Sweden
Sverige

Study Circle Material

Horticultural Production and Marketing

A study guide to help farmers increase production, productivity and generate more income from their horticultural enterprises

imoved
INCLUSIVE MARKET-ORIENTED VALUE CHAINS FOR ECONOMIC DEVELOPMENT

WE EFFECT

We Effect

We Effect was created by the Swedish Cooperative Movement in 1958. It is an international NGO with its HQ in Stockholm Sweden. Its development cooperation is founded on the principle of help for self-help and thrives towards the vision of a world free from poverty and injustice. We Effect works with partners of mostly member based organizations to ensure members empower themselves with knowledge and skills to alleviate poverty and injustice. We Effect works in various countries globally with Regional offices in Southern Africa, East Africa, Latin America, Asia and Eastern Europe and Sweden, it works in the sectors of sustainable rural development, habitat and rural finance.

Inclusive, Market-Oriented Value Chains for Economic Development (*i*Moved)

We Effect, in partnership with three local partner organisations: the Zimbabwe Association of Dairy Farmers (ZADF), Women and Land in Zimbabwe (WLZ) and Zimbabwe Dairy Industry Trust (ZDIT), is implementing Inclusive, Market-Oriented Value Chains for Economic Development (*i*Moved) project (2022–2026). The action is funded by the Embassy of Sweden in Harare. The project aims to contribute to an inclusive, market-oriented value chain development of the dairy, soyabean and horticulture sector for sustainable livelihoods of female, male and youth smallholder farmers of Zimbabwe. This farmer guide provides guidance on smallholder horticulture production.

Disclaimer

The views expressed in this information product are those of the authors and do not necessarily reflect the views of or policies of the Embassy of Sweden, We Effect or any of the *i*Moved partners whose logos are displayed below:

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Printed by:	Rent A Copier (Pvt) Ltd.

Acknowledgements

This study circle material: Horticultural Production and Marketing Study Circle material is compiled by We Effect as part of a programme to contribute to an inclusive, market-oriented value chain development of the dairy, soyabean and horticulture sector for sustainable livelihoods of female, male and youth smallholder farmers of Zimbabwe under the *i*Moved project funded by the Embassy of Sweden in Harare. The material addresses aspects of horticulture production, productivity and marketing. Farmers can use the material as part of the study circle methodology where small groups of 8-16 adults or youths meet regularly and carry out planned studies. The material is built around the participants' search for niche specific knowledge according to their own needs and interests.

This study circle material is aimed at increasing farmer groups' access to horticulture production and marketing information and knowledge in a participatory manner. Special thanks goes to the Embassy of Sweden in Zimbabwe for funding the development and printing of this study circle material. This study material has been improved from earlier versions and if you have any suggestions to improve it please contact the undersigned.

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How to use this study circle material

This guide is divided into 18 sessions. Each session begins with the learning objectives. There is an introduction, and content topics. At the end of each session there is a summary of the main topics covered in the session.

Instructions for the study circle leader are given in blue. Discussions are for the whole group to answer questions. Self-reflection is for individual group members to think about questions. There are also exercises when the whole group has to do an activity together. At the end of some of the sessions suggestions for homework are given. There is a glossary at the end of the guide to define technical terms used in the book.

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SESSION 1: INTRODUCTION TO STUDY CIRCLES

1.1 Introduction

Greet each other and review the learning objectives for this session.

LEARNING OBJECTIVES

By the end of this session, participants should be able to explain:

- What a study circle is;
- Why and how adults learn;
- The use of study circles;
- The need for a study circle leader;
- The role of your study circle leader and your role as participants.

1.2 What is a study circle?

Talk about what a study circle is. Then read the following…

A study circle is a group of 8-16 people who meet regularly to learn about a topic together. During the meetings, group members share ideas, and learn new things to improve their skills and knowledge. At the meetings, everyone in the group is encouraged to participate on an equal basis. The group meets once or twice per week for 8-16 weeks, to study a selected topic for about two hours.

Study circle guidelines

All group member (participants) wish to learn more about a subject to improve their own daily lives;

- All participants are equal and have respect for one another;
- Participants sit in a circle, facing each other to promote effective communication,
- Discussions are encouraged to share and analyse individual experiences;
- Study materials are used to provide information that is relevant to the participants;
- Participants are involved in planning and implementation of their work;
- A study plan is developed to guide the participant to achieve their study objectives.

Answer the following questions

- Why did you join this study circle?
- How do you, as an adult, want to learn?
- Talk about how adult learning is different from the way children learn.

Then read the following…

1.3 How do adults learn?

Unlike children, adults learn because they want to and their learning has a purpose. For instance, they might want to find out how to improve their livestock production in order to get more milk or they may want to find out how to attract more customers to their shops.

Adults learn best when:

- the content is useful and relevant to their lives;
- they are respected and appreciated for what they already know and not proved wrong in front of others;
- they can choose what to learn at their own pace, at a convenient time and place;
- they are given an opportunity to share their knowledge and experiences;
- topics are practical and they can practice what they learn;
- they learn from their peers through exchange visits.

Think about what advice have you recently sought from a neighbour that proved to be very useful? Share your thoughts with the group.

1.4 Choosing a study circle leader

In order to start a study circle, the participants need to elect a leader. The leader should be reliable and must have leadership qualities. The study circle leader should be trained in how to facilitate a study circle session. The leader requires continuous support during study circle work. The study circle leader must be able to:

- Bring people together and motivate them to learn;
- Help set goals for each session; and
- Help other participants achieve their learning goals.

Talk about what a study circle is. Then read the following…

A good study circle leader can:

- encourage the inclusion of members from different backgrounds;
- be honest and open;
- be equal (not superior) to other participants;
- control their temper and be tolerant;
- remain friendly and diffuse any disagreements within the group;
- encourage all participants and open-up discussions;
- encourage participants to share their ideas;
- listen to others (ask questions and avoid lecturing others);
- prepare, study ahead and be familiar with the study material;
- summarise discussions or key lessons;
- be approachable and be interested in other group members.

Talk about the roles and responsibilities of a study circle leader? You can include the following…

A study circle leader should be able to:

- motivate and encourage the participants to actively look for knowledge;
- work in cooperation with the fellow participants;
- put the participants' own development in focus and ask stimulating questions.
- develop dialogue between the participants and encourage them to ask questions and come up with solutions;
- develop team spirit so that the participants feel secure;
- strengthen the participants' self-confidence;
- enable participants to arrive at common decisions and apply what they have learnt in everyday situations;
- make different options clear and act as a guide;
- encourage cooperation among the participants and discourage competition;
- be a resource person in organising the studies but not an expert in the subject;
- guide members in discussing the questions and ensure that answers are put down.

Now elect your study circle leader.

1.5 Role of participants

The study circle participants also have roles and responsibilities.

Talk about the roles of the participants in the study circle. Then read the following…

Study circle participants help each other to search for knowledge and cooperate on how to solve problems together. All participants must use their knowledge and experience to benefit others in the group. Once a participant has put forward an idea, it becomes a group idea. This improves group knowledge and allows each member to contribute. All study circle participants should encourage cooperation and discourage competition. The participants should share the responsibility for the success or failure of the study circle.

Work in a study circle is made up of:

- The study material;
- The skill of the study circle leader;
- Knowledge and experiences of the members.

1.6 Making the study learning plan

The next step in setting up your study circle is to develop a study circle plan.

- Discuss and agree on the following…
- What topic will we study?
- Where shall we meet?
- How often and for how long shall we meet?
- What day and time?
- Responsibilities - who shall do what in our group?
- Who could provide extra guidance if we get stuck and for which topics or session will we need an external resource person?

- Assessment - how shall we test our understanding and whether we have met our study objectives?
- Where can we find more information on our study topic?

What is a study plan?

The success of the study circle will depend on good planning and preparation in order to achieve goals in an effective manner. A study plan is the way learning sessions will be run, how the group will work together. A study plan includes:

Objectives of the study circle;

- Dividing the topic into suitable steps;
- Providing information on the issue (s) under study;
- Providing advice to the group on how their learning sessions can be effective;
- Setting the time frame: During the planning session, the group should agree on the how much time will be spent on a topic(s).

Study plan for Horticultural Production

The Horticultural Production topic study circle activities can include:

- Sharing experiences on horticultural production for small-scale producers;
- Familiarising study circle participants with the study material;
- Comparing content of the study material with the study circle group members' expectations;
- Ensuring the study plan meets the wishes and needs of the participants.

A study can be a session-by-session outline on the issues you intend to study during the study circle.

What can you expect to learn?

Horticulture Production and Marketing for smallholder farmers in Zimbabwe is a practical manual aimed at enhancing knowledge, increase productivity and commercialization of horticulture production. The topics contained in this book include: an overview of horticulture production, starting a horticulture production project, soil management, crop protection and production of traditional vegetables, cabbage, rape and kales, tomatoes, onions and carrots.

Review what you have learned in this session then read the summary to check that you have remembered everything.

Summary

- A study circle is a group of 8-16 people who meet regularly to learn about a topic
- Adults learn differently from children and their learning has a purpose
- A study circle needs a reliable leader with strong leadership qualities.
- The study circle participants help each other to search for knowledge and cooperate on how to solve problems together
- A study circle needs a study plan for each topic studied.

SESSION 2: OVERVIEW OF HORTICULTURAL PRODUCTION

2.1 Introduction

Greet each other and review the learning objectives for this session.

LEARNING OBJECTIVES

By the end of this session, you will be able to:

- Know the meaning of horticulture
- Understand the different branches of horticulture
- Know basic information about mushroom production
- Understand the importance of vegetables
- Group vegetables into different classes
- Understand the growing conditions that vegetables need

Discuss

Talk about the following:

- What is a vegetable?
- List the vegetables which you grow and eat.
- Are there any other vegetables that you are interested in growing or eating?
- Why is growing and eating vegetables beneficial?

Now read the next section…

2.2 Introduction to horticulture

Horticulture is a branch of agriculture which deals with the intensive cultivation of high value food crops and ornamental or decorative plants. Branches of horticulture include: olericulture, pomology, ornamental horticulture, and mushroom production.

a) Pomology (Fruit production)

This branch deals with cultivation of fruit and nut crops, e.g. mango, orange, guava, macadamia nut and citrus fruits.

Fruit production (pomology)

b) Ornamental horticulture (flower production and landscaping)

Ornamental horticulture is a branch of horticulture which deals with ***floriculture*** and ***landscaping***. Floriculture deals with the production of flowers and ornamental plants; generally, cut flowers, pot plants, and greenery. Landscape horticulture is a broad category that includes plants for the landscape, including lawn turf but particularly nursery crops such as shrubs, trees, and vines.

c) Mushroom production

Although mushrooms are not plants, they form an important and profitable component of horticultural production. Mushrooms are not plants, they are fungi. The part of the organism that we see and call a mushroom is just the fruiting body of a fungus. Mushroom production is completely different from growing green plants. Mushrooms depend on other

plant material (the “substrate”) for their food.

Small-scale mushroom production represents an opportunity for farmers interested in an additional enterprise and is a specialty option for farmers without much land. This brief section is designed for market gardeners or smallholder farmers who want to incorporate mushrooms into their horticultural systems and for those farmers who want to use mushroom cultivation to extract value from farm and agro-industrial “waste” materials like wheat straw, maize stover, corncobs, groundnut shells and hulls, cotton lint waste, and wood shavings. Mushroom production can play an important role in managing farm organic wastes when agricultural and food processing by-products are used as growing media/substrate for edible fungi. The spent substrate can then be composted and applied directly back to the soil.

Various substrates which can be used for mushroom culture

In Zimbabwe, there are two types of cultivated edible mushrooms: oyster mushroom (*Pleurotus species*) and button mushroom (*Agaricus bisporus*). Oyster mushrooms are a good choice for beginning mushroom cultivators because they are easier to grow than many of the other species, and they can be grown on a small scale with a moderate initial investment.

Oyster mushroom

White button mushroom

Although commonly grown on sterile straw from wheat or rice, they will also grow on a wide variety of high-cellulose waste materials like cotton waste, wood shavings, thatch grass, maize stover and corncobs. Some of these materials do not require sterilization, only pasteurization, which is less expensive. Another advantage of growing oyster mushrooms is that a high percentage of the substrate converts to fruiting bodies, increasing the potential profitability. Oyster mushrooms can become an integral part of a sustainable agriculture system. Many types of organic wastes from crop production or the food processing industry can be used to support oyster mushroom production.

Points to remember about mushroom production:

- The market for mushrooms continues to grow due to interest in their culinary, nutritional, and health benefits.
- They also show potential for use in waste management. However, as fungi, mushrooms have life cycles very different from those of green plants.
- The choice of species to raise depends both on the growth media/substrate available and on market considerations.
- Oyster mushrooms, which grow on many substrates, are easiest for a beginner.
- Mushroom cultivation offers benefits to market gardens when it is integrated into the existing horticultural production system.
- A careful analysis of potential markets must be the first step in deciding whether to raise mushrooms to sell.

- Mushrooms require low start-up capital, have high returns, can be grown throughout the year, and can be harvested from 3 to 4 weeks after planting (spawning).
- Mushrooms do not need a big piece of land, you can use your abandoned thatched hut or your garage! Simple structures existing at your home can be used as mushroom growing houses as long you are able to control light and aeration.
- Mushroom production does not compete for space with other horticultural crops.

A simple mushroom growing house made from an unused existing building at a homestead

d) Olericulture (Vegetable production)

It deals with cultivation of vegetable crops, e.g. cabbage, rape, carrot, watermelon, cucumber, onion, carrot and tomato. This book will be mostly concentrating on vegetable production hence we will go in detail discussing vegetable production in detail in the next sessions.

Smallholder vegetable production is expanding rapidly in Zimbabwe both for local sale in urban markets and for export. The smallholder vegetable sector requires support in the form of improved access to existing pest management information (in an appropriate form) and focused research targeted at the knowledge gaps which currently impede implementation of sustainable integrated pest management.

A vegetable can be defined as an edible, usually a succulent plant or a portion of it eaten with staples as main course or as supplementary food in cooked or raw form.

A proud young farmer showing her variety of vegetables in her garden

Vegetables are a complex group of a wide variety of different types of plants. Some species grow from year to year; other–grow and die within one or two years. They have diverse forms of propagation: by seeds or vegetative parts. They may be herbaceous, viny, shrubby, or tree in growth habit. They differ in growth requirements. Many vegetables can be grown under a wide range of conditions; while others have more exacting requirements for water, temperature, and light. Thus, in one place several species can be grown throughout the year, but there are others that can be grown only during certain times of the year. Irrigation is an absolute necessity for many species, but a few can be grown under rainfed conditions. Different parts of a plant may be used as a vegetable, depending on localities and culture. In general, developing countries utilize more parts of a particular plant as a vegetable than developed countries. Most vegetables are high in water which makes them bulky and highly perishable, particularly the leafy ones.

Health benefits of vegetables

Vegetables are the main source of minerals and vitamins in our diet as shown in table 2.1. Our bodies need these substances for us to remain healthy. They help to protect us from disease by strengthening our body and immune system. Vegetables also contain large amounts of fibre which help our digestive system to work properly. The more vegetables that are consumed by a person, the less likely that person is to be affected by diabetes,

high blood pressure, heart problems and some types of cancer. Absence of vegetables in a diet causes serious health problems. Below is a table which lists some examples of good vegetable sources of various vitamins.

Table 2.1 Vegetable sources for vitamins and minerals

Vitamin	**Sources**
A	Bush green amaranthus (*mowa; imbuya*), carrot, pepper, peas, yellow vegetable , tomato and all dark green leafed vegetables.
B	Beans, dried peas and spinach
C	Uncooked cabbage, lettuce, sweet pepper, tomato,
D	All green vegetables
E	Lettuce, green-leafed vegetables
K	Green-leafed vegetables
Mineral	**Sources**
Calcium	Beans, green vegetables, *nyevhe (ulude), mowa, derere regusha, nyemba (ndumba)* and peas.
Iodine	Carrot, green beans, spinach
Iron	*Nyevhe, derere regusha*, cauliflower, dried beans, green vegetables both traditional and exotic, tomato and spinach
Magnesium	Beans, peas and spinach
Potassium	Beans, potato, Vegetable and spinach
Phosphorus	Beans, *tsunga* and *chembere dzagumhana*
Sodium	Celery, beetroot, spinach.

Other benefits of vegetables

- Vegetable production can be a very good source of regular household income as vegetables fetch a good market price. Vegetables can also be processed into high value products such as dried foods, juices or soup powders.
- Vegetables sold to other countries bring in foreign currency which Zimbabwe needs to buy goods it does not produce from other countries.
- Most vegetables have a relatively quick production cycle, making it possible to sell them in short spaces of time.
- You do not need large pieces of land in order to grow vegetables.
- Vegetable production can provide employment to many people since it is labour-intensive.
- Some vegetable crops are also valued for their medicinal uses, as handed down from generation to generation, especially in the rural areas. Garlic cloves, for example, are used for curing high blood pressure and rheumatism.
- Some vegetables are known to have insecticidal properties, such as the hot pepper fruits.
- Still others are valued for cosmetic purposes. Slices of cucumber on the face cleanse and close pores to prevent dust from getting in.

Vegetable crop groups

It is useful to group vegetables into classes in order to understand the growth requirements of similar vegetables.

Discuss

Talk about the following:

- How can we group vegetables? Which vegetables have similar growing requirements?

Now read the next section…

Vegetable families

Vegetables can be grouped according to the family which they come from. Each family is given a name that usually describes a common feature of its members. Members of the same family often have the same growing requirements. Members of the same family often share the same pests and diseases. Therefore, grouping vegetables into families helps with planning crop rotation. Table 2.3 shows the common vegetable families and examples of vegetables in each family.

Table 2.2 Common vegetable families

Family	Examples of members
Cabbage family (Brassicas)	Cabbage, *tsunga*, cauliflower, rape, broccoli, covo, chomoulier and *rugare*.
Tomato family (Solanaceous)	Tomato, potato, eggplant, tobacco, pepper.
Legume family	Pea, beans, cowpea, soya beans.
Pumpkin family (Cucurbits)	Cucumber, butternut, pumpkin, squash
Onion family (Bulbs)	Bulb onion, shallots, garlic, leeks
Carrot family	Carrot, celery, parsley

Reasons for Vegetable Classification

1. To understand the requirement of soil & water on different crops.
2. To know adaptability of crops.
3. To know the growing habit of crops.
4. To understand climatic requirement of different vegetable crops.
5. To know the economic produce of the crop plant & its use.
6. To know the growing season of the crop

Table 2.3 Vegetable Families Classification

LEAF CROPS	Requirements	ROOT CROPS	Requirements
Cabbage family: cabbbage, tsunga, rape, covo, choumolier etc.	Heavy feeders, need regular water, prefer cool times of year.	Onion family: onion, garlic, shallots/ spring onions, leeks.	Light feeders, lower water requirements, onions and garlic must be grown at cool times of year.
Spinach	Lighter feeders, can grow all year	Carrot	Can grow all-year round.
FRUIT CROPS	**Requirements**	**ROOT CROPS**	**Requirements**
Tomato family: tomato, chillies, peppers, paprika (and Irish potatoes)	Heavy feeders, need regular water, prefer warm times of year.	Sugar beans, butter beans, cowpeas, groundnuts, roundnuts, peas	Help in nitrogen fixation. Grow best at warm times of year. Grow best at cool times of year.
Pumpkin family: pump- kins, squash cucumber, melons	Heavy feeders, need regular water, prefer warm times of year		

2.3 Water requirements in horticultural production

The production of horticultural crops in Zimbabwe depends largely upon the availability of water for irrigation as rainfall occurs mainly during the summer months and tends to be uneven in distribution and variable in amount. Plants need large quantities of water to survive. Water carries nutrients such as those from manures and fertilizers from the soil into the plant roots. Water carries the nutrients through the plant and finally leaves the plant through openings into the air. This movement of water is faster during hot and dry periods. To be a successful horticulture producer there should be a good and reliable water source.

Discuss

Talk about the following:

- How can we reduce water loss from plants and the soil surface?

Now read the next section…

Irrigation

If water is inadequate, irrigation is need to meet the crop requirements for water. In Zimbabwe, all production in winter must be under irrigation since we do not have rains during this period.

Table 2.4 compares different irrigation methods.

Table 2.4 Advantages and disadvantages of different irrigation methods

Type of irrigation	Advantages	Disadvantages
Hand bucket	• Cheap • Not complicated	• Very hard work • Water distribution poor • Only suitable for small areas
Furrow Irrigation	• Lower pumping costs than with sprinkler • Lower initial investment costs in equipment	• Increased erosion risk • Difficult to apply water uniformly in the furrows • Need for expensive levelling of field • Difficult to move machinery across the furrows
Sprinkler (water is applied under pressure over the crop)	• No need for expensive level- ling of field • Uniform water distribution	• High cost of pumping • Evaporation losses during irrigation • Wetting the crop leaves may increase disease problems
Drip irrigation (water drips slowly to the roots via some pipes and emitters)	• Saves water • Lower running costs compared to sprinkler • Waters plant station only with almost no water made available to weeds • Improved infiltration in heavy soils • Low water evaporation losses • Low labour costs	• Problems of pipe blockages • High initial costs • The sun and animals can damage the pipes.

Mulching

Water in the soil can be conserved through mulching. Mulching means covering the soil with material such as dried grass, dried leaves, stover or compost. The mulch acts as a barrier to evaporation from the soil surface. Mulching also reduces soil erosion, and it can add organic matter and nutrients to the soil.

2.4 Soil requirements for horticultural crops

Soils hold the plant upright and supply water and minerals. Soil contains nutrients, water, organic matter, air and living things. The proportions of these things differ in different soils and thus different soils need different management methods. Most horticultural crops need soils with high levels of fertility and a fine texture. To have a successful horticultural production project, a farmer must work hard to improve the soil.

2.5 Temperature, light and wind

Horticultural crops are very sensitive to temperatures and the amount of light which they receive.

Temperature

Temperature is a measurement of hotness or coldness. Each plant has a temperature at which it grows best. Vegetable plants which are native to Zimbabwe are better adapted to our climate than those brought in from other countries. In order to have success with vegetable production you must take note of the temperature requirements of the crop that you want to grow. So, when choosing crops to grow, select those that can grow well in the particular season.

Talk about the following:

- Which vegetables grow better during the hot rainy season?
- Which vegetables grow better during

Now read the next section…

Table 2.5 Cold season and warm season vegetables

Cool season vegetables	Warm season vegetables
Broccoli, cabbage, rape, onion, potato, pea, garlic.	Cowpea, cucumber, tomato, eggplant, okra.

Light intensity

Plants use sunlight in order to make their food. Some crops can grow in the shade or with partial shade. Leaf crops such as spinach, covo and lettuce may tolerate some shade. Many vegetable crops need full sun in order to grow particularly tomatoes and onions.

Day-length

Some plants need more hours of sunlight during the day than others. During winter in Zimbabwe, the sun sets earlier while in summer we get longer days. In the countries where many of our vegetable seeds come from the summer day length is longer than ours. When buying seeds, you should make sure that the variety is adapted to our short-day region.

Onions for example, have short and long-day varieties. Long day onions from the temperate regions can only bulb if a minimum of about 16 hours of day-length are available. If a farmer in Zimbabwe grows such an onion variety it will not produce a bulb.

Wind

Plants are very sensitive to wind because it can cause chilling, drying out and can bring dust and pests and diseases to a crop growing area. Use of wind breaks will minimise the effect of strong winds.

Review what you have learnt in this session then read the summary to check that you have remembered everything.

Summary

- Horticulture is the growing of vegetables, fruits and ornamental plants.
- Fruit production, vegetable production, flower production, mushroom production and landscaping are branches of horticulture.
- Mushroom production is a form horticulture which farmers can do without much competition with other horticultural crops.
- Vegetable crops have many benefits including improving the health of people who eat them, and improving household income. They can be grown in a small area, have a short growing cycle.
- Vegetables can be grouped according to their families or the products which they produce. These groupings help the vegetable farmer to improve crop management.
- Horticultural crops require adequate water supply, fertile soils and adequate temperatures and light. Vegetable growing areas should be protected from wind.

SESSION 3: AGROECOLOGICAL PRACTICES IN HORTICULTURAL PRODUCTION

3.1 Introduction

Greet each other and review the learning objectives for this session.

LEARNING OBJECTIVES

By the end of this session, you will be able to:

- Appreciate w the meaning of agroecology
- Understand the elements and principles of agroecology
- Apply agroecological practices in horticultural production
- Know how agroecology contributes to climate change adaptation
- Practice agroecological practices in your horticultural enterprises

Discuss

Talk about the following:

- What is agroecology?
- What are the principles of agroecology?

Now read the next section…

3.2 What is agroecology?

Agroecology is defined as the application of **ecological concepts** and **principles to the design and management** of sustainable agroecosystems (Gliessman, 2012). Agroecology integrates ecological principles for agricultural production for improved biodiversity, improves soil fertility, and reduces the use of external inputs such as synthetic fertilizers and pesticides. Therefore, it is a sustainable farming approach that centres on food production that makes the best use of nature's resources without damaging them. The following points best describe agroecology:

- Agroecology acts as a holistic practice that is increasing smallholder farmer productivity, reducing malnutrition, heightening biodiversity, resilience and adaptation to climate change and variability.
- It promotes growing of indigenous or orphan crops and diversity that are well suited to low rainfall areas, hence, farmers are guaranteed of getting something in

case of severe droughts. It has promoted local diets and culturally acceptable foods that are nutritious and healthy for the local people.

- In Zimbabwe, agroecology has become increasingly popular among small-scale farmers to address food insecurity, climate change, and economic challenges.
- Agroecology is a sustainable and cost-effective approach to farming that can benefit both small-scale and commercial farmers in Zimbabwe.
- By reducing the use of external inputs like synthetic fertilizers and pesticides, agroecology can help farmers save money on inputs while improving the health of the soil and the environment.
- Agroecological farming emphasises diversification, mixed cultivation, intercropping, cultivar mixtures, habitat management techniques for crop-associated biodiversity, biological pest control, improvement of soil structure and health, biological nitrogen fixation, and the recycling of nutrients, energy, and "waste" as inputs to the production process.
- Furthermore, by promoting biodiversity and ecosystem services like natural pest control, agro-ecology can help farmers increase yields and reduce crop losses. This can be especially beneficial for small-scale farmers who may not have the resources to invest in expensive inputs or equipment.

3.3 Principles/elements of agroecology

Agroecology is a comprehensive approach that applies ecological and social principles to the design and management of sustainable food and agricultural systems. It seeks to optimize the interactions between plants, animals, humans and the environment while also addressing the need for socially equitable food systems within which people can exercise choice over what they eat and how and where it is produced. Thus, agroecology represents a transdisciplinary field that includes the ecological, socio-cultural, technological, economic and political dimensions of food systems, from production to consumption. Agroecology encompasses a comprehensive approach that integrates the following ten elements of agroecology:

i) Diversity: Emphasizing the importance of diversification in agroecological transitions to ensure food security, nutrition, and the conservation, protection, and enhancement of natural resources;

ii) Co-creation and sharing of knowledge: Recognizing that agricultural innovations are more effective when they are co-created through participatory processes that respond to local challenges;

iii) Synergies: Building synergies across food systems to enhance key functions, supporting production and multiple ecosystem services;

iv) Efficiency: Promoting innovative agroecological practices that enable increased productivity while utilizing fewer external resources;

v) Recycling: Encouraging more recycling in agricultural production, leading to reduced economic and environmental costs;

vi) Resilience: Enhancing the resilience of individuals, communities, and ecosystems as a crucial aspect of sustainable agricultural and food systems;

vii) Human and social values: Protecting and improving rural livelihoods, equity, and social well-being, recognizing their significance for sustainable agricultural and food systems;

viii) Culture and food traditions: Supporting healthy, diversified, and culturally appropriate diets to contribute to food security and nutrition while maintaining the health of ecosystems;

ix) Responsible governance: Recognizing that sustainable food and agriculture require responsible and effective governance mechanisms at various scales, from local to national to global; and

x) Circular and solidarity economy: Promoting circular and solidarity economies that reconnect producers and consumers, providing innovative solutions for living within planetary boundaries and ensuring inclusive and sustainable development.

In addition to these elements, Agroecology implementation is guided by thirteen principles of agroecology, which further guide the implementation and practice of agroecological systems namely:

i) Recycling: Giving priority to the use of local renewable resources and closing resource cycles of nutrients and biomass as much as possible;

ii) Input reduction: Reducing or eliminating dependency on purchased inputs;

iii) Soil health: Ensuring and enhancing soil health and functioning through the management of organic matter and the promotion of soil biological activity;

iv) Animal health: Ensuring animal health and welfare within agroecological systems;

v) Biodiversity: Maintaining and enhancing species diversity, functional diversity, and genetic resources at the field, farm, and landscape scales;

vi) Synergy: Promoting positive ecological interactions, synergy, integration, and complementarity among the elements of agroecosystems;

vii) Economic diversification: Supporting on-farm income diversification for small-scale farmers, providing financial independence, value addition opportunities, and responsiveness to consumer demand;

viii) Co-creation of knowledge: Enhancing the co-creation and horizontal sharing of knowledge, including local and scientific innovation, with a focus on farmer-to-farmer exchange;

ix) Social values and diets: Building food systems that respect the culture, identity, tradition, and social and gender equity of local communities, providing healthy, diversified, seasonally and culturally appropriate diets;

x) Fairness: Promoting fair trade, fair employment, and fair treatment of intellectual property rights to ensure dignified and robust livelihoods for all actors engaged in food systems, particularly small-scale food producers;

xi) Connectivity: Encouraging proximity and trust between producers and consumers through the promotion of fair and short distribution networks and the re-embedding of food systems into local economies;

xii) Land and natural resource governance: Recognizing and supporting the needs and interests of family farmers, smallholders, and peasant food producers as sustainable managers and guardians of natural and genetic resources; and

xiii) Participation: Encouraging social organization and greater participation in decision-making by food producers and consumers to support decentralized governance and local adaptive management of agricultural and food systems.

Discuss

Talk about the following:

- List agroecological farming practices which can be used in horticultural production.

Now read the next section…

3.4 Agroecology practices

The horticulture sector in Zimbabwe faces numerous challenges, ranging from high costs of agricultural inputs, environmental degradation and biodiversity loss that lead to food insecurity. Agroecological practices offers solution to these challenges by promoting biodiversity, enhancing soil health, conserving natural resources, and fostering resilient farming practices. Agroecological processes are equitable, environmentally friendly, locally adapted and owned; and tare integrated within a systems approach. .

This section presents 5 different agroecological practices namely:

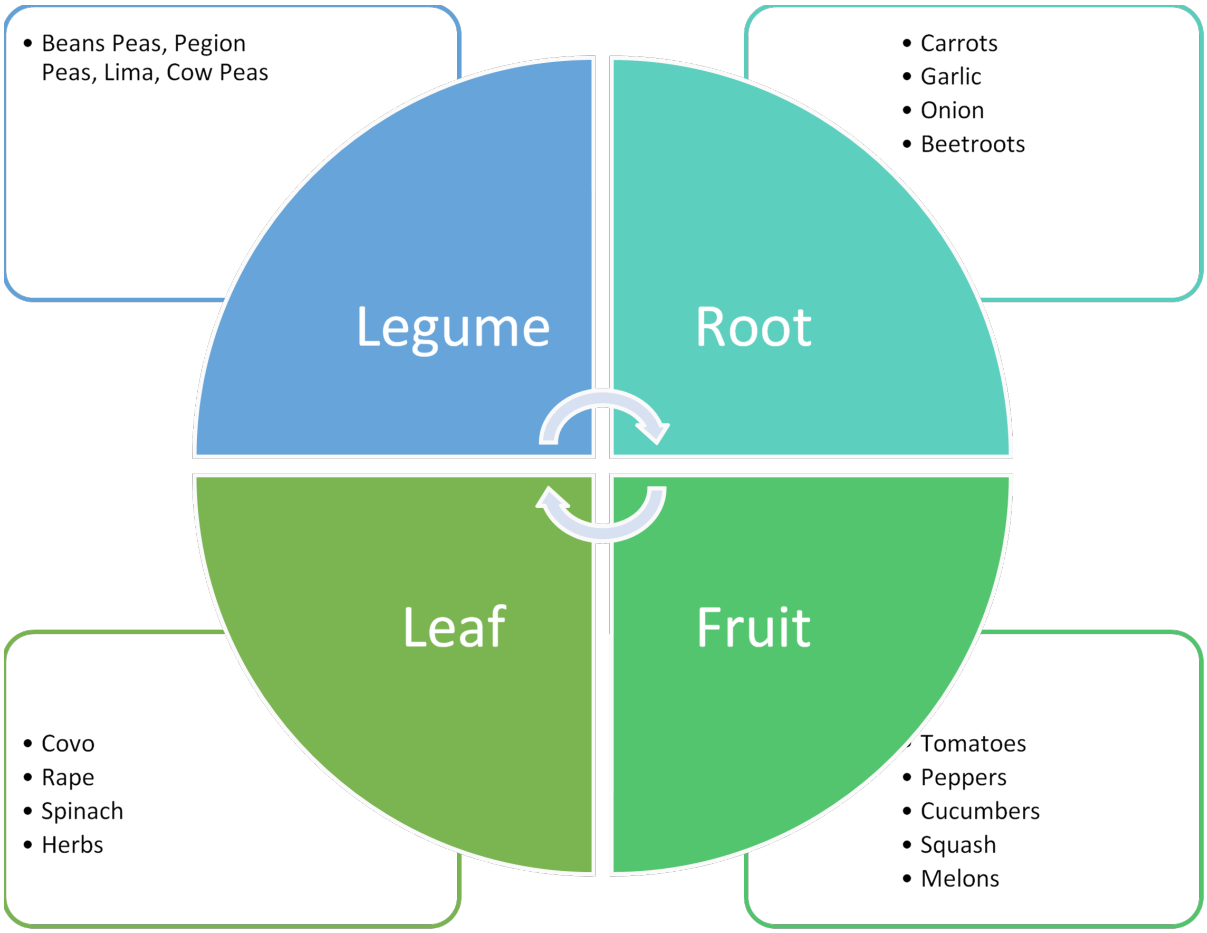
- Agroecology Cropping systems
- tillage practices
- fertilisation practices
- irrigation practices
- weed, pest, and disease management practices.

1. Agroecology cropping systems

Cropping system refers to the crops and crop sequences and the management techniques used on a particular field over a period of years.

Crop rotation: integration of different crops in rotations including cover crops helps in reduction of weed and pest infestation and thus reduced use of pesticides. Moreover, there is reduction of fertiliser use if leguminous horticultural crops like beans are used in the rotations and there is increase in soil biological activity. Increase in diversity of feed and

food produced.This helps to optimize the diversification of the system as no one plant family dominates the rotation.



Optimum Rotation Sequence of Four Groups of Crops (Elwell and Maas, 1995)

Intercropping: is the growing of two or more crops on the same piece of land. It helps provide good soil cover which conserves soil moisture and helps in controlling pests and diseases. Intercropping also reduces inputs and improves soil structure and fertility. When cover crops like cowpeas are used, there is reduction of leaching and soil erosion.

Cabbage crop intercropped with potato and bean

Agroforestry: this involves planting vegetables between the rows of fruit trees or woody perennial leguminous tree species or shrubs like acacia, leucaena and moringa.

Potato crop planted between rows of a leguminous shrub

The vegetable crops benefit from the nitrogen fixed into the soil by the leguminous tree species and the shrubs also protects the soil from erosion by slowing water runoff and increasing its infiltration rate. Trees also provide very effective protection for crops against strong winds and they can provide mulching material through their leaves.

Enhanced crop diversity: growing different types of horticultural crops help spread the risk of climate change effects as they have different water, temperature and nutritional requirements. Crop diversification can improve resilience in a variety of ways, such as engendering the ability to suppress pest outbreaks, dampening pathogen transmission, buffering crop production from the effects of greater climate variability and extreme events, and increasing household incomes.

Cultivar choice: choosing an adequate crop and cultivar can help to improve crop resistance to abiotic stresses (N and water deficiency), pests and diseases. Farmers should choose varieties for their horticultural crops from reputable breeders which are resistant to nutrient and water deficiencies as well as to pests and diseases. This results in yield increase and more income for the farmer

Use of improved varieties: high-yielding varieties which pest and disease tolerant potentially increase crop yield and quality, hence greater farmer profits. They also increases food availability and access; increases farmers' capacity to limit the crop exposure to damage caused by pests and diseases; reduces use of synthetic pesticides and fungicides, thus reducing related GHG emissions and carbon footprint.

High yielding tomato and cabbage varieties

2. Tillage practices

- **No till:** Direct seeding into living cover crops or mulch: planting of crops directly (no tillage) in preceding cover crop (living or destroyed, i.e. mulched) or crop residues reduces of energy consumption for seedbed preparation. Moreover, it decreases wind and water erosion as well as soil compaction. It also increases soil organic matter, limits weed growth and reduces herbicide use.
- **Minimum tillage:** increases soil moisture due to the mulch layer and conservation of soil structure. It also reduces wind and water erosion. Minimum tillage also reduces soil compaction and increases in soil organic matter.

A mulched vegetable crop

3. Fertilisation practices

- **Split fertilization:** this is fertiliser application (chemical and organic) with several operations helps in reduction of fertiliser use and increases nutrient uptake efficiency by your horticultural crops. Split fertilization also reduces risk of ground and surface water contamination.
- **Precise fertilizer and manure application:** application methods like dolloping and fertigation improve nutrient use efficiency by the horticultural crops thereby helping them to grow better than competing weeds and prevents loss of nutrients through leaching, surface run-off and volatilization.
- **On-farm organic manure:** increases the horticultural crops yield as a result of enhanced soil health and fertility; reduces use of external inputs hence reducing production costs; increases in income through high quality and healthy produce.

4. Irrigation practices

- **Drip irrigation:** increases yield and quality of produce; allows constant production throughout the year; reduces labor requirement; increases farmers' capacity to limit the crop exposure to climate risks; reduces soil erosion; increases water and nutrient use efficiency per unit of output.

