cease to produce rhizomes.

The inner tissue of the rhizomes become reduced to a soft, black, purifying mass. The disease is more prevalent in poorly drained soils.

Control is by plant sanitation. It is important to select a well-drained site, practice crop rotation and use only healthy rhizomes for seed which should be treated with a fungicide.

(ii) **Rhizome rot** *(Fusarium oxysporum)*

The disease causes severe rhizome rot and pseudostem collapse, sometimes it causes a brown streaking of the vascular tissue of the rhizomes and pseudostem. The disease spreads rapidly in the field with wet weather.

The disease can be controlled by avoiding mechanical injury to the rhizomes when weeding and while carrying out other agronomic practices.

(iii) **Bacterial Wilt** *(Pseudomonas solanacearum)*

The first symptoms are yellowing and wilting of the lower leaves which quickly spread upwards. In advanced stages the base of the pseudostem becomes water- soaked, readily breaking away from the rhizomes. The vascular tissues become dark brown or black. If the pseudostem and rhizome are cut, they give a white, milky exudate. The disease can be controlled by crop rotation.

3.9.3.3.4. Nematode control

Nematodes can severely affect the growth of the crop and cause serious losses. Control is by treating the planting material with hot water at 48°C for 20 minutes. Fumigate the field with a nematicide where possible. Rotate ginger with other crops which are not susceptible to nematodes such as maize, cabbage and other brassicas and grass crops.

3.9.3.3.5. Harvesting

The crop is ready for lifting at about 7 to 9 months after planting when the lower leaves turn yellow. When harvesting, care should be taken not to cut or bruise rhizomes and ensure that the whole clump is lifted. The leafy tops should be cut off, all the adhering soil shaken or rubbed off and the rhizomes washed in water.

3.9.3.3.6. Seed storage

It is necessary to keep adequate seed rhizomes for planting. Seed rhizomes should be stored in pits covered with sand under shade.

3.9.4. CARDAMOM *(Ellettaria cardamomum)*

Cardamoms are fruits of a perennial herb belonging to the ginger family, Zingiberaceae. Cardamom is an expensive spice, exceeded among spices only by saffron and vanilla. Cardamom seeds have a pleasant aroma and a characteristic warm, slightly pungent taste. The spice is used for flavouring curries, cakes and bread, and for other cooking purposes. Cardamoms are also used for confectionery, and as an aromatic stimulant and a carminative. An essential oil is obtained from the seeds and used in perfumery and for flavouring processed foods, liquors and other beverages.

Cardamoms can be grown at altitudes ranging from 760 to 1,500m above sea level with an annual rainfall of 1,500 to 3,000mm and a temperature range of 10°C to 35°C.The crop grows well under moderate natural shade and in soils which have received minimum disturbance, good mulch and adequate water supplies. Cardamoms require good drainage and cannot tolerate water logging. Suitable areas in Malawi include Thyolo, Mulanje, Nkhata Bay and Misuku Hills.

3.9.4.1. National aims

The aim is to introduce and increase production of cardamoms to satisfy domestic demand and export any surplus. The objective is therefore to encourage farmers to adopt the growing of the crop in all suitable areas.

3.9.4.2. Improving yields

In order to improve yields and quality, the following cultural practices are recommended:-

3.9.4.2.1. Use of seed

Currently, no recommended varieties of cardamoms are available; however local types such as Mysore and Malabar should be encouraged. Farmers requiring seed should contact their Agricultural Development Divisions.

3.9.4.2.2. Nursery management

Collect seed from vigorous high yielding disease free plants. Germination is poor, delayed and erratic. One kilogramme of seed is therefore required for a hectare. Storing seed for long periods will further reduce viability.

To improve germination, it is recommended that seed should be planted soon after harvest. They should be extracted from the capsule, washed in water and sown immediately. Alternatively, the washed seed should be mixed with ash and dried for 2 to 9 days before sowing.

Nursery sites should be fenced to ensure that they are protected. Construct seedbeds 120cm wide, 20 to 25cm high and to any convenient length. The seed is broadcast on the surface of the bed and covered thinly with soil. Then mulched with fine grass. Seedbeds should be kept moist but not too wet.

Seedlings emerge 5 to 7 weeks after sowing. They should be transplanted on nursery beds when 3 to 4 months old and about 15cm high.

Nursery beds should be prepared in the same way as seedbeds. The seedlings should be spaced 15cm between rows and 15 cm between plants on the row. Transplant one seedling per station.

Water nursery beds regularly to keep the soil moist.

Seedlings are ready when they are 2 years old. They should be hardened off by withholding watering for 2 weeks before transplanting in the field.

3.9.4.2.3. Field preparation and plant spacing

Cardamoms grow well in deep, free draining soils rich in organic matter.

Fields should be deeply ploughed. Farmers should break clods, make a fine tilth and dig holes in preparation for planting. Holes should be 60cm in diameter and 45 cm deep. Malabar cardamom types which are small should be spaced at 1.8m x 1.8m, while Mysore types should be spaced at

3m x 3m. Fill the hole with top soil mixed with 5 to 10kg of well decomposed manure at least one month before planting.

3.9.4.2.4. Planting

Cardamoms are shallow rooted and should not be deeply planted. Plant two seedlings per planting hole one of which can be used for filling gaps in the plantation. Where the crop is vegetatively propagated, rhizomes from large clumps of growing plants should be taken out, separated into small clumps each consisting of at least one old and one young shoot and then planted in prepared planting holes. Basins should be made around each plant to trap water.

3.9.4.2.5. Mulching

Cardamoms should be kept mulched to conserve moisture and suppress weeds.

3.9.4.2.6. Fertilizer application

Apply 5 to 10kg of well decomposed manure per plant annually at the beginning of the rainy season. Cardamoms require 50kg nitrogen, 20kg phosphate and 50 kg potash per hectare per annum. Nitrogen and potash should be applied in two equal applications while phosphorus should be applied at the beginning of the rainy season only.

For Malabar cardamom types, apply 100kg 23:10:5 + 6s +1Zn together with 50kg Muriate of Potash by applying 32g and 16g per planting station using one cupful of cup No.30 and 16, respectively. Top dress with 100 kg CAN and 50 kg Muriate of Potash by applying 32g and 16g per planting station using one cupful of cup No.30 and one cupful of cup No.16, respectively.

Or

34kg Triple Super phosphate by applying 11g per station using one cupful of cup No.8, together with 92kg CAN and 50g Muriate of Potash by applying 30g per station using one cupful of cup No.30 and 16g per station using one cupful of cup No.16, respectively. Top dress with 92kg CAN and 50kg Muriate of Potash by applying 30g and 16g per planting station using one cupful of cups No.30 and 16, respectively.

For Mysore types, apply 100kg 23:10:5 + 6s +1Zn by applying 90g per planting station using 3 cupfuls of cup No.30 together with 50kg Muriate of Potash by applying 45g per planting station using one and half cupfus of cup No.30. Top dress with 100kg CAN and 50kg Muriate of Potash by applying 90g and 45g per planting station using 3 cupfuls and one and half cupfuls of cup No.30, respectively.

Or

Apply 34kg Triple Superphosphate by applying 31g per planting station using one cupful of cup No.30 together with 92kg CAN and 50kg Muriate of Potash by applying 83g and 45g per planting station using 3 cupfuls and one and half cupfuls of cup No. 30, respectively. Top dress with 92 kg CAN and 50kg Muriate of Potash 83g and 45g using 3 cupfuls and one and half cupfuls of cup No.30, respectively.

3.9.4.2.7. Pruning

Remove old, dry stems and leaves.

3.9.4.2.8. Shade regulation

The crop thrives under moderate shade. Existing trees may be utilized as shade but where they are not available, appropriate shade trees should be planted. Cut excess branches and canopy of shade trees to maintain medium shading condition. Where there is no or inadequate shading, more shade trees should be planted.

3.9.4.3. Pest control

3.9.4.3.1. Weed control

It is important to keep cardamom fields weed free.

3.9.4.3.2. Insect pest and disease control

No insect pests and diseases of economic importance have been recorded in the country.

3.9.4.3.3. Nematode control

Where nematodes have been observed to be of economic importance, it is recommended that adequate quantities of organic manure should be applied to suppress nematode attack.

3.9.4.3.4. Harvesting and drying

Cardamoms come into bearing 3years after planting and continue bearing up to the 10 or 15 year depending on type. Fruits mature over an extended period and are usually gathered at intervals of 30 to 40 days.

The fruits are picked when they are green and fully plump before they develop yellow colour. It is therefore desirable that fruits are harvested individually at the correct stage of maturity. Over ripe (yellow colour) fruits tend to split on drying and do not give good green colour on curing. On the other hand, immature fruits give uneven, shriveled and badly discoloured products. Cardamoms should be dried in the sun. They are well dried if they give a dry rattling sound when touched.

3.9.4.3.5. Storage

Dried cardamoms should be stored in hessian bags at 10% moisture content in a cool dry place to avoid rotting and loss of the fixed green colour. In long term storage, occasional redrying should be done to maintain the quality of the crop. Plastic bags should not be used for storage because they encourage fungal growth which induce rotting and discolour the crop.

3.9.5. PEPPER *(Piper nigrum)*

Pepper berries are obtained from a woody perennial evergreen climbing vine. Black pepper is the whole dried fruit while white pepper is the fruit whose mesocarp has been removed.

Pepper is used as a spice in a wide range of food stuffs including flavouring processed foods such as oleoresin oil, in meat products, light coloured sauces, mayonnaise and cream soups.

Pepper can be grown at altitudes of up to 1,500m above sea level. It thrives best at 500m or below. Hot wet weather conditions and a well distributed annual rainfall of 2,500mm or more per annum are desirable. Pepper grows well in free draining soils rich in organic matter and slightly acidic. Suitable areas in Malawi are Thyolo, Nkhata Bay, Karonga North and Mulanje.

3.9.5.1. National aims

The aim is to increase production of pepper to satisfy domestic demand and export any surplus. The objective therefore is to encourage farmers to adopt the growing of pepper in all suitable areas.

3.9.5.2. Improving yields

In order to improve yields and quality, the following cultural practices are recommended:-

3.9.5.2.1. Use of good seed

Currently, there are no recommended varieties of pepper in Malawi. Farmers requiring seed should contact Agricultural Development Divisions.

3.9.5.2.2. Nursery

Nurseries should be sited in free draining soils and should be properly fenced. Growing of pepper from seed is not recommended as the resulting plants are not necessarily true to type and delay in bearing fruit. Cuttings from primary or secondary wood should be used. They should be potted and placed 3 to 4 nodes deep in sterilized light oil mixed with organic manure. Frequent watering in the nursery is necessary to maintain high humidity.

3.9.5.2.3. Field preparation and spacing

The field should be ploughed and harrowed. Contour bunds should be constructed to reduce the risk of soil erosion and control runoff. Contour bunds should be spaced according to the slope. Planting mounds should then be made 2m apart, 45cm in diameter and 15cm high at the center. This should give a plant population of about 2,000 to 3,000 plants per hectare. Supporting poles of stout hardwood 3.5m to 4m tall and sunk 60cm in the ground should be provided.

3.9.5.2.4. Shade regulation

The crop thrives under moderate shade. Existing trees may be utilized as shade but where they are not available, appropriate shade trees should be planted.

Cut excess branches and canopy of shade trees to maintain medium shading condition. Where there is no adequate shading, more shade trees should be planted.

3.9.5.2.5. Planting

Rooted cuttings are ready for transplanting after 6 to 8 weeks. Plant one rooted cutting per mound in a slanting manner facing the stake.

3.9.5.2.6. Training and pruning

Young plants are cut back at 20 to 30cm high to induce vigorous growth and formation of bearing wood. Three main climbing stems are maintained tied to the stake and pruned regularly when 8 to 9 nodes have been produced to encourage the development of lateral fruiting branches. These should be tied to the stakes to enhance side growth which is desirable. This is repeated several times until stems reach the top of the stakes. Pruning is done to remove unproductive nodes without lateral branches leaving only stems with nodes each bearing a branch so that when mature, the vine will have maximum number of fruiting branches with profuse leaf development. Spikes should be stripped regularly to prevent premature fruiting. Vines should not be allowed to produce flowerings spikes until they are at least 2 years old.

3.9.5.2.7. Fertilizer application

Pepper has a high requirement for nutrients. Fertilizer application is therefore necessary. To mature vines apply 100g Urea using 4 cupfuls of cup No.30, 35g super D compound using 2 cupfuls of cup No.22; 165g CAN using 6 cupfuls of cup No.30; and 70g Sulphate of Potash using 3 cupfuls of cup No.22 per mound. The application should be done early in the rainy season followed by 2 to 3 equal applications at intervals of 30 to 40 days. The Super D compound fertilizer should be applied in one dose at the beginning of the rainy season. The fertilizer should be placed in bands in close proximity to the roots and covered with soil. In the first year, one third of the mature vine dose should be applied and in the second year, half of the manure vine dose should be applied. Apply full dose in the third year.

3.9.5.2.8. Manure application

Apply 5 to 10kg of well decomposed manure in addition to chemical fertilizer at the beginning of the rainy season per mound as organic material is very advantageous to pepper plants.

3.9.5.2.9. Pest control

3.9.5.2.9.1. Weed control

The crop should be kept weed free at all times.

3.9.5.2.9.2. Insect pest control

No insect pests of economic importance have been reported on pepper plants in the country.

3.9.5.2.9.3. Disease control

(i) **Foot rot** *(Phytophthora palmivora)*

The first above ground symptom is a slight droop over the whole vine, followed by a yellowing of leaves which drop rapidly.

Most of the leaves fall within 7 to 14 days, leaving the branches bare. Rapid die-back occurs and the vine dies. Transmission of this disease is through soil and water. Sanitation is therefore important.In severe cases apply Captafol 80WP at the rate of 1.25kg per litre of water.

Cut away Infected bark and discoloured wood. Apply a paste of a suitable fungicide, such as 2% copper sulphate to the wood.

(ii) **White root rot** *(Fomeo lognosus)*

The disease occurs more frequently on land that has been cleared from forest. White branching thread-like rhizomorphs attack the underground stem and roots, and the infected wood is greyish in colour. The foliage turns yellow, droops and leaf fall occurs slowly. Usually only a few vines in a garden are affected.

Control is by removing the rhizomorphs and painting the infected as with a suitable fungicide such as a 2% copper sulphate solution.

(iii) **Red root rot** *(Gamoderma lucidum)*

The disease is capable of causing serious root rot. The main source and reservoir of infection is old tree stumps. The rhizomorphs form a continuous rubbery skin over the roots, which is dirty white in colour at first, later changing to dark red and rotting the roots.

If inspection of the collar region discloses the fungus at an early stage, rotten roots and adhering mycelium should be removed and burnt and root system painted or sprayed with a 2% copper sulphate solution.

3.9.5.2.9.4. Nematode control

Root knot nematode (Meloidogyne javanica) and the burrowing nematode (Radopholus similes) are suppressed by applying organic manure.

3.9.5.2.9.5. Harvesting

The first crop is harvested in the 3rd year and productive life of the crop is usually 12 to 15 years. When harvesting for black pepper, pick spikes when the fruits are still green. When harvesting for white pepper, spikes should be picked when a few of the fruits have turned red. Whole spikes should be harvested at weekly or fortnightly intervals for a period of 2 to 3 months. Towards the end of the harvest period, vines should be stripped of all fruits spikes and the ripe and unripe fruits should be made in to black pepper.

3.9.5.2.9.6. Processing

For black pepper, mature but green fruits should be picked, stacked and allowed to incubate for 2 to 6 hours. The berries are then spread and allowed to dry in the sun for 16 to 20 hours. When processing for white pepper, either of the 3 ways maybe used:-

(i) Fruits are picked when red, transfer red into hessian bags which should be left to lie in running water for 7 to 10 days. The pips are then easily separated from fermented flesh or pulp. After final washing, the pips are dried in the sun.

(ii) Black pepper can be polished mechanically to result in white pepper.

(iii) The dry hard flesh of black pepper can be removed chemically. Once removed, the remaining kernel should be polished and results in white pepper.

3.9.6. CORIANDER *(Coriandum sativum)*

Coriander is an annual erect and roundish herb, 20 to 90 cm high. The fruits turn yellowish-brown when ripe. They produce unpleasant smell when unripe and become pleasantly aromatic on ripening. Coriander is an important ingredient of curry powder usually contributing the greatest quantity of all ingredients in curry powder. It is used in food seasoning, pastries, baking and in confectionery.

Coriander grows under a wide range of climatic conditions. It thrives on medium to heavy soils that are free draining. The crop requires well distributed rainfall and is usually grown as rainfed. It may, however, be grown under irrigation where required.

3.9.6.1. National aims

The aim is to introduce and increase production of coriander to satisfy domestic demand and export any surplus. The objective is therefore to encourage farmers to adopt the growing of the crop in all suitable areas.

3.9.6.2. Improving yields

In order to improve yields and quality, the following cultural practices are recommended:-

3.9.6.2.1. Use of good seed

There are no recommended varieties of coriander in the country. Farmers requiring seed are advised to contact their Agricultural Development Divisions.

3.9.6.2.2. Field preparation

Fields should be deeply dug and large clods broken to provide a fine tilth. A clean and reasonably fine bed is required. Beds should be constructed 120cm wide, 20 to 25cm high and to any convenient length. Apply 5 to 10kg of well decomposed manure per square metre and incorporate into the soil.

3.9.6.2.3. Planting and spacing

Plant with the first planting rains. Seed is drilled in rows 25cm apart and 25cm between the stations within the row. Seed rate ranges from 18 to 28kg per hectare. The crop is slow to emerge and may take 10 to 25 days.

3.9.6.2.4. Fertilizer application

Economic fertilizer recommendation rates are not currently available.

3.9.6.2.5. Weed control

The crop should be kept weed free at all times.

3.9.6.2.6. Harvesting

The crop matures 3 to 31/ 2 months after sowing. It should be harvested when fully ripe and pleasant aroma has developed. Pull or cut the crop in the morning when there is dew to avoid shattering.

3.9.6.2.7. Threshing and drying

After cutting, plants should be heaped into small stacks in the field to wither for 2 to 3 days. The fruits are then threshed out of the plant and dried in partial shed. When thoroughly dried, the spice is cleaned by sieving to remove stalks, plant debris and dirt. The fruits will deteriorate in both colour and flavour if not thoroughly dried.

3.9.7. PAPRIKA
(Capsicum annum L.)

Paprika was introduced in Malawi in 1994. The crop has become popular among both smallholders and commercial farmers. Paprika favours well drained fertile sandy loamy soils. Hot areas may promote flower abortion hence causes yield reductions. If the crop is rain fed, a minimum rainfall of 800mm is required.

Extremely humid and cold areas are less favourable and not recommended for paprika production. Currently, paprika is produced in the whole country but with the highest concentration of farmers in the following districts, Lilongwe, Mchinji, Kasungu, Dedza, Ntchisi, Salima, Ntcheu, Nkhotakota, Mzimba and Rumphi.

3.9.7.1. National aims

Present yields under rain fed range from 500 to 800kg per hectare dry weight. Yields of up to 2,500kg per hectare dry weight can be achieved under proper production management. The objective therefore is to improve yields to meet domestic and export demands.

3.9.7.2. Improving yields

In order to improve both yields and quality, recommended husbandry practices should be followed.

3.9.7.2.1. Use of improved varieties

Two varieties are currently recommended for yields and quality which is expressed in American Spice Trade Association (ASTA Units). The varieties vary in shape and size. In Paprika, pungency is not desired. The recommended varieties therefore do not have pungency.

The recommended varieties are:

i) Paprika Queen

ii) CPS133

In order to avoid pungency, seed recycling is not permitted.

3.9.7.2.2. Nursery management
3.9.7.2.2.1. Site selection

i) Nursery beds should be located on a new site every year. Avoid land planted to tomatoes, potato and egg plants, in order to prevent disease such as dumping off and nematodes.

ii) Well drained fertile soils should be used and those soils which cake, pack or crust should be avoided.-

3.9.7.2.2.2. Seed bed preparation

i) Prepare your site by clearing, ploughing, harrowing, fencing and breaking the soil clods to achieve fine tilth.

ii) Prepare the seed beds of any convenient length, 1m wide, and 20 to 25cm high. Space them with pathways of 45 to 60cm wide. North-south orientation gives more even exposure to light than east-west orientation.

iii) 5 seed beds of 30m x 1m are enough for 1ha, 3 seedbeds are enough for 0.4ha. Similarly 1.5 seedbeds are enough for 0.2ha.

iv) Seedbed should be sterilized by burning with maize stalks to control damping off diseases (Pythium, Fusarium, Phytophthora Rhizoctonia spp), soil insect pests, weed seeds and nematodes.Maize stalks should be stacked about 1m high and burned slowly during calm weather, preferably early in the morning or late afternoon.

v) Apply 2 to 5kg of well decomposed organic manure per square metre and mixed thoroughly with the soil. Add 125g compound “S” fertilizer per square metre using 4 cupfuls of cup No30.

3.9.7.2.2.3. Seed sowing

i) Seedbeds should be sown 2 days after sterilization. Use certified seed and not recycled seed. About 750g is sufficient for one hectare. Seed should be sown 0.5 to 1cm deep in rows 15cm apart in October for Southern Region. For Central and Northern regions, sow seed in November. Paprika seedlings will be ready in 6weeks from sowing.

ii) Mulch seedbeds lightly with grass after sowing and water immediately.

3.9.7.2.2.4. Seedling management

i) After seedling emergence the mulch should be thinned gradually over time.

ii) Start hardening the seedlings 5 weeks after emergence to prepare them with stand field conditions.

iii) Clip seedlings when necessary to avoid flowering on the nursery in case there is no rain.

3.9.7.2.2.5. Nursery hygiene

To avoid transmission of diseases such as Bacteria rot, Blights and Viral disease, farmers are advised to observe the following nursery hygiene practices:-

i) Wash hands and feet before entering the nursery area.

ii) Avoid snuffing and smoking in the nursery.

iii) Disinfect all tools used elsewhere before use in the nursery.

3.9.7.2.2.6. Field preparation

Avoid areas close to tobacco and chillies to control diseases and pungency in paprika and preferably should be at 360m away. Fields should be ploughed and harrowed to bring the soil to a fine tilth. Prepare ridges spaced at 90cm apart.

3.9.7.2.2.7. Time of planting

Transplanting should be done with the first rains when the seedlings are 6-7weeks and 8-10cm high before 15 December for the central and southern regions and 15 December to 7 January for the northern region. Adequate watering of seedbeds should be done before uprooting seedlings to minimize root damage and enhance early establishment of seedlings in the field. Seedlings should not lay drying in the sun waiting to be transplanted. Seedlings must be transplanted absolutely vertical as any slanting will encourage lodging later. Roots must be covered completely with soil but not higher than cotyledon nodes of the stem Tap root should not bend and must be placed pointing directly downwards. Bent roots will result in lower yields and poor quality.

J bents should therefore be avoided. For irrigated paprika, irrigation should be on 4-5 day interval from planting until plants are well established.

3.9.7.2.2.8. Spacing

Plant spacing is very crucial and the exercise should aim at 60,000 or 74,000 plants per hectare. Plants should be spaced at 15 cm apart. Correct plant population enables optimum use of land, labour, chemicals and fertilizers.

3.9.7.2.2.9. Manure

The best time to apply manure is when preparing land. Manure can be spread evenly in the field and when incorporated, place manure in old furrows and ridge and cover it with soil. Only well decomposed manure should be used all the time for fear of enhancing weed problem. Where no chemical fertilizers will be applied the farmer should aim at applying compost manure at the rate of 10 tons per hectare or 5 to10kg per square metre.

3.9.7.2.2.10. Fertilizers

Basal dress with 500kg per hectare D compound fertilizer using cup No.8. Fertilizer should be applied before or during transplanting and should be either banded on the side of the ridge or dolloped between the just transplanted seedlings.

Top dressing with 50kg of Urea or 50kg of CAN, using cups No.4 or 5 respectively, and 50kg of Potassium Chloride (KC) or Potassium Sulphate (K_2SO_4) should also be applied. Apply fertilizer between planting stations. This should be repeated every four weeks to ensure fertilizer application at flowering, fruiting and ripening.

The application of Calcium and trace elements such as Sulphur, Boron and Zinc may be of great importance for a successful crop.

3.9.7.2.2.11. Crop rotation

A 3 year rotation is recommended. Paprika belong to the same family of crops such as tomato, tobacco, egg plant and potato hence have similar diseases, insect pests and nematode problems. Paprika should therefore not follow these crops in rotation until after 3 years.

3.9.7.2.2.12. Pest control

Paprika suffers from a number of pests and diseases

3.9.7.2.2.12.1. Weed control

Weed regularly to loosen the soil and remove weeds to reduce competition for plant nutrient, sunlight and soil moisture. Weeding during fruiting and ripening help reduce incidences of anthracnose.

3.9.7.2.2.12.2. Insect pest control

(i) **Aphids and Thrips**

These usually suck the cell sap causing leaf distortion and wilting. Control is by spraying Actellic 50EC at one millilitre in 1 litre of water and apply Malathion at the rate of 10.5ml in 14litres of water for knapsack sprayer or 10.5ml in 1 liter of water for ULV sprayer (Cup No.5 holds 5ml).

(ii) **Boll worm** *(African boll worm Helicoverpa armigera)*

This is a serious problem of paprika fruit pods. The larva leaves a hole of 3mm in diameter which allows water and dust enter the fruit and results into rotting. Spraying with Decis 2.5EC, following instructions indicated on the label will control boll worm.

(iii) **Cutworm**

Can be a problem immediately after transplanting the seedlings. They can reduce the plant population and yields tremendously. Early weeding as soon as weeds appear will effectively reduce the population of cutworms. Physical control of the worm is recommended.

3.9.7.2.2.12.3. Diseases control

(i) **Damping-off** *(Rhizoctonia,phytophthora, Pythium,Fusarium spp).*

Seedlings are infected in the nursery. Seedlings appear water-soaked at ground level and just fall off. Control is by avoiding dense sowing and over watering. In case of dense sowing thinning should be encouraged.

(ii) **Late Blight** *(Phytophthora infestans).*

Blight shows signs of water soaking and browning or shriveling of stem tissues at soil level. The disease is encouraged by excessive wet conditions. Blights can be controlled by spraying Mancozeb (Dithane M45) 80WP at the rate of 28 g in 14 litres of water for knapsack or 28g in 1 litre of water for ULV sprayer; or Chlorothalonil (Daconil 2787W-75) 40g in 14 litres of water for knapsack or 40g in 1 litre of water for ULV sprayer. Spray at weekly intervals.

(iii) **Bacterial spot** *(Xanthomonas vesicatoria pv campestris)*

This is a soil and seed borne disease which affects all plant parts except fruits. Symptoms include water soaked circular spots which become necrotic, severe fruit drop and leaf defoliation. Control is by practising crop rotation and use of clean dressed seed.

(iv) **Cercospora leaf spot**

Currently this is the major disease of paprika and it causes grey to white circular spots with a dark brown to reddish margin on leaves. Leaves with numerous holes turn yellow and fall off. Control is as for bacterial leafspot.

(v) **Phytophthora root rot**

The disease causes dark brown stem discoloration and wilting. This disease is common in poor drained soils.

It is spread through rain drops. Control is by spraying with copper hydroxide, Dithane M45 and Benomyl. Practising crop rotation and destroying infected plants.

(vi) **Fusarium wilt**

The disease thrives in poorly drained soil. Plant leaves turn yellow and eventually wilt.It also causes ring barking of the main stem. Control is by the use of 10 liters of water for knapsack or 5g in 1 liter of water for ULV sprayer respectively. Planting on good draining soils can also control the disease and crop rotation.

(vii) **Root knot (Nematode)**

Nematode affect the plant by causing roots to develop galls. Eventually plant dies. Control is by sterilizing nursery beds, applying Furadan and practising a 3 year rotation.

(viii) **Virus diseases**

Aphids and thrips are transmitters of virus diseases such as cucumber mosaic virus, pep per mottle virus, potato virus, tobacco mosaic virus, and tomato spotted wilt virus. Control of aphids and thrips is very important. The use of Malathion at the rate of 10.5 ml in 14 litres of water for knapsack or 10.5ml in 1 litre of water for ULV sprayer. Cypermethrin at the rate of 3.5ml for knapsack sprayer or 3.5ml in 1 litre of water for ULV will help to control aphids and thrips. Control of aphids and thrips will assist in reducing the transmission of virus diseases.

(ix) **Physiological Disorder Sunscald**

Sunscald usually occurs in fruits fully exposed to excessive sunlight on plants without adequate foliage. Control is by ensuring that plants have good foliage to cover fruits. Good foliage can be achieved by routine spraying with pesticides already described in this section. This can also be achieved through avoidance of excessive evaporation from the field.

3.9.7.2.2.13. Harvesting/drying

Pick only fruit pods which have developed a dark red maroon colour with their skin wrinkled and seeds cracking and completely withered. Dry withered destalked fruit pods on open drying racks constructed from bamboo, reeds, dry grass, chicken wire, wooden stick sand mats. It takes between 2 to 3 days to dry if harvested at the correct time. Avoid harvesting deep red watery fruit pods as they turn black at drying and not sellable.

3.9.7.2.2.14. Grading

Proper grading is extremely important and essential for successful marketing. A well graded paprika is of higher value than a poorly gradedone. Grading is based on the visible color intensity and not on size.

Seeding is a process of removing seeds from the fruit pod by hand. De-seeded paprika normally fetches high prices. The seed can be sold separately. Full pod paprika is another style of paprika presentation where only the fruit pod stalk is removed. Full pod paprika normally fetches low price. The seed contained in the fruit pod is not paid for.

There are 4 grades for the skin and 2 grades for the seed:.

a) Skin Grades

Grade A: Dark red to maroon color, free from diseases pots and has a thick skin.

Grade B: Is represented by purple paprika with slightly thick skin, no disease spots, or

Grade A: which has some spots not exceeding 15%.

Grade C: Dark red paprika with no diseases.

Grade D: Paprika which is clean no disease and has red color with spots.

b) Seed Grades

Grade S1: Clean seed which is yellow in color with no chaff.

Grade S2: Good seed which is not thoroughly cleaned.

3.9.7.2.2.15. Storage

Paprika should be stored in cool dry dark places preferably on a raised platform such as a pallet. Avoid exposure to high moisture intensities. Stored paprika should be checked regularly for moisture condition, rat damage. Avoid long storage to prevent weight loss and quality deterioration.

3.9.8. CINNAMON
(Cinnamomum verum)

This is an evergreen tree which grows to a height of up to 17m particularly under natural conditions. Its bark is used as a spice for cakes, sweets, curry powder and perfumes. Oil extracted from the bark is used in confectionery, pharmaceutical, dental preparations and soaps.

Cinnamon requires warm and wet conditions with moderate temperatures of about 27°C. Extremes of heat or cold are unsuitable. An annual rainfall of 1,500mm is ideal. The soil should be fine sandy and free draining. Waterlogged conditions should be avoided as they give a bitter product which is less aromatic. The crop grows best in Thyolo, Mulanje and Nkhata-Bay.

3.9.8.1. National aims

The aim is to increase production of cinnamon to satisfy domestic demand and export any surplus. The objective is therefore to encourage farmers to adopt the growing of cinnamon in all suitable areas.

3.9.8.2. Improving yields

Inorder to improve yields and quality, the following cultural practices are recommended:-

3.9.8.2.1. Use of good seed

Currently there are no recommended varieties for Cinnamon. Farmers are, however, advised to obtain seedlings from Bvumbwe and Mkondezi Agricultural Research Stations.

3.9.8.2.2. Nursery management

Fruits are kept in heaps until the pulp is fermented. They are then washed in water and dried under shade. Seeds should be planted immediately after drying as viability is quickly reduced.

They should be sown in nursery beds. Sites should be properly fenced and well managed. Seedlings should be potted after 4 months in the nursery. Transplant seedlings in the field 4 to 5 months after they have been potted.Seedlings should be hardened off before they are transplanted to prepare them for field conditions.

3.9.8.2.3. Field preparation and spacing

Fields should be deeply dug and large clods broken to provide a fine tilth. Dig holes 60 cm in diameter, 60 cm deep and 2 m apart. At least one month before planting, mix top soil with 5 to 10kg of well decomposed manure and fill up the holes.

3.9.8.2.4. Planting

Planting should be done early in the rainy season. Basins should be made around the plant to trap rain water. Make a mound around the tree in the basin.

3.9.8.2.5. Mulching

Mulch soon after planting to conserve moisture.

3.9.8.2.6. Fertilizer application

Fertilizer application will depend on soil and leaf analysis results.

3.9.8.2.7. Coppicing

Cinnamon plants should be coppiced 2years after planting. This induces formation of new shoots. The stem should be cut 10 to 15 cm from the ground and covered with soil. Four to six shoots should be allowed to grow for a further 2 years before harvesting. Stems should be kept straight by pruning.

3.9.8.3. Pest control

3.9.8.3.1. Weed control

Cinnamon trees should be weeded regularly. Weeds should be buried between rows and the soil drawn up around the plants to maintain mounds.

3.9.8.3.2. Insect pest and disease control

Currently there are no insect pests and diseases of economic importance that have been observed in the country.

3.9.8.3.3. Harvesting

Harvest when stems are 2to 3metres high and 1.2 to 5 cm in diameter. Stems are harvested when the red flush of young leaves is beginning to turn green and the sap is flowing freely. Farmers should test the stems to see if the bark peels off easily. The stems should be cut at 10 to 15 cm above the ground and all unwanted branches and leaves removed. After cutting, the stump should be pruned to get rid of all unwanted and distorted shoots leaving new selected 4 to 6 shoots to grow for a further 2 years. More soil should be drawn up around the stumps.

3.9.8.3.4. Processing

The stems should be cut into pieces 90 cm long. Two opposite slits be made length wise using a sharp knife. Loosen the inner bark and peel. The peeled bark should be tied into bundles and left for 24 hours to ferment. The loose outer layer of the bark is then carefully scrapped off.

3.9.8.3.5. Drying and storage

When the bark is scrapped off, it should be dried. As the bark dries, it curls inward forming a hollow tube-like structure commercially known as a quill. Good quality quills should be 4mm to1cm thick. The quills should be stored in a cool dry place.The first harvest usually yields a thick bark of inferior quality which improves with subsequent harvests.

3.10. VEGETABLES

Vegetables are an important source of mineral salts and vitamins which are vital for good health. In addition to being an important food crop, they provide income. Despite being widely grown in the country, adequate supplies of vegetables are mostly available in the rainy season. As a result, supplies are not adequate throughout the year. Production of some exotic vegetables such as rape, cabbage, lettuce, turnips, tomatoes, onions and leaf mustard should be encouraged. In addition to these exotic vegetables, farmers should also be encouraged to grow and preserve local and indigenous vegetables such as Bonongwe *(Amaranthus spp.),* nkhwani *(Cucurbita maxima),* Khwanya *(Phaseolous vulgaris),* Mwamunaaligone, *(Galinsoga parviflora),* Chisoso *(Bidens pilosa)*, Kamganje (Brassica juncea), Chitambe *(Vigna unguiculata)* Denje *(Corchorus trilocularis, Corchorus aestuans)* and many others. To optimize yields it is important to irrigate as need arises. Vegetables are easily attacked by many insect pests and diseases. It is therefore important that farmers use only recommended pesticides and observe safety precautions, particularly time allowed between last application and next harvest.

3.10.1. National aims

The aim is to increase production of vegetables to meet domestic demand in order to improve the nutritional status of the rural and urban population and export where opportunities arise. The objective is therefore to encourage farmers to grow vegetables in the rainy season and in dimbas during the dry season. Farmers should be advised to preserve surplus vegetables for use in times of scarcity.

3.10.2. Nursery management

i) Nurseries should be sited near a permanent water supply and located on new land every year so as to reduce the build-up of insect pests, nematodes and diseases. Soils should be well drained and the site should be away from shaded areas.

ii) Sites should be dug deeply and all large clods broken up to make a fine tilth. Construct beds 20 to 25 cm high, 1m wide and to a convenient length. They should be separated by paths 45 to 60cm wide. On sloppy lands seedbeds should be constructed on the contour.

iii) Apply 3 to 5kg of well decomposed manure per square meter and mix thoroughly with the soil.

iv) To reduce damping off disease and nematodes, seedbeds should be sterilized by burning maize stalks heaped at least 1m high. This should be done preferably in the morning or afternoon when the weather is calm. Alternatively, seedbeds should be fumigated with Basamid.

v) Seeds should be sown 0.5 to 1cm deep in rows 15cm apart. Seedbeds should be mulched lightly and watered immediately.

vi) Apply a 5% solution of Sulphate of Ammonia (5 g dissolved in 1litre of water) when seedlings are 2 weeks old to promote faster establishment.

vii) Damping off disease should be controlled with either Benlate, Captan or Thiram. Use the chemicals as specified on the label. Use Ripcord 20EC, 10ml in 14litres of water as a spray in case of an attack of cutworms or Carbaryl 85WP at 85g in 14litres of water. Aphids, Thrips and Jassids may be controlled by spraying Metasystox at 1g in 1litre of water if there is an attack or Dimethoate 20WP at the rate of 34g in 14 liters water.

Some vegetables commonly grown in the country include:-

3.10.3. CABBAGE *(Brassica oleracea L.var capitata)*

Cabbages are commonly grown throughout the country but there is need to improve quality through recommended methods of production. They grow well in cool areas of over 750m above sea level. Soils should be free draining and rich in organic matter. Cabbage can yield 11,000kg to 70,000kg per hectare depending on variety and management.

3.10.3.1. Improving yields

In order to improve yields and quality, the following cultural practices are recommended:

3.10.3.1.1. Use of recommended varieties

Use the following recommended varieties:

i) Large headed varieties are Rhiana, Giant Drumhead, Drumhead, Sugarloaf, Hercules, Chogo, Gloria F, Marcanta and Glory of Enkhuizen.

ii) Small headed varieties are Copenhagen Market, Ventura, Golden Acre, Stonehead and Gloria Osena.

Seed Rate: 300g/ha

3.10.3.1.2. Time of sowing and transplanting

Sow the seed in drills 15cm apart on the seedbed. In cool areas, sowing can be done throughout the year, but in hot dry areas, sowing can only be done in rainy and cool months. Transplant well-hardened seedlings when they are 10cm tall or 3 to 4 weeks after sowing.

3.10.3.1.3. Spacing

For larger headed varieties, transplant at 60cm x 60cm while for small headed varieties transplant at 50cm x 45cm.

3.10.3.1.4. Fertilizer application

Apply a basal dressing of 90g “S” compound per square metre immediately before transplanting. Top dress with 20g of CAN or Sulphate of Ammonia using a level full of a leopard match box or one cupful of cup No.22 or 10g Urea per square meter every 3 weeks. Water plants regularly as required to maintain adequate soil moisture at all times.

3.10.3.1.5. Pest control

3.10.3.1.5.1. Weed control

Weed and loosen the soil by shallow cultivation.

3.10.3.1.5.2. Insect pest control

(i) **Aphids** *(Brevicoryne brassicae)*

Aphids are controlled by spraying with Dimethoate 40EC at the rate of 17ml in 14litres of water using a knapsack sprayer or 17ml in 1litre of water using ULV sprayer.

(ii) **Diamond-back moth** *(Plutella xylostella)*

There is no effective chemical control for Diamond back moth. However, the pest succumbs if chemicals like Endosulfan 35% EC at 1ml per litre of water, Cypemethrin, Fenitrothion and Fenivalerate are applied alternatively and at regular (10 days) intervals.

Neem *(Azadirachita indica)* seed (50gms) crushed and socked in 1litre of water over night and sprayed on to the crop at weekly intervals is also effective in Diamond back moth control.

3.10.3.1.5.3. Disease control

i) **Black rot** *(Xanthomonas campestris)* and softrot (*Erwinia carotovora)* can be controlled by crop rotation, rouging and removal of all debris and growing of tolerant varieties such as Hercules, particularly for Black rot.

ii) **Club root disease** *(Plasmodiaphora brassicae)*. This can be controlled as follows:

(a) An application of agricultural lime at the rate of 7,500kg/hectare. The changes that occur in the soil following the application of lime, including soil pH, reduce the incidence of club root disease and thereby increase yields.

(b) Soil application of Flusulfamide 5%SC at the rate of 6 liters /ha.

3.10.3.2. Harvesting

Observe safety periods of chemicals before harvesting. Harvest by cutting off the heads when they are firm and uproot the stumps.

3.10.4. TOMATOES *(Lycopersicon esculentum)*

Tomatoes are widely grown throughout the country but there is need to improve quality and availability throughout the year. They can be grown all year round except in extremely hot dry conditions because, heat retards growth and fruit set. The soil should be free draining and rich inorganic matter. Potential yield for tomatoes ranges from 18,000 to 50,000kg per hectare depending on variety.

3.10.4.1. Improving yields

In order to improve yields and quality, the following cultural practices are recommended:-

3.10.4.1.1. Use of recommended varieties

Use the following recommended varieties: Money Maker, Marglobe, Heinz, Homestead and Roma VF. The latter is suitable for the processing industry. The new varieties are Mpindulitsa, Mbambande, Khama, Changu, Cheyenne, and Steel.

Table 67: Newly released tomato varieties

Variety	Yield/ha (mt)
Rodade (Mpindulitsa)	26
Mbambande	26
Khama	26
Lomittel (Changu)	26
Phindu	50
Cheyenne	26.7
Steel	27.3

Seed rate: 200g/ha

3.10.4.1.2. Field preparation

Plough deeply and incorporate 5 to 10 kg of compost or khola manure per square meter. Make beds 120cm wide and to a convenient length. The beds should be 20 to 25cm high. Sunken beds are recommended for dry season cultivation. Pathways should be 50cm between beds.

3.10.4.1.3. Fertilizer application

Two to three days before planting, apply100g of “B” Compound fertilizer per square meter. Top dress 5 weeks after transplanting with 20g of CAN per sq meter using one cupful of cup No. 22.