Drip irrigation system

5. Pest, and disease management practices

Natural crop protection (NCP) is a broad based ecological approach to pest and disease control that integrates cultural, biological and botanical methods into a management system. It incorporates a range of practices for economic control of pests, considering the ecological interactions between the environment, crops and the pest. The practices follows a 3-step approach outlined below:

Step 1: Crop Management Practices

These practices aim at providing good growing conditions to enhance plant health and prevention of introduction and spread of pests and diseases and common practices are outlined below:

- Choice of appropriate crop varieties suitable for the location. Where possible, varieties tolerant or resistant to pests and diseases should be used.
- Using clean planting materials.
- Soil fertility improvement to encourage strong and vigorous growing plants, by using compost, animal manure, green manure and other organic materials.
- Intercropping and crop rotation to reduce the multiplication rate of pests.
- Other good management practices to ensure proper growth (e.g. timely planting, proper spacing, water conservation, pruning, shade management and timely harvesting)

Step 2: Habit Management Practices

These practices aim at enhancing the proliferation of a variety of organisms (including natural enemies) around and within the crop fields. The following practices can be used:

- Planting hedges of indigenous plant species around fields to attract natural enemies.
- Allowing flowering plant species to grow within crops to provide nectar and pollen for natural enemies like ladybird beetles, hoverflies and parasitoids.
- Trap cropping to attract pests to non-crops or push away pests from the crops (e.g. push-pull strategy).
- Field hygiene, including timely weeding to remove alternative hosts, rouging infected plants and plant parts, proper disposal of infected plants and disinfecting tools used on infected plants/field

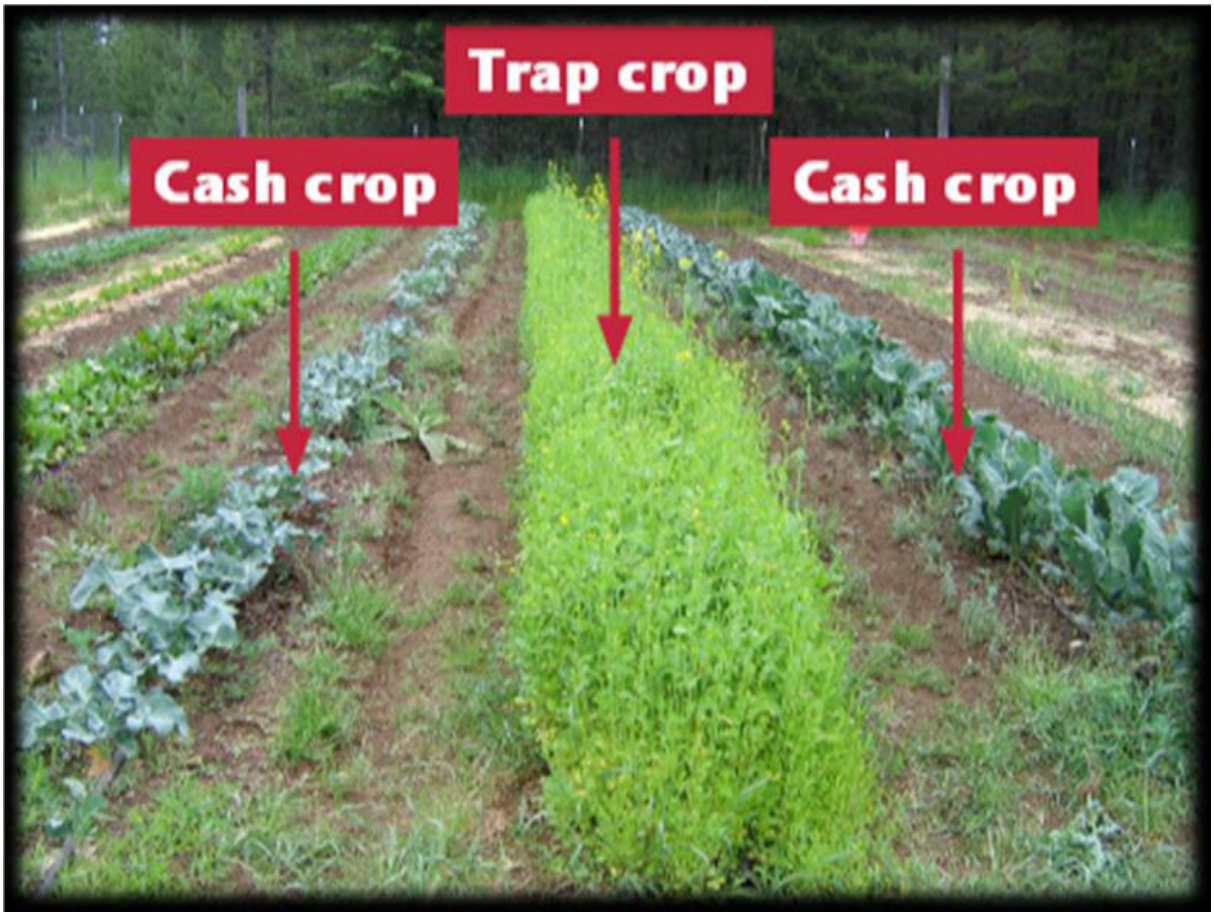
Step 3:Direct control

In situations of heavy infestations or very devastative pests and diseases, direct measures will be needed to minimize losses. These tools will only be fully effective when tools in the other two steps are applied properly, and these include:

- Biological control agents such as predatory insects and mites, insect parasitoids, viruses and bacteria.
- Approved or self-made insecticides or acaricides (against mites) of biological or mineral origin including plant extracts, plant oils, mineral oil, copper and sulphur.
- If available, insect pheromone traps may be used to disrupt mating of pests.
- Light, bait or colour traps may be used for mass-trapping pests.
- Hot water treatments of seeds to limit seed-borne diseases

Ladybird beetle as a natural enemy of aphids

Growing garlic with strawberries can help prevent spider mites



Mature mustard plants lure flea beetles away from young broccoli plants

The above-mentioned agroecology practices contribute to climate change adaptation The key combined effects of rising temperatures, increasingly variable and unpredictable rainfall, and higher frequency of extreme weather events, such as droughts and floods that are negatively affecting farmers therefore, agroecology can help farmers adapt to and mitigate the impacts of climate change by promoting soil health, water conservation, and the use of drought-resistant crops. This can be crucial in a country like Zimbabwe, where climate variability and extreme weather events are increasingly common.

Do you think climate change is here to stay or it will end soon?

From your understanding of agroecology, suggest other practices which you think can be practiced in horticultural production.

Summary

- Agroecology is a farming system that integrates ecological principles with agricultural production in a way that promotes biodiversity, improves soil fertility, and reduces the use of external inputs such as synthetic fertilizers and pesticides.
- Agroecology acts as a holistic practice that is increasing smallholder farmer productivity, reducing malnutrition, heightening biodiversity, resilience and adaptation to climate change and variability.
- Principles/elements of agroecology include diversity, synergies, efficiency and recycling, resilience
- Agroecological practices aim to move away from an "industrial agriculture model," dominated by large-scale specialised farms, relying heavily on fossil fuel and external artificial inputs, toward more environmentally friendly and sustainable agricultural systems, optimizing the use of biological processes and ecosystem functions.
- Agroecological practices include cultivar choice, crop rotation, intercropping, agroforestry, diversity, on-farm organic manure, natural/botanical pesticides, biological pest control, use of trap crops and repellants.

SESSION 4: SOIL MANAGEMENT IN VEGETABLE PRODUCTION

4.1 Introduction

Greet each other and review the learning objectives for this session.

LEARNING OBJECTIVES

By the end of this session, you will be able to:

- explain ways to manage the texture of their soil for better vegetable production
- explain ways to manage soil fertility
- understand the importance of using compost and how to make it
- understand how to make and use liquid fertiliser
- understand the importance and method of crop rotation and intercropping

Discuss

Talk about the following:

- What is soil made of?
- Why do plants need soil?
- What types of soil do you have on your farms?

Now read the next section…

Soil is a dynamic natural body composed of mineral and organic materials and living forms in which plants grow. It is a mixture of minerals, animal matter, microorganisms, air and water capable of supporting life. Soil originates from the breaking down of the basic mineral of the earth. To grow well, vegetable crop plants need a supply of different nutrients which come from the soil. These nutrients are taken in through the roots of the plants. The nutrients in the soil come from tiny pieces of rock and decaying plants and animals (organic matter). These are broken down by the many living creatures such as worms, insects and micro-organisms which live in the soil. Healthy, fertile soil contains a lot of organic matter which helps to store water and plant nutrients. Healthy soil also contains enough air for the soil creatures to survive. So, healthy soil contains: organic matter, living creatures, water and air.

Too much digging, ploughing, burning or use of chemicals can kill the soil creatures and destroy organic matter. Leaving the soil bare, causes it to become hard and compact with very little air or moisture. This makes the soil less fertile and easily eroded.

4.2 General soil requirements for vegetable production

Soil types include Sand, Sand Loam, Loam, Clay, Clay Loam and Gravel and silt. Soils can light, medium or heavy. Light soils are sandy and have low clay content whilst heavy soils have high clay content. Medium soils are in between the light and heavy soils.

Light soils allow water to sink into them easily but they dry out quickly. Water enters heavy soils more slowly but it stays in the soil for longer. Light soils contain more air than heavy soils.

The best soils for growing vegetables are well-drained, deep soils that are high in organic matter. These soils should have good structure and have been adequately limed and fertilized. Loamy sand and sandy loam soils are generally better suited for growing early market crops because they drain quickly and warm early. Deep, well-drained organic soils are ideal for leafy vegetables, bulb and root crops that offer a high return per acre. Soils that are not ideal for vegetable production may be made suitable for production by addressing the underlying problem(s). For example, poorly drained soils may require tiling to improve drainage.

4.3 General soil management practices

Soil management and improvement maximises soil life, improves structure, increase organic matter, moisture and nutrients thereby contributing to a pattern of agriculture which is environmentally friendly, economically viable. Fertility of a soil is defined by its ability to provide all essential nutrients in adequate quantities and in the proper balance for the growth of plants – independent of direct application of nutrients – when other growth factors like light, temperature and water are favorable. Soil fertility management can be seen as a three-step approach with a range of tools to manage soil fertility and plant nutrition.

Step 1 – Conserving the soil, soil organic matter and soil water from loss

Applied measures aim at protecting the soil surface from being exposed to the sun and drying out, and from being carried away by wind or washed down by rain. The aim is to establish a stable and less vulnerable soil as the foundation to managing its fertility.

- Preventing soil erosion by reducing the movement of water with contour ridges and bunds, grass strips and terraces, and application of mulch to the soil surface.
- Protecting the soil with mulch and cover crops.
- Harvesting water with pits and water catchments.
- Application of reduced tillage to minimize soil disturbance.

Step 2 – improving organic matter content and enhancing biological activity in the soil

The aim here is to identify appropriate organic resources that can build an active soil with good structure which can hold water and supply plant nutrients.

- Producing own compost or supplying compost or other organic materials from outside the farm supplies stable humus substances to the soil and thus improves its structure and water holding capacity contributing to improvement of soil organic matter content on a long term.
- Growing green manures to produce large quantities of fresh plant material, which are incorporated into the soil, feed the soil organisms and mineralize rapidly to provide nutrients to the crop that follows.
- Recycling of valuable animal manures for composting or fertilization of the crops

Step 3 – Supplementing the nutrient requirements as well as improving the growing conditions by applying some soil amendments

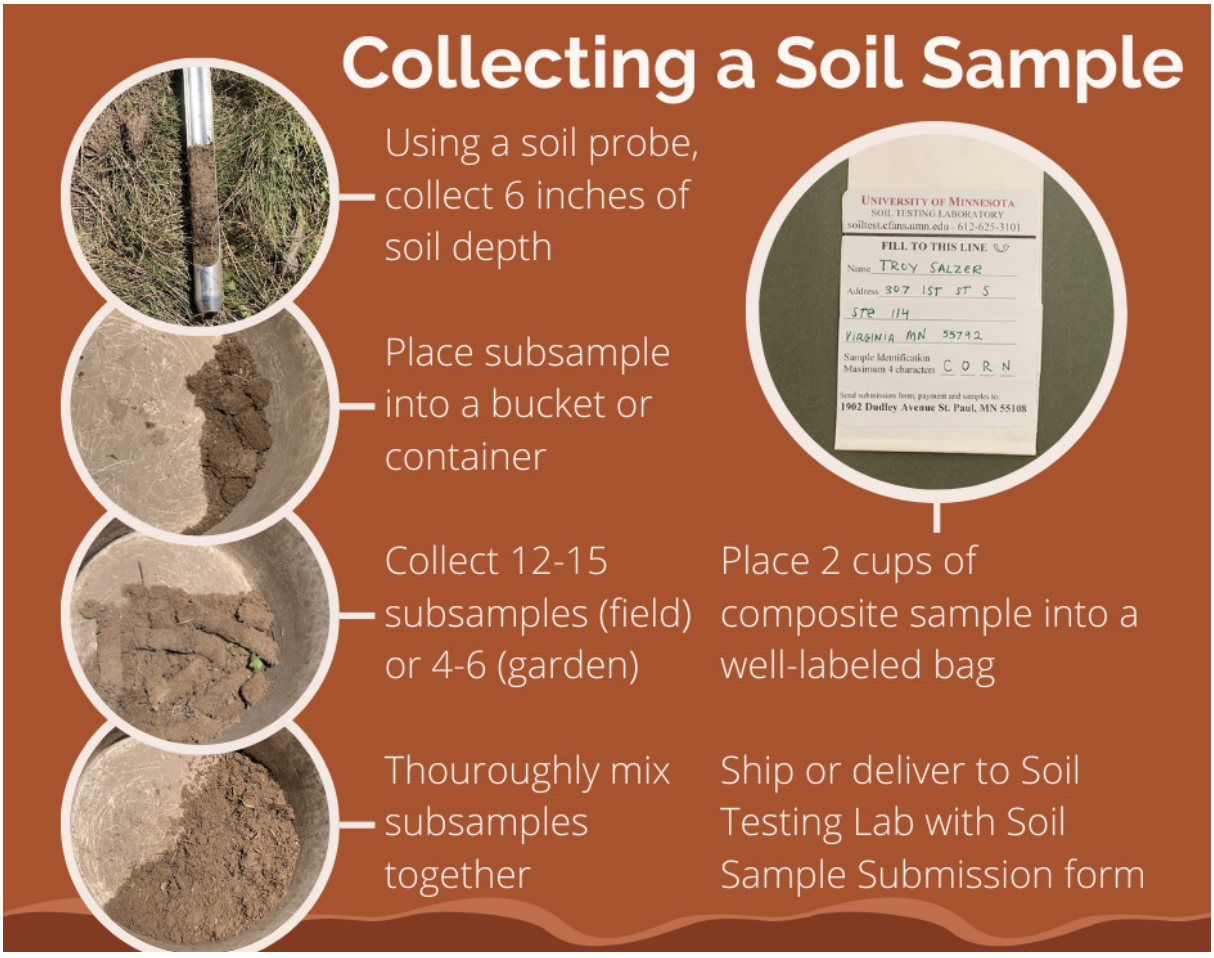
- Use of self-made liquid manures that are easily available to plants.
- Use of soil amendments such as lime to correct soil pH and microbial inoculations to enhance biological activity of the soil and nitrogen fixation in the soil.
- Use of irrigation to supplement water requirements.
- Use of commercial organic and selected mineral fertilizers to satisfy specific nutrient needs

Soil sampling and testing

Soil sampling is the process of taking a small sample of soil, which is then sent to a lab to determine the nutrient content. Firstly, a spade or an auger is used to collect about 15 by 1kg samples in a zig-zag manner from a hectare or smaller piece of land. These samples are called ***sub-samples***. They are then thoroughly mixed. A 1kg amount of soil is taken from that mixture and put in clean container like a plastic bag. This is called a ***composite sample*** and is the one which will be taken to the soil chemistry testing laboratory for soil testing, where it is analysed for nutrients and pH among other things. Ensure that the composite sample is well labelled with the following information: name of field/garden owner, name of field/garden sampled (e.g. Field A) and address of the farm or plot.

Soil testing is a process done in the laboratory to determine mainly nutrients and pH of a given soil. Primarily, soil tests report on the content of nitrogen (N), phosphorus (P), and potassium (K), which are the most important nutrients for vegetable crops. Secondary nutrients to examine are calcium (Ca), sulfur (S), and magnesium (Mg). Soil testing also determines the pH of the given soil. The goal of soil testing is for the farmer to know the amount of nutrients in his soil and then to know the amount of fertilizers to apply. Soil testing also helps the farmer in knowing the soil pH level (acidity and alkalinity) which will determine the amount of lime to apply. Examples of soil testing laboratories in Zimbabwe where you can send your composite samples are Department of Research and Specialist Services (DRSS), Kutsaga Research Station, University of Zimbabwe and Zimlabs.

A composite sample



A summary of soil sampling procedures

Chemical fertilisers

Chemical fertilizers are special mixtures of mineral nutrients that have been made by agricultural chemical companies for improvement of the growth of different crops. Compound fertilizers usually have numbers that indicate the amount of each of the above nutrients that can be found in 50kg of that fertilizer. For example, Compound D has the numbers 7:14:7. These numbers mean that for every 50kg of compound D, there is 7kg of nitrogen, 14kg of phosphorus, and 7kg of potassium. The order N:P:K is never changed.

Advantages of Chemical fertilisers are:

- You can give the crop the right nutrients that it needs in the right quantities.
- They are quickly absorbed by plants.

Disadvantages of fertilisers are that they:

- are not readily available in many communities;
- are expensive to buy;
- are easily washed out of the soil (leached) by rain water or irrigation;
- do not improve the long-term soil fertility;
- do not improve the texture of the soil or its ability to store water or nutrients.
- Can cause pest problems as pests will be attracted to fast-growing, dark green plants fed on fertilisers.

Discuss

Talk about the following:

- Have you ever used lime on your crops?
- Why did you decide to use it?
- How was it applied?
- How did you know how much to use?

Now read the next section…

Lime

Lime helps to balance the soil to improve the ability for plants to absorb nutrients from the soil. Without balancing the soil using lime, crops cannot absorb nutrients effectively. Ideally you should have your soil tested once per year to find out how much lime to use. Examples of liming materials used in Zimbabwe are:

- dolomitic lime (calcium magnesium carbonate),
- ground limestone (calcium carbonate),
- quicklime/burnt lime (calcium oxide), and

- hydrated or slaked lime (calcium hydroxide).

To apply lime, sprinkle a thin layer on to beds once per year (especially for leaf crops and legumes).

4.4 Some important soil-improvement methods

Plants need many nutrients in order to grow well. Livestock manure is readily available and it contains a lot of nitrogen but not many other nutrients. The nitrogen in livestock manure is quickly lost if the manure is not combined into the soil or compost. Using compost is a better method for improving the soil because it stores many different nutrients and lasts a long time in the soil.

Discuss

Talk about the following:

- Have you ever made compost?
- What method did you use?
- How did you apply the compost to your crops?

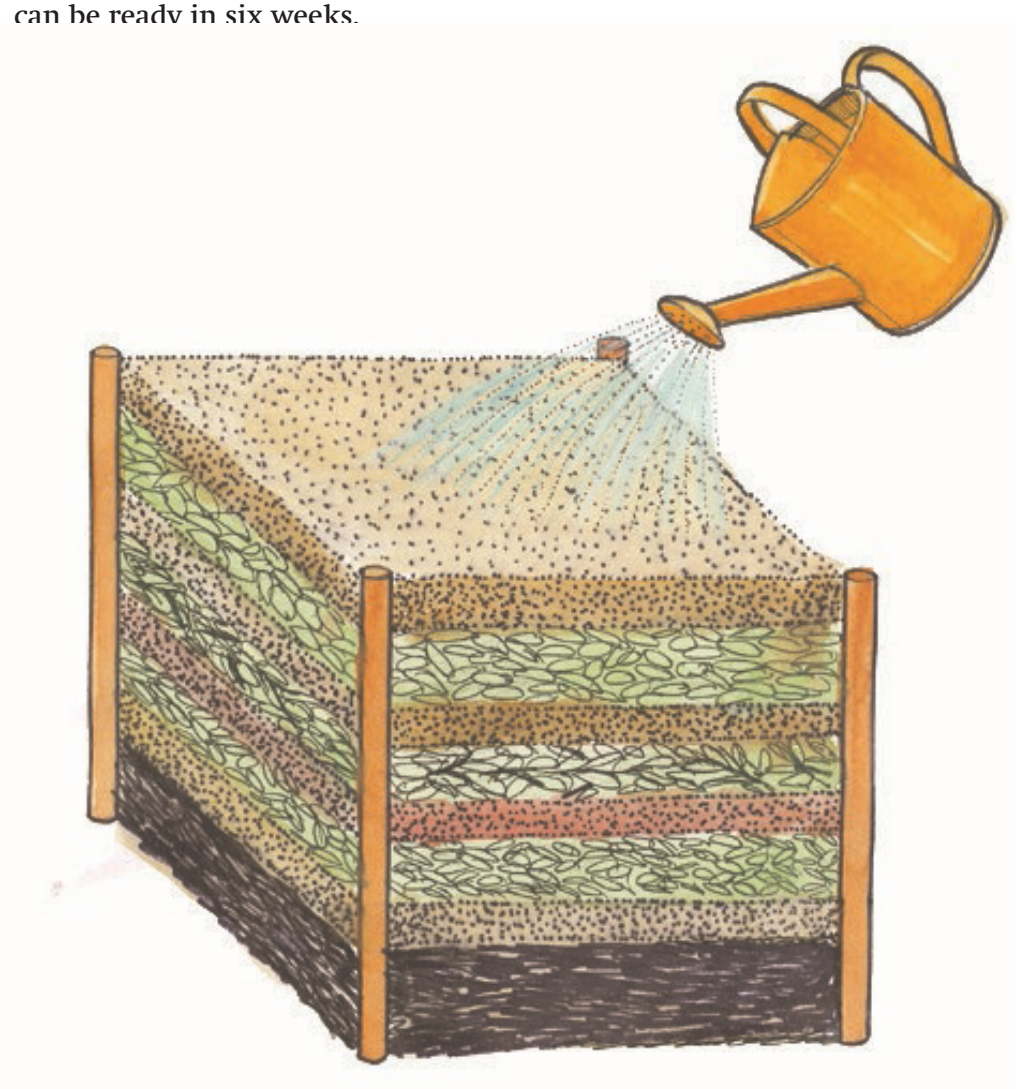
Now read the next section…

How to make compost

Compost is a dark, crumbly material formed by soil creatures. If it is made correctly it stores nutrients and water and slowly releases them for plants. To have a successful vegetable project you need to keep adding compost to your crop beds so you will need to have a lot of compost available. Try to make compost four times per year. Use the following method:

- First collect the different materials you need to make the compost heap. Collect dry materials (containing carbon) e.g. dried grass, dry leaves, paper, cardboard and green materials (containing nitrogen) e.g., green grass, green leaves, food scraps and animal manure.
- Find a cool, shady, sheltered place, close to water to make the compost heap.
- Mark the area where you are going to make the heap – it should be 2m by 2m.
- Fork the surface of the soil where you want to make the heap. Put down a layer of coarse material, such as maize husks, stover or twigs on the soil.
- The compost heap should be made from layers of different materials.
- The layers of green material should be thin while the layers of dry material should be thick.
- Do not add soil, plastic, metal, thick twigs or branches to compost.
- Cut up any large pieces of material before adding to the heap.
- Add a thin layer of manure or other green material. Sprinkle lime if you are using fresh chicken manure. Add a bucket of water to the layer.

- Next add a thick layer of dry material. Water each layer as you add it.
- Keep adding layers of green material and dry material until the heap is as high as your chest. Use dry material for the last layer to keep away flies.
- Make air holes in the heap with a sharp pole and cover the heap with old sacks to conserve moisture.
- Check the heap each day to make sure it is not too dry. It should feel damp but not dripping wet. If it feels too dry, add more water.
- Check that the heap is getting hot by pushing your hand in to one of the air holes. If it is not hot, turn the heap, and add more manure.
- If the heap smells strongly of urine it may contain too much manure and you should add some more dry material.
- After about a week the heap will begin to cool and it is the time to turn it over to mix the layers together.
- The heap should be turned at least five times in the composting process. The more you turn the heap, the quicker your compost will break down. Well-made compost can be ready in six weeks.



Compost heap

How to use compost

When using compost apply it on the soil surface as mulch. It can be applied to the beds before planting and should be applied as a top-dressing to heavy feeder crops as they mature. Fresh compost must not be dug in to the soil. Compost should be applied to beds every time you plant new crops at a rate of 1.5 buckets per metre of bed.

Home-made liquid fertiliser

Some heavy-feeder crops (such as leaf vegetable crops, fruit vegetable crops and potatoes) need extra nutrients in order to give high yields. These will benefit from liquid fertiliser which can be made using manure or rotted leaves.

Preparation of liquid manure

Liquid Manuring

Liquid manure is a fermented aqueous mixture of animal manure and plant based, which may be used as a fertilizer and/or treatment product depending on the materials it contains. It is also a liquid made so that when applied to the crops it will make available nutrients required for plant growth. Liquid manure is made by soaking animal dung or chopped plant materials when still green and succulent e.g. grass, soft green leaves and branches, or fermenting animal urine for 14 days. The manure is then diluted before applying in the field. It provides crops with nutrients quickly during the growing season. It is best to apply liquid manure every two or three weeks in vegetables, Chadza (2011).

Requirements

- Manure: poultry or bat droppings, pig manure, cow dung, sheep/goat manure, etc.
- Or Plant-based material (leaves): leguminous (sesbania, leucaena, Moringa oleifera): Enhance nitrogen input
- Woven fiber sack and a drum or earthenware jar for containing the liquid manure
- Wooden stick for stirring

Making liquid compost involves a fermentation process for plant materials in an aqueous environment.

Preparing Liquid Compost

- Find a drum or jar or any container of any size depending on the quantity of liquid manure required.
- Measure one quarter of the container of manure and add the manure into the fiber sack.
- Fill a woven fiber sack with the manure and hand it in the container used for measuring. Fill the container with water
- Alternatively after measuring the one quarter of manure in a container, you can add water straight on the manure if a sack cannot be found. The sack works just to make the separation process of manure and liquid manure easy since the residue are all contained in the sack rather than being mixed with water.

- Close the container with a lid or a mat to avoid flies and foul smells as well as for safety reasons (to prevent child-related risks), Do not seal otherwise it will result in anaerobic fermentation.

-
- Stir the water for 5 minutes twice a day everyday for two weeks.
- The length of the process varies according to outside temperatures. Therefore, the liquid compost is ready for use after 2-4 weeks.
- The liquid manure is mature when it is odor free and clear.

Application

- The liquid manure is diluted before application
- Dilution depends on the type of manure used as shown on the table below:

Manure Type	Dilution Rate for Seedlings	Dilution Rate for Matureplants
Cattle Manure	1 part water to 2 parts liquid manure	1 part water to1 part liquid manure
Goat/Sheep/Rabbit Manure	1 part water to 3 or 4 part liquid manure	1 part water to2 or 3 part liquid manure
Pig	1 part water to 6-8 part liquid manure	1 part water to 4 or 5 part liquid manure
Poultry	1 part water to 10 part liquid manure	1 part water to 5or 6 part liquid manure

FPC (2014)

- Liquid manure should be applied on moist ground and not as irrigation to a dry portion because it will burn the roots of the crop.
- Care should be taken to avoid burning of the roots by applying the diluted manure on one or two plants and monitor for one hour before applying to the whole field. If the plant on which the manure has been applied shows signs of stress then the dilution rations need to be added with one more part of water and repeat the process to monitor how the plants react.

Exercise

As a group, follow the above steps and prepare liquid manure from available animal manure or any other organic manure.

Use the manure correctly on your preferred crop and observe any differences.

Trench bed

Trenching gives very good results, especially in very dry areas and where there is little water

and poor soil. It is hard work at first, but your efforts are well rewarded with bumper crops. It is particularly good in sandy and loamy soils.

Trench Bed Making Steps

- First mark out the bed to be used for making the trench bed based on the mobilized resources.
- Dig out the top soil (one spade-head or 30cm deep) and place it to one side of the bed.
- Dig out the bottom soil (subsoil), also to one spade-head deep and put this soil on the opposite side of the bed. Remove all large stones and boulders.
- Loosen the soil at the bottom of the trench with a fork and lay plastic material cover with a layer of plastic material to facilitate the trapping of water.
- Start by laying on the base metal scraps and bones, these are potential sources of micro nutrients such as iron, zinc, calcium and magnesium
- Put a layer (about 20cm deep) of coarse rubbish at the bottom of the trench and cover it with a 10cm layer of subsoil. Water both layers well.
- Now make 20cm layers of brown, dry and green, wet organic waste, sprinkle with manure and water and add another 10cm layer of subsoil.
- Continue with these layers, removing any tins, bottles, plastic, synthetic (man-made) materials and rubber, until the trench is full.
- Replace the topsoil that you removed from the trench. The surface of the bed will be about 15 – 25cm higher than the path when you have finished. The bed will slowly sink as the rubbish decomposes.
- Spread one bucket of compost (if you have it) over each square meter of bed. Work it in and level the bed using a rake or a flat piece of wood.
- Remember never to walk or stand on the bed.
- Cover the bed with a layer of mulch.
- Plant light feeder and shallow rooted crops after preparation of the trench bed.

Summary

- Soil management is very important for successful vegetable production. You can use chemical methods, organic methods and crop rotation to improve your soil.
- You can improve the texture, nutrient and water holding ability of your soil by increasing the organic matter content.
- You can improve soil fertility by using chemical or organic fertilisers or by practicing crop rotation and intercropping with legumes.
- Properly made compost should be the foundation of your soil management method.
- It is very important to practice crop rotation when you are growing vegetables to avoid degrading your soil and causing a build-up of pests and diseases on your land.

SESSION 5: WEED MANAGEMENT IN VEGETABLE PRODUCTION

5.1 Introduction

Greet each other and review the learning objectives for this session.

LEARNING OBJECTIVES

By the end of this session, you will be able to:

- understand the importance of managing weeds in vegetables;
- explain different methods of weed control and management;
- explain how to control weeds using cultural methods.

Discuss

Talk about the following:

- What is a weed?
- What are the effects of weeds on vegetable crops?
- What are the different weed management options?

Now read the next section…

Weeds are plants which grow where they are not wanted. Managing weeds in the vegetable garden is important for growing healthy and productive plants. There are several methods that can be used to manage weeds and, in most cases, using several methods together will produce the best results.

5.2 Common weeds in vegetable production

In Zimbabwe, there are many weeds which are a problem in arable lands including gardens. These include blackjack, purple nutsedge, yellow nutsedge, upright starbur, pig weed, natal red top, wandering jew, Mexican marigold, salt weed, gallant soldier and witch weed.

Salt weed

Gallant soldier

Upright starbur

Natal red top

Mexican marigold

Landering jew

Black jack

Witch weed

Pig weed

Purple nutsedge

Yellow nutsedge

Discuss

Which weed is most prevalent in your vegetable crop?

5.3 Effect of weeds

Generally, weeds compete with crops for space, nutrients, sunlight and water. Weeds can impact on farm management in a number of ways:

- Compete with Crops for nutrients.
- Reduced effectiveness of insecticide and fungicide applications due to plant density.
- Increased difficulty in harvesting crop through reduced access or blocking equipment.
- Increased vulnerability of the crop before the crop canopy develops within the first few weeks after emergence, for example carrots, cabbage and beets. Some crops that don't form a canopy, such as onions and leeks, will remain at a competitive disadvantage with weeds and are more challenging to manage.

5.4 Weed control methods

There are a number of weed control methods available to vegetable growers, which can be grouped into chemical control, mechanical weed control, manual, cultural and integrated weed management methods. Their application will depend on the time of the season, production system and compatibility with each other, as they are rarely used in isolation. Each method's relative effectiveness of weed control and affordability to implement varies. The critical success factors for weed control include:

- **Choose the appropriate methods** by considering the available options, preparing beds to reduce the weed seed bank, as well as the role of tillage, cover crops and crop rotation within your system.
- **Consider timing** such as weather and access to paddocks, weed life stage, crop life cycle, and ground conditions, particularly moisture.
- **Be diligent** about applying appropriate weed control methods, focusing on removing weeds before they set seed or spread further.

Manual and mechanical weed control

Cultivation through hoe weeding and hand pulling effectively control most annual weeds. It is very important to destroy these weeds while they are small, before they produce thousands of seeds, guaranteeing a weed problem for many years in the future.

Like annual weeds, perennial weeds are easy to control when in the seedling stage. Once they become established they are very difficult to control because of their perennial root system and rhizomes. Repeated cultivation of perennial weeds is necessary, being careful to not chop up or leave behind plant pieces that can root to become a new plant, multiplying the problem.

When cultivating the garden, avoid deep tillage. The roots of many vegetable plants grow near the soil surface. Deep cultivation will cut off some of these roots. Also, deep cultivation will bring deeply buried weed seeds to the soil surface where they can germinate.

Cultural weed control

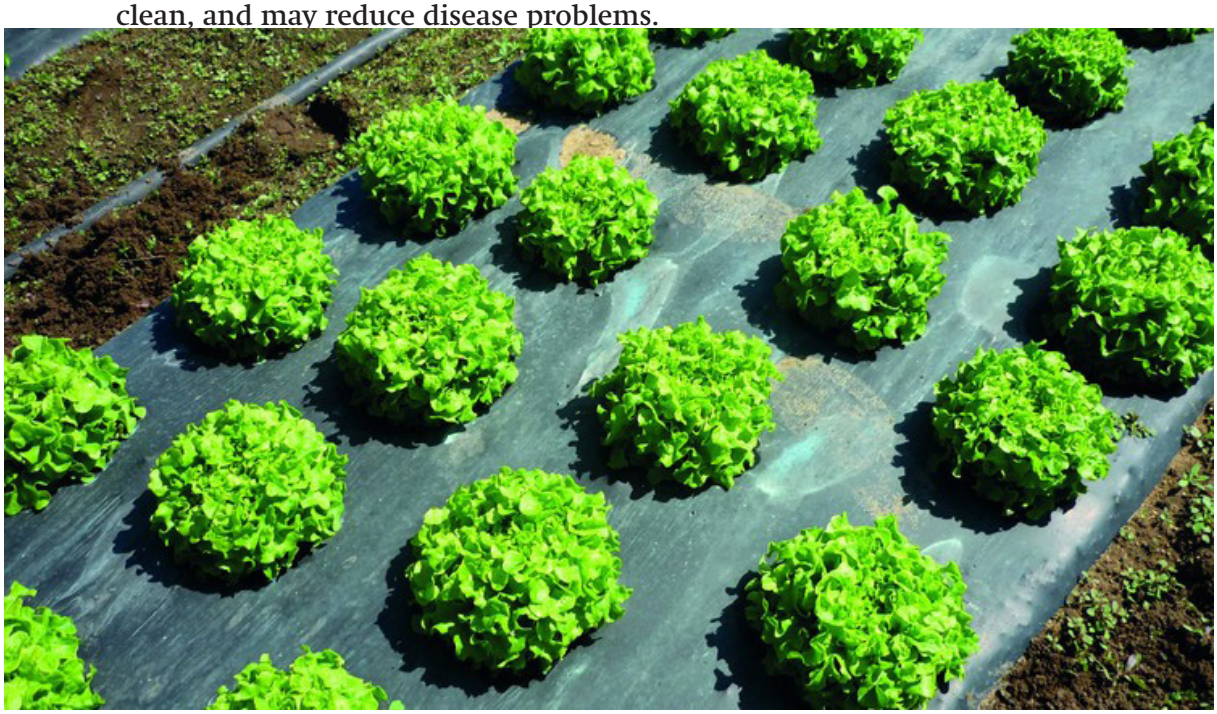
Cultural control methods involve good crop management practices which control weeds. There are several cultural or management techniques the farmer can use to reduce weeds in the vegetable crops. These include the following:

- Proper plant spacing: when vegetables are planted at an ideal spacing the foliage can help shade the ground and reduce the amount of weed seed germination and slow weed growth. When plants are spaced too far apart, weeds more easily grow.
- Irrigation management: water plants directly by hand or using drip irrigation systems. Unlike overhead watering with a sprinkler, drip irrigation provides water directly to the plant and does not provide the moisture needed for weed seeds to germinate.
- Crop rotation
- Early planting
- Use of clean certified seed

Physical weed control

Physical methods involves use of physical barriers and natural factors. These include the following:

- Mulching: grass and plastic mulches control weeds by preventing the germination of weed seeds. Established weeds should be destroyed prior to the application of the mulch. In addition to weed control, mulches help conserve soil moisture, reduce soil erosion, prevent crusting of the soil surface, keep foliage, fruits, and vegetables clean, and may reduce disease problems.



Use of plastic mulch in weed management

Grass mulch keeping cabbage plants weed-free

Grass mulch keeping tomato plants weed-free

Solarization of beds using clear plastic

Chemical weed control (herbicides)

This involves use of chemicals to control weeds. These chemicals are called herbicides. Many farmers choose to avoid the use of herbicides in their vegetable gardens since they are growing edible crops. Several factors limit the usefulness of herbicides in the vegetable garden. Most vegetable gardens contain a wide variety of plants in a small area. This restricts herbicide use because it is unlikely that the herbicide will be labeled for all plants in the

garden. In certain situations, however, a gardener can use herbicides to supplement other weed control strategies.

- Pre-emergent herbicides: these are used to prevent weed seeds from completing the germination process. They have limited use in the vegetable garden because they will also prevent germination and growth of those vegetable crops that are directly sown in the garden such as beans, lettuce, corn, and others. If only vegetable transplants are used, pre-emergent herbicides can help reduce annual weeds but the timing is important. Consult the herbicide container label to apply these herbicides at the appropriate time and frequency to control weeds and not impact the germination of future seed-driven vegetable crops.
- Post-emergent herbicides: these are used to kill weeds that have already begun growing. They must be carefully applied as they have a high potential to harm both weeds and crops.

Always apply herbicides when winds are calm and temperatures are cool to prevent drift and damage to desirable plants. Protect nearby plants with barriers like buckets, tarps, or boxes to further reduce problems with drift. Herbicides can also be applied with a sponge and wiped onto the leaves of the weed to prevent collateral damage to nearby plants. Herbicides must be used according to the label instructions on the package. Failure to follow directions may kill desirable plants or prevent other plants from being grown in the area.

Integrated Weed Management (IWM)

Integrated Weed Management (IWM) is a sustainable management system that combines all appropriate weed control methods for a particular vegetable crop(s). The purpose of IWM is to:

- Reduce the possibility of weed control failure
- Reduce the impact of weed management activities on the environment
- Increase crop yield and quality, while assisting to manage insect pests, diseases and soil health
- Increase the possibility that the mix of methods used will continue to work, for example preventing herbicide resistance.

IWM is more than just relying on a few conventional practices, such as herbicides, tillage and hand weeding. An example of an IWM strategy for cucumbers and water melons production is:

- Use plastic mulch where appropriate
- Implement drip irrigation (subsurface if feasible)
- Control of weeds in the inter-row space before the crop vines had spread
- Chipping or hand weeding within the crop beds • Use mechanical inter row management
- Consider crop rotation
- Use cover crops
- Ensure farm hygiene

IWM is also an important component of the integrated crop protection approach, which combines chemical, cultural and biological methods to keep weeds, insect pests and disease pressure low enough to prevent significant economic loss.

Do you think plastic solarization is possible for weed control in your vegetable garden?

From the aboved discussed weed control and management options, choose the one appropriate for your vegetable enterprises. Explain why you have chosen that option.

Summary

- A weed is a plant growing where it is not wanted.
- weeds compete with crops for space, nutrients, sunlight and water.
- Common weeds found growing in vegetables are black jack, couch grass, nutsedge, salt weed, Mexican marigold, spear grass and upright starbur.
- Droughts, heat waves, floods, pest and disease outbreaks are some of the effects of climate change.
- Climate-smart agriculture aims to achieve food security under a changing climate and increasing food demand.
- Climate-smart agriculture practices in vegetable production include intercropping, crop rotation, soil moisture conservation techniques, water harvesting, agroforestry, solar powered water abstraction, drip irrigation and use of high yielding varieties.

SESSION 6: TRADITIONAL VEGETABLES PRODUCTION

6.1 Introduction

Greet each other and review the learning objectives for this session.

LEARNING OBJECTIVES

By the end of this session, you will be able to:

- Understand that a range of indigenous vegetables have market potential
- Choose the best varieties of traditional vegetables for production under different situations.
- Produce high yields of quality traditional vegetables through using recommended practices.
- Identify the major pests and diseases for traditional vegetables and use effective methods to control them.
- To increase tsunga yields through correct harvesting.

6.2 Overview of traditional vegetables

In the past, a wide range of traditional vegetables were grown including nyevhe (*ulude*) (*Cleome gynandra*), *mowa* (*Amaranthus hybridus*), black jack (*Bidens pilosa*) and okra. In addition, leaf vegetables from other crops such as cowpea and pumpkin were used. These products are once again becoming popular and are starting to be seen on supermarket shelves showing that there is an increasing demand. Customers are realising that many of these vegetables are more nutritious than the exotic vegetables that they are consuming. In addition, these crops are better adapted to some of the climatic conditions in Zimbabwe.

Although being neglected and underutilized, traditional African vegetables offer hope within our communities as a source of income and food. The vegetables offer a diverse base in terms of the nutrients required for growth by the body. Traditional vegetables have in the past been regarded as poor man's crop and have thus received very little attention. However, with the increase of chronic diseases which are associated with urbanization, the demand for indigenous African leafy vegetables is on the rise.

In this session, we will focus on two traditional vegetables grown in Zimbabwe, *tsunga* (brown mustard) and *chembere-dzagumana* (Ethiopian mustard). These two vegetables belong to the cabbage family. Compared to other members of the family, especially the exotics, there is little information on their production requirements. This is so because the crops have not been considered to be of high value enough in the West to warrant huge investments in research. The trend has been repeated in Africa because of lack of research funds.

Brown mustard (*Tsunga*)

Brown mustard (*Brassica juncea*) is a variable species cultivated for centuries as a vegetable and oil crop, and is also a widespread weed. It is known by diverse common names, which include Indian mustard, leaf mustard and brown mustard among many others. In Zimbabwe, the crop is one of the main cultivated leafy vegetable species.

Brown mustard (tsunga) plant

The *tsunga* plant belongs to the cabbage family. It has a short, fleshy stem initially which can reach heights of 1 to 5m. The leaves are light green with a distinct mustard smell and taste. The flowers are yellow and each develops into a seed pod. The seeds are small at first and turn brown when mature and dry. Very dry pods can shatter.

There are several varieties grown in Zimbabwe:

- Ndakupuka – has large smooth leaves
- Chikare - small shiny leaves
- Zifodya - big hairy leaves
- Machembere - big hairy leaves
- Bhama - big hairy leaves
- Marengenya - lacerated leaves
- Paida – big leaves
- ZGS – medium leaves

Discuss

Talk about the following:

- Have you ever grown any of these tsunga varieties?
- Share your experiences with your group.
- Talk about the advantages and disadvantages.

Now read the next section…

Land preparation and planting

Tsunga is grown from seed planted direct or grown in a nursery and then transplanted into beds when the seedlings are 10-15cm tall.

Tsunga seedlings ready for transplanting

Tsunga grows best during cool times of year (April – May). Low temperatures delay flowering making the plant produce large leaves. Growing the crop in soils that are rich in organic matter give good results by increasing leaf size and quality. For good nutrient uptake, the pH should be 5 – 6 (CaCl2).

Planting

If planting direct, put three to four seeds on stations spaced 30 – 50cm between rows and 30cm within the rows. The crop is thinned to one plant per station when seedlings are 2-3 weeks old. Irrigate before and after thinning to firm the soil around the seedlings and to aid recovery of the disturbed plants that remain. The first top dressing is also applied soon after thinning.

Crop management

Soil improvement

Three options are available:

- The first option is to apply 50 t/ha (50kg per 10m x 1m bed) of well rotten manure or compost. All the manure/ compost is incorporated into the soil and thoroughly mixed before planting.

Irrigation

Since the best time to grow the crop in Zimbabwe is dry, irrigation will be needed. Evaporation rates are lower due to low temperatures so irrigation of about 25mm per week may be adequate.

Crop protection

Aphids are likely to be a problem be a problem on *tsunga*. It is important to regularly inspect the crop and treat for aphids as soon as their populations begin to increase.

Established tsunga at flowering stage

See Appendix 1 and 2 for natural control measures and appendix 3 for chemical control measures.

Discuss

Talk about the following:

- What other methods are available to control pests and diseases of *tsunga*?
- Have you tried making any home-made sprays that are effective?
- How did you make and use them?

Harvesting

Leaves are harvested after six weeks of growth once per week. At least one large leaf should be left per plant to allow growth to continue. The plant growth condition will guide you to decide the number of leaves to be harvested per plant. Leaves should be kept cool and moist and eaten or sold as soon as possible after harvesting.

Ethopian mustard (*Chembere-dzagumana*) overview

Chembere-dzagumana is a Zimbabwean traditional vegetable also from the cabbage family. Some varieties have green stems while others have purple stems and green leaves. Some can be smooth and shiny hence the name shushine. The plants produce yellow flowers that result in flattish seed pods. The seeds, which are bigger and more than those of *tsunga*, turn brown on maturity. Seed pods do not shatter easily and they can be kept in pods in a dry and cool place for a long time.

Ethopian mustard

Chembere-dzagumana needs plenty of water but tolerates a wide range of temperatures although it grows best in areas with day time temperatures are between 10-25°C. Good quality leaves are produced between April to August. High temperatures promote flowering thereby reducing leaf yields. The crop can grow on a wide range of soil types provided they have good drainage. Best results are attained in soils rich in organic matter.

Land preparation and planting

Soils should be prepared to get a fine tilth and be levelled. The crop is best planted by direct seeding although it can be transplanted. Transplanted plants tend to flower earlier. It is advised to plant three to four seeds per station and then thin to one plant three to four weeks after emergence. Plant spacing between the rows should be 30 to 50cm whilst it should be 30 to 45cm within the row. The plant germinates in four to five days and grows vigorously producing abundant side shoots on each node. These side shoots should be removed otherwise the leaves will be abundant but small.

Crop management

Soil improvement

The crop response well to organic fertilizers mixed into the soil before planting. Fertilizer and manure applications should be the same as those for *tsunga*.

Irrigation

Irrigate as for *tsunga*.

Established Ethopian mustard (Chembere-dzagumana) crop at flowering stage

Crop protection

Aphids can be a problem at the seed pod stage and bagrada bugs may infest the crop. For natural control see appendix 1,2 and for chemical control see appendix 3.

No diseases have been observed in the rainy season. This does not mean we should not be on guard. Keep fields clean of weeds.

6.4.3 Harvesting

Leaves should be picked once they reach desired size. Delays in harvesting results in loss of quality. Yields are higher in the cooler months. Yields of around 35 to 75 tonnes per ha can be obtained.

Discuss

Review what you have learnt in this session then read the summary to check that you have remembered everything.

Summary

- A wide range of traditional vegetables can be grown including *nyeve*, *mowa*, black jack, cowpea leaves, pumpkin leaves and vegetable leaves.
- Two traditional vegetables with high market potential are *tsunga* and *chembere-dzagumana*.
- These vegetables both belong to the cabbage family and have similar growing requirements.

SESSION 7: BRASSICA VEGETABLES PRODUCTION

7.1 Introduction

Greet each other and review the learning objectives for this session.

LEARNING OBJECTIVES

By the end of this session, you will be able to:

- Explain the characteristics, varieties and growth requirements of Brassicas (cabbage, rape, kale and cauliflower.
- Grow high quality and high yielding Brassicas by applying good production practices.
- Identify the pests and diseases of Brassicas and use appropriate methods to control them
- Outline the crop management methods for cabbage, rape, kale and cauliflower.
- Explain harvesting and marketing of Brassicas.

Brassicas are group of plants in the cabbage and mustard family. Brassica vegetables include cabbage, cauliflower, broccoli, Brussels Sprouts, kale (Chomolia and Covo), rape, Indian mustard (tsunga) and spinach. These vegetables are popular around the world today and have been a major food source. Brassicas contain high levels of vitamin C, A, E, K, as well as calcium, iron, potassium and phosphorus. They are a good source of dietary fibre.

Talk about the following:

- Describe the cabbage varieties you know and for each give the advantages and disadvantages..

Now read the next section…

Cabbage Production

Varieties

So how do you select your seed variety? Careful selection of your cabbage variety is important to the success of your crop. You must read the seed packet to make sure you understand that particular seed cultivar's specific properties. You can also test out different varieties to see which do best for you.

Cabbage cultivars differ in terms of head size, density, head shape (conical/sugarloaf-headed, ball-headed/roundhead and large/drum-headed), colour (green, red or purple), leaf texture, disease resistance and date to maturity (early, mid-season or late-season). Other varieties are Chinese cabbage and Savoy. Savoy cultivars have crinkly leaves and are not very popular in Zimbabwe.

Recommended varieties include the following:

- Star 3301, Star 3311, Golden Acre, Cabbage Attraction F1 are good summer cultivars. Star 3301, for example, is great for its uniformity and high yield potential.
- Conquistador, Megaton Hybrid, Star 3301, Star 3306, Green Coronet, Brunswick, Hercules are good cold/cool weather cultivars.
- Other good cultivars: Cape Spitzkool, Green Star, Grandslam, Matador and Tenacity.

One should choose the cabbage varieties which you grow based on market requirements. After identifying the varieties that the market wants, you can then consider factors like drought tolerance, time to maturity and disease and pest resistance. Seed should be bought from reputable suppliers to avoid buying diseased seed.

One should purchase your selected cabbage seed from reputable suppliers.

Cabbage

Cabbage needs about 380mm to 500mm rainfall or irrigation in the dry season. Cabbage

prefers cool temperatures (18 to 20oC) so does best during winter. The most difficult time to grow cabbage is the rainy season because of high pest and disease pressures. However, there are varieties like Majesty which performs well in summer. Farmers who want to prolong their cabbage growing season for the benefit of the market can play around with such varieties.

Cabbages can be grown in a wide range of soils from light sand to heavier clays. Soils with high organic matter content give the best yields. Soil pH should be between 5.5 to 6.0 for ideal growth. Good drainage is important and soils that become water logged after heavy rain or irrigation are unsuitable. To improve production of cabbages like most vegetables we should apply good quality manure or compost.

Land preparation

The land should be ploughed well and deeply before planting.

Planting can be by direct seeding or by transplanting seedlings. Direct seeding will require about 2kg of seed per ha. Three to five seeds are placed at each permanent planting station and after 3 to 4 weeks after emergence thinning is done to leave one healthy plant per station. The field is watered one day before planting. When transplanting water the beds just before seedlings are planted and soon after transplanting. To avoid severe shock, it is advisable to do this during the cooler times of the day.

Discuss

Talk about the following:

- Why is it that the seed required for direct seeding is more than four times that for seedlings production to plant the same area?

Now read the next section…

The common method of propagating cabbage in Zimbabwe is through seedlings raised in seedbeds. A better method is to produce seedlings in trays.

About 300 to 450g of seed will raise enough seedlings for a 1 ha or 2.5 acre field. Approximately 1g of seed will give 200 - 300 plants. The seedbeds should be fertilised with Compound S (7-21-8) at 60g per m2). The seed is sown in 150 mm spaced rows at a depth of not more than 10mm. Germination takes about 5 to 7 days when temperatures are in the range 20 to 30oC. After germination, the seedlings are thinned to about 11mm apart in the row. The use of grass mulch will improve growth and uniformity of seedlings. The seedlings will be ready for transplanting in four to six weeks after emergence. At this stage they will be about 100 to 150mm tall. Seedlings should be hardened before transplanting by placing them in a sunny position for a day or two.

Spacing

When planting small headed cabbage, rows are spaced 45 to 50cm apart with plants in the row spaced 30 cm (a full ruler). For large-headed cabbages we use 45 to 50 cm inside rows, and 50 to 60 cm between the rows.

Crop management

Cabbages have shallow root systems and are heavy feeders, so they require heavy applications of fertilizer. This means we require adequate levels of fertilisers or compost/ manure.

Soil improvement

Manure or compost can be applied at amounts of 50 t/ha, (5 kg per m2). If compost or manure is not available in large quantities, use 30 t/ha manure plus 200 kg/ha Compound S (7:21:8) or Compound C (6:15:12). This translates to 3 kg/m2 manure plus 20g/m2, Compound S or C. If manure is not available at all, then apply 600 - 700kg/ha of a compound fertiliser (about 60 to 70g or 2 x size 30 fertilizer cups per m2).

Both the compound and manure should be ploughed into the soil before planting. This helps the plants to start developing a strong root system which will result in healthy growing plants.

Top dressing with ammonium nitrate should be applied at the rate of 5g/m2 at three weeks after trans- planting, 10g/m2, three weeks later and another 10g/m2, after three to four weeks. Too much nitrogen application should be avoided, as it can lead to splitting of the head.

Calcium and boron are important nutrients in cabbage production. Additional boron may need to be added to avoid decay and hollowing of the pith (core), and calcium may be needed to avoid tip-burn.

Irrigation

Adequate water must be given throughout the growing season. How often watering is done depends on the soil type, climate and condition of the crop. During the first weeks, irrigate frequently using small amounts of water. As the plants grow (by six weeks) you can reduce watering to giving larger amounts once a week.

Crop protection

Weed control

It is essential to maintain good weed control if maximum yields and quality are to be achieved and labour costs reduced. Competition from weeds early in the season will slow both emergence and early growth. Weeds should be controlled with shallow tillage to destroy any weed seedlings. Weeds can be controlled by using mulching and hoeing, using herbicides but these are expensive and dangerous so must be used as a last resort. See appendix 4 for a list of herbicides.

Pest control

Pests that attack cabbage are the same for rape and kales. See appendix 1 and 2 for natural control. See appendix 3 for chemical control.

In these discussions we are going to look at some of the most troublesome insect pests of cabbage and what methods we can employ to control them before they damage our crops.

(a) Cut worms: This cause direct lose and affect plant stand. It's a major problem after

transplanting, cuts the plant at the base, use Karate at 100 ml/100 l water spray at the base of the plant, this will give the best results. Carbaryl 85 WP at the rate of 150 - 200 g/100 l, applied in the planting hole, is also recommended. Pyrinex 48EC at a rate of 200ml in 100lt of water drenched soon after transplanting using cup 30/plant is also recommended.

Cutworms

(b) Bargrada bugs: Black and orange bugs (Fig 7.2) which are usually seen in twos joined back to back. These can cause very serious damage to leaves. The insects will cause the leaves to dry, like a chemical burn, causing poor growth to the plants.

The adult bagrada bug

Initial symptoms of damage by bagrada bugs. Note small white punctures on the edges of leaves

Crop severely damaged by bagrada bugs

(i) Chemical Control, We can control using chemicals like, Dedevap (Dichlorvos) at 15 to 20

ml in 15 litres of water. This is enough to cover an area 1000square metres (100 metres by 10 metres). Anoth- er chemical we can use is carbaryl, mix 30 grams in 15 litres of water. Always read the label for full instructions.

(ii) Natural pesticides are recommended (by The Natural Farming Network) for controlling Bargrada bugs, stink bugs and green stink bugs. Large beetles which do not appear in large numbers we can pick by hand, chickens or Guinea fowl on free range can also reduce their numbers and we can use aromatic sprays (sprays made from plants that smell) to repel them. For small beetles we can use aromatic plants.

(iii) Sprays, ash, clay, lime, chickens, manure, soap solutions, tea, pawpaw, syringa. Make sure there are enough trees for birds and other plant diversity for predators (those insects we are our friends)

(c) Cabbage Aphid: This is another troublesome insect pest. It is a small pear shaped insect with a soft body, can have or may not have wings. Aphids suck sap and can also spread virus diseases.

Aphids underside of the leaf

(i) Chemical control: We can control by spraying with Dimethoate (Rogor), 40% EC at 75ml in 15 litres of water will be enough for an area 100m by 10m (1000m2). We must wait for two weeks before we harvest after sparaying. Other chemicals include Malathion 25 WP and Thionex 35 EC.

(ii) Natural control Methods: Aphids can be controlled by inter or strip cropping of plants like garlic, marigold and onion, which repel certain types of aphids. For natural pesticides we can also use ash, clay, soap solutions like Naturrel, garlic chilli, sweet potato, tomato, tobacco, onion, wild cucumber and syringe. At the back of the book we will find some examples of preparation methods for some of the natural pesticides we have discussed.

(d) Diamond Back Moth: This is one of the insect pests we shall find giving us problems in cabbage and its relatives, in particular from August throughout the rainy season. The adult is a moth (small butterfly) but the damage is from small bright green caterpillar which causes short holes in the leaves, see below picture. This is the larva stage which builds a web (cocoon) around which it can make control difficult because sprays will not reach the pest due to protection by the web or cocoon. It usually attacks the growing parts of the cabbage and its relatives, affecting subsequent growth and giving vegetable leaves holes which are unattractive in appearance.

Diamond Back moth larvae

Damage caused by Diamond Back moth larvae

(i) Chemical control:

DDVP, Dichlorvos 1000: apply at 100ml/100 l water as a high volume, full cover spray and repeated at weekly intervals if necessary. The harvest interval is 3 days. Dichlorvos 1000 will also control aphids, caterpillars and whitefly.

Endosulfan 50 WP: spray at 100g + 30ml Sanawett 90/100 l water. Apply as a high volume, full cover spray in at least 100 l mix/ha and repeat at 7 - 10 day intervals as necessary. The harvest interval is 7 days. Thiodan will also control caterpillars.

Methamidophos 600 SL at 100ml/100 l water as a full cover spray repeated weekly if necessary. Do not harvest for at least 21 days after date of last application. Methamidophos will also control aphids and caterpillars.

Malathion 25 WP at 20g + 30ml Sanawett 90/100 l water as a full cover spray applied in at least 1000 l mix/ha and repeated at 7 - 10 day intervals before harvesting. can be used to control the larva.

(ii) Natural Control: We can use dusting or spraying with lime which effectively controls eggs, cater- pillars and the pupae. Natural pesticide sprays made out of pyrethrum, tobacco, rain tree, and dusting with lime will effectively control the larvae and prevent holes on leaves.

Diseases management in cabbages

(a) Black Rot: caused by the bacterium Xanthomonas campestris: This is one good example of a disease that is caused by bacteria. Black rot is one of the most serious cabbage diseases. It can cause severe damage during the rainy season.

Symptoms are black rot generally begin with yellowing at the leaf margin, which expands into the characteristic “V”-shaped lesion along the leaf margins and necrotic patches on the main leaf laminae. Leaf veins are also darkened. We can control it by the hot water treatment on the seeds (see under tomato). We can also remove or rogue out infected plants and burn them. We should not feed infected material to animals because the diseases can be transferred back to the field when we apply manure. The disease can also be passed through infected seed, from plant to plant in the field or from the soil. Since it stays for a long time in the soil, we should always practice rotations with non-related crops. Also use clean certified seed and practice strict hygiene in the field.

The cabbage field has been destroyed by the black rot pathogen. Portions of the field on the right have been overtaken by related weeds which can serve as a source of inoculum

The cabbage above shows typical black rot symptoms, with V-shaped lesions moving into the leaf from the leaf margin.

(b) Downy mildew: This is an example of a disease caused by fungi. Signs that the crop is infected are a white fluffy fungal growth on the underside of the first leaf structures (cotyledon leaves). Infection on seedlings can be very severe resulting in high mortality.

Downy mildew on cabbage leaves.

(i) Chemical Control: We should always start with healthy transplants and a routine spraying pro- gramme can control the disease in mature plants, e.g Dithane M45, at 30grams in 15 litres of water, or use Ridomil Gold

(c) Damping off: is a common disease in seedlings in general caused by a number of fungi. Plants at seedlings stage will die very close to the ground resulting in the whole plant collapsing. We must make sure the soils are well drained and seedlings are not over crowded.

Seedlings affected by damping-off

(i) Chemical Control: Use Apron Star 42 WS as a seed dressing. Use 10g/4kg seed. Apron Star 42 WS can also control other diseases as well as protect seedlings from aphids for up to 4 weeks after sowing. Can also use Thiram 80 WP as a seed dressing, at 100g/50kg of seed, mixing well. This will also control some other seedling diseases. If the attack is high we can also drench or spray with, the fungicides, Apron star 42 WS, Captan, Thiram 80 WP around the base of the seedling.

(d) Natural Control Methods; to control most fungal diseases, as recommended by the Natural Farming Network, we can use Ash, Baking soda, burning, compost, manure, milk, mulch, soap solutions, onion, garlic, chilli, pawpaw, sunhemp, african marigold, thorn apple and pigweed. Garden hygiene and planting of health plants that is use certified seeds, time of planting, Avoid excessive watering and fertilization particularly with nitrate, practice crop rotation, and watering regime will all assist in reducing fungal diseases.

(e) Stem Rot, Sore Shin (Rhizoctonia solani) and Other Soil Diseases

These could be a problem to brassicas use Quintozene 75 WP at 10g/m2 should be incorporated in to the soil to a depth of 50 - 100mm in the planting holes. The soil surface should be kept moist during the early post-transplanting stage. For seed-box treatment use Quintozene 75 WP at 100g/m3 well mixed into the soil and well watered in, you can also seed dress the seed with Apron star 42 WS at 10g/4kg seed.

Physiological disorders

Physiological disorders are caused by changes in the growing conditions and are not a result of pests or diseases.

Hollow stem - If boron is deficient, cabbage stems become hollow and cracked This condition will interfere with nutrient and water uptake. Browning of the head may occur as well. Use vegetable basal fertilizers to avoid this problem.

Tip burn - lack of calcium in the soil causes the tips of cabbage leaves to dry. Often the problem is not lack of calcium in the soil, but conditions like poor watering and low soil pH (acidic conditions). Irrigation with moderate levels of ammonium nitrate will reduce the problem. If calcium is deficient apply lime at 800 to 1000 kg/ha or 80 to 100gm2.

Cracking and bolting - Uniform soil moisture and frequent light irrigations will reduce head cracking in some varieties as they reach maturity, especially during the hotter months. Some varieties are inclined to bolt, producing a seed stalk if planted during the coldest time of the year, or if extreme variations of night and day temperatures are experienced. Such varieties should not be planted in late autumn or winter.

Oedema – If there is too much soil moisture during periods of cool nights and warm, humid days, many small, scabby wounds form on the underside of the cabbage leaves. Oedema may be confused with thrip damage. Avoid over-watering.

Head rot and browning – Both these problems are caused by several factors. Problems with calcium uptake combined with rapid growth can result in either condition, even when soil calcium levels are high. Head rot results from bacteria breaking down the tissues under wet conditions. Browning results from individual flower buds dying under dry conditions. Extended periods of wet or dry conditions during warm temperatures give rise to rapid plant growth while calcium uptake is diminished due to poor transpiration rates in the plants.

The best way to address this problem is through mixing varieties. Select a later-maturing variety to be harvested along with your regular variety for that part of the growing season when you have experienced the problems in the past. The slower growth rate of the later maturing cultivar may prevent your total loss of your crop.

Frost Injury - This is common on margins of the lower leaves which wilt and turn brown leading to death in severe situations. The main veins may crack. Avoid planting in areas that experience frost.

Harvesting

It is important to harvest cabbage at the correct stage of maturity.

Harvesting of cabbages can be done after four to five months depending on the variety grown. Heads should be harvested when firm. Heads may crack if harvesting is delayed. To minimize the cracking problem, farmers should do staggered planting. Staggered planting is growing the same vegetable, but planting the seeds on different dates

throughout the season so you can enjoy a longer period of fresh vegetables. This helps where farmers do not have a market that takes all the cabbages at once.

Marketing

Most cabbages in Zimbabwe are sold at fresh produce markets in major urban areas like Harare, Bulawayo, Gweru and Mutare. Farmers located close to our neighboring countries can and should consider exporting. You can sell your cabbage crop either loose or in bags. Supermarkets across the country are one of the potential customers who can buy in bulk.

The viability of your cabbage production operation is based on your input costs (seed, fertilizer, irrigation water, labor and machinery time). You need to track and calculate all these to get an idea of your cost of production.

Market timing: The biggest challenge with cabbages is an oversupply or market glut on the local market which causes a sharp drop in cabbage prices. You should work on understanding the demand and supply of the various markets so that you don't supply your cabbages during a glut.

Profitably from growing cabbages comes from good growing practices, managing expenses and also year round production to improve consistency and prices.

Value addition of cabbages

Summary

- There are many different varieties of cabbage. You should choose a variety best suited to your market and the growing conditions in your area.
- Cabbage does best during cool times of year. It must be given adequate soil fertility and water for good results.
- Pests, diseases and weeds must be controlled in order to get good results from your cabbage production projects. Cabbage and cauliflower may also suffer from physiological disorders.
- Cabbage must be harvested at the correct time when the head is firm to avoid head-cracking.

CABBAGE PRODUCTION GROSS MARGIN BUDGET

ITEM	QUANTITY NEEDED	UNIT COST (US$)	TOTAL COST (US$)
PRE-PLANTING			
Diquat [non-selective herbicide]	2 litres	$20/ litre	40
AT PLANTING			
Cabbage seedlings [hybrids e.g. Fabiola]	40 000	$20/ 1000 seedlings	800
Fertiliser compound C (5:15:12)	600kgs	$50/ 50kg	600
Fenvelerate 20 EC [for cutworm]	500ml	$20/ litre	10
AT TOP-DRESSING			
Fertiliser ammonium nitrate (34.5%N)	200kgs	$50/50kg	200
OTHER COSTS			
Dimethoate 40 EC [for aphid control]	1 litre	$20/ litre	20
Ddvp [for bagrada bug control]	500ml	$10/ 500ml	10
Lufenuron 5 EC [for diamond-back moth control]	1 litre	$30/ litre	30
GRAND TOTAL			**$1 710**
EXPECTED GROSS INCOME: Estimated at 70% pack-out: 0.7×40 000 = 28 000 heads Selling price ranges from $1 for 2 heads to $1 for 4 heads under normal circumstances! Using $1 for 4 as a worst-case scenario: = 28 000 ÷ 4 = $7 000 Therefore: **GROSS INCOME** = $7 000	**$7 000.00**		
GROSS MARGIN: $7 000 – $1 710 = $5 290	**$5 290.00**		

ASSUMPTIONS MADE IN THE BUDGET:

- All quantities needed are for 1 ha crop.
- Farmers to provide their own labour for planting, weeding, pest and overall crop maintenance.
- Land costs not included, assumption is farmers are not leasing land.
- Land preparation costs for tractor also not included in budget (it's usually $100/ha + 20 L diesel).

Rape production

Rape (*Brassica napus*) is one of the most widely eaten vegetable in Zimbabwe. Rape is a member of the cabbage family but unlike cabbage and cauliflower, it does not form heads. This gives an advantage of a longer harvesting time. The crop is a versatile leafy vegetable that can be used in a variety of recipes. What makes this a must-have vegetable in your garden or farm is that it can be grown all year round (though it is better suited to the cool season), and it is a steady, high-yielding vegetable that can guarantee you a constant supply of income. It is also suitable for urban farmers because it requires limited space.

Established rape crop

Climatic and soil requirements

Rape is typically planted in early February but April is considered the best time to plant it. It does best at temperatures of about 15-20°C during the day and night temperatures of 10°C. Kale can withstand lower temperatures compared to rape. While the cool season is the best time to plant, rape can be grown year round though hot summer periods can be challenging due to increased pest pressure.

Rape can be grown on a wide range of soil types, but the best results are obtained on sandy loamy soils if they are well drained and not subject to the high water table. The optimum soil pH range is 5.5 to 7. Choose a site with full sun for best growth.

Varieties

- Giant Essex: this is the most popular variety of rape. It is adapted to local conditions and does not bolt (early production of seed, resulting in deterioration in quality of the consumable part). It is selected for its hardiness. It's dark green; provides immense growth and has large broad leaves.
- English Giant: is also adapted to local conditions and is also widely marketed locally.
- Rape Hobson: this is a rape variety. It is dark green with large leaves and great taste. Resistant to powdery mildew.
- Rape Rampart: this is a very popular leaf vegetable grown throughout the year in Zimbabwe. Vigorous dark green plant with a high tolerance to diseases. Harvesting starts at 30 days after transplanting.

Rape Rampart variety

Land preparation and planting

When choosing a site to plant your rape crop practice crop rotations by not planting where other brassicas were previously planted in the past 2-3 years. Prepare seedbeds for planting by removing weeds and debris and ploughing and discing to a fine tilth. The seed rate is

usually 3 to 5kg/ha, if sown in the seedbed the rate is reduced to 0.5kg/ha. Final field spacing should be 75 to 150mm × 450mm. This is ideal if cultivation is to be done by hand, but for tractors, the row spacing should be increased to 600mm the seedlings are thinned when they are 150 to 200mm tall.

The seed is planted 12 to 35 mm deep, depending on the soil texture. Seeds germinate fast in about 4 to 7 days. If transplanting, seedlings are transplanted when they are about 15cm. Transplant hardened seedlings when it is cool (early in the morning or late afternoon) to avoid seedlings wilting.

Rape seedlings

Crop management

Fertilization

Rape is a heavy feeder and responds well to the application of well-rotted organic manure (e.g chicken or cattle manure), supplemented with a compound or straight fertilizer. Soil analysis is also required. Basal dressing, Compound L (5:10:10) 700 to 800kg/ha, should be incorporated into the soil 4 weeks before planting.

Top dressing with liquid manure or Ammonium Nitrate (AN) 100kg/ha should be applied every 2 to 3 weeks from planting for 2 to three times. This is because rape is continuously harvested and nitrogen contributes to good yields. Rape is sensitive to boron deficiencies just like any other brassica, Borate can be applied at 20 to 40kg/ha with compound fertilizer in the basal dressing.

Discuss

Talk about the following:

- What are the main pests of rape in your area? How are you controlling these pests?
- What are the main diseases of the cabbage family and how are they controlled?

Now read the next section…

Management

- The crop should be kept weed free, especially in the early days when competition for nutrients and space is high. Cultivation must be shallow to avoid root damage.
- Before planting the soil should be brought to field capacity to a depth of 500mm since planting into dry soil followed by irrigation is seldom satisfactory.
- As the crop is grown predominantly in winter, irrigation is necessary. As a guide, the crop should be irrigated when available soil moisture has been depleted by 50%. You can apply mulch to conserve water.
- Rape succumbs to most of the insect pests and disease that attack other brassicas. Scout for pests weekly because early disease detection helps with controlling pest and disease outbreaks and reducing losses or yields. Refer to pests and diseases of cabbage in the previous session and See Appendix 1 and 2 for natural control measures of the following pests and diseases. See Appendix 3 for details on application of chemical sprays.

Rape crop ready for harvesting

Harvesting

- Depending on the variety and the conditions, rape is ready for harvesting about 4 weeks after transplanting and usually lasts for three months. Only mature leaves that are acceptable for market should be harvested. Rape is harvested continuously and yields can range from 25 to 50t/ ha (fresh weight) over the harvest period though they have been known to reach as high as 75t/ha under optimal conditions.

Harvested rape

Marketing

There is a steady market for vegetables such as rape. Prices are however highly volatile due to supply and demand. Look for markets (e.g. supermarkets, traders and wholesalers) before selling because rape is highly perishable. It can be sun-dried for value addition or to reduce perishability.

Summary

- Rape belongs to the cabbage family, it lives only a few months.
- Rape grow best during the cold season. It requires fertile, well-drained soil.
- The crop is prone to a wide range of pests and diseases so good crop management is very important.
- The advantage of rape over cabbages is that it can be harvested for a few months. This can bring in a steady income for the farmer and supply a regular source of vegetables for the family.

African Kale (Covo and Chomolia) production

Land preparation

African types of kale are cultivated widely in Zimbabwe and form an important component of the diet. The crop can be grown during winter and it comes in two varieties, namely Covo and Chomolia. These vegetables form an important component of local households' diet. Below are points to consider when producing African kale.

Varieties and plant material

There are two main types that are grown in different ways: Chomolia and Covo Rugare. Chomolia has a shorter growing season and is grown from seeds while Covo Rugare can easily be propagated by cuttings and side shoots.

Cuttings and side shoots of Covo Rugare

Chomolia seedlings

Planting and site

African kale needs to be grown on fairly free draining soil with good soil fertility. Manure should be applied beforehand. For Chomolia, sow seeds into modules or trays in May then transplant in June or July. Plants should be spaced at 60 to 70cm both between and within rows.

Covo Rugare can only be grown from cuttings. July and August is a good time to plant Covo. Small side shoots of about five to 10cm should be broken from a mature plant. Stems should be trimmed back to a node, and any excess leaves removed so that there are two to three small leaves remaining.

Crop Management

Pests, weeds and diseases

African kale will succumb to all the normal pests and diseases that afflict brassicas. At an early stage, the plants are tempting bird feed, so should be kept covered. In a dry season, leaves may become infested with cabbage aphid, especially from August. The plants should not be grown in an area where brassicas have been grown in the last four years to reduce the risk of club-root infestation. Aphids are often a problem, but try rinsing them away with a spray of cool water. Natural predators such as syrphid fly larvae often bring the problem under control. Prevent soil-borne diseases by growing African kale in the same spot no more than once every three years. Use pest and disease control measures as those used in cabbages.

Established Covo Rugare ready for harvesting

Established chomolia crop

Watering and feeding

African kale have shallow roots, so it is important to keep the soil where they grow moist but not soggy. Light, frequent watering will help the leaves develop quickly and produce a high-quality plant. If you're using fertiliser or compost in your garden, you will want to add more once the kale has grown to a few centimetres high. Apply it to both sides of the rows where plants are growing. This is called side-dressing.

Fertilisers

Ideally, fertiliser recommendations should be based on the results of recent soil analysis done on representative soil samples. Where vegetable crops are to be grown for the first time, or only sporadically, or on virgin soil, the importance of submitting representative soil samples for analysis and recommendations has to be emphasised. Analysing soils before planting each crop, or at least annually, is recommended. Obvious or serious nutrient deficiencies or imbalances may then be corrected before planting and any lime required could be applied. Where vegetables have been grown intensively for some time with heavy

fertiliser dressings, the soil nutrient status is likely to be more satisfactory.

While annual soil analysis would still be beneficial, submitting soil samples for analysis every two or three years may be adequate. The objectives of such analyses are to correct imbalances of the major nutrients and to economise on fertiliser costs by applying only what is required. In the high rainfall areas, soils tend to be inherently infertile and more acid. Liming should be considered in these areas.

Because of leaching or non-availability of fixed elements, fertiliser requirements are also likely to be high, unless intensive cropping with adequate fertilisation has been practised for some time In drier areas, lime and potassium are less likely to be needed in large quantities, if at all, but phosphorus will probably be deficient in virgin soils. Where this inherent phosphorus deficiency has been corrected by high phosphate dressings, the fertiliser requirements are expected to be relatively low. Obviously, on very poor soils, crop results would be improved by even higher fertiliser application rates.

Harvesting, storage and marketing

Leaves of both chomolia and covo can be cut when required, tied in bundles, and will store for a few days under cool conditions. Covo will continue to produce leaves over an extended period. When the crop is harvested for fresh market, you may sprinkle water to prolong the shelf-life and keep them fresh as shown below. You can sell to venders, supermarkets or individuals.

Sprinkling water on harvested covo

Harvested kale in bundles

Cauliflower production

Discuss

Talk about the following:

- Describe the cauliflower varieties you know and outline their characteristics.

Now read the next section…

Cauliflower

Cauliflower belongs to the cabbage family. It is endowed with rich nutritional content either when it is eaten raw or when it is cooked. It takes cauliflower roughly 3 months to reach maturity which creates room for multiple batches per year. Maturation varies from variety to variety. Some varieties take 2 months to mature whilst some can take as long as roughly 5 months. Cauliflower is rich in carbohydrates and calories – its superior richness is in Vitamins though (C and K in particular). It has great export value and here is something worth noting. The vegetable comes in many colours which include purple, yellow and orange though it tastes the same.

In principle, the farming approaches employed in cabbage farming work for cauliflower too. Farming cauliflowers is considered to be simple and straightforward.

Cauliflower varieties

There are so many cauliflower varieties to choose from. Choices do depend on characteristics of varieties, availability, and weather patterns, amongst others. For instance, cauliflower varieties have different colours – they are white, green, yellow, and purple. Examples of

popularly cultivated varieties are Nevada F1, Twister F1, Cauliflower Spacestar, Candid, Charm, Incline, Apex and Panther. We will look at the characteristics of 3 selected varieties in the table below:

Variety	Description/Characteristics
Nevada F1 	• Description: Excellent quality, smooth texture, very well-tucked. It can be used for year-round production. High marketable yield-potential. • Type: An extremely versatile variety, performs well under a wide range of agricultural and climatic conditions. Excellent leaf cover. Dense curd which breaks easily into neat florettes, therefore good for freezing. • Plant population: 35,000 – 40,000 plants per hectare • Fruit (head): Large white curds with a good dome shape, perfectly suited to both pre-pack and processing requirements. Produces tightly-wrapped heads with intense white colour. • Average fruit (head) weight: 1.2kg • Maturity: It needs 70-80 days to maturity • Disease resistance: Good tolerance to leaf diseases
Twister F1 	• Description: Excellent quality, smooth texture, very well-tucked. High marketable yield-potential. This variety has the ability to withstand extreme heat/ climatic changes. In mild climatic conditions. It can be used for year-round production. • Type: An extremely versatile variety, performs well under a wide range of agricultural and climatic conditions. This variety has an excellent wrap – careful attention should be paid to when the variety is ready for harvest since it doesn't open up as quickly as other varieties • Plant population: 35,000 – 40,000 plants per hectare • Fruit (head): Large white curds with a good dome shape, perfectly suited to both pre-pack and processing requirements. Very tightly-wrapped heads with intense white colour. Excellent leaf cover Dense curd which breaks easily into neat florets, therefore good for freezing. • Average fruit (head) weight: 1.0 Kg. • Maturity: it needs 70-75 days to maturity. Exceptional wrap, minimizing loss due to sunburn damage and this speaks to a good field holding ability. • Disease resistance: Good tolerance to leaf diseases.