3.10.4.1.4. Time of transplanting and spacing

Transplant when seedlings are 10 to 15cm tall or 4 weeks after sowing. Transplant seedlings at 90cm x 60cm. Plants should be staked and side shoots may be removed to increase the fruit size and improve quality.

3.10.4.1.5. Pest control

3.10.4.1.5.1. Weed control

Weed regularly to reduce competition for plant nutrients and moisture.

3.10.4.1.5.2. Insect pest control

i) **Aphids** *(Aphididae)* can be controlled by spraying with Dimethoate 20WP at the rate of 34g in 14litres of water for knapsack sprayer or 34g in 1 litre of water for ULV sprayer.

ii) **Caterpillars** should be controlled by spraying with carbaryl 85WP at 35g in 14 litres of water for knapsack sprayer or in 1litre of water for ULV sprayer.

iii) Red spider mites

a) An application of tobacco, ash and soap concoction is effective in controlling red spider mite on tomato. The concoction consists of tobacco + ash + soap (handful of dark fire cured tobacco, a quarter tablet of soap (30g) and a handful of ordinary ash). This should be mixed and boiled in five liters of water, and cooled overnight. This concoction should then be sprayed to tomato every two weeks based on fortnightly scouts.

b) Intercropping tomato with onions reduces red spider mite infestation compared to pure stand of tomato. Onions have a repellency effect on the mites. Onions should be transplanted four weeks before the transplanting of tomato. This ensures that the onions are established, and start emitting enough pungent smell before the tomato is planted. Transplant both onion and tomato in rows at their recommended plant spacing. Plant at least three to four seedlings of onion between tomato planting stations.

c) Uprooting and burning infested plants and crop residues after harvest, and burning all left over seedlings after transplanting.

3.10.4.1.5.3. Nematode control

Nematodes can be controlled by using a 5 year crop rotation with crops such as maize and Rhodes grass. Nematicides such as Carbofuran (Furadan) at the rate of 4g per plant may be used. Nematicide are toxic, farmers wishing to use them should therefore seek advice from agricultural field staff.

3.10.4.1.5.4. Disease control

i) Early Blight *(Alternaria solani)* and **Late Blight** *(Phytopthora infestans)*

a) Blights can be controlled by Kickback, a generic fungicide (mixture of two compounds namely Mancozeb and Matalaxyl) at the rate of 320ml per 100litres of water, Mancozeb (DithaneM45) 80WP at the rate of 28g in 14litres of water for knapsack sprayer, or 28g in 1litre of water for ULV sprayer, or Chlorothalonil (Daconil 2787W-75) 40g in 14litres of water for knapsack or 40g in 1litre of water for ULV sprayer. Spray at weekly intervals.

b) An application of plastic shelter, in combination with dithane is effective in controlling late blight disease in tomato. Late blight disease is most severe under cool temperatures and prolonged leaf wetness as experienced at Lobi in Dedza. This is an alternative solution to sole chemical sprays in growing tomatoes. This is combined with weekly sprays of Dithane M45 at the rate of 2g/litre, which is more effective and cheaper than spraying Dithane alone.

ii) Bacterial Wilt *(Pseudomonas solanacearum)*

Can be controlled through crop rotation and roguing of infested plants and removal of plant debris.

3.10.4.1.6. Harvesting

Observe safety periods of chemicals before harvesting. Harvest when the fruits have just started ripening to reduce damage during long distance transportation.

3.10.5. ONIONS *(Allium cepa)*

Onions are widely grown throughout the country both for food and for cash. They require cool to warm seasons for good bulb formation. Soils should be rich inorganic matter and free draining. The crop should be sown from mid-February to April. Potential yields for onions range from 22,000kg to 24,000kg per hectare.

3.10.5.1. Improving yields

In order to improve yields and quality, the following cultural practices are recommended:-

3.10.5.1.1. Use of recommended varieties

Use the recommended varieties such as Early Texas Grano, De Wildt, pyramid and Red Creole.

Seed rate: 3 - 3.5kg/ha

3.10.5.1.2. Field preparation

Plough deeply and incorporate well decomposed compost or khola manure at the rate of 3 to 5kg per square meter. Make beds 120cm wide and to a convenient length. The beds should be 20 to 25cm high. Pathways should be 50cm between beds.

3.10.5.1.3. Transplanting

Transplant seedlings when their bases are of pencil thickness, 6 to 8 weeks after sowing. Spacing should be 30 cm by 10 cm. Water regularly as required. Stop watering in the 5th month to allow bulbs to dry.

3.10.5.1.4. Fertilizer application

Apply 60g of "S" Compound fertilizer per square meter as a basal application using 2 cupfuls of cup No.22. Top dress with 30g of CAN or Sulphate of Ammonia per square metre using one cupful of cup No.30 only when there is slow growth of seedlings.

3.10.5.1.5. Pest control

3.10.5.1.5.1. Weed control

Keep the field weed free at all times.

3.10.5.1.5.2. Insect pest control

Thrips *(Thrips tabaci)* are controlled by spraying with Pirimiphos-methyl (Actellic) 50EC at the rate of 1ml in 14 liters of water for knapsack or 1ml in 1litre of water for ULV sprayer.

3.10.5.1.5.3. Disease control

Purple blotch *(Alternaria porri)* disease is controlled by spraying with Mancozeb (Dithane M45) at the rate of 20g in 10litres of water or Captan 50WP at the rate of 20g in 10litres of water or alternatively 28g in 1litre of water for ULV.

3.10.5.2. Harvesting and Storage

As bulbs mature, the neck of the stem shrivels and falls over. Lift the bulbs when they are matured at about six months after sowing. Dry the bulbs in the sun for two to three days to cure them. Very large and thick-necked bulbs should be quickly used or sold because they do not keep well. Cured bulbs should be tied in bunches by the leaves and hung along a string in an open sided store where there is free flow of air.

3.10.6. GARLIC

(Allium sativum)

Garlic is a herb, 30 to 60cm tall with superficial adventitious roots. It has flattened solid leaf blades and produces composite or compound bulbs, consisting of several small densely crowded, angular, tunicate bulblets or cloves enclosed within the white or pink skin of the parent bulb. It has pharmaceutical values as an antiseptic and bactericide and is used as a flavouring vegetable.

Garlic does not tolerate excessive humidity or rainfall. It can grow in a wide range of soils with high content of organic matter. Dry season cultivation in high altitude areas gives better economic yields. Yields range from 5,000 to10,000 kg per hectare depending on the cultivar.

3.10.6.1. Improving yields

In order to obtain high yields and quality, the following agronomic practices are recommended:-

3.10.6.1.1. Use of good seed

Currently there are no recommended varieties in Malawi. Farmers are therefore advised to grow locally available cultivars.

3.10.6.1.2. Field preparation

Land should be deeply dug and clods broken to a fine tilth. Incorporate compost or khola manure at the rate of 3 to 4 kg per square metre. Make beds 120cm wide and to a convenient length. The beds should be 20 cm high with pathways of 50 cm between beds.

3.10.6.1.3. Planting

Garlic is propagated vegetatively by using cloves. Rows should be spaced 25 to 30cm and 10 to12cm between plants. Cloves should be separated and planted singly in shallow drill sand pressed into the soil until almost covered. Plant in firm soil during later part of rains with a pointed-end of the clove upwards. Approximately 400 to 500kg of cloves are required per hectare. Water regularly as required until the bulb become physiologically mature (when the neck of the stem shrivels and leaves fall over).

3.10.6.1.4. Fertilizer application

Apply 60g of "S" Compound fertilizer per square meter as a basal application using 2 cupfuls of Cup No.22. Top dress with 30g of CAN or Sulphate of Ammonia per square meter using one cupful of cup No. 30 only when there is slow growth of seedlings.

3.10.6.1.5. Pest control

3.10.6.1.5.1. Weed control

Weed regularly to reduce competition for plant nutrients, soil moisture and solar radiation.

3.10.6.1.5.2. Insect pest control

(i) **Thrips** *(Thrips tabaci)*

Thrips cause severe foliage damage in warm weather and can be controlled by spraying Pirimiphosmethyl (Actellic) 50EC at the rate of 10ml per 10litres of water for knapsack sprayer or 14ml in 1litre of water for ULV sprayer.

(ii) **Onion Aphid** *(Aphididae)*

Onion aphids can be controlled by spraying with Pirimophos-methyl (Actellic) 50EC at the rate of 1ml per litre of water.

3.10.6.1.5.3. Nematode control

Bulb nematodes *(Ditylenchus dispasci)* can be eradicated from planting stock by pre-soaking bulbs for 2hours in a solution containing 1% formalin and 0.1% of any detergent and then immersing the bulbs in the same solution heated to 49oC for 20 minutes.

3.10.6.1.5.4. Disease Control

(i) **Rust** caused by Puccinia porri *(syn P.allii)* may seriously damage the leaves and cause heavy yield losses. Control is by spraying Mancozeb (Dithane M45) at the rate of 20g per 10litres of water or captan 50WP at the rate of 20g per 10litres of water. Alternatively apply 28g in 1litre of water using ULV sprayer.

(ii) **Purple blotch** *(Alternaria porri)*

Purple blotch can be controlled by spraying Mancozeb (Dithane M45) at the rate of 15g in 10litres of water for knapsack sprayer or 21g in 1litre of water for ULV sprayer.

(iii) **White rot** *(Sclerotium cepivorum)*

The disease is characterized by loss of turgor, plants wilt and there is chlorotic leaf die back and stunted growth. Control is by practising crop rotation. Chlorothalonil (Daconil 2787W-75) at the rate of 20g Maneb M22 at the rate of 20g in 10litres of water.

(iv) **Pink rot** *(Pyrenochaeta terrestris)*

Pink rot causes a characteristic pink colouration in the roots. The affected roots are firm but later become soft and collapse and the colour becomes purplish. The number of leaves and size are reduced, bulbing starts early and final bulb size is reduced. Foliar symptoms are chlorotic leaf die back and wilting. Control is by spraying Mancozeb (Dithane M45) at the rate of 20g in 10 liters of water for knapsack sprayer or 28g in 1litre of water for ULV sprayer.

3.10.6.2. Harvesting and storage

Observe safety period of chemicals before harvesting. Bulbs begin to mature 4 to 6 months after planting when tops start to dry and turn brown. Leaves used for flavouring are first removed while green with a sharp knife above the bulbs. Bulbs are dried in the field for one week or under shade. Dried bulbs can be stored for up to one year in a well-ventilated shed.

3.10.7. LEAFY VEGETABLES

Popular leafy vegetables in the country include; Rape *(Brassica napus)*, Mustard *(Brassica carinata)* and Chinese cabbage (*Brassica chinensis)*. The best soils for these cabbages are those which are well drained and rich in organic matter.

3.10.7.1. Improving yields

In order to improve yields and quality, the following cultural practices are recommended:-

3.10.7.1.1. Use of recommended varieties

Use the following recommended varieties:

(i) **Rape:** Giant Essex and Local cultivars

(ii) **Mustard** (Mpiru): Local cultivars

(iii) **Chinese cabbage:** Wong Bok, Pse-Tsai and Chihili.

Seed rate: 300-350g/ha

3.10.7.1.2. Field preparation

Plough deeply and incorporate 5 to 10kg of compost or khola manure per square metre. Make beds 120cm wide and to a convenient length. Pathways should be 50cm between beds.

3.10.7.1.3. Sowing

3.10.7.1.3.1. Rape and mustard

Sow seeds in the nursery in rows 15 cm apart between February and March.

3.10.7.1.3.2. Chinese Cabbage

Chinese cabbage is best established by direct sowing, however, seedlings could be raised in the seed bed as described above. Direct seeding should be done by placing 3 to 5 seeds at 45cm x 45cm. Seedlings should be thinned leaving only one when they have 4 to 5 true leaves.

3.10.7.2. Spacing and transplanting

After about 4weeks, or when seedlings are 10cm high, the seedlings are ready for transplanting into the field. Transplant in rows 45cm apart and 45cm between plants. Transplanting should be done late in the afternoon or when it is cool.

3.10.7.3. Fertilizer application

Being leafy vegetables, rape, mustard and Chinese cabbage require adequate nitrogen supply. Apply a basal dressing of 70g of compound “S” per square metre using three heaped cupfuls of Cup No.22 and top dress with 70g CAN per square metre using cup No. 22.

3.10.7.4. Pest control

3.10.7.4.1. Weed control

Weed regularly to loosen the soil and reduce competition for plant nutrients, sunlight and soil moisture.

3.10.7.4.2. Insect pest control

(i) Aphids *(Aphididae)*

These usually suck the cell sap causing leaf distortion and wilting. Control is by spraying Pirimiphos-methyl (Actellic) 50EC at 1 millilitre in1litre of water.

(ii) Cutworms *(Agrotis spp)*

These are controlled by drenching the soil with Pirimiphos methyl (Actellic) 50EC at one milliliter in1litre of water. Drenching is done by directing the spray nozzle to the base of each plant.

Other leaf eating caterpillars are controlled by spraying Carbaryl (Sevin) 85WP at the rate of 85g in 14 litres of water for knapsack sprayer or 85g in 1 litre of water for ULV sprayer.

3.10.7.4.3. Disease control

i) **Blackrot** *(Xanthomonas campestris)* and **Bacterial softrot** *(Erwinia caratovora)*. These can be controlled by crop rotation, field hygiene and avoiding physical damage to the plant.

ii) **Alternaria leaf spot** *(Alternaria brassicae)* The disease can be controlled by using clean seed, crop rotation, burying all infected plant materials and spraying Chlorothanil (Daconil 2787W-75) at the rate of 2g in 1litre of water.

iii) **Damping-off diseases** *(Rhizoctonia, Phytophthora, Pythium, Fusarium spp.)* They infect seedlings on the nursery. Seedlings appear water-soaked at ground level and just fall off. To prevent the disease, avoid dense sowing and over watering.

iv) **Downy mildew** *(Peronospora parasitica)* Young plants develop irregular brown or white leaf spots with white mycelia on the underside of the leaf. Control is by spraying Mancozeb (Dithane M45) at the rate of 2g in 1 litre of water.

3.10.7.5. Harvesting

Observe safety periods of chemicals before harvesting. Harvesting can be done by stripping leaves from plants beginning 50 days from transplanting. All leafy vegetables should be washed thoroughly before consumption.

3.10.8. OKRA
(Hibiscus esculentus)

Okra thrives in low altitude areas with warm climate. It grows best in areas below 1,200m above sea level and in plateau areas only in summer. It doesn't do well on too acidic or water logged soil. Yields of 2,000 to 3,000kg per hectare green pods can be achieved over a 4 to 8 week harvesting period.

3.10.8.1. Improving yields

In order to improve yields and quality, the following cultural practices are recommended:-

3.10.8.1.1. Use of recommended varieties

Use Clemson Spineless which is the only recommended variety and is early maturing. Local cultivars may also be used. It is important to note that local cultivars are late maturing.
Seed rate: 6-9kg/ha

3.10.8.1.2. Field preparation

Dig the soil to a depth of 25cm, incorporating 3 to 5kg of well decomposed manure per square metre (m2)

3.10.8.1.3. Fertilizer application

Before sowing, apply 70 g "D" Compound per square meter using 3 cupfuls of cup No.30; or 30g of 23-10-5+6S+1Zn, per square metre using 2½ cupful of cup No.20 and irrigate thoroughly. Fertilisers high in phosphorus are usually recommended for okra production. As okra has along growing season, an additional fertilizer application of CAN at 40g per square metre is beneficial at the time when fruits begin to form. A fertilizer high in nitrogen should be avoided as this stimulates vegetative growth and reduces the number of pods produced.

3.10.8.2. Seed sowing

Okra does not transplant well and should therefore be directly sown on ridges or beds. Sow 2 to 3seeds 2.5cm deep and 30cm apart in rows 60cm apart. For local cultivars sow at 60cm x 60cm. Sow every month from October to January for continuous supply.

3.10.8.2.1. Pest control

3.10.8.1.2.1. Weed control

Keep the crop weed-free especially in the first 6 to 8 weeks of growth.

3.10.8.1.2.2. Insect pest control

A number of insect pests that attack cotton such as cotton aphids *(Aphis gossypii)* and cotton stainers *(Dysdercus spp)* will also attack okra. Okra is also a host of some leaf eating beetles. Carbaryl 85WP at the rate of 85g in 14litres of water for knapsack sprayer or alternatively Cypermethrin 20EC at the rate of 10 ml in 14 litres of water for knapsack sprayer or 10ml in 1litre of water for ULV Sprayer will control these insect pests except aphids which can be controlled by Cygon *(Dimethoate, Rogor)* 40EC at the rate of 17ml in 14 litres of water for knapsack sprayer or 17ml in 1 litre of water for ULV sprayer.

3.10.8.1.2.3. Disease control

Mosaic virus should be controlled by controlling vectors (Aphids), rotation and the use of disease free seed. Leaf spot *(Cercospora abelmoschi)* is sometimes serious but can be controlled by copper sprays.

3.10.8.1.2.4. Nematode control

Nematodes *(Meloidogyne javanica and M. incognita)* can cause serious loss of yield. Okra should therefore not be rotated with the solanaceous group of plants. Nematicides such as Furadan may be used but at the present market price of okra, it is not economical. If there is need to use nematicides, advice should be sought from field staff.

3.10.8.3. Harvesting

Okra come in to bearing 2 to 3 months after sowing. The fruits should be harvested frequently sometimes every 3 days and when young and tender. A good test for the correct stage to harvest is when the pods snap easily. Harvesting takes as long as 4 to 6 weeks or even more.

3.10.9. CARROT
(Daucus carota)

Carrot is biannual crop but is grown as an annual crop for its root. It will grow in nearly all areas in Malawi, although high soil temperatures will lead to the production of short roots. A lighter textured soil well enriched with organic matter is best and it should not be very acidic. Optimum soil pH is 5.5 to 6.5.Yields of up to 36,000kg per hectare can be achieved with good management.

When the root is cut across, it shows two distinct layers, an outer and inner layer. High quality carrots have a larger outer area compared to the inner one. The outer layer contains more sugars and vitamins than inner layer.

3.10.9.1. Improving yields

Inorder to improve yields and quality, the following cultural practices are recommended:-

3.10.9.1.1. Use of recommended varieties

Use the following recommended varieties: Chantenay, Early Cape Market and Nantes. These are all long rooted varieties.

Seed rate: 4.5-5kg/ha

3.10.9.1.2. Field preparation

Dig deeply to a depth of 20 to 25cm for production of long roots and high yields. Long rooted varieties will deform if grown in poorly prepared or shallow stony soils.

3.10.9.1.3. Fertilizer application

Apply 40g of Compound D per square metre using 1½ cupfuls of cup No.30; or 20g 23:10:5 + 6s +1Zn per square metre using 1 cupful of cup No.30, before sowing. Top dress with 40g CAN per square metre using 2 cupfuls of cup No.22 when the roots start to swell. Good management practices are essential if optimum fertilizer responses are to be realised.

3.10.9.1.4. Time of sowing and spacing

Sow seed directly and thinly in drills 30cm apart and 1.25cm deep. After emergence thin out the young plants to a spacing of 5 to 8cm apart. Final thinning can be done later to 10 to 15cm. The seedlings being removed are usually suitable for consumption. About 14g of seed is required for every 30m of drill. Sow on beds during the rains and on the flat during the dry season. Sowings in January and February are difficult to establish due to heavy rains.

3.10.9.1.5. Irrigation

Irrigation is critical during crop establishment. Frequent application of water may prevent crusting and also burning off of young seedlings especially when grown during the dry season.

3.10.9.6. Pest control

3.10.9.6.1. Weed control

Keep fields weed-free and well watered throughout the life of the crop.

3.10.9.6.2. Nematode control

Nematodes (Meloidogyne javanica and M.incognita) should be controlled by crop rotation. Carrots should therefore not be grown in rotation with solanaceous plants.

3.10.9.6.3. Disease control

(i) Alternaria leaf blight *(Alternaria dauci)*

This is serious during January and February but can be controlled by weekly sprays of Mancozeb (Dithane M45) 80WP at the rate of 20g in 10litres of water for knapsack sprayer or 20g in 1litre of water for ULV sprayer. The disease can also be controlled by use of dis ease free seed and crop rotation.

(ii) Bacterial softrot *(Erwinia carotovora)*

Bacterial soft rot is sometimes a problem in the wet season and if the site is not well drained. Control is by crop rotation and field hygiene such as roguing of infected plants and removing diseased plant debris.

3.10.9.7. Harvesting

Roots are ready for harvesting when they are 3months old from sowing. Pull or lift the roots carefully. At this stage they are usually 1.5 to 2.5cm wide at the shoulders depending upon the variety.

3.10.10. EGGPLANT
(Solanum melongena)

Eggplants grow in nearly all areas satisfactorily, with the exception of the high plateau areas of 1,500m above sea level. They grow faster and yield better during summer. Soils should be well drained, fertile and relatively high inorganic matter. Yields of up to 35,000 to 90,000kg per hectare depending on variety, time of planting and management can be achieved.

3.10.10.1. Improving yields

In order to improve yields and quality, the following cultral practices are recommended:-

3.10.10.1.1. Use of recommended varieties

Use the following recommended varieties: Black Beauty, Pompanol Pride and Florida High Bush.

Seed rate: 350-500g/ha

3.10.10.1.2. Field preparation

Plough deeply and incorporate 3 to 5kg of compost or khola manure per square meter. Make beds 120cm wide and to a convenient length. The beds should be 20 to 25cm high. Pathways should be 50cm between beds.

3.10.10.1.3. Seed sowing and spacing

Sow seeds thinly in nursery beds in rows 15cm apart. Mulch the beds after sowing with fine grass. After emergence, thin to spacing of 5cm between plants. Sow every 4 to 6 weeks from September to December in order to have a continuous supply.

3.10.10.1.4. Transplanting

Transplanting in to the field 4 to 5 weeks after sowing when seedlings are 8 to10cm high. Plant healthy seedlings 60cm apart in rows 90cm apart. Set the plants slightly deeper than they grew in the nursery. Keep them well watered and weeded.

3.10.10.1.5. Fertilizer application

Before transplanting apply 70g compound D per square meter using 3cupfuls of cup No.30 or 30g 23:10:5 + 6s +1Zn using 2 cupfuls of cup No.22 per square metre and irrigate thoroughly. When fruiting starts, top dress with 70g CAN per square metre using 2heaped cupfuls of cup No.30.

3.10.10.1.6. Pest control

3.10.10.1.6.1. Weed control

Aphids *(Aphididae)* should be controlled with Dimethoate 20WP or 40EC at the rate of 34g and 17ml per 14 litres of water for Knapsack sprayer, respectively.

Caterpillars and eggplant lace bug should be controlled using Carbaryl 85WP at the rate of 85g in 14litres of water or 1litre of water for knapsack sprayer and in 1litre of water for ULV sprayer.

3.10.10.1.6.2. Disease control

Bacterial wilt *(Pseudomonas solanacearum)* should be controlled by proper rotation and the use of resistant cultivars. Sprays of copper fungicides and immediate removal of rotten fruits are recommended to reduce the disease in the field.

3.10.10.1.6.3. Nematode control

Root knot nematodes (*Meloidogyen Javanica and Meloidogynein cognita)* can cause severe damage to the root system. Eggplants should not be rotated with solanaceous plants.

3.10.10.1.6.4. Harvesting

The fruits are harvested 75 to 90days after transplanting. Maturity can be tested by pressing a thumb against the side of the fruit. If the indentation springs back to its original shape, the fruit is immature. If the thumb pressure leaves an indentation in the flesh of the fruit, then the fruits are mature. Harvest by cutting off the fruits regularly as soon as they mature. If fruits are not harvested regularly the plant will reduce flowering. Handle with care to avoid bruising. Fruit picking lasts from 4 to 6 weeks depending on variety. Yields are usually 5 to12 fruits per plant.

3.10.11. LETTUCE
(Lactuca sativa)

Lettuce is a cool season crop. It grows best in areas with a mean temperature of 10^0C to 20^0 C. The crop may however be grown in low altitude areas during the cold season. Cool night temperatures are required for high quality lettuce. Well-drained fertile soils with pH range of 6 to 7 are desirable for lettuce growing. Generally, the leafy type varieties such as London White and Cos will tolerate high temperatures better than others. At low altitudes during hot months, lettuce does not produce heads. Yields of 30,000 to 40,000kg per hectare can be obtained depending on variety and management.

3.10.11.1. Improving yields

Inorder to improve both yields and quality, the following cultural practices are recommended:-

3.10.11.1.1. Use of recommended varieties

Use of the following recommended varieties: London White, Cos, Butter crunch (Soft-leaf-cabbage-type), New York, Webbs's Wonderful and Great Lakes.

Seed rate: 50g/ha

3.10.11.1.2. Seed sowing and spacing

Sow seed thinly in drills 0.5 to 1cm deep in a seed bed or seed box. Alternatively, sow directly on beds. About 500g of seed is required per hectare or 2g per 30m of row length. In both cases thin to 30 to 40cm between rows after seedling emergence.

3.10.11.1.3. Fertilizer application

Before transplanting, apply Compound S at the rate of 90g per square metre using 3 cupfuls of cup No.30. Top dress after establishment with 50g CAN per square metre using 2 cupfuls of cup No.22.

3.10.11.1.4. Transplanting

Transplanting when seedlings are 7cm tall and space them at 30cm between plants and 30cm between rows.

3.10.11.1.5. Pest control

3.10.11.1.5.1. Weed control

Weed regularly to reduce competition for plant nutrients, soil moisture and light.

3.10.11.1.5.2. Insect pest control

The crop may be attacked by aphids *(Aphididae)*. Control is by spraying Pirimophos-methyl (Actellic) 50EC at the rate of 14ml in 14litres of water for knapsack sprayer or 14ml in 1litre of water for ULV sprayer. The crop is safe for harvesting 4 days after spraying.

3.10.11.1.5.3. Disease control

Some heads are lost through heart rot *(Rhizoctonia solani)* in the wet season. Damage can be reduced by wider planting.

3.10.11.1.5.4. Nematode control

Root knot nematode *(Meloidogyne javanica)* severely damages the root system. Lettuce beds therefore should not be rotated with other vegetable that suffer from similar nematodes.

3.10.11.2. Harvesting

Harvest when the heads are fully developed by cutting off heads at ground level. A stronger bitter taste and toughness develops if harvesting is delayed.

3.10.12. CUCUMBER
(Cucumis sativus)

Cucumber will grow well in all areas up to an altitude of 1,800m above sea level. The soil should be fertile with pH of 5.5 or more and well supplied with compost manure.

Yields of 34,000kg to 44,000kg per hectare over a harvesting period of 6 to 8weeks can be achieved with good management.

3.10.12.1. Improving yields

In order to improve both yields and quality, the following cultural practices are recommended:-

3.10.12.1.1. Use of recommended varieties

Use the following recommended varieties; Stono, Gemin, Burpee Hybrid and Improved Telegraph.

Seed rate: 2.5-3.5kg/ha

3.10.12.1.2. Field preparation and fertilizer application

After digging and breaking clods, apply at least 2 to 3kg of compost manure per square metre particularly on the planting stations. Before planting, apply Compound D at the rate of 100g per square metre using 3 cupfuls of cup No.30. Top dress every 21 days until flowering with 30g CAN per station using 1cupful of cup No.30.

3.10.12.1.3. Seed sowing and spacing

Cucumbers are usually directly sown although they can be started as transplants, seed can be sown into small pots in the nursery and transplanted later. The plant spacing should be 60cm x 60cm x 4 seeds per station. The 4 seeds in the planting station should be spaced at 10cm apart in a square and 2.5cm deep. Two and a half (2.5) kilogrammes of seed are required per hectare or 4g for 30m row.

3.10.12.1.4. Mulching

Both transplanted and directly planted plants should be mulched with grass.

3.10.12.1.5. Cultural practices

After young plants have grown to 7.5 to 10cm, thin to 3 plants at each stand. Cucumber vines are easily trained on to trellis, fence, or cage. It is best done by erecting a frame on which the trailing vines can be tied. When vines of long-fruited varieties are supported, the fruits hang free and are long and straight. This reduces damage by diseases and results in higher yields of high quality fruit. Remove the main growing points at 90cm to encourage the development of lateral shoots. Cucumbers are relatively shallow-rooted and require irrigation in most parts of the country. Apply plenty of water especially during the dry season.

3.10.12.1.6. Pest control

3.10.12.1.6.1. Weed control

Weed regularly to reduce competition for plant nutrients, soil moisture and light.

3.10.12.1.6.2. Insect pest control

Melon fly *(Dacus curcubiatae)* will cause some loss of fruit and if infestation is severe apply Trichlorophon (Dipterex) or Fenthion (Lebaycid) at the rate of 7ml in 14litres of water for knapsack sprayer or 7ml in 1litre of water for ULV sprayer. Destruction of all infested fruits by deep burying away from the field also reduces the infestation. Bagging also protects the fruits.

3.10.12.1.6.3. Disease control

i) **Powdery** *(Erysiphecichora cearum)* and **downy** *(Pseudorperonospora cubensis)* mildews cause considerable damage to leaves and may kill the plants. Downy mildew symptoms are white spots which develop on the underside of older leaves.

The leaves then become covered with a white mould growth and eventually die. Some varieties are fairly resistant to the diseases, for example Stono. Control is by spraying Anvil at the rate of 1ml per two litres of water for knapsack sprayer or 7ml in 1litre of water for ULV sprayer, alternatively apply Mancozeb at the rate of 20g in 10litres of water for knapsack, or 28g in 1litre of water for ULV sprayer.

ii) **Mosaic** is caused by the watermelon mosaic. Watermelon mosaic-2virus which is transmitted by aphids *(Aphididae)*. Squash mosaic virus, on the other hand, is seed borne and carried by cucumber beetle *(Diabrotica undercimpunctata)* Symptom appear as light green mottling of leaves. Young leaves and flowers are malformed and small. Leaves are dwarfed while veins fail to grow. Prevention is achieved by controlling aphids and cucumber beetles and by growing resistant varieties. Control of aphids and cucumber beetles is done by spraying with pirimiphos- methyl (Actellic) 20EC at the rate of 1ml per litre of water.

3.10.12.1.6.3. Nematode control

Root-knot nematodes *(Meloidogyne javanica)* and *(Meloidgyne incognita)* can cause severe damage to the root system. Cucumber should not be rotated with the solanaceous group of plants.

3.10.12.1.7. Harvesting and yields

Cucumbers are usually harvested immature and are of high quality when they are dark green, firm and crisp. Harvest by cutting fruits regularly, not allowing them to become over mature. Allowing the fruit to fully develop their seeds reduces the vigor of the plant and the yield of the crop. Harvesting period varies with variety and can extend from 4 to 8 weeks and even more. To induce the plant to produce continuously, fruits should be picked every other day, even if the fruits are not required.

Table 68: Withholding periods or safety periods for chemicals/fungicides used on different vegetables and some horticultural crops

Chemical Substance	Comodity/ crop	Withholding Period (days)	Chemical Substance	Comodity/ crop	Withholding period (days)
Benomyl	Tomatoes	3	Copper oxychloride and other copper salts	Cucurbits	3
	Peppers	3		Cruciferae	3
	Peas	21		Lettuce	14
	Brussels sprouts	3		Apples	14
	Cucurbits	3		Cherries	14
	Apples	14		Citrus	14
	Avocadoes	14		Avocado	14
	Peaches	7		Peppers	3
Mancozeb, Zineband Maneb	Tomatoes	3		Peaches	14
	Cruciferae	3		Potatoes (Irish)	14
	Beans	3		Strawberries	14
	Peppers	3		Carrot	7
	Potatoes (Irish)	3		Egg plant	-
	Cucurbits	3		Tomatoes	3
	Apples	14		Coffee	14 before harvesting and processing
	Peaches	28			
	Citrus	14			
	Mangoes	14			
	Papaya	14		Beans	3
	Guavas	14			
	Lettuce	21	Captan	Garlic	-
				Onion	-
Chlorothalonil	Beans	3 (42 days if fed to livestock)		Guava	-
				Tomato	-
				Apples	14
	Peas	14		Apricots	14
	Cucurbits	3		Pears	7
	Potatoes	3			
	Tomatoes	3		Apples	14
	Leafy vegetables	14		Apricots	14
	Onions	14 (do not apply more than six (6) sprays per season	Thirum	Peaches	14
				Plums	14
			Hexaconazole (Anvil)	Cucumber	-
	Brassicas	7			

3.10.13. MUSHROOM PRODUCTION

For a long time the nation has depended on naturally growing mushrooms, collected from the forests and gardens only during the rainy seasons and sometimes in localized areas. Wrong identification of mushrooms has resulted in poisoning hence the need to have the cultivated strains that are known and are safe for consumption.

Mushrooms are an important source of proteins, vitamins and minerals which are vital for good health. They are also a good source of income to growers and can help to save foreign exchange by import substitution. Mushroom production can assist in diversification and provides a better way of utilizing crop, forestry and animal wastes. Additionally they don't require a large piece of land for cultivation and most importantly production can be done at a time when most agricultural activities have ended. Mushrooms can be grown out the year in cool areas but during cool months in warm areas. Presently, 2 types of mushrooms are grown in Malawi, that is oyster and button mushrooms.

13.10.13.1. National aims

The aim is to increase mushroom production to satisfy domestic demand, whilst broadening the source of proteins, vitamins and mineral' income. The objective therefore is to encourage mushroom production in all areas.

13.10.13.2. Improving yields

To increase mushroom production, the following husbandry practices are recommended:

3.10.13.2.1. OYSTER MUSHROOM

Oyster mushroom *(Pleurotus spp.)* is relatively new type of mushroom in Malawi and is picking very well. It is also very versatile and relatively easy to growth an button mushrooms because of its low in put requirement and nature. Yield levels are very elastic, varying from one substrate to another. The biological efficacy ranges from a slow as 20% to as high as 10%. Different species of *pleurotus* are suited for growing within the temperature ranges of 15^0C-30^0C. *Pleurotus ssp.* can be grown on most lignocellulotic agricultural and forestry waste. Most of the substrates require pasteurization to give economic yields.

3.10.13.2.1.1 Use of good seed

Pleurotus sajor caju, which is highly adaptive, prefer temperatures of between 22^0C and 24^0C while *pleurotus ostreatus* produces very well at 12^0C-20^0C

3.10.13.2.1.2. Recommendations

(i) **Mushroom fruiting house:** This is where mushroom production takes place. It can be cheaply constructed from a wooden frame-work covered with a plastic sheet (clear or black) and optionally thatched with grass. It can either have a rack if the hanging method is to be used. Alternatively, some designs may have an 'A 'frame with two shelves at the bottom one on each side. Colonization of mycelia does not require light but it is necessary for fruiting.

(ii) **Incubation room (optional):** This is where spawning bags are incubated for substrate colonization. Alternatively a black plastic sheet can be used to cover the bags in the same fruiting house.

(iii) **Sterilizer:** This is used for pasteurization of the substrate.

(iv) **Thermometer and hygrometer:** These are required for monitoring the environmental conditions (relative humidity and temperature) in the mushroom house.

(v) **Sprayer or watering can:** These are used for water application on to fruiting bags during cropping. The water can or a bucket can be used for watering the floors to control relative humidity and temperature.

(vi) **Substrates:** Either of these can be used as substrate with good results.

- Finely chopped dry maize stalks, rice straw or ban an a leaves with supplementation.
- Shredded maize cobs wither without supplementation.
- Cotton waste with or without supplementation.
- Saw dust with supplementation. The most common supplementation includes rice or wheat bran (15-20%), water hyacinth (10-20%) and calcium carbonate (1-2%).

(vii) **Plastic bags:** These should be clear for ease of visualizing mycelia colonization and detection of contaminants. Autoclavable bags can be used if they are easily available.

(viii) **Strings:** Used for tying the mouths of the bags after spawning and also for hanging of the bags, if the hanging method is going to be used.

(ix) **Spawning:** The mushroom seed is technically known as spawn. Spawning is the sowing of mushroom seed.

3.10.13.2.1.3. Preparation of different materials as substrates for oyster mushroom

It should be noted that the higher the nutrient content the substrate has, the higher the yield but also less selective it is. This also influences the handling of the substrate at pasteurization at spawning stage.

i) Maize stalks or rice straw and banana leaves

Pre-wet the chopped maize stalks or rice/ wheat straw or banana leaves and incubate them on a cemented platform or on a plastic sheet overnight. Optionally, after soaking overnight and draining, they can be supplemented with rice/ wheat bran, water hyacinth and calcitec lime. Supplementation significantly improves the yield.

ii) Cotton wastes

The cotton waste is soaked or wetted for a few hours in water to which a detergent has been added as a softener and disinfectant. The water is squeezed out the cotton waste loosened. It either can be pasteurized or unpasteurized. Supplementation with lime ($CaCO_3$) and other materials can be done to improve pH and aeration.

iii) Saw dust from hardwood

Saw dust for the production of oyster mush room should be that from hardwood or broad leaved trees. This is wetted and incubated overnight with supplements added and then pasteurized. Sometimes it can be allowed to ferment for a few days before pasteurization.

iv) Corncobs

Should be shredded into 1-2 cm pieces. The cobs can be moisturized and incubated for 1-2 days and then pasteurized. Supplements including calcitic lime are normally added before pasteurization. Sometimes the immersion-in-hot-water method is employed with use of corncobs. This is done to leach the readily available nutrients in order to reduce the risks of contamination.

v) Maize stalks, maize stalks + maize husks (makoko) and cotton waste

The maize stalks and husks should be shredded and these are suitable substrates for oyster mushroom cultivation. These are cheaper means of producing planting spawn as well as improving yields for oyster mushroom.

3.10.13.2.1.4. Pasteurization and spawning

a) After the substrate preparatory stage for the different substrates, the substrates are packed into a home- made sterilizer which can be made from an open drum with a plat form with holes. After loading it is tightly covered with a plastics sheet or sealable cover with an opening. This is a semi-bulk pasteurization but where auto-clavable bags are used, pack them into the wire mesh basket and then put the basket into the sterilization unit.

b) Pasteurize for 1 hour and then empty the pasteurized substrate on to a plastic sheet for it to cool down to about 40^{o}C. In cases where the hot water immersion is used, immerse the substrate for 30-40 minutes.

c) Pack the substrates into bags while adding planting spawn and then tie the mouth of the bags. This should be done in an enclosed place or where there is no air current.

d) Incubate the spawned bags in the dark or alternatively cover with a plastic sheet until the bags are fully colonized. It normally takes about 14-40 days at 24^{o}C for full colonization to take place. This period depends on the size of the bags and spawn in grate.

e) When the bags are fully colonized transfer them into the fruiting house. The fruiting house should provide enough light for the mushroom to start forming. Light, which would enable one to read a newspaper when inside the mushroom house, is just enough. The bags should be opened after exposure to light for one day. If tray fruiting is used, open one end facing the passage. For the hanging method, tie them on to the racks and make a few long slit son the bags using a clean sharp knife or clean razor blade.

f) Maintain the temperature at about 18^{o}C-25^{o}C and the relative humidity at 80%-90%. The air freshness in the mushroom house also needs to be maintained at this stage .Relative humidity is maintained by applying water several times a day on the floors and walls and the air freshness by routine opening of the vents. Insufficient fresh air (too much carbon dioxide) lead to failure to fruiting and or development of deformed fruits.

3.10.13.2.1.5. Common pest and diseases and their control

(i) **Mobweb moulds (***Cladobotryum spp.)*

This is usually due to too little air movement, high relative humidity and relatively high temperatures in the mushroom house. This fungus parasitize the mushroom mycelium and has a tendency of spreading very fast. In the mushroom house you observe cobweb-like structures growing rapidly from dead stumps or dead primodium, forming a veil which spreads rapidly. Spread is through aerial hyphae, pickers and insects. The fungus colour, with time changes to yellowish - pink. Control is by removal of stumps and dead mushroom regularly from the beds or bags at the end of picking. One can also spray a 0.5% for maldehyde-solutiononthe spots where the cobwebs occurs or use of fungicides like Benomyl, Carbendazimor Thiofanatemethyl in severe case in between flushes.

(ii) **Penicillium spp.**

Few Penicillium species cause trouble in mushroom growing. If they do occur, it is usually assign of improper substrate pasteuri- zation or unsterile conditions during spawning of sterilized substrate. This fungus typically produces a large number of spores, which look like smoke when contaminated compost is touched. The mycelium is white at first, and later it turns brown. Infections can reduce yields by up to 80%. Effective control is achieved through observation of hygienic conditions during spawning and the immediate removal of infected substrate.

(iii) **Green moulds** *(Trichoderma spp.)*

This comprises a group of very common green moulds that is often encountered in mushroom cultivation. The spores are sticky and can easily be carried by flies, mites and pickers' hands to uninfected areas. Trichodermaspp. Can be found as spots on dead mushrooms, stumps and both pasteurized and sterilized substrate, as well as in freshly cut wood logs.

(iv) **Snail**

These appear in different forms and normally eat the mushroom during the night. In the early days when the populations are low, they can be controlled by hand picking, use of baits and traps.

(v) **Phorid and Scarid flies**

The lar vae of these f lies feed on the mushrooms my celia and eventually tunnel in to the mushroom fruiting body. They also act as transport agent of mites and other fungal contaminants. They are less of a problem during spawn run in sterilized mushroom bag production system since the bags are sealed.

(vi) **Beetles**

These actually chew the mushroom from the inside (gill side) and tend to tunnel holes and hide in there when disturbed. They have a red or orange head and dark wings.

(vii) **Mites**

These are very tiny spiders, which feed on mycelium or on the mushroom themselves. Mites are also carriers of unwanted fungi spores in to the substrate They can be effectively controlled by use of Malathion or by sprinkling with quick lime.

3.10.13.2.1.6. Harvesting

Pluck mushrooms when fully grown. It takes about 5-9 days for the first flush to come out after opening the bags.