Cauliflower Spacestar 	• Vigorous healthy plant, with semi-erect leaves. High quality heads. • Firm, flat round, nice tight floret heads. • Fresh market growers, home growers and processing industry. • 75 days to maturity. • 0.4kg-1.2kg average weight.

Crop growth requirements

This is one vegetable that does well under full sun and cool temperatures of 15°C-20°C. It requires optimum pH of 6 -6.5. Cauliflower prefers deep loamy soils which have good water retention, good drainage, and good fertility. The soil should be rich in nutrients such as potassium and nitrogen so you should apply potassium and nitrogen based fertilizers. It is also advisable to add organic content to the soil so as to improve yields. Cauliflower takes 2 to 3 months (after transplanting) to maturity, depending on the cultivar of course.

Land preparation and planting

Where possible, soil preparation must include ripping, ploughing, and even discing. It is best to start with seedbeds and then you transplant later. Seeds should be sown roughly a centimetre under the ground. The ideal inter-row spacing is half a metre. Transplanting is usually imminent about a month after sowing. The other tell-tale sign is the number of leaves – if there are about six or so leaves then transplanting can commence. When transplanting inter-row spacing should be 75 centimetres and inter-row spacing should be 30 centimetres. If you have to irrigate you must use overhead irrigation. Weed control is very important and must be done especially during the first month after transplanting the cauliflower. It is advised also that boron be applied because cauliflower tends to be susceptible to a lack of boron.

Discuss

Talk about the following:

- • Why is it that the seed required for direct seeding is more than four times that for seedlings production to plant the same area?.

Now read the next section…

Crop management

Cauliflower have shallow root systems and are heavy feeders, so they require heavy applications of fertilizer. This means we require adequate levels of fertilisers or compost/

manure. Follow fertilizer and irrigation requirements as those outlined for cabbage production in the last session.

Blanching

Some cultivars, such as Twister F1, will naturally wrap their inner leaves around the maturing heads (curds). Others have foliage that grows upward and outward, away from the curds. This does little, if anything, to shade the developing curds from the sun. These varieties require blanching by hand to protect them from damage. **Blanching** is the simple practice of binding large outer leaves together over and around developing cauliflower curds, to prevent them from yellowing or browning and developing a bitter flavour due to an overabundance of sun exposure.

About a month after sowing, healthy cauliflower plants will be lush with leafy foliage. At this time, the first tiny curds should begin to appear. Here's how to do it. It is very easy. Imagine peeling a banana in reverse.

1. Choose a large leaf with which to begin.
2. Gently bend the leaf inward over the center of the plant. Hold the leaf in place.
3. Grasp a second leaf in the same fashion, and fold it over to meet the first, over the center of the plant. Hold the tops of both leaves together in one hand.
4. Use your other hand to gently bend a third leaf inward to meet the first two. Grasp all three leaves together in one hand, over the center of the plant.
5. If necessary, bend a fourth leaf inward to meet the other three, to effectively hide the developing curd.
6. Use twine, rubber bands, or clothes pins to loosely bind the leaves you are grasping together. Secure them either at the top or around the middle, so they go over and around the curd, completely covering it.

However, we also need to leave some room for airflow, for peeking in to monitor progress, and to allow the head to reach its mature dimensions of six to eight inches in diameter. This is why we bind them loosely.

Here's a tip: Blanch on a dry day, after the morning dew has evaporated. This way, no moisture gets trapped near the curds and fungal growth is inhibited.

Crop protection

Pests and diseases of cauliflower are the same as those for cabbage. Common pests of cauliflower include aphids, caterpillars, cabbage fly, flea beetles, slugs, nematodes. Common diseases of cauliflower include grey leaf spot and grey leaf spot, downy mildew, clubroot, black rot fungal diseases. See the session on cabbage and rape for control measures).

Exercise

Divide into groups

- Each group choose one pest and one disease. Using appendix 1 and 2 write down natural recipes to control this pest or disease.
- Using appendix 3 write down some chemical measures that can be used. Present your work to the whole group

Now read the next section…

Harvesting

Cauliflower is hand-picked so it is labour-intensive. You should carefully harvest them because any slight damage will reduce the shelf life of cauliflower. It should be harvested when the curds attain a proper size and before it starts to discolour. Cauliflower does not store well so it is better you harvest the cauliflowers you want to consume or sell soon after.

Typically, it takes an average of 3 months for cauliflowers to mature – duration varies as I mentioned earlier. The norm is that maturity is reached faster in summer and takes longer if it is winter. It is advised that the best time for harvesting cauliflower is in the morning. Harvesting is typically done by hand so it is labour-intensive. The most recommended approach is to harvest gradually i.e. as and when the cauliflowers mature.

When cauliflower is ready for harvesting the head (known as the white curd) must be roughly 15 centimetres in diameter. Bear in mind that the height at which cauliflower is mature stands at around 50 centimetres. When harvesting, caution must be exercised to ensure that there is no damage to the heads. They are very delicate and susceptible to damage – any damage no matter how slight can reduce the shelf life of the cauliflower. As soon as they are harvested, the white curds must be kept in plastics to preserve freshness.

Summary

- There are many different varieties of cauliflower. You should choose a variety best suited to your market and the growing conditions in your area.
- Cauliflower does best during cool times of year. It must be given adequate soil fertility and water for good results.
- Pests, diseases and weeds must be controlled in order to get good results from your cauliflower production project. Cabbage may also suffer from physiological disorders.
- Cauliflower must be harvested at the correct time when the head is firm to avoid head-cracking.

SESSION 8: SOLANACEOUS VEGETABLES PRODUCTION

8.1 Introduction

Greet each other and review the learning objectives for this session.

LEARNING OBJECTIVES

By the end of this session, you will be able to:

- Identify the different growth patterns of the solanaceous vegetables (tomato, potato and chillies) and use the skill to better manage the crop.
- Identify the different maturity stages of solanaceous vegetables and use the skill to reduce post-harvest losses.
- know all the agronomic practices of tomato, potato and chilli production from planting to harvesting.
- Achieve high tomato, potato and chilli yields of high quality by using appropriate production methods.
- Reduce yield and quality losses through correct identification and control of tomato, potato and chilli pests and diseases.
- grow solanaceous vegetables in your own garden or field.

The Solanaceae family of vegetables include potatoes, tomatoes, eggplant, capsicum and chillies. Solanaceous vegetables are affected by a range of viral diseases. Therefore, it is important to control weeds which may be a host to a virus. In this book, we will look at tomato, potato and chillies.

Tomato production

Overview of tomato production

The tomato belongs to the same family as potatoes, eggplant, tobacco and pepper. The tomato is an important crop in Zimbabwe which is grown by many farmers.

Growth habit

Tomatoes are classified into three groups based on their growth patterns;

- **Indeterminate types** – the main and side stems continue their growth in a continuous pattern.
- **Determinate types** – the main and side stems stop growth after a specific number of flower heads. Semi-determinate types - branches stop growth when a flower head develops, but this usually occurs at an advanced growth stage.

Tomato varieties

There are numerous tomato varieties available in Zimbabwe. New varieties continue to be made available every season. The most common varieties are Starke Ayres Tomatoes such as Star 9008, Star 9011, Star 9062 and Star 9068. The more traditional varieties include Moneymaker, Roma, Rodade, Tshibili, Tengeru (from Tanzania), Jam,

Growth requirements

Tomatoes are a warm season crop and do not tolerate very low temperatures. The optimum temperature is in the range 26 - 29°C. Temperature influences all stages of development of the plant.

Tomatoes can be grown on a wide range of soil types, from light, sandy soils to heavy, clay. Very high levels of fertility are required since they are heavy feeders. Under optimal soil conditions, root development is extensive and can reach a depth of 1.5m.

Talk about the following:

- How would the addition of organic matter to the soil benefit the tomato?

Now read the next section…

Land preparation and planting

Strict crop rotation must be practiced with tomatoes. Never plant tomatoes time after time in the same beds as this will cause serious pest and disease problems for you. Never put tomato crop residues in your compost heap as this may cause the spread of diseases.

Tomato seedling production

The crop is best grown for seedlings. Soil for the seedlings must be very fertile and free of nematodes, diseases and weeds. The seedbed site should be fenced and windbreaks are desirable. High standards of hygiene will reduce the incidence of disease.

Because tomatoes are deep-rooted the field should be ploughed as deep as possible. The soil must be light and friable, well drained and non-crusting. The addition of compost or manure will improve the friability of the soil.

Beds should be fertilized at the rate of 3kg of Compound S (7:20:8) per 25m2 plus 2 kg dolomitic limestone (where necessary). Seed is sown in rows 7.5 cm apart with 2.5 cm between plants. The depth of sowing is 6mm. A 40m2 bed sown at the rate of 150g seed will be sufficient to plant a hectare.

Give the beds a good watering a few days before sowing. After sowing and before germination, water early in the morning and again at noon using a fine hose. After germination, one watering in the early morning is all that is required. At no time should seedlings be over-watered. Older seedlings require watering only two to three times per week. When seedlings are as thick as a pencil and 12 - 15cm tall, reduce watering, and give water only when they show signs of wilting. This is called **hardening-off**. Hardened seedlings have higher survival rate.

Tomato seedlings

Transplanting

If seedlings have been planted in trays, gradually introduce them to sunny conditions until the plants can withstand direct sunlight. Tomatoes can root from the stem so plant them slightly deeper than most other vegetables.

Avoid transplanting when the leaves are wet, as bacterial canker entry is greater under these conditions. Plants should be handled carefully and placed in planting holes so that that the soil when planted is the same level as it was in the tray or seedbed. The slightest damage to the seedlings will increase the possibility of bacterial canker infection.

Plant the seedlings at 30 to 50 cm between plants with 0.75 to 1.2m between rows depending on our chosen method of staking. Try to have at least 30 000 - 35 000 plants per ha.

Discuss

Talk about the following:

- Why is staking and trellising important for tomatoes?

Now read the next section…

Crop management

Staking and trellising

Staking will reduce diseases by keeping the fruit and the leaves away from the soil. It makes it easy to spray, weed, top-dress and harvest.

There are various methods of staking or trellising depending on availability of materials and resources. We should stake as soon as planting has been done, if left too late, plants are more likely to break when tying them.

Discuss

Talk about the following:

- Why should we encourage one main stem by removing all suckers below the first flower cluster?

Now read the next section…

Pruning

Pruning should be done to remove the suckers that form in the space between the leaves and main stem of indeterminate tomato types in order to help the plant produce its food efficiently and reduce risk of diseases. A strong main stem is encouraged by removing all suckers below the first flower cluster. Side shoots should be removed before they are about 5cm in length since smaller wounds will heal faster. Scissors or finger tips can be used to remove the side shoot. However, a disinfectant should be used to avoid the spread of diseases.

Soil improvement

Basal fertiliser: Apply compost or manure at the rate of 25 to 50 t/ha (2.5 - 5kg/m2. If are using fertilizers, apply 100 - 150g of Compound S or Compound C, per m2.

Top dressing: apply the top-dressing in stages three weeks apart. You can use ammonium nitrate and potassium sulphate (or sulphate of potash - 50% potassium and 16% sulphur), at a rate of 10g/m2 every three weeks repeated two to three times. The first application is done when the first fruits reach marble size (1cm in diameter). A side dressing or foliar spray of calcium nitrate is required during fruit setting and development.

Irrigation

Tomatoes need frequent irrigation when they are still at seedling stage. After establishment water application can be done in response to the climatic conditions. Once the first fruits are formed, apply water as frequently as possible. Mulching can be used to reduce evaporation. In winter use of the mulch is not advisable.

Discuss

Talk about the following:

- Why do you think the use of a mulch in winter is not advisable?

Now read the next section…

Mulching

In summer application of mulch helps reduce water loss from the soil and protects the roots from high temperatures by blocking the heat of the sun. In winter a mulch would prevent the less intense sun from warming the roots and may also reduce cold air drainage which will settle in the field.

Physiological disorders

Because they are sensitive to temperature, moisture and soil nutrients, tomatoes can suffer from many physiological disorders. It is important to be able to identify the difference between these and symptoms of diseases.

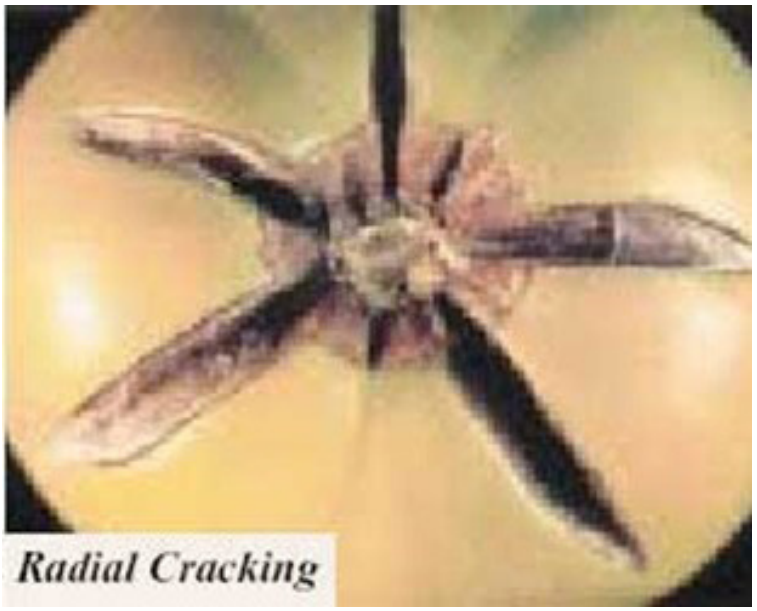
Blossom end rot - occurs when calcium is inadequate in the soil. It shows as a rotten looking patch at the base of the fruit. Often the problem is not that there is no calcium in the soil, but that watering is irregular. Improving watering often solves the problem.

If calcium is lacking, liming or calcium sprays will reduce the problem.

Water-soaked area at the blossom end of the fruit

Blotchy ripening - occurs when tomatoes have hard green areas which do not change colour when the rest of the fruit is ripe. This is caused by lack of potassium. It usually occurs when there is lot of moisture in the air during humid weather, and the plants are growing vigorously.

Fruit cracking - occurs when soil moisture changes rapidly from wet to too dry. To avoid it, select resistant varieties and keep moisture in the soil at good levels.



Fruit cracking

Sunscald - affects immature fruits on the side exposed to the sun. It appears as a pale patch. Trellising can increase sunburn by increased fruit exposure due to reduced leaf cover.

Sunscald

Discuss

Talk about the following:

- What are common tomato pests and diseases in your area?
- How are they controlled?

Now read the next section…

Tomato crop protection

Tomatoes are very susceptible to attack by pests particularly aphids, cut worms, heliothis bollworm, leaf miner, nematodes, red spider mite, thrips and whitefly, See the natural pest and disease section appendix 1 and 2 for home-made remedies for these pests or appendix 3 for chemical solutions.

Tomatoes can be affected by a wide range of diseases particularly bacterial canker, bacterial speck, bacterial spot, bacterial wilt, damping off, early blight, late blight, leaf spot and powdery mildew. The best way to control these is to practice crop rotation, good hygiene in the field and correct timing of plant- ing. See the natural pest and disease section appendix 1 and 2 for home-made remedies and appendix 3 for chemical remedies.

Tomato Diseases

(a) Bacterial diseases

(i) Bacterial Canker: Plants at any stage of growth are susceptible. Infected seedlings may be quickly killed, or they may produce weak, stunted plants, or if conditions are unfavorable for disease development, infected seedlings may develop into apparently healthy plants that fail to show disease symptoms until they are set in the field. The early symptoms of the disease are wilting, curling of leaflets, and browning of leaves, often

only on one side of the plant. As the leaves die, the petioles remain green and firmly attached to the stem. A cut through the stem shows yellowish brown discoloration of the vascular element. We also see small spots on the fruit with a white or yellow spot.

Control: Bacterial canker is one of the most difficult tomato diseases to control. First, there is the problem of detecting infected plants, due to the wide variability of symptom expression. We can control the disease by hot water treatment of seed as we discussed before. We can easily leave the disease in the soil or it can be transmitted through seed. Use only certified, disease-free seed from canker-free plants. Never save seed from a source known to have had bacterial canker. Plant only certified disease-free transplants that have been produced under a vigorous inspection program. It is usually not possible to distinguish between infected or healthy seedlings at the time of transplanting. Fixed copper sprays may help in protecting healthy plants, particularly if only superficial symptoms are present. Practice strict crop rotations and sanitation.

(ii) Bacterial Spot: It usually appears as dark-brown raised spots on the fruits becoming sunken and rough to the touch. The disease is carried through seed and infection only occurs during wet weather. To control we should practice hygiene during seed bed preparation and planting. We can also use fungicides like, copper oxychloride at 45 grams mixed in 15 litres of water.

Bacterial spot

(iii) Bacterial Wilt: which causes a sudden dying of plants (Fig 14), browning inside the wood flesh, from which bacterial slime comes out after cutting across the main root and lower part of the stem. We can control by hygienic practices and avoid places where water stands (water logging soils) without good drainage or use copper oxychloride.

Crop affected with bacterial wilt

(iv) Bacterial Speck: another common bacterial disease that we can encounter in tomatoes production. We will find occurring to plants during rains and cool weather. The diseases can attack the whole plant including the fruit. On leaves it will be appear as brown spots surrounded by a yellow ring (Fig 15). On fruits we will see black raised spots resulting in a rough appearance on the fruit skin if we touch it. We can control with chemicals like Copper Oxychloride and Mancozeb.

Fruit affected with bacterial speck

The natural control methods recommended (by the Natural Farming Network) against bacterial diseases are Ash, Burning, Compost, Manure, Sun, Garlic, Chilli, Tomato and Goat Weed.

See Natural Pesticide Preparations in the last pages in Chapter two, on Traditional Vegetable Production Techniques. Regular routine spraying with compost extract, manure and urine mixes are considered to be among the most effective control measures to suppress bacterial diseases.

(b) Viral Diseases

(i) Mosaic Virus: This disease is called mosaic because of the appearance of infected leaves. The disease causes plants to grow slowly with a distorted appearance (stunted growth), leaf curling, purpling of the leaf veins, brown markings sometimes appear on the fruits. We have to practice rotations and avoid cropping where other Solanaceae crops were planted before.

(ii) Bunchy Top Virus: It causes a marked reduction in shoot length, resulting in closely crowded leaves at the top of the plant hence the name bunchy top. Fruits will be small and distorted.

Viruses are difficult to control once they are present. If infections are serious leave the land fallow for long periods. They can be prevented by growing and planting healthy plants, rotations, general hygiene. Control of sucking insects which spread the viruses, like aphids, leafhoppers, thrips and mites. Natural pesticides we could also use are Compost, Manure, Milk, Mulch, Oil-mineral-paraffins, Chilli,- Tobacco and Wild tobacco.

(c) Fungal Diseases

(i) Early Blight is the most common tomato disease. It appears as dark reddish-brown leaf spots with concentric (round) markings appearing on the bottom leaves causing defoliation. We can at times see the disease on the fruits as well. It appears at any time during wet weather. We can control it by use of fungicides as routine spraying where it is prevalent. For control, spray with Mancozeb as from flowering, once a week, at 20g mixed in 15 litres of water. For curative treatment use Folicur 250 EC at 12ml per 15 litres of water or Score 250 EC at 6ml per 15 litres of water.

Early blight

(ii) Late Blight is the second disease caused by fungi. It is very common but it is one of the most destructive diseases in tomatoes and potatoes. Greyish-green water-soaked blisters on the leaves rapidly turning black. Stem blisters are dark brown and large mottled areas develop on the fruit. We can experience this disease mostly during wet weather and it can be very serious. Several chemicals are available but it is always better to prevent than to control when it has already attacked the crop. We must also use clean planting material. If we are to use chemical control use Mancozeb as in Early blight, or Ridomil Gold) at 190g per 15 litres of water or use Bravo 500 SC at 30ml in 15 litres of water sprayed once a week. Other recommended products include Milraz, Melody Duo.

Fruit affected with late blight

(iii) Leaf Spot is another fungal disease we are likely to meet in tomato cultivation. We usually see it as small spots with light coloured centres appearing on the older leaves, first causing leaves to turn yellow and then they drop. The disease can cause a lot of damage to tomatoes during wet weather. Use fungicides and natural pesticides.

(iv) Powdery Mildew: We often see it appearing as white powder on the plant. Common in hot and dry weather. Chemical control is by Sulphur 80 WP and Alto at 28mls mixed in 15 litres of water (harvest interval 3 days), plus natural pesticides as we mentioned before. You can also use Sulphur 80 WP at 30 grams per 15 litres of water or Score 250 EC at 6ml per 15 litres of water or Benomyl at 7 grams per 15 litres of water.

Symptoms of powdery mildew on tomato leaves

(v) Damping off: is a disease caused by two fungal agencies and it affects crops at seedling stage. The plants will die at the soil level and then collapse. We must make sure soils are well drained. Control by dressing seeds with Apron star at 10 grams per 4kg seed or applying a fungicide like Copper oxychloride and Ridomil (Metalaxyl) at the base of the plants.

Seedling killed by damping-off

The natural control measures recommended (by Natural Farming Network) for control of fungal diseases are Baking Soda, Burning, Compost, Manure,Milk, Soap solutions, Onions, Garlic, Chilli, Pawpaw, Sunhemp, Tobacco, Castor oil and Mexican marigold.

Insect Pests

(a) Aphid. Aphids are small green sap sucking insects (see picture under cabbage). These small, green insects cluster on the undersides of young leaves and stems and can multiply very rapidly. The leaves of infested plants may become distorted and severely infested plants may become stunted. Aphids are also spread virus disease. Many chemicals are available to control them. Actara 25 WG at 10 grams mixed in 15 litres of water. Dimethoate (Rogor) at 75 mls mixed in 15 litres of water (harvest crop after 14 days) and Malathion 25 WP at 30 grams mixed in 15 litres of water (harvest after 3 days), Chess 50WG at 400g/ha Its harvest interval is 3 days. We can also natural control measures, like Garlic, Marigold, Onions grown as intercrops to repel certain species of aphids. Black nightshade is good trap plants to attract aphids away from the main crop. We can use natural pesticides but, because aphids attack the growing parts, we must ensure concentrations of natural pesticides do not affect plant growth. The following we use as dust or sprays: Ash, Clay, Manure, Salt, preparations, soap solutions, vinegar, garlic, chilli, pyrethrum, sweet potato, tomato, tobacco, wild custard apple, black jack, lantana, mexican marigold, wild cucumber.

(b) Red Spider Mite. A small orange to red mite with 4 pairs of legs of equal size. We occasionally see webs on the plant, very visible when seriously attacked. Red Spider mite is a sucking pest which causes wilting and spots on leaves. We can use many chemicals to control it, like Kelthane at 15 millimetres mixed in 15 litres of water, dicofol, diazinon and amitraz (check rates on labels). We need to rotate the chemicals as these insects build resistance.

Crop attacked by red spider mite

We can also use natural pesticides like Ash, Clay, Manure, Milk, Soap Solutions, Onion, Garlic, Pyrethrum, Tomato, Syringa, Tobacco, Black Jack and Eurphobia. When plants are severely infested the best way we can control is to remove and burn the plants. We should also check weeds that can host Red spider mite and remove them.

(c) Cut worms: This cause direct lose and affect plant stand. It's a major problem after transplanting, cuts the plant at the base, use Karate at 100 ml/100 l water spray at the base of the plant,this will give the best results. Carbaryl 85 WP at the rate of 150 - 200 g/100 lt, applied in the planting hole, is also recommended. Pyrinex 48EC at a rate of 200ml in 100lt of water drenched soon after transplanting using cup 30/plant is also recommended.

Cut worm

(d) Thrips are another insect pest that we are likely to encounter in tomato cultivation. When we see small insects shaped with a point (torpedo shaped), with hairy wings they are thrips. Thrips sucks sap causing dying of leaves and they also spread diseases. For control we can use chemicals like Malathion, Dichlorvos (Dedevap), Monocrotophos, Cypermentrin and Endosulfan (Thiodan or Thionex), for how much to apply we must read the label. We can also use following natural pesticides: Clay, Glue, Manure, Soap solutions Onion and Tobacco. Adult thrips can be trapped by hanging blue or yellow sticky boards, a light coating of engine oil can be used in place of glue. Any of the natural control measures mentioned for aphids we can also use to control thrips, although thrips are more difficult to control because they hide in buds and leaf sheaths.

(e) Heliothis Bolloworm: Fruitworms, primarily the tomato fruitworm, feed on tomato leaves and fruit. Distorted leaves often result from feeding upon the tips of the leaves in the developing bud. Color varies from greenish-yellow and reddish-brown or even black with paler stripes running lengthwise on the body. The moth lays its eggs on the tomato foliage and the caterpillars feed on the leaves and fruit, caus- ing extensive damage. It is controlled by using Methamidophos 585 SL at 500ml/Ha, harvest interval 3 days. Carbaryl 85 WP can also be used at 200 g/100 l water full cover spray. Harvest interval for Carbaryl is 7 days. or Thionex 35 EC at 190 ml/100 water full cover spray. Harvest interval is 1 day.

Heliothis damaging the fruit

Tomato fruits severe damaged by tomato fruitworm

(f) Whitefly: Like aphids, whiteflies have piercing-sucking mouthparts so the damage caused is very similar to that of aphids. Direct damage to tomato plants causes deformed new growth and wilting, chlorotic leaves. Whiteflies can also transmit some plant viruses. If your plant gets infected with a virus, do your neighbor a favor and pull it out. Whiteflies, like aphids, secrete honeydew, causing the opportunity for sooty mold to grow. Feeding by whiteflies can also cause deformed fruit and discoloration of your tomatoes. Is becoming increasingly important, especially under greenhouses. Control using Imidacloprid 200 SL ® at 50 ml/100 lt water. Apply in 300 - 500 lt mix/ha. Chess 50WG is recommended at 600g/ha. Harvest interval is 3 days. Actara 25WG at a rate of 400g/ha spray or 0.02g/plant drench is recommended. Harvest interval is 7 days. (Harvest interval: 0 days).

Whiteflies under the tomato leaf

(g) Nematodes

Nematodes are not insects but very small worms that cause a lot of damage to the roots of tomato. We can face serious problems with them if our soils are sandy. We can control them by rotations, and use of resistant varieties. We can use chemicals like Nemacur granules at 10 grams per square metre, Nemacur 400 EC at 18 to 20 mls mixed. However, the chemicals can be very expensive.

Tomato roots damaged by nematodes

Natural pesticides like Ash, Burning, Garlic, Pawpaw, Tomato, Cassava, Syringa and Thorn weed can also be used. Adding organic manure has been reported to reduce nematodes; rotations will also assist us to keep levels low.

(h) Tomato leaf miner, Tuta absoluta: The tomato leaf miner moth Tuta absoluta is a very harmful leaf miner moth that is becoming an increasingly big problem in vegetable cultivation. This pest particularly affects the tomato, but it can also cause damage in eggplants and peppers. They do this by eating both the leaf and fruit of these plants. Originally from South America, feeds voraciously on tomato plants and is a serious threat to production and profit in the sector, regardless of whether the crop is grown under cover or in open fields. The highly adaptable insect has been able to advance rapidly across territories, and pick up resistance to pesticides along the way. Although they prefer the leaves and stems of the plant, caterpillars are also found in the fruit and under the fruit crown. Leaf mines look like irregular tomato fruit gives bacteria and fungi access and the opportunity inflict more damage.

Tuta absoluta larvae and mining damage on tomato leaf

Fruit damage by Tuta absoluta

Agronomists advise clearing of all crop residues. One doesn't want to provide survival shelters for insects:

- eliminate the parasitized leaves, stems and fruits, and burn them quickly. It will be the same for the plants or the plants too attacked;
- pluck regularly parasitized plants and remove the leaves;
- do not leave parasitized plant debris in heaps on the ground in or near greenhouses or tunnels, which allows this pest to remain locally;
- fruits that have fallen to the ground must be collected and destroyed.

Mass trapping with baited pheromone traps takes out the males, attracted by the sex signals of the pheromone to a sticky end on the surface of the trap. Mass trapping should be carried out before planting. Apply recommended chemicals 10 days after planting and re-apply a different chemical to kill off survivors. Tuta absoluta is resistant to pyrethroids and methamidophos; imadocloprid, indoxocarb and deltamethrin are said to be effective.

There is need for at least three to four different chemicals or chemical combinations. Tuta absoluta has no specific chemicals that can hammer it on its own hence the need to consider alternating chemicals from different chemical groups, with different modes of action, for effective control and for resistance management. The list is as follows:

- Abamectin + DDVP
- Belt + Decis forte
- Emamectin benzoate + Lufenuron
- Emamectin benzoate + Thiamethoxam
- Emamectin benzoate + Lambda cyhalothrin
- Runner (Insect growth regulator)
- Delegate

- Tracer
- Cartap hydrochloride
- Acephate
- Lannate/Methomyl
- Biobit (this is a biological insecticide)
- Imidacloprid
- Avaunt

Exercise

Divide into groups

- Each group choose one pest and one disease. Using appendix 1 and 2 write down natural recipes to control this pest or disease.
- Use appendix 3 to write down the chemical solutions.
- Present your work to the whole group.

Now read the next section…

Harvesting

Ripening stages

Tomatoes can be harvested green and allowed to ripen while in storage. This is because tomatoes fruits produce a gas that helps ripening. Colour changes in tomatoes are due to various chemical changes in the fruit, this is why we notice a tomato does not get red immediately but gradually. As the colour changes the fruit starts to soften and the flavour changes as well. The following are the various colour changes we find occurring in a tomato.

- Pale blossom end: cream coloured streaks appear at the blossom end, the skin is tougher and the fruit picked at this stage will last a week or more before becoming fully ripe.
- Pink blossom end: seeds are developed; stalk gets a brownish colour and the fruit appears light green at the base. The jelly around the seed will have formed. The tomato fruit ripens from bottom upwards. Harvest at this stage if the market is a long distance away and they will ripen well.
- Pink or breaker stage: the majority of the fruit has fully ripened. A pink colour covers a quarter of the bottom end, ripening gas production is beginning.
- Pink stage: Majority of the fruit is ripe.

- Ripe stage: the fruit is red, soft and you can peel off the skin. This stage is too late for any long-distance travel.

Marketing

Discuss

Talk about the following:

- What are your customers' requirements for tomatoes?
- What is the time of year when prices for tomatoes are highest?
- How will this help you when to plant your tomatoes?
- How do you grade and pack tomatoes?

Now read the next section…

Tomatoes should be graded according to size and quality? Tomato fruit should be sorted and the packed in standard wooden or cardboard boxes, the sizes of boxes will vary depending on the mode of marketing. The most desirable temperature at which to transport tomatoes is 13 - 21°C with a relative humidity of 85 - 90%.

Discuss

Review what you have learnt in this session then read the summary to check that you have remembered everything.

Summary

- There are three types of tomatoes; indeterminate, determinate and semi-determinate.
- Tomatoes are a warm season crop and do better in areas where frost does not occur.
- Tomatoes need fertile soils. Care must be taken when irrigating this crop.
- Physiological disorders include fruit cracking (rapid soil moisture changes), blossom end rot (calcium deficiency), blotchy ripening (Potassium deficiency) and sunburn (fruit exposure to sun).
- Tomatoes suffer from a wide range of pests and diseases. Crop rotation, timing of planting and other good crop management practices are very important to reduce these.
- Trellising of tomatoes especially the indeterminate types is important to reduce risk of diseases and to facilitate cultural practices.

TOMATO PRODUCTION GROSS MARGIN BUDGET

ITEM	QUANTITY NEEDED	UNIT COST (US$)	TOTAL COST (US$)
AT PLANTING			
Tomato seedlings [hybrids]	20 000 sdlings	$0.08/ sdling	$1,600
Fertiliser compound C [5:15:12]	600 kg	$50/ 50kg	$600
Oxamyl [nematicide]	4 litre	$30/ litre	$120
Fenvelerate 20 EC	500ml	$20/ litre	$10
TOP-DRESSING FERTILISERS NEEDED			
Ammonium nitrate	200kg	$50/ 50kg	$200
Potassium nitrate	200kg	$80/ 25kg	$640
Magnesium sulphate	100kg	$60/ 25kg	$240
Calcium nitrate	150kg	$20/ 10kg	$300
OTHER REQUIREMENTS			
Imidacloprid [for white fly control]	1 litre	$15/ 500ml	$30
Abamectin	1 litre	$16/ 500ml	$32
Red spider kill	500 ml	$20/ 500ml	$20
Acetamiprid	60 grams	$2/ 15grams	$8
Dimethoate 40 EC [for aphids]	1 litre	$20/ litre	$20
Dichlorvos [for fruitworms, semi-loopers]	1 litre	$10/ 500ml	$20
Ridomil gold [curative fungicide]	1kg	$25/ kg	$25
Azoxystrobin	500 ml	$20/ 500ml	$20
Copper oxychloride 80WP [preventative fungicide]	2kg	$16/ kg	$32
Dithane M45 [preventative fungicide]	2kg	$16/kg	$32
GRAND TOTAL			**$3 949.00**
EXPECTED GROSS INCOME: Expected yield: [conservative]: 60 tonnes/ hectare At 70% pack-out = 0.7 × 60 000 kg = 42 000 kg Crates [1 crate = 30kg] Therefore: number of crates = 42 000/ 30 = 1 400 crates Selling price = $10/ crate × 1 400 = $14 000 Therefore: **GROSS INCOME** = $14 000.00	**$14 000.00**		
GROSS MARGIN: $14 000 – $3 949= $10 051	**$10 051.00**		

ASSUMPTIONS MADE IN THE BUDGET:

- All quantities needed are for 1 ha crop.
- Farmers to provide their own labour for planting, weeding, pest and overall crop maintenance.
- Land costs not included, assumption is farmers are not leasing land.
- Land preparation costs for tractor also not included in budget (it's usually $100/ha + 20 L diesel).

Irish potato production

Potatoes (*Solanum tuberosum*) are the world's most important vegetable crop. They originated in the Andean region of South America. Potatoes grow best in fertile, well-drained, sandy loam soils. Planting on poorly drained soils usually results in a poor plant stand due to seed piece decay and poor-quality potatoes at harvest. Soils susceptible to wind erosion or have poor water-holding capacity should be avoided. The tubers are rich in carbohydrates, Vitamin A and C. They can be processed in several ways which include, chips,

Discuss

Talk about the following:

- Which soils are ideal for potato production and why?
- Why do you think it is important to select the most suitable soil for potato production?
- In Zimbabwe which areas produce most of the potatoes and in your opinion why?

Now read the next section…

Potatoes grow well on a wide variety of soils. In some areas where potatoes are commercially grown, the soils are acidic whereas in other areas they are alkaline. Ideal soils for potato are deep, well- drained, and friable. Soils rich in organic matter such as peat or muck, if adequately drained, can also produce high quality potatoes, particularly for the fresh market. Sandy soils, which contain little clay or organic matter and have almost no soil structure when properly irrigated and fertilized, will produce high yields of tubers with excellent culinary and processing quality. Potatoes are more tolerant to low pH than most other crops. Incidence of common scab tends to be less of a problem where soil pH is lower than 5.4. For cultivars that are susceptible to common scab, the disease is often managed by maintaining soil pH in the range of 5.0 to 5.4. Although potatoes tolerate acid soils, there are benefits from raising the pH up to 6.0 to 6.5. In Zimbabwe most of the potato producing area are mainly in the eastern high lands where conditions are ideal for seed potato.

Factors influencing growth

Growth and quality of potato are mainly influenced by environmental factors such as temperature, moisture, light, soil type and nutrients. Many factors that influence potato growth are largely uncontrollable. Length of growing season, air and soil temperature, light intensity and duration, humidity and wind. However, the grower can control variety, plant stand, moisture, soil texture, pest management, planting date and harvest. Only when all the necessary conditions are met, can one get a good yield out of the crop.

Potatoes should be grown in areas where temperatures do not exceed 320c, temperatures above 320c results in poor yields. There are also very susceptible to frost. Optimum temperatures for production are between 15 – 20°c.

Potato can grow on a wide range of soils; the best soils are medium textured loam soils with good drainage and high organic matter content. Heavy soils that may become hard can affect the shape of the tubers, however yield can be very high. Soil ph. of 5-5.5 (CaCl2) are favourable), Avoid water logging conditions and liming should not be applied directly to avoid potato scab.

Common varieties of Irish potato

Choice of variety is dependent on the environment in which the farmers is in and on the type of market that the farmer is targeting. Potatoes can be grown for fresh marketing or be grown for industrial processing. Below are some of the varieties available in Zimbabwe.

BP1

The following are characteristics of BP1 variety:

- Early maturing (sometimes medium).
- Has white skin and flesh.
- Tubers have shallow eyes and an oval shape.
- It is resistant to late blight.
- It has an expected yield of 13.5 to 21.5 t/ha.

BP1 tubers

Amethyst

The following are characteristics of Amethyst variety:

- Late maturity variety
- Has flat oval tubers with white skin and flesh.
- Has rough skin, shallow eyes.

Pimpernel

The following are characteristics of Pimpernel variety:

- Late maturing.

- Red skin and yellow flesh which is mainly used in processing.
- Produces small to medium oval tubers with deep eyes.
- Has an expected yield of up to 20t/ha.

Pimpernel tubers

Jasper

The following are characteristics of Jasper variety:

- Late maturing variety (127 days in winter).
- White skin and flesh.
- Tubers are oval shaped and it yields up to 30 t/ha.
- It tolerates Late blight disease and grows vigorously.

Garnet

The following are characteristics of Garnet variety:

- Late maturity variety.
- Produces tubers that have white skin and yellow flesh.
- Tubers are medium sized and round.
- Produces up to 28 t/ha.

Diamond

The following are characteristics of Diamond variety:

- Medium maturity with white skin and white fleshed tubers.
- The tubers have an oval shape.
- Yields up to 60 t/ha.

Diamond tubers

Other varieties

Other varieties in the market are as follows:

- **Early Maturing:** Mnandi, Valor, Sifra.
- **Late Maturing:** Montclaire, Mondial, Ky20, Emerald

The following table summarises some of the common varieties commonly grown in Zimbabwe.

Irish potato varieties common in Zimbabwe

Variety	Summer crop (November)		First irrigated crop (Feb-April)		Second irrigated crop (July-August)	
	Yield (ton/ha)	Days to maturity	Yield (ton/ha)	Days to maturity	Yield (ton/ha)	Days to maturity
Garnet	23.2	98	28.4	120	25.8	120
Pimpernel	12.4	98	-	-	12.4	98
Nyanga Amethyst	19.5	97	11.8	108	15.7	108
BP1	22.3	-	20.8	108	21.5	-
Jasper	12.2	-	28.5	127	20.4	-

Discuss

Make a list of varieties of potato that are grown in your area and look at their advantages and disadvantages.

Who is the supplier of the seed of those varieties and are they certified?

What are some of the disadvantaged of using uncertified seed?