3.10.13.2.2. Button mushroom

Two varieties are recommended.

(i) TNS1 which requires a cropping temperature of 16-20^{0}C. It is white in colour and has a potential yield of 15 kg per square meter.

(ii) TN2 requires a cropping temperature of 18-22^{0}C. It is bigger than TNS1. It is white in colour and is scaly with a potential yield of 15 kg per square metre. These temperatures are prevalent between March and July in most parts of the country. Mushrooms therefore can be best grown during these months.

3.10.13.2.3. Housing

Cultivated mushrooms are grown in a house. The house provides conditions favourable for the growth of mushrooms. The important conditions include humidity, temperature, ventilation and moisture. The house should satisfy the following conditions:-

3.10.13.2.3.1. Sitting

The house should be free from any obstruction and be oriented in such a way that ventilators and doors face in the direction of the wind to allow free air movement. The house should be constructed away from livestock kraals, rubbish pits and latrines to avoid attraction of flies to the mushroom house.

3.10.13.2.3.2. Framework

The mushroom house should have a wooden framework covered with a heavy guage plastic sheet for controlling humidity and outer grass thatch for insulation. Requirements for construction of a mushroom house include wooden poles, 500 or 600 guage plastic sheets, bamboos, timbers nails, thatching grass and wire or plastic gauze.

3.10.13.2.3.3. Dimensions

Suitable houses for growing mushroom shave dimensions of 5 mx 3 mx 2 m for smaller houses, and 7 mx 5 mx 3 m for larger ones. Mushrooms are grown on shelves inside the house. These shelves can be as long as the house itself or slightly less. The widths of the shelves range from0.5m to1.0m, depending on the size of fruiting bags

3.10.13.4. Composting

This is a process whereby organic materials are connected in to a satisfactory and stable medium for the growth of mushrooms. The recommended quantities of in gradients based on one tone (1,000kg) of well dried cut maize stover or rice straw are as follows: 20kg Soya bean powder or cotton seed cake, 20 kg white wash lime, 20 kg molasses; 30 kg of single superphosphate and 30 kg of rice bran; 150kg of chicken manure and 10kg of calcitic lime. There are 2 composting phases, the first phase is out door while the second is indoor.

3.10.13.4.1. Phase1 Composting

This is also known as outdoor composting because the activity is done outside the house under shed. This phase involves wetting and mixing of the compost ingredients. The first step is to cut the straw or stover into pieces of 3 to 4 cm in length. Thirty kilogrammes of dry cut stover or straw is enough to fill one square meter of bed. The outside composting takes about16 days. A summary of activities on a daily basis is presented in Table 69.

Table 69: Procedure for phase 1 composting

Day	Activity
1	Pre-wetting of straw
2-4	Add water to straw if necessary
5	First turning of compost. Add white wash lime, chicken manure and half the amount of sulphate of ammonia.
6-7	No activity
8	Second turning of compost. Add calcitic lime and single super phosphate.
9	No activity
10	Mix and wet soybean powder or cotton seed cake, rice bran and molasses in a drum
11	No activity
12	Third turning of compost. Add the wetted mixture prepared on day10 and the remaining sulphate of ammonia
13-14	No activity
15	Fourth turning. Loosen the compost
16	Filling: transferring of the compost on to growing beds up to 15 cm deep. Close all ventilator sand doors

3.10.13.4.2. Phase 2 composting

This composting takes place inside the mushroom house. The main objective is to pasteurize and condition the compost. Pasteurization is accomplished by introducing live steam generated from a boiler outside the house through metal pipes into the mushroom house. This phase lasts 12 to14 days and is a continuation of phase1, as seen in Table 70.

Table 70: Summaryof activities for phase 2 composting

Day	Activity
17	Introduction of live steam into the mushroom house
18	Maintain compost temperature at 65^0Cto70^0C for 4-10 hours
19-21	Decrease temperature slowly to between 50^0C and 52^0C by opening vents and reducing fire
22-25	Decrease temperature to between 40^0Cand45^0C
26-28	Aerate and cool compost to25^0C By opening ventilators
29-30	If there is ammonia odour and the compost has high moisture content continue aerating

3.10.13.5. Spawning

Spawning is the planting of mushroom seed. It should be done when the moisture content of the compost is about 70%. This is when a handful of compos t is squeezed in t h e hands 4 to 6 drops of water should come out. Ensure that there is no ammonia odour in the house and the compost temperature is about 25^oC. The recommended spawning rate is 400 ml per square meter.

The actual spawning is done by broad casting three quarters of the required spawn quantity on to the compost and mixing it thoroughly with the compost right down to the bottom. The remaining one quarter is broadcast on top and incorporated in to the remaining very top layer of the compost (about1cm deep). Doors and ventilators should be closed from spawning day to 3 days after spawning. From day 4 introduce ventilation once in the morning and evening for 30 minutes a teach time. Colonization of the compostbythemushroomfungustakes12 to 14 days spawning.

3.10.13.6. Casing

Casing is the addition of moist pasteurized soil on to the compost. Casing soil must be clay loam subsoil, low in organic matter content and must have a pH of 7.0 to 7.5. Normally casing soil is obtained after removal of 10 to 13 cm of the top soil layer. Casing soil is pasteurized by steaming at 70 to 80 C for 15 minutes. Casing is done at end of about 14 days when the compost is completely colonized by white my celia. Casing soil stimulates and promotes fruiting bodies and retains needed moisture for mushroom growth. The casing soil is put on top of the compost to a thickness of 3 to 4cm. About 30 liters of soil will be required per square meter. From casing to formation of fruiting bodies, the casing should be moist at all times and the temperatures should be between 16 and 22^0C. Mushroom pin heads start forming from day16 after casing.

3.10.13.7. Pest control

3.10.13.7.1 Insect and mite control

(i) **Mushroom flies** *(Megaselia agarici)*

Mushroom flies feed on the mushroom fruiting body and mycelia. They also cause indirect damage since they carry mites, eelworms and spores of other moulds. Control is by sanitation and around the farm, removal of left over compost and bur ying of stems and pieces of mushroom.

(ii) **Mites**

Mites are a problem because they feed on mushroom mycelia and on the developed mush room causing surface discoloration. Control is kept by keeping the mushroom house and surrounding clean.

3.10.13.7.2. Rodent

Rodents *(Rattus spp.)* on the mushroom fruiting body and mycelia. The y are very destructive as they make unwanted holes in the casing and compost. Rodents can be controlled killing them or using traps.

3.10.13.7.3. Mollusc control

Snails and slugs feed directly on the mushroom. Control is by hand picking.

3.10.13.7.4. Disease control

i) Dry bubble *(Verticillium fungi cola)*

Dry bubble is most severe in summer months especially when fly populations are high. It is characterized by pale brown spot son the cap. Practicing farm hygiene to reduce fly population scan reduce the disease. In addition, reduction in air temperature and humidity helps control the problem.

ii) Olive green mould *(Chaetomium spp.)*

The mould appears on compost surfaces soon after pasteurization and can also lead to complete failure of mushroom growth. It is characterized by green grit-like projections on the compost.

iii) Mat *(chrysosporium spp.)*

This disease is characterized by a creamy to yellow mycelia fungal growth on both the compost and casing soil, coating it completely. Them at impedes air and water penetration. Prevent the disease by ensuring that casing is not shallow. Farm hygiene is important in reducing this disease.

3.10.13.8. Harvesting

Mushrooms are ready for harvesting 14 to 20 days after casing and they come in weekly flushes. To harvest, hold the cap, twist the mushroom and pull it together with the roots. Cut off the roots and dispose them by burying .The holes left behind by harvested mushrooms should be filled with fresh casing soil. Watering of bed should be done soon after harvest and all vents opened for 1 to 2 hours to dry the surface. Depending on the variety, compost type and management, yield of mushrooms range from 5 to 10 kg per square meter under smallholder farming. A cropping period of 8 to 12 weeks is normal. After the cropping period, the soil and compost should be removed in preparation for a new season. It is possible to grow 2 crops in a year.

3.10.13.9. Marketing

Mushrooms ready for the market are divided into various grades depending on size and degree of maturity. The right stage for harvesting, however, depends on one's own market. Mushrooms may be divided into 3 grades:-

(i) **Buttons** - These are closed mushroom, they could be small or big. They fetch the highest price on the market.

(ii) **Caps** - These are mushrooms whose veils have opened or are likely to open. They still have a rounded cap. They normally have a medium value

(iii) **Flats** - The veils have opened and the caps are flat and gills exposed fully. They normally fetch low prices.

Farmers wishing to grow mushroom should contact Bvumbwe, Chitedze, Lunyangwa Agricultural Research Stations and Bunda College. Through their nearest field staff.

CHAPTER 4

AGROFORESTRY

Agroforestry is a farming system in which trees/shrubs (woody perennials) are deliberately integrated with crops and or animals on the same unit of land. The mixed cropping practices of most smallholder farmers in Malawi can be considered as agroforestry when trees or shrubs are present and used for specific purposes. Most trees in farmers' fields have not been intentionally planted but their wide spread retention on farms demonstrates that agroforestry is simply a new word for an old practice.

In addition, agroforestry should also be broadly understood to be practices that involve a wide range of trees that are protected or planted and managed on farms and agricultural landscapes. These include trees that provide fruit, nuts, oils and leaves for food and nutrition, fodder trees that improve smallholder livestock production, fertilizer trees for land regeneration that improve soil health and thus contribute to food security; trees that are hosts to edible insects or used in honey production, trees that provide timber and wood energy, others that provide shelter; medicinal trees to combat disease; and trees that produce gums, resins or latex products. Many of these trees have multiple uses, providing a range of these benefits.

Trees in agricultural landscapes provide many livelihood and environmental benefits, among them:

- Increased genetic and crop diversity on farms
- Increased access to dietary diversity, as a means for reducing under nutrition
- Safety net and resilience in an increasingly erratic climate, providing foods all year round and also when annual crops fail
- Enriched asset base of poor households
- Improved soil fertility and livestock productivity on farms
- Links to markets for high-value fruits, oils, cash crops and medicines
- A balance between improved productivity and the sustainable management of natural resources
- Stable or enhanced supply of environmental services in agricultural landscapes for water, soil health, carbon sequestration and biodiversity.

Promotion of agroforestry to include all tree types and functions - fertilizer trees, fuelwood trees, fodder trees and fruit trees – the four Fs of agroforestry should therefore remain the focus in all agroforestry interventions.

Agroforestry systems offer opportunities for realizing higher productivity, more dependable economic return and a greater diversity of outputs and benefits on a sustainable basis. The promotion of agroforestry lies in the multi-purpose uses of woody plants as well as their products. Some tree species play a vital role in sustaining and improving crop yields by helping to improves oil structure and fertility, reducing soil erosion and providing shade. In addition to these functions, trees yield a variety of products such as fruits, fodder, fuelwood, timber, poles and medicines. Certain agroforestry species are reputed to decrease infestation by *Striga*, a common parasitic pest of cereal and legume crops.

4.1. National aims

Agroforestry aims at improving food security, agricultural sustainability and the conservation of the natural resource base by addressing common problems faced by smallholder farmers. The problems include;-

i) smaller farm holdings, and lack of land for agricultural expansion;

ii) low or declining soil fertility and crop yields;

iii) increasing soil erosion and water runoff on steep slopes;

iv) animal nutrition problems and inadequate fodder;

v) shortage of fuel wood and building materials;

vi) accelerated deforestation and overgrazing; and

vii) rising costs of farm inputs coupled with limited credit opportunities.

4.2. Best Bet practices

The Best Bet practices are those cultural practices that are promising. They have proved popular, easy to manage and beneficial to farmers. They include:-

1. dispersed systematic tree interplanting;
2. regeneration of natural soil improving trees;
3. annual undersowing; and
4. improved fallows.

More management intensive systems described later in the chapter, include alley cropping; mixed inter- cropping; and green manure banks.

4.2.1. Dispersed systematic tree interplanting

The system involves planting certain types of trees with crops at wide spacing to improve soil fertility and crop yields. Systematic planting provides uniform coverage of the area and facilitates farm operations including use of ox-drawn implements. If properly managed this practice sustains farm productivity over the long term and provides other useful tree products. It is popular with smallholder farmers because it builds upon traditional agroforestry practices, offering a range of tree species to meet different farmer needs.

4.2.1.1. Benefits

Dispersed systematic tree interplanting practices have the following benefits:-

i) improve soil fertility and crop yields

ii) extend the period of crop productivity

iii) supply fuel, building material, fodder and other products for household use or sale

4.2.1.2. Recommended types of trees

Faidherbia albida (Msangu) is the tree most commonly recommended for this practice, but *Acacia polycanta* (mthethe) and *A.galpinii* (nkunkhu) are also valuable. All are large, fast-growing leguminous trees, indigenous to Malawi and well adapted to a wide range of habitats. They have multiple uses and are easy to raise from seed. Seed for these trees is easy to collect and the sources are abundant.

Note: Msangu tree is particularly beneficial to soils and crops for its unique feature of dropping nutrient- rich leaves by the start of the rains. Its bare canopy and leaf fall offer light and soil conditions ideal for optimum crop growth. Farmers in Malawi and elsewhere in Africa have maintained crop yields beneath msangu trees for long periods without adding fertilizers. Maize production under mature trees is commonly 50% to 250% higher than outside the canopy. Variation in yield depends on the crop variety and husbandry practices used, particularly early planting and weeding. Msangu also has other uses including fire wood and building materials, shade during the hot dry season, and high quality fodder from its abundant yields of nutritious pods which can be fed to livestock.

4.2.1.3. Nursery practices

Nursery stock is recommended for all 3 species. Although direct sowing has been attempted with *Faidherbia albida* field results have been poor, and therefore direct sowing is discouraged. (for nursery management refer to chapter on forestry).

4.2.1.4. Spacing of out planted seedlings

Dig pits 60cm deep x 60cm diameter before the rains. Loosely replace the soil in the pits. A closer spacing of 10m x 5m is recommended due to poor survival rates under farm conditions. This spacing helps to ensure an adequate density of healthy surviving trees, and provides a faster benefit to the crop when the trees are still young.

4.2.1.5. Out planting of nursery seedlings

Out plant seedlings into pits prepared during the dry season. Make sure the tap root is not bent or damaged when out planting, and that the seedling has recovered from any root pruning. Plant maize at least 90cm from seedlings. This helps to reduce competition and to encourage good growth. Msangu seedlings deserve a special care, because of its sensitivity to root pruning, out plant at 5-8weeks of age. Alternatively, seedlings may be raised off the ground on wire mesh platforms. This prevents roots growing through the tube so that root pruning is not needed.

4.2.1.6.Time of planting

Out plant seedlings into prepared pits early in the season by mid December or early January. Plant when the soils are moist, preferably early morning or late afternoon to avoid midday heat. Early plan encourages good root development for survival over the dry season. It also helps seedlings to withstand common pests and diseases.

Note: Poor performance in the field occurs from:

i) late out planting

ii) using over grown seedlings that have stayed too long in the nursery, and

iii) incorrect techniques when out planting.

4.2.1.7. Replanting

Replace seedlings that have died within 2 weeks of first planting to ensure a good stand of trees.

4.2.1.8. Weeding

Seedlings will grow better by keeping the crop well weeded during the first season. This reduces competition for soil moisture and nutrients, as well as risk of fire damage.

4.2.1.9. Marking and protecting trees

Reduce losses from accidental weeding and trampling by marking each seedling with a stake. If livestock are a risk, erect a protective fence around each seedling. In the event of disease or pest attacks, seek advice from the nearest Forestry or Agriculture Office.

4.2.1.10. Thinning

Thin trees as they grow in size to prevent crowding and to supply wood and fodder. Use the regime in Table 71 below;

Table 71: Thinning regime for trees

Tree canopy	Recommended spacing	Recommended density
3 metres	10 x 5m	200 trees/ha
5 metres	10 x 10m	100 trees/ha
8 metres	10 x 20m	50 trees/ha
10 metres	20 x 20m	25 trees/ha
>10 meters	increase spacing by selective thinning and pruning branches	circa 20 trees/ ha

4.2.1.11. Pruning

Prune bottom branches of seedlings after the first season to promote straighter healthier trees, and to reduce interference with field operations. Time pruning when trees begin active growth to reduce die back, fungal diseases and termite attack. This is April-May for Msangu, and October-November for other species. Make clean angled cuts with a sharp blade or saw to reduce injury to the tree. As trees grow to maturity, a few branches may be selectively lopped to reduce the density of the canopy. Spread the cut foliage on the ground to act as green manure, or use it as animal feed if the tree is a good fodder species. Collect the wood for fuel or other uses.

4.2.1.12. Calendar of key activities

August-November:

Prepare nursery, collect inputs and raise seedlings; identify out planting sites and dig pits at the right spacing.

November-January:

Out plant and stake seedlings.

January-Onwards:

Weeding and protecting seedling from animals and bushfire.

Start of Next Season:

Prune lower branches to encourage an upright growing habit and reduce interference with field operations.

4.2.2. Farmer Managed Natural Regeneration (FMNR)

Farmers are encouraged to protect naturally regenerating trees in their fields. This is the easiest agroforestry system to adopt as it requires no tree nurseries or out planting, and the trees are already adapted to the area. Key factors that motivate farmers to adopt this practice are highlighted below:

- **Tree uses and needs** – Trees provide many products and uses essential to the lives and livelihoods of farm households: fuel for cooking and heating; building materials for houses, animal enclosures and other farm structures; wood for doors, windows, furniture and handles of farm tools; fodder and shade for animals, fruits, oils, resins, dyes, and a host of medicinal and cultural uses. But many smallholders lack the knowledge, land, labour and inputs to raise and plant trees on and around their homes and farms. FMNR circumvents these challenges for reasons explained below which makes it attractive to farmers.
- **Low Cost and Easy to do** – The key advantages of FMNR is that it easy to do and requires no special technical training, knowledge or timely provision of costly inputs typical of tree planting programs. FMNR minimizes expenses and labour demanding tasks to produce, transport, out-plant, manage, and protect seedlings raised in nurseries. It simply requires selecting and protecting trees already present on the land through natural regeneration of root stock, coppiced stumps and seedlings. Adaptability – Natural regenerating trees are healthy plants selected by nature with strong root systems that can withstand climate shocks. They are well adapted to the local ecology with inherent resistance to drought, fire, browsing, pests and diseases. Consequently, there is little or no risk of setbacks common with planted seedlings.
- **Flexibility** - Most work can be done in the dry season to minimize labour conflicts with farming whereas planting of seedlings is time sensitive and coincides with critical farm operations at the start of the rains. There is no prescribed number or density of trees to retain on farms. This depends on the species selected and interests of individual farmers. The critical issue is to allow adequate space and light for crops to grow normally. This can be assisted by managing the canopy of the trees and trimming branches which can be collected for a variety of uses.
- **Multiple benefits and products** – FMNR helps to restore the biodiversity of the natural landscape and to protect the local environment against adverse climate conditions while providing multiple products and uses by communities and households – firewood, building material, fodder, fruits, wood for farm tools, and many medicinal and cultural uses. This is not possible from single species plantations and agroforestry systems.

- **Impact on soils and crops** – Many trees benefit soils and crops by replenishing nutrients, improving the cost effectiveness of fertilizers, maximizing the capture of rainfall and water infiltration, minimizing effects of dry spells by conserving moisture, and reducing water runoff and loss of top soil. Impacts on crop yields can be 3-5 years with fast growing species planted at moderate to high densities vs. 10 years with species like F. albida.

Note – Protecting trees from fire and cutting by people ensures good tree survival and growth, which will provide farmers with a diverse range of products and uses at low cost.

- there is no prescribed density or spatial arrangement although the size and type of trees are an important consideration depending on the interests of the farmer. Typically, densities range from 25/ha for large trees to 200/ha for small trees
- The first task is to select the trees to retain on the land based on the interests of the farmer and desired uses of the trees. This means removing other trees to provide space and light for growing crops. As mentioned above, the density or spacing depends on the type and size of the trees present on the land.
- After selecting the trees to manage, thin the stems or shoots as needed to 1 or 2 dominant stems to promote vertical growth. This avoids the development of scrubby bush which reduces space for crop production. Scrubby growth also produces low quantities of wood of a size to meet the different needs of farmers. The best tool for pruning and trimming is a bow saw, but a sharp panga is adequate for small diameter stems and branches.
- Pruning and thinning should be done with an upward slanting cut to minimize damage to the tree. For example, a downward cut may cause the branch or stem to split or the bark may be torn downwards along the living branch or stem.
- Collect thinned shoots and trimmings for fuel or other uses.
- Other products may be collected as and when available such as fruits, fodder and various parts of trees for medicinal or other uses.
- Manage tree canopies before and during the cropping season as necessary by trimming branches to ensure adequate space and light for good crop growth.
- Although most natural trees are fire resistant, they need protection from fire in the dry season to minimize damage to young trees. This is best organized through by-laws with communities and their leaders

4.2.2.1. Species

Choice of species depends on individual farmer preferences. Natural trees need protection from fires and animals and kept weed free just like planted ones. As they grow in size, they also need management to minimize shade effects on crops, and to supply wood and other products desired by the household. Follow the pruning practices specified in the section under pruning for healthier, straighter growing trees, taking care to avoid over-pruning which retards the ability of trees to regenerate.

Soil improving leguminous trees is recommended, as this is the primary aim. Suitable species include: *Acacia galpinii, A.nigrescens, A.polycantha, A tortilis, Albiza adanthifolia, Aharveyi, Bauhinia thonningi, Branchystegia spiciformis, Erythrina abyssinica, Faidherbia albida, Lonchocarpus capassa, Pericopsi angolensis* and *Pterocarpuangolesis*. Non leguminous trees are also retained on cropland by farmers for a variety of uses though their effect on soil fertility is lower. Common species include *Annona senegalesis, Azanza garnkena, Combretum spp., Ficus natalesis, Kigelia africana, Melia azaderack, Sclerocarya birrea, Terminalia sericea, Uapaca kirkiana* and *Ziziphus mauritiana.*

4.2.3. Annual undersowing

This technology aims to restore crop productivity by improving the chemical, physical and biological properties of the soil with fast growing, nitrogen fixing shrubs. It entails intercropping the shrub with maize when the rains start, followed by harvesting it just before land preparation at the start of next rains. This practice continues every year.

4.2.3.1. Recommended species

Tephrosia vogelii is one of the best because it is easy to establish and manage and can be intercropped with crops just like pigeon peas and gives a better crop response along other benefits (refer to section 4.2.3.2). *Sesbania sesban* has also been used, but it does not germinate well from direct sowing and is commonly damaged by leaf-eating pests and goats. Species of *Crotalaria* are also promising but more research is needed before making recommendations.

4.2.3.2. Benefits of under-sowing

Key benefits include:

a) Fast restoration of soil fertility and structure from high biomass yields. Deep roots help break through hard pans to improve water infiltration and root development in crops.

b) Soil and water conservation from good vegetative cover and litter combined with suppression of weeds, Striga and termites.

c) Produces abundant fuel wood, though low in quality.

d) Prolific seeding to meet growing demand for seed.

e) *Tephrosia* can also be used as a pesticide for controlling pests such as stem borers, aphids, leaf eaters, weevils, and fleas. A common recipe is to crush fresh leaves and other plant parts, soak them in water over- night away from sunlight, then filter off the solution for use as a spray. Crushed leaves mixed in granaries are effective against weevils.

Caution:

Since *Cajanus, Sesbania* and *Tephrosia* are host to root knot nematodes, do not undersow them in rotation with crops susceptible to nematode attack such as tobacco.

4.2.3.3.Time and method of sowing

Sow seed directly into the top of every ridge with the start of the rains on the same day as crop planting. Do not plant *Tephrosia* in furrows, as it is susceptible to water logging.

The species recommended do not compete with crops because of slow initial growth. Failure to plant early limits growth and makes the shrubs less tolerant to pests and diseases. This may make it necessary to retain the trees as a fallow in the 2nd season to produce adequate biomass (refer to section on improved fallows).

4.2.3.4. Seed rate

Cajanus:	7.5Kg/ha
Sesbania:	2Kg/ha
Tephrosia:	5Kg/ha

Note: Adjust the seed rate with 10% for suplying gaps.

4.2.3.5. Seed depth and number of seed

Cajanus/Tephrosia: 1.5-2cm with 3seeds/station.

Sesbania: 1cm with 5-8 seeds/station.

Note: Germination will be poor for all species if planted too deep.

4.2.3.6. Spacing for direct sowing

With maize on ridge 75-90cm apart and 90cm within the row, sow 2 stations 30cm apart between maize stations one very ridge.

75 - 90 cm x o o x o o x o o x

x o o x o o x o o x

x = maize o =Tree species

Undersowing is not recommended for closer spacing of maize (e.g. 75 x 25 cm) as the high population will have shading effect and shrubs may not survive.

4.2.3.7. Spacing for Sesbania seedling

Sesbania is best grown from bare-root seedlings on every ridge between maize stations. For maize 90cm within the row, out plant one seedling between each station:

75 - 90cm o x o x o x o x o

o x o x o x o x o

x = maize o = Sesbania

4.2.3.8. Weeding

Keep fields weed free to improve survival, growth and biomass yields. Take care that the young plants are not mistaken for weeds.

4.2.3.9. Year of harvesting biomass

Most crops respond better in the field if there is adequate biomass from planted trees. A farmer may choose whether to harvest the shrubs after the first year, or to leave them fallow for the next season if you have enough land (refer to section on improved fallows). An indicator of good biomass is a dense, vigorous stand with at least 75% survival and plants averaging 1.5m tall or more.

4.2.3.10. Time of harvesting biomass

This is best done at the time of land preparation, or before the start of the rains in October or November.

4.2.3.11. Harvesting and using biomass

i) Cut down at ground level with a sharp Panga.

ii) Lay cut materials uniformly over the soil surface.

iii) After a few days of sun drying, shake the leaves off and remove woody stems for fuel.

iv) Bury leaf biomass into the ridges, or lightly cover with soil to minimize loss of quality from exposure to hot, dry conditions.

Make sure that you do not bury woody stems as they immobilize nitrogen, making it unavailable to the crop.

Note: Good crop and biomass results depends on the proper time and method of sowing. To help break the nematode cycle and to reduce nutrient depletion, grow groundnuts every third year in rotation with maize.

4.2.3.12. Seed banks

Farmers should establish small seed banks in the form of hedges around their homestead or other plots to meet future seed needs, and possibly for sale to other parties. Another option is to maintain plants on the perimeter of their undersown plots for seed production.

4.2.3.13. Seed supply and cost

Sesbania and Tephrosia seed is in short supply, so avoid wastage. Seed will be supplied at a cost. For more information contact the Department of Land Resources Conservation.

4.2.3.14. Calendar of key activities

November-December

Undersow (intercrop) shrubs at the start of the rains before 2 weeks elapse after planting the main crop; plant on top of every ridge at the correct spacing and depth for good establishment. Continue this practice annually.

May-September

Leave shrubs to continue growing after the crop harvest.

October-November

Cut shrubs down at ground level. Bury leaf biomass in the ridges, or lightly cover with soil to avoid loss of quality. Always remove woody stems.

4.2.4.Improved fallows

Improved fallows of fast growing trees speed up soil restoration and yield secondary products. The best species are those that fix nitrogen and those with good ground cover. Improved fallows generally produce a higher crop response than other agroforestry systems because of the higher biomass generated.

The drawback is the need for large land holdings and loss of crop production during the fallow period. These are important factors limiting adoption among farmers in Malawi.

Improved fallows may be short or long term, and may be combined with other practices on the same land, e.g. boundary planting and vetiver hedges.

Both types of fallows require targeting farmers who have adequate resources to fallow, or land that will be left idle in the following season.

4.2.4.1. Fallows with short lived shrubs

4.2.4.1.1. First year

Intercrop fast-growing shrubs with maize when the rains start so that trees can be established on the same land with little extra labour.

4.2.4.1.1.1. Recommended species

Tephrosia vogeli has proved the most successful, but *Cajanus cajan* and Sesbania sesban may also be used.

4.2.4.1.1.2. Establishment of *Cajanus* and *Tephrosia*

Direct sow one on every ridge with 3 seeds per station. For maize on ridges 75-90 cm apart and 90 cm within the row, sow 2 stations 30cm apart between maize stations on every ridge.

75 - 90 cm x o o x o o x o o x

x o o x o o x o o x

x = maize o =Tree species

4.2.4.1.1.3. Establishment of *Sesbania*

Sesbania is best grown from bare-root seedlings on every ridge between maize stations. For maize 90cm apart, outplant one seedling between each station.

75 - 90 cm x o x o x o x o x

x o x o x o x o x

x = maize o = Sesbania

Note: When direct sowing Sesbania, plant 5-8 seeds per station between maize as shown for Tephrosia and Cajanus above.

4.2.4.1.2. Second year

Abandon cultivation after the first season, leaving the trees as a fallow for the 2nd season to restore soil fertility from the high biomass of foliage and roots. With good establishment in the first year, weeding the fallow is often not necessary. Before cultivation resumes, cut the shrubs down at ground level during land preparation, and bury the leaves when dry enough to shake off. Collect woody material for fuel or tiers.

4.2.4.1.3. Third and fourth seasons

Annual crop cultivation is resumed for the 3rd season with much improved yields. Repeat the whole cycle in the 4th season starting with the undersowing phase. Although cropland is lost for 1 season during the fallow period, it involves only small amount of land (i.e., returns to labour and capital are low). Gains in crop yields, wood and seed sales will compensate for this loss.

4.2.4.1.4. Calendar of key activities

Year 1:

November - December

Undersow (intercrop) shrubs with maize on the top of every ridge at the start of the rains; plant at the correct depth for good germination.

May - October

Leave shrubs to continue growing after the crop harvest.

Year 2:

October - September

Keep the shrubs as a fallow for the next full season.

Year 3:

October - November

Cut the shrubs down at ground level. Bury leaf biomass in the ridges, or lightly cover with soil to avoid loss of quality. Always remove woody stems.

November-May

Resume annual cropping

Year 4:

November - May

Undersow as in the first year, and repeat the whole cycle.

4.2.4.2. Fallows with long-lived trees

Larger and longer-lived trees may also be used in fallows to improve soil fertility. Soil improvement may take longer because the trees are slower growing, but they offer better quality wood and a greater range of products.

4.2.4.2.1. Recommended species

Acacia galpinii, A. nigrescens A, polycantha, Albizia lebbeck, A. zimmermannii, Bauhinia thonningii, Erythrina abyssinica, Gliricidia sepium, and Leucaena diversifolia, If wood is a higher priority, Azadirachta indica, Senna siamea, S. spectablis and *Toona ciliate* may be used.

4.2.4.2.2. First and second years:

Interplant crops with the trees for 1-2 years as there will be little or no competition while they are still young. This makes good use of land, and guarantees good weeding for tree growth.

4.2.4.2.3.Third year and beyond:

Leave the trees to grow until fertility is restored, or until they reach a size for harvesting the desired wood products. Cultivation may resume after removing the trees, or while allowing them to coppice. Some trees may need to be thinned out. The wood may be used for fuel or building purposes.

4.2.4.2.4. Tree spacing

Space small trees like *Gliricidia* and *Leucaena* at 0.9 m x 0.9 m, and medium to large trees like *Acacia, albizia, Bauhinia, Erythriana, senna* and *Toona* at 1.8m. x 1.8m.

4.3. Other practices

This section describes other practices that have shown good results on soil fertility and crop yields, but are not being widely adopted because of their complexity and management-intensive needs. Promoting these practices should be limited to programmes, which are capable of targeting farmers with the interest and resources to adopt the technology.

4.3.1. Alley cropping and mixed tree inter-cropping

These two practices are combined here because of their close similarity. The difference is the spacing arrangement. Alley cropping involves planting hedges 4-5m apart with an interplant spacing of 45 - 90cm, while mixed tree intercropping has rows 1.8m apart and an interplant spacing of 0.9m. Otherwise establishment and management practices are essentially identical. Both practices involve cultivating annual crops between rows of woody plants.

4.3.1.1. Benefits

The major benefit of alley cropping and mixed tree intercropping is to improve soil fertility and crop yields. They also compliment chemical fertilizer to reduce costs and rates used. Hedges are pruned 2 or 3 times during the year to minimize shading and competition, and to provide leaf biomass for soil fertility, weed suppression and soil conservation. Pruned branches make useful fuel wood or racks for drying crops. The foliage of some species is good fodder.

4.3.1.2. Tree species

Recommended species are fast-growing, high yielding leguminous shrubs and trees with nutrient-rich foliage. Species recommended are *Gliricidia sepium, Leucaena diversifolia, Sennaspectabilis* and *Tephrosia vogelii*. Choice of species depends on the environment and products desired. *Tephrosia* is shorter-lived than the other species, but it is faster growing, and can be direct sown.

4.3.1.3. Establishment by direct sowing

Direct sowing greatly reduces costs of raising and transplanting nursery seedlings, but only *Tephrosia* has proved consistently successful. Direct sow on the same day as maize planting.

4.3.1.4. *Tephrosia* sowing time and depth

Sow seed at crop planting to a depth of 1.5cm to 2cm with 3 seeds per station.

4.3.1.5. Seed rate

The recommended seed rate is 1.2.Kg/ha for maize spaced 90 x 90cm. Keep enough seed to replant in case of poor germination after dry spells and to fill any gaps.

4.3.1.6.*Tephrosia* spacing for Alley Cropping

Sow on top of every4th ridge. For maize spaced 90cm within the row, sow 1 station of *Tephrosia* between maize stations.

4.3.1.7.*Tephrosia* spacing for mixed inter- cropping

Sow seeds on top of every other ridge. For maize spaced 90 cm within the row, sow 1 station of *Tephrosia* between maize stations.

Note: Alley cropping and mixed intercropping are not recommended for close spacings of maize, e.g., 75 x 25cm. *Tephrosia* does not compete with crops in the first season due to its slow initial growth. Failure to plant early limits growth and makes it susceptible to pests and diseases.

4.3.1.8. Establishment with nursery seedlings

Use nursery seedlings for *Gliricidia, Leucaena* and *Senn* aspectabilis since direct sowing gives poor results. Plant seedlings at the start of the rains, or soon after planting the crop. The spacing for each system is specified overleaf.

4.3.1.8.1. Inter-row Spacing

Alley cropping: Every 5th ridge.

Mixed Intercropping: Every other ridge.

4.3.1.8.2. Within row spacing

This is the same for both practices. For maize planted 90cm apart, plant one seedling between each maize station.

Note: Do not count marker ridges or vetiver hedges when deciding where to plant hedge rows.

4.3.1.8.3. Number of seedlings needed

Alley cropping: 2,500 seedlings/ha

Mixed Intercropping : 6,200 seedlings/ha

4.3.1.9. Management during the 1st year

This section applies to both alley cropping and mixed tree intercropping.

Plant hedges early otherwise the taller and faster growing crops may retard hedge growth due to shading and competition. To minimize this risk in year one, plant hedges with short-growing or with crops normally planted later in the season such as groundnuts, soya beans, cassava, or sweet potatoes. The growth of the young hedges will benefit from weeding and fertilizing the crop.

4.3.1.9.1. Protection of seedlings

Hedge rows may require protection from browsing animals and trampling. To do this, control animal movements, or establish dead or live fences around the plots. Hedgerows may also be marked with stakes to make them more visible so that they are less likely to be mistaken for weeds. Finally, because establishing hedgerows is labour-intensive, encourage farmers to start small, say 0.05ha. This may be increased gradually to match the desired target area.

4.3.1.9.2.Pruning and biomass management

Begin pruning in the second season if hedges are more than1meter tall. This helps sufficient resilience for recovery after pruning. Prune branches with a clean, upward slanting cut within 2 weeks of planting the crop. Timing is critical to reduce possible shading and competition. The most useful tool for pruning is the tea knife (scauter). Distribute the fresh prunings in the farrows and along the maize ridges. After the leaves fall off, collect all woody branches for fuel wood or tobacco tiers. A mid season pruning is needed only if shading is apparent.

4.3.1.9.3. Pruning after crop harvest:

This pruning supplies most of the biomass produced. Distribute the pruning evenly over furrows, and remove all woody stems after the leaves fall off. Cover the green biomass with soil, or bury it in the ridges with the crop residues. Do this right after pruning to avoid nutrient losses from leaching and exposure to the sun, rain and wind.

If the biomass is low, concentrate it on half the area, otherwise it may be spread too thinly for the desired impact.

4.3.1.9.4. Fertiliser supplements

Hedges contribute considerable organic matter, nitrogen, potassium, calcium, magnesium, and sulphur. If resources permit, supplemental chemical fertilizer will boost crop yields. During the first 2 - 3 years, Nitrogen fertilizer is recommended at 30kg/ ha until the biomass meets the demands of the crop. Use 20-30 kg P205/ha every other year in phosphorous deficient soils, since trees return small quantities of P.

4.3.1.9.5. Re-ridging

Rebuild the same ridges each year to maintain the correct spacing and to avoid losing land for crop production.

4.3.1.10. Calendar of key activities

Year1:

November - December

Establish the hedgerows at the correct spacing with the start of the rains.

January - October

Allow the hedgerows to grow with the crop for the whole season

June - October

Protect the hedgerows from livestock and bush fires.

Year 2 and onwards

November - December

Prune the hedgerows in the correct manner 2 weeks after planting the crop. Distribute the fresh prunings evenly along all the crop ridges as green manure. After the leaves fall off, remove the stems for fuelwood or other uses.

January - February

Prune hedgerows again at midseason. This must be done only if the hedgerows are shading or competing with the crop. Distribute the prunings as done for the first pruning.

May - June

Prune hedgerows after crop harvest. Distribute the prunings evenly over the furrows, and cover the leaf material with soil as soon as the leaves fall off after removing the stems. Leaf biomass may also be buried in the ridges with the crop residues. Burying or covering leaves with soil must be done soon after pruning to avoid loss of nutrients

July - October

Protect the hedgerows from bushfire and livestock.

4.3.2. Green manure banks

Tree banks may be established for green manure using species such as *Leucaena, Sesbania, Tephrosia, Grilicidia* and *Senna spectabilis*. The pruned leaves are collected and transferred to cropping areas for use as fertilizer by applying the leaf biomass to the soil.

4.3.2.1. Spacing

Plant *Leucaena* and *Sesbania* at 0.9m x 0.9m. *Grilicidia* and *Senna* may be planted wider apart at1.8m x 1.8m because of their larger size. Tephrosia is best spaced at 0.9m x 0.45m.

4.3.2.2. Pruning

Prune branches at the start of the growing season to supply fresh leaf biomass for direct application to the desired crop. Pruning at the end of the rainy season provide the bulk of the biomass produced during the year. After sun drying the branches for a few days, shake off the leaves and store for use next season. Stems may again be collected for fuel wood or other uses.

4.3.2.3. Application of leaf biomass

Bury or apply fresh or dry leaves on the surface around the planting stations within 15days of crop emergence. A general guide is to apply leaves at a minimum rate of 1.5tons/ha or roughly a double handful per station (120g/station). Storage of dried leaves for later use should be necessary only when the hedges are young and producing low levels of biomass.

Once the green manure bank is fully established and producing 2 or more tones per hectare, a less labour-demanding system of application may be used such as shaking off the pruned branches at the end of the crop season and may be incorporated into the ridges with crop residues. It is important to do this immediately after pruning to avoid nutrient losses from leaching and volatilisation.

When the bank has out lived its usefulness interms of productive biomass, farmers may opt to remove the bank to cultivate crops.

Table 72: Recommended Hedge Species with Characteristics, Uses and Management

	Leucaena diversifolia	*Senna spectabilis*	*Grilicidia sepium*	*Tephrosia vogelli*
Ecological & Altitude range	50 -1500mm rainfall Basic or neutral fertilesoils 800 – 2000.a.s.l	600 -1500mm rainfall Most types neutral to basic soils 500 - 2000.a.s.l	500 -1500mm rainfall Basic or neutral fertile soils 0 - 2000.a.s.l	800 -1500 mm rainfall Most soil types 500 - 2000.a.s.l
Growth rate	Medium	Medium to fast	Medium	Fast
Biomass yield	Medium	High	Medium to high	Medium to high
Nutrient content	High	Medium to high	High	Medium to high
Forage value	High	None	Low. Good for ruminants; but only use dry or wilted leaves, other parts are poisonous	None
Wood & other values	Good fuelwood & small poles	Good fuelwood & small poles	Fair fuelwood & small poles	Poor wood; foliage for fish poison & insecticides
Life span	More than10 years	Morethan 10 years	More than 10 years	3 to 6 years
Soil/pest & disease problem	Adapted to most soils; tolerant to acidicconditions; resistant to pests	Affected by acidic soils & certain nutrient deficiencies resistant to psyllid & aphids	Affected by acidic soils & certain nutrient deficiencies in soils; some leaf damage	Prone to root nematodes which could harm current or subsequent crops such as tobacco
Seed treatment	Nick	Nick	None or nick	None
Establishment by direct sowing	Poor	Poor	Poor	Excellent
Pruning management height	75cm. Leave 2 to 3 upper lateral branches intact to improve regrowth			
Methods/tools	Use a sharp panga knife to make a clean upward slanting cut. Prune secondary or lateral branches to10 to15cm from the primary or main stem			
Time & frequency	The first pruning is done when the plants are at least 1m tall (usually 12 to 18 months of age) Within 2 weeks of planting the crop and after crop harvest. Prune at mid season only if the crop shows effects of shade or competition from the hedge			

4.4. Tree planting for wood and other products

The majority of trees planted by farmers in Malawi are for fuel wood and building poles in response to the rapid rate of deforestation. Farmers are spending more time in search of wood and are convinced of the benefits of planting trees for this purpose around homesteads, on farm boundaries and in woodlots. Farmers are also planting trees, although less commonly, for other products including animal fodder, green manure, live fencing, and farm sheds.

4.4.1. Homestead, boundary and woodlot planting

Homestead planting is the most popular form of tree planting in Malawi because it is easy to establish and manage, and generates many useful products for household use and sale. Fruit and other Multi-Purpose Tree (MPT) species may be planted along boundaries of farms, roads, homesteads, or simply scattered around the homestead. Trees may also be planted in small woodlots or orchards, depending on available land, or integrated in dimba and home gardens. Planting trees in this manner generates important sources of food, fuelwood, poles, fodder, and income to complement other household and farming activities. Some tree species also have valuable medicinal, pesticidal, or cultural values.

4.4.1.1. Recommended tree species

Any fruit tree such as citrus, avocado, banana, papaya, mango, guava, and custard apple is recommended. Temperate fruit trees may be used in high, cool areas, especially apples, peaches, and plums.

Some common non-fruit MPT species and their uses are listed in Table 73. These include many fast- growing trees that are adapted to a wide range of environments. Species well suited to low and medium elevation include *Acaciagalpinii, A. seiberana, Afzelia quanzensis, Albizia lebbeck, A.zimmermannii* and *Terminalia serices.* Trees that have widespread adaptation include *Acacia polycantha, Bauhinia thonningii, Erythrina abyssinica, Ficus natalensis, Khaya nyasica, Sennasimaea, S.spectabilis* and *Toona ciliata.*

Table 73: Common non-fruit tree species for homestead planting and their uses

Botanic name	Local name	Fuel wood	Timber / furniture	Fodder	Medicine	Growth rate
Acaciagalpinii	Nkunkhu	X	X	X		Fast
Acacia polyacantha	Mthethe	X	X	X	X	Fast
Acacia seiberiana	Minganzolo	X	X	X		Medium
Afzelia quanzensis	Msambamfumu	X	X	X	X	Medium
Albizia lebbeck	Mtangatanga	X	X	X		Fast
Albizia zimmermannii	Mtangatanga	X	X	X		Fast
Bauhinia thonningii	Chitimbe			X	X	Medium
Erythrina abyssinica	Mbwale			X	X	Medium
Ficus natalensis	Kachere		X	X	X	Fast
Khaya nyasica	Mbawa	X	X		X	Fast
Senna siammea	Keshya wa milimo	X	X		X	Fast
Senna spectabilis	Keshya wa maluwa	X	X			Fast
Terminalia sericca	Naphini	X	X		X	Medium
Taoona ciliata	Sendrella	X	X		X	Fast

Note: X indicates use while blank indicates none existence of the function

4.4.1.2. Tree spacing

i) Woodlots: 2m x 2m for fuel wood;
1m x 2m for poles apart.

ii) Around homesteads: 4mx4m apart.

iii) Along boundaries: 2m - 4m apart.

iv) Fruit orchards: 4m x 4m apart.

4.4.1.3. Planting pits

Dig planting pits 60 cm deep x 60 cm diameter before the rains start. Loosely replace the soil in the pits starting with the top soil first, then add the sub-soil.

4.4.1.4. Time of out planting

Plant seedlings with the start of the rains in the wet soil of prepared pits by mid-December or early January. This encourages good root development for survival over the dry season. Preferably, plant early morning or late afternoon to avoid mid-day heat.

4.4.1.5. Out planting method

Use a basket or box to carry seedlings to planting sites. Squeeze the container to loosen soil in the polytube and then place the seedling in the hole with soil around the base. Remove the polytube by pulling it up and over the seedling. If a closed pot is used, open the bottom end so that it can be pulled over the seedling. Continue filling soil around the seedling up to the root collar; then firm the soil around the seedling with the heel of your foot. Make a small basin around the seedling as a micro-catchment to increase moisture retention. Add a double-handful of manure to the soil surface around each seedling to encourage good growth and establishment.

4.4.1.6. Weeding

Cultivate 1m around the base of each seedling. Weed 3 times during the first 2 seasons to improve growth, and to reduce risks of fire damage. Crops may be grown with the trees during this season to ensure weed-free conditions and efficient land use.

4.4.1.7. Pruning

Prune bottom branches of seedlings after the first season to promote straighter, healthier trees and to reduce interference with field operations. Prune when trees begin active growth to reduced ie back, fungal diseases and termite attack. This is April-May for msangu, and October -November for other species. Make clean angled cuts with a sharp blade or saw to reduce injury to the tree. As trees grow to maturity, a few branches may be selectively lopped (removed) to reduce the density of the canopy. Spread the cut foliage on the ground as green manure, or use it as animal feed if the tree is a good fodder species. Collect the wood for fuel or other uses.

4.4.1.8. Protecting trees

Erect a protective fence around each seedling where livestock damage is a problem. Mark other seedlings with stakes to minimize accidental weeding or trampling. Make fire breaks to protect woodlots and other plantings from damage by fires. Mulch or thatching grass placed around the base of the tree will help keep moisture in the soil around the tree. Make sure the mulch is clear of the tree trunk to minimize termite attack. In the event of disease or pest attack, seek advice from the nearest Forestry or Agriculture Office.

4.4.1.9. Calendar for key activities

July - November:

Prepare nursery and raise seedlings.

November – January

Dig planting pits at the correct spacing before the rains; outplant seedlings in wet soil once the rains start, and clear 1m around each seedling.

January onwards

Weed and protect seedlings from animals and bush fire. Manage the trees to provide the desired products on a sustainable basis. This may require replanting and coppicing on a rotational basis.

4.4.2. Fodder banks

Fodder banks are small plots of high yielding plants with nutrient-rich foliage and pods ideal for farmers involved in intensive livestock production. The fodder is especially beneficial in the dry season as a feed supplement, with fuel wood and poles as useful by-products. This practice is recommended for dimba areas which have the best growing conditions and protection from free-ranging livestock.

Recommended species are *Leucaena diversifolia, Gliricidia sepium* and *Sesbania sesban* planted in pure stands.

Note: Feed *Gliricidia* when wilted or dried, and only to ruminant animals, i.e.,cattle, sheep and goats.

4.4.2.1. Establishment and maintenance

Planting: Space trees at 0.9m x 0.9m. During establishment, seedlings may require protection from animals.

Pruning: Begin pruning at the start of the second growing season when the trees are greater than1m tall. This size allows the trees to recover from pruning. Prune branches of *Leucaena* and *Gliricidi*a to 30-40cm with a clean upward slanting cut 1 to 2 weeks after crop planting. Prune *Sesbania* at 75cm using the same angled cut, but leave 2-3 lower branches for faster recovery. Pruned trees may also be pruned again during the rainy season for additional fodder. Pruned material may be dried and fed to livestock, with the branches used as fuel wood or poles. For optimal for age quantity and quality, prune 3 times per year: December, February and June. If fuel wood is a priority, prune twice, first in December then in June. Fodder may also be harvested and fed as needed on a daily basis.

4.4.2.2. Tree pods for fodder

Pods from a number of tree species canal so be used as a feed supplement. These include *Acacia sieberiana, Bauhinia thonnigii, Dischrostachys cinerea,* and *Faidherbia albida* all of which produce substantial quantities of nutritious pods when mature. Pods may be harvested in the dry season (July - September) from the ground undermature trees and stored in bags for later use as a feed supplement.

4.4.3. Live fences

Living fences serve a variety of purposes. Their main function is to eliminate the need to construct and replace dead fences every year, or the cost of purchasing and maintaining wire fences. Often, live fences are planted to keep out domestic or wild animals where they are not well controlled. The live hedge is also used to mark boundaries off arm plots, gardens, or homesteads. Some live fences are used to enclose animals in the form of a khola. Depending on the use, the live fence provides multi-purpose uses such as fodder, green manure, fruits, wood for fuel and farm tools, as well as privacy.

4.4.3.1. Establishment and maintenance

Live fences are considered permanent or semi-permanent structures. Space seedlings 40cm apart. Thorn species recommended in the mid-altitude plateau include: *Acacia galpinii, A. polyacantha, Agave sisalana, Caesalphiniade capetala, Pyracantha coccinea, Ziziphus abyssinica, Z. mauritiana,* and *Z. mucronata.* Thorny species for the Lakeshore/ShireValley include: *Acacia nigrescens, A. polyacantha, Caesalpinia decapetala, Prosopis juliflora, Ziziphus mauritiana* and *Z. mucronata*. Plants that are palatable to livestock are the *Acacia* and *Ziziphus species,* which need protection during the first year of growth. Species that donot need protection from livestock are sisal, *Prosopis* and *Caesalpinia*. Pods from *Prosopis* however are good fodder.

Several species also make good live fence posts. These include species of *Commiphora, Erythrina, Ficus* and *Kirkia acuminata, Moringa oleifera* and *Sclerocaryabirrea.* Plant truncheons (cuttings) of these species 1m apart about one month before the rains and 30 to 50cm deep. If desired, other thorny species can be planted to fill in gaps between the truncheons. Details of planting truncheons are provided in the section under soil and water conservation.

4.4.3.2. Trimming

At the onset of the second or third season, trim hedges to 50-75 cm high to encourage low and dense lateral branching. One plant may be left untrimmed every 5-10m for production of seed, fruit, fuel wood, poles or fodder, depending on the species used. Trim sides and tops of plants to 1-1.5m periodically to prevent excessive spreading growth. Trimmed branches can provide fuel wood, fodder, and thorn material for protecting other seedlings or crops.

Caesalpinia needs frequent pruning to avoid overgrowing and the dangers of becoming weed from prolific seed production.

4.4.4. Live farm sheds

Most farm sheds in the smallholder sector are constructed using dry wood poles which have to be replaced every 2-3 seasons because of termite damage. The volume of wood required exacerbates deforestation.

A sustainable solution is to encourage farmers to use live trees in place of upright poles. The trees may be allowed to grow above the roof during the dry season, and coppiced before or during the rains. Cut branches may be used for crop tiers or other purposes. Since a typical "dead" shed lasts only 3years, live farm sheds reduce labour and maintenance, as well as deforestation. A shed 30m long with 45 upright poles is sufficient to cure 300kg of tobacco.

Although the concept of live farm sheds is new to smallholders, some tenant farmers on tobacco estates are using this technology. *Gmelina arborea* is the most common species used and is raised mainly from seedlings. *Eucalyptus* species have been used with mixed results from poor coppicing. Promising species are shown in Table 74.

Guidelines for establishing and managing live farm sheds are as follows:

i) Carefully match species with the local environment, farmer preferences and availability of planting material. Select species that are fast growing with good coppicing ability. Ideal species are ones that grow well from truncheons to speed up shed construction and use.

ii) Encourage farmers to raise their own nursery seedlings. This can be done adjacent to their crop nurseries or dimba gardens.

iii) If cuttings or truncheons are used, identify species and sources of material before the start of the rains. Cuttings are best taken when the tree is dormant before new leaves appear and not when in flower or fruit. Refer to a section in the Forestry chapter.

iv) Provides takes up ports and prune branches to encourage a straight-growing trunk.

v) Locate the shed near the house or farm, preferably not on good farm land. Establish seedlings or truncheons in the configuration of a typical shed, 2m x 2m in 3lines. The centre line poles are 2.5m to 3m tall, while the outside poles are 1.5-2m tall.

vi) Protect young trees from browsing and other damage to avoid un even or mis-shapen poles. Fill in gaps where seedlings have died, or where truncheons have failed to grow. With truncheons, allow 1-2 years for roots and foliage to develop before building the roof.

vii) Construct the shed only when the live trees are large and strong enough to support the roof. Ensure coppicing is done evenly so that the roof is uniform, sloping from the center down each side.

viii) Coppice/pollard trees which are well established. This can be timed to provide crop tiers and to minimize roof damage from winds. Encourage a fork to form where the roof beams will sit. Coppiced branches may also be used for fuel wood and fodder depending on the species. The bark of some trees may also be stripped from cut branches for use as rope.

Table 74: Trees species suitable for live farm sheds

Species	Local name	Range	Method of establishment
Acacia polyacantha	Mthethe	Wide	Seedlings
Bredelia micrantha	Mpasa	Low to medium	Seedlings
Burttda vyanyasica	Mbvule	Low to medium	Seedlings
Commihpora africana	Khobe	Low to medium	Seedlings/cuttings
Erythrin aabyssinica	Mbwale	Low to medium	Seedlings/cuttings
Ficus natalensis	Kachere	Low to medium	Seedlings/cuttings
Ficus capensis	Mkuyu	Low to medium	Seedlings/cuttings
Gmelina arborea	Malaina	Wide	Seedlings/cuttings
Kirkiaa cuminata	Mtumbu	Low to medium	Seedlings/cuttings
Pterocarpus angolensis	Mlombwa	Low to medium	Seedlings/cuttings
Sclerocarya birrea	Mfula	Low to medium	Seedlings/cuttings
Senna siammea	Keshya wa milimo	Low to medium	Seedlings
Senna spectabilis	Keshya wa maluwa	Wide	Seedlings

CHAPTER 5

SMALLHOLDER CROP AUTHORITIES

5.1 Smallholder Coffee Production

Coffee *(Coffee Arabica)* production in the country has remained on a small scale and is now largely confined to the highland areas of the Northern region where it is the major cash crop. These areas are Misuku Hills, Phoka Hills, Viphya North, Nkhata Bay Highlands and South East Mzimba. The production has extended to Dedza and Ntchisi in the Central Region where coffee cultivation is minimal due to market limitations. Since potential coffee growing areas are in all the regions, there are plans to extend and cover all these areas. Some Coffee is also produced by estates in the other districts such as Thyolo, Mulanje, Zomba Chiradzulu and Nkhatabay.

Smallholder Coffee Farmers Trust (SCFT), started its operations when the Government privatized the functions of Smallholder Coffee Authority through the Privatisation Commission. SCFT is a temporal structure with the aim of managing the transition of the smallholder coffee subsector from being controlled by the government to being controlled by the farmers involved. The objectives of SCFT are to promote;

i) Coffee production through farmer managed and controlled business organisations;

ii) Improved processing and marketing of coffee and other crops for the benefit of the members;

iii) Crop diversification and better land and crop husbandry practices amongst coffee farmers to improve household food security and incomes;

iv) Formation of farmers controlled financial institution for input acquisition and credit services to association members.

5.1.1. National aims

The present average yield is 200-250 kg of clean coffee per hectare. An average yield of 750 kg of clean coffee per hectare can be achieved in all suitable areas. The objective is therefore to narrow the yield gap between current low yield in the smallholder sector and the potential yield while improving quality and encouraging farmers to expand hectarage.

Coffee management should be of the highest standard in order to optimize yields. The following are recommended cultural practices:-

5.1.2. Use of improved varieties

The recommended varieties are Geisha, Agaro and Catimor Populations.

5.1.3. Site selection and terracing

Deep, well-drained soils are required for proper root development. All unwanted trees should be ring-barked and left to die 2 years in advance in order to prevent Armillaria root rot disease. Trees that may not die by ring barking should be dug out with as much root systems as possible. On all slopes of over15%, bench terracing is a must to conserve the soil.

5.1.4. Field preparation, planting, shading and windbreaks

Planting holes should be dug along the centres of terraces or on contours at 2.1m x 2.1m or 2.4m x 2.4m. Each hole should be 60cm deep and 60cm in diameter. This is for the Geisha and Agaro varieties. For the Catimor and all dwarf varieties, a trench of 60cm x 46cm should be dug. The spacing between plants should be 3m between rows and 0.6m between plants. This will result to tree densities of 3,333 to 5,555 per hectare.

Shade trees such as Albizzia spp (Mtangatanga) and Grevillea robusta should be planted within the coffee field at a spacing of 12m x12m to protect the coffee bushes from intense heat of the sun.

Plant a windbreak around the field using fish beans or bananas to protect the bushes from strong winds.

5.1.5. Time of transplanting

Coffee seedlings may normally be obtained from Smallholder Coffee Nursery producers. Farmers are encouraged to raise their own seedlings preferably in groups under the supervision of the Coffee Extension Staff. Transplanting should start with the first planting rains (rains of 50mm or wetting to a depth of 15cm) and should be completed in January to allow the roots to establish before the end of the rains.

5.1.6. Fertilizer application

5.1.6.1. Manure application

One tin (20 litres) of well decomposed manure, 72g of Single Super Phosphate (SSP) and 360g of Lime should be applied to each planting hole during the time of filling the holes before planting. This operation should be completed in September each Year to allow the soil to settle before planting with the first rains in November/ December. Apply manure annually at the rate of 20-litre tin per bush.

5.1.6.2. Chemical fertilizer application

Coffee requires a compound fertilizer in the ratio of 2:1:2 (16:8:16). In the absence of such a fertilizer, Compound J (15:15:20) is recommended and can be obtained from fertilizer selling companies.

Various combinations of 23:21:0+4S, CAN and Muriate of Potash (MOP) or Compound J are recommended depending on age of the bush as shown in Tables 75 and 76. Apply1to 2 tonnes of Lime per hectare depending on the soil and leaf sample analysis results. Evenly broadcast the fertilizer within the drip line of the coffee bush under mulch.

5.1.7. Small scale irrigation

Irrigation of Coffee is important to increase productivity. Small scale irrigation is being promoted in all the Coffee growing areas where access to water is not limiting.

i) Use of gravity

Use of canals to irrigate coffee is economical and affordable to smallholder farmers who have access to water. Farmers should be assisted to lay out the canals on a gradient to ensure steady supply of water to the fields.

ii) Use of canals

Use of canals to irrigate coffee is economical and affordable to small holder farmers who have access to water. Farmers should be assisted to lay out the canals on a gradient to ensure steady supply of water to the fields without causing erosion.

iii) Use of treadle pumps

For fields which are on the higher side from water source, use of treadle pumps to supply water to the field should be followed. The canal to take water to the field should be at a gradient.

iv) Use of Family Drip System

This is a very economical system. It supplies water to the plant only and is also used in applying fertilizers. It is capable of catering for up to 1,000 bushes. The tank is put at 1-metre-high and water can be drawn in to the tank by gravity or treadle pump.

Table 75: Fertilizer recommendation for conventional tall varieties (2,000 trees per ha)

Age of bush	Type of fertilizer	Rate per bush (gm)	No. of applications	Total applied/ Ha(Kg)	Application per bush(gm)	
					Nov/Dec	Jan
To planting hole	SSP or 23:21:0+4S Lime	50-100 50-100 360	1 1 1	100-200 100-200 360	50-100 50-100 360	0 0 0
1st year	23:21:0+4S or Compound J CAN Lime	25 50 25 360	1 1 2 2	50 100 50 720	25 50.0 0 180	0 12.5
2nd and 3rd year	23:21:0+4S or Compound J CAN Lime	50 50 50 360	1 1 2 2	100 100 100 720	50 50.0 180	0 25 0
4th and 5th year	23:21:0+4S or Compound J CAN Lime	50 100 50 360	1 1 2 2	100 200 100 720	50 33.3 0 180	0 33.3 25 0
6th year	23:21:0+4S or Compound J CAN Lime	100 150 100 360	1 3 2 2	200 300 200 720	100 50 50 180	0 50 0

Table 76: Fertilizer recommendation for catimor population (Dwarf varieties 5,555 per ha)

Age of bush	Type of fertiliser	Rate per bush (gms)	No. of applications	Total applied/ Ha(kg)	Application per bush(gms)				
					Nov	Dec	Jan	Feb	Mar
To planting hole	SSP Lime	72 360	1 1	4,000 2,000	72 360	0 0	0 0	0 0	0 0
1st Year	Compound J Lime	90 360	4 2	500 2,000	0 0	22 120	22 120	23 120	23 0
2nd year	Compound J Lime	132 360	4 2	735 2,000	0 0	33 180	33 0	33 180	33 0
3rd year	Compound J Lime	210 360	4 2	1,170 2,000	0 0	52.5 180	52.5 0	52.5 180	52.5 0

5.1.8. Mulching and firebreaks

Mulching should be done in March/April in order to retain soil moisture, regulate temperature and suppress weeds. To prevent fire from destroying the Coffee bushes, fire-breaks of 3m wide should be made around the coffee fields.

5.1.9. Pruning

Pruning which applies to Geisha and Agaro is intended to serve 3 major purposes namely:

i) Training the coffee tree to a required growth habit.

ii) Enhancing new shoots to grow on bearing branches there by promoting formation of flowers which will bear the crop; and

iii) Minimizing build-up of pests and diseases. Single stem pruning with 3 cappings at 60cm, 120cm and 180cm tree height is recommended. Prune by removing all dead woods or branches, interlocking branches and suckers. Pruning should be done soon after harvesting in September/October.

Pruning allows air to circulate within the plant, provides all parts of the tree access to solar radiation (sunlight) and better spray penetration.

Handling (removal of unwanted shoots) should be done anytime shoots appear on the tree. It is important for every coffee grower to have secateurs for pruning.

Catimor and all dwarf varieties are not pruned.

5.1.10. Pest control

Coffee suffers attacks from a number of pests which severely limit production. Control of pests through cultural practices is more appropriate especially to smallholder farmers because of financial constraints. Field hygiene is, therefore, very important in minimizing the effects of pests. Similarly, correct insecticide application at the right time is recommended for best results.

5.1.10.1. Weed control

i) Mechanical control

Coffee grows well in fields which are free from weeds because there is no competition in the uptake of nutrient sand water. Hand weeding should be done near the Coffee trees while a hoe should be used away from the trees to avoid bruising the stem and roots. Where fields are properly mulched, weeding is very minimal because weeds are suppressed.

ii) Herbicide control

The use of herbicide to control weeds in coffee is another method that is promoted. Apply herbicides using the correct nozzles. Apply the herbicide in the inter row. The application of herbicides should be done on a calm day, early in the morning or late in the afternoon to avoid drift, which can kill the coffee trees. An example of herbicide used in coffee is Glyphosate at a rate of 1.2 litre per ha.

5.1.10.2. Insect pest control

Insect pests of economic importance in coffee are: Antensia bug *(Antestiopsis orbitalls)*, leaf miner *(Leucoptera meyricki)* and stem borers. Antensia bug can be controlled by proper pruning as they do not like light. Lambada cyhalothrin (Karate 5 EC)at the rate of 3ml in15 litres of water should be used to control antensia bug and leaf miner. Granular system insecticide, for example Furadan 10g and Disyston 5g evenly applied in a ring within the drip line of the coffee bush and under the mulch at the beginning of the rains may also be used specifically for leaf miner control. Fenitrothion 60EC also controls stem borers, however, farmers should be trained to identify the adults so that they can kill them physically when they are out from the plants during mating season (October-December).

Economic threshold for Antensia bug is either more than 2 bugs on any single tree or more than 3 bugs on10 trees. For a leaf miner, spray when more than 35 moths are found after shaking trees.

5.1.10.3. Disease control

Coffee Berry Disease and Leaf Rust are the 2 most important diseases that attack coffee. However, leaf spot can be severe in the nursery and Fusarium bark disease can cause severe damage if proper cultural practices are not followed.

Strategically applied foliar sprays of the copper based products during the rainy season form the basis of any successful disease control programme for coffee.

i) Coffee Berry Disease (CBD) ***(colletotri chum coffeanum)***

During the period of 16 weeks after blossoming, the developing berries are most susceptible to CBD infection. Tank mixes of Daconil 2787-75WP and Copper Oxy-chloride 85WP, Cupric Hydroxide (Kocide 101) 50WP at half the full recommended rates (that is 2.2 kg/ha and 5.5 kg/ha respectively) effectively and more economically control CBD. Chemical control for Coffee Berry disease should start at the beginning of rains (November/December) and continue up to the end of the rains (March/April) at 4 weekly intervals. The berries are also susceptible to the disease at ripening. Stripping cherries after harvesting and proper pruning to reduce prolonged wetness will reduce the disease

ii) Coffee Leaf Rust ***(Hemileia vastratrix)***

The disease can result in heavy leaf defoliation of the affected trees and results in "dieback".

Control measures

a) **Use of resistant Varieties**
Farmers should be encouraged to plant Catimor Populations which are resistant to all races of the known Coffee Leaf Rust.

b) **Use of cultural methods**
Pruning and regulation of shade trees will keep the disease down.

c) **Chemical Control**

Culpric Hydroxide (*Kocide101)* 50WP or Copper Oxy-chloride, 50WP at the rate of 52.5g (2.5 conical cups) into 15 litres of water sprayed to 15 bushes controls the disease. Any of the triazole group of fungicides, for example, Triadimenol (Bayfidan) 250EC, Alto100SL, and Hexaconazole (Anvil) 5EC will also control the disease and should be used as a curative measure at the rate of 28ml in 15 liters of water when 10% or more of the lower leaves are affected using 10 random sample bushes. If leaf rust persists after 2 weeks, respray but not 2 weeks before harvesting or after the rains have ended. The triazole group or fungicides should only be applied twice per season to prevent disease resistance.

iii) Fusarium Bark Disease ***(Fusarium stillboides)***

This is a seed borne disease, therefore, seed must be free of infection by treating with Benomyl (Benlate) 50WP at 1g per 1kg of seed before planting on the nursery. As the seed emerges, the disease is characterised by matching lesions on both cotyledonous leaves. In the field, scaly barks and collar rots are also symptoms of the disease.

Uprooting and burning of infected bushes is one of the remedies for this disease. Leave the hole open after uprooting the bush for a minimum of 6 months before replanting. After pruning, paint the wounds with copper based fungicidal paste such as Copper Oxy-chloride.

iv) Leaf Spot ***(Cercospora coffeicola)***

If this disease occurs in nurseries, control is by spraying Copper Oxy-chloride 85WP at the rate of 9 cupfuls of cup No.8 in 15 litres of water. In the field, mix 6 vaseline blue seal cups of the chemical in 15 litres of water and spray 15 trees.

5.1.11. Harvesting and marketing

To achieve high quality coffee, only cherries that are fully ripe should be harvested. Over ripe and under ripe cherries damaged in the pulping process produce beans with strongly tainted flavors in the “liquor”. This leads to down grading of the coffee produced. It is therefore important to pick cherries at the correct stage of ripenes.

All Cherries that have been picked should be pulped or sold for pulping the same day. Dried parchment coffee should be graded and sold to Smallholder Coffee Farmers’ Trust.

5.2. Smallholder Tea Production

Tea (*Camelia simensis)* is an important export crop in the country and is the third earner of foreign exchange from tobacco and sugar. The growing and production of tea in Malawi is largely confined to areas of Mulanje, Thyolo and Nkhata-Bay. Tea grows well in medium to high altitude areas with well distributed annual rainfall exceeding 1250mm, where there are deep, acidic and well drained soils. It thrives in escarpment areas which receive some off season rains such as chiperoni in May to October. Tea production by smallholder farmers contributes significantly to national total production. The bulk of the production is however grown by the estate sub sector. The aim is therefore to encourage the smallholder tea production in order to ensure achievement of the government objective of poverty reduction for the rural masses.

5.2.1. National aims

In improving tea production, the government aims at improving the country's earnings through a continued consolidation and expansion of the tea industry based on improvements made with regard to productivity on land as well as quality of tea; and enabling smallholder growers earn cash incomes through tea production so that they improve their standards of living.

Average yields range from 6,000 kg to 7,000 kg per hectare of green leaf per year. A potential yield of 10,000 kg per ha may be achieved particularly under good management and use of improved clones/varieties. The objective is therefore to increase yields towards the potential while improving quality. The following are the specific objectives:-

i) To expand the area grown under tea in order to enable new growers be absorbed into the Tea Industry.

ii) To improve smallholder tea grower services such as agricultural extension, green leaf transportation operations and rehabilitation of customary land previously grown under annual crops.

5.2.2. Improving yields and quality

In order to improve both yields and quality, the following cultural practices are recommended:-

5.2.2.1. Varieties

The recommended tea varieties for smallholder growers are:-

SFS 150, SFS 180, SFS 204, PC 81, PC 108, PC110, PC 113, PC 117, PC 119, PC 122, PC 123, PC 165, PC 168, PC 184, PC 185 and PC 198.

5.2.2.2. Site selection

The soil should be deep, fertile and well drained with pH ranging from 4.5. to 6.0. Site selection checklist is as follows:

Permanently unsuitable land

This type of land is usually very localized and easy to identify. Water logged, dambos or other poorly drained land prevents root development, retards growth and often causes early death. Slab rock or shallow soils prevent root development and causes early death. Old house, khola sites and brick kiln sites, charcoal pits and anthills are alkaline and tea will not grow well on them.

Temporarily unsuitable land

i) **Land on which trees are growing:** Removal of trees without ring-barking always leads to deaths of subsequently planted tea due to root rot. This can be prevented by ring-barking all trees in the plot and allowing them to dry out, die and uprooted.

ii) **Heavily cropped and eroded land:**

This type of land should be protected by constructing a storm drain or contour bund at the top of the plot.

The plot should be planted with guatemala grass and left for 1 to 2 years before tea is planted.

iii) **Very steep land**

Land steeper than 25 % has to be terraced.

5.2.2.3. Location

The current policy for smallholder tea production is to consolidate the existing areas. No plots outside the block boundary are accepted.

5.2.2.4. Field preparation and spacing

Land preparation starts with ring barking of trees followed by uprooting. After uprooting, soil and water conservation structures should be designed before planting.

As soon as bunds have been constructed, master rows should be marked between each pair of bunds. Ridges should be 60cm parallel to master rows. Planting stations should be 90cm apart along every second furrow. This gives a plant population of 9,250 bushes per ha.

5.2.2.5. Pitting

Planting pits shouldbe dug well in advance of planting to trap water from early rains. Pits should be dug 45cm deep and 25cm wide.

5.2.2.6. Planting

Tea should be planted between late December to mid-February when soil is warm, well aerated and its nutrients most easily available. Before planting, mix the soil with 60g (two match boxes) of single superphosphate fertilizer. Fill the pit to the right level with soil so that when the pot stands in the pit the collar of the seedling is at the same level with the surrounding soil. Place the plant in the pit and fill a few centimeters of top soil around the base of the pot. Gently pull the polythene off while supporting the pot with the other hand.

5.2.2.7. Box - ridging and mulching

Box ridges should be made to trap rain water and protect the soil from being eroded. Box ridges should be at 90cm long interval with the tie ridges two thirds the height of the row ridge.

Soil moisture should be conserved by mulching using either a layer of grass or any other organic material which when laid on bare soil will also act as a buffer against the impact of raindrops. Farmers should be encouraged to plant guatemala grass (*Trispacu laxum*) and use it for mulching.

5.2.2.8. Fertiliser application

Fertilizer should be applied based on soil and leaf analysis. In the absence of such analyses, use rates as indicated in Table 77.

5.2.2.9. Pruning

Young tea bushes of between 2 to 5 years should be pruned annually while old bushes of 6 years should be pruned bi-annually. Pruning should be done according to details given in Table 78.

5.2.2.9. Young tea

Tea which is in its second and third year should be pruned starting from 16th July and finishing by 31st of the same month. For tea in its fourth or fifth year start on 25th June and finish by 14th July to reduce water loss in the bushes. In young tea timing is important to protect the young bush from moisture stress during the dry period.

5.2.2.10. Mature tea

Tea in its 6th year up to 26 years should be pruned starting from 1st May and finish by 31st of the same month because it does not take long to regenerate.

5.2.2.11. Old tea

Tea should be down pruned once every 28 years starting from 1st March and finish by 31st of the same month to take advantage of soil moisture and to facilitate quick regeneration.

Those plants which are pruned late may have small buds killed by thrips in the dry season giving a delayed return and consequent severe loss of crop

Table 77: Fertilizer recommendations in tea production

Year	Kg N/ha	Source of N (kg/ha)	Number of coca-cola bottle tops per bush	0:22:30 Complex (kg/ha)	No. of coca-cola bottles tops per bush.
1	30	SA 143	2.5	-	-
2	30	SA 190	4	-	-
3	50	SI 238	5	-	-
4	65	SA 310	5.3	-	-
5	80	SA 381	7	75	2
6	95	Urea 207	4.5	86	2.5
7	115	Urea 250	5.5	105	2.5
8	130	Urea 283	6.5	118	3
9	140	Urea 340	7	128	3
10	150	Urea 326	7.5	136	3
11	150	Urea 326	7.5	136	3
12	150	Urea 326	7.5	136	3
13	160	Urea 348	8	145	3.5
14	160	Urea 348	8	145	3.5
15	160	Urea 348	8	145	3.5
16	160	Urea 348	8	145	3.5
17	165	Urea 359	9	150	4
18	165	Urea 359	9	150	4
19	165	Urea 359	9	150	4
20	165	Urea 359	9	150	4

Table 78: Pruning and tipping recommendations

Age of tea in the field	Pruning height (cm)	Tipping height (cm)
2	32	60
3	34	60
4	36	60
5	38	60
6	40	60
7	No pruning	No tipping
8	42	62
9	No pruning	No tipping
10	44	64
11	No pruning	No tipping
12	46	66
13	No pruning	No tipping
14	48	68
15	No pruning	No tipping
16	50	70
17	No pruning	No tipping
18	52	72
19	No pruning	No tipping
20	54	74
21	No pruning	No tipping
22	56	76
23	No pruning	No tipping
24	58	78
25	No pruning	No tipping
26	60	80
27	No pruning	No tipping
28	40	60
29	No pruning	No tipping
30	42	62

5.2.2.12. Pest control

5.2.2.12.1. Weed control

Tea should be kept free from weeds to minimize competition for moisture and nutrients. Weeds can also be a fire hazard particularly during the dry season.

5.2.2.12.2. Insect pest control

i) Tea thrips *(Scirtothrips aurantii)* and **Mosquito bugs** *(Helopeltis schoutedeni)*

These are major pests of economic importance in the tea industry. Chemical sprays of Cypermethrin (Sherpa 20 EC, Cymbush EC, Ripcord 20 EC) are required where infestation of these insect pest has reached economic threshold levels. Recommended rates for the control of tea thrips is 5ml in 15 litres of water. For mosquito bugs it is 10ml in 15 litres of water. Where mosquito bug is prevalent, preventive sprays are recommended after pruning

ii) Jelly grub *(Niphadolepis alianta)*

Of late the appearance of this inspect pest has increased and is causing serious damage. Control is either by hand picking or spraying with Cypermethrin at the rate of 50 ml to 62.5 ml per ha in 15 litres of water.

iii) Carpenter moth *(Teragra quadrangula)* This is also a pest of economic importance. Carbaryl 85 WP at the rate of 1kg per hectare is recommended for controlling the insect pest. It is strongly recommended that the growers seek extension advice wherever insect pests are observed. Chemical control should only be used when insect populations have reached economic threshold levels.

5.2.2.12.3. Disease control

Armillaria root rot which causes death of tea bushes is caused by armillaria mellea. This fungus lives on the roots of trees and occurs naturally in forests and bushes.

Planting tea on land that contains dead roots of other tree species or near live trees is the mode of infection. Infected tea bushes become weak, leaves turn yellow, wilts and eventually the bush dies. The affected bush including the surrounding ones should be dug up at wilting stage to avoid spread of the disease. The dug up bushes should be burnt immediately on site.

5.2.2.13. Harvesting

A grower's income is directly related to his plucking skills. Plucking is, therefore, one of the most important activities that a farmer does in his field during the whole year.

Plucking should be done so that shoots of 42 days old are always plucked during the main growing season. This is achieved by following a regular plucking round of 7 days, 10 days alternating with 11 days or 14 days from the end of December to the end of April. Thereafter, this should be extended to 21 days. Growers should adhere to the plucking round of their choice throughout the season. Growers are strongly advised to pluck only shots consisting of either 2 leaves and a bud or soft banjhi (dormant shoot). Plucking of small shoots that consists of one leaf and a bud is not recommended because yields are later on reduced.

Where 4 leaves and a bud develop because of vigorous growth, only 2 or 3 leaves and a bud should be plucked. To maintain the plucking table, the remaining leaf (leaves) should be removed. This process is called breaking back.

.

5.3. Smallholder Sugarcane Production

Sugar is Malawi's second largest agricultural industry and second largest agricultural export commodity after tobacco. The total area under sugarcane is 25,539 ha with 20,177 ha under Illovo and the rest under smallholder farmers. The industry produces about 300,000 tons of sugar per year, of which about 55% to 70% is consumed domestically and the rest is exported.

Production of sugarcane (*Saccharum officinarum*) by smallholder farmers for chewing is nationwide in Malawi. However, production of sugarcane for processing has been confined to Dwangwa in Nkhotakota district and Nchalo in Chikwawa district. In both Dwangwa and Nchalo, sugar mills are managed by Illovo Sugar Group (Illovo). Illovo has sugar estates in Nkhotakota District (Dwangwa) and Chikwawa district (Nchalo). There are about 4000 smallholder farmers producing sugarcane besides that produced by Illovo estates. These out grower associations and companies produce 21% of total sugarcane that is processed into sugar by Illovo. About 70% of the area for out growers is under irrigation while the rest is rain-fed. The several out grower associations have a national umbrella body called Sugarcane Growers Association of Malawi (SUGAM).

A new sugar mill has been commissioned in Salima at Chikwawa estate.

Considering current investments in sugar milling, smallholders offer the best opportunity for extension of the area under cane and for productivity gains, and are therefore vital to the future success of the Malawian sugarcane industry.

5.3.1. National aims

The objective of Sugarcane Growers Association of Malawi (SUGAM) is to promote and foster

the development of sugar production by the participation of smallholder farmers in the growing of sugarcane in specified areas deemed suitable within Malawi. Among other things, SUGAM is there to facilitate capacity building initiatives for smallholder sugarcane growers' associations in Malawi. The aggregate long term yields have averaged 103,000 kg cane per ha (13,620 kg sugar per ha).

The aim is therefore to improve the average production for smallholders to 120,000 kg cane per ha (16,500 kg sugar per ha).

5.3.2. Improving yields and quality

Apart from general crop management, weather and varietal characteristics are also critical to cane and sugar production. Crop husbandry factors leading to improving yields include timely planting, proper irrigation, correct and timely fertilizer application, timely weeding, disease and pest control, gap filling to maintain optimum plant population, drainage, dry off periods and harvesting.

Weather factors favourable for cane growth are temperatures measuring on an average 20oC minimum and 30oC maximum at elongation phase (from September to March); and rainfall averaging 1,000 to 1,500mm annually, evenly distributed throughout the rainy months of December to March. Sunshine averaging 8 to 9 hours per day is ideal. Depending on their genetic characteristics cane varieties are staggered to suit their optimum harvesting periods to sustain an optimum overall smallholder sugarcane growers' average cane and sugar production.

Harvesting schedules are dependent on maturity periods of cane varieties. Early maturing varieties are placed early in the harvesting programme (May to July), intermediate maturing varieties are harvested in the middle of the programme (August to September) and late maturing varieties are harvested last, (October to November) without significant decline in yields.

5.3.3. Cane varieties and yields

Current varieties in commercial cane growing are

NCO 376, NI4, CO 775, Triton, Waya, B41-227, N19, N23, N25, N41, CO 62175, MN1, R570 and R579

NCO 376, N14 and MN1 flower and mature early; and are therefore ideal for early harvesting. The average yields of these varieties are 140,000 kg cane per ha (17,000 kg sugar per ha).

CO 775, N25, N19, Co 62175, and Triton flower in the middle of the season and are therefore suitable for second harvesting. CO 775 has an average yield of 117,000 kg cane per ha (19,000 kg sugar per ha); while Triton has an average yield of 130,000 kg cane per ha (19,000 kg sugar per ha).

Waya, R570 and B41-227 are shy flowering and suitable for late harvesting. Their average yield is up to 106,000 kg cane per ha and 16,000 kg sugar per ha.

5.3.4. Field preparation

Fields should be prepared and planted between May and November. Planting cane on virgin land starts with bush clearing, leveling, sub-soil ripping, ploughing, harrowing, feeder irrigation building and making planting furrows which are later converted into cane ridges spaced at 1.5 m interval. When replanting an established field, ratoon stools are ripped off and thereafter the procedure is as described above.

For rain fed cane production, ridges should be spaced at 1.0m interval.

5.3.5. Planting

Before planting, furrows are pre-irrigated to moisten the soil. Seed cane obtained from immature plant cane of 8 to 10 months must be topped at the natural breaking point and the roots cut off. Any dead or damaged buds must be discarded. Cuttings (setts) should have 3-6 nodes. Plant by laying stem cuttings (setts) 'head to toe' in furrows to get a better and more even germination.

Cover the cuttings thinly with soil using a hoe. When planting on a large scale, whole sticks may be used and chopped into halves while laid into the furrows. Irrigation should follow planting as soon as possible to bring the soil to the field capacity.

Planting can be done as single stick, one and a halve stick or double stick. The planting rate of one and a half stick will use a seed rate of 8 tons per hectare and should be considered only when seed cane is of excellent quality and if the internodes are short. Using double stick will require 10 tons per hectare or more and is preferred of the seed cane is available.

If row spacing is narrower than 1.5m, seed rate will increase up to 13 tons per hectare.

NB-for varieties that are susceptible to smut such as N14 and NCO 376, seed cane must be stripped of all trash and setts submerged in Bayleton solution (75ml Bayleton/75 litres of water) for 5 minutes before planting. This is a preventive measure against smut disease.

5.3.6. Fertiliser application

Fertilizers in sugar cane are applied using a 714 cc cup.

5.3.6.1. Plant cane (newly planted cane)

Apply DAP at the rate of 250 kg per hectare into furrows when the cane has sprouted using one cupful per 18m of row length. Alternatively, apply 300 kg DAP per hectare into furrows when the cane has sprouted using one cupful per 14m of row length. When cane is 30cm high, apply 260 kg Sulphate of Ammonia using 1 cup full per 18m of row length, and 300 kg Muriate of Potash using one cupful per 13m of furrow length. Top dress with Urea at 150 kg per hectare using 1 cupful per 21 metres of furrow length after 8 to 12 weeks of basal dressing.