Exercise

Which of the varieties are you familiar with and from your experience which one do better in your community?

Comment on the availability of these varieties from certified sources in your area.

Availability of seed in Zimbabwe

Seed potato is available from Nyanga where there is an experiment station on potatoes (Nyanga Experiment Station). Farmers in and around Nyanga produce seed potato. There are numerous other farmers now settled in Zimbabwe producing quality seed. A potato seed producer has to be certified to ensure quality seed. In Harare, seed is available in Msasa at Potato Seed Company, Matapiri, Agricrop and Edda Seeds

Planting time and land preparation

Discuss

How do we do our land preparation for potato, and what are some of the issues that we need to take into consideration when working on the soil.

Potato production costs are too great to risk using non-certified seed. Certified seed of good quality grown in Zimbabwe normally produces the largest yields, the highest quality tubers and the fewest disease problems. Planting times vary considerably in different regions, depending on local weather conditions, cultivar and intended market use. The summer crop is planted in November. The first irrigated crop is grown in February to April, whereas the second irrigated crop is grown in late July to August. In general, potatoes should be planted when the soil temperature is higher than 7°C and lower than 21°C. At the time of planting, soils should be moist but not excessively wet. Irrigation is applied prior to planting to add moisture to dry soils. Planting into soils that are excessively cold, hot, wet, or dry may increase the potential for seed decay. In most cases, early establishment of a crop increases yield and dry matter potential. In regions where the growing season length doesn't limit the plants ability to fully mature, planting dates are often selected to provide the crop with a growing environment that will produce the highest economic yield for the desired market. Potatoes usually take, 90-120 days to reach maturity.

Sprouting

Sprouting is the development of shoots in potatoes. Each tuber has two to 10 buds (or "eyes"), arranged in a spiral pattern around its surface. The buds generate shoots that grow into new plants when conditions are favorable. Sprouting of tubers helps to increase the number of main stems, and consequently the crop's final yield. Sprouting also ensures quick, uniform and full germination. Sprouting is done by storing the tubers in the dark. Tubers smaller than 25 mm should not be used for seed. Farmers may sprout the tubers in chitting trays or by the force sprouting method. These methods are described below:

Chitting trays

Potato tubers are naturally sprouted in diffuse light (darkness) but protected from strong sun. Apply suitable pesticides to the tubers to protect them from tuber moth and aphids. If cut tubers are used, treat them for 10-14 days at 7-8 °C and at near 100% relative humidity. Dipping of cut tubers in fungicide drench is recommended if temperatures exceed 18 °C. They may also be dusted with Captan or Thiram to control fungal diseases.

Potato chitting trays

Force sprouting

The method involves use of heat or acetylene.

Heat: Cover potatoes in tarpaulin in moderate sunshine. Maintain the temperature at 30-35 ^{0}c to initiate sprouting.

Acetyline: Pass 0.1 % of acetylene gas in an air-tight room between 21-27 °C to initiate sprouting. About 30 g of calcium carbide will generate enough gas for 2 m^{3}Authority Immerse the tubers in an acetylene solution for 4-6 hours. The mixture is made by mixing 45 litres of water with 230 g of calcium carbide added slowly.

Chemical sprouting

Gibberellic acid can also be applied to stimulate sprouting in potatoes. The mixture is 16 ml/100 litres of water. The seed potatoes should be dipped in the mixture for 3 - 4 minutes and then sun-dried before storing and sprouting.

Land preparation

Good potato production starts with good field selection followed by correct tillage practices. It is essential to properly prepare seedbeds to develop maximum potato quality and yield. Even the best soil will produce inferior yields and quality if the soil isn't prepared correctly.

The soil where all production takes place is a dynamic resource that supports life. Soil provides several essential services:

- it supports plant growth,
- it regulates the distribution of water,
- it stores and manages nutrients,

Potatoes develop larger and more extensive root systems in response to proper cultivation. Loose, friable soil improves tuber set and development of smooth, well-shaped and even-coloured potatoes. Cultivation may be necessary to control weeds, keep soil hilled-up, and aid water penetration and soil aeration. Soils should not be worked while they are still wet to avoid compaction. Ploughing can go at deep as 50cm to increase water percolation.

Planting

If the soil is to be limed this must be done five months before planting to as early planting will result in potato scab. Once the land has been ploughed to a fine tilth plant spacing can be at 0.3m intra row spacing and 0.9m to achieve a plant population of 36000 plants per hectare. Planting depth can be between 15-30cm and a hectare will require 2500kg of seed.

Crop management

Crop rotation

To ensure maximum production a potato crop should not be followed by another crop in the same family. These include tomatoes, all peppers, and tobacco. These tend to have the same pest and diseases.

Fertilization

Farmers must be guided by soil test results; however, a general rule of thumb potatoes need 1200-1400kg/ha of Compound C or Tobacco Fert (6:19:25) for basal fertilizer and three weeks after emergence farmers must top dress with potassium Nitrate split applied at 400kg per ha. After top dressing farmers are advised to earth or ridge the plants to avoid direct sunlight contact with the tubers and pest attack. These fertilisers are available from ZFC, Windmill and Omnia or any retail hardwares.

Ridging

Ridging or earthing up is simply the process of adding soil to the crop such that the bed height is increased. Yields are increased by ridging because tubers are formed from the stems. Ridging also improves soil aeration, and enhances tuber growth, and minimizes tuber greening. The kind and extent of ridging will depend on the planting method, kind and severity of weed infestation, irrigation method used, and to a lesser extent, the potato cultivar grown. If potatoes are planted in such a manner as to leave the field flat, one or more post-planting bed shaping, or ridging may be necessary. Alternative for small scale production mounds can be done around the potato plant.

Ridging

Irrigation

Water management and/or rainfall are among the most important factors determining yield and quality of potatoes. Water is important to promote emergence, at tuber set (flowering), tuber bulking up. While the volume of water required for optimum growth of potatoes varies somewhat with cultivar, relative humidity, solar radiation, day length, length of growing season, and other environmental factors, the seasonal requirement for cultivars in most areas will be at least 460 mm of water. As much as 760 to 910 mm of water will be required in some specific production areas depending on soil type, weather conditions, and potato cultivar. Water should be applied to the soil frequently in small volumes to maintain the crop with an adequate water supply throughout all growth stages of the crop, particularly during tuber initiation and tuber enlargement. For irrigation scheduling decisions, the following considerations should be kept in mind:

a) The effective rooting depth of potatoes is 0.6 m.

b) The soil should not be allowed to dry out below 65% field capacity.

c) Moisture levels above field capacity will seriously affect yield and quality.

d) Soil types can vary three-fold in their respective water holding capacities.

Irrigation options include sprinkler, centre pivot, furrow and drip irrigations.

Centre pivot irrigation

Sprinkler irrigation

Furrow irrigation

Drip irrigation

Weed control

Weeds must be controlled in potato fields, since they compete with the crop for water, nutrients and light, and are hosts for insects and diseases. Weed control can include systems that utilize cultivation only, herbicides or a combination of cultivation and herbicides. An effective weed control program considers problem weed species in the field. Fields containing perennial weeds should be avoided. Broadleaf annual weeds, except for nightshade, are usually easy to control. The most difficult weed to control is the perennial weeds species. The major perennial problem weeds include nutsedges (*Cyperus spp.*), quack grass (*Elytrigia repens L.*), and Canada Thistsle (*Cirisium arvenes L*). In addition to causing yield reduction and decreasing harvest efficiency, rooting structures of perennial grasses and nutsedges can penetrate potato tubers causing severe reduction in quality. When perennial weeds are the primary problem, more than the standard number of tillage operations may be needed for effective weed control even though herbicides are used. Perennial weed control may be more effective and economical in crops rotated with potatoes, such as winter wheat.

Pest control

Nematodes

Nematodes (eelworms) are microscopic invertebrate roundworms that can cause extensive damage to the roots of host crops such as potatoes. The three main types of nematodes found in Zimbabwe are as follows:

1. Root-knot nematodes (*Meloidogyne spp*) give rise to characteristic watery blisters on the tubers at lifting time. These subsequently collapse and present a rough surface of crinkly scar tissue. This type is most common and economically dangerous.
2. Root-lesion nematodes (*Pratylenchus spp*) are characterised by lesions on tubers which are visible as slightly raised, light to dark brown purple areas with a groove like depressed border. Symptoms may develop during storage.
3. Burrowing nematodes (*Radopholus similis*).

Irish potato tubers affected by nematodes

To control nematodes, apply Curaterr, Nemacur and Fenamiphos 40EC to the soil as you plant the seed.

Cutworms *(Agrostis spp.)*

Cutworms are the larvae (caterpillars) of several species of night-flying moths in the family *Noctuidae*. The larvae are called cutworms because they cut down young potato plants as they feed on stems at or below the soil surface. There are also species of climbing cutworms that move up potato plants and feed upon foliage, buds and shoots. The adults are night-flying moths and do not cause damage. Apply Monocron and Lambda as guided by the Windmill I hectare sheets.

Cutworm

Tuber moth

The potato tuber moth, or as it is sometimes called, tobacco leaf miner, *Phthorimaea operculella*, is a small greyish-brown moth with narrow fringed wings and a wingspan of about 15 mm. The forewings are darkish with indistinct paler markings, and the hind-wings are dirty white. The moths are active at night, and rest under clods of earth or leaves during the daylight hours. The caterpillars' tunnel between upper and lower leaf surfaces, damage stems thus cutting off nutrient supply, and tunnel the tubers. They reach a length of about 10 mm when full-grown.

Potato tuber moth

Aphids

Green peach, melon or potato aphid may occur in potato, colonizing from mid-June through July. These aphids are important because they can transmit several diseases such as Leaf roll, Necrotic virus Y, and virus Y. Potato aphid is the largest aphid of the three, 3 to 4 mm long, and may be pink or green. Plants of the rose family serve as alternate hosts to potato aphid in autumn and spring. A wide range of weeds, field crops and vegetable crops are hosts in summer. In potato, they feed first on young growing tips and spreading downwards onto older leaves. Damage includes leaf deformity and dieback. Aphids spread viruses to seed and table stock potatoes which can reduce yields and quality. High populations of aphids can cause foliage decline.

Fields should be scouted for aphids starting in late June. Examine aphids/leaf on 50 fully grown compound leaves (5 leaves at ten locations in the field) from top, middle and bottom of the canopy. In fresh market and processing potato, the threshold for insecticide application is when an average of 5 aphids per leaf are present, or 10 per leaf within 2 weeks. The economic threshold for table stock and processing fields is when aphids are found on 50% of the plants.

Potato aphids

Potato leaf hopper

Low levels of leaf hopper feeding can severely damage plants and cause symptoms known as hopper burn. Leaves yellow, turn brown and die. Adults are light green and wedge shaped, while nymphs are bright green, flatter and fatter than adults, and move sideways in a crab like fashions. Sample with sweep net and treat if more than one adult per sweep is found. Nymphs can be monitored by visually inspecting lower leaf surfaces on the lower leaves. Treatment if more than nymphs are found per 50 leaves. Carbaryl 85 WP can be used to control leaf hoppers.

Leafhopper

Red spider mite

Red spider mite refers to small, red colored arachnid that feeds on the sap of plants. Mites are difficult to see without magnification. They are generally small with eight legs. They

can vary in colour from light orange to deep orange red or brown. The red spider mite can be found on both sides of leaves. In high infestations, dense webbing can mummify plants. Leaf defoliation follows infestation and plants may die in several attacks. Red spider mite can be controlled by applying Dimethoate as guided by the Windmill I hectare sheet.

Red spider mite

False wireworms

Wireworms are the subterranean larval stage of click beetles (*Coleoptera: Elateridae*). They are pests of many agricultural crops including corn, sorghum, small grains, tobacco, and various vegetables, but are particularly damaging to potatoes, since the marketable portion of that crop is in the soil. Wireworms are omnivores, preferentially feeding on other soil insects or roots of grasses and weeds. In agricultural crops, where weeds are killed, and land is cultivated, wireworms seek out the only food available, which are the underground portions of the planted crop. Wireworms may injure potatoes by feeding on the seed piece resulting in weak stands, but most of their damage is caused by tunneling into tubers, which reduces yield quality.

False wireworm

Disease control

Fungi attack all parts of a plant and under favourable conditions, fungi can damage plant translocation tissues killing them in a relatively short period of time. Some of the most common fungal diseases include damping off, leaf spot, anthracnose and rust. Some of the fungi are responsible for foliar diseases – Downy mildews; Powdery mildews; and early and late blight. Other fungi – Clubroot; Pythium species; Fusarium species; Rhizoctonia species; Sclerotinia and Sclerotium species – are soil borne diseases. Plant diseases caused by bacteria are not as prevalent as those caused by fungi. Damage caused by bacterial infection results primarily in rotting of the plant tissue. The following is a select list of symptoms related to fungi and bacteria:

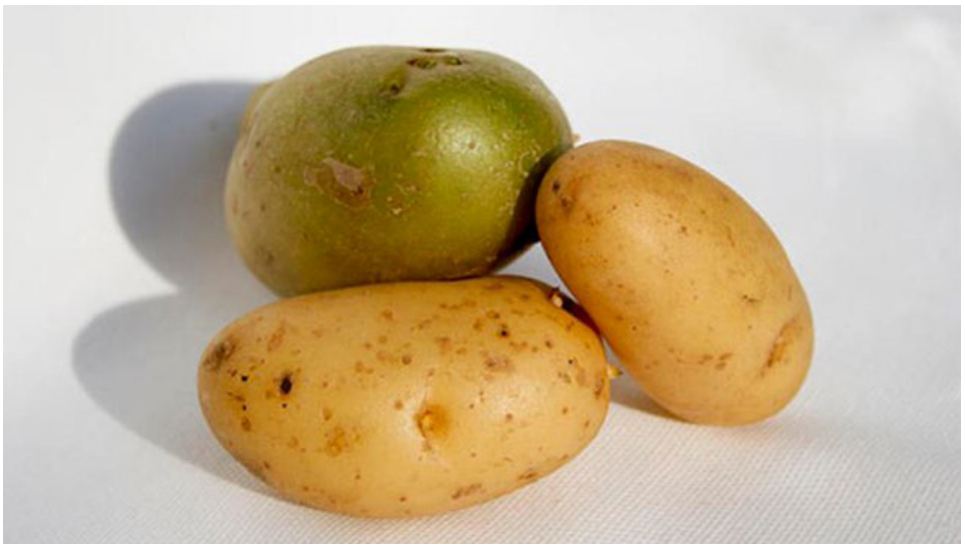
Potato fungal/bacteria diseases	Symptoms	Chemical
Early blight (*Alternaria solani*)	Dark brown , round lesions, with concentric rings develop on the leaves and yellowing.	Copper Oxychloride 85 WP, Dithane M45
Late blight (*Phytophthora infestans*)	Small, light green, circular to irregularly shaped water soaked spots. The lesions usually appear on the older leaves and often begin to develop near the tips or edges of leaves, where dew drops form.	Copper Oxychloride 85 WP, Dithane M45, Ridomil Gold.
Common Scab (*Streptonyces scabies*)	Powdery scab lesions are smaller and almost round with clearly defined edges. The first tuber symptoms are light brown, raised areas as small as a pinhead. The lesions enlarge and the skin covering the lesions tears to reveal hollows filled with dark brown to black, powdery spore balls.	Quintozene 75 WP.
Bacterial wilt (*Pseudomonas solanacearum*)	wilting of the youngest leaves, usually during the hottest part of the day. This can easily go unnoticed because the leaves stay green but eventually the entire plant wilts and dies.	Ensure soil is sterilized if the soil has a history of wilting.

Physiological disorders

These are not diseases but conditions that develop due to the environment. They include greening, cracking and hollow heart.

Greening

This is when tubers are exposed to direct sunlight. These tubers become unmarketable. This can be controlled by ridging.



Potato greening

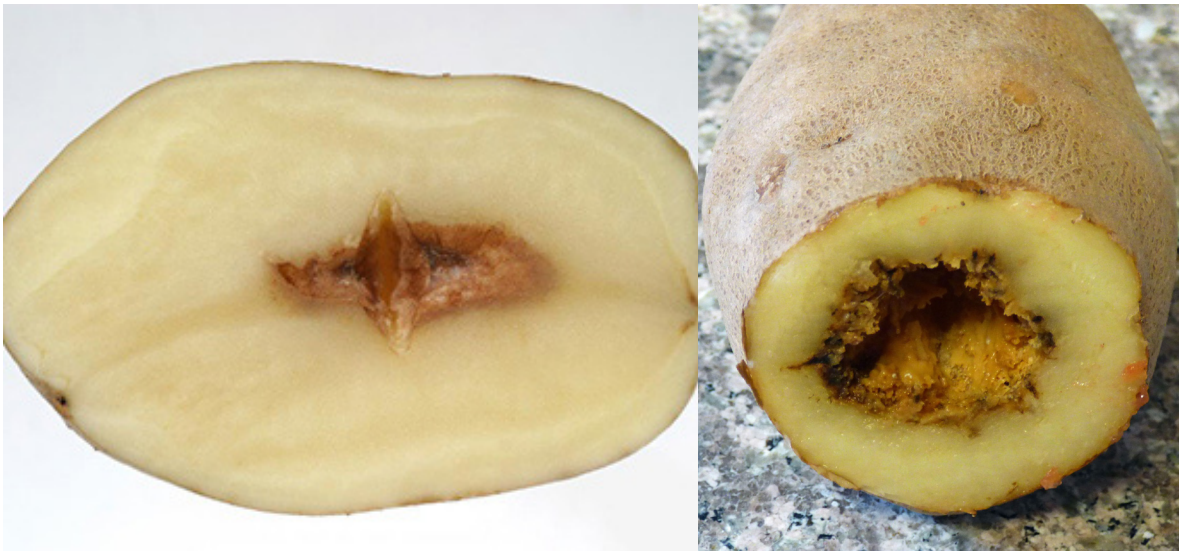
Cracking

This is caused by uneven water distribution supply. The tuber develops severe cracks on the surface.

Potato cracking

Hollow heart

This is when tubers develop large holes at the centre. This is common on large tubers because of uneven fertilizer and moisture management.



Hollow heart

Harvesting

Depending on varieties, crop matures from 85 to 140 days. Maturity indexes include senescence of leaves. Harvesting can be done using a hoe for small holder farmers or a potato reaper for large scale production. Tubers are graded into extra-large, large, medium and small.

Marketing

The potato value chain starts at arm gate up to large wholesalers and retailers. The value and price of the tomato increase as it exchanges hands. Farmers should know when to release their product to avoid market glut. Now Zimbabwe has a huge unmet market demand for potato for both fresh market and industrial processing. Main markets in Zimbabwe are Mbare Musika and other urban outlets, fast food restaurants and directly to consumers.

Exercise

What do you understand by the term Integrated Pest Management and how can you practice it to reduce your production cost.

Taking all production costs, do a gross margin analysis to determine your break-even price. Consult your external resource person to help you on this exercise

Summary

- Potato can grow in a variety of soils, with the best being medium textured to loam soils with good drainage.
- Production of potatoes depends on environmental and agronomic factors.
- Potatoes need to be sprouted to ensure a uniform crop stand.
- Potatoes require adequate and deep land preparation.
- Ridging must be done to ensure a good root zone for potatoes.
- Weed, pest and disease control is essential to ensure good potato production.
- Weeds, pests and diseases can be managed through use of chemicals as well as physical cultural and biological methods.
- Harvesting can be done using a hoe for small holder farmers or a potato reaper for large scale production.
- Main markets are Mbare Musika and other urban outlets and fast food restaurants.

Chilli production

Almost every household in Zimbabwe has a small garden in their back yard. In that backyard garden amongst the popular "covo" plants there is always that short perennial "Mhiripiri", chillies plant that seems to live on forever even though it is not irrigated much. Farmers in Zimbabwe mostly grow chillies for both local processing and export markets, with the main destinations being Europe and the Middle East.

Discuss

Talk about the following:

- What factors should we consider when selecting a chilli variety?
- Which varieties have you grown before?

Now read the next section…

Varieties

The main chilli varieties grown in Zimbabwe include the Cayenne chilli, Bird's Eye chilli, Malaga, and Habanero chilli. Red Thunder F1, Serenade, Bandai and Demon are other varieties available in Zimbabwe. The bird's eye chilli is the most common variety that is exportable. Its greatest advantage is that it can be sold fresh from the farm and may actually be sold after being dried. We will look at the characteristics of 4 selected varieties in the table below:

Chilli varieties

Variety	Description/Characteristics
Demon 	• Demon hot chillies are an excellent performing hybrid which is very attractive and with a very good fruit aroma. • 70-75 days to maturity • Bright red mature colour • Thin wall thickness • High pungency

Bandai 	• Hot chillie bandai are an attractive fruit quality firm, very nice bright red colour and uniform in size and shape. • 70-75 days to maturity • Red mature colour • Thin wall thickness • Very high pungency
Serenade 	• Hot Chillies Serenade are a high yielding variety • Early maturity • Green turning red colour • Slim shape • 8-10cm
Red Thunder F1 	• Bird eye Chilli type variety • 40 to 60t per ha fresh-harvested . • 70 to 80 days to maturity • Red Thunder F1 is an open field variety. • Very vigorous and easy growing. Extremely productive. • Easy picking during harvesting. • Very good uniformity and production continuity • Turns from green to glossy red • Fruit size: 7-9cm

Climatic condition to grow chillies

Chillies do well under hot and humid climatic conditions. They require sunny, semi-tropic or tropical conditions and an annual rainfall of between 600mm and 1250mm. The ideal temperature for good growth is 18-32°C. Low humidity will result in bad fruit set due to the dropping of flower buds. The crop is prone to frost damage and should not be grown in areas that are usually hit by frost, the reproductive phase of the crop tends to shut down during winter if cold temperatures persist.

Site selection

Chillies grow on a wide range of soils but thrive best in sandy loams with lots of organic matter. Select well-drained land with a gentle slope and soils with a pH of 5.0-7.0 (slightly acidic to neutral). In chilli production, avoid or sterilised soils previously planted with

tomato, garden eggs, okra or papaya within the last four years.

Special requirement

Chillies are prone to attack by false codling moth which is a pest of economic importance. This pest is considered a red flag in the EU and any shipment found with the pest is condemned and destroyed. To prevent this, each field needs to be inspected and certified free on the pest by the plant quarantine services which is a government department this is a free service the last time I checked.

Labour requirements

The labour required is minimum, at most 60 man-hours per hectare. However, high labour pool is required especially at the harvesting stage. The crop quickly ripens when the temperatures are hot and thrives under these conditions, late picking will result in moisture loss, drop in quality and fresh weight.

Land preparation

The land should be cleared of trees, grasses and root stumps. A well-decomposed manure or compost at 3-10kg/m2 should be applied in 4-6 weeks before planting.

The greatest advantage of chillies is that farmers can buy seeds and do a nursery on their own. Despite the fact that chillies are a summer crop, the seedlings fare well during the winter season. In chilli production, seed rate of about 150g seed is required for 1ha at a density of 30,000 plants/ha. Test seeds before nursing. Seeds are most suitable if test results show 95-100% germination.

Sow one seed per cell (in seed trays) or broadcast the seeds lightly in a seedbed and cover with 1 cm layer of soil. On the seedbed, cover with non-seeded dry grass or palm fronds until seeds emerge and cover the bed with an insect-proof net or sow them inside a greenhouse or screen house. Upon emergence, water the seedlings thoroughly every morning or as needed, using a fine sprinkler. Avoid overwatering to prevent damping-off. The seedlings have a high resistance to frost and pests. They are also not prone to fungi.

Transplant seedlings at 5-true leaf stage in the cool of the day or late afternoon. The soil should be moist and of a fine tilth.

Staking

Chilli plants may be staked to prevent lodging, particularly when they have a heavy load of fruits. This is very important in chilli production to avoid losses in fruits.

Discuss

Talk about the following:

- What are the major pests and diseases of chilli?
- How do you control pests and disease of chilli?

Now read the next section…

Crop Management

Chillies are also affected by pests of tomato, with false codling moth, aphids, termites, broad mites and thrips being of most economic importance. Use both cultural and chemical control methods as in tomatoes. Blights, bacterial wilt, bacterial spot and anthracnose are commo disease. Control these by use of copper-based fungicides and relevant cultural practices like crop rotation, use of certified seeds and use raised beds to facilitate drainage. (See section on pests and disease under tomato production).

Chilli affected by nthracnose

Chilli affected by phytophthora blight

Harvesting

Chillies are ready for harvesting 6-8 weeks after transplanting. Harvest red ripe or green depending on market demand. To harvest, snap the fruit stalk from the stems by hand. Expected yield is 2 to 3 tonnes/ha under smallholder farming but can reach around 8 tonnes/ha under commercial farming, Finance based on 1 ha at modest yield.

Marketing

Getting direct access to the market is a challenge and the best-case scenario for farmers in Zimbabwe would be to grow the crop on contract with reputable companies. Zimtrade can assist with giving direction on such companies.

Summary

- Farmers in Zimbabwe mostly grow chillies for both local processing and export markets.
- The main chilli varieties grown in Zimbabwe include the Cayenne chilli, Bird's Eye chilli, Malaga, and Habanero chilli. Red Thunder F1, Serenade, Bandai and Dem.
- Chillies do well under hot and humid climatic conditions.
- Chilli plants may be staked to prevent lodging, particularly when they have a heavy load of fruits.
- Chillies are also affected by pests of tomato, with false codling moth, aphids, termites, broad mites and thrips being of most economic importance.
- Chillies are ready for harvesting 6-8 weeks after transplanting.

SESSION 9: BULB AND ROOT VEGETABLES

9.1 Introduction

Greet each other and review the learning objectives for this session.

LEARNING OBJECTIVES

By the end of this session, you will be able to:

- Identify the different growth patterns of the solanaceous vegetables (tomato, potato and chillies) and use the skill to better manage the crop.
- Identify the different maturity stages of solanaceous vegetables and use the skill to reduce post-harvest losses.
- know all the agronomic practices of tomato, potato and chilli production from planting to harvesting.
- Achieve high tomato, potato and chilli yields of high quality by using appropriate production methods.
- Reduce yield and quality losses through correct identification and control of tomato, potato and chilli pests and diseases.
- grow solanaceous vegetables in your own garden or field.

Bulb and root vegetables include those vegetables like onion, carrot, sweet potato, potato and garlic. However, in this book, we did not include potato under this group of vegetables. The edible part of these vegetables is usually buried underground.

Onion production

The onion is a very important vegetable crop that is widely grown and consumed in Zimbabwe. It be- longs to the same family as garlic, leeks and shallots.

The onion produces a bulb in the first season of growth and produces flowers and seeds in the second. We commonly grow it as an annual crop whereby we harvest the bulb and leaves as a vegetable before the seeds are produced. Onion is a shallow rooted crop with a fibrous root system; roots reach a maxi- mum depth of 60cm and are produced from the base of a very short stem.

Growing requirements

For best growth and bulb quality, onion requires cool weather during the early stages of growth and a dry atmosphere with moderately high temperature for bulb development and maturation. Planting should be done between April and May. Onions will grow on a wide range of soils from sandy to clay soils. Soils should be well drained and fertile.

Varieties

Onions varieties start forming bulbs based on day- length. Short-day onions form bulbs when the day length is between 10 and 12 hours whilst long-day onions start to form bulbs when the day length is between 14 and 16 hours.

For cultivation in Zimbabwe choose short-day onion varieties. Such as Early Premium F1, Hazera, Bon Accord, Texas Grano, Pyramid and Yali (red).

Discuss

Talk about the following:

- What factors should we consider when selecting an onion variety?
- Which varieties have you grown before?
- What were their advantages and disadvantages?

Now read the next section…

Land preparation

Plough the field as deep as possible breaking up all clods. Lime should be applied a month before trans- planting and ploughed in the soil if the soil pH goes below 5 ($CaCI_2$).

In the absence of soil analysis, apply 600 to 800kg/ha of Compound S (50 - 80 g/m2) as a basal dressing. Mix the fertilizer into the soil before planting. The crop responds well to organic matter which should be incorporate together with the fertilizer before planting if available.

Crop Establishment

Onions can be established from direct seeding, by transplants or by using setts (small mature onion bulbs).

Onions sown from seed directly into fields will mature four to six weeks earlier than transplanted onion. This is because the plants will not suffer transfer shock. Bolting problems are also reduced because of less stress. However, the method requires high levels of management to keep the small plants growing well on a large area. Watering and weed management should be spot on.

When using seedlings to establish the crop, sow seeds in a well prepared fertilised seedbed. If using trays or boxes, mix fertiliser and the soil well. A 1ha production area requires 5kg seeds. A 300-500m2 seedbed produces enough transplants for one ha. Prepare beds 1m wide and incorporate fertilizer, compost or manure. Line sow 3-5 kg seeds in rows set across the bed 7-10 cm apart. Distribute seeds thinly and evenly to control damping off. Cover the seeds lightly with compost and mulch with wheat straw or grass clippings. Maintain adequate soil moisture. Seeds will germinate in seven - ten days. Speed up seedling growth by top dressing, at two to three weeks after seed sowing, with 30g/m2 ammonium nitrate. Seedlings will be ready for transplanting

after six to eight weeks, when they as thick as a pencil. When transplanting, select vigorously growing and healthy plants. When planting bury only the roots. Sets is another method. Sets are produced by sowing onion seeds are sown in a seedbed at a rate of 10 to 13.5g/m2. Once bulbs mature, they are lifted, dried and stored in a cool dry place. Good sets should be 25mm in diameter and 120 to 135 bulbs per kg. Use of sets bigger than 35mm increase the chances of bulb splitting. Planting out into the field can be done during the warm rainy season. These onions will best be sold as green onions and will mature early when there are no onions on the market.

Spacing and transplanting

Transplant seedlings five - six weeks after sowing. Gently uproot the seedlings to prevent root damage. Plant at 15 - 20cm between rows and 7- 10cm between transplants. Use markers for proper spacing and to facilitate transplanting. Care must be taken so as not to damage the basal portion of the plant. Place the white portion of the plant below the soil surface. Press the soil firmly around the basal portion. Irrigate the field before and after transplanting. Sets can be spaced at 5 -7cm within rows spaced 30cm apart.

Crop management

Soil improvement

Top dressing is applied at the rate of 300kg/ha of ammonium nitrate (34.5% Nitrogen) or 30g/m2, four - six weeks after transplanting. This can be applied in two applications of 15g each if necessary. The first 15g are applied at four - six weeks after transplanting and the second at three weeks later.

Irrigation

Onion, like most horticultural crops, are best produced during the cool dry season. This means water for irrigation is needed. As the crop grows, watering should increase but reduce as the crop nears maturity. Watering should be stopped when the tops of more than half of the crop have collapsed.

Discuss

Talk about the following:

- What problems have you experienced when growing onions?
- What caused those problems (pests, diseases, weeds, other conditions)?
- How did you address the problems?

Now read the next section…

Crop protection

Weed control and cultivation

Onion is a poor weed competitor. Hand weeding can be done between rows but is difficult within the rows owing to the close plant spacing used for onions. See appendix 4 for a list of herbicides.

Discuss

Talk about the following:

- It is difficult to weed onions by hand because of the crop spacing. Divide into two small groups.
- Using appendix 4 develop a presentation on weed control for onions using herbicides. One group should present on control of grasses while the other should look at broadleaf weed control.

After reporting back to the main group, read the next section…

Pests and diseases

Unlike tomatoes or members of the cabbage family, onions are not attacked by many pests or disease. The main onion pests are cutworm and thrips. In terms of diseases onions are affected by downy mil- dew, purple blotch, and storage rots.

Onions do not have problems with a lot of insect pests and disease like tomatoes or the Brassica family.

(a) Thrips: One of the most common and troublesome insect pest. These are sucking insects which feed on the young leaves causing silver color. Thrips can reduce onion yields to very low levels. We can control by use of chemicals like Malathion 25 WPor Endosulfan (see control of thrips under tomato).

Onion thrips

adult thrips

(b) Cutworms: Another pest that can cause damage to onion seedling. Cutworms are dull grey to black C-shaped caterpillars (worms) with a smooth skin. They feed at night, cutting plants just below the soil level. One cut worm can cut several plants in one night. They also feed on a wide range of crops at tender age. We can control cutworms by making sure the area we are going to plant is free of weeds six weeks before planting. When we use undecomposed manure or compost.

When we observe cutworm damage and dig slightly around the plant, we will find the cutworm and should kill it. Chemicals to control cutworms are available and these are Kaate 5EC, Carbaryl 85 WP spray or maize baits of Endosulfan 50% WP and Trichlofon 95% SP.

Cutworm

Diseases

(a) Purple blotch: One of the major onion diseases we are likely to encounter, a disease caused by fungi. As we have said for insect pests, onions also do not have many diseases like other crops we have discussed before. The disease can cause damage when humidity (moisture in the air) and temperatures (heat) are high. When we see small irregular white patches white patches on the leaves, which can enlarge to big dry patches with purplish centres it will be purple blotch. Leaf parts beyond this point will dry. We can control the disease by spraying once a week with fungicides like Dithane M45 at 30 grams mixed in 15 litres of water, Mancozeb at 20 millimetres mixed in 15 litres of water. Natural pesticides we discussed for tomato diseases can also work on onion.

Purple blotch

(b) Downy mildew (Perenospora destructor) is a serious disease of onions. This disease attacks onions when the weather has full of moisture (humid conditions) in winter. Control is by spraying once a week with fungicides like Dithane M45 at 30 grams mixed in 15 litres of water. Natural pesticide, discussed under tomato, also work.

Onion crop affected with downy mildew

(c) storage rots, can be experienced and the most common is White Bulb Rot. This is characterized by a black sooty-like mold which develops between the scales of the bulb. Remove and destroy all infected bulbs, and always inspect onion in storage.

Physiological disorders

Common disorders of onion are:

Thick necks - these develop when plants fail to mature properly due to either too much water, excessive top dressing with nitrogen-rich fertiliser and a low plant population. Very wide plant to plant spacing can also encourage thick necks. If we apply manure to onions and use wide inside-row spacing the crop will have a lot of thick necks. Onions which we want to sell or keep as dry bulbs must have thin necks so that they will close or seal at the top of the bulb. This will protect the bulbs from rotting. When thick necks are left to dry, they do not seal at the top causing the bulb to rot from the inside.

Bolting – this occurs during unusually hot weather. The onion may flower in the first season. This affects the bulb quality by producing a hollow flower stalk starting from the top of the flower going down to the bulb.

Split bulbs - this occurs when the developing bulb does not remain as one solid unit, but split into two parts. This will not affect bulb quality but onion with bad shapes will not sell well.

Harvesting

How do you know onion are ready for harvesting? How do you harvest onion?

Onions can be very rewarding because of high yields. On average, we can get 25t/ha or 2.5kg/m2 but yields as high as 40 to 60 t/ha can be achieved depending on variety and management. About a month before harvest, it is best to start working the soil away from the bulbs. This process should involve two or three cultivations so that about seven to ten days before harvest time, the bulb is about one-third above ground. This speeds-up bulb and neck drying.

Begin lifting onions from the soil when half of the tops of the crop have fallen over. At this stage, the leaf scales will have sealed over the neck of the bulb and the young innermost leaves would have stopped growing. Avoid lifting onions when rains are expected and make sure the crop is exposed to air circulation if it rains.

Leave the crop in the field while the leaves turn yellow and dries out. Bulbs should not be exposed to direct sunlight since they sunburn easily. The tops are cut 1-1.5cm from the bulb, the roots trimmed off, the bulbs placed (not thrown) in field crates and transported out of the field within one to two hours.

Discuss

Talk about the following:

- What is curing?
- Why do we cure onions?

Now read the next section…

Curing

Curing means drying out the onion. This improves its shelf-life and is very important. If necks are not thoroughly dry, neck-rot results. Tobacco barns or groundnut A-frames or similar structures can be used for curing.

Storage

Bulbs can be stored for household use or to wait for periods when onion prices are high prices. When we want to store for long periods, bulbs should be allowed to mature fully in the field. Maturity is seen when the join between the bulb and the green leaves becomes soft and the tops fall over. Storage structures must protect the bulbs from the sun and rain and maintain good air circulation around the bulbs. This can be achieved by:

- Stacking bulbs on mesh wire or a wooden or cane platform with an air space below.
- Spreading bulbs out on a shelf (not heaping a lot of bulbs on top of each other).
- Plaiting the dried leaves of the bulbs into bunches and hanging these bunches from the ceiling.

The maximum length of time we can store onions depends on:

- Variety
- What sort of storage structure we have
- Whether we have money to buy mesh wire.
- The quality of bulbs that the buyers want.
- Conditions of the bulb when they are placed in storage.

Discuss

Talk about the following:

- What are your customers' requirements for onions?
- What is the time of year when prices for onions are highest?
- How do you grade onions?

Now read the next section…

Marketing

Onions are graded according to size and quality. A high-quality pack is obtained by eliminating immature, decayed, sunburned, and mechanically injured bulbs, double bulbs, and bulbs that have started a second growth. Buyers usually specify minimum size of the onions they will buy. This minimum size is usually 5cm in diameter although some will buy onions 2.5 cm in diameter. Usually onions 7 to 7.5cm being a premium price. Onions are usually sold in 15kg bags.

Discuss

Review what you have learned in this session then read the summary to check that you have remembered everything.

Summary

- The onion is sensitive to day-length and as such we should only grow short-day onion varieties in Zimbabwe. They should be grown during the cold, dry season with irrigation.
- Onions are easy to grow as they are not heavy-feeders and are not attacked by many pests and diseases.
- Thrips and the disease purple blotch are some of the major problems of growing onion in Zimbabwe.
- Onions can suffer from several physiological disorders.
- For marketing onions should be lifted when the leaves yellow and fall. They should then be cured on drying structures to improve their shelf-life.

Carrot production

The carrot belongs to the same family as celery, parsnip and parsley. It is a root crop which is highly nutritious. Carrots are particularly rich in carotene (pro-vitamin A). They are consumed either fresh, as a salad crop, or cooked. Large quantizes are also processed either mixed with other vegetables.

Carrots

Discuss

Talk about the following:

- What carrot varieties do you know?
- Which have you grown?
- What are the advantages and disadvantages of those that you have grown?

Now read the next section…

Common varieties

Nantes: these are almost cylindrical in shape, and round off at the end rather than tapering off. They have a small core and a larger outer cortex where sugars accumulate, giving Nantes their sweet taste. Nantes have short storage potential.

Imperator: This is the most commonly grown carrot because of its high yields and has long storage potential. Imperators are long and tapered. They are a late maturing variety, and generally have a large, more fibrous core, therefore they do not have the sweet taste of other carrot types.

Chantenay: these are intermediate between a Nantes and an imperator. They are tapered like the Imperator, but the bottom rounds off somewhat like the Nantes. Chantenay is sweet tasting like Nantes. Danver: this is medium-length carrots, conical in shape, and thicker than Imperators. The end of the root is tapered. Danvers varieties are used in both the processing and commercial fresh market.

Climatic requirements

Carrots are hardy plants that are not sensitive to winter cold and frost. Carrots do best under cool conditions and the seeds germinate quite well, though slowly. Carrots can thus be grown throughout the year, though summer production is not easy because of the high rainfall. Diseases such as Alternaria leaf blight also cause more problems, with warm temperatures and high humidity.

Temperature and soil moisture influence the shape, colour and quality of carrots. Plant growth is optimal between temperatures of 15 to 20oC, and the roots also develop the best colour and flavour at such temperatures. When high temperatures prevail, roots tend to be shorter, often with poor flavour. Forked and cracked roots are more common in summer and the central core tends to be thicker.

Land preparation

Carrots favour well-drained, fine textured soils with good water-holding capacity and a pH range of

5.5 to 6.0. Sandy, loamy soils are most suitable. Carrot seedlings are very weak, and do not tolerate soil crusting so avoid heavy clay soils. Seedbed preparation must eliminate clods as they interfere with uniform growth of the roots.

Seed treatment: It is a good idea to treat seed with fungicides such as Apron star 42 WS, Thiram 80 WP, to prevent seedling blight, damping off and seed decay.

Discuss

Talk about the following:

- When should carrots be planted?
- How should the land be prepared for carrots?
- How should we plant the carrot seeds?

Now read the next section…

Planting

Carrots should be planted at the beginning of winter.

Since the taproot is the part eaten, the field should be tilled to 30 cm deep to ensure that root penetration is not restricted. Raised beds are very popular in carrot production as they help the soil warm up faster in winter, promoting faster emergence.

Always base your fertilizer program on a soil test. Random soil samples should be collected from the entire field that you intend to plant. Over application of ammonium nitrate can lead to excess top growth at the expense of the tap root. Avoid applying fresh manure as it leads to root branching (forking). If phosphate level is low broadcast 200 to 250kg/ha of Single super phosphate, and then broadcast 700kg/ Ha of Fruitfert (Compound J 15:5:20).

Carrots are sown straight into beds which means there is no transplanting. The seed is very small, and should be planted not more than 1cm deep. Seedlings are delicate and cannot push through a tight or deep covering of soil. The first seedlings to emerge usually remain dominant and the later emergences are suppressed.

Plant population density

About 4 - 5 kg seed is required to plant 1 ha. Mixing seed with sand in a 1:6 ratio is helpful in planting to achieving a good distribution. It is important to try to achieve the optimum plant population. General seeding rates are 10 to 16 plants per 30cm of row. If the plants are too widely spaced, roots become too large, and can split. If the plants are too close together roots tend to smaller and of poor quality. Dense plantings should be thinned out.

Crop management

Topdressings are not usually required after planting. On sandy soils, or where there has been leaching of nitrogen, apply 100 - 150 kg/ha ammonium nitrate six weeks after sowing.

Irrigation

Carrots are most sensitive to moisture stress during root enlargement and seed germination. Irrigation can improve emergence. Watering at germination will also help to prevent soil crusting, which retards the growth of new seedlings. Lack of water or inconsistent watering will lead to woody flavoured carrots and irregular growth patterns or misshapen roots.

Water stress may also cause growth cracks and cracking often occurs when watering after the plant has suffered from water deficiency. Insufficient soil moisture results in a longer and thinner root, while very wet conditions have the opposite effect and also give rise to a lighter colour. It is important to maintain the soil moisture at 50% of available moisture throughout growth. Generally, 25mm of water per week should be adequate, but under warm, dry, summer conditions, especially if accompanied by hot, dry winds, up to 50mm may be necessary.

Discuss

Talk about the following:

- How have you controlled weeds when growing carrots?

Now read the next section…

Crop protection

Weed control

Carrots are small, delicate plants during the early stages of growth. Many weeds, can easily compete with them so it is very important that weeds be controlled in the early stages of crop development. Weed control can be achieved mechanically, by hand, chemically or by combination of these methods. See appendix 4 for recommended herbicides.

Discuss

Talk about the following:

- What are the common carrot pests in your area?
- Describe the damage they cause.
- How did you control them?

Now read the next section…

Pests

A three-year rotation is advisable between planting carrots, mainly to reduce the risk of pest and disease build-up. By including deeper-rooted crops in rotation with shallow rooted carrots, nutrients and moisture from the deeper soil layers can be utilized.

The most common pests affecting carrots are aphids, leaf hoppers and nematodes. Mature carrots are often affected by Alternaria leaf blight and powdery mildew. Sclerotinia can also be a problem.

Root knot nematode on carrots roots.

Physiological disorders

Carrots can suffer from a wide range of physiological disorders.

Root browning – this is caused by lack of moisture after harvest, reasons for this include, harvest in hot conditions, delay in transporting carrots to storage, and failure to quickly cool the carrots once in storage.

Greening - this will occur if the top part of the carrot root is exposure to sunlight. It tends to be a problem in light soils prone to wind or water erosion and when carrots are planted in raised beds. Hilling carrots during the season will help to control this. Thick stands create enough shade to protect the roots from the sun.

Misshapen roots - can be caused by a number of factors such as, hardpan, cultivars, compacted soil and over irrigation. Hardpans prevent the root from growing straight down. Untimely or uneven precipitation causes the root not to grow straight. Deep tillage of the soil prior to planting may cure some of these problems, as well as ensuring a finely worked seedbed. Carrots do poorly in heavier soils. Longer rooted cultivars may be stunted or exhibit forking in these heavy soils. If you have heavier soils, the use of raised beds may be the better option for you.

Carrots with multiple taproots (forks) are not specific cultivars but are a byproduct of damage to earlier forks often associated with rocky soil

Harvesting

Harvest occurs when carrots reach adequate size, however carrots do not mature evenly so larger roots are often selectively harvested prior to lifting the main crop. Sweetness and storage potential increase with maturity. Avoid wounding carrots during harvest to reduce the incidence of Sclerotinia in storage. Carrots are harvested either through lifting the roots by hand or by cutting off the tops, and using a digger to lift the carrots. Avoid drying out the carrots between harvest and in storage. There is greater moisture loss (reduced shelf life) when the leaves are left on the carrots so leaf removal is highly recommended.

Discuss

Talk about the following:

- What are your customers' requirements for carrots?
- How do you grade carrots?

Now read the next section…

Marketing

The following are some market requirements for carrots: they should not be soft, flabby or woody or misshapen; they must be reasonable clean and properly trimmed.

Storage

Carrots should be kept cool as soon as they are taken from the field. They should be cleaned and washed before storage. During washing, remove any damaged or diseased carrots. Prior to harvest two percent of copper sulphate should be used to clean the storage area and kill any disease organism is that may be present.

Discuss

Talk about the roles of the participants in the study circle. Then read the following…

Summary

- Four varieties of carrot are grown in Zimbabwe: Nantes, Imperator, Chantenay and Danver.
- Land for planting carrots should be ploughed as deeply as possible and free of clods.
- Fresh manure should never be used on carrot as it causes forking.
- Winter period is the best planting time in Zimbabwe.
- Plants should be thinned to create an optimum population density.
- Leaf blight is a serious disease especially for carrots planted in the rainy season.

CARROT PRODUCTION GROSS MARGIN BUDGET

ITEM	QUANTITY NEEDED	UNIT COST (US$)	TOTAL COST (US$)
Carrot seed	2 kg	$40/ 500 grams	$160
Compound J [14:6:20]	600 kg	$60/ 50 kg	$720
Potassium nitrate [13:0:46]	100kg	$80/ 25kg	$320
Gypsum	250 kg	$15/ 50kg	$75
Fenvelerate 20 EC	500ml	$20/ litre	$10
Dimethoate 40 EC	500ml	$20/ litre	$10
Mancozeb	1kg	$16/ kg	$16
Chlorothalonil	2litre	$22/ litre	$44
GRAND TOTAL			**$1,355**
EXPECTED GROSS INCOME: 1 ha = 1 000 000 plants 65% final crop stand = 650 000 plants @ 50g per carrot = 0.5 × 650 000 = 325 000kg @ $0.40 per kg = $13 000 Therefore: **GROSS INCOME** = $13 000	**$13 000.00**		
GROSS MARGIN: $13 000 – $1,355 = $11 645	**$11 645.00**		

ASSUMPTIONS MADE IN THE BUDGET:

- All quantities needed are for 1 ha crop.
- Farmers to provide their own labour for planting, weeding, pest and overall crop maintenance.
- Land costs not included, assumption is farmers are not leasing land.
- Land preparation costs for tractor also not included in budget (it's usually $100/ha + 20 L diesel).

Sweet potato production

The sweet potato plant grows as a trailing vine producing starchy, succulent, tuberous storage roots. The plant is a perennial but is grown as an annual by vegetative propagation using either roots or stem cuttings. Different varieties of sweet potatoes have different growth habits – erect, semi-erect, spreading and very spreading.

Production requirements

Sweet potato is a drought tolerant crop which performs very well under harsh conditions. The crop is highly adaptable and can grow in a wide range of agroecological zones. It does best where average temperatures are 24°C or above, with 750-1250mm of rainfall, abundant sunshine and moist nights. It is sensitive to frost but can withstand very hot temperatures of up to 360C and as low as 18oC. Fertile, loamy and sandy well drained soils with a pH of 5.8 to 6, are ideal for sweet potatoes. Additional organic matter can be added to keep the soil moist and well drained.

Discuss

Talk about the following:

- What are the uses of sweet potato?
- What are the advantages of growing sweet potato?

Now read the next section…

Advantages of growing sweet potatoes

Sweet potato is among the fastest expanding crops in Africa, measured by area under cultivation. Reasons for this development include:

- The resilience of the crop that continues to yield reliably high harvests under variable rainfall and on more marginal soils.
- While not without its own challenges from pests and diseases, sweet potato is relatively robust compared to grains and other roots and tubers.
- Farmers tend to turn to sweet potato when other crops fail.
- Both the root and leaves can be eaten and are highly nutritious.
- Sweet potatoes can be processed into numerous marketable products including juice, chips and flour.
- The crop can be successfully grown even on a small piece of land.
- Sweet potato tubers are rich in carbohydrates, vitamins A,B ,C and K which are essential especially amongst children. The leaves are a source of essential vitamins and macro nutrients.
- Several dishes can be prepared from boiled, mashed, roasted and baked.

The following is a summary of some of the uses of sweet potato:

- The leaves can be cooked as vegetable relish.
- The leaves can be used as feed for livestock.
- The tubers can be eaten boiled, roasted or fried.
- The tubers can be dried, and the powder used for processed products such as buns, biscuits, scones, jam, drinks salad, chips, roasted, flakes, cakes, salad and soups.
- Grated sweet potato tubers can be used to thicken soup and curries, as a filler in cakes, breads and fritters.

Sweet potato is among the fastest expanding crops in Africa, measured by area under cultivation. Reasons for this development.

Market considerations

There are two broad categories of sweet Potatoes which are as follows:

- The staple type with white flesh and white or purple skin has a high starch and dry matter content.
- The desert flesh and orange skin with a high sugar and beta-carotene content.

Selection of a variety to grow should be based on market demand. Varieties are assessed on several parameters, including root shape and uniformity, marketable yield, skin and flesh attractiveness and plant vigour.

Exercise

Do you think your local area provides the ideal conditions for sweet potato production?

What should one consider when selecting a variety to produce.

Sweet potato varieties

New sweet potato varieties are being developed by crop breeders. Each of these sweet potato varieties has certain advantages and disadvantages. Before selecting a variety, farmers should find out how it performs in their local area and its acceptance by the market. The nomenclature of varieties has been derived from their origins, tastes, shapes and growth patterns. The absence of certified breeders of sweet potato has led to some varieties being named differently in different communities.

Group Reflection

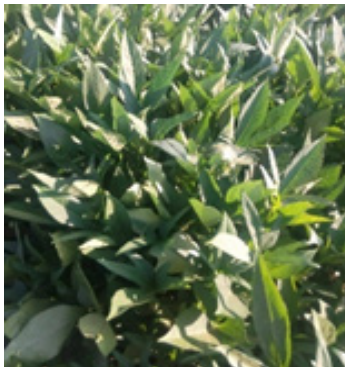
List some of the common varieties in your community and explain how they got their names.

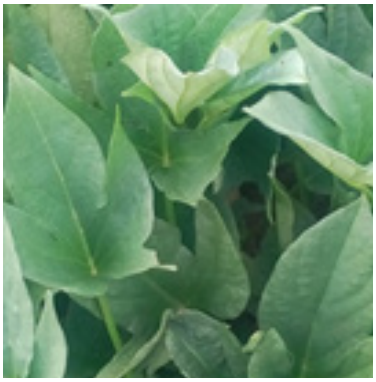
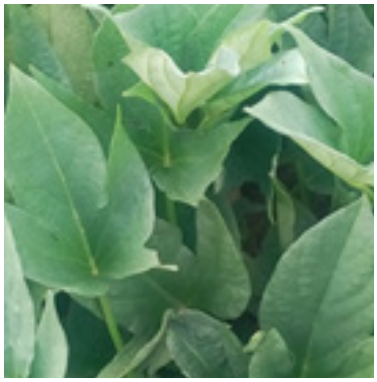
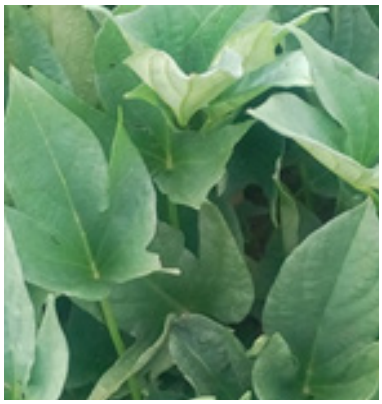
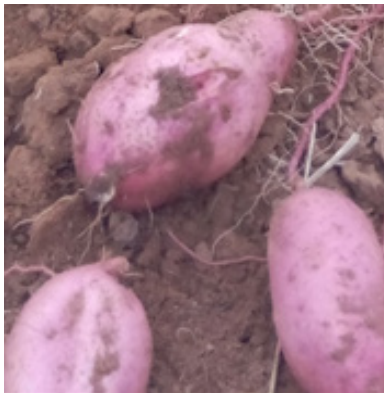
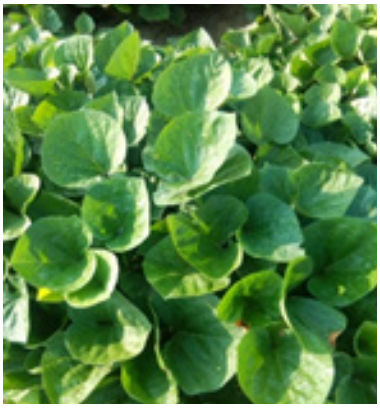
How do you get to select which variety you are going to produce?

Some common sweet potato varieties

Name	Brondal	German2	Nema Gold	Mozambique white	Beauregard
Seed yield	Low	Highest	Medium	High	High
Tuber yield	Up to 60 tons	Up to 32 tons	Up to 24 tons	Up to 32 tons	Up to 60 tons

Disease resistance	High	High	Low	High	High
Maturity (days)	Early (85)	M e d i u m (120)	Late (120)	Early (100)	Medium (120)
Drought Tolerance	High	Medium	Medium	Medium	High
Colour of tubers	Red skin and white fleshed	Pink skin and white fleshed	Orange fleshed	White fleshed	Orange fleshed
Shelf life	Up to 21 days	Up to 30 days	Up to 30 days	Up to 30 days	Up to 21 days
Taste preservation	Sweetens with time	Remains unchanged	Remains unchanged	Remains unchanged	Remains unchanged

German 2 		
Chingofa 		
Chingofa 15 		

Chingofa 16 		
Chizai 		
Nema Gold 		
Brondal 		

Propagation

Sweet Potatoes are propagated from sprouts or from slips (vine cuttings). Sprouts are grown from plant stock selected for its appearance, freedom from disease and off-types. Approximately 75kg of planting stock sweet potatoes are needed to produce enough sprouts to plant one hectare.

Vine cuttings

Tip cuttings of about 30 to 40 cm long with approximately eight nodes are collected from the nursery bed, or the last established planting. Tip cutting should be taken from crops that are old enough to provide material without excessive damage. Avoid "back cuts" as these will have variable maturity and result in significant yield reduction. The lower leaves should be cut away as tearing these off may damage the nodes that will produce the roots. Sanitize the cutting instruments by washing them in a fresh solution of one-part laundry bleach and 99 parts water, then cut upward to minimize contact with the soil. Cuttings can be left under a moist cloth in the shade for a couple of days to promote nodal rooting before planting in the field. Cuttings should be planted at an about 45 degrees angle into heaps as this promotes good, even root development. Half of the cutting or three to four nodes should be buried at a spacing of 30cm between plants.

Sprouting

Sprouting involves the use of small to medium sized storage roots to obtain slips for planting. Storage roots selected for sprouting should be free of pests and washed carefully with a disinfectant before planting (egg 20% bleach solution). Sweet potatoes selected should be cut crosswise into two or three sections to increase the number of sprouts produced. To avoid spreading viruses, cutting knives should be disinfected. Cut roots should be planted in a nursery bed that is in an area where there is good drainage. To prevent contamination, the nursery bed should be established far away from existing sweet potato fields. To prepare planting material for one hectare, a nursery bed of approximately 32m^2 is needed. Six to eight weeks may be needed if roots have not been "pre-conditioned" Adequate moisture is especially critical to germination of the sprouts and proper root formation on the sprouts.

Sprouted sweet potato storage root

The vines or sprouts can be produced in a nursery bed off season in preparation for the rain season. This will be mainly under irrigation. Normal nursery production starts in August/ September when temperatures are starting to increase for maximum growth. Farmers can then cut vines from their nurseries and plant them in the field at the onset of the rain season. Vines can still be cut from the main crop after two to three months and be planted to increase area under production. This staggering type of planting ensures that the crop does not mature at the same time and spreads the risk of crop failure as a result or droughts or floods.

Land preparation

Sweet potato is grown on raised beds or mounds. This provides the developing roots with loose, friable soil to expand to their potential size and shape without restriction. It allows adequate drainage and provides easy harvesting with a mechanical digger. Mounds should be approximately 30 cm high and 40 cm wide at the base. Ridges should be 75-90cm wide and 30-45cm height. On slopped areas, the ridges should take the direction of the contour line to avoid land degradation and to harvest water.

Raised beds

Planting

Planting time is mainly determined by the climate of a location. Sweet potato plants are damaged by light frost and the plants require high temperatures for a period of 4-5 months to yield well. In areas with mild frost, mid-November to mid-December is the best time to plant, and usually the crops get ready for harvest from April to May. Mid November to be the beginning of December is recommended areas with heavy frost and with, harvesting taking place from April to May. It's common to plant from January to March in frost free areas so that the growing season extends through winter. Cold spells during winter can be a risk depending on the climate of the specific area. Plant spacing is usually between 25-30cm intra row spacing with ridges spaced between 90-100cm. This can attain a plant population of between 30000 to 40000 plants per hectare.

Plant spacing in the field

Crop management

Fertilization

It is always recommended for farmers to do soil testing to get correct recommendation on the fertility requirement of their crop. Sweet potato crop will need Phosphorus nutrient for robust root development and they will also require Nitrogen to increase surface area for photosynthesis and Potassium for the translocation of food from the leaves into the roots when its time for tuber formation. Basal fertilizer farmers can use the most available compound fertilizer with Phosphorus, Potassium, Nitrogen and Calcium. It will have to be noted that Calcium can be supplied by lime or dolomite if the farmer did a soil test and there is need to adjust the soil pH. The most available compound fertilizer is Compound D (7:14:7) at a rate of 350-400kg/ha. After four to six weeks from planting the crop can be top dressed using Ammonium Nitrate at a rate of 100kg/ha. When top dressing fertilizer placement is done 5-10cm away from the plant. This should be done when conditions are conducive or be supplemented with irrigation to ensure that the fertilizer dissolves and becomes available for the plant. Application of Ammonium Nitrate under low/ no moisture condition may result in reverse osmosis, which will lead to the drying of the crop.

Irrigation

Maintaining a constant water supply, especially during the tuber formation stage at 7 to 9 weeks after planting, is important for large yields and quality crop. Irrigation is recommended when 40 to 50% of the field-capacity moisture has been depleted. Soil is said to have reached field capacity when you can form a firm ball of soil with your hand. Stop irrigation about 1 month before harvest. Inadequate soil moisture is a consistent limiting factor in sweet potato production.

Rains are rarely spaced to provide uniform and adequate moisture throughout the growing season. Actual needs will vary with soil type, plant size and temperature. Too much water is harmful and reduces yield and quality. Moisture should be withheld toward the end of the growing season to condition the soil and roots from harvesting and to discourage the development of cracks and very large roots.

Weeds

Weeds compete for moisture and nutrients with the main crop and help harbour pest and diseases. Manual weeding has been traditionally used and proved to be effective if done on time and through out the growing season. However, with the advent of technology farmers can also use herbicides to suppress weed pressure. This however comes with careful selection of herbicides and farmers are advised to seek advice on choice of herbicide to use.

Exercise

List the different local names of sweet potato varieties and the colour of their skin and flesh.

Discuss on why each variety is important in your local community.

Which method of planting do you use in your community and what are the advantages and disadvantages?

Integrated Pest Management (IPM)

This is the management of pest through a combination of complimentary strategies. It is premised on early and correct identification of pest through scouting. It emphasizes on using chemical control as a last resort when all other strategies have proven ineffective. Other methods which are supported by IPM include cultural control (selection of resistant varieties, early planting) biological control (use of repellent plants, promotion of other insect) and mechanical control which involve physical removing and destroying of the pest. All these methods aim at reducing the cost of production thus giving the farmer the best returns.

Group Reflection

List some of the cultural and physical methods of pest control that you normally employ in Sweet Potato production?

Why do you think early detection of pest and diseases and correct identification and diagnosis are important in Integrated Pest Management?

Major pest of sweet potatoes

Several insects attack the leaves, stem and tubers of sweet potato, however of economic significance are sweet potato weevils, sweet potato beetle and stem borer.

Sweet potato weevil

The sweet potato weevil is one of the most destructive insect pest in sweet potato. Adult weevil is like beetles about a 60mm long. The adult weevil feeds on all parts of the sweet potato plant but mainly prefers the roots. The adult female lays eggs in stems or the surface of the roots just under the skin. The eggs hatch and the larvae tunnel into the vine and

roots where they develop. The feeding of the larvae results in tunnels within the sweet potato tuber reducing its quality and palatability.

Sweet potato weevil (larva and adult)

IPM measures

Having studied the growth cycle of the pest here are some of the measures that farmers can employ:

- Use certified seed/vines free from weevils
- Rotate your fields to cut the cycle of the pest
- Where ever possible avoid using root cuttings, always use plant cuttings
- Always cover the tubers to avoid entry by adult weevils

White grub

This is a larvae stage of a beetle, C shaped with well developed legs and range in colour from white to off white depending on species. The larvae feeds on tubers thus reducing their marketability.

White grub larvae and their damage

IPM measures

Management of white grubs includes the use of cultural control like using mature animal manure, land preparation which will expose the white grubs to birds and physical control measures like spotting and destroying the pest.

Sweet potato flea beetle

The adult beetle is are black in colour and mainly target sweet potato foliage. However, the larvae make small winding tunnels just beneath the skin of sweet potato roots. The tunnels are nearly invisible at first, but soon darken. As the potato grows the skin over the tunnels splits away, leaving shallow scars on the surface.

Sweet potato flea beetle and damage

Whiteflies

Adults sweet potato whiteflies are small, approximately 1/25 inch in length with a pale-yellow body and two pairs of white wings covered with white waxy powder. At rest wings are held in an inverted V position. They are sap sucking and normally cause wilting of leaves. However, of economic significance is the fact that they are a vector of Sweet Potato Mosaic Virus.

Whiteflies

Nematodes

These are microscopic worms that feed on roots of sweet potato and can significantly impact on yields. Of significant importance is the root-knot nematode. They feed on the xylem vessels of the plant thus cutting of water and nutrient supply of the plant resulting in plant stunting and wilting.

Sweet potato tubers damaged by nematodes

IPM measures

Growing of nematode resistant varieties and crop rotation are some of the measure's farmers can employ. Clean planting material and the use of repellent plants like neem and marigold can also be another measure.

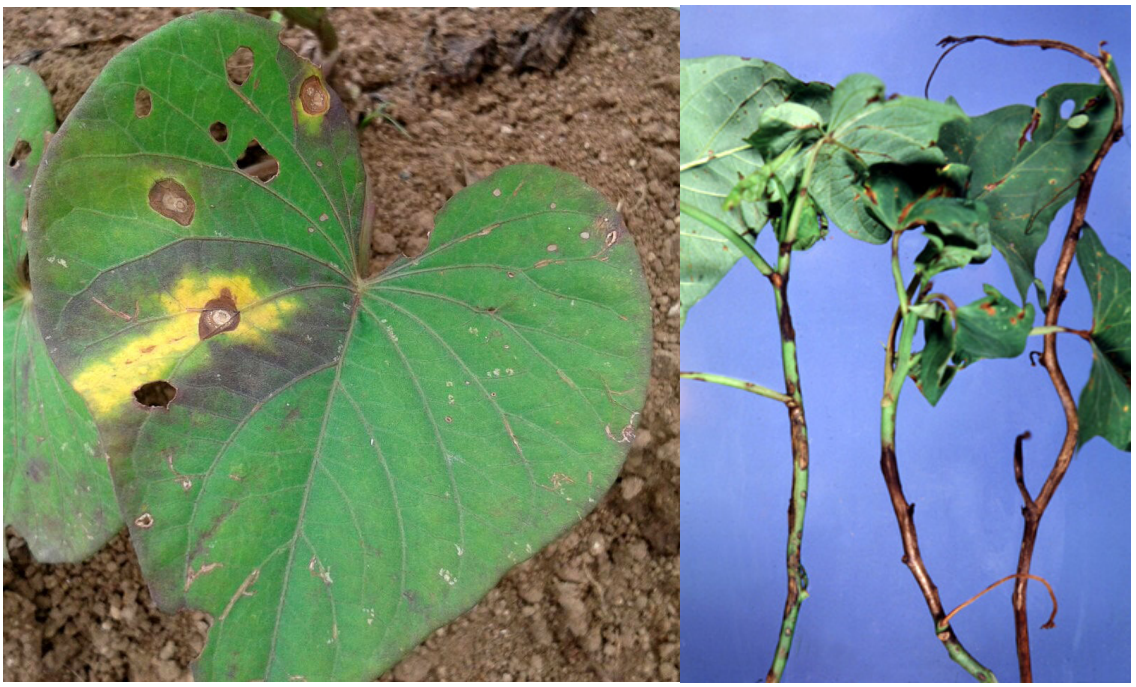
Sweet potato diseases

Sweet potato diseases can cause heavy losses in the field and in storage. Management is primarily using preventive measures. The most common diseases in Zimbabwe with economic significance are black rot, stem rot and blights.

Alternaria leaf spot & Leaf and stem blight (*Alternaria spp.*)

Symptoms

Brown lesions on leaves with concentric rings resembling a target; lesions are usually restricted to the older leaves and may be surrounded by a yellow halo; small gray-black oval lesions with lighter centers may occur on stems and leaf petioles and occasionally on leaves; stem and petiole lesions enlarge and often coalesce resulting in girdling of the stem; defoliation may occur. The disease is caused by a fungus.



Some symptoms of Alternaria on leaves and stems

Management

Destroy all sweet potato crop residue immediately following harvest; plant resistant or tolerant sweet potato varieties where available; plant only disease-free seed material

Black rot (*Ceratocystis fimbriata*)

Symptoms

Stunted plants; wilting plants; yellowing plants; dropping leaves; plant death; circular brown-black patches of rot on tubers.

Ceratocystis black rot of sweet potato

Management

Only disease-free seed material should be planted; sweet potato should not be planted in sites where sweet potato has been grown during the previous 3-4 years; transplant material should be collected from plant by making cuts above-ground; seed material should be treated with an appropriate fungicide prior to planting.

Bacterial wilt (*Ralstonia solanacearum*)

Symptoms

New sprouts wilting and have water-soaked bases which turn yellow-brown to dark brown in colour; vascular system of the sprouts is discoloured brown; infection of healthy transplants causes the lower portions of the stems to become water-soaked and turn a similar colour to infected sprouts; yellow-brown streaks may develop inside storage roots and, if infection is severe, gray-brown water-soaked lesions may be present on the root surface.

Bacterial wilt

Management

Quarantine procedures have been put in place in regions of China where the disease is severe; only disease-free storage roots should be used for planting and planting should only be done in sites free of the disease; rotating sweet potato with a flood crop such as paddy rice or a non-host such as corn or wheat can be beneficial; growing sweet potato during cooler periods of the year allows some avoidance of the disease.

Sweet potato virus disease (SPVD)

Symptoms

Sweet potato virus disease is a disease complex caused by two viruses; sweet potato chlorotic stunt virus (SPCSV) and sweet potato feathery mottle virus (SPFMV). The symptoms are severe stunting of infected plants, stunting, distorted and chlorotic mottle or vein clearing of the leaves. It is confirmed that SPCSV enhances the accumulation of SPFMV. The symptoms caused by SPCSV alone is negligible. Where as symptoms caused by SPFMV is localized,

mild and often asymptomatic and won't cause significant damage to the plant. Common symptom include appearance of feathery, purple patterns on the leaves.

Sweet potato chlorotic stunt virus (SPCSV)

Sweet potato feathery mottle virus (SPFMV)

Exercise

Why is it important to understand the life cycle of a pest?

What is your understanding of economic thresh hold level in Integrated Pest Management

Harvesting

The maturity index of sweet potato includes yellowing and senescence of leaves. The tubers can also be tested for maturity by cutting them into half. If the latex which is exuded by the tuber remains creamy white when exposed to the air is a sign that the tubers are mature. Some varieties like Brondal and Nemagold flower towards maturity. This again is a sign that the crop is maturing and ready for harvest. Farmers can also consult earlier session where the maturity dates for different varieties were discussed. This takes good record keeping practices as the farmer will have to count the number of days since planting.

Before harvesting, most of the top growth needs to be removed. Roots are lifted from the soil using a single row potato digger or a hoe. To avoid digger damage, this should be done while the hills are still moist so that some soil travels up the digger bars with the roots. The dug roots are then manually collected into trays and transported to the shed. The harvested crop must be kept away from lengthy exposure to the sun, and skin damage will be less if the roots are kept wet during handling.

Harvesting methods

Sweet potatoes can be harvested using any of the following depending on equipment available to the farmer and type of soil:

Manual method

The vines are cut and a fork/cutlass or other appropriate lifting tool should be placed more than 30 cm away from where the vine is attached to the storage roots. The roots are exposed by turning the soil. The vines may not separate easily and individual roots must be detached by hand.

Sweet potato vines cleared from the ridges in preparation for the harvester (manual)

Manual harvesting

Mechanical method

The sweet potato ridges are cleared of vines to allow the harvester to have easy access. The harvester moves slowly through the field and the sweet potatoes are brought to the surface along the ridge. The skin of the sweet potato is thin and delicate and easily damaged at harvest. Storage roots should therefore be handled carefully and sparingly. The harvested crop, whether by hand or mechanically should be placed in field crates to be transported from the field. Do not use sacks as this can result in rubbing off the surface skin and the build-up of disease organisms. Sweet potatoes should be graded in the field.

Tuber harvesting

Mechanical harvesting sweet potatoes using a tractor

Root curing

Sweet potatoes to be stored for later marketing or for seed stock must be cured immediately after harvesting to minimize storage losses. Curing involves controlling temperatures and relative humidity and providing ventilation for seven to ten days. Curing is a wound-healing process which occurs most rapidly at 26 to 32 °C, a relative humidity of 85 to 90% and good ventilation to remove carbon dioxide from the curing area. Wounds and bruises heal, and a protective cork layer develops over the entire root surface. In addition, suberin, a waxy material, is deposited.

The cork layer and suberin act as a barrier to decay-causing organisms and to moisture loss during storage. This process involves the forced hot air treatment of roots at 30 0C with 90% relative humidity for between 4 to 6 days. This must be done immediately after harvest and will result in the formation of a wound skin, which heals any mechanical damage suffered during harvesting. Post-harvest rot infections are minimized, and excessive moisture loss prevented. Curing can also improve eating quality by increasing sweetness.

Marketing

Correct post-harvest handling is critical for any produce, and sweet potato is no exception. Harvested roots should be washed, graded and cooled soon after being dug and not left in the field for an extended period. Keeping the roots wet or moist will help prevent skin damage. The grades are dependent on the market. The common grades are the small, medium size and large sizes. Other markets like the informal sector can have the different grades mixed in the same tin.

Summary

- Sweet potato tubers can be consumed while the leaves can be used as a vegetable.
- Sweet potato can be propagated through vine cuttings or sprouted tubers.
- The crop must be scouted for pests and diseases to enable effective control.
- The sweet potato crop is ready for harvesting when many leaves turn yellow and begin to fall off the plant.
- Great care must be taken when harvesting sweet potatoes as it is easy to damage the tubers when you are digging them up.
- Damaged tubers are susceptible to rotting and may not be marketable.

SESSION 10: CUCURBIT VEGETABLES PRODUCTION

10.1 Introduction

Greet each other and review the learning objectives for this session.

LEARNING OBJECTIVES

By the end of this session, you will be able to:

- Know the soil and climatic requirements of cucumbers and watermelons;
- Achieve high-quality yields through appropriate growing methods;
- Identify the major cucumber and watermelon pests and diseases and use appropriate methods to control them;
- Reduce production losses in cucurbits through good postharvest practices.
- Grow any cucurbit vegetable of your own choice.

Vegetable crops which belong to the cucumber family are known as cucurbits. These are normally grown for use as salads, dessert fruit. They include cucumber, watermelon, butternut squash and pumpkin. In this book, we will discuss about watermelons and cucumbers.

Cucumber production

Cucumber is a member of the cucurbit or pumpkin family native to Africa. Cucumber is an annual deep-rooted crop with plenty of tendrils and has hairy leaves. When talking about vegetable production in Zimbabwe, we can never skip cucumber farming. It is one of the profitable niches when it comes to vegetable farming in Zimbabwe. Cucumbers are considered by most as a vegetable but some consider them a fruit. In this session, we shall be discussing how you can grow cucumbers.

Discuss

Talk about the following:

- What cucumber varieties do you know?
- Which have you grown?
- What are the advantages and disadvantages of those that you have grown?

Now read the next section…

Common varieties

Always consult your local extension officer for best varieties to grow. For greenhouse production, the hybrid Dreamliner F1, supplied by Seed Co produce vigorous plants that give high yields. For open yield production, Seed Co supplies hybrids Olympian F1 and Stonewall F1 with excellent disease tolerance and adaptability.

Climatic requirements

Optimum growing temperatures are between 20°C to 25°C. At temperatures below 16°C growth slows

down and cucumbers are frost sensitive. Cucumbers thrive best under warm conditions – when temperatures are above 18 degrees Celsius that is when it will be ideal. Cucumbers require adequate water which is why irrigation is largely inevitable.

Soil requirements

The PH should be between 5.5 – 6.0. Cucumbers are adapted to a wide variety of soil types that have good drainage and adequate water holding capacity. Soil should be harrowed to a reasonable tilth after ploughing or sub soiling so direct seeding can have good soil to seed contact.

Discuss

Talk about the following:

- When should cucumbers be planted?
- How should the land be prepared for cucumbers?
- How should we plant the cucumber seeds?

Now read the next section…

Land preparation

Ploughing or sub soiling needs to be done to a depth to break up a hard pan if present in the soil. Rows can be 1.2m - 1.8m apart on the flat and 50cm – 1m apart in row, depending on what plant population is needed and varieties selected. Plastic mulch can be applied where drip irrigation is used. Plastic mulch helps control weeds, improves the use of water and fertilizer. It also reduces incidents of fruit rot where the fruits are not in contact with the soil. If cucumbers are to be grown on beds a spacing of 1.2m – 1.8m bed center to bed center, then 2 rows can be put on the top of the beds. The rows can be 40cm apart, and in row of 50cm – 80cm apart. Cucumbers can be direct seeded in the ground or seedlings grown in a nursery for transplanting. If direct seeding is used, then the soil temperature must not be below 13°C or poor uneven germination will take place. With direct seeding the depth of the seed should be 20mm – 28mm deep. Seedlings need to be covered when transplanted up to the top of the plug. Plant populations can vary from 14,000 per hectare up to 40,000 per hectare.

Crop management

Fertilization

Rates can be based on soil sample analysis results. Basal: - Compound "D" at 600kgs – 750kgs per hectare can be used. Top dressing: - Apply first application two weeks after germination or transplanting of 50kg per hectare AN. Then every two weeks until first fruit set, then add 35kgs per hectare Muriate of Potash and every two weeks from then on both the AN and Muriate of Potash. Potassium helps to produce a deep green color to the fruit as well as firm flesh and helps to produce good yields. Manure or Compost applications improve quality and yields. Up to 20tons per hectare is recommended, as this helps to improve soil texture and improves root growth.

Irrigation

Cucumbers need a constant water supply to enable a good yield of quality fruits. Generally, soils must not dry out at planting or transplanting. Soil types will determine the frequency and amount. From flowering to fruit development depending on the weather, amounts should be supplied by checking on evaporation pan figures. Roughly 50 mm irrigation is required per week. Normally drip irrigation is recommended for cucumbers.

Trellising

Cucumbers can be trellised in order to achieve better yields with better quality of the fruits. If trellising is used it should be 1.6m up to 1.8m in height. Strong poles are spaced every 4m apart. A twelve-gauge wire is placed about 12cm off the soil level and an 8-gauge wire is pulled on the top. Twine or netting can be strung between the wires so plants can be trained up. Planning for rotation purposes, if the trellising is used say for a tomato crop then the cucumber crop can follow the tomato crop using the same trellis system saving on double work. Training needs to be done on a weekly basis to ensure all the vines are tied onto the netting or twine. Pinch out the side shoots from the bottom up to around 50cm, after this leave them to grow out. Advantages of trellised cucumbers are:

- Increased picking efficiency.
- Better yields.

- Straight fruits
- Uniform color, not like fruits grown on the soil which have a white/yellow area where it has
- been lying on the soil surface.
- Reduces fruit loss to soil diseases.
- Better pest management.
- Disadvantages: -
- Extra cost of trellising materials.
- Extra labor costs to erect, dismantle and training of the vines.
- Plants are prone to wind damage therefore wind breaks need to be put in, in wind prone
- areas by putting up 50% shade cloth of 2m height up wind of the crop.

Discuss

Talk about the following:

- How have you controlled weeds when growing cucumbers?

Now read the next section…

Weed control

Weeds during the early stages of growth. Many weeds, can easily compete with them so it is very important that weeds be controlled in the early stages of crop development. Weed control can be achieved mechanically, by hand, chemically or by combination of these methods. See appendix 4 for recommended herbicides.