5.3.6.2. Ratoon cane

After cane is harvested, the stool ratoon to a new crop. Fertilizer recommendations for the ratoon crop are as follows:

i) **Basal dressing**

Apply the following fertilizers at the same time using the following rates: - 200kg Sulphate of Ammonia per hectare applying 1 cupful per 24m of furrow length; 130 kg or 300 kg of DAP per hectare applying 1 cupful per 34m and 14m of furrow length, respectively; and 200 kg or 400 kg Muriate of Potash per hectare applying 1 cupful per 23m and 11m of furrow length respectively. Depending on foliar analysis, Zinc and Sulphur carriers should be applied at appropriate rates.

ii) **Top dressing**

Apply 250 or 300 kg of Urea per hectare within 7 weeks of basal dressing using 1 cupful per 14m and 11m of furrow length, respectively.

5.3.7. Irrigation

The first irrigation to bring the soil to field capacity follows soon after planting and for the ratoon soon after cane is harvested and transported to the factory. Thereafter irrigation is based on water usage throughout the dry season, that is a maximum of 2 cycles a month in low temperature months (April to July) and 3 to 4 cycles a month in high temperature months (August to November). Furrows are shaped using a tractor to ensure smooth flow and even distribution of irrigation water.

5.3.8. Drainage

At the onset of rains, farmers should clear the furrows of any obstacles which may lead to standing water in the fields. Tail ditches should also be cleared of weeds and silt to stop water standing.

5.3.9.Pest and disease control

5.3.9.1. Weed control

Weed competition is undesirable in young cane. Early and timely weeding should be maintained until the crop establishes full canopy after which weeds are less competitive. A maximum of 3 to 4 weeding cycles is recommended.

5.3.9.2. Insect pest, nematodes and monkeys

Pests which have been observed in the field include aphids *(Melanaphis sacchari)*, beetles *(Melolonthidae)*, stalkborers *(Eldanas saccharina*), scales *(Aulacosysis tegelensis)*, mealy bugs *(Saccharicosccus sacchari)*, nematodes *(Meloidogyne spp)*, grubs *(Heteronychus licas)* and monkeys *(Cercopithecus pygerythrus)*. Insect pests and nematodes are presently not of economic importance, hence use of pesticides and nematicides are currently not recommended. Monkeys are kept off the field by scaring.

5.3.9.3. Disease control

Smut (Ustilago scitaminea) is the only disease of economic importance which has been observed in the estate. The disease is reduced by using tolerant or resistant varieties such as B41-227, Waya, CO775 and Triton; elimination of volunteers from previous cane crops and roguing infected cane. It can also be controlled by ploughing out field where smut percentage is up to or exceeds 4 %.

5.3.10. Firebreaks

Firebreaks of 3 to 8 metres wide depending on the shape of the fields should be made. These should be cleared from April to May around the fields to prevent creeping fires.

5.3.11. Cane harvesting

Plant cane and ratoon cane are harvested at 12, and 10 to 12 months, respectively. To facilitate cutting, cane is burnt before harvesting to reduce trash, after giving it a dry off period of 60 to 80 days in cool months of May to July and 42 days in hot months of August to October. Dry off (withholding irrigation) is important to improve quality of cane and to ease haulage.

Harvesting is done by cutting the cane off at ground level using curved cane knives. The cane is topped and bundled in 6,000 to 7,000 kg stack ready for mechanical haulage.

Heavy trash should be windrow burnt. The unburnt trash should be evenly scattered within the field.

CHAPTER 6

ANIMAL HEALTH AND LIVESTOCK DEVELOPMENT

Livestock figures for 2016-2017 Physical year were 1,449,654 for beef cattle, 903,55 for dairy cattle, 17,672,737 for goats, 302,090 for sheep, 5,051,874 for pigs, 99,995,311 for all chickens, 5,823,436 for pigeons/doves, 2,339,030 for for ducks, 2008,983 for guinea fowls and 1,735,875 for rabbits (DAHLD APES figures Round 3, 2017). Although there is scope for increasing the numbers of livestock, this should be viewed with caution particularly in areas with an overstocking problem. It is more important to improve the productivity of existing livestock than increasing numbers.

Greater attention has to be paid to practices that will lead to increased productivity of livestock and increased offtake while conserving the grazing areas. Farmers should be advised to cull unproductive animals and sell surplus stock.

There is an increasing scope for more smallholder farmers to keep a few productive cattle for beef or milk production. Advice for improved pasture and fodder production is now available to support the programme.

Farmers should be encouraged to use improved bulls and castrate or sell surplus bull calves. Inbreeding should be discouraged in favour of using good quality bulls from other distant unrelated herd. Improved bulls may be bought from Government livestock farms and commercial producers.

Herds should be allowed at least eight hours of grazing and should not be walked back to the villages at mid-day. Farmers are advised to use crop residues and agro-industry by-products such as bran, molasses and cotton seed cake in animal feeding.

Large number of calves die because of parasites and parasitic diseases, poor nutrition, and poor management in general, particularly housing. Every cattle owner should have a properly roofed calf khola and be advised to follow good husbandry practices. Manure from properly housed cattle is a very valuable by-product.

Farmers should consider the advantages of keeping more sheep and goats. Use of improved locally available genetic material is encouraged. However, exotic rams and bucks and their crosses such as Dorper sheep and Boer goats are available from Government farms, commercial farms and other small scale producers. Farmers should be advised on improved feeding and housing. Worms and respiratory diseases are common in goats and sheep and should be controlled.

The poultry industry is expanding fast. Commercial breeds of broilers and layers are available from several commercial producers. The hardy Black Australorp (Mikolongwe) chickens are still being produced and are available from the Department's outlets at day old, six weeks and fertile eggs.

Poultry keepers are advised to expand their units depending on their capability and availability of the market for their product. Diseases become more common unless houses are cleaned and disinfected thoroughly between batches. Do not mix age groups.

Houses should be cleaned and disinfected and left for two to four weeks before restocking. Where chicksand feed have to be purchased, they should be obtained from reliable suppliers. Farmers should be encouraged to seek advice on vaccination from veterinary staff.

6.1. National aims

The mission statement for the Department of Animal Health and Livestock Development (DAHLD)is to ensure sustainable livestock development to improve nutritional well-being of Malawians and improved rural livelihoods while guaranteeing the safety of the general public from consumption and utilization of livestock products and by-products.

6.2. ANIMAL HEALTH

6.2.1. Disease Control

The mandate of animal health is to promote increased and sustainable livestock production and productivity through the provision of animal health and production services and the protection of the public from zoonotic diseases (diseases transmitted between man and animals).

6.2.1.1. Veterinary Stations

Veterinary stations are centers where dissease control services are provided.The services offered in the stations are:

i) Animal treatment
ii) Vaccinations
iii) Animal husbandry extension services

The stations therefore cater as animal health extension centres and are located throughout the country. Farmers are encouraged to bring their animals for attention. More specialized advice can be obtained from District Animal Health and Livestock Development Officers (DAHLDO) at District Agricultural Offices and Chief Animal Health and Livestock Development Officers (CAHLDO) basedatAgricultural Development Divisions(ADD) Headquarters. Farmers are encouraged to carefully read and understand instructions on the labels and instruction sheets interms of administration of any shelf drug purchased. Prescription drugs should only bead ministered by qualified veterinary personnel.

6.2.1.2. Movement Control

Livestock owners are required to get a permit by law (chapter 66.02 Laws of Malawi), before animals are moved from one veterinary station area to another.

Movement permits are encouraged because they serve the following purpose:

- Prevention of spread of infectious diseases such as Foot and Mouth Dis ease and African Swine Fever present in an area at a particular time,
- To curb livestock theft,
- To show livestock ownership,
- To control the slaughter of the immature and breedable stock,
- Traceability.

Assistant Veterinary Officers can only issue a permit for movement of livestock from one station to another within the same District. The Chief Animal Health and Livestock Development Officer will issue a permit for a movement of livestock from one Agricultural Development Division to another and the Director of Animal Health and Livestock Development issue International Livestock movement permits. When moving animals, owners should have the permit ready for inspection by veterinary officers or other officials authorized by law.

Animals will not be allowed to move at night unless under special permission given by the veterinary authority.

Farmers are urged to comply with the movement control or restriction measures put by veterinary authorities during a notifiable disease outbreak.

6.2.1.3. Reporting of sickness or death

The most important notifiable livestock diseases in Malawi are African Swine Fever (ASF), Black Quarter (BQ), East Coast Fever (ECF), Foot and Mouth Diseases (FMD), Lumpy Skin Disease (LSD), New castle Disease (ND), Rabies, Rift Valley Fever (RVF) and Bovine Tuberculosis. Livestock owners should report to the nearest veterinary office or agricultural office if they suspect any of these diseases.

Farmers should report the death of livestock to the nearest veterinary station before disposing off the carcass. The Department will then investigate the cause of death through systematic collection and analysis of appropriate samples and may institute temporary restriction on movement of animals or carcasses, market and slaughter of animals if a notifiable disease is suspected. It is dangerous to sell meat from an animal that was not inspected before and after death. People maybecome sick if they consume infected meat. Infected meat and livestock products can also spread livestock and human diseases.

6.2.1.4. Vaccinations

Compulsory vaccination against Foot and Mouth disease is done thrice when there is an out break with the first round of vaccination done followed by a booster vaccination after two weeks and the third vaccination after six (6) months. Thereafter annual vaccinations atsix (6) months intervals should be done to ensure prolongred protection against the disease.

Vaccinations for other diseases such as Black quarter, lumpy skin, Newcastle, Rabies. Gumboro and tick-borne diseases are recommended too.

6.2.2. Notifiable Livestock Diseases

6.2.2.1. African Swine Fever

This is contagious viral disease of pigs characterized by fever, diarrhea and discolouration of the skin. The majority of affected pigs will die. Haemorrhages will be seen on many of the internal organs at post-mortem.

Fig. 32a: Skin discolouration due to African Swine Flue

The disease is transmitted by contact with sick or dead pigs, or pigs which have recovered from the disease, infected pig meat or contaminated objects such as feed, water and boots of people working with sick pigs and vector tick, (*Ornithodorus moubata*).

Fig. 32b: African Swine Fever infected pigs

If African Swine Fever is suspected, report immediately to the nearest veterinary office. If the disease is confirmed, a temporary ban on the movement of pigs and sale of pig meat, destruction of all sick and dead pigs will be enforced in the area. Pig owners should cooperate to ensure that these measures are successful in stopping the spread of African Swine Fever.

African Swine Fever is endemic in the Central region and has recently spread to both Southern and Northern Regions. Control is difficult because there is no vaccine for this disease. It spreads easily where pigs are kept in a free-range or scavenging system. Both wild pigs and ticks (Ornithodorus moubata)can transmit the disease. Commercial farmers should keep pigs in brick or concrete buildings surrounded by a double fence, toprevent contact with domestic and wild pigs.

To stop African Swine Fever getting into thefarm, farmers should always be advised to quarantine newly purchased pigs for at least two weeks. Farmers should buy feed from places which do not keep pigs and not to go near other peoples' pigs. They should give stockmen boots to wear on their farms. Farms should not buy pig meat and bring it on to the farm.

6.2.2.2. Blackquarter (BQ)

Black quarter is caused by a Bacterium called Chrostridium chauvoei present in the soil especially in dambo grazing or cultivated field. Cattle become acutely lame on one leg and die within a few hours. The limb is swollen and affected muscle looks black. The carcass of an animal which has died of Blackquarter is full of spores of the causal bacterium. Do not cut up (butcher) the carcass nor use the meat because it will spread the infection.

Bury or burn the carcass and disinfect the area where the carcass was lying.

Vaccination is recommended in endemic areas such as Chitipa, Karonga, Mzimba South, Kasungu, Dowa, Salima, Lilongwe and parts of Dedza. Full protection is achieved by vaccinating cattle twice in the first year of life, and vaccination is only recommended if the disease is known to be present.

6.2.2.3. Foot and Mouth Disease

This is a very contagious viral disease which affects cloven hoofed animals like cattle, sheep, goats and pigs. The disease is milderin sheep and goats as compared to cattle and pigs. Buffalos in the national parks are carriers of the disease. Malawi experiences sporadic outbreaks. The disease has in the past occurred in the districts of Karonga, Chitipa, Mzimba, Chikwawa, Nsanje and Blantyre.

In cattle the classical clinical signs of the acute disease include: drooping salivation; painful vesicles(blisters) of the mouth and feet, fever, loss of appetite, lameness, depression, and a disinclination to rise. The disease is particularly severe in high yielding dairy cattle which also develop blisters on the teats to result in viral mastitis. Similar mouth and feet blisters are seen in pigs and lameness can be very severe. Sheep and goats usually show only mild or in apparent disease. Clinical FMD in Malawi has commonly been apparent in cattle and rarely, to date, in small ruminants or pigs.

Milk yield is drastically reduced and mortality rate is usually low.

The disease spreads most commonly through direct contact between infected and non infected animals. Saliva, days before the appearance of clinical disease. Transmission also occurs through fomites including: contaminated feed and water; agricultural and especially animal products; people; vehi cles of transportation such as cattle, lorries, oxcarts, other vehicles Keep infected animals away from others if the disease is suspected.

Fig. 33: Foot and Mouth disease in Cattle

Also report quickly to the nearest veterinary or agricultural office. The Department of Animal Health and Livestock Development carries out free compulsory vaccinations following an outbreak occurrence. Livestock owners should cooperate and bring all their animals for vaccination when the programme is announced.

6.2.2.4. Lumpy Skin Disease

The disease affects cattle and is caused by a Lumpy Skin Disease virus transmittedby biting insects. The disease is more prevalent during the wet season. It is often confused with other kinds of diseases such as Senkobo(Streptothricosis), and Ringworm. The disease is characterized by fever and lumps all over the body. The lumps are deep in the skin and are very hard to pull off. Less than 5% of affected animals die. Mortality is high in high-grade animals and their crosses.

Productivity in dairy animals is greatly reduced. Farmers keeping high grade and their crosses should vaccinate them against this disease. A single vaccination for animals above 3 months is recommended followed by annual booster vaccinations.

Fig. 34: Lumphy Skin disease in Cattle

6.2.2.5. Newcastle Disease

This is a viral disease transmitted by contact with sick or dead birds, contaminated feed, workers' boots and litter. Newcastle disease is characterized by one or more of the following symptoms; fever, diarrhoea,respiratory distress and twisting of the neck. It is widespread in the country. To reduce the chances of introducing the infection, have a stock proof fence around the farm, keep wild birds out of houses, buy birds only from suppliers known to be free from the disease and other contagious diseases. Farmers should be advised not to allow visitors into their poultry houses.

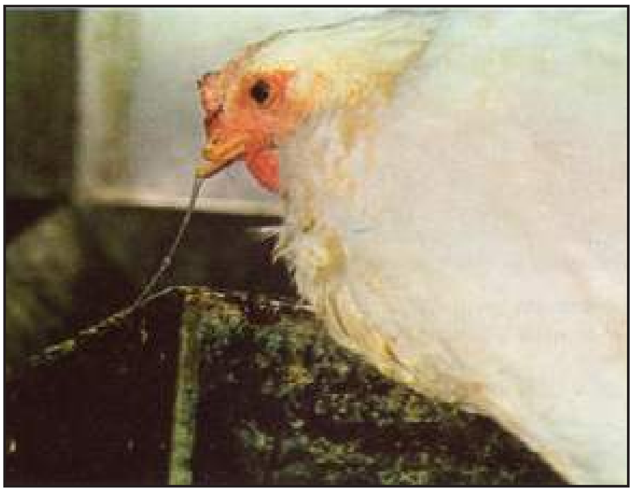


Fig. 35: Chicken suffering from Newcastle disease

Birds should be vaccinated every 3 months using a vaccine e.g. Lasota which can be purchased from Veterinary Assistants Association of Malawi(VAAM), and other reputable veterinary drug pharmaceuticals. I-2 vaccine currently being produced at Central Veterinary Laboratory can be used and is thermo tolerant, easy to administer.

6.2.2.6. Rabies

Rabies is a zoonotic viral disease that is endemic in Malawi and affects all warm blooded animals including man. The source of infection is usually a dog, and less commonly hyena sand jackals. Thevirusistransmitted throughabite of a rabid animal.

Dogs should be vaccinated annually and vaccination is free during the rabies vaccination month. Vaccinations outside the campaign month are schargeable. Communities should be encouraged to restrain dogs all the time and not just during campaigns. The Department of Animal Health and Livestock Development and local authorities may shoot all un controlled dogs. The Department will also shoot or destroy animals suspected of being rabid.

Fig. 36: Vaccinating dogs against rabbies

6.2.2.7. Rift Valley Fever(RVF)

Rift Valley Fever is a zoonotic disease of ruminants and occasionally man. It is transmitted by biting insects such as mosquitoes and causes fever, abortions and sometimes jaundice. Sheep and goats are the most severely affected compared to cattle. In Malawi, it has only been recorded in dairy cattle and should be vaccinated annually with an inactivated vaccine.

6.2.2.8. Tuberculosis

Tuberculosis is a zoonotic bacterial disease caused by *Mycobacterium spp.* and is common in cattle and rare in other domestic animals in Malawi. It causes chronic wasting and is spread to other cattle through aerosol(by coughing) and sometimes through ingestion of contaminated faeces or milk. Man becomes infected by aerosol, drinking raw milk or eating infected meat which is not properly cooked.

Infection can be detected by the tuberculin test, which involves inoculation of a small quantity of test reagent into the skin. Reactors to the test should be culled. The Department runs a meat inspection service. One of its functions is to detect and condemn meat or organs showing tuberculosis lesions. Livestock owners should ask their assistant veterinary officers to inspect their animals before and after slaughter to prevent transmission of tuberculosis and other diseases. Heat treatment of milk(pasteurization) and cooking meat kills the tuberculosis causing organisms. Currently the Department is advocating TB testing on all dairy national herds to ensure the control of this zoonotic disease.

6.2.3. Other diseases of economic importance in Malawi

6.2.3.1. EnzooticBovineLeucosis(EBL)

This is a viral disease transmitted from cow to calf through milk and can be transmitted by contaminated instruments and biting insects. It appears in older animals as tumours in lymph nodes and internal organs.

The majority of infected animals neverdevelop detectable clinical signs. The onlycontrol method is to test the blood of individual animals and slaughter the ones that are positive. Farmers should be advised not to use breeding stock from affected farms.

6.2.3.2. Helminthiasis (Roundworm, tape worm, Flukes)

This is a disease caused by worm infestation characterized by anaemia and progressive emaciation. All animals harbour worms in the stomach, intestines and liver. Afewworms are not harmful, but a heavy burden makes animals unproductive and may kill young animals. The most important way of reducing the build-up of worms in houses and yards is by deworming, daily removal of faeces and mud. Keeping the ground dry by good drainage also prevents worm larvae from developing. Allow young animals to graze pastures which have not been grazed in the previous months by old animals. In addition to that also practice rotational grazing.

Drenching (drug administering by mouth through a receptacle) in the dry season is advisable as this helps reduce pasture reinfestation during the following rainy season. Young animals will benefit from drenching during the rainy season. Adult cattle do not usually need treatment, but adult sheep and goats may require it if their grazing area is not restricted. There are several broad spectrum antihelmintics available in pharmacies. Drench animals with Thiabendazole(Valbazen) if stomach or intestinal worms are suspected and with Ranide if it is liver fluke. It is important to alternate use of antihelmintics to avoid drug resistant.

6.2.3.3. Infectious Bursal Disease(IBD) Or Gumboro Disease

A virulent strain of the virus causing Gumboro disease is present in Malawi and is causing mortality rates of 10 to 50% in many intensive poultry units. It affects 3 to 8weeks old birds, characterized by depression, a little diarrhea and death. Vaccination of parent stock is recommended. Growing chickens should be vaccinated when there are 7 to 10 day sold, with a booster at 21 days of age. Farmers are advised to buy Bursine 2 or Bursine N-K from pharmacies, and these are vaccines of choice.

6.2.3.4. Tick-borne Diseases

East Coast Fever (ECF) is caused by protozoa *Theileriaparva*. It occurs in the Central and Northern Regions; Gall sickness caused by *Anaplasma marginale,* Redwater(Babesiosis) caused by Babesiabovis and Heart water caused by *Cowdriaruminatium* occur throughout Malawi. Of these four diseases, ECF causes highest economic losses.

Dipping is used to control tick-borne diseases and heavy tick infestations. Farmers should be advised to dip or spray their animals from November to May every year when tick populations are high. This is called strategic dipping.

Cross bred and exotic cattle are more susceptible to all tick-borne diseases and mortality rate can be high. Zero-grazing reduces the chances of tick infestation and is recommended for smallholder dairy herds. Vaccines for controlling tick-borne diseases are being produced at the Centre for Ticks and Tick borne Diseases(CTTBD) in Lilongwe, and are highly recommended for cross bred and exotic cattle.

6.2.3.5. Trypanosomosis(Nagana)

This is a zoonotic protozoa disease transmitted by Tsetseflies(Glossinaspp). It affects cattle, other domesticated animals and man. It causes intermittent fever, anaemia and loss of weight. Pregnant cows often abort. The disease is common in areas adjacent to wild life and forest reserves. In the rainy season, the tsetse fly can travel up to 20km a day especially along water courses.

The disease can be prevented by treating cattle once every 3 to 4 months with aprophylactic drug such as “Samorin”. Animals which are already sick should be treated with a curative dose of Diaminazineacetuate (Berenil) as per instructions on the label.

6.2.3.6. Anthrax

The disease is azoonotic caused by *Bacillus anthracis* and has never been reported in Malawi. However, it is present in neighbouring countries such as Zambia, Zimbabwe, Mozambique, Tanzania and could be introduced in the country by movement of sick animals, infected meat or other animal products such as hides and skins or meat and bone meal. Anthrax is most common in cattle and pigs, but can affect any mammal including man. Affected animals show fever and there is oozing of unclotted blood through natural openings from dead animals. The disease usually causes death after short illness of 1 to 2 days. If the animal survives long enough, it may show throat swelling. Farmers and general public are advised to notify the nearest veterinary staff immediately the disease is suspected. Carcasses should not be cut open if the disease is suspected. Assistant Veterinary Officers should be called who will carefully take a peripheral blood sample (thin smear) for laboratory examination. Carcasses should be burnt, or buried 2 metres deep and covered with lime.

6.2.3.7. Contagious Bovine Pleuropneumonia (CBPP)

This is a disease of cattle caused by bacteria *(Mycoplasmamycoidesmycoides)*.The disease is present in neighboring states of Tanzania and Zambia and has never been recorded in Malawi. The disease also affects goats(Contagious Caprine Pleuropneumonia (CCPP).

The disease can be introduced through illegal movement of animals and animal products and direct contact. It is characterized by painful and difficult breathing, loss of weight, congested lungs, sequestered and necrotic lungs. The thoracic cavity may contain up to five litres of clear yellow or turbid fluid.

The disease can be controlled through vaccination, movement control, quarantine and testing.

Fig. 37: Picture showing yellow fluid like an egg omelette (Courtecy IZST Italy)

Since live vaccine is used, vaccination is prohibited in Malawi to avoid introducing the disease.

6.2.4. Emerging and Re-emerging Diseases

6.2.4.1 Highly Pathogenic Avian

Highly Pathogenic Avian influenza is a viral disease caused by H5N1strain of the AI virus. The disease affects most domesticated birds which include chickens, turkeys, guinea fowls, ducks, quails and ostriches. Some wild birds are also affected. It also affects humans(zoonotic).

It can also cause severe clinical signs which include quietness, depression, drop in egg production, congested wattles and combs, coughing, sneezing, diarrhea and 100% mortality within 48 hours The virus can be spread by migratory birds, international trade in poultry and poultry products direct contact and contaminated drinking water. It is a zoonotic disease.

Control measures include maintenance of recommended phytosanitory and biosecurity practices, surveillance, avoid introduction of birds from unknown sources, report unusual high mortalities, thorough decontamination of infected premises and human destruction of infected and exposed animals.

Farmers are advised to report any unusual high mortality rates of wild birds, migratory birds or domesticated birds to the nearest veterinary office or agricultural office.

6.2.4.2. Bovine Spongiform Encephalopathy(BSE)

BSE is widely known as 'Mad Cow Disease'. It is achronic degenerative zoonotic disease affecting thenervous system. Microscopically, it is characterized by a spongy appearance of the brain tissue of affected cattle. The diseaseis transmittable to human beings (zoonotic). This disease is not currently present in Malawi.

The causative agent of the disease is a prion which is the abnormal form of a protein, known as a cellular prion. These agents are resistant to radiation, UV ight, normal sterilization and even use of disinfectant.

Transmission is through feeding cattle with contaminated feed which has infectious BSE agents. These BSE agents are commonly found in many parts of the brain and spinal cord of cattle.

Fortunately BSE is not a contagious disease since it can not be transmitted from one cow to another.

Control measures

- Prohibiting the use of most mammalian protein in the manufacture of animal feeds given to ruminant animals.
- Avoiding importing cattle from countries affected with BSE.

6.2.4.3 PestedesPetits Ruminants (PPR) also called Goat and Sheep plague.

Pestedes Petits Ruminants(PPR) is a highly contagious and infectious viral disease caused by a virus. It affects domestic and wild smallruminants. Goats and sheep are the most affected animals.

Animals may die within the first week after the onset of symptoms. The disease has a high mortality rate of 50-80% and morbidity rate of 90%. However, the disease has never beenreported in Malawi meaning that our smallruminant population has never been exposed to this disease implying no immunity.

PPR can be recognized by the following signs: sudden rise in body temperature (40-41°C) with restlessness, dull coat, dry muzzle and depression of appetite, nasal discharge becoming mucopurulent followed by areas of necrosis from the gums and nose.

Fig. 38: Goat infected with Pestedes Petits Ruminants

6.3. ANIMAL HUSBANDRY

6.3.1. Beef production

Beef production is important in Malawi for improved human nutrition and increased income. There are 3 beef production systems in Malawi which are stallfeeding, feed lotting and off pasture. The smallholder stallfeeding scheme is operational in some parts of the country. The production of beef is constrained by low cattle population, inadequate nutrition, poor management, parasites and diseases. The objective is to increase beef production and off-take of national herd. Inorde to improve beef production, the following production practices are recommended:-

6.3.1.1. Stall-feeding

(i) Breeds

Major breeds used in the stall feeding programme are Malawi Zebu, Brahman, Boran, Bonsmar and their crosses. Steers, culled cows and bulls from dairy breeds can also be used as stall feeders.

(ii) Housing

Construct pole and thatch kholas using locally available materials. One steer requires a khola space of 2.1 meters long, 2.1 meters wide and 2.4 meters high. The length of the khola will depend upon the number of animals to be stall fed. Construct a feeding rack and provide feed and water troughs. The feed rack is for roughages. Provide initial and subsequent bedding as required. It is recommended that each animal is confined to its pen for better management.

(iii) Feeding

In the stall feeding system, steers weighing about 250 kg live weight with 4 to 6 permanent teeth are fed intensively in the stall for a period not exceeding 150days.

In the off pasture system farmers should be encouraged to fatten culls and unprodutive cows, bulls and work oxen before slaughter.The best time to start stall feeding is April or May when there are plenty of crop residues.

Farmers are advised to collect and store crop residues including maize stover, wheat and rice straw, groundnut and bean haulms. The home made concentrates can be made of 75 parts dry madeya, 24 parts dry Leucaena or Sesbania leaves and 1 part salt by weight.

Farmers are encouraged to grow pastures such as Napier grass, forage legumes and Leucaena or Sesbania. Potato vines and banana pseudo stems can be cut and fed to animals as roughage. When feeding Sweet potato vines it is advisable to wilt them as fresh ones may cause diarrhoea.

Animals should be given crop residues, or any other roughage such as cut grass, banana pseudo stems, and potato vines adlibitum with maize bran (madeya) fed at 5 kg per animal per day. When the roughage in take is restricted, then maize bran should be fed at 6.5 kg per animal per ay. Weight gains of up to 0.7 kg/ day can be achieved with a mixture of maize bran and cotton seed in the ratio of 4 parts of maize bran to1 part of cotton seedcake; or 4 kg of maize bran mixed with leucaena leaves in the proportion of 4 parts maize branto1 part dried leucaena leaves. Cross bred steers from Brahmans or Friesians should begiven 1 to 2kg more supplement than Malawi zebu steers because of their higher maintenance requirements due to their larger body size.

When feeding maize stover with groundnut tops, the best combination is 50 parts of maize stover to 50 parts of groundnut tops supplemented with 5kg of maize bran. This gives an expected weight gain of 0.75kg per animal per day.

The higher the proportion of groundnut top sin the rough age, the higher the expected live weight gains by the steers. Supplement the coarse roughages with 1kg of fresh green forage to promote intake.

(iv) Internaland external parasite control

Animals should be dewormed against both round worms and liver flukes, dipped or sprayed against ticks before stall feeding. Apply tick grease to animal parts affected by ticks.

(v) Marketing

With good management, animals are normally finished in about 150 days. A finished animal will have a shiny skin, round rump and a full back. The major buyers are abattoirs in cities of Blantyre and Lilongwe. Currently, Malawi has four major abattoirs. However, farmers may also sell to the buyers like butchermen.

6.3.1.2. Off-pasture

Farmers should be advised to graze theiranimals at least for 8 hours so that they get enough feed. Animals should be given enough drinking water each day and that earmarkedfor sale or slaughter should be supplied with1 to 2kg of bran (madeya) per animal per day.

6.3.1.3. Feeding- Lotting

Apart from the smallholder stall-feeding scheme there are some commercial feed lots whose management levels are higher than those of the smallholders.

6.3.1.4. Cattle marketing

Most cattle owners do not sell their animals at the opportune time. They often sell cattle when cash need arises. Farmers should cull sterile, old (broken mouth) and unproductive animals at the right stage and fatten them before marketing.

There are several cattle markets countrywide. These markets are owned and managed by farmer groups. Through these markets, farmers are able to sell their animals at reasonable price because the animals are auctioned and the buyers bid. Farmers assisted by the government set guaranteed minimum floor prices for various grades of cattle as seen in Table 79.

Farmers are encouraged to sell their animals at these markets because they get more money and livestock theft is reduced. Farmers selling cattle must process valid livestock movement permits for animals they are selling. The permit system ensures proper ownership over cattle being sold, checks the spread of diseases, slaughter of young breedable stock and also curbs down live stock theft.

6.3.2. Milk Production

Milk is important for human nutrition and as a source of income for smallholder farmers. The overall production of milk in Malawi is low because of low genetic potential and poor management such as housing, nutrition, disease control and breeding. Cattle are the main source of milk, but goat also plays a role. Cow milk production is estimated at 151,411 metric tones (Agricultural Production and Estimate Survey, 2011).

Traditionally milk is produced from the Malawi zebu which has low milk production potential. Special dairy breeds and their crosses produce more milk than indigenous Malawi Zebu. The supply cross bred dairy cows, however, is limited. However government stations like Mikolongwe in the south, Dwambazi in the north and Likasi in the centre, stock these dairy crosses.

Table 79: Grades for floor prices of cattle, sheep and goats

Grade	Description
Standard	Fairly well fleshed and in medium condition.Bulls in this grade must be really fat
Commercial	Cattle in this grade shall be in reasonable condition with no indication of poverty.
Inferior	Below the standard of the foregoing cattle grades.
Feeder Grade A	Not more than four permanent teeth and a minimum live weight of 250kg.
Feeder Grade B	Not more than six permanent teeth and a minimum live weight of 225kg
Goat and Sheep Grade I	Goat and sheep of good finish and quality with not more than four permanent teeth.
	Goats and sheep not in the foregoing grade.

Therefore farmers are encouraged to purchase them when need arises. Sales of crossbred heifers among farmers should, therefore, be promoted with the involvement of Agricultural field staff.

Currently government is importing pure dairy animals from the Republic of South Africa for sale to smallholder dairy farmers with the aim of increasing dairy animals in Malawi.

6.3.2.1. National aims

The aim is to be self-sufficient in milk and milk products to meet domestic demand. The objective is therefore to expand dairy schemes to suitable areas in order to increase milk production.

6.3.2.2. Smallholder dairy programme

The smallholder dairy programme is operational in milk bulking groups throughout the country. Milk production is based on Friesian cows and their crosses. Dairy cows are obtained on cash basis by carefully selected farmers who have satisfied the following conditions:-

i) The farmer should be industrious and have interest and willingness to keep dairy cows.

ii) Should establish at least 1.2 hectares pasture (e.g. Napier or Rhodes grass) for 2 dairy cows.

iii) Should construct a khola, milking parlour with concrete floor, exercise yard, a handling crush and a calf pen.

iv) Should be located within an area with readily available market.

v) Should be within proximity of a permanent clean water source. In order to improve milk production, the following husbandry practices are recommended:-

6.3.2.3. Breeds

Farmers are encouraged to use Friesian crosses (Friesian x Malawi Zebu). The Malawi Zebu is adapted to local conditions while the Friesian has high milk production. Where artificial insemination (AI) services are available farmers are encouraged to utilize them.

Recommended dairy breeds in Malawi are Friesians, Holstein Friesians, Ayrshire, Jersey, and Guernsey.

6.3.2.4. Housing and handling facilities

Housing and handling facilities are important in milk production for better management of the dairy animals and subsequent dairy products. These facilities include khola, milk parlour, crush and exercise yard.

6.3.2.4.1. Khola

Kholas should be sited on land with a slightslope to enable some effective drainage. Cattle kholas should be sited 70 metres away from houses and on the wind ward side to avoid foul smell. They may be made of low cost locally available material such as pole and thatch. Farmers usually buy 2 dairy cowsas it is economical and affordable to the farmer. Keeping 2 animals also assists in heat detection as compared to keeping1since an animal on heat shows tendency to ride and to be ridden. 2 cows require a khola of 3.7m wide, 6.1m long and 2.4m high.

Farmers are strongly encouraged to place cattle beddings in the khola. This ensures that animals lie on a dry place. Beddings mix with cattle dung and urine making good farm yard manure. This should eventually be applied on to crops and pasture as manure. Replenishbeddings when wet to keep the khola dry.

6.3.2.4.2. Milking Parlour

A parlour should be constructed 1.8m wide, 2.7m long and 1.5m high. It should be situated upwind from a spray crush. This avoids milk and utensils getting contaminated with acaricides. The floor of the milking parlour should be made of rough concrete with as light slope to allow drainage and avoid milk contamination with dust. A neck yoke for restraining the animals during milking should be constructed in the milking parlour. Enough space should be provided in front of the neck yoke for a feed trough and passage of the milker. An adjoining room is recommended for storing utensils and some feed stuff.

6.3.2.4.3. Crush

A crush should be constructed down of 0.6 m internal width and 4m long. The crush is used for general animal handling, treatment, artificial insemination, and acaricides application.

6.3.2.4.4. Exercise yard

An exercise yard should be provided for heat detection and control of over grown hooves. The area should be 9m x 12m.

6.3.2.5. Feeding

Animals should be fed roughage and concentrates for high milk yield. Hay and silage constitute most of the roughages and these should be supplemented with concentrate rations.

The rule of thumb is to offer1kg concentrate ration for every 2 kg of milk the cow produces. Farmers who may not be able to purchase already formulated concentrates should be provided with a locally compounded ration composed of 65 parts madeya, 34 parts dry leucaena or sesbania leaves and 1part salt and feed to animals at the rate of 4 kg per day, split equally at milking times. Other feeds include groundnut haulms, maize stover, banana leaves and banana stems (pseudo stems), Napier grass, potato vines, cassava silage, liquid feed and other crop by-products. Each animal should be given 45 litres of clean and fresh water every day.

6.3.2.6. Milking

To ensure clean milk production, the milker, the cow, and all utensils should be clean. Check for mastitis (inflammation of the udder) before milking. Clean the udder with warm water and use a separate clean cloth,for each animal. Warm water induces milk let down. Mop the udder and apply milk salve. Milk using the hand squeeze method. Ensure nearly all the milk is milked to avoid build-up of mastitis causing organisms. Apply teat dip to prevent mastitis, weigh milk and record the production per animal. Filter the milk into a churn using a dry clean white cloth. Sudden drop in milk yield is an indication of either heat, disease, or some management constraint. After milking clean the parlour and all utensils.

Animals should be milked twice a day in the morning and in the afternoon. It is important to maintain a minimum of 8hour milking interval during the day. 1 teat (quarter) should be reserved for the calf. The calf should sucklefor 30minutes. It should thereafter be separated from the cow.

6.3.2.7. Parasites and diseases

Parasites and diseases reduce productivity of dairy cows. Tickborne diseases and mastitis (inflammation of the udder) are the main diseases of economic importance. Regular application of a recommended acaricides will control ticks and tick borne diseases, while clean liness and proper milking techniques will prevent mastitis. Signs of mastitis are inflammation of the udder and sourness of milk.

6.3.2.8. Marketing

Milk collecting centres are established throughout the country, where milk is purchased through bulking groups and collected by commercial dairies. Farmers should becouraged to form groups around each milk collecting centre. The advantages of these groups are:-

i) Groups facilitate the distribution and management of inputs.

ii) Groups facilitate training, demonstrations, and disseminations of messages and feed back.

iii) Groups encourage active participation of members in the dairy industry.

Farmers should get rid of excess heifers by selling them to other fellow farmers.

6.3.3. Goat husbandry

Goats *(Capris hicus)* are a source of protein and income to the rural population.They also supply manure which may be used in crop production. Local goats in Malawi are hardy as far as feeding is concerned. They are prolific but do suffer from diseases just like other species of livestock. They are small to medium sized and have slow to medium growth rates.This calls for improvement. The aim is therefore to improve the productivity andofftake. To achieve this objective the following husbandry practices are recommended:-

6.3.3.1. Breeds

Apart from the indigenous goat which is mainly used for the provision of meat, the large South African Boer buck (male goat) is available from Mikolongwe and Dwambazi livestock centres for crossing with indigenous does (female-goats) in order to increase both size and growth rates. Boer goats and high grade crosses are also available from the commercial and recognized stud breeders.

The other breeds that are recommended in Malawi are: Saanen (for milk production), Torgenburg, and Alpine (for meat).

Fig. 39a: Indigenous Breed

Fig. 39b: Saanen Breed (Dairy)

Fig. 39 c: Alpine Breed (Dual purpose)

Fig. 39d: Boer (Meat)

6.3.3.2. Housing

The recommended Khola could be constructed from mud, pole and thatch but should be well ventilated. Space requirements for mature does are 1.8 sq. m, 0.3 sq.m for a kid and 2.8 sq.m for a buck. Raised slatted Kholas reduce worm infestation.

In this type of housing, the floor of the house should be raised about 1 to 1.5m above ground level. In this way, urine will pass and manure can easily be collected. The windward side should be covered to minimize respiratory disorders.

With the ground level house, a drainage ditch around the housing area will keep the floor dry during the heavy rains. If a dirty floor is used, make pallets or sleeping benches or better still, lay poles on the ground so that urine and manure can collect between these.The poles must, however, be removed and the ground cleaned every 2 weeks or once a month to reduce worm infestation.

Table 80: Recommendations for goat house/khola construction

No. of animals	Features	Rectangular House	Roundhouse
<10 breeding animals	Size	1.8 X 2.8	Diameter (m) 2.5
10-20 breeding animals	Size	2.7x3.7	3.5
	Wall	2m from the ground 1.8m from the khonde 20cm thick	2.2 from the ground 2m from the khonde
	Ventilation holes First row 2nd and 3rd row	12x12cm in size 50cm apart 1m from the floor 30 cm apart	12x12cm in size 50 cm apart1m from the floor 30 cm apart

Fig. 40: Standard Khola/house

6.3.3.3. Feeding

Goats browsing ability enables it to eat on a variety of herbage. However, under confinedconditions goats need to be supplemented with formulated rations. It is recommended to feed 230g (2 handfuls) of madeya or ration 5 in Table 81 per day to the does during sucking stage.Water should always be made available to goats.

When goats are herded, they should be grazed away from dambos during the rainy season. When tied or tethered during the rainy season, they should be rotated 2 to 3 times a day. The length of the tether (below) should be long enough (of about 4.5m long).

For stall fed goats, other for ages may be tied to a pen or tree branch so that forages are kept off the ground in order to imitate browsing behaviour.

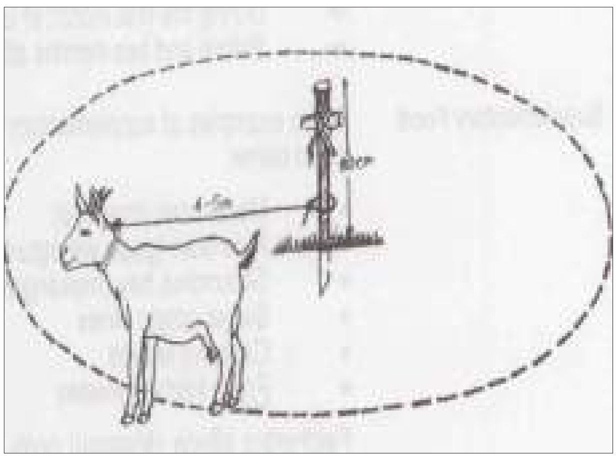


Fig. 41a: Tethering with long rope (4.5m)

A running tether (below) which has a rope or wire staked at both ends with the tether attached to this staked rope with some kind of ring or loop will give the goat opportunity to forage in a wider area.

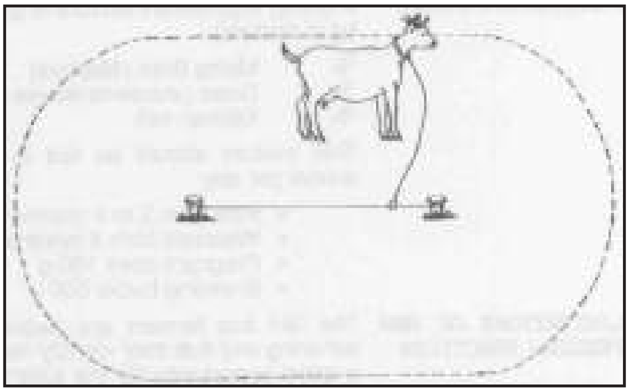


Fig. 41b: Running tether with rope staked at both ends.