Discuss

Talk about the following:

- What are the common cucumber pests and diseases in your area?
- Describe the damage they cause.
- How do you control them?

Now read the next section…

Pests control

Aphids

Aphids on cucumber vine

Identification: 1/16 to 1/8 inch long and of almost any color; winged or wingless with two tubes that protrude from their belly and one ling slender antenna, though these features can be hard to see with the naked eye.
Damage: Aphids feed on plant sap, which can keep the plant from thriving and setting fruit. They also excrete a substance that causes black, spotty mold, further reducing plant yields. And they can be vectors for viruses, particularly the cucumber mosaic virus.

Control: Introduce natural predators such as lady beetles in adult and larvae form, lacewing larvae and parasitic wasps; avoid planting downwind from hedgerows or forested areas that decrease the wind, which can disperse aphids; as a last resort, use chemical insecticides formulated for aphids and apply according to the label, treat the underside of the leaves, as that is where the aphids will often clump.

C

Cucumbeer beetles on leaves

Identification: 1/5 to 1/2 inch long; striped beetles have three black stripes the length of their bodies; the spotted ones, twelve black spots on the back; and the banded ones, three transverse bands of green atop a yellow outer shell.

Damage: Cucumber beetles migrate in the spring from wooded areas and fields to cucurbit crops, feeding voraciously on leaves, stems and flowers, all negatively impact the quality and quantity of the fruit and the health of the plant. The larval stage of the beetles, known as the rindworm, feeds directly on the cucumbers' roots. The beetles are also the primary vector of bacterial wilt.

Control: To control rindworm, eliminate the adult beetles before they have a chance to lay their eggs. Control adults by eliminating surrounding weeds in the fall, which are overwintering sites for beetles, plant wilt resistant cultivars, and use insecticides approved in your state for cucumber beetles.

Thrips

Thrips

Identification: 1/25-inch yellowish bugs with fringed wings.

Damage: Thrips suck the contents of the cucumber's cells, weakening the plant and leaving leaves and fruits damaged, malformed and sometimes covered in silver spots.

Control: Scatter diatomaceous earth on the ground around the plants and plant leaves to destroy larvae and feeding bugs; use reflective mulches or ground covers; Introduce Hypoaspis and cucumeris mites or pirate bugs when the plants are small and an infestation is not yet established; spray leaves regularly with an insecticidal soap such as Neem (it's necessary to cover both the top and bottoms of all leaves, a process that may make this impractical as a method of control for the home gardener).

Spider Mites

Spider mites leaf damage

Identification: Miniscule mites practically invisible to the naked eye; when spider mites are present, leaves develop yellowing between the veins and their bottoms turn brown and crusty.

Damage: The mites feed on the underside of the leaves, causing them to die and fall off, eventually killing the plants.

Control: Spider mites thrive in arid, hot weather and tend to migrate in from surrounding grassy areas. Biological controls through natural predators are not realistic given the area (including not just the cucumber beds but also any surrounding weeds or grassy patches) that must be treated; avoiding cutting fields or grasses nearby until mid-summer or dry times can help keep the mites from migrating to your crop; applying insecticidal soap or chemical insecticides must be done on both sides of every leaf to work and hence is impractical.

Disease control

Angular Leaf Spot

Symptoms: Small angular-shaped spots on leaves, often sunken and brown; yellow leaves; circular spots on fruit that can crack and turn white.

Causes: Bacteria that thrive in hot, humid conditions; spreads through the handling of plants, wind-blown rain.

Control: Choose (from the many) disease-resistant cultivars; avoid watering from above or working the plants when they are wet; no effective natural controls but some copper-based chemical treatments can work if applied early.

Bacterial Wilt

Symptoms: Wilting first in infected branches and leaves, spreading eventually to the entire plant.

Causes: Bacteria transmitted by cucumber beetles as they feed.

Control: Use floating row covers to keep beetles from feeding, removing them when flowers appear (they must be uncovered for bees to pollinate them and fruits to form); remove and destroy wilted plants; consider planting late season cucumbers (cucumber beetles are done feeding by midsummer); while cucumber beetle traps get mixed reviews, chemical insecticides targeting cucumber beetles are available but must be applied regularly starting when plants are one week old or when beetles first appear in the spring.

Anthracnose

Symptoms: Large yellow to brown spots on leaves, eventually forming ragged holes; sunken lesions on fruits, sometimes colored pinkish by spore masses.

Causes: Infection that thrives in rainy and humid conditions; spreads through the handling of plants, wind, wind-blown rain.

Control: Plant disease-resistant cultivars; treat with chemical fungicides as soon as vines

start to run or earlier if symptoms appear; the pathogen can overwinter for several years in infected soil, so practice strict crop rotation and remove all plant debris, dispose of it far from your vegetable beds.

Downy Mildew

Symptoms: Yellowish brown irregular spots which quickly spread over the top of the leaves; occasionally gray fungus develops on the leaves' undersides.

Causes: Spores that spread rapidly in wet weather when the nights are cool through air currents, rain and handling.

Control: Plant (one of the many excellent) disease-resistant cultivars; treat with chemical fungicides as soon as vines start to run, though it is rare for the disease to appear before mid-summer.

Powdery Mildew

Symptoms: White powdery mass covering leaves and stems, starting in mid-July through the end of the season and eventually leading to the leaves turning yellow and brown, shriveling and dying. Fruits are unaffected by the spores themselves but can have secondary damage (sunscald, malformed fruits) caused by the leaves' death.

Causes: Spores thrive in humid, shady conditions among crowded, fertile plants.

Control: Plant (one of the many excellent) disease-resistant cultivars; treat with chemical fungicides as soon as vines start to run, though it is rare for the disease to appear before mid-summer; quell excessive leaf growth by avoiding excessive nitrogen fertilization, and don't crowd plants; practice strict crop rotation and remove all plant debris, dispose of it far from your vegetable beds to keep the spores from overwintering.

Cucumber Mosaic Virus

Symptoms: Distinct green and yellow mosaic pattern on leaves, eventually leading them to curl; stunted growth and little fruiting.

Causes: Infected seeds or transplants, insect feeding (primarily aphids), cuttings.

Control: Plant (one of the many excellent) virus-resistant cultivars; keep weeds, which can harbor the virus over winter, cut and cleared from around your beds; no chemical controls exist though insecticidal soaps may help control the aphids that often carry the virus. Plant cucurbit crops in beds as far from each other as space allows to keep aphids from transferring the virus from one infected plot to another healthy one.

Harvesting and postharvest handling

Generally, first harvest from planting takes 45 – 55 days. Depending on disease and pest control cucumbers can normally carry on producing for 14 weeks. At harvest the fruit must have reached full diameter and while the seeds inside are still soft and small. Normally the average length is between 15cm – 20cm and a diameter 4cm – 7cm. From pollination to harvest is normally 15 – 18 days. Cucumber plants set fruits and develop over a long period of time, therefore marketable fruits extend over a period.

Marketing

Cucumbers are handpicked. When picking, the fruits should be clipped or snapped near the stem and not pulled off or damage to the vine will occur. Once picked place gently in the picking crate and keep cool and covered with a damp cloth. Once transported to the pack shed, keep the fruits cooled down to 10°C for best shelf life. Remove any oversize fruits left on the vine by mistake from the previous harvest as they will drain the plant of all nutrients and can cause yield loss. Damaged or decaying fruit should also be removed. If cucumbers have to be stored the average shelf life is about 10 – 14 days at a temperature of between 10° C – 13° C, and 90% to 95% relative humidity.

Review what you have learned in this session then read the summary to check that you have remembered everything.

Summary

- Cucumbers belong to the cucurbit family along with water melons.
- They can be grown in deep well drained soils.
- Good crop management is needed for cucumbers which include proper fertilization, irrigation, weed management as well as pest and disease management.
- Generally, first harvest from planting takes 45 – 55 days.

CUCUMBER PRODUCTION GROSS MARGIN BUDGET

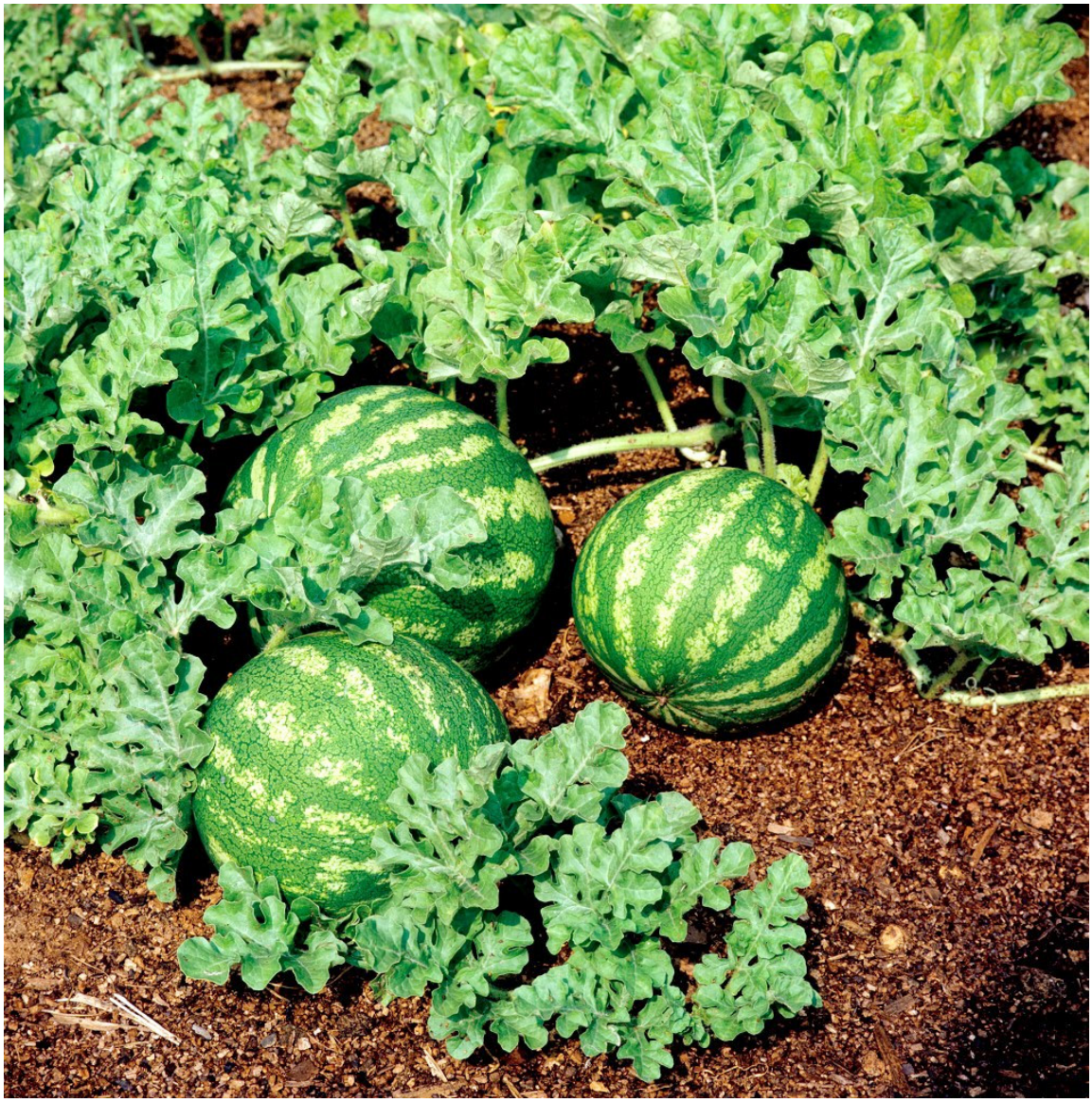
ITEM	QUANTITY NEEDED	UNIT COST (US$)	TOTAL COST (US$)
PRE-PLANTING			
Cucumber seed [open-pollinated varieties]	500 grams	$40/500 grams	$40
Oxamyl [for control of nematodes]	3 litres	$30/litre	$90
Fenvelerate 20 EC	500ml	$20/litre	$10
Fertiliser compound C [5:15:12]	800kgs	$50/50kg	$800
AT TOP-DRESSING			
Fertiliser ammonium nitrate (34.5%N)	150kgs	$50/50kg	$150
OTHER REQUIREMENTS			
Malathion 50 EC [for aphid control]	500ml	$15/500ml	$15
Dicofol [for red spider mite control]	500ml	$15/500ml	$15
Ridomil gold [curative fungicide]	1kg	$25/1kg	$25
Dithane M45 [preventative fungicide]	2kg	$16/kg	$32
Kontakill [for fruit fly control]	500 ml	$16/500ml	$16
GRAND TOTAL			**$1 193**
EXPECTED GROSS INCOME: 1 ha = 37 000 plants Estimated @ 70% packout 0.7 × 37 000 = 25 900 plants @ 2 fruits per plant = 51 800 fruits @ 0.3 kg per fruit = 15 540 kg @ $0.20 per kg = $3108 Therefore: **GROSS INCOME =** $3 108	**$3 108.00**		
GROSS MARGIN: $3108 – $1 193 = $1915	**$1 915.00**		

ASSUMPTIONS MADE IN THE BUDGET:

- All quantities needed are for 1 ha crop.
- Farmers to provide their own labour for planting, weeding, pest and overall crop maintenance.
- Land costs not included, assumption is farmers are not leasing land.
- Land preparation costs for tractor also not included in budget (it's usually $100/ha + 20 L diesel).

Watermelon production

Just as cucumber, watermelon belongs to the cucurbit family. It is a simple crop to grow and generally thrive in hot and humid climatic regions. Watermelons in Zimbabwe are generally consumed by all sections of society and are quickly gaining popularity with health activists.



Discuss

Talk about the following:

- What watermelon varieties do you know?
- Which have you grown?
- What are the advantages and disadvantages of those that you have grown?

Now read the next section…

Common varieties

It is recommended to use improved varieties of watermelons (hybrids) because the plants are resistant to diseases and the fruits are resistant to shocks during handling. Some examples of watermelon varieties are Kito F1, Charleston Gray, Crimson Sweet, Sugar Baby, Tiger, Carina, Tiger, Crimson Sweet and Fahari.

Climatic requirements

Watermelons are generally sensitive to cold temperatures and even a mild frost can severely damage the crop. The best average temperature range for water melon production during the growing season is between 18°C and 35°C. Temperatures above 35°C or below 10°C will slow the growth and maturation of the crop.

Land Preparation

Watermelons grow best on non-saline sandy loam or silt loam soils. Fields with light textured soils warm up faster in the spring and are, therefore, favoured for early production. Very sandy soils have limited water holding capacities and must be carefully irrigated and fertilised to allow for high yield potential. Clay soils are generally avoided for watermelon culture, but they can be productive if irrigated with care to prevent prolonged saturation of the root zone (a condition that favours the development of root rot pathogens) and to allow good drainage between irrigations. The soil should have a pH of 5.8 to 6.6.

Fields should be prepared thoroughly by ploughing and harrowing and removing the different types of plant debris. It should also be pulverised and levelled. Furrows are made 2 m apart. Watermelon is known to be sensitive to manganese toxicity, a frequent problem in low-pH soils. Further research studies indicate an association between high leaf manganese concentration and poor growth and yield of water melon. Seedlings of watermelons react to manganese toxicity with stunted growth and yellowish, crinkled leaves. Older plants generally exhibit spots on leaves that may be mistaken for symptoms of gummy stem blight. Manganese toxicity is usually associated with soils having a pH below 5.5. However, in wet seasons the condition may occur at higher pH levels. This condition was also noted in several water melon fields with pH ranges at 5.8 or slightly higher when the crop was planted on the flat. Planting water melons and other cucurbits on a bed is good insurance against manganese toxicity during a wet season. The best solution to manganese toxicity is to apply lime in autumn at rates based on the results of a soil test. A pH of 6.0 should be maintained for maximum yields.

Discuss

Talk about the following:

- When should watermelons be planted?
- How should the land be prepared for watermelons?
- How should we plant the watermelon seeds?

Now read the next section…

Planting

In Zimbabwe, water melons can be planted in the Lowveld from June to August and in the rest of the country from August to October. The crop matures three months after planting, and the yield varies from 5 to 72 ton/ha. It is usually takes about 80 to 90 days for baby bush varieties and 90 to 100 days or more for the large varieties to reach maturity. Spacing In large-scale production, few seeded varieties are currently grown. Watermelons are planted on flat beds 2 m wide and 20 cm to 30 cm high. In direct-seeded plantings, seed is placed 1.2 cm to 1.9 cm deep. After thinning and side dressing, furrows are reformed to the condition prior to furrow irrigation. For transplants, a single drip irrigation tape is laid 15 cm to 20 cm below the bed surface. Plastic film, 1.8 m wide, is then laid flat on 2 m beds to heat the soil and reduce weeds. Seeds or transplants are then planted directly through the plastic. Transplants are set 60 cm to 90 cm apart. About 15 cm of the plastic is covered with soil at the edges to hold the mulch in place.

Use of plastic films in watermelon production

Common seedless water melon planting configurations are 1 row of the seed variety (pollinator) for every 2 to 3 rows of the seedless variety. However, other novel configurations are being used. The most popular is the mixing of seedless and pollinator plants from 2:1 to 5:1. As the seedless to pollinator ratio increases, the number of beehives should be increased to ensure pollination. The seed rate is 16 to 25 seeds per 10 m2 (1.0-3.0 kg/ ha).

Crop management

Fertilization

Water melons have moderate nutrient requirements compared to other vegetable crops, and because of its deep rooting it is efficient in extracting nutrient requirements from the soil. We recommend Windmill's compound L (4:17:11) or Compound C (5:15:12) for basal fertiliser application, and Windmill's Ammonium Nitrate (34.5 % N) as top dressing.

Irrigation

Cucumbers need a constant water supply to enable a good yield of quality fruits. Generally, soils must not dry out at planting or transplanting. Soil types will determine the frequency and amount. From flowering to fruit development depending on the weather, amounts should be supplied by checking on evaporation pan figures. Roughly 50 mm irrigation is required per week. Normally drip irrigation is recommended for cucumbers.

An established watermelon crop

Pruning

Pruning is an essential part of growing watermelon plants, as it helps promote healthy growth, increase yield, and improve air circulation. Pruning removes unwanted side shoots, leaves, and branches, allowing the plant to focus its energy on producing quality fruit. It also keeps the plant at a more manageable size and shape so it can be easily harvested.

By pruning regularly, it is possible to reduce the risk of disease and pests that thrive in humid conditions by improving air circulation throughout the plant. This method is especially useful when there is limited space available since it helps control the number of fruits produced; fewer but larger fruits are usually desired when growing watermelons in a small area.

To properly prune a watermelon plant, cut off any side shoots or branches that detract from the main stem and maintain the desired shape for better airflow. If needed, trim away any dead or diseased parts of the plant so they do not spread further contagion. Also, be sure to remove any rotting fruit from around the base of the plant to prevent further decay and maintain good hygiene near your crop.

Pruning plays an important role in ensuring healthy and successful growth for watermelon plants. Through careful removal of side shoots, leaves, and branches; keeping their size

and shape under control; and increasing air circulation around them; it is possible to reap higher yields of quality produce.

Fruit pruning

Pruning watermelon fruits will increase your yield, improve the fruit quality and enhance your plant health. Fruit pruning in water melons should begin as soon as defective melons are noticed. Remove misshapen and blossom end rot fruit to promote additional fruit set and better size of the remaining melons. If a market demands larger melons, remove all but two or three well-shaped melons from each plant. To avoid disease spread, do not prune melons when vines are wet.

Talk about the following:

- How have you controlled weeds when growing watermelons?

Now read the next section…

Weed control

Where plastic mulch is used, no need to control weeds. Shallow mechanical cultivation and hand-hoeing are needed to control weeds before plants have developed vines. Pruning roots and vines with cultivating equipment slows melon development and reduces yield. Several pre-emergence herbicides are available that will control germinating broad leaf weeds and grasses in seeded and transplanted water melons if used properly. Chemicals are economical when used as narrow band applications in the planted row. Other chemicals can be used as a lay by application between the rows before vines begin to run. Herbicides are applied with shallow incorporation and transplants are placed with the roots below the treated zone. Post-emergence herbicides such as Agil 100EC are used to control grasses. Methyl bromide was commonly used in the past in field fumigations, but currently metham sodium is used to control weeds pre-emergent.

Talk about the following:

- What are the common watermelon pests and diseases in your area?
- Describe the damage they cause.
- How do you control them?

Now read the next section…

Pests control

Pests which affect cucumbers also affect water melons. They should be controlled early before yield is affected.

Common watermelon pests and their remedies

Pest	Control (Windmill recommended)
Cutworm	Fenvalerate/Lambda-cyhalothrin
Aphids	Dimethoate 40 EC, Malathion 25 WP
Fruit fly	Lebaycid 50 EC, Malathion 25 WP, or Dipterex 95 SP.

Disease control

Watermelons are susceptible to several diseases that attack the roots, foliage, and fruit. Disease control is essential in the production of high quality water melons. A preventative programme that combines the use of cultural practices, genetic resistance, and chemical control as needed usually provides the best results. Cultural practices are useful for limiting the establishment, spread and survival of pathogens that cause water melon diseases. Many of the fungal, bacterial, and nematode pathogens survive in old crop debris and in the soil. Fields with the proper soil characteristics should be selected.

Common diseases and their remedies

Disease	Symptoms	Control
Verticillium Wilt	Yellowing of the foliage and wilting.	Copper oxychloride 85 WP
Anthracnose	Early signs of infection by this bacterial disease are water-soaked spots on the leaves and fruit.	Mancozeb, Chlorothalonil.
Fusarium wilt	Affects runners of the plant, at advanced stage may cause wilting	Benomyl 50 WP
Powdery mildew	Premature defoliation, and reduced crop growth.	Bavistin, Benomyl 50 WP.
Charcoal rot	Death of crown leaves combined with grey stem lesions.	Apply potassium and phosphorous fertilisers
Downey mildew	Initial symptoms include large, angular or blocky, yellow areas visible on the upper surface.	Polyram DF, Copper Oxychloride 85 WP
Rhizoctonia and soil- borne diseases.	"Damping off", or the Failure of infected seeds to germinate.	Seed dressings with Vitavax Plus or Thiram 80 WP.

Physiological disorders

Physiological disorders are caused by non-pathogen agents that affect fruit quality. Usually, aesthetic quality is negatively affected. The cause can be either one or a combination of environmental, genetic or nutritional factors. Below is a list of some of the common fruit disorders:

- Misshapen melons (gourd-necked or bottlenecked) are frequently produced by varieties with long fruit. Moisture stress is a cause. Occasionally melons of any variety may misshape because they lie on uneven ground or were damaged when small. Misshapen or pear-shaped fruit can also be caused by poor pollination that leads to restricted growth at the stem end because of the absence of developing seeds. Poor pollination can be minimised by increasing the number of beehives in the field. Low temperatures can also cause misshapen fruit.

Misshapen watermelons

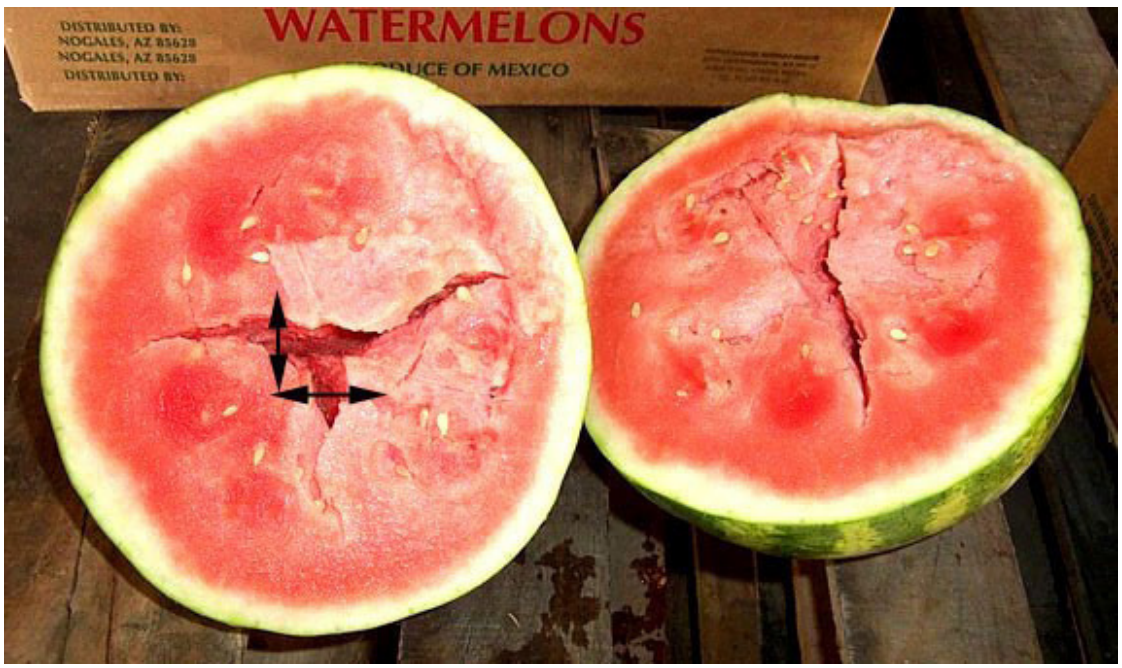
- Blossom end rot is a deterioration of the blossom end of the fruit. The usual order of development is softening, slight shrivelling, browning, blackening with extensive shrivelling, and sometimes secondary decay. Poor calcium nutrition and moisture stress cause blossom-end rot. Hot, dry winds, nematode damage, excessive fertiliser, low levels of calcium in the soil, pruned roots from late cultivations, and other conditions are contributing factors.

Blossom end rot

- Bursting may result from an uneven growth rate, which is particularly associated with heavy rainfall or irrigation when the fruit is maturing. The percentage of bursted fruit is usually low, and types with round fruit are more susceptible.
- White heart consists of white streaks or bands of undesirable flesh in the heart (centre) of the fruit. This is caused by excessive moisture (and too much nitrogen) during fruit maturation.

White heart

- Hollow heart is a disorder that varies among varieties. Hollow heart is marked by cracks in the heart of the water melon fruit owing to accelerated growth in response to ideal growth conditions facilitated by ample water and warm temperatures.



Hollow heart

- Sun Scald (burn) results from exposure to intense solar radiation that leads to dehydration and overheating damage of the rind tissue. Sun Scald can be alleviated by covering the fruit with vines or straw materials. The melons crack when sun scald in unattended.
- Sun burn occurs most frequently in varieties that have dark green rinds. Charleston Grey types and other melons with grey grin rinds rarely suffer from sunburn. Good healthy foliage will minimise sunburn damage as well as favour good yields and quality. Strong winds can blow unprotected vines away from the developing fruit along the edges of the rows and cause full exposure of the fruit to the sun.
- Rind necrosis is an internal disorder of the watermelon rind. Symptoms are brown, corky, or mealy textured spots on the rind which may enlarge to form large bands of discoloration that rarely extend into the flesh. Experienced pickers often can detect affected melons by the subtle knobbiness that is visible on the surface of the affected melons. The cause of rind necrosis is unknown. Bacterial infection has been reported to be a cause, although similar bacteria are found in healthy melons. Drought stress also is reported to predispose melons to rind necrosis.

- Cross stitches are elongated necrotic wounds (2 cm long) that are perpendicular to fruit length. The cause of cross stitches is unknown.

Harvesting

Determining optimum maturity of a water melon can be difficult. Water melons reach harvest maturity five to six weeks after pollination, depending upon variety and season. Varieties may differ in certain characteristics that include maturity. An experienced person can identify a ripe water melon just by glancing at the glossy rind surface. Other indications of ripeness include a change in the colour of the ground spot from white to light yellow, a change of tendrils nearest the fruit from green to brown and dry. Thumping the fruit, a metallic, ringing sound indicates immaturity and a more muffled or dull sounds indicates maturity to over maturity in round-shaped melons. The best method is to cut a few melons in various parts of the field. Harvesting and marketing green or over-ripe melons lessens the damage by the consuming public. Sugar content does not increase after the harvest. However, a red colour will continue to develop after a slightly immature melon is picked.

Harvested watermelons

Harvesting methods

Watermelons do not slip from the vine or emit an odour when ripening. Indicators for picking watermelons include colour change (the most reliable), blossom-end conditions, rind roughness and drying of the nearest tendril to the fruit (less reliable). A sharp knife should be used to cut melons from the vines. Melons pulled from the vines may crack open. Harvested fruit is windrowed to nearby roadways, often located ten beds apart. A pitching crew follows the cutters and pitches the melons from hand to hand, then loads them in trucks to be transported to a shed. Melons should never be stacked on the blossom end, as excessive breakage may occur. Loss of foliage covering the melons can increase sunburn. Exposed melons should be covered with vines and straw as they start to mature to prevent sunburn. Each time the field is harvested, the exposed melons must be re-covered. Most fields are picked at least twice. Some fields may be harvested a third or fourth time depending upon field conditions and market prices.

Marketing

Melons should be cut from the vine rather than pulled, twisted or broken off to reduce the chances of stem decay. Leave a long stem on the fruit. To avoid bruising melons, handle them carefully at all times. Never stand melons on end to avoid bruising and flesh separation from the rind. Do not place melons with the bottom sides turned up as the ground spot is easily sun-scalded. Haul melons from the field in straw or paper padded vehicles to reduce bruising, punctures, and rind abrasion. To help prevent bruising, put them directly into trucks for ferrying to the market, or haul them to a central grading station for reloading and transportation. Melons are usually graded and sized during the loading operation. Traditionally, melons have been bulk- hauled in trucks. The use of containers has gained popularity because they are more efficient in unloading and damage caused by rough handling during loading and unloading is reduced. Bulk bins made of corrugated fireboard and holding around 450 kg as well as cartons holding three to five melons are also used.

Discuss

Review what you have learned in this session then read the summary to check that you have remembered everything.

Summary

- Watermelons belong to the cucurbit family along with water melons.
- They can be grown in deep well drained soils.
- Good crop management is needed for waterelonss which include proper fertilization, irrigation, weed management as well as pest and disease management.
- Water melons reach harvest maturity five to six weeks after pollination, depending upon variety and season.
- When harvesting, watermelons should be cut from the vine rather than pulled, twisted or broken off to reduce the chances of stem decay.

SESSION 11: MARKETING SYSTEMS DEVELOPMENT IN HORTICULTURAL PRODUCTION

11.1 Introduction

Greet each other and review the learning objectives for this session.

LEARNING OBJECTIVES

By the end of this session, you will be able to:

- understand the horticultural value chain
- know where to find information for horticultural crops marketing.
- appreciate the importance of carefully choosing which horticultural crops to produce
- choose the best site for their horticultural production project'
- prepare their site for horticultural production project
- explain the best methods for propagating selected horticultural crops

Discuss

Talk about the following:

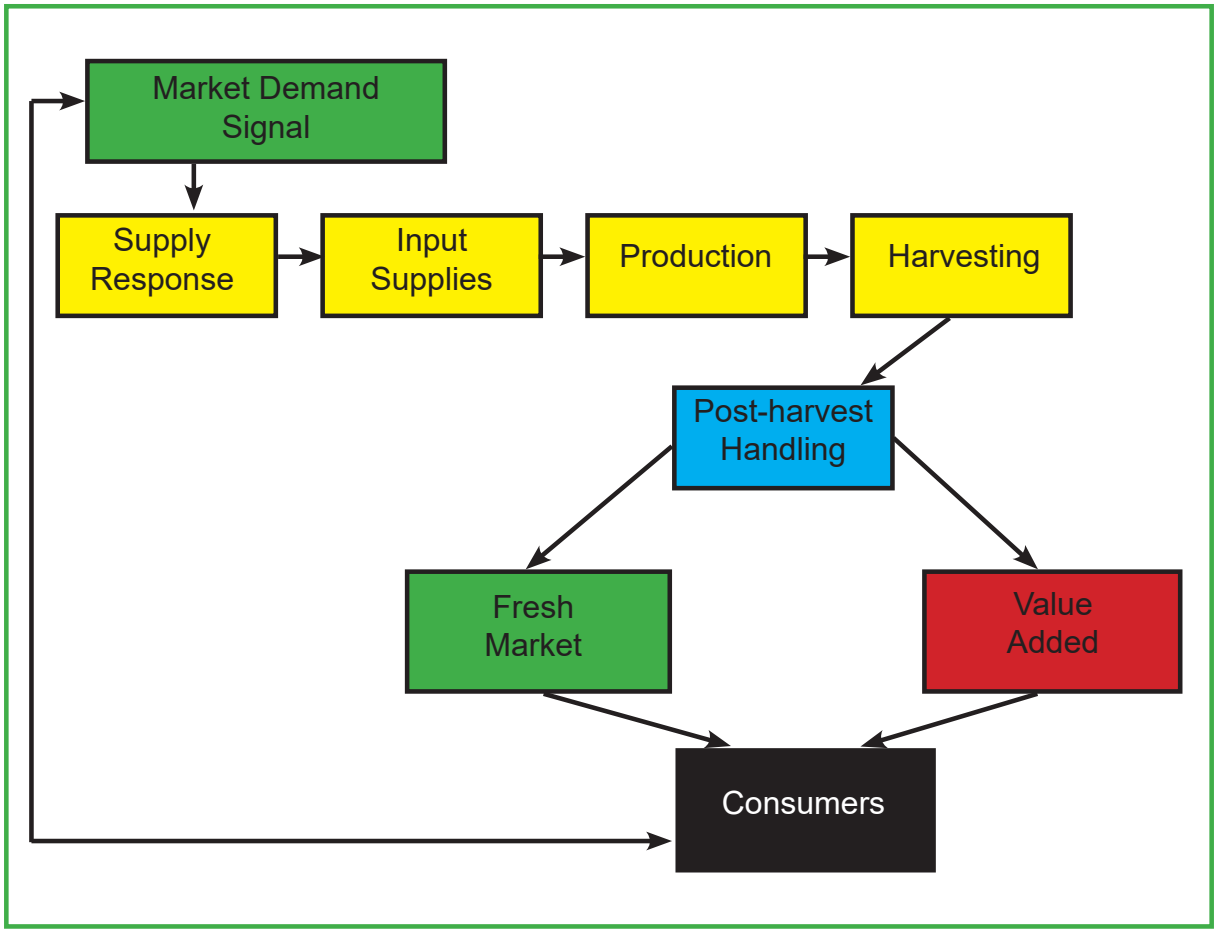
- What are the market options for horticultural crops?
- What are the sources of horticultural crops marketing information?

Now read the next section…

11.2 The horticulture value chain

In the current global market, before a farmer can start production he or she must carry out market research to determine market preferences in terms of varieties, sizes and shapes of different horticultural crops. He or she must then use this information to choose the varieties to produce. An important part of market research is to understand the value chain for your product. The diagram below shows the value chain for horticultural crops.

The value chain begins with a demand which happens when the market shows a need for something. This stimulates producers to supply the product. In order to produce inputs are required. Once the product is harvested it can be graded, packaged and sold fresh to the consumer or it may be processed in some way (to add value) before packaging and selling.



The horticulture value chain

Markets for processing most horticultural crops like vegetables are limited in Zimbabwe. Most of the crop goes directly to local and urban markets. The main markets for horticultural crops in Zimbabwe are urban markets like supermarkets and Mbare Musika, or along main roads. In other cases, size restrictions are placed by the buyer, who, for example, may prefer the smaller grade crops or those with a better shelf-life. Before growing vegetable crops for processing, be sure to contact the potential buyer to determine specific requirements.

The challenge for small-scale farmers is not only to produce optimal yields but also to optimise the price, terms and conditions when they sale their produce or procure farming needs.

11.3 Market research

When carrying out market research you should find out:

- Does the target market prefer only organically produced crops?
- Which varieties are preferred by the target market?
- How much of the product is required per season?
- What are the quality concerns of the target market?
- What sizes and shapes are preferred?

- How are prices offered (per Kg or 20L bucket or bundle or fruit)?

Once the farmer has gathered this information he or she may draw up a production plan and must maintain communication with the buyers updating each other about the stages of his or her produce. Market research is a continuous process.

Price strategy

Price, terms and conditions are key to any business. Small-scale farmers must find out the following:

- Will the price fluctuate or remain constant?
- Where will the farmer get packaging material?
- Who pays for transport and what is the transportation cost?
- Should the farmer get insurance in the case of supplying an export market?
- What are the terms of payment? (cash or credit?)
- Is contract farming an option?

Competition

Another part of market research is to find out the strengths and weaknesses of your competitors (other producers). For a seller to be strong, he or she must take note of the following:

- The best price terms are those that bring about mutual benefit between the seller and the buyer.
- The seller who cheats the buyer generally fails.
- The seller must manage his or her reputation and preserve good relationships with buyers.
- Update your buyer on the progress of your crop. If possible give dates of when they can expect the crop.
- Become well-known for consistence in supply.
- Ensure high quality of produce and consistency in sizes and shape.
- Use appropriate packaging material.
- Offer a competitive price.

Sources of market Information

Newspapers – you may find tables giving prices of different commodities in various markets around

the country.

Radio – you may find programmes which publicise prices and which commodities are in high demand.

Farmer-to farmer – Sharing between farmers is common but may not be very accurate and may be out of date.

Traders to farmer – This is also common but may not be accurate if the trader is trying to get an unfair advantage by telling farmers that prices are low for their product.

Mobile phones – this is a new and effective way of finding out current prices for commodities and finding out what crops are in demand.

Before planting your horticultural crops, prospective growers need to target a market, understand monthly market trends, and identify specific buyers. Prices normally fluctuate from time to time. Nationally, harvest volumes differ with the type of crop and time of the year.

11.4 Building a market plan

There are many different markets for horticultural crops including fresh or processed; domestic, regional and extra-regional. The requirements of different markets vary widely. Building a market plan for horticultural crops requires a clear identification of the targeted market. The use of the product in the targeted markets can be fresh, value added or industrial (e.g. oil, animal feed, starch). In the region, the major market is for fresh produce consumption.

Talk about the following:

- Where do horticultural farmers sell their crops?
- Where there is no market, how could marketing be organised?