It is recommended that goats should be herded wherever possible.

Table 81: Ration Options for Goats and Sheep

Composition	1	2	3	4	5
Maize meal	40	65	-	65	-
Madeya					
(Maize bran)	25	-	30	-	89
Bean meal	35	35	50	-	-
Cotton seed cake	-	-	20	20	-
DriedLeucaena leaves or sesbania leaves	-	-	-	-	10
Groundnut cake	-	-	-	15	-
Salt	-	-	-	-	1
Total	**100**	**100**	**100**	**100**	**100**

Note: All proportions are by weight

6.3.3.4. Parasites and diseases

Goats are tolerant to parasites and diseases. However, when goats are managed intensively they are susceptible to worms and respiratory diseases just like any other class of livestock. They should be dewormed and routinely at the beginning and end of the rainy season every year. Additional doses of anti-helmintic may be required if animals are restricted in paddocks.

6.3.3.5. Marketing

Goat's meat is generally sold locally and is on high demand. Farmers wishing to sell goats at livestock markets are free to do so. Grades offered are as indicated in Table 79.

6.3.4. Sheep husbandry

Sheep (Ovis aries) are mainly raised for meat and a source of income. The sheep population is, however, low because sheep production is constrained by the availability of improved breeding stock, poor husbandry practices, parasites and diseases. Sheep require more careful management. This has again to becomplemented with a programme of crossing the local with exotic breed or well selected rams to produce more lamb meat and mutton for both the urban and rural markets.

6.3.4.1. National aims

The aims are to increase the numbers of sheep and improve the productivity of indigenous sheep by practicing improved standards of management such astheuse of improvedbreeds, housing and feeding. In order to achieve these aims, the following are recommended:-

6.3.4.2. Breeds

The recommended breed to be used for crossing with the indigenous ewes is Dorper and Hampshire. These rams may be obtained from Mikolongwe and Dwambazi Livestock Centres and commercial stud breeders. Well selected indigenous rams may be used in the breeding programme. Efforts should be made to encourage private stud breeders to produce male breeding stock for sale to other producers.

Sheep Breeds

Fig. 42a: Indigenous breed

Fig. 42b: Dorper Breed

Fig. 42c: Merino

6.3.4.3 Housing

The recommended Kholas should be well ventilated, have good drainage and can be easy to clean. Floors of ground level Kholas should be made of rummed clay or concrete. Hard floored kholas should be thoroughly cleaned at least twice a week. Alternatively, raised, slatted Kholas may be made of timber or bamboos. Roofing material could be either iron sheets or grass. The floor space for an adult sheep is1.3mx1m. The Khola should be sited on dry high ground to ensure good drainage. Provide feed and water troughs.

6.3.4.4 Feeding

Sheep should go out grazing early in the morning and stay out for at least 8 hours so that they have the advantage of grazing as much as possible. Supplementary feeding ration options for faster growth are shown in Table 81. A home made ration should be made out of maize meal, madeya, bean meal and cotton seed cake or groundnut cake. Adequate clean water should be made available to the sheep daily.

It is recommended that either of the rations stipulated in the table be given to pregnant ewes, suckling lambs, servicing rams and ewes. Provide 230g (2 handfuls) per animal per day. Lamb fattening under smallholder could be achieved by giving each sheep 350g (3 heaped handfuls) madeya, 900g groundnut tops and 110g maize stoves per day.

Sheep of all ages should be given salt and minerals in the form of mineral lick blocks which are obtained from pharmacies and other suppliers, or by arrangement with Agricultural Development Divisions (ADDs). Where they are not available, use of ordinary salt at the rate of 1% could be an alternative. Since sheep are low grazers, it is advisable to graze them after cattle to clean pasture in order to encourage re-growth.

6.3.4.5 Parasites and diseases

Sheep are generally susceptible to internal parasites and foot rot. Regular dosing against worms and use of foot bath with copper sulphate is essential. Farmers should be encouraged to deworm their sheep at least twice a year, before and after the rainy season. Minimum level of worm infestation would be achieved when deworming is followed by weekly change of grazing area and avoidance of marshy grazing areas.

6.3.4.6 Marketing

Fattened sheep may be sold to abattoirs or other buyers. Programmes of fattening excess lambs for sale should be encouraged. Farmers should be encouraged to sell unfinished sheep at livestock markets. Grades offered are as indicated in Table 79.

6.3.5 Hides and Skins

Hides are outer coverings of cattle while skins are outer coverings of sheep and goats. Hides and skins are important sources of income. They should not be wasted after the animals are slaughtered. They may be downgraded because of tick damage, bruising, wounding, poor flaying, poor drying and putrefaction. Suspension dried and wet salted hides and skins are of better quality than ground dried ones. A few private companies and licensed buyers buy hides and skins in rural areas for export. Farmers should be encouraged to flay and handle hides and skins properly for sale.

6.3.6 Pig Husbandry

The majority of pigs (Suisvittatus) in the rural areas of Malawi are the indigenous breeds. Critical factors limiting the production of pig meat include type of breeds, management aspects like feeding, housing, control of parasites and diseases. Management by smallholder farmers in rural areas is often poor. Exotic breeds which grow faster than indigenous, have better efficiency of food conversion, higher productivity of sows, better carcass quality and fetch high prices. Farmers should be encouraged to keep exotic breeds.

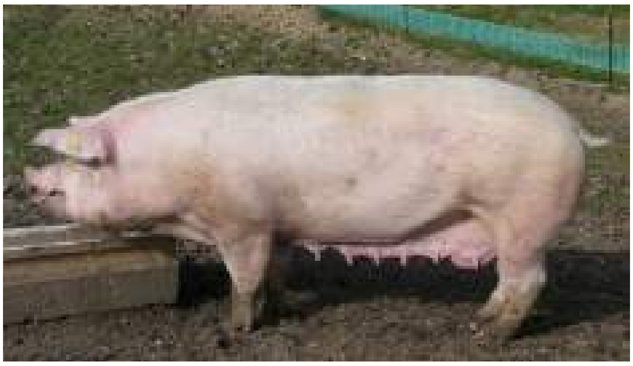


Fig. 43a: Landrace sow

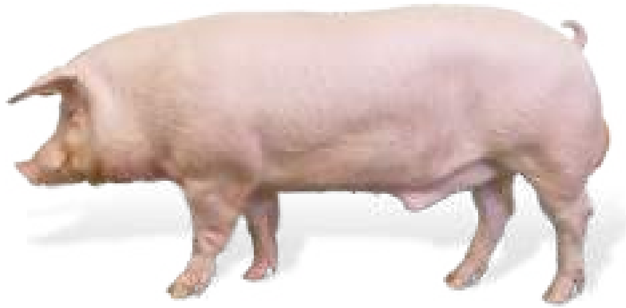


Fig. 43a: Landrace Boar

6.3.6.1. National aim

To encourage smallholder farmers to practice improved standards of management, especially in the use of improved breeds, housing, feeding and disease control measures. This will enable the increase of better quality pig meat production for local consumption. In order to achieve the aim, the following husbandry practices are recommended:-

6.3.6.2 Breeds

Currently the 2 breeds used for crossing with the local breed are Landrace and Large White Males and females of good conformation should be well grown before they are used for breeding. They are generally sexuallymature at about 6 months of age and should be separated from the group. It should be served till she is 8-9 months for good results. If served earlier, it may get stunted. Gilts should be selected from prolific sows. With good management, a sow is capable of giving 2 liters per year with an average of 10 piglets per furrowing.

Fig. 43c: Large White Sow

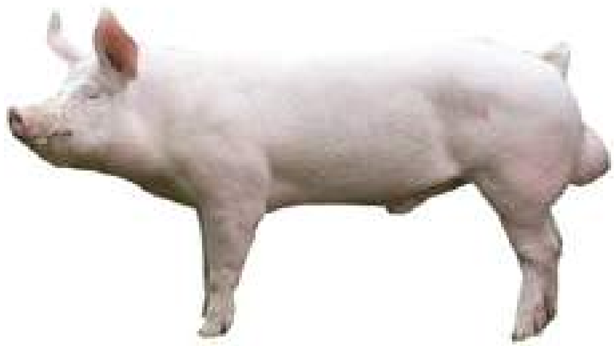


Fig. 43d: Large White Boar

6.3.6.3. Housing

Successful pig rearing requires a simple standard house constructed of bricks or stones with a thick thatched roof to keep the animals cool in hot weather. Permanently confined pigs do better than those on free range and risks of contracting diseases are minimized. Double fenced Kholas are recommended to minimize the risk of contracting African swine fever. Concrete floors are preferable because they allow easy cleaning and prevent barrowing.

A pen measuring 3m x 2.5m and an exercise yard 3m x 3m provide sufficient room for a sow and her litter. The walls of the room should be 1.2m high with an allowance for circulation of air at the top. The yard wall should only be 0.9m high. It is recommended that a dung way passage be provided. It is also advisable to keep pigs penned all times.

6.3.6.4. Feeding

Pigs should normally be fed in the khola. Commercial feeds should be purchased from reliable suppliers. Pigs require different types of feeds at different stages of growth. The feeds required will include pig starter, pig grower, pig finisher, sow and boar meal. Where this is not possible, a simple, locally formulated ration should be used. This is done by mixing 2 pails (24kg) maize meal, 1 pail (12kg) processed or roasted bean meal and 1 pail (8kg) maize bran (madeya). A few handfuls of green feed such as grass or chopped banana stems should be provided everyday. Clean drinking water should always be made available. Apart from genetic factors, feeding determines thefinal quality and grade of the meat product.

Approximate amounts of feed that pigs of different ages are recommended to consume are shown in Table 82.

Table 82: Feed requirement for cross bred and exotic pigs

Age in weeks	Approximate live weight	Total meal per head per day in Kg
3-12	9-22	0.5-1
12-16	22-36	1-2
16-20	36-55	2-2.7
20-24	55-77	2.7-3.4
24-20	77-100	3.4 and over

6.3.6.5. Parasites and diseases

African Swine Fever is the most serious disease of pigs in Malawi. Meat from infected carcasses should not be handled or sold to prevent the disease from spreading. Visitors should not be allowed to enter pig premises.

Pigs which are not confined in Kholasmay be infected with *Cysticercuscellulosae* (Misere ya m'minofu). This is a larval stage of the tape-worm *(Taeniasolium)*, commonly found in human and dog faeces and the pig acts as an intermediate host.

Control of this disease is strict observance of good hygiene (use of toilets) for humans and meat inspection for pig meat. Fungi, ticks and fleas do affect the skin of pigs. The symptoms are intense or severe itching and pigs spend most of their time scratching their skins against poles or walls of their kholas.

Other diseases and parasites of economic importance are:

i) Ring worm is caused by fungi and is characterized by skin crust.

ii) Ticks suck blood and some may spread viruses such as those causing African Swine Fever (ASF) disease. The important ticks are *Ornithodoros moubata* and *Amblyoma* species.

iii) Fleas-suck blood and important ones are *Pulex irritans, Cytenocephalides-felis Sand Echid noplaga gallinacea.*

Farmers should be advised to contact their respective District Animal Health and Livestock Development Officers (DAHLDOs) and Assistant Veterinary Officers (AVO) and their nearest veterinary stations for advice on control and treatment of these diseases once they have noticed their pigs severely scratching against poles or walls of their kholas.

Worm infestation is also common in pigs, especially amongst young ones and is particularly common under unhygienic conditions. Regular deworming of at least twice a year is recommended. Drugs for deworming pigsmay be purchased either from pharmacies and VAAM and other approved service providers on request through Agricultural Development Divisions (ADDs). Instructions on the label in terms of dosage and frequency of application should be properly read and followed.

6.3.6.6. Marketing

Pig meat is in great demand in the rural and urban areas. Pig weaners weighing between 25 to 43kg are classified as porkers while those weighing between 44 kg and 73 kg are classified as baconers. Pigs weighing 74 kg and above are classified as lard (overweight).

In the past, strategy on animal production mainly emphasized on larger animals like cattle. However, recently poultry especially chickens *(gallus gallus)* have become extremely important to Malawians as a source of meat, eggs, income and manure. Introduction of exotic breeds and increasing demand for indigenous chickens have seen the industry growing rapidly in Malawi.

6.3.7. Poultry Husbandry

6.3.7.1. National Aims

The objective is to promote use of commercial breeds for meat and egg production and conservation of indigenous breeds of chickens. In order to achieve this objective, the following strategies are being pursued:

- Expansion and improvement of poultry production in order to increase the availability of poultry and poultry products.
- Register all hatcheries, producers and traders for monitoring purposes.
- Promote local production of parent commercial strains.
- Promote production of indigenous and Black Australorp chickens.

The recommended breeds include Indigenous Malawi chicken, BlackAustralorp, Hyline, Shaver and Cobb.

In order to improve meat and egg production the following husbandry practices are recommended:-

6.3.7.2. Breeds

There are 3 types of improved breeds, these are:-

(i) The Black Australorp (Mikolongwe chicken)

This is a dual purpose breed reared for both meat and egg production. The average weight of an adult chicken ranges from 1.5 kg to 2.5kg. Cockerels weigh more than hens.

Black Australorp hen will lay between 180 and 200 eggs per year under good management. The aim of introducing this breed to smallholder farmers is to improve the weight of the local chicken, egg size and number of eggs laid. This is achieved by crossing Black Australorp cock with the local hen. Black Australorp can be used as a table chicken after laying for 50 weeks or more. Farmers should therefore be encouraged to buy Black Australorp to improve local chickens.

(ii) The Hyline

This is a hybrid chicken supplied by commercial hatcheries for commercial egg producers. This breed has high genetic egg production potential of up to 300 eggs per year under good management. The added advantage is that it has a smaller body size and eats less feed than Black Australorp.

(iii) Broiler breeds

The available breeds for meat production are the Ross and Cobb 500. These are also supplied by commercial hatcheries for commercial broiler producers. Broilers are ready for table meat at 6 weeks after hatching. At this time the average weight of the chicken ranges from 1.5 to 2kg. The body weight depends on the type of breed, sex, management and quality of feeds.

6.3.7.3. System of poultry keeping

There are 3 main systems of poultry keeping available to farmers:-

(i) Free range

Under this system, chickens are let out free all day and are housed at night. They are not restricted at all by wire netting or fence. Most birds kept by smallholder farmers are under this system.

Management is however low resulting in low returns. There is risk of birds being eaten by predators or contracting diseases such as New Castle Disease, Avian Influenza and others. Chickens find food for themselves and are rarely supplemented with madeya and leftovers from the table. They feed on insects and greens which are valuable, resulting in tasty meat and eggs. This system is ideal for hardy chickens such as indigenous and Black Australorp.

(ii) Semi-intensive

Chickens are let out of the khola into a fenced yard. As birds are kept in a fenced yard, there is less risk of predation. More control over the birds ensures better management than that of free range. Farmers with limited resources are encouraged to adopt this system. Green leafy vegetables should be given to chickens. These will supply carotene and minerals. There is high egg production as compared to free range system.

In the absence of recommended commercial feed, a ration comprising one part pigeon peas or bean flour meal, one part maize meal (Mgaiwa) and one part maize bran (madeya) by weight may be fed as a maintenance ration.

(iii) Intensive

(a) Deep litter

In this system chickens are kept inside the house all the time and given balanced feed. Materials such as wood shavings, chopped

dry grass, chopped maize cobs and rice husks should be placed on the floor to a depth of 15 to 23cm so that droppings are absorbed by the litter added from time to time. Under deep litter system farmers use less space for a large number of chickens. Good management and supply of balanced feeds should therefore been couraged to improve poultry productivity.

(b) Battery cage (laying cages)

Chickens are confined to cages 45cm long, 45cm deep and 23cm wide which have a sloping floor so that laid eggs roll away from them and stop against a soft bar. Complete balanced feeds and clean fresh water are made available to chickens at all times. The droppings either fall in to a collecting tray below the cage or on the floor.

This system enables many chickens to be kept in a small space. Feed wastage is minimal, in other systems and laid eggs remain clean. Hen pecking and cannibalism are reduced and internal parasites are easily controlled. Unproductive hens are easily identified and culled. Capital cost for the cages is higher than in the deep litter system. Farmers with adequate capital resources should be advised to use the system for increased egg production.

6.3.7.4. Management of layers

(i) Brooding

Chicks should be kept warm and dry from day old up to 2 to 3 weeks of age. A charcoal stove may be used as an artificial brooder to provide warmth. The initial brooding temperature is 32o C which should be reduced by 4oC every week. Where thermometers are not available it is best to be guided by the behavior pattern of the chicks. Chicks will chill when it is cold and gasp when hot. When it is cold they will crowd around a source of heat. If they are spaced out well, then room is warm enough. It is also necessary to cover a brooding house with a hessian sack for the first 3 weeks to conserve warmth when it is cold.

(ii) Housing

Chicks (day old to 8 weeks) and growers (9 weeks to point of lay at 18 to 20weeks) each requires 450 sq. cm of floor space. The chicken pen should be well thatched and ventilated to let in fresh air and light and be leak proof. Materials such as wood shavings, rice husks, and chopped straw and chopped maize cobs should be placed on the floor so that droppings of chicks are absorbed by litter, and the pen kept dry.

Layers from point of lay to 52 weeks of laying may be housed in a pigeon type house, brick house or laying cages. In a pigeon type house allow 900sq. cm (30cm x30cm) of floor space per adult bird. In a mud or brick house provide 3,600 sq.cm (60cmx60cm) of floor space per adult bird. For battery cage housing, the size of the cage should be 45cm long, 45cm deep and 23cm wide. In the pigeon-type house, the floor needs to be at least 90cm above the ground.

All housing should be well ventilated.

(iii) Feeding

Chicks under layer system should be fed with chick mash from day old to 8 weeks. The feed troughs should be shallow during the first2 weeks. After 2 weeks, the shallow tray should be replaced by deeper one. Chicks should be provided with feed at all times. Growers (9 weeks to point of lay) should be fed on growers mash. From point of lay onwards (18 to 20 weeks), birds should be fed on layers mash. Ensures that the feed is available at all times.

6.3.7.5. Management of broilers

(i) Brooding and housing is the same as in the management of layers.

(ii) Feeding

From day old to 3 weeks, chicks should be fed broiler starter. From 4 to 6th week birds should fed broiler finisher mash.As a guide feed requirement is 1.5 kg from day old to 3 weeks and 3kg from week 4 to week 6 per bird.

6.3.7.6. Water

Many small water troughs for both layers and broilers should be used during the first few days. As the chicks get older and more accustomed to drinking, fewer troughs should be used but larger quantities of water will be required, thus necessitating larger troughs. Fill the troughs with clean water. These should provide at least 15cm of drinking space per chick and should be widely scattered throughout the area. Water troughs should be washed every morning.

6.3.7.7. Indigenous chicken husbandary

Indigenous chickens are very important as source of income, nutritious food and organic manure. They do survive to harsh conditions although if not vaccinated against New Castle Disease, the death losses can reach economic levels. Demand for indigenous chicken meat in restaurants is ever increasing. Therefore indigenous chickens can also be kept for commercial purposes.

Traditional chicks rearing system:

The hen moves around the neighbourhood with the chicks to scavenge for feed. In the early ages the chicks depend on the hen's resourcefulness in getting their feed.

In most cases, it is survival of the fittest. The chicks moving closer to their mother get more feed that those trailing behind as the mother hen moves around the compound/neighbourhood.

Advantage:

Low input in terms of feed and labour.

Disadvantages:

- Survival of the fittest.
- High chick losses due to predation, accidents.
- Undernourished chicks
- Prone to diseases
- Low output.

Chicks Basket/Box rearing system:

- This is an improvement to traditional chick rearing system. The technology uses either wood box or basket for chick rearing. In hot climates, the best and cheapest method to guard the small newly hatched chicks is the so-called "basket system"
- **Night basket**: Chicks should be kept with their mother overnight in a so-called night basket, i.e. a round conical cage with a floor.

Fig.44: Night basket

A night basket may be made from bamboo or thin pieces of wood. Dry cut straw, rice husk, saw dust or shavings of 8-10 cm depth can be used as litter.

- The night basket must be kept under heavy protection from rain, wind and predators. Best places could be in the chicken house or separate secure house.

Day basket: In the morning, the chicks should be removed from the night basket and kept in a day basket, which is a bottomless conical cage, A dry straw mat should be placed in the cage if the soil is damp or wet.

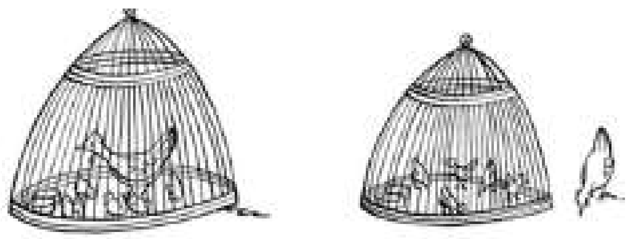


Fig. 45: Day basket

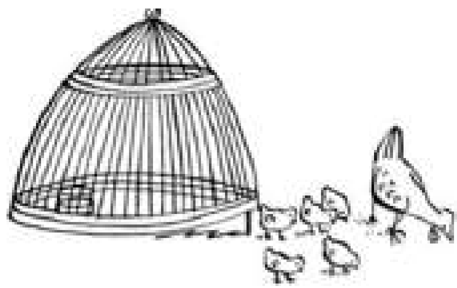


Fig. 46: Day basket titlted to allow chicks in and out.

- Note from above figure, the basket is tilted on one side to allow chicks either getting out or in depending on the situation and circumstances prevailing. For examples chicks may run away from predators and be able to hide in the basket.
- The day basket should be moved to a new clean spot every day to avoid diseases. The night basket is closed in order to prevent predators from entering and in order to keep the hen and chicks warm at night.
- If you can afford, make a potable box chick rearing house that should be small enough for easy movement from the bigger chicken house to outside and vice-versa.
- The basket should easily be moved around. The day basket needs to be bigger and more open in order for the chicks to move around without the hen stepping on them and in order to secure good ventilation.
- Put a small feeder and drinker in the day basket. Make sure that the day basket is roomy enough to accommodate these utensils.

Advantages of chicks' basket rearing system:

- Protect the chicks against predators, and rain hence high survival rate to adulthood.
- Grow well as chicks do no move long distances with their mother hen to feed and get good quality feed.
- Receives maximum attention from the farmer/owner.

Disadvantage:

- High Labour demand to move the chicks daily.

Separating mother hen from chicks:

- This is done if you do not want a hen to go broody and you want to shorten the clutch interval. This is an improvement as a farmer would want to have as many clutches as possible in a year.

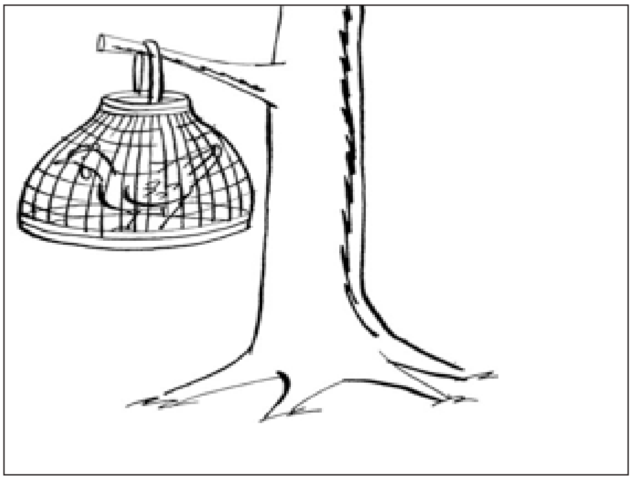


Fig. 47: Separating Mother hen from chicks.

- Do not hatch new chicks if you don't have enough feed for them. If you hatch too many chicks, they may die from starvation or or malnutrition, or their resistance to diseases mabe reduced

HOUSING FOR INDIGENOUS CHICKENS

Purpose of chicken house

- Protection from the elements, rain, heat, cold, wind.
- Protection from preditor: scats,dogs, wild animals, humans.
- Comfort for the chickens, perches.

General requirements for an indigenous chicken house:

- **Location:** The chicken house (khola) should be located on high ground, not muddy. It might need to be close to the house for security. The general area should be dry. There should be a source of drinking water nearby.
- **Size:** Minimum floor area - each adult chicken needs 30 cm x 30 cm of floor space plus space for any other smaller birds. (Note: This is for a night khola; more space is required for chickens which are housed full-time).
- **Floor:** Dirt floors are common. Cement floors are easier to clean. The floor should be dry to keep diseases away. It should be raised at least 20 cm above the ground level outside.

Wet muddy floors carry germs which can spread diseases. The floor can be a raised platform of stakes with spaces to allow the droppings to fall below. This is referred to as the "pigeon type".

- **Space requirement:** Space requirements for chickens regardless of chicken house type:

Table 83: Age and space requirement per bird

Age (weeks)	Space per bird
4-8	10 birds/m2
8 – 20	4 birds/m2
20 +	3 birds/m2

- **Walls:** Can use mud bricks, burned bricks or wood walls in construction of indigenous chicken house. Walls should be strong enough to prevent excessive drafts but there should be spaces to allow some ventilation inside. Two thirds of the wall area should be well ventilated. There should also be access to allow the manure to be cleaned out.
- **Roof:** For the ground based khola, the roof should be 2 metres high and waterproof. It should extend well beyond the walls to prevent entry of rain. Thatch should be thick enough to prevent rain entering. Tin roofs are good but they can cause the interior to get very hot during the day.

Two types of indigenous chicken houses

A) Pigeon type

Fig. 48: Pigeon Type house.

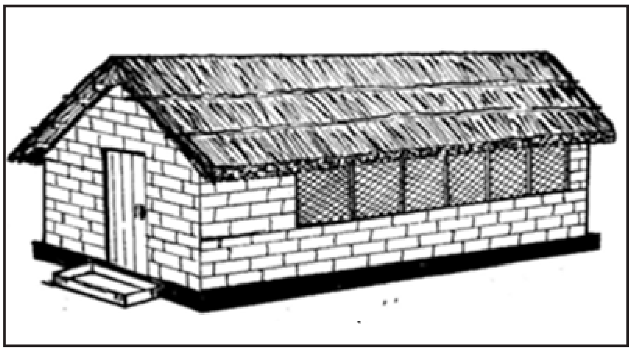
Pigeon type house: The house is made of locally available materials such as wood bamboo or reeds and is raised at least 1 meter above the ground so that the dung accumulated can easily be removed. The wall should be 1.5 m high from the slats. Each hen requires 30 cm by 30 cm.

Advantages:

- Easy manure collection as they fall down.
- Easy to construct and cheap where local resources are available.
- Protection from predators e.g. hyena.

Disadvantages:

- Bad for chicks as they fail to climb.
- Small entrance make it difficult to clean.
- Limited space as chicken population increases.



- Requires heavy maintenance

Fig.49: Deep litter House

Advantages	Disadvantages
Use simple materials to construction.	Requires more litter to avoid dampness.
Chicks can easily access.	Requires frequency cleaning to avoid disease outbreaks and too much ammonia accumulation.
Good access for cleaning.	

Perches: Chickens like to be able to roost at night. They need perches. Perches should be made of wood or bamboo, 3-5 cm in diameter.Perches should be strong and securely bound so that they do not bend, move or twist.

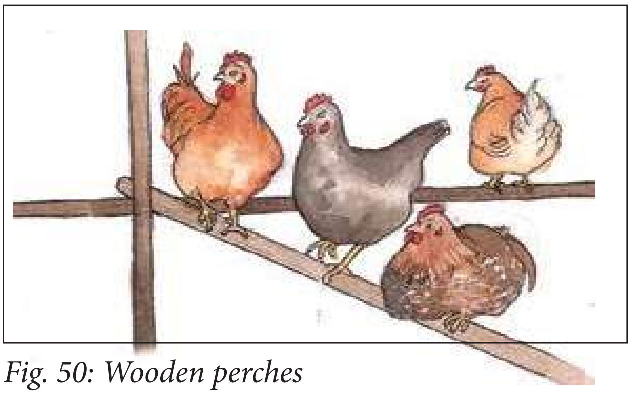


Fig. 50: Wooden perches

- Each adult chicken needs 20 cm of perch space. Higher perches should be placed such that droppings do not fall on birds on lower perches. Perches should be provided 0.6 m from slats. Each perch should be 3-5cm in diameter and each bird requires 20 cm of perch space. The roof should have a slope of 45^0.

Nesting Facilities:

- They are for hens to lay in their eggs.
- Hens like laying eggs in more protected
- places hence nest boxes are important.
- They can be made of wood, bamboo, grass.
- Nests should be put inside the khola.
- To keep eggs clean and safe from cracks.
- One nest box measuring 30cm x 30cm and 40cm high is enough for 1 hen.

Fig 51. Different types of nesting boxes

- Put in some dry litter e.g. grass, wood shavings.

Feed troughs for supplementary feeding

- Feeders should be safe to the chickens.
- These should be provided for economical use of supplementary feed and to keep the feed clean.
- Feeders can be either:
  1. Round.
  2. Rectangular.

Fig.52: Wooden Feed trough

- They may be of wood, old tyres, pots, tins, etc.
- Make sure there are enough feeders.

Drinkers:

- Chickens drink more water than the feed they eat therefore put clean water within the fence throughout.

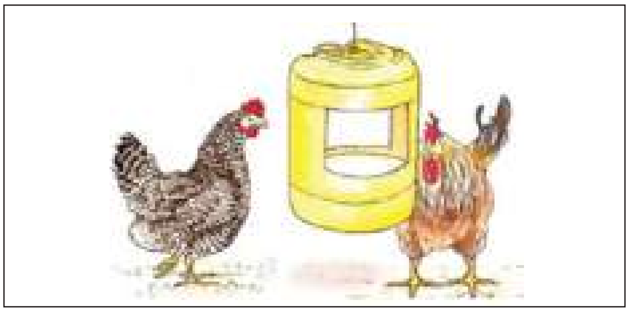


Fig.53: Improvised drinker from 20 litres plastic jerry can

- House hygiene: Clean the house frequently.

FEEDING INDIGENOUS CHICKENS

- Feeding is important for maintenance and production of meat and eggs. Lack of feed and/or water will reduce resistance to diseases and parasites, and subsequently increase flock mortality.
- The genetic potential of indigenous chickens is limited by access to feed and water. Egg production and growth of indigenous chicken maybe improved through supplementary feeding.
- Cost-benefit analysis will help to determine the most suitable feeding system for optimal indigenous chicken commercial production.

Feed Needed for Indigenous chickens

- Poultry need feed containing energy and protein, as well as vitamins, minerals and water. Vitamins and nutrients are destroyed when stored for too long or under sub-optimal conditions.
- Knowledge of feed quality and sources of different feed types is important for feed safety. The composition and availability of feeds will vary, depending on the season, locality and production system. The need for feed will change, depending on the age and status {chicks, growers and layers}of the chicken.
- Commercial diets are divided into three distinct categories, based on protein content as follows:
  a) Chick mash or starter diet is high in protein (18-20% crude protein) and is offered from day old to 8weeks;
  b) A growers' mash has medium protein (15-17% crude protein) and is offered from 9 weeks to the start of lay;
  c) A layers' mash has medium protein (16-17% crude protein)and is offered to hens from the start of lay.
- Before buying commercial feeds, establish whether it is profitable based on prevailing market price for eggs or meat. Indigenous chicks may be offered commercial diets profitably from day old to six weeks of age to enhance performance.
- Local feed resources are the cheapest and often the best supplements for scavenging chicken.

Scavenging for feed resources

Scavenging for feed is a major characteristic of free range production systems. Chickenscavenge freely and usually get a balanced diet depending on the feed resources richness in the homestead compound and/or neighborhoods.

It is a good idea to owners of indigenous chickens to supplement with kitchen scraps, madeya, or other sources of feed, especially during the dry season. If they do this the chickens will grow more quickly and the owners will get more eggs.

a) Energy: (in the form of carbohydrates and fats) is essential for growth. If feed is low in energy content, chickens need to eat more of it to grow well. If animals consume excessive, they get fat.

Fig.54: Examples of energy sources

In general, grains have high levels of energy. Chickens grow well when they are fed plenty of grain based feeds.

b) Protein Sources: for early growth and for production of meat and eggs. Young chickens need more protein in their diet than older chickens.

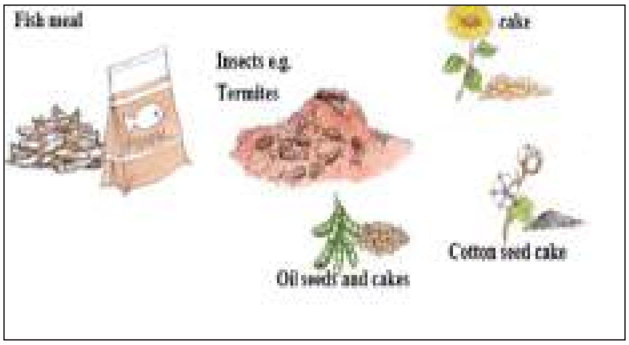


Fig.55: Examples of protein sources

Some feeds which are better sources of protein include: beans, cow-peas cotton seed cake and ground nut cake (after oil extraction) leucaena leaves and crushed leucaena seed fish meal, or meat and bone meal, blood, and insects such as termites.

c) **Minerals:** are important especially for young growing chickens and layers. Calcium is important for bone growth and strong egg shells.

Animal and fish bones, egg shells and evesnail shells, can be burned and crushed and added to the feed to improve the mineral content.

Fig.56: Examples of mineral sources

d) **Vitamins and minerals** can be obtained in commercial products called premixes. Usually, it is not necessary to add these to the diet of free-range chickens. They get sufficient when they forage the soils.

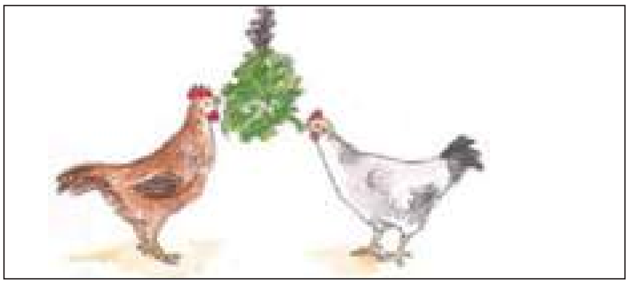


Fig.57: Examples of vitamin sources

Scavenging chicken get vitamins from green grass, vegetables, fresh cow dung and through sunlight(vitamin mD). Green grass and fodder normally provide Vitamin A and D, whereas Vitamin B may come from fresh cow dung. Supplementary vitamins are usually not required when birds are left to scavenge.

Confined or intensively managed chicken requires additional vitamins. Thismay be obtained from vitamin/mineral premix purchased from stockiest.

e) **Water:** Clean water must be given to indigenous chickens adlibtumly (as much as you can).

Cafeteria Feeding System

- Mature chicken are able to mix their own feed according to their needs. The best way to feed semi-intensively managed birds above 8 weeks of age is a cafeteria system, whereby various types of feeds are offered separately.
- It is easier to notice also the type of feed which the chicken likes according to its body needs.

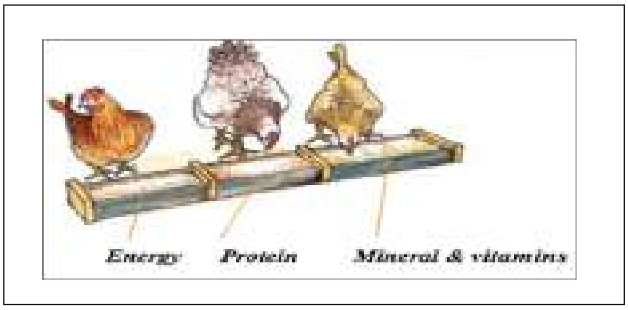


Fig.58: Cafeteria feeding system

- In the cafeteria system, there should be at least one feeding compartment for:
  - a) Energy rich feeds, e.g. maize, millet,white sorghum
  - b) Protein rich feeds,e.g., oil cakes, fish, soyabean meal, green gram, maggots, and termites.
  - c) Mineral rich feeds, e.g. bone meal, burnt egg shells.
- *Please observe and note the feeding behavior and provide enough of each type depending on chickens' preference.*

Parasites and diseases

Poultry suffer from a wide range of diseases. Diseases of economic importance in poultry are Newcastle diseases, Infectious Bursal Disease (Gumboro Disease) and Coccidiosis. Visitors should not be allowed into the poultry unit. Control for Newcastle disease and infectious Bursal disease is as described in animal health chapters.

Coccidiosis is a disease caused by protozoa of Eimeria spp. There are nine Eimeria spp. which cause the disease in poultry. E.tenella and E.necatrixare the most devastating species which cause great losses in chickens in Malawi. The symptoms are mostly bloody diarrhoea. For the control and treatment of coccidiosis, farmers should contact the nearest Agricultural extension staff.

6.3.7.7. Marketing

Egg and broiler prices are affected by demand and supply, therefore farmers are advised to study their market situations in order for their product to fetch high prices.

6.3.8. Rabbit Keeping

Rabbits can be reared either in small numbers or on large scale. They have short reproductive cycles, high prolificacy and an efficient feed conversion rate. Several breeds are available in Agricultural Development Divisions (ADDs) in order to ensure a regular supply of breeding stock and assist farmers to become self sufficient in meat products.

6.3.8.1. National aim

The aim is to encourage the adoption of rabbit keeping by smallholder farmers in all areas of the country. To achieve this aim the following husbandry practices are recommended:-

6.3.8.2. Breeds and breeding

There are several breeds available in Malawi.The recommended breeds are New ZealandWhite and Californian. The former is whiteand the later grey.

Adults weigh between 4 to 5.5kg. The younghave low feed conversion efficiency. Thesebreeds are able to adapt to a wider variety ofconditions and systems.

Rabbits may be mated at 20 weeks of age. Their gestation period is 31 days. It is possible to raise 4 litters of bunnies from one doe within a year. Young ones are weaned at 4 to 6 weeks of age. Soon after weaning, the doe is ready for servicing.

Fig.59a: Califonia White

Fig.59b: New Zealand

Fig,59c: Flemish Giant

6.3.8.3. Housing

Rabbit kholas should be constructed eitherfrom mud, pole and thatch or the materials such as bricks and stone. The khola should stand 1m above the ground. Rabbits may be kept either under deep litter system or in cages. A standard rabbit cage measures 90cm x 75cm x 45cm high. The cage bottom should have holes big enough for droppings to fall through and small enough for young ones not to fall through. Breeding hatches should be placed in the building. The weaned litter requires a separate pen for fattening. This allows the doe to be serviced and have another litter. A doe and a litter need 0.6sq.m to 0.8.Sq.m of hatch space. On wire mesh floors allow 0.9sq. m of hatch space per animal. Under deep litter system use materials such as wood shavings placed to a depth of 7.5.cm. Allow 160sq. cm (40cm x 40cm) of floor space per rabbit.

6.3.8.4. Feeding

Proper feeding combined with good health maintenance is the key to successful rabbit production. Rabbits kept in hutches or colonies are totally dependent on the keeper for their feed. Therefore, a balanced concentrated feed should be fed to the rabbits at all times.Where affordable, chicken mash may be fed to rabbits.

Green vegatables and some plants should also be fed to rabbits daily as a supplement. Rabbits prefer fresh materials such as carrots, potato vines, cabbage and groundnut haulms.

Table 84: Common Concentrated Feed Stuffs and how to mix them

		Crude protein (%)
Group A	Sun flower Cake Groundnut Cake	26 40
Group B	Boiled and dried beans Cotton seed cake (Low gossypol)	18 22
Group C	Maize, Rice,Sorghum or Millet meal, Maize, Rice, Sorghum or Millet bran	7 9
Group D	Dried Cassava Dried Sweet Potato	2 2

- Mix 4 cups of C with1cup of A or
- Mix 3 cups of C with 2 cups of B or

Mix 2 cups of D with 2 cups of Band 1cup of A

Table 85: Age and feeding regime

Class of stock	Size of Rabit		
	Small (gm)	Medium (gm)	Large(gm)
Young breeding stock (8 week old-mating)	60-80	80-100	100-120
Older-non pregnant does and breedingbucks	80-100	100-120	120-140
Pregnant does(1st 3 weeks of pregnancy	100-120	140-160	160-180
Pregnant does (1st10 days lactating does with litters). Young rabbits weaning to slaughter	ADLIB	ADLIB	ADLIB

(Any suitable container can be used instead of a cup

Note: ADLIB means giving the rabbit as much food as it can eat.

Care should be taken not to let these ferment as they may poison the rabbits in their ferment state. Clean water should be provided at all times as an adult rabbit requires about 0.25 litres of water per day.

Table84 shows a list of the common concentrates feed stuff and an indication of how to mix them.

Table 85 gives a guide on feeding regimes, indicating the amount of feed (gm per day) for different classes of rabbits.

6.3.8.5. Parasites and diseases

Parasitic diseases of rabbits include tape worm infestation, ear mite and mange infection. Coccidiosis is a very common fatal disease in young rabbits. There are 2 forms of this disease; namely hepatic (liver) and intestinal coccidiosis. The hepatic coccidiosis is caused by *Eimeriastiadae* while the intestinal coccidiosis may be caused by *Eimeriamagna, E.irresidua, E.media* or *E.perforans.* It is characterized by diarrhoea, weakness and swollen belly. Prevention is by avoiding feeding rabbits with contaminated feed and keeping rabbit houses dry and clean. Sulphamethazine is recommended curative drug. It should be used as indicated on the label. It can be obtained from pharmacies or by arrangement with the nearest DAHLDO and AVO.

Note: ADLIB means giving the rabbit as much food as it can eat.

Other diseases of rabbits include tuberculosis (*Mycobacteriumtuberculosis*) pseudo-tuberculosis *(Pasteurellapseudo tuber culosis rodentium),* rabbit syphilis *(Treponemacuniculi),* haemorrhagicsepticaema *(Pasteurellaspp)*, rabbit pox *(Variolaspp)*, salmonellosis *(Salmonellaspp)* to xoplasmosis *(Toxoplasmaspp),* listeriosis *(Listeriamonocytogenes)* and rabies *(Rabiesvirus).*

Farmers are encouraged to seek advice on the control and treatment of these diseases from veterinary staff in the districts.

6.3.8.6. Marketing

Rabbits can be sold locally.

6.3.9. Marketing of Livestock

6.3.9.1. On the hoof

Farmers are encouraged to sell their livestock at the nearest livestock market. Table 86 shows grades offered at these markets. However, among other outlets, farmers can also sell their livestock to private abattoirs and other buyers.

6.3.9.2. Marketing of cold dressed meat

Grades of cold dressed meat offered at private abattoirs are as shown in Table 86

Table 86: National grades for various cold dressed meats

Carcas grade	Roller mark	Colour dye	Description of grade
Choice	Choice	Red	Carcass weight of not less than182 kg, well fleshed with an even distribution fat of creamy white
Prime	Prime	Red	Carcass weight of not more than148 kg, well fleshed but with less fat than in the choice grade
Standard	Standard	Brown	Moderately well fleshed and moderately covered with fat
Commercial	4444	Brown	Fairly well fleshed and some covering of fat
Inferior	xxxx	Brown	Below standard beef
Mutton Lamb			
Choice Lamb	Choice	Red	Carcass of good conformation and good even finish
Prime Lamb	Prime	Red	Carcass of good conformation and reasonable even finish
Grade 1Mutton	Mutton 1	Brown	Carcass of reasonably good conformation, finish and quality
Grade 2Mutton	Mutton 2	Brown	Carcass of fair conformation, finish and quality
Goat			
Grade 1 Goat	Goat1	Brown	Carcass of good conformation and reasonable finish
Grade 2 Goat	Goat2	Brown	Carcass below standard
Pork and Bacon			
Porker A	1111	Red	Carcass very well fleshed; good depth of loin; back fat neither excessive nor deficient and reasonably white and firm
Porker B	222	Red	Of good all-round suitability for pork but below the grade above
Porker X	333	Brown	Below standard ofgrade 1111 or on account of excessive fatness or under-finish
Cater A	1111	Red	Same as grade 111
Cutter B	2222	Brown	Same as grade 222
Cutter X	3333	Brown	Same as grade 333

Table 86: National grades for various cold dressed meats *(continued)*

Carcas grade	Roller mark	Colour dye	Description of grade
Baconer A	1111	Red	Carcass has maximum fat measurement of 2.5cm for the mid-back,5.0 cm for shoulder 2.5cm ofrump,and about 2.0 cm for the mid-back
Pork and Bacon			
Baconer A	1111	Red	Carcass has maximum fat measurement of 2.5cm for the mid-back, 5.0 cm for shoulder 2.5cm of rump,and about 2.0 cm for the mid-back
Baconer B	2222	Baconer B	Carcass has a maximum fat measurement of 2.8 cm for the mid-back,5.0 cm for the shoulder, 3.0 cm for the rump, and 20 cm for mid-back
Baconer C	3333	Red	Carcass has fat measurement of4.0 cm for the mid-back,5.3 cm for the shoulder, 4.2 for the rump, 2.0 cm for the mid-back
Sow and stand A	55111	Red	Any carcass from a sow or castrated pig or suitable quality for manufacturing purposes
Sow and stand B	552222	Red	Any carcass from a sow or castrated pig or suitable quality below grade 552222
Boar A	B111		Any carcass from a sow and an uncastrated pig of suitable quality for manufacturing purposes
Boar B	B222		Any carcass from an uncastrated pig below the quality of the grade above
Underweight A	1111		A carcass of less than 25kg
Over weight A	AWTO		Carcas has fat measurements of 4.0 cm for mid-back,5.3cm for the shoulder, 4.0 cm for the rump and 2.0 cm for the mid-back
Overweight B	BOWT		Carcass below grade above on account of excessive fatness

6.4. PASTURES AND FODDER CROPS

Natural grasses, legumes and bushes constitute the cheapest source of grazing and browsing for Malawi's cattle and other ruminants (sheep and goats). The carrying capacity of natural pasture is limited and yet land for grazing is constrained by human population growth and environmental degradation. If livestock production is to be improved, there is need to properly manage the natural pastures under communal grazing and also establish improved pastures as well as encourage utilization of crop residues for animal feeding. Two cattle rearing systems exist in Malawi.

The first system is dependent solely on natural pastures and the majority of the country's cattle (1,060,221) depend on this resource as a source of nutrients under dry land and dambo grazing conditions.

In the past, dambos were traditionally used mainly in the dry season for grazing but recently owing to human population growth and increasing land pressure, there is less dry land available for wet season grazing. Cattle are therefore, frequently herded on the dambos throughout the year. Other roughage supplements are, however, available and these include maize stover, banana stems and groundnut tops especially during the dry season.

Careless bush burning during the dry season further reduces the already poor grazing resource. This leads to animals being confined to dambos. Since dambos are communally grazed, improved pasture management is difficult.

They are overgrazed resulting in animals losing weight, retarded growth and high mortality in calves. This is a big problem which can only be resolved with the cooperation of traditional leaders.

The other system of cattle production and one commonly associated with a commercial establishment is based on improved pastures and efficient utilization of crop residues such maize stover and bran, and groundnut tops. To this system belong a majority of stall-feeding smallholder beef and dairy producers. These farmers are advised to establish grass such as Rhodes grass *(Chlorisgayana)* and or Napier grass *(Pennisetum purpureum)* and legumes such as leucaena *(Leucaena leucocelphala)* in the milk shed and stall-feeding areas, by collaborative efforts of agricultural field staff. This is being done by establishing seed nurseries and demonstration plots at farmer training centres. Efforts should be made to encourage farmers to occasionally under sow Rhodes grass and a legume inamaize crop to enhance the efficient utilization of maize stover in the dry season.

In order to derive maximum animal production from natural pasture of grassland resources, animal numbers must be controlled through:-

i) Castration of excess males which canbe stall fed and sold to livestock markets for beef or for draught purposes.

ii) Culling of unproductive animals.

Note: Farmers are also advised to control and prevent overgrazing and bush fires in order to make maximum use of natural pasture and grassland.

Farmers can buy pasture seeds and seedlings from Chitedze Research Station in Lilongwe, Land Resources Department. Table 87 gives some recommendations that should be followed in order to achieve optimum pasture and fodder crop yields that will in turn boost livestock (beef and milk) production.

Table 87: Pasture and fodder crops recommendations

Pastures/fodder types	Seed rate	Fertilizer rate(kg/ha)	Recommended areas for production	Utilization
1. Rhodes grass *(Chloris gayana)* (a) Giant (b) Boma (c) Mbarara (d) Katambora	5 to 7 for all cultivars broadcast onto a well prepared seed bed and lightly worked into the soil	200kg 23:21:0+4S in pure stand	Most areas receiving more than 760mm ofrainfall	Grazing and making of hay or silage cut at 50% heading stage. Rest the pasture 3 to 4weeks between grazings. Grazing and nematode control in a rotation system that includes tobacco
2. Buffel grass *(cenchrus ciliaris)* (a) Biloela (b) Molopo (c) American (d) Gyandah	For all cultivars either broadcast 2 to3.5kg or drill 1.1to 2.2kg in rows 60to 90cm apart	200kg 23:21:0+4S	Areas receiving more than 800mm ofrainfall	Permanent grazing. Rest the pasture 3 to 4 weeks between grazing
3. Stargrass *(Cynodon spp)* (a) Henderson No.2 (b) Muguga	Rooted cuttings at a spacingof 60 to 90cm x 90cm	200kg 23:21:0+4S	Areas receiving more than 800mm rainfall	Permanent grazing and hay making cut at early bloom stage. Rest pasture 3 to 4weeks between grazings
4. Napier grass (*Pennisetum pur pureum)* (a) Gold Coast (b) Cameroons (c) Congo	For all cultivars sets are planted at an angle of 45 degrees at a spacing of 90x90cm	200kg23:21:0+4S	Areas receiving more than760mm ofrainfall	Cut and carry for stall-feeding and can be cut for silage making
5. Guinea grass *(Panicum maximum)* Ntchisi panicum	Rooted splits spaced at 60 x 60cm for grazing or 90 x 90cm apart for cut and carry	200kg 23:21:0+4S at the beginning ofthe rainy season plus 100kg of CAN after first cut	Areas receiving more than1000mm and on dambo margins	Cut and carry for stall-feeding and grazing during wet season allowing 4 weeks rest between grazings

Table 87: Pasture and fodder crops recommendations *(Continued)*

6. Leucaena *(Leucaena leucocephala)* Cunningham (low mimosine	10kg drilled in rows1metre apart and thinned to 30 cm between plants	200kg 23:21:0+4S,100 to 200kg singlesuper phosphate and MG707 rhizobiuminoculant	Upland plateau areas receiving more than 760mm rainfall. On alkaline soils in areas with altitude below 1200metres above sea level	Cut at 15 to 30cm above ground level for sun drying. 3 to 4 cuttings per year. Dry cuttings 2 to 3 cuttings days in the sun and beat off leaves when dry. Dried leaf may be fed to animals mixed with madeya. Restrict to only 30 percent of daily ration on dry matter basis. Can be browsed or grazed when grown in association with grasse
7. Sirato *(Macroptilium Airopurpureum)*	Scarified seed 2 to 3 kg/ha drilled in rows 90cm apart or 3.5to 4.5kg broadcast	100 to 200kg single superphosphate and MG 5013 Rhizobium inoculant	Since it is drought tolerant, it does well in awide range of soils and climatic conditions	Grazing and proving valuable high protein feed at the end of the rains when grown in association with Rhodes grass or under sown in a maize crop
8. Silver leaf desmodium *(Desmodium uncinatum*	3kg drilled in rows 90cm apart or 4kg broadcast	100 to 200kg single superphosphate and MG500 rhizobium inoculant	Plateau areas with more than 780mm rainfall	Grazing during rainy season together with Rhodes grass directly or under sown in maize. Can be conserved as hay at the end of rains for dry season feeding
9. Axillaris *(Macrotyloma axillare Dolichos axillaris*	3kg drilled in rows 90cm apart	100 to 200kg single superphosphate and MG5013 rhizobium inoculant	Grown in association with Napier grass or Ntchisi panicumin areas with more than760 mm rainfall and can be undersown in a maize crop	Grazing,cut and carry for stall-feeding or conserved as hay
10. Glycine (Neonoto *niawighii)*	Drilled to a depth of 1.3cm at the rate of 3.5 to 4.5kg in rows 90cm apart	100 to 200kg single superphosphate and MG 5013 rhizobium inoculant	Areas with well drained soils and more than 760mm rainfall.It can be grown in association with Napier grass, Ntchisi panicum or undersown in a maize crop	Grazing and provides valuable source of crude protein during the first months of the dry season
11. Cook stylo *(Stylosanthes guyanensis)*	Drilled in rows 60 to 90cm apart at 2 to 4kg per hectare or Broadcast at 4.5kg per hectare	100 to 200kg single superphosphate and MG 5013 rhizobium inoculant	Areas with well drained soils and more than 500mm rainfall. It can be grown in association with Napier grass, Ntchisi panicum or under sown in a maize crop	Grazing

Table 88 and 89 give recommendations for the establishment of direct seeding and direct planted pastures, and fertilizer recommendation for maintenance of established pastures.

Table 88: Fertilizer recommendations for the establishment of direct seeded and direct planted pastures

Pasture Type	Fertilizer Type		
	23:21:0+4S (Kg/Ha	CAN (Kg/Ha	Superphosphate(Kg/Ha)
Pure grass sward	200	-	100
Cut and carry grass	200	-	200
Grass and legume mixture	-	85	200
Leucaena	-	-	200
Pure stylo sward	-	-	200

Table 89: Fertilizer recommendations for the maintenance of established pastures at vigorous production levels

Pasture Type	Fertilizer Type			
	23:21:0+4S (Kg/Ha	CAN (Kg/Ha	Superphosphate(Kg/Ha)	Potassium (Kg/Ha)
Pure grass ley or permanent pasture	100	100-200	-	-
Cut and carry grass	100	100-200	-	100
Grass and legume mixture	-	85	100	-
Leucaena	-	-	100	-
Pure stylo sward	-	-	100	-

6.5. PRESERVATION OF FORAGES AND FODDER FOR DRY SEASON FEEDING

A high efficiency of livestock production demand attention to the feed resources in terms of their availability, quality, suitability for feeding and utilisation. However, there is feed scarcity during the dry season leading to loss in weight and condition of ruminant livestock although more forage of high quality is available during the rainy season.

This shows that there is no feed preservation and conservation during the rainy season for dry season feeding although technologies and techniques for forage and fodder preservation exist.

6.5.1. Methods of feed preservation

Forages are used as livestock feed in three basic forms: pasture, hay, and silage. However, preservation of feed for dry season feeding forages are preserved in form of hay and silage, and straw and stover.

6.5.1.1. Hay

The traditional method of conserving green crops and grass is that of haymaking. The aim of hay making is to reduce the moisture content of the green crops and grasses to a low level that enables satisfactory storage in stacks and bales for dry season feeding.

The stage of growth at the time of cutting is the most important factor in determining the nutritive value of the conserved product. The later the date of cutting, the larger the yield, however, the lower the digestibility, energy value and the lower the voluntary intake of dry matter by animals.

When the crops and grasses are at the most appropriate stage of cutting, the cloudy, humid weather usually does not permit proper drying or curing. The convenient period forhay making is at or near the end of the rainy season.

Good hay can be made provided special techniques are utilised. The following are some of the techniques:

(a) Hut frame structures

These are simple hutframe structures, with thatched roofs where thin layers of cut forages can be spread daily on elevated platforms of logs or stones. This allows the cut forage to dry and cure during the rainy season.

(b) Steep peak

Hay can also be made by stacking forages to a steep peak around a tripod on a well-drained site.

6.5.1.2. Straws and related by-product

Straws consist of stems and leaves of plants after the removal of the ripe seeds by threshing, and are produced from most cereal crops and from some legumes.

Most farmers have the practice of leaving the straw and stover in the field to be grazed by ruminant livestock. This practice salvages only a minor part of the feed nutrients. However, this loss can be avoided by the collection andstacking of these materials where they could be rationed out to ruminant livestock.

The solution is to use these residues for feed at a time of harvest rather than leave them to leaching by the weather and trampling in the fields. The straw and stover can be stacked and protected by thorn bush barriers.

In case of maize, another way is that of removing the leaves and tassels after the crops have dried and tie them in bundles. These can be fed to ruminant livestock during the dry season. To increase the feeding value of straw and stover, it is necessary to add a mixture of urea and molasses (1.5-2.0% feed grade urea and 10% molasses).

6.5.1.3. Tree leaves and road side grass

Smallholder farmers can also use tree leaves as feed for ruminant livestock. These add variety to the diet and help to meet the nutrient requirement for maintenance and production. Some of the tree leaves that can be fed to ruminant livestock are: Acacia spp leaves, Amaranths spp leaves *(Bonongwe),* Cassava leaves *(masamba a chinangwa),* pigeon pea leaves *(masamba a nandolo),* sweet potato leaves *(kholowa)*. Grass that grows along the road side is useful forage that can be used to feed ruminant livestock in form of hay or silage.

6.5.1.4. Silage

Silage results from the preservation of green forage under the control led fermentation. The process is called ensilage, and the container in which the silage is stored is called silo.Almost all crops can be preserved as silage, although the commonest crops are grasses, legumes and whole cereals, especially maize.

In practice native grasses offer the greatest opportunity for silage making for smallholder producers. Silage is made by cutting and chopping the crop during harvesting, rapidly filling the silo and by adequate consolidation and sealing. The main aim of sealing is to prevent entry and circulation of air during the storage.

There are various types of silo. They rangefrom plastic bags, pits, clamp and bunker silo.

When full, the silo is covered with plastic sheeting and weighed with some suitable materials such as tyres or stones.

6.6. USE OF CROP RESIDUES AND AGRO-INDUSTRIAL BY-PRODUCTS

Crop residues and agro industrial by products contribute significantly to livestock production in Malawi as a cheap source of nutrients. Crops such as maize, rice, wheat, sorghum, millet, groundnut, cotton, sunflower, sugarcane, beans, cassava, sweet potato, banana, and coffee are some of the major crops that produce substantial quantities of crop residues and agro-industrial by-products which can be utilized in animal feeding. Though low nutritive value because of their inherent deficiencies, they are high in energy yielding cell wall material.

Therefore, by suitable supplementation/ treatment, their feeding value can be improved and well balanced ration formulated; to sustain medium to high level of livestock production.

Crop residues and agroindustrial byproductscan be used in smallholder stall feeding operations for the production of beef and milk.

Improved pasture grasses such as Napier, Rhodes and indigenous grass species are fed to dairy cattle and stall-feeding animals. Crop residues and other farm by-products are used as additional feeds to fodder crops, compounded feeds, grasses and tree legume leaves in the dairy farming system.

CHAPTER 7

FISHERIES AND AQUACULTURE

Malawi has vast water resources (20% of the land) such as lakes, rivers and swamps from which fisheries resources are harvested. However, current fish landings from capture fisheries are dwindling. “Fish production varies annually with estimates from 2000 to 2015 averaging 90,000 tonnes per annum”. The situation has been aggravated further by high population growth and the resultant increase in fish demand. As a result, the average per capita fish consumption dropped from 14 kg in the 1970s to about 8 kg in 2015. In view of this, the Government of Malawi has embarked on various measures to restore the production from capture fisheries. Aquaculture has the potential to supplement the rising fish demand as well as significantly contribute to the national economy through employment creation, income earnings, poverty reduction, enhanced household livelihood and food security in Malawi.

7.1. National aim

National Fisheries and Aquaculture Policy aims at promoting sustainable fisheries resource utilization and aquaculture development in order to contribute to food and nutritional security and economic growth of the country.

The objectives of fisheries sector in Malawi are therefore to:

1. Increase annual fish production from capture fisheries from 90,000 to 110,000 tonnes;
2. Increase small and large scale aquaculture production from 3,600 to 10,000 tonnes;
3. Strengthen participatory fisheries management regimes;
4. Reduce fish post-harvest losses from 40 to 20 percent;
5. Increase annual fish exports from 500 to 3,000 tonnes;
6. Increase per capita fish consumption from 8 to 10kg;
7. Increase decent employment in fishing communities for youth, women, and men to reduce the number of child labourers;
8. Promote applied research in fisheries and aquaculture and monitor the impact of pollution and environmental changes including climate change; and
9. Develop capacity of the government and local management institutions.

7.2. Capture Fisheries

Capture fisheries is the fishing in the natural waters. The main water bodies where fishing takes place are lakes Malawi, Malombe, Chilwa and Chiuta and major rivers such as Shire, Linthipe, Bua, Dwambazi, Lweya, South and North Rukuru and Songwe.

Types of Fishery

7.2.1. Large scale operators

These contribute 10-15% and comprise:

i) Medium scale operators who use trawl nets dragged at the bottom with a pair of powered in board engines of 45hp each.

ii) Industrial fishing operators who use much bigger boats made of steel with more powerful engines of up to 350hp and better cold storage facilities.

Table 90: Main fishing water bodies and major fish species found

Water body	Examples of fish species found	Fish catches
Lake Malawi i) Shallow demersal (up 50m) ii) Deep water demersal (greater than 50m) iii) Semi-pelagic (mid water bottom dwelling fish) iv) True-pelagic (mid water dwelling fish)	Mbuna, Chambo, Chisawasawa, Utaka Kampango, Mcheni, Chambo Chambo, Utaka Usipa, Ndunduma, Mcheni	Utaka, Usipa and Chambo contribute to over 70% catches
Lake Malombe	Chambo, Kambuzi	Kambuzi contribute to over 90% of the catches
Lake Chilwa	Matemba, Makumba, Mlamba	Makumba and Matemba contributes up to70% of the catches
Lake Chiuta	Makumba	Makumba contribute up to 65% of total catches
Upper Shire River	Chambo, Kambuzi	Kambuzi contributes to large percentage of the catches
Lower shire	Mphende (Makakana), Mlamba	Both species contribute to over 70% of the catches
Other major rivers	Mpasa, Sanjika	Mpasa contribute 65% of the total catches

Source; Fisheries Department (2017)

7.2.2 Small-scale operators

Small-scale fishing contributes about 85 to 90% of total landings. Small-scale fishing is associated with fishing gears like gill nets, chilimira (an open water seine net targeting mainly usipa), kambuzi seines, chambo seines, mosquito seines, long lines, hand lines, cast nets, fish traps and a variant of other gears designed by fishers to target specific species. Small scale fishers use dugout canoes or plank boats with engines of 15hp or without engines.

7.2.3 Aquarist operators

This involves catching of live ornamental fish for trade. This fishery comprises only Mbuna species in lake Malawi. Mbuna fishes are brightly coloured rock dwelling species and are confined to areas around lands and submerged rocky areas such as Cape Maclear, Maleri island and Likoma/Chizumulu islands. Yield of this fishery is recorded in numbers of live fish exported. The live fish is exported to countries like United Kingdom, France, USA, Germany, Sweden, China, Norway, Canada, Holland, Belgium and Switzerland. Currently there are only three licensed operators (see table 91 for fisheries and aquarists license fees) This fishery contributes to generation of foreign exchange.

The information on fish type, location, quantities and sizes in terms of maturity suitable for harvesting is provided by the Fisheries Research Unit at Monkey-Bay and satellite stations in the districts. Fish landing from capture fisheries have fluctuated between 90,000 and 110,000 metric tonnes over the past 5 years. This fluctuation has been mainly due to localized over fishing, environmental degradation in shallow waters of less than 50m, the drying up of Lake Chilwa, and agricultural and industrial waste disposal into lakes and rivers. It is therefore important to note that declining in fish stocks cannot solely be apportioned to fishing activities alone.

There is need for concerted effort by all relevant sectors, on water bodies' ecosystem management in order for Malawi Fisheries development programme to be sustained. Examples of malpractices and environment changes experienced in Malawi are:

i) The use of small mesh size nets to catch juvenile fishes.

ii) The use of Tephrosia vogelli (Katupe, Mthuthu, Mtetezga) as a quick method of catching fish.

iii) Uncoordinated development leading to removal of reeds in the lake shore areas in order to erect cottages or other type of structures.

iv) Drying up of Lake Chilwa in the following years 1923, 1933, 1947, 1956,1968, 1971 and the recent recessions in 1994/95, 2005, 2013 and 2017 seasons.

7.2.3.1 Management of capture fisheries

There are three governance systems used in Malawi to manage fisheries:

1. Traditional system – where traditional authorities are custodians of the fisheries resources and this system is used to manage specific fisheries.

2. Government centered system - focuses on the control of the fisheries resources based on regulations and restrictions outlined in the fisheries laws of Malawi.

3.Co-management is the participation of the user groups in the management of the fisheries resources working hand in hand with government. This is also called Participatory Fisheries Management (PFM). In PFM, local structures called Beach Village Committees (BVCs) and Associations are established to work hand in hand with government and other stakeholder to sustainably exploit and conserve the fisheries resources of Malawi.

To sustainably manage the fisheries resources the following measures are used:

- **Licensing**

Large scale fisheries are issued with commercial fishing license which specifies the fishing area for each operator. The number of licenses available to fish in a particular area is fixed. These licenses are issued to large scale operators and renewable on annual basis. The aim of these licenses is to limit the number of fishers operating in the fishery. Large scale fishers do pay their license fees upon inspection for renewal to Fisheries Department Headquarters while all other fishers pay and renew their licenses in respective district fisheries offices.

Table 91: Outline of fishing gear license fees and designated fishing zones

i) Commercial fishing category

Type of gear	Fishing Zone	Engine Size	Fees (MK)
Pair trawler	Area C, D, E, F, G and H	38 -78 kW	682,000
Pair trawler	Area N	38 -78 kW	510,000
Stern trawler	Area B	>74 kW	1,650,000
	Area C, D, E, F, G and H	>74 kW	1,330,000
	Area N	>74 kW	580,000

(ii) Artisanal / traditional fishing category

Type of gear	Basic fee (MK)	Pre - qualification
Gill net	2,000	Per 100 meters and part thereof
Nkacha net	12,750	Per 50 meters and part thereof
Kambuzi seine	12,750	Per 50 meters and part thereof
Usipa beach seine	12,750	Per 50 meters and part thereof
Matemba beach seine	12,750	Per 50 meters and part thereof
Chambo seine	17,000	Per 50 meters and part thereof
Chilimira	25,000	Per unit
Chambo ring net	225,000	Basic fee
Usipa lift net	225,000	Per unit

(iii) Aquarist trade license

Area	Engine Capacity	Fees (MK)
F,G and H	N/A	750,000

Source; Department of Fisheries (2016)

Note: License fees quoted herein are subject to be revised without advance notice.

Fig. 60: A map showing demarcated fishing zones of Lake Malawi

Source; Department of Fisheries (2016)

Note: Areas A and B of Lake Malawi remain restricted to pair trawling for stock conservation purposes as they are deemed shallow.

- **Fishing equipment limitations**

Various regulations and restrictions govern water bodies for sustainable fisheries resource exploitation based on target species. Restrictions mainly relate to types of fishing gear as well as mesh sizes, fishing time and allowable catch size. Table 92 gives a summary of the various types of fishing equipment that are prohibited in different water bodies.

Table 92: Summary of various types of fishing equipment that are prohibited in different water bodies

Areas	Fishing Gear
All waters	Chalira
Lake Chiuta	Nkacha nets and beach seine nets
Lake Chilwa	Nkacha nets Fishing while sitting on floating is land (Chimbowela)
Lake Malawi-hallow waters	Bottom trawls pulled by more than 100 hp
Lake Malawi-Areas A, D, and E	Kambuzi beach seine nets
Lake Malawi- Area A	Bottom trawls pulled by more than 100 hp
Lake Malawi	Kambuzi beach seine nets
Lake Malawi	Mid water Trawls
Lake Malombe	Kauni for Chambo
Upper Shire River	Nkacha
Lower Shire	Mosquitonets
Upper Shire River	Nkacha
Lower Shire	Mosquito net

Source; Fisheries Department (2017)

- **Closed season**

This is a period when some fishing gears are prohibited for use in certain water bodies. This is done mainly to allow fish to breed and the young ones to grow without disturbing the breeding grounds, the breeding stocks and the young ones. Closed season also reduce effort in the fishery as a whole. Table 93 shows the period various lakes and rivers are closed to fishing and the fishing equipment that are prohibited during that period.

- **Protected/Closed areas**

These are areas where fishing using any kind of gear is prohibited thus providing a sanctuary for fish. Examples of such areas are Lake Malawi and Liwonde National Park with the latter covering part of Lake Malombe. The protected area consists of a water area extending 100 meters from the shore.

Table 93: Fishing closed seasons by

water body and prohibited fishing equipment

WATERBODY	CLOSED SEASON	PROHIBITED FISHING EQUIPMENT
Lake Malombe	1st Octoberto31stDecember	Nkacha Chambo Beach Seines Kambuzi Beach Seines Usipa Beach Seines
Upper Shire	1st October to 31st December	Chambo Beach Seines Kambuzi Beach Seines Usipa Beach Seines
Lake Malawi	1st November to 31st December	Chambo Beach Seines Kambuzi Beach Seines Usipa Beach Seines All Ring nets
Lake Chilwa	1st December to end February	All Beach Seines
Mpoto Lagoon	1st December to 28th February	All Beach Seines

Source; Fisheries Department (2017)

- **Post-havest fish handling**

The policy objective of the National Aquaculture and Fisheries Policy is to reduce fish post-harvest losses from 40 to 20 percent. When fish is landed at the beaches some traders buy and take it fresh to the market, while others buy and process it to add value and increase shelf life that will enable them to take it to far places whilst in good state. Fish processing methods currently used include freezing using ice to allow fresh fish to stay long and reach far markets without getting spoiled; smoking using palm fruits or firewood, sun drying, solar tent drying and para-boiling.

Importation and exportation of fish into Malawi

While production from both aquaculture and capture fishery remains low to meet national demand, traders and processors are exporting fish to neighboring countries such as Zimbabwe, Zambia and South Africa in marginal volumes. Before one decides on exporting processed fish for foreign market or mere household consumption, procedures as outlined below have to be followed to ensure that the fish products are in a desirable state befitting human consumption.

1. One has to seek clearance from Fisheries Department (Fish Inspection Unit) with samples or whole consignment for verification.
2. Once the Inspector is satisfied of the quality based on prescribed fish food safety parameters, the applicant is issued with a duly certified sanitory certificate at a fee of MK 5.000.
3. The sanitory certificate is valid for 10 days from the day of issue and it is advisable for the applicant acquire it few days before leaving or exporting the fish. Currently fish sanitory services can be obtained from Karonga boarder post, Mzuzu, Lilongwe (Fisheries Department Headquarters), Mchinji, Dedza boarder post, Mangochi, Zomba, Blantyre fisheries offices and Mwanza boarder post.

The Department of Fisheries also realizes that the country is flooded with fish products from other countries including far east nations. Fisheries Inspectors have been deployed in key border posts of the country to check on the quality, standards and volumes of both fish products leaving or entering the country. In case of a business entity wanting to be importing large volumes of fish, it is first required to obtain an import permit from the Veterinary Department and Business License from the Ministry of Trade and Industry and latter liaise with the Malawi Bureau of Standards (MBS) on product certifications.

Note on the same, it remains illegal importing live fish for introduction for aquaculture practices into Malawi's ecosystems. This is with respect to provisions of the Fisheries Management and Conservation Act (1997). Convention on Biodiversity and its subsidiary protocols, which commits Malawi to the preservation of biodiversity; and the FAO Code of Conduct for Responsible Fisheries (CCRF) of 1995.

Table 94: Fish production trends (mt) by waterbody from 2006-2016

Year	Lake Malawi-Artisanal	Lake Malawi-Commercial	Lake Malombe	Lake Chilwa	Lake Chiuta	Upper, iddle & Middle Shire	Total (mt)
2006	51,796	4,413	780	4350	1,085	3,840	65,484
2007	50,527	4,102	530	5904	1,024	3,643	65,200
2008	56,846	3,597	671	6006	1,018	3,128	71,266
2009	56,850	3,752	590	5879	1,034	3,184	71,289
2010	80,623	3,470	3,336	8019	2,549	1,197	95,724
2011	56,923	1,296	4,109	16,960	2,627	451	82,366
2012	106,769	2,367	1,608	7993	1,322	269	120,328
2013	102,769	1,867	1,847	2,982	290	823	109,889
2014	105,284	2,455	4,170	2,889	293	137	116,128
2015	127,438	2,672	5,904	5,660	1,150	1,491	144,315
2016	143556	4,416	4,053	2,834	1,298	1,111	157,268

Source: Ministry of Finance and Economic Development, Annual Economic Report 2017, GoM

Fish Production

Fish production trends have been fluctuating with an increasing trend. Table 94 above gives rounded catch statistics over the past years. In terms of catch composition, the dominant fish species for 2016 included Usipa, Utaka, Kambuzi Mlamba, Mlamba, Mcheni, Chambo, Makumba, Mbaba and Kampango contributing 70%, 9%, 4%, 3%, 1%, 1%, and 1% respectively to the total catch.

7.3. Fish farming (Aquaculture)

Fish farming is the rearing of fish in ponds, tanks and cages. In Malawi fish farming started in the 1950's. Fish ponds are the dominant production facilities. Presently there are over 6000 farmers owning 7500 ponds. Fish production from fish farming is estimated at 3600 tonnes. The potential to increase production from aquaculture is very high provided that farmers increase the level of production and follow recommended practices. The fish farming goal is to increase and sustain fish production from small holder and large fish farming operations in order to improve fish supply in Malawi. This guide provides guideline for pond fish culture only.

7.3.1. Production systems

There are different production systems that are employed based on the understanding of the fundamental processes. The Fish Farming goal is to increase and sustain fish production from smallholder and large fish farming operations in order to improve fish supply in Malawi. The three systems adopted in Malawi are as follows:

(i) Extensive system:

This system is characterized by culturing of fish in earthen ponds where fish is stocked in low densities with no supplemental feeding or fertilization. It is commonly practiced in large ponds of 1 to several hectares. The system requires two growing seasons to produce marketable fish of 0.5-0.8kg. In-terms of fish yields, the system is further characterized by low levels of stocking rates of 300-800 fish/ha giving yields of 300-600kg/ha/year.

(ii) Semi-intensive system:

Involves artificial enhancement of natural food production (add manure) and provision of supplementary feeds such as maize bran, green leafy vegetable and kitchen wastes wherever applicable. The system production is up to 4,000kg/ha/year.

(iii) Intensive system:

This system relies on formulated feed of high nutritive value. Stocking densities are high, therefore mechanical aeration is required. Production can reach up to 10,000kg/ha/year. Cage culture is one of the intensive fish culture systems that is being operated in Lake Malawi by MALDECO. Currently, it is contributing about 500 metric tonnes per annum.

Of these three systems, Malawi is currently encouraging the adoption of the semi-intensive system due to its advantages of ensuring faster economic returns.

7.3.2. Fish rearing

Fish can be reared in earthen ponds, tanks (concrete, plastic or canvas), race ways or cages placed in dams or in lakes. In Malawi, the semi- intensive system is predominantly practiced in earthen ponds. The important factors to be considered in rearing fish in earthen ponds are as follows:

i) Source of good water-permanent flowing streams and springs;

ii) Topography – It is easy to construct a pond on a site with good topography.

iii) A good site must have a gentle slope (1m rise to 100m horizontal distance). This kind of topography will facilitate the supply of water into the pond by gravity. It also facilitates the efficient and effective management of the pond as water can be easily controlled. For example, at harvest or when there is a disease outbreak, a pond can be drained easily as required.

iv) Soil-The soil should be able to hold water, (clay or silt) and rich in nutrients that would be released in to the water to stimulate primary production of food for the fish, (to increase *phytoplankton, zooplankton* and *benthic* organisms). The soil should also be free from chemicals such as acids and heavy metals like mercury or lead compounds which could poison the fish.

7.3.3. Recommended fish farming species

There are 5 fish species recommended (4 tilapias and 1cat fish). These are: *Oreochromis shiranus* (Makumba), *Tilapia rendalli* (Chilunguni), *Oreochromis karongae* (Chambo), *Oreochromis mossambicus* (Makakana) and *Clarias gariepinus* (Mlamba). A brief description of each species is given below:

(a) Oreochromis shiranus

Oreochromis shiranus in figure15 was introduced in aquaculture in Malawi during the early 1950s due to its ecological adaptability from Lake Malawi. The species is a mouth brooder, inhabits shallow marshy areas of the lake and breeds easily in fish ponds. O.shiranusis easily distinguished from other species within the genus Oreochromis due to:

- Four anal spines as opposed to the other *Oreochromis species.*
- Ripe males have a bright red margin on the dorsal fin instead of a white margin in Chambo species.

Fig. 61: Female (top) and male (bottom) Oreochromis shiranus

O.shiranus breed easily in ponds and start reproducing at 20g and are very prolific, i.e. a female can reproduce every 14 days when the minimum water temperatures are above 19^{o}C. Up to 8,000 fingerlings are harvested from earthen ponds (300 m^{2}) when stocked with 35-42g brood stock at a density of 1 fish/m2 and a sex ratio of 1 male: 2 females. The mature males establish a territory and defend it from intruders. On the territory, the male builds a nest and attract females to breed on the nest. *O.shiranusis* a mouth brooder and the embryos remain in the mouth for about 14 days. During this time the female does not feed.

Oreochromis shiranus can feed on cereal bran such as maize and rice. Growth performance in aquaculture depends upon the nutritive value of the feeds supplied among other factors.

(b) Tilapia rendalli

Tilapia rendalli in figure 16 belongs to the genus *Tilapia*, which are substrate spawners. *T. rendalli* can be identified in the field because of their brighter coloration with 5-7 olive vertical bars, having bright red in fusion on the throat and breast especially males, and distinct black spot on soft dorsal called the 'tilapia mark'.

Fig. 62: Tilapia rendalli

The adult *Tilapia rendalli* are essentially macrophagous plant feeders in areas of abundant vegetation. This capacity to digest aquatic macrophytes makes this fish important in polyculture with other tilapia species in ponds. The fish also feed on algae attached to leaves of macrophytes, filamentous algae, aquatic weedy cover as well as terrestrial vegetation that have been sub merged.

Tilapia rendalli is difficult to sex manually, because the coloration does not help to distinguish sexes. The use of magnifying glasses can help to distinguish sexes. Males are larger than females. Unlike other tilapias that brood eggs in their mouth, *T.rendalli* is a substrate spawner. Eggs are laid and attached to substrates on the marginal, shallow, sloping bottom among the grassy areas along the water banks. Once the eggs are hatched they are guarded by both parents fanning them, and transferring them from one pit to another. *T.rendalli* has high fecundity and produces about 5,000-7,000 fry per brood and breed about 8 times per year in natural environment.

(c) Oreochromis karongae

Oreochromis karongae in figure 17 also locally known as Chambo is domesticated in fish farms in all regions of Malawi.

Fig. 63: Oreochromis karongae **male and female**

O. karongae grows fast and attains first maturity at 80-114g which is higher than *O. shiranus, T. rendalli* and *O. mossambicus*. This shows that stunted growth is not a serious problem in *O.karongae* compared to other tilapias being farmed in Malawi. The growth rate of males and females is similar. Males are darker than females during breeding time. *O. karongae* grows faster due to late maturity.

(d) Oreochromis mossambicus

This species is indigenous in the Lower Shire river system and is a mouth brooder. It is highly omnivorous and accepts a wide range of food including zoo plankton, phytoplankton and artificial feeds such as maize and rice bran.

Fig. 64: Oreochromis mossambicus

***(e) Clarias gariepinus* (The African cat fish)**

Clarias gariepinus in figure 19 can be grown in polyculture with tilapias. To improve total fish production it may be stocked at one third of the total fish stocked in the ponds.

Fig. 65: Clarias gariepinus "Mlamba"

C.gariepinus is resistant to handling stress, hence making it possible to transfer it over long distances with minimum or no fish mortalities. It can with stand poor water quality. It can withstand overcrowding and this enables high stocking densities, which in turn give high fish yields. It can be stocked at a density of up to 200,000 fish per hectare (or 20 fish/m2) without any adverse effect on growth. Clarias gariepinus above 5g are omnivorous (feed on both plants and animals) and are able to convert low protein agriculture wastes such as animal manure and compost into rich animal protein.

7.4.0. Fish pond design, location and construction

The basic requirements of a fish pond is that it should hold water, be filled and drained by gravity and be easily stocked, harvested and managed. Poor design and construction may lead to disastrous and/ or expensive problems in future.

7.4.1. Site selection

The suitability of the prospective farm site must be as curtained prior to any construction or other planning. The critical parameters are topography, soil character, water quantity and quality, flooding and access or proximity to a dwelling unit.

7.4.1.1. Topography

The site should have a gentle slope to allow filling and draining of the ponds by gravity. This saves money unlike pumping, which need operational costs. Wide gently sloping valleys are the best, while narrow deep sloping valleys are usually not suitable for constructing fish ponds.

7.4.1.2. Water supply

The water source should be perennial with enough water all the year round to fill the pond and to compensate for losses due to seepage and evaporation. The quantity of water available will amongst other factors determine the size and number of fish ponds. Seasonal rivers and streams are not recommended as direct source of water for fish ponds.

7.4.1.3. Soils

Soil with too much sand or gravel in it will not hold water. The best soils for fish farming are the sandy clay, loamy clay and clay soils. The quality of the soil influences both water quality and pond productivity. Soil that compacts easily is suitable for dike construction. To determine the best soil for sitting a pond, the two most important properties to examine are soil texture (particle size composition) and porosity or permeability (ability to let water pass through). The pond bottom must be able to hold water (have a low porosity) and the soil should also contribute to fertility of the water by providing nutrients. So the best soil for pond construction is the one that has a lot of clay content.

7.4.1.4. Flooding

Areas prone to flooding are not suitable for fish pond construction. It is important to check for marks on trees or river banks left after flooding, and enquire from the farmer or other people about the history of flooding of the river.

7.4.1.5. Site access and proximity to the house

The site should be close to the farmer's home for easy pond management and reducing risk of theft and predation.

7.4.2. Types of Ponds

There are several types of fish ponds based mainly on the topography of the land and how the ponds are constructed.

- Barrage ponds consist of a dam built across a deep gorge or steep slopping valley.
- Contour ponds are constructed on a fairly level land or valley with walls on three sides.
- Paddy ponds are usually constructed on a flat land (Dambo) with a wall on all sides.

The most common types of ponds built by smallholder farmers are contour and paddy. This is because most of the areas where ponds are construct agricultural lands with streams flowing along the side.

7.4.3. Main features of a fishpond

The main parts/features of a fish pond are as follows:

- Walls (also called banks, dikes, embankments) are raised above the natural ground. These retain the water in the pond.
- An inlet, to let water into the pond. There are several types of water inlets such as:

- *Earth channel*- This is a canal on the ground leading directly into the pond, this is easier and cheaper to construct.
- *Concrete channel*- This is made up of cement and frequently used in preference to earth channel, if see page is a problem.
- *PVC pipe*- This is a synthetic pipe that can be bought from shops.
- *Bamboos* or *bark of trees*- The bamboos or barks of trees are used to let water into the ponds. These are locally available and have the least cost.
- An outlet to let water flow out of the pond. An outlet can be made of a monk for large ponds. An outlet can also be made of a PVC pipe.

7.4.4. Site Clearing

Once a proper site has been identified, the next step is the clearing of the pond site.

- Mark out the area where the pond will be constructed, taking into account the walls.
- Trees, shrubs, including roots and stones should be removed from marked areas.
- Top soil containing mainly organic matter, which is not suitable for pond walls, should be removed. The topsoil should be put aside to be later spread over the walls for planting grass; and also applied at the pond bottom to increase the pond fertility.

7.4.5. Pegging out a pond

Pond sizes will normally be dictated by the size of the land, topography, and the number of ponds the farmer would like to construct. From economic point of view, it is generally advisable to construct a number of smaller ponds (500m2) than a few large ones (over a hectare).

A pond can be designed anyhow; although rectangular ponds are favoured for easy management. Once the appropriate site has been identified a survey should be conducted to mark the pond. Pegs should act as guide to show the farmer where to place oil for marking the pond walls.

7.4.6. Inlet and outlet structure

There are a number of structures, which can be used to control the flow of water into and out of the pond (refer to section 4.3). The type of inlet and outlet will depend upon the resources available to the farmer. The position of water inlet and outlet depends on the slope of the land in relation to the water source.

7.4.7. Pond digging

For contour ponds, it is best to start digging from the upper part of the pond (near the water inlet), and most of the soil will need to go to the bottom wall (down hillside).

The soil should be placed uniformly all around the pond dikes. For maximum strength of the pond wall, after 20-30cm layer of soil has been placed on the wall, it must be moistened, if dry, and tightly compacted using tree trunks or any other appropriate earth ramming (e.g. wooden pole in 5 litre tin, filled with cement mortar, or 200 litre oil drum filled with water).

It is important that the pond bottom be made in such a way that the deepest part is at the drainage point and the shallowest part at the inlet.

When the pond walls are completed, the inlet and overflow are put in place. The overflow pipe is important in preventing water flowing over the top of the dikes and thereby eroding the dikes.

The slope on the inside of the walls should be about 1:2. The slope on the outside of the walls can be about 1:1. The slope depends on the type of soils used to make the walls. Banks made of clay soils can have steeper slopes than banks made of soils, such as loam or sandy loam. Water depth in the pond should be at least 1to1.2m at the deepest end and 0.5 to 0.7/m at the shallowest end. If ponds are constructed in areas where water supply is not reliable, water depth should be increased to about 1.5m at the deep end.

7.4.8. Shaping the pond

Strings are stretched between the pegs to indicate the top and bottom of the wall slopes. An even slope is then made scraping away compacted soil. The scrapped off soil can be recompacted to fill in lower parts of the pond.

7.4.9. Planting grass

When pond digging is completed, grass should be planted on the dikes as a protection to reduce erosion. Best species are Pasparum, Kapinga (Star grass) and Kikuyu grass. Do not plant trees or shrubs as the roots can cause seepage.

7.5.0. Pond filling

Fill the pond slowly with water to allow the new dikes to settle properly. A screen (perforated tin or piece of iron sheet or netting material) should be fitted at the water inlet to stop predators and their eggs from entering the pond. An over flow pipe is required to prevent fish from escaping out of the pond. Put stones on the bottom of the pond below the inlet pipe to avoid erosion of the dike and pond bottom. Ponds should never be filled level with the dikes. Leave a free board of 15-30cm between the top of the dike and the water level.

7.5.1. Pond fertilisation

The principal aim of fertilization of ponds is to increase the quantity of natural food (planktons) in the pond and thus fish production.

Fertilization of pond can be done with organic manure (compost, artificial manure) or inorganic (chemical) fertilisers. Organic fertilizers such as animal manures, (mainly from chickens, pigs, cattle) and compost are often used by smallholder farmers, since they are easily and locally available and cost the farmer almost nothing. For a 100 square meter pond, it is recommended to apply:

- 2 to 3kg of chicken droppings per week or
- 8 to 10kg of pig manure per week or
- 10 to15kg of cow dung per week.

Chemical fertilizers should be added to the pond every two weeks. Maximum concentrations needed in ponds of 0.5mg/1 for phosphorus and 1.4mg/1 for nitrogen are used to determine fertilization rates and can be calculated from the known ingredients written on the bag. NPK should be applied at a rate of 20kg/ha (2g per square meter of pond area). Inorganic fertilizers should not come in contact with the pond bottom, as the added phosphorus will be adsorbed onto the mud. The fertilizer should therefore be dissolved with water and sprayed/sprinkled over the pond.

Note the following:

The farmer should check whether the water is green or not before applying fertilizer. Check whether the water is green (fertilized) by dipping an arm in the water up to the elbow level. If the ends of the fingers are seen, the water is not green enough and more manure or fertilizer should be added.

If fish are coming to the surface to gulp for air after fertilizing, it means that the ponds have been over-fertilized and there is little oxygen available to this situation, stop fertilizing and add more water to the pond.

7.5.2. Liming of fish ponds

Liming of ponds is important for the following:

i) neutralize acidic conditions;

ii) make fertilizer applied to ponds work more effectively; and

iii) kill parasites when applied at pond preparation.

7.6.0 Pond Management

Good pond management includes:

- feeding the fish
- controlled stocking of pond (i.e. fish species and stocking rate);
- keeping the pond fertilized
- proper water management
- control of aquatic weeds and plants
- prevention of entry of wild fish and control of predatory animals and birds;
- controlled production period and harvesting techniques.

7.6.1. Feeding

The most important activity during the growth period of fish is feeding. The primary food for tilapia is plankton. Application of fertilizer and manure helps improve fertility of the water, which subsequently enhances proliferation of plankton *(phytoplankton and zooplankton)* and benthic organisms. A combination of supplementary feed (madeya) and chicken manure produces good results, yielding up to 4 tonnes of fish per hectare (80kg per 200square metres of pond).

Supplementary feed provides the energy required for normal metabolism and growth. The supplementary feed mainly comes from maize or rice bran. Feed the fish made at the rate of 3-5% of total biomass per day. The total amount of feed changes as time progresses and as the fish grows. A simple guide of maize bran feeding rates is provided in Table 95. Excellent yields of fish can be obtained when fish are fed complete formulated feed. Yields of 8 tonnes of fish per hectare per growing period can be achieved (160kg per 200 square meter of pond).

Table 95: Feeding rates for fish

Months after stocking	Kgs of maize bran (madeya) to feed (Number of chibuku packets or l litre Nido tins)				
	Pond size (m^2)				
	100	200	300	500	1000
1	0.5	1	1	2	4
2	0.5	1	2	3	5
3	1	2	2	4	7
4	1	2	3	5	10
5	2	3	4	7	14
6	2	4	6	10	20
7	3	6	9	15	29

7.6.2 Control of disease and predators

Tilapia rarely suffers from diseases. Recently mid 2020 there was an outbreak of Epzootic ulcerative syndrome (EUS) disease which affected mainlyb Bua river and some farmers in Mchinji and Kasungu. The disease mainly infected *Clarias gariepinus* (Mlamba), (catfish), *Oreochromis shiranus* (chambo/tilapia) Matemba, and *Barbus paludinosus* (straight fin barb) were observed and dead fish had ulcerative lesions on their skin.

EUS is a seasonal epizootic condition of great importance in wild and farmed freshwater and estuarine fish. The fungus involved in EUS is also known variously as *Aphanomyces invadans, A. piscicida, A. invaderis* and ERA (EUS-related Aphanomyces). It occurs mostly during periods of low temperatures and after periods of heavy rainfall. These conditions favour sporulation of A. invadans, and low temperatures have been shown to delay the inflammatory response of fish to fungal infection. EUS is transmitted from one fish to another through the water supply. The susceptible life stages of the fish are usually juvenile and young adults. There is no report of EUS being found in fish fry or fish larvae. When EUS spreads into a fish culture pond, high morbidity (>50%) and high mortality (>50%)

might be observed in those years that have a long cold season, with water temperatures between 18 and 220C. Some infected fish may recover when the cold period is over.

The Government of Malawi put in place measures to prevent further spread of the disease as such:

- Temporary suspension of transportation of and selling of live or dead fish around the Bua river system and surrounding fish farms;
- Suspension of fishing from the infected rivers and dams;
- Fishers were also advised to avoid the use of same fishing equipment used in the infected waters to other water bodies; and
- Communities were also advised to avoid carrying water from the infected rivers and fish ponds to other water bodies.

Fig. 66: Observed dead fish with ulcerative lesions on their skin

Recently, a number of parasites have been reported in fish at the National Aquaculture Centre, but no field observations have been made. These parasites are *Trichodina spp*.This is a protozoan parasites which infests the gills, fins and skin of Tilapia fish. Second types of parasites are trematodes, notably *Neodiplostomus spp* or *Posthodiplostomum spp*., also known as "Black Spot" disease. These trematodes infest the skin of the fish. A third type of parasites is crustaceans, notably *Ergasilus spp* and *Lernaeocera spp*. These infest the gills of many types of fish.

As a prophylaxis, it is recommended to apply quick lime (CaO) to the ponds, after draining, at the rate of 120kg per hectare inorder to kill the cysts of the parasites at the bottom of the pond. Small numbers of fish can be treated by dipping them in salt solution (NaCl), at a concentration of not greater than 2%.

Predators are the biggest problem. These include various types of birds, monitor lizards *(Ng'azi* or *Mmwazi)*, and otters *(Katumbu)*. Otters and birds are the most destructive predators, they can cause up to 75% losses. Birds can be controlled by scaring them, as is done in rice, wheat and cereal fields. However, otters are night feeders, and hence difficult to control. Sometimes, traps are effective on otters as shown in figure 20.

Fig. 67: A double fence across the pond to control otters

7.6.3. Harvesting

Fish should be harvested in 5 to 6 months from stocking if the culture period was during the warm months (September to March). The period is a little longer (7 to 8months) if the fish were grown in cooler months (April to August). Yields of up to 4-8 tonnes (80-160kg per 200 square metres of pond) per hectare can be achieved depending on management.

Fish should be harvested after a production cycle and farmers must adhere to a production cycle, because if the fish are not harvested, the farmer keeps on feeding them when the rate of growth has slowed down, as a result the farmer does not get any benefits in return. Predation and theft also destroy the fish stock if not harvested on time. Farmers should harvest fish for sale or home consumption at the right time.

There are several fish harvesting methods, which are;

7.6.4. Draining by cutting dike

For smallholder farmers, draining by cutting dike is the most common harvesting method. Cutting of dike should always be done at the lowest side of the pond to empty the pond completely. When using this method, care should be taken to avoid stirring mud at the pond bottom.

In most cases, fish are collected from inside the pond. Fish are hindered from escaping through the cut dike by a screen, a short net or a basket.

For easy collection of fish, a 30 to 40 cm deep harvesting depression of 1m x 3m size should be built in front of the depression.

Before refilling the pond, the dike should be thoroughly repaired and compacted to avoid any later seepage or breakage.

7.6.5. Drainage pipe

Pond is completely drained through a drain-pipe and fish collected in a bamboo basket. This method is usually applicable to small and medium-size ponds of up to 1000m^2 size. Advantages of harvesting by draining are as follows:

- Regular drying of the pond bottom helps control fish predators. The effect is even higher if lime applied
- Nutrients locked in the pond bottom (sediments) are released thereby increasing primary production
- Regular maintenance is made easier
- Excess pond mud can be removed and used as fertilizer for nearby gardens.

7.6.6. Harvesting by non-draining of ponds

Harvesting by non-draining is frequently practiced in situations where:

- partial harvests are targeted
- the water supply is unreliable
- ponds are non-drainable or draining is not known as an efficient harvesting method

The example of harvesting by non-drainage of ponds method include use of seine nets, cast nets and fish traps.

Fig. 67: Farmers harvesting fish using a seine net

7.6.6.1. Seine nets

Easiest most convenient method but the nets can be expensive. A minimum of two persons are normally required to use a seine net in a pond as shown in figure 23. Seine nets with 1/4” (7mm) mesh in the central catching section will normally catch over 70% of total fish (biomass) in 3 to 4 hauls.

7.6.6.2. Fish traps

Fish traps are usually made of locally available materials such as bamboo. Traps are normally baited. For tilapias, roasted maize bran made into moulds is the most effective bait, and may catch up to 0.5kg per trap per half a day (Length =76 cm, aperture =13cm).

7.6.6.3. Reed fence

Fish can also be harvested using a fence made from reeds, in the same way as mats are made. The fence is dragged through the pond, until the fish are confined in the corner of the pond. Then the fish are caught one by one, or scooped using a basket.

7.7.0. Pond maintenance

After harvest, leave the pond to dry for 2 to 3 weeks until the pond bottom cracks. After that, repair the damaged dike, normally the damage would have been caused by breeding fish, because they make their nests by digging.

Seal the leaking parts and reshape the dykes. If quick-lime is available apply at the rate of 120 kg per hectare, to kill parasites. Fertilizer should also be applied in the pond. Refill the pond and restock.

7.8.0. Marketing

There are 2 ways of marketing the produce as follows:-

a) The harvest day is announced in the neighbourhood, and customers come to buy the fish right at the site.
b) The fish can also be taken to the nearest market place.

Fish farmers must keep good records of quantities of fish harvested, value of fish sold, given to the needy and friends and that taken as relish (ndiwo).

Table 96: Aquaculture production (mt) by species

Year	Species					Total
	Oreochromis shiranus/ mossambicus/ karongae	*Tilapia rendalli*	*Clarias gariepinus*	*Cyprinus carpio*	*Onchorrhychus mykiss*	
2010	850	630	42	30	48	1600
2011	1420	862	175	76	98	2631
2012	2186	633	262	67	84	3232
2013	2578	641	333	71	82	3705
2014	3299.84	820.48	426.24	90.68	104.96	4742.40
2015	3422.09	850.56	508.47	94.25	108.85	4984.22
2016	7079.78	141.60	212.39	118.00	94	7646.17

Source: Ministry of Finance and Economic Development, Annual Economic Report 2017, GoM.

Detailed information on fish farming and further assistance can be obtained from Fisheries Department Headquarters, the National Aquaculture Centre at Domasi or any other Fisheries Office at District Councils throughout the country.

CHAPTER 8

BEE-KEEPING (API-CULTURE)

Bee-keeping (Api-culture) is the art of keeping bees *(Apis melliferas cutellata)*. It is an activity that can be integrated into agricultural, wildlife and forestry projects. Bee-keeping is an activity that can be done by both male and female, old and young and people of any profession. Bee-keeping involves the use and management of bee hives and colonies by the bee keeper inorder to make the best use of colonies. It provides sources of income and food such as honey, which consists of simple sugars that do not need to be digested but are assimilated directly by the body, thus making it a quick source of energy. Honey is a natural sweetener that can be used in any type of cooking and for sweetening beverages. It can also be used for wine making, wound dressing and honey beer.

Bee-keeping also provides bees-wax which has a lot of industrial uses as it is used in the making of cosmetics, candles, polishes and pharmaceuticals. It is also used for strengthening and water proofing thread for sewing and for baiting bees in newly installed hives.

Another bee product is propolis. This can be used as an antibiotic by the bees or for sealing unneeded gaps in the hive. Propolis can also be used in baiting or rebaiting hives.

Both products of bees honey and bees-wax are sources of income.

They can be marketed locally and surplus exported for foreign exchange.

In relation to other agricultural activities bee-keeping has the following advantages:-

i) It requires little land and the quality of land is not crucial. Bee-keeping also utilizes the land without harmful effects;

ii) Bee-keeping does not compete for resources with other types of enterprises. The nectar and pollen of plants are largely wasted if not collected by bees;

iii) It does not require high investment or complicated technology as all necessary inputs can be made locally,

iv) Bees transfer pollen from one plant to another, hence increasing the yields of many flowering plants. They therefore play an important ecological role; and

v) Bee-keeping is not an energy intensive farm activity and can therefore be done by anyone be it male, female, young, old or a person of any profession.

Many areas of Malawi provide excellent conditions for bee-keeping especially natural forest area, forest plantations of *Eucalyptus spp.* And agricultural areas within interspersed woodlots with melliferous plants (Bee pasture or plants liked by bees).

Prices for clean and pure honey are good and demand is very high. At present the market for bees wax is small but African bees wax is highly valued and prospects for Malawi products are excellent.

8.1. National aims

The aim is to increase production of honey and bees-wax inorder to satisfy local demand and have surplus for export. The objectives are, therefore, to promote bee-keeping as an additional source of cash income and food; and to utilize bees in pollination of crops such as sunflower, citrus, plums and macadamia including the natural vegetation.

8.2. Recommended practices

In order to improve the quantity and quality of both honey and bees-wax, the following husbandry practices are recommended:-

8.2.1. Recommended bee hive

The Kenya Top Bar Hive is recommended for high production, ease of monitoring and harvesting. This type of hive is a simple long box covered with 30 movable slats called top bars. The hive can be constructed using timber or straw. For dimensions of the bee hive and other bee equipment, farmers are advised to contact their field extension workers, Wildlife offices or bee-keeping expert in consultation with any agriculture office. Where bees become a threat to human life, members of the community are advised to contact local bee-keeping expert.

Beside the Kenya Top Bar Hive there is also the Malawi Standard Top Bar Hive which is an adaptation of the Kenyan type to suit Malawi conditions. Farmers are therefore encouraged to use such top bar hives and refrain from using log or bark hives because these cause a lot of deforestation. In addition to the scarce tree resources. These are difficult to manage and are a source of bushfires.

8.2.2. Siting and hanging bee hives

The site should have vegetation that will adequately provide nectar, a good shade to protect the bees from excessive heat, dry and accessible and beat least 100m away from people's and domesticated animals' paths. Humid conditions are conducive to disease infection. Hang the hive between 2 strong trees or on a single strong branch using wire or strong rope. The distance from the ground will depend upon the bee-keeper's height. Where honey badger *(Mellivora capensis)* (Chiuli) is a problem, suspend the hive at a minimum distance of 1.5m from the ground as well as from the supporting trees. After 2 to 3days check for bee colonization and ensure that pests and other unfavourable bee colonization conditions are either eliminated or controlled.

8.2.3. Starting a colony

A farmer can start bee-keeping by either baiting or catching swarms.

8.2.3.1. Baiting swarms

Rub the inside of the hive and along the ridge on the top bars with melted bees-wax or propolis so that it smells like bees and attracts them. Place the top bars on the hive and close with a lid. After the hive is colonized inspect once every fortnight or as convenient (at shorter frequencies) to assess growth, queen presence and righteousness, (each bee cluster performing its functions accordingly) insect pests and diseases incidences, and honey availability.

8.2.3.2. Catching a swarm

A natural swarm hanging from a tree is normally docile and can easily be removed and hived. When catching a swarm, the bee-keeper should have a smoker-ready and put on a veil and gloves. Avoid using inappropriate protective gear to ensure full personal safety from stings. Take a capture box or a carton and put it beneath the clustering bees. Smoke the bees gently, shake or brush the bees off directly into the capture box and make sure most of the bees have entered the box before you cover it. This will ensure that the queen has entered the box as well; otherwise the swarm will not grow.

Put the swarm in an already installed hive and keep on inspecting 2 times a month to monitor growth. Where possible monitoring at closer frequencies is encouraged.

8.2.4. Initial feeding

As soon as the hive is colonized, provide a sugar syrup in the ratio of 1:1(one part of sugar and one part of water) or honey, if available, to feed the bees while they are getting established. Put the syrup in a container which has a cover (like a chicken water drinker) and place it in the hive in such a way that the syrup trickles on to a cover from where bees can feed. The duration for initial feeding will normally depend on whether bees have started to acclimatize to the surrounding environment. This is provided for a period of 2 to 3 days.

8.2.5. Bee handling

When handling bees, it is important to make sure that they are kept under control by good sense of judgment, confidence and gentleness of the bee- keeper in addition to smoke. The bees should be under control from the time the hives are approached to the end of the operation. The following practices should be followed in order to manage bees properly when rearing them.

i) All unnecessary movements or noise when working with bees should be avoided. Rapid and nervous movements will annoy the bees. The bee-keeper should go by the side of the hive and not in-front as he/she may block the flight path and annoy the bees.

ii) Avoid perfumes and scented lotions when working with bees. Strong scents attract the bees and incite them to sting.

iii) Use smoke to control the bees. Smouldering pieces of dry cattle dung will provide the best smoke for bee handling. Make sure there is no glowing dung but plenty of cool white smoke should be maintained. Do not puff in too much smoke as this may affect the quality of honey through smell. Smoke induces the bees to start consuming some honey there by reducing their tendency to fly and sting. Smoke also assists to direct the bees away from areas of the hive in which the bee-keeper is working.

iv) Avoid killing bees as this may annoy the others and incite them to sting or swarm. Once a bee stings, it later on dies. The more the stings, the more the colony is depopulated by way of death.

v) When opening a hive, blow a little smoke into the entrance holes several times and then move behind the hive. After 1 or 2 minutes lift the top cover and detector determine the empty side of the hive without combs. Then start working from the empty side of the hive. Every time you lift a top bar blow some smoke into the gap to keep the bees away and after the operation is over, quietly close the hive and move away.

vi) Controlling Swarming: is a method by which bee colonies reproduce and control over crowding. A major cause of swarming is that the colony has grown so large that the hive is getting congested. If swarming is not checked a lot of colonies will leave the apiary, leaving behind small colonies that will take time to build-up again. This will result in producing very little honey. Prevent swarming by harvesting honey or dividing the bee colony in order to provide adequate room in the hive. This will result in brood rearing and honey storage.

Dividing a colony prevents swarming. This can be done by removing 12 to 15 combs that should include bees, sealed, and unsealed brood, honey and pollen, into a capture hive. Carry the capture hive to a new site and transfer the colony into an empty hive, which has already been installed. This will have been properly baited or positioned for bee colonization.

Note: Avoid using open fire because it kills bees and causes bushfires that are unplanned and destructive to bee pastures.

8.2.6. Pest control

8.2.6.1. Insect Pest control

(i) Wax Moth *(Galleria mellonella)*

This is the most serious pest on honey bee colonies. It is a small brown moth which normally attacks weak colonies where there are unguarded combs.

Weak colonies are characterized by few number of bees usually because of inadequate feeding. The moth lays eggs in the combs and the larvae burrow through the wax, feeding on pollen while weaving tunnels of silk as they go.

Before pupating the larvae will often chew a depression in the wood of the hive and then spin a rough cocoon. If left unprotected, the combs are reduced to a mass of webs.

Control is by making sure the colonies are strong with proper feeding, that is, with sugar syrup during the time of food shortage and leaving enough honey for the bees to feed on when harvesting. This will ensure that all combs are well guarded.

(ii) Beetles *(Aethin atumida)*

Beetles vary in color and size. They damage the colonies by feeding on the stored pollen. The greatest damage is done in weak colonies where the beetle will breed and the larvae allowed to burrow through the comb.

Control is by reducing the entrance holes of the hive to 1cm diameter. This will allow free passage to the hive but will prevent the entry of the large hive beetles.

(iii) Ants *(Iridomyrmex humilis)*

These are a common pest of bee colonies in the country. Ants attack the brood (eggs, larvae and pupae) and not the honey. Ants usually overwhelm the colony by their numbers causing the bees to leave the hive. Control is by applying oil or grease to hive stands or wire supports so that ants have no access to the hive.

(iv) Bee pirate (Palarus latifrons)

When in large numbers, the pest demoralizes a colony causing the bees to stop for aging or collecting nectar, pollen and resins. It waits around hives during the heat of the day and pounces on passing foragers, stinging them off as food for its larvae. Control is by seeking wasp nests and burning them.

(v) Bee lice *(Braula spp.)*

It is occasionally seen clinging to the body of the queen bee. It eats some food from the mouth parts of its host.

Control is by putting a heavily infested queen bee in a matchbox and blowing in tobacco smoke. The bee lice will fall off then the queen bee can be returned to her colony.

(vi) The Honey Badger or Ratel *(Mellivora capensis) (chiuli)*

This is a destructive animal about 1m long with very tough skin and long strong curved claws. It breaks up bee hives and feeds on all combs without being worried by stings. It can also attack human beings.

Constructing a fence around the apiary so that it has no access to the hive can control the Honey Badger. Where wires suspend hives, pile thorns on bottom of trees supporting the hive.

You can also ensure that hives are suspended at a height slightly above a metre. This will disable the honey badger reaching the hive. However, it has to be noted that honey badger is capable of climbing trees and can jump onto the hive from tree branches. Hence, where this animal is a problem, avoid branches hanging over the hive.

8.2.6.2. Disease control

At the moment, there are no bee diseases of economic importance.

8.2.7. Bee safety

Where sprays and dusts are used to control crop pests, a farmer and bee-keepers should cooperate if the lives of bees are to be protected. The danger can be minimized by the farmer not spraying crops when flowers are open; and the bee-keeper shutting hives the night before spraying is to begin making sure no chemical dust will fall on his hives One can also avoid hanging hives close or where there is heavy use of pesticides or insecticides.

8.2.8. Harvesting of honey

Have a bee suit, smoker, bee brush, hive too land pail ready when preparing to harvest honey. Honey is ready after 5 to 9 months from colonization depending on climate, vegetation and pest infestation. Honey is ripe when combs are sealed. Sealed honey has 17% water content and will not ferment. Harvest honey when 8 or more combs have sealed honey. Any comb with honey and brood mixture should not be harvested. Harvest by cutting the honey comb off the top bar. Put the comb in a plastic or stainless steel bucket or pail and close tightly to prevent other bees from feeding on the honey.

Honey is the bees' food. Leave enough combs for bees to feed on. Harvesting may be done up to 3 times a year. Average yields vary from 15 to 35kg per colony per harvest.

8.3. Other hive products

Other hive products are bees-wax, pollen, bee brood, propolis and royal jelly, honey and bees-wax being the major products.

8.4. Processing

8.4.1. Honey

Cut the combs into small pieces and strain the honey through a coarse strainer, screen wire or nylon cloth. Then strain the honey through a fine strainer and leave the strained honey in a clean container such as pail for 3 to 5 days to settle. Then bottle the honey and close tightly ready for sale.

8.4.2. Bees-wax

Bees-wax is a product of body metabolism of the honey bee and is produced by special gland called wax glands.

When processing wax, put the empty combs in a pot of water and heat the water till the wax melts but the water should not boil. Strain the wax through a screen into a soap rubbed container and leave the wax there till it hardens then remove it and scrape debris off the bottom.

8.5. Marketing

Honey and bees-wax can be marketed locally. It is important to satisfy the local market before selling honey and bees-wax outside the country.

It is advisable to properly bottle honey and label the bottles with appropriate details that conform to the Malawi Bureau of Standards. However, honey can also be sold on combs or by use of a pre-determined measure especially in villages.

CHAPTER 9

FORESTRY

It is estimated that about 28% (2,632,000) of the total land area in Malawi can be broadly classified as forest land covered with predominantly trees or other woody vegetation, (Encarta). Out of this forest resource 160,000 hectares constitute plantations and woodlots. Gazetted forest reserves amount to 85 in number, totaling to 1, 109,626 hectares whereas 154,137 (2,632,000 hectares) are proposed forest reserves and protected hill slopes. In addition, 800,000 hectares are natural woodlands on customary land. The remaining 1,047,000 ha are under National Parks and Wildlife Reserves.

The forest resource on customary land is under pressure because it is annually being depleted at a rate of 1.6% (50,000ha) because of opening-up of new gardens and estates, firewood and pole collection, overgrazing, building infrastructure such as roads, settlements and bushfires. This has led to deforestation and land degradation which have far reaching effects on living standards of the people. This situation has been aggravated by a high annual population growth rate of 2.8% (2008 census).

9.1. National aims

The goal of the National Forest Policy (2016) is for the conservation, establishment, protection and management of trees and forests for the sustainable development of Malawi.

The Policy Outcomes are:

1. Sustained management and utilization of forest resources;
2. Improved and sustained financial benefits and other livelihoods outcomes (including food, biomass, shelter, health) from forests;
3. Sustained conservation and enhancement of forest biodiversity and ecosystem services;
4. Increased opportunities for eco-tourism and recreation;
5. Improved and sustained financing to the forestry sector;
6. Improved knowledge base and its application in forestry;
7. Increased participation of all stakeholders in forest conservation and management;
8. Improved, well regulated and monitored forestry sector; and
9. Enhanced cooperation and collaboration in forestry related issues at regional and international levels.

To fulfill the above outcomes, the Forestry Department has the following objectives:

1. Provide an enabling framework for promoting the participation of local communities, the civil society and the private sector in forest conservation and management;
2. Promote the establishment of forest based small and medium scale industries;
3. Promote the growing of trees by all sections of the communities in order to achieve sustainable self-sufficiency of wood and forest derived products and services;
4. Promote sustainable management of forests for the protection of the environment, conservation of biodiversity and climate change management;
5. Promote the development of initiatives for adequate and sustainable short, medium and long term financing mechanisms for the forestry sector and its contribution to GDP;
6. Enhance the development of requisite human resource commensurate with the implementation of the policy;
7. Promote the sustained management and utilization of forest resources based on research findings and recommendations;
8. Promote a well regulated, compliant and monitored forestry sector with clearly defined forest standards and guidelines; and
9. Enhance cooperation in forestry related issues at national, regional and international levels to maximize resources and information flows into the forestry sector.

9.2. Woodlot Establishment

9.2.1. Species selection

Farmers may plant trees of their choice. This will however depend on the purpose for which the farmer wishes to grow them and the tree recommended by forestry or agricultural staff for their areas.

Generally, the following tree species grow better in high altitude areas:

Pinuspatula (Mkungudza)

Eucalyptus grandis (Bulugama)

E. saligna (Bulugama)

Cupressus lusitanica

Widdringtonia nodiflora (Mulanje cedar).

The following are recommended for lowland areas:

Leucaena leucocephala (Lukina)

Pinus kesiya (Kesiyasi)

Pinus oocarpa

Senna siamea (Kesha)

E. tereticornis (Bulugama)

E. camaldulensis (Bulugama)

Melia azederach (Indiya)

Toona ciliate (Sendelera)

Azaderachta indica (Nimu)

Afzelia quanzesis (Msambafumu)

Gmelina arborea (Malayina)

Oxytenathexa abyssinica (Nsungwi)

Khaya anthotheca (Mbawa)

Faidhebi aalbida (Msangu)

Pterocarpus angolensis (Mlombwa).

9.2.2. Nursery site selection and preparation

Farmers should be advised to choose a tree nursery site which is near a permanent and salt free water supply, preferably on drained loamy clay soils. The nursery should be fenced to protect tree seedlings from damage by livestock.

The site should be tilled before seedbed preparation. Seed beds should be 90cm wide, 15cm high and of convenient length depending on quantity of seedlings to be raised. The soil should be worked to a fine tilth. Seedbeds for *Eucalyptus* species should be sterilized by burning as in tobacco nursery management.

9.2.3. Pot filling

Soil used in filling pots should be collected from natural woodlands, however, for pines, the soil should be collected from near the surface under pine trees. The soil under pine trees contains *mychorrizae* fungi which are essential for pins to grow successfully. This soil should be mixed with that collected from natural woodlands in the ratio of one *mychorrizae* soil to three natural woodland soil.

9.2.4. Seed supply

The Forestry Research Institute of Malawi (FRIM) in Zomba stocks various types of tree seed of both exotic and indigenous tree species. The seed can be ordered directly from FRIM or through the nearest District Forestry Office. Packages of seed of various sizes are made available according to the order. The quality of seed, its viability and source are indicated on the seed batch. Farmers are advised to seek advice on suitable tree species for their areas.

9.2.5.Seed sowing

9.2.5.1. Small seeds

For small seeds of trees such as Eucalyptus a total of 1,600 seeds should be sown per square meter of seed bed in July or August. The seed should be mixed with fine sand and broadcasted evenly. Then the seed should be covered with fine sand to a depth of one millimeter.

After the seed has been sown, the seed should be covered with a combed grass mat raised about 60cm above the bed. Watering should be done regularly to keep the seedbed pots moist. Over watering should be avoided as it may create favourable conditions for damping off disease which may kill the seedlings. The seed normally germinate in 10days.

9.2.5.2 Medium seeds

For medium seed, such as pine sand cypress a total of 2,200 seeds should be sown per square metre of seed bed in March or April. The seed should be pressed down with a flat board or base of a plate, and should be covered to a depth of about 6mm. Seedlings normally emerge after 14 to 21 days.

9.2.5.3. Large seeds

Large seeds of trees such as *Gmelina arborea, cassia siamea, Pterocarpus angolensis (Mlombwa)* and *Khaya anthotheca (Mbawa)* are sown in pots in July or August. Emergence period for indigenous seeds vary from species to species with 21 days being the maximum.

Seed for tree species such as *Faidhebia albida, Senna siamea* and *Leucaena leucocephala* need to be scarified before being sown.

9.2.5.4. Bamboo planting

The indigenous bamboos *(Oxytenathexa abssinica)* can be grown in many areas but bamboos require a lot of water for good growth, for example along river banks. Bamboos can either be raised from rhizomes and shoots or from sections of shoots.

(i) Rhizomes and shoots

Carefully dig up a 30cm length of rhizome (underground stem) with shoot and cut it off just above anode about 45cm above the rhizome. These cuttings must be planted immediately by burying the rhizome at approximately the same level as it was originally.

(ii) Section of shoots

Cut lengths of young shoots about 30 to 45cm long which should include at least one node. These can either be buried horizontally in the ground or at an angle so that the bud and node are just below the ground.

The best time for planting bamboos is during the months of August and September. Bury the rhizome or shoot at a spacing of 5m by 5m in pits 45cm deep, 45cm long and 45cm wide. The soils must be adequately moist at the time of planting. The recommended planting espacement for exotic bamboos 8m by 8m.

9.2.6. Pricking out or transplanting into pots

Seedlings should be pricked out when they have 2 to 3 pairs of true leaves for *Eucalyptus* and before the seed coat sheds off for pines.

9.2.7. Supply of seedlings

All institutions are encouraged to raise tree seedlings for their own planting and they may sell or issue surplus seedlings to others who may need them.

9.2.8. Site selection

Trees can be planted on any selected sites such as around homes, along garden boundaries, river or stream banks, along roads, bare hills and other degraded areas. Besides providing wood, trees will rehabilitate degraded lands. Farmers are advised to avoid cutting down indigenous trees inorder to replace them with exotic tree species.

9.2.9. Tree planting

After identifying the tree planting site, farmers should dig pits 30cm wide by 30cm deep in July or August.

The spacing of planting pits depends on the species to plant, and the end use. Trees planted for poles and fire wood, are usually closely spaced compared with timber trees.

To have a well established woodlot, the following general guidelines should be observed:-

i) all pits should be filled in after first rains;

ii) Plant strong and healthy seedlings;

iii) each site should be planted with the right tree species;

iv) plant early with the first rains to enable good tree establishment. After transplanting the seedling into the pit, it should be filled with soil to the root collar and should be pressed firmly around the seedling to get rid of air while ensuring that the soil is in contact with the roots.

9.2.10. Woodlot tending

After seedlings are established, one may apply Compound D (8:18:15) fertilizer, 50g per tree using 2 cupfuls of cup No. 22. Woodlots should be weeded 2 to 3 times a season till good canopy is achieved.

Woodlots intended for firewood do not require pruning. However, Eucalyptus species even if intended for other uses other than firewood do not require pruning because they are self pruning.

9.2.11. Woodlot protection

9.2.11.1. Fire prevention

Fires can burn a woodlot in less time than it took to establish it. Farmers should protect the woodlot by making a fire break of 3 to 5 metres wide around it. If the woodlot area is large, farmers should make internal fire breaks as well. These operations should be done before the onset of the dry season. If possible, farmers should slash or cultivate the area to keep fire hazards to a minimum. Farmers should be advised to slash the grass outside the firebreak and conduct early burning on its perimeter as soon as rains tail off.

9.2.11.2. Animal control

Domestic and wild animals can cause considerable damage to trees. Farmers should therefore protect their woodlot from animals by live fencing using sisal or any hedge tree species found locally. The individual tree can be protected by basket type of fencing using dry grass and thorny shrubs or scaring the animals away. Where wild animals cause damage, assistance can be sought from the nearest office of the Department of National Parks and Wildlife.

9.2.11.3. Disease control

Diseases, particularly fungal diseases can kill trees. The early attack may not easily be notice able and it is at this early stage of the attack that damage can be caused. The damage could be rotting of root, dying of the bark or drying of leaves. Where these are observed farmers should immediately report to the nearest Forestry Office for advice.

9.2.11.4. Insect pest control

Pests such as termites, weevils, grasshoppers, beetles, caterpillars and aphids can damage the woodlot and should therefore be controlled. Farmers should periodically inspect their woodlots for presence of pests.

Termites can be controlled by keeping the woodlot clean and boosting tree growth is a control measure which can be undertaken.

9.2.12. Harvesting

Plan to harvest trees in such a manner that there is a continuous supply of wood throughout the year. Exotic trees should also be used for firewood and not for poles and timber only. Trees should be cut at 15cm above the ground. This enables easy transportation of the harvest out of the woodlot as it presents less danger to movement sand avoids wastes. It also enables and facilitates better development of coppice shoots. For trees which coppice, the cut should be sloping to prevent rain water collecting on the stump which results into rotting.

9.3. Wood Conservation

The Department of Forestry developed technologies of making pine and eucalyptus charcoal from wood wastes (thinnings). The Department is also encouraging the use of briquettes, pellets, biogas, liquefied petroleum gas (LPG) and electricity for heating and cooking. These are elaborated in the National Charcoal Strategy. Those interested in these technologies can contact the Director of Forestry.

The Department of Forestry developed Malawi ceramic Mbaula which are now on the local markets in both rural and urban centres. These fuel efficient stoves are good for energy saving and do not use a lot of biomass. These are important as they substantially cut down on the amount of wood used for cooking. In the tobacco industry, use of wood for curing tobacco has been reduced from 40 to 20 cubic metres of stacked firewood to cure one tonne of tobacco. Moreover, some tobacco estates are using pine charcoal for curing tobacco as an alternative source of energy and this should be encouraged.

9.4. Indigenous Woodland Management

Malawi currently experiences high deforestation rate, forest degradation, unpredictable climate shifts and landscape degradation. The Department of Forestry has developed a National Forest Landscape Restoration Strategy to address these challenges. The Strategy outlines priority opportunities and interventions that can translate the potential of restoration into multiple benefits such as improved food security, increased biodiversity, improved water supply, job creation, income, carbon sequestration and enhanced resilience to climate change.

The Department of Forestry has developed technologies on appropriate management of indigenous woodlands especially on customary land. Village Natural Resources Management Committees (VNRMCs) have been established to manage forest resources at village level. The VNRMCs, in consultation with the local traditional leadership and members of the community, formulate by-laws and constitutions to guide them in the management of the forest resources. The Department of Forestry facilitates the process.

Village Forest Areas (VFAs) are demarcated and management plans are drawn up. Management plans indicate the appropriate seasons for replanting, protection against livestock and wildfires. Natural regeneration is encouraged in the VFAs to retain tree species indigenous to respective areas.

Preparation of Participatory Forest Management Plans

The Department of Forestry has developed procedures for preparation of Participatory Forest Management Plans (PFMPs). Communities are pre-sensitized and mobilized.

Joint planning for the PFMPs takes place with the communities and other stakeholders. Joint forest resource investigation walks and participatory resource mapping of the VFAs are done. A forest product demand matrix is prepared and the findings are feedback to the community. The resource is assessed through joint setting and measuring of sample plots. The supply is determined by joint resource data processing and interpretation. Management objectives and strategies and resource use rules are developed. Responsibilities, costs and benefits are agreed. Feedback to the communities is done and the activity plans are drafted. PFMPs ensure that VFAs or forests on any land are sustainably managed.

In case of doubt on what species to grow in one's area, contact the nearest forestry office for advice.

FOR FURTHER DETAILS, CONTACT THE FOLLOWING:

The Secretary for Agriculture,
P.O. Box 30134, Lilongwe 3.
Tel: 265(1)789033

The Director,
Department of Animal Health and Livestock,
P.O. Box 2096, Lilongwe 3.
Tel: 01756389/01750455

The Director,
Department of Agriculture Extension Services,
P.O. Box 30145, Lilongwe.
Tel: 01755522/01754049

The Director,
Department of Crop Production, Private Bag 30145,
Lilongwe 3.
Tel: 01789252

The Director,
Department of Land Resources Conservation,
P.O. Box 30291, Lilongwe 3. Tel: 01755352

The Director, Department of Fisheries,
P.O. Box 593, Lilongwe.
Tel: 01788511/01788716

The Director, Department of Forestry, Private Bag 30048,
Lilongwe.

The Manager,
Bvumbwe Agricultural Research Station,
P.O. Box 5748, Limbe.
Tel: 01471206/207/01471527

The Station Manager,
Makoka Agricultural Research Station, Private Bag 3,
Thondwe.
Tel: 01534254/283/249

The Station Manager,
Kasinthula Agricultural Research Station,
P.O. Box 28, Chikhwawa
Tel: 01420207/439/22

The Station Manager,
Chitedze Agricultural Research Station,
P.O. Box 158, Chitedze.
Tel: 0170722/041/224/398/023

The Station Manager,
Chitala Agricultural Research Station,
P.O. Box 315, Salima.
Tel: 01262850

The Programme Manager, Karonga ADD,
Private Bag 4,
Karonga.
Tel: 01362382/01362244

The Programme Manager, Mzuzu ADD
P.O. Box 131, Mzuzu.
Tel: 01334056

The Programme Manager, Salima ADD, Private Bag 1
Salima
Tel: 0162213

The Programme Manager, Kasungu ADD,
Private Bag 28,
Kasungu.
Tel: 01253744

The Programme Manager, Lilongwe ADD,
P.O. Box 259, Lilongwe 3.
Tel: 01753171/01754577

The Programme Manager, Machinga ADD,
Private Bag 3,
Liwonde.
Tel: 01542410

The Programme Manager, Blantyre ADD,
Private Bag 379,
Blantyre 3
Tel: 01824300

The Programme Manager, ShireValley ADD,
Private Bag 1,
Ngabu
Tel: 01427211/01427204

Designed and printed by
Agriculture Communication Branch
Department of Agriculture Extension Services
Ministry of Agriculture
P.O. Box 30145
Lilongwe 3

ISBN999-34-00-9