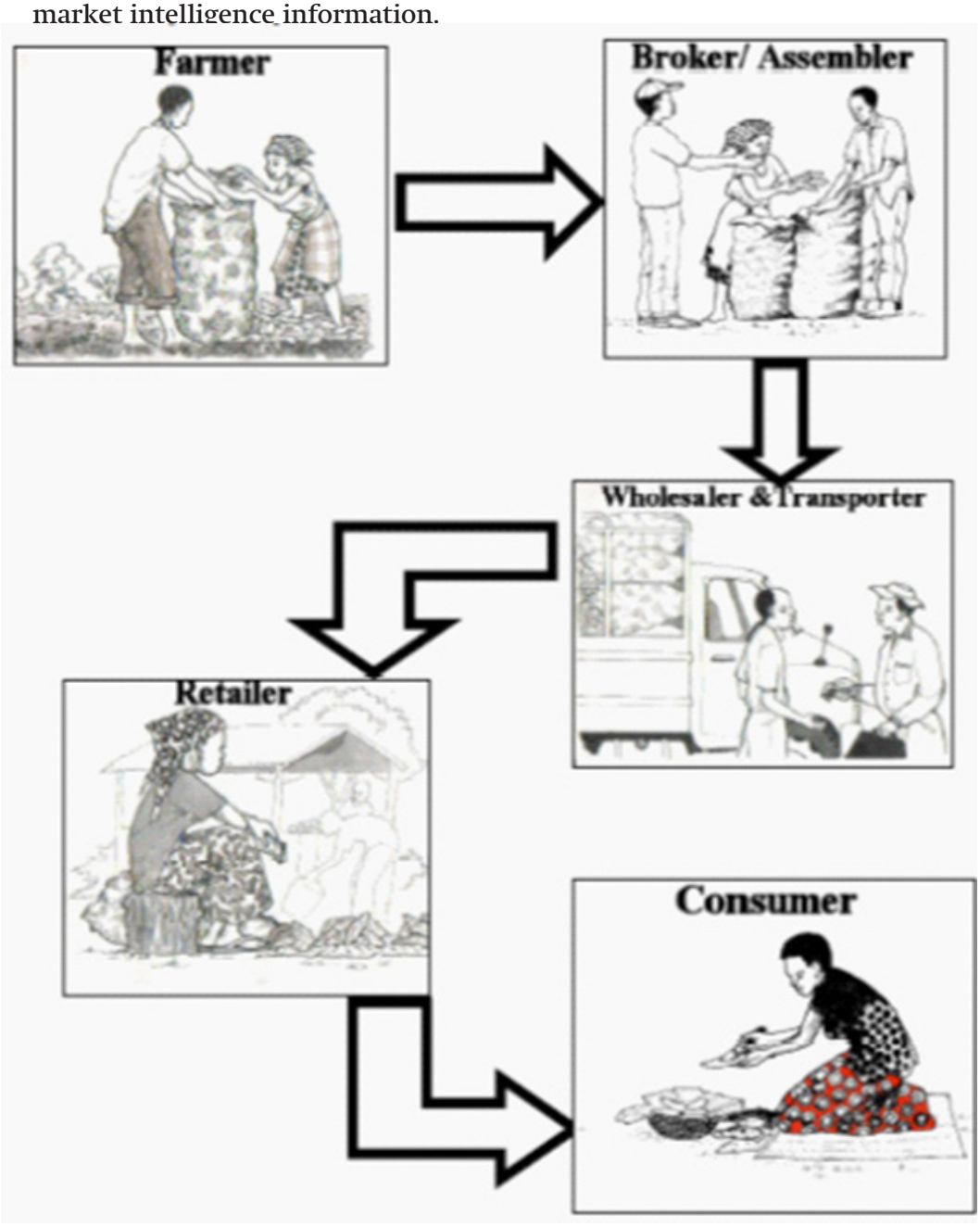
Now read the next section…

11.5 Guidelines for marketing

An in-depth assessment of the markets should be conducted to help the producer to select production systems which are appropriate. Here are some tips:

- Identify the target market
- Determine the volumes required by the market including possible changes in production volumes over time
- Identify the buyer(s)
- Determine the volumes the buyer is willing to take and the frequency of purchase
- Determine and follow the guidelines of the buyers. They know the targeted market segment (i.e. varieties, production and post-harvest practices inclusive of packaging required)

- Build strong relationships along the value chain
- Produce consistently high quality crops at competitive prices
- Ensure that quantities produced are sufficient for the market
- Keep abreast of the changes in the requirements of the market, as they are dynamic. As such, it is also important to link into a market system which provides updated market intelligence information.



The journey of horticultural crops, from the farmer's field to the consumer's table

11.6 Possible market outlets for horticultural crops

The following are possible market outlets for horticultural crops:

Local sales:

This is when a farmer sells to neighbours and around their farm.

Roadside sales:

A number of roadside markets have formed in Zimbabwe and these have become a major outlet market for farmers. Farmers scramble to sell their produce to motorists, passer-bys and passengers in buses.

Retail outlets:

These retail outlets include supermarkets and fruit and vegetable outlets like Pick 'n' Pay, OK, Foodlovers etc.

Major urban markets:

This includes major markets such as Kwekwe, Kudzanai market in Gweru, Mbare Musika in Harare, Masvingo etc. Farmers either go and sell in the farmers market or they sell to middlemen (who often cheat them) and these middlemen then sell to vendors or to consumers.

Mbare Musika in Harare

Wholesale markets:

Wholesale markets include fresh produce wholesalers often located in towns like FAVCO. Unfortunately, most such fruit and vegetables wholesalers are no longer functioning as before.

11.7 Starting a horticultural production project

Talk about the following:

- What do you need to think about when choosing the best crops for your horticultural production project?

Now read the next section…

Horticulture is a business and varietal selection plays a crucial role in unlocking its profitability. It is one of the earliest and most important decisions a vegetable grower makes at the onset of every planting window. A grower must live with this single decision all season long from seed sowing all the way to produce marketing.

Choosing the crops

The first step in starting a garden is to plan what you are going to produce during the year. If you are growing vegetables for market then you need to find out what vegetables are popular for your customers and what kinds of prices you can expect for the vegetables at different times of the year. It is also important for you to know who you are going to market to. Will you be selling to friends and neighbours from your home? Will you be setting up a stall on the roadside? Will you be selling to a stallholder or vendor at a market? Will you be selling to a supermarket? Before choosing your crop, you must think about:

- How long the crop takes to mature – this will help you know what time of year you are likely to be selling the crop and you can inform your customers.
- What inputs (seed, fertilisers, irrigation equipment etc.) will be required to produce the crop – this will help you know how much you are going to spend on the crop. If you compare this with the price you expect from selling the crop you will be able to see whether producing this crop is viable or not.
- How perishable the crop is (how long it will keep before you must sell it. Leaf crops need to be sold the day of harvesting, carrots and onions last a few days if stored correctly, but onions and pumpkins can last for many months before they need to be sold.

Talk about the following:

- What is the ideal site for your chosen horticultural crops?
- Which areas should you avoid?

Now read the next section…

Choosing the site

Choose a suitable area for your horticultural project based on the requirements of the different crops. Ideally you should find an area that has fertile, well-drained, loam soils (not too heavy and not too light) with an optimum pH of 6.5 (see more information on soil sampling and testing in the next session). The site should be close to your water source but not closer than 30m to a river or wetland because of the danger of soil erosion.

The area should be large enough for your beds as well as having an area for: the nursery or seedbed, compost and harvesting/ curing. If you do not have a flat area you may need to make contour ridges or terraces if it is very steep. Avoid sites in low-lying areas as they may be affected by frost in winter.

Sun and shelter

The area should be in a sunny position but should be sheltered from wind. If it is not sheltered then you will have to make a windbreak. This can be a fence made from dry grass which can eventually be replaced by plants such as bananas or sugar cane. It should be made at least 6m away from the nearest crop. The area should be protected from livestock. If it is not protected then you will have to make a fence. The windbreak can double up as a fence.

Making a map

Once you have chosen your area it is a good idea to draw a map of the area and work out how many beds you can fit in, which direction the beds are going to face and where you are going to locate other activities such as the nursery, seedbed and compost area.

Site clearance and preparation

All large plants should be removed from the area where you want to make your beds however you should leave some trees around the edge of the area to make a windbreak. You can also leave trees to provide shade in the compost area and the nursery area.

Use trees that you have chopped down to make a strong fence around the garden that can keep out all livestock including chickens. Use any small plants, weeds or leaves to make compost.

Remove any stones and level land where it is not flat. You should also level termite mounds. The soil from these mounds is rich in minerals and can be spread on the vegetable beds to improve fertility.

Preparing beds

Beds should be laid out using pegs and string to ensure that space is not wasted. A good size for a bed is 1.2m wide by 5m long with 50cm paths in between. The soil of the bed should be loosened to 20cm depth with a fork or hoe. Try to avoid turning the soil or mixing the layers. The soil can then be levelled using a rake. Make ridges at the edges of the beds to define them and contain the soil and water. Add one and a half buckets of well-rotted compost per 1m of bed to the surface of beds at least two weeks before planting.

Generally, the beds help in soil moisture conservation and also in managing drainage in waterlogged conditions. However, there is this option of using ridges without beds, especially for vegetable crops like tomatoes and cabbages. This also saves time required for land preparation.

Row layout

Depending on the type of crop you have two options for row layout:

For large, heavy feeder crop (such as tomatoes, spinach, covo or okra) crops make two rows, 60cm apart in each bed with 30cm to the edge of the bed.

For smaller light feeder crops (such as onions, garlic, carrots or bush beans) make four rows per bed: If using a drip kit mark each row 15cms each side of each dripline.

The nursery and compost area

Compost is going to be a very important part of your vegetable production project. Choose a site with enough space to make three compost heaps, each 2m x 2m square with 1m paths in between. This will give you enough space for collecting compost materials and turning the compost heaps.

Most vegetable growers use wither a nursery or a seedbed system. A nursery is a special place (usually a raised structure with a roof) where we raise small plants (seedlings) before they are transplanted to the beds. The advantage of a nursery is that seedlings can be given all of the nutrients and protection that they need until they are strong enough to be planted in the main beds. This increases their productivity and saves you money because most seeds that you plant will survive and turn into adult plants. A nursery or seedbed area should be shaded, protected from wind and must be close to the sources of water and compost.

Discuss

Talk about the following:

- How have you raised vegetables before?
- Have you used a seed bed or nursery method?
- What successes or challenges did you face?

Now read the next section…

Vegetable propagation

In order to grow well, young plants need cool, moist conditions and protection from pests and diseases until they become strong enough to survive on their own. Some vegetable types should be planted in containers in a nursery. Others such as peas, beans, pumpkins, cucumber and squash cannot be grown in containers and must be planted directly into beds.

Some vegetable seeds (such as those of carrots and onions) are small so be careful not to plant them too deep. The best way to avoid this is to sprinkle the seeds onto the surface of the soil and then cover with a 15mm layer of soil followed by a thin layer of grass or leaf mulch.

Planting seeds

In order to germinate successfully, seedlings need soft, fertile soil. Make soil for seedlings by mixing four buckets of loamy soil, one bucket of well-rotted compost and one bucket of river sand. Sieve the mixture to remove any stones, twigs or clods. Pack the soil into old plastic or metal containers which have drainage holes in their base. Line containers with a thin layer of stones, then fill them to a height of 7.5cm with the soil mixture. After filling the container pour boiling water over the soil to kill pests or diseases. Wait for the soil to cool before planting seeds in it.

Plant the seeds in rows, about 5cm apart, with seeds not more than 1cm deep. Place a thin layer of fine dry grass or compost over the surface of the soil. Water the seedlings. Make a label for the container stating the crop variety and the date of sowing. When the seedling is 10-15cm high it is ready for transplanting. If you do not have space in your garden for the seedling, transplant it into a larger bag or container until space becomes available.

Discuss

Review what you have learnt in this session then read the summary to check that you have remembered everything.

Homework

Visit the new site for a horticultural production project of one of the members of your group. Discuss the characteristics of the area and give advice about how to improve the site for vegetable production.

Summary

- Before you plant your horticultural crops, study your market and develop a market plan.
- In your market research find out who your target market will be, what they expect in terms of quality and quantity and what you can expect in terms of price.
- You can get information about prices from newspapers, radio, other farmers or buyers or mobile phone systems.
- You should also find out what your competitors are doing and try to improve on their projects.
- Before starting a horticultural project, it is important to choose which crop you are going to produce considering the crop requirements and the market requirements.
- The site which you choose for horticultural production should satisfy all of the crop requirements for water, soil fertility, sun, shelter and protection from predators.
- Good fencing is very important for a horticultural production area to prevent crop damage from livestock.
- When clearing the site make sure that you leave enough trees to provide a windbreak as well as shade for the nursery and compost area.
- When planning your site, it is a good idea to make a map to help plan how many beds you can fit into an area as well as the location of the compost and nursery areas.
- Young plants need special growing conditions. By starting a nursery, you can improve the success of your vegetable production project.

Appendix 1: Natural pest and disease remedies

The following recipes are taken from: Natural Pest & Disease Control by Henry Elwell and Anita Maas. Natural Farming Network (1995).

Apple of Sodom *(munhundurwa, intume)* spray

Use on ants, cutworm, red spider mite and termites.

- Cut 10 -15 fruit into four pieces.
- Soak in 1L of water for 24 hours
- Spray the affected crop.

Basil spray

Use on soil born pests and diseases or as a fungicide.

- Crush basil leaves. Soak in water for 24 hours. Pour on soil around plants on seed bed before planting.
- Use dry leaves to make a dusting powder.
- Plant basil in beds as a repellent.

Black jack *(muuwu, ucucuza)* spray

A general repellent spray for most insects.

- Crush seeds. Boil in water for 5-10 minutes. When it has cooled use as a spray or pour on soil around affected plants for soil pests.

Baking soda spray

Controls downy mildew and rusts

- Mix 100g baking soda with 50g green soap. Dilute with 2L of water and spray infected leaves. Do not use on hot days.

Castor oil plant *(mupfuta, umhlafutho)* spray

Spray for aphids, caterpillars, cutworm, mites, stinkbugs, termites, nematodes, fleas, lice, moles, fungi, anthracnose, brown patch, damping off and root rot.

- Soak crushed green seeds and leaves in water for 24hours, filter and spray.
- Dry green seeds and leaves and grind for dusting powder.
- For cutworm, place 4 cups of crushed shelled seeds in 2L water. Boil for 10 minutes; add 2 tea spoons of paraffin and some soap. Dilute to 10L and water immediately into the soil.
- Put green seeds into mole holes or rat nests as repellent.
- Dig seeds or leaves into the soil to kill fungal diseases.
- Mulch with branches and leaves to repel termites.

WARNING: poisonous to people and poultry

Cassava spray

A very effective treatment for nematodes.

- Crush cassava roots and dilute the juice with equal amount of water. Spray soil immediately.

Chilli and garlic spray

Used as a general spray for all insect pests.

- Grind up five red chillies and five cloves of garlic. Pour in half a litre of boiling water. Leave to soak overnight. Add a teaspoon of dishwasher or washing powder or green soap or 1tsp paraffin or cooking oil.
- Spray affected part but should not be used on legumes as it repels soil bacteria

Cooking oil and soap spray

Spray for aphids, caterpillars, flies, insect eggs, red spider mite, scale, trips and whitefly.

- Mix 20ml cooking oil with 100g green soap in 15L water.
- Spray at cool times of day to avoid leaf scorch.
- Avoid spraying soft leaved plants such as tomatoes and cucurbits.

Flour and sour milk spray

Spray for ants, aphids, beetles, bugs caterpillars, cutworm, and eggs of insects, mites, trips, white fly and club root.

- Mix 4 cups flour, half a cup of sour milk and 20L of water. Spray plants.

Garlic or onion powder

For bean rust, tomato blight, mildew and scab.

- Used dry crushed bulbs as dusting powder.
- Should not be used on legumes.

Lantana *(mbarapati, ubuhobe)* spray

A general repellent spray for most insects.

- Crush 1 handful of leaves in 1L water. Add little soap. Spray affected plant.
- Burn lantana branches and use the ash to dust over beetles and leaf miner.

Liquid manure spray

Spray for aphids, bugs, birds, caterpillars, cutworm, fruit flies, grasshoppers, mites, thrips, fungal, bacterial and viral diseases.

- Mix 3 tablespoons vinegar, 3 tablespoons liquid soap, 2 tablespoons liquid manure and 10L of water. Spray plants.

Mexican marigold *(mbanda, imbanje)* spray

Controls fungal diseases, nematodes, termites, ants, aphids and grain storage pests.

- Collect one mature plant (before it has flowered). Crush and soak in 2L of water for 24 hours.

Filter and spray.

- Allow some mature plants to remain in beds to repel nematodes. Cut the leaves and dig them into the soil to repel ants and control soil diseases.
- Plant Mexican marigold around gardens to repel insects and soil pests.
- Dried plants can be used to repel grain storage pests in grain bins.

Milk spray

Controls red spider mite, fungal and viral diseases.

- Use 1L milk, diluted with 10-15L water. Spray affected plants. Repeat after 10 days.

Onion spray

Used as a general spray.

- Soak 10-100g onion in 1L of water for 4-7 days. Spray plants.

Pawpaw spray

Can be used to control aphids, bugs, caterpillars, cutworm, root-knot nematodes, termites, coffee rust, powdery mildew, and rice brown leaf spot.

- Add 1kg finely shredded leaves to 1L of water and shake vigorously.
- Filter, then add 4L of water, 2 teaspoons of paraffin and about 20g soap.
- Spray or water into the soil for cutworm.
- Extract the juice from green fruit to control termites.

Rubber hedge sap spray

Effective spray against red spider mites

- Spray with 10 drops of rubber hedge sap in 1L of water.

Salt and vinegar spray

- Spray for aphids, cabbage worm, caterpillars, slugs, snails and whitefly.
- Mix 1 teaspoon of salt with 20ml vinegar, one litre of water and half a teaspoon of soap. Spray affected plants.

Soap spray

Spray for aphids, caterpillars and whitefly.

- Use 50g (10 teaspoons) green bar soap dissolved in2-5L water. Spray plants

Soap powder spray

Spray for armoured crickets, army worm, caterpillars, leaf miner.

- Add 1 tablespoon of soap powder and 1 and a half teaspoons of bar soap to 1L of water. Spray plants

Squashed pest spray

This is a general spray for many pests

- Mix one handful of crushed pests into 10L water. Add a little liquid soap. Leave for 12-24 hours.
- Spray on affected plants

Starch spray

Spray for aphids, caterpillars, spider mites, thrips and whitefly.

- Boil potatoes or cassava. Reduce liquid by boiling until gluey starch is left in the pot.
- Spray pests when starch has cooled.

Sugar spray

An effective treatment for nematodes.

- Pour a mix of 2kg sugar in 5L of water on the affected soil.
- After 24 hours, flush the sugar out of the soil with plenty of water.

Tephrosia spray

Crush 50 leaves in 1L water.

- Leave for 24 hours. Filter, and then spray plants.
- Warning – this spray is toxic to all insects.

Tomato leaf spray

This is a general spray for most insects.

- Soak tomato leaves in water for a few hours. Filter and spray
- Or place tomato leaves over cabbage heads at night to repel caterpillars.

Urine spray

Spray to prevent aphids, caterpillars, cutworm, mealy bugs, mites and thrips, and plant diseases.

- Collect cattle/ goat or donkey urine. Leave overnight in a bottle to ferment.
- Dilute 1 part urine with 1 part water.
- Spray on a warm day.

Zumbani spray

Spray for ants, aphids, caterpillars, termites and whitefly.

- Crush leaves and branches of zumbani. Leave to soak in water for 2-3 days. Add a little soap. Spray plants.

Appendix 2: Natural controls for pests and diseases

Pest/ Disease	Description	Method of Control
Ants	Small, black ants usually do not attack plants but they may build their nests around the base of some crops especially beans and carrots Ants often encourage aphids which attack crops. Ants drink the sweet liquid produced by aphids. This liquid can lead to bacterial and fungal diseases on leaves.	• Apply grease or petroleum jelly, dung or clay to trunks and stems. • Mulch with ash or fine powder. • Spray with Mexican marigold, chili and garlic, garlic, lantana, Zumbani (umsuzwane), blackjack. • Intercrop with garlic. • Place garlic cloves or chopped onions in ant holes. • Dust with chilli powder at base of plants.
Aphids, also spider mites, thrips and whitefly	These tiny sucking insects attack most vegetables. Some are winged, others wingless. Grey and green aphids attack rape, covo, tsunga and cabbage. Black aphids eat bean leaves while tomato aphids are often green. Aphids may spread viral dis- eases. They prefer hot times of year.	• Avoid use of manures and fer- tilisers, especially liquid ma- nure. • Avoid over-watering plants. • Intercrop with garlic, chives, marigold, nasturtiums, onions and milkweed. • Use any of the following sprays: flour and sour milk spray, cooking oil and soap spray, salt and vinegar spray or spray with liq- uid or bar soap diluted in water, liquid manure spray, onion spray, tomato spray, lantana or zumbani spray.
American bollworm	This caterpillar grows about 3.5cm long and feeds on buds, flowers and fruit of beans, crucifers, cucurbits, groundnuts, maize, peas, potatoes and tomatoes.	• Handpick caterpillars and crush. • Use squashed pest spray, soap spray or starch spray. • Dust caterpillars and plants with lime. • Send chickens into the garden to eat caterpillars. Remove birds before they damage crops.

Beetles and bugs (bagrada bug, CMR beetle, tip wilters)	These tiny sucking insects attack most vegetables. Some are winged, others wingless. Grey and green aphids attack rape, covo, tsunga and cabbage. Black aphids eat bean leaves while tomato aphids are often green. Aphids may spread viral dis- eases. They prefer hot times of year.	• Intercrop with repellent plants • Use chili and garlic, spray pawpaw spray or blackjack spray. • Make barriers around the stems of affected plants with mineral oil or other sticky substances. • Hand-pick and squash adults. Use the squashed bugs to make a repellent spray.
Cabbage webworm	These small greenish-yellow caterpillars attack the leaves of brassicas. They make white web-like cocoons and turn into grey moths.	• Dust leaves with flour, ash or lime. • Use the following sprays: blackjack, castor leaf, cooking oil, garlic, mexican marigold, pawpaw, salt and vinegar, starch, tomato, urine, zumbani (umsuzwane). • Intercrop brassicas with garlic. • Use onion spray
Crickets (Armourd crickets)	There are many species of cricket. Some are brightly coloured. They can become serious pests if there are large numbers of them, eating practically anything in their path.	• Plant millet or sunnhemp as a trap around the garden. Slash crop when crickets are seen. • Trample or beat insects with brooms. • Use soap powder spray. • Make traps by pouring old beer into small bowls. Place in beds. • As a last resort send chickens or other poultry into the garden to eat crickets. Remove before they damage crops. • Use blackjack spray
Codling moth	This is a type of caterpillar.	• Paint trunks of trees with a paste of cattle manure and clay. Use it to seal wounds and cuts after pruning.

Cutworm	These greyish caterpillars spend the day in the soil. At night they feed on the stems of seedlings by cutting the stem with their bodies. They do not seriously damage adult plants. They attack beans, crucifers, cucurbits, groundnuts, maize, onion, peas, potatoes, tomatoes and many other crops.	• Grow seedlings in containers rather than seed beds. • Transplant seedlings only when the stem is too wide or strong for the worm to cut. • Improve the soil using plenty of well-rotted compost. • Use lime on acid soil to repel. • Use mulch of repellent plants. • Use poultry to clear beds before planting. • Transplant seedlings only when the stem is too wide or strong for the worm to cut. • Protect individual plants with barriers made from sticks pushed into the soil. • Make pawpaw leaf spray from 1kg shredded pawpaw leaves shaken in 1L of water. Filter and dilute in 4L of water. Add two teaspoons of paraffin and a little soap. Spray the soil.
Diamond Back moth	The caterpillars are about 12mm long, green and feed on the under- sides of leaves. They attack rape, covo, tsunga and cabbage. They at- tack throughout the year, especially in hot dry weather. The adult moth is 7-8mm long.	• Intercrop crucifers with tomatoes, onions or basil to repel moths. • Spray the upper surface of leaves with garlic, tomato or basil. • Dust caterpillars with ash. Spread rings of ash around plants. • Spray undersides of leaves with blackjack, castor, cooking oil, garlic, Mexican marigold, pawpaw, salt and vinegar, starch, tomato, urine or zumbani.
Fruit fly	Fruit flies are tiny insects which lay their eggs in most fruit including pumpkins, squash and cucumbers. The eggs hatch into tiny maggots which feed on the fruit.	• Collect and bury all fallen fruit or feed them to livestock. • Spray the fruit with repellent sprays such as chilli and garlic, tomato leaf and Mexican marigold. • Spray flies with spray made from soaked residue of finger millet.

Grain and seed storage pests (such as weevils and borer)	These tiny beetles feed off grain.	• Place dried lavender leaves in grain/ seed storage containers. • Line storage containers with dried, crushed Mexican marigold plants or zumbani (umsuzwane) leafy branches. Or sprinkle Mexican marigold powder between layers of stored grain. • Line storage containers with a layer of 3-5 cm of leafy Zumbani branches.
Grasshoppers/ locusts	These are long-legged jumping in- sects. There are hundreds of different species of grasshoppers and locusts. Some are tiny and some are over 10cm long. Some can fly.	• Plant millet or sunnhemp around the garden as a trap. Slash and trample crop when locusts are observed in the trap crop. • Intercrop vegetables with marigolds. • Use ash mulch. • Use Tomato or tephrosia spray. • Trample or beat insects with brooms. • As a last resort send chickens or other poultry into the garden to eat locusts. Remove before they damage crops.
Leaf miner	These tiny grubs burrow into leaves making white or grey tunnels. The adult is a small fly. Vegetables which are commonly attacked are legumes, spinach, tomatoes.	• Make sticky traps - yellow boards painted with a sticky substance such as oil or tree resin. Place on sticks about 60cm high. This will trap the flies. • Hand picking - squash worms in their tunnels in leaves. • Use soap powder spray or lantana spray.
Leaf roller	There are many types of leaf roller caterpillars of different shapes and sizes and attack a wide range of vegetables. They make a protective cover for themselves by folding the edges of leaves over and sticking them down. They then eat the leaves beneath.	• Dust caterpillars and plants with lime or ash. • Use the following sprays: blackjack, castor leaf, cooking oil, garlic, mexican marigold, pawpaw, salt and vinegar, starch, tomato, urine and zumbani (umsuzwane). • Intercrop brassicas with garlic.

Maize stalk-borer	This insect larva lives in the stems of maize plants.	• During the dry season, compost crop residues or feed to livestock. If residue is left as mulch, chop maize stover into small lengths to expose the larvae to the sun. Practice rotations with wide gaps between members of the grass family. • Block central funnel of the maize plant with dry soil. Pour soil into the area where the leaf meets the stem. This suffocates the pest. Use the method when maize plants are small and re- peat when they have grown larger.
Mealybug and scale insects	These are sucking insects which attach to stems of plants.	• Control ants which protect these insects. Wipe insects off plant by hand. • Spray plant with light oil or chili and garlic. • Encourage predators such as wasps, ladybirds, spiders, dragonflies and mantids.
Nematodes	These tiny worm-like creatures live in the soil. Most species are beneficial but some enter roots and damage crops such as legumes, carrots, cucurbits, spinach, onions and tomatoes. Plants which are attacked have swollen roots with cracks and dead spots.	• Keep soil organic matter levels high. • Practice crop rotation. • Plant barriers of sunnhemp and Mexican marigold around the garden. • Avoid digging and ploughing. • Intercrop with garlic, cassava, leeks, mustard, onions, pawpaw, marigolds. • Pour a mix of 2kg sugar in 5L of water on the affected soil. After 24 hours, flush the sugar out of the soil with plenty of water. • Make spray from pawpaw leaves or tomato leaves. • Crush cassava roots and dilute the juice with equal amount of water. Spray immediately.

Red spider mite	This tiny, red mite, with eight legs, makes webs. Sometimes it is mis- taken for a disease in early stages of attack. It is found on lower sides of leaves of tomatoes and other members of the tomato family. It is often spread from cotton or tobacco fields. Most usual period of attack is during hot, dry weather.	• Practice crop rotation and intercropping especially between host plants such as cotton, tomatoes and brassicas. • Plant crops close together and water regularly. • Plant a hedge of pigeon pea round the garden to encourage predators. • Intercrop tomatoes with onions or basil to help repel and to create a moist microclimate. • Mulch soil to increase moisture retention. • Remove and burn heavily infest- ed plants. • Use chilli and garlic spray mixed with soap, sour milk and flour to increase stickiness. • Use Apple of Sodom spray, milk spray or rubber hedge spray
Slugs and snails	These are soft-bodied creatures that breed in wet conditions.	• Mulch with ash or fine powder. Sprinkle grains of salt on slugs or snails. Rotate poultry throughout vegetable garden to get rid of infestations. Dust affected areas with dry builder's lime or mix lime and water leave to stand for a few days. • Spray plants.
Termites	These insects live in nests and are about 15mm long. Most termites do not intentionally eat living plants. However, when no other food is available they may damage crops. At dry times, mulch may attract termites which may damage crops especially seedlings or weak plants.	• Use the crushed pods of snake bean (*Swartzia madagascarensis*) or long pod cassia either placed directly around the infested soil or a water extract of the crushed pods is poured into the ground. Soak the crushed pods in water for 2 hours or longer, even over- night. • Blackjack spray. • Intercrop with garlic. Use garlic spray. Place garlic cloves or chopped onions in ant holes. • Spray with juice from immature paw-paws.

Thrips	These are tiny black, brown or yellow sucking insects. Attack is worst during hot dry times of year. They mainly attack onions and garlic but sometimes go for tomatoes, and other crops. Onion thrips can spread tomato spotted wilt virus.	• Dust leaves of crops with ash or clay dust. Repeat after watering or rain. • Spray with flour and sour milk, starch spray, urine, cooking oil, soap, onion, chilli and garlic. • Make sticky traps with yellow boards painted with sticky sub- stances. • Use onion spray
Whitefly	Tiny white sucking insects.	• Use the same methods as for aphids • Intercrop tomatoes with basil. • Use blackjack or onion spray

Appendix 3: Chemical control of pests and diseases

Pests

Aphids

To control aphids, you must also control back ants which attract aphids, scale and mealy bugs. Ants encourage these pests to attack the soft parts of plants and they protect these pests from attack by other insects. Control black ants by placing a ring of ash around each crop plant.

Control aphids by spraying with Dimethoate (Rogor), 40% EC at 75ml in 15L water. This will be enough for an area 100m x 10m (1000m2). Wait two weeks (harvest interval) after spraying before harvesting. Other chemicals include Malathion 25 WP and Thionex 35 EC.

Bagrada bugs

These damage the leaves of the crop so that they look as though they have been burned. Control them using Dedevap (Dichlorvos) at 15 - 20ml in 15L of water. This is enough to cover an area 1000m2 (100 metres x 10 metres). You can also use is Carbaryl, (mix 30 grams in 15L of water). Always read the label for full instructions.

Cut worms

Cut worms are a common problem for seedlings. To control, use Karate at 100 ml/100L water spray at the base of the plant, this will give the best results. Carbaryl 85 WP at the rate of 150 -200g/100L, applied in the planting hole, is also recommended. Pyrinex 48EC at a rate of 200ml in 100L of water drenched soon after transplanting using cup 30/plant is also recommended.

Diamond Back Moth

This is one of the insect pests which gives problems in the cabbage family, in particular from August throughout the rainy season. The adult is a moth (small butterfly) but the damage is from small bright green caterpillar which causes short holes in the leaves. This builds a web (cocoon) which makes its control difficult because sprays will not reach it.

Chemical control: DDVP, Dichlorvos 1000: apply at 100ml/100L water as a high volume, full cover spray and repeated at weekly intervals if necessary. The harvest interval is three days. Dichlorvos 1000 will also control aphids, caterpillars and whitefly. Endosulfan 50 WP: spray at 100g + 30ml Sanawett 90/100L water. Apply as a high volume, full cover spray in at least 100L mix/ha and repeat at seven to ten day intervals as necessary. The harvest interval is seven days.

Methamidophos 600 SL at 100ml per 100l water as a full cover spray repeated weekly if necessary. Do not harvest for at least 21 days after date of last application. Methamidophos will also control aphids and caterpillars.

Malathion 25 WP at 20g + 30ml Sanawett 90 per 100L water as a full cover spray applied in at least 1000L mix/ha and repeated at 7-10 day intervals before harvesting. It can be used to control the larva.

Heliothis bollworm

This fruit caterpillar feeds on tomato leaves and fruit. It causes distorted leaves. The moth lays its eggs on tomato leaves and the caterpillars feed on the leaves and fruit, causing extensive damage. The colour of the caterpillar varies from greenish-yellow and reddish-brown or even black with paler stripes run- ning lengthwise down the body. It is controlled by using Methamidophos 585 SL at 500ml/ha, (harvest interval three days). Carbaryl 85 WP can also be used at 200 g/100L water full cover spray (harvest inter- val seven days), or Thionex 35 EC at 190 ml/100L water full cover spray (harvest interval 1 day).

Leaf Hoppers

These are small flattened green insects with transparent wings. They are very active in hot weather and cause damage to carrots. Apply: Malathion 1% Dust at 100 -175 g/10m2. Harvest interval is 3 days. Malathi- on 25% WP at 200 g/100L water. Harvest interval is 7 days and Malathion 1 Dust at 100-175g/m2, Harvest interval is 3 days. Repeat sprays as necessary. These sprays will also control red spider mite.

Leaf miner

The adult insect punctures the leaves especially at the leaf tip and along the leaf margins. The larvae, tunnels into the leaf. The effect is reduced growth in the plant as well as leaf drop, which can result in lack of shading and sun scalding of fruit. Wounding of the leaves also allows entry of bacterial and fungal diseases. Use sprays of Cyromazine 75 WP at 150 g/ha or Abamectin 18 EC at 100 ml/100L water. Both products have a harvest interval of three days. The tuber moth adult can be controlled by spraying with Methamidophos 585 SL at 100 ml/100L water or 500 ml/ha. Leaf miner attack often predisposes plants to infection by early blight.

Nematodes

Nematodes are small worms that cause a lot of damage to the roots of crops especially in sandy soils. They can be controlled by crop rotation and the use of resistant varieties. Adding organic manure to the soil has been reported to reduce nematodes.

Chemical control is with Nemacur granules at 10g/m^2 or Nemacur 400 EC at 18 to 20ml mixed. However, the chemicals can be very expensive. For attack on carrots, fumigation with EDB 45, EDB 92 or EDB Tech is advisable on light soils.

Red spider mite

This small orange to red mite has eight legs like a tiny spider and sometimes makes webs on the plant. This is a very serious sucking pest which causes wilting and spots on the leaves. When plants are severely infested, the best way to control is to remove and burn the plants. Also remove any weeds that might host red spider mite. Many chemicals can be used to control it, such as Kelthane at 15ml mixed in 15L of water, dicofol, diazinon and amitraz (check rates on labels). We need to rotate the chemicals as these insects build resistance.

Thrips

Thrips are small sucking insects shaped with a point, with hairy wings. They suck sap causing dying of leaves and they also spread diseases. They are one of the most common and troublesome pests in onions. They feed on the young leaves causing them to turn silver in colour. Thrips can reduce onion yields to very low levels. Any of the control measures mentioned for aphids also use to control thrips, although thrips are more difficult to control because they hide in buds and leaf sheaths.

For chemical control use Malathion, Dichlorvos (dedevap), Monocrotophos, Cypermentrin and Endosulfan (Thiodan or Thionex).

Adult thrips can be trapped by hanging blue or yellow boards painted with a light coating of engine oil, resin or glue.

Whitefly

Like aphids, whiteflies have piercing-sucking mouthparts. Direct damage to tomato plants causes deformed new growth and wilting, yellow leaves. Whiteflies can also transmit some plant viruses. If your plant gets infected with a virus destroy it. Whiteflies, like aphids, secrete honeydew, often causing sooty mould to grow. Feeding by whiteflies can also cause deformed fruit and discoloration of tomatoes. Is becoming more common especially under greenhouses. Control using Imidacloprid 200 SL at 50 ml/100l water. Apply as a 300 – 500L/ha mixture. Chess 50WG is recommended at 600g/ha (harvest interval three days). Actara 25WG at a rate of 400g/ha spray or 0.02g/plant drench is recommended (harvest interval seven days).

Disease control

Alternaria leaf blight (*Alternaria dauci*)

Leaf blight is a common disease of carrots in Zimbabwe. It occurs mainly during wet weather in summer, with prolonged heavy dews frequently promoting severe outbreaks. Dark brown to black spots, some with yellow edge, appear on the leaves. The spots at first appear mainly on the leaf edges, where they merge, so that the leaves assume scorched appearance. Older leaves are more susceptible than younger ones. The fungus can be transmitted with seed, and may cause damping-off of the seedlings. Control: plant cultivars that are tolerant to the fungus ensure the seed is disease-free that is certified seed. Practice strict crop rotation programme. Spray with: Dithane(R) M-45 (Mancozeb) at 200 g/100L water prior to the onset of rains and repeat at 10 - 14 day intervals throughout the wet period. Harvest interval is 3 days. Flower Power at 500-800 g/100L water is another good option.

Bacterial canker

Infected seedlings will either die or produce weak, stunted plants. Infected seedlings may also develop into healthy-looking plants that do not show disease symptoms until they are set in the field. The early symptoms of the disease are wilting, curling of leaflets and browning of leaves, often only on one side of the plant. As the leaves die, the petioles

(leaf stems) remain green and firmly attached to the stem. A cut through the stem shows yellowish brown discoloration. Small white or yellow spots appear on the fruit. Control: Bacterial canker is one of the most difficult tomato diseases to control. Soaking the seed in hot water before planting can help. Use only certified, disease-free seed and seedlings. Never save seed from a source known to have had bacterial canker. It is difficult to distinguish between infected or healthy seedlings at the time of transplanting. Fixed copper sprays may help in protecting healthy plants, particularly if only superficial symptoms are present. Practice strict crop rotations and sanitation.

Bacterial speck

This is another common bacterial disease in tomatoes production. It happens to plants during rains and cool weather. The diseases can attack the whole plant including the fruit. On leaves, it will appear as brown spots surrounded by a yellow ring. On fruits, we will see black raised spots resulting in a rough appearance on the fruit skin. Control with chemicals such as copper oxychloride and mancozeb.

Bacterial spot

This usually appears as dark-brown raised spots on the fruits becoming sunken and rough to the touch. The disease is carried through seed and infection only occurs during wet weather. To control we should practice hygiene during seed bed preparation and planting. Also use fungicides like, copper oxychloride at 45g mixed in 15L water.

Bacterial wilt

This causes a sudden dying of plants, browning inside the wood flesh, from which bacterial slime comes out after cutting across the main root and lower part of the stem. Control it through hygienic practices and avoid water-logged soils. To control use copper oxychloride.

Black rot

This can cause severe damage during the rainy season. The disease can be passed through infected seed, from plant to plant in the field or from the soil. Since it stays for a long time in the soil, we should always practice rotations with non-related crops. Also use clean certified seed and practice strict hygiene in the field.

Symptoms begin with yellowing at the leaf margin, which expands into the characteristic V-shaped wound along the leaf margins with dead patches on the main leaf area. Leaf veins are also darkened. Control it by soaking the seeds in hot water before planting them. Also remove infected plants and burn them. Do not feed infected material to animals because the diseases can be transferred back to the field when you apply manure.

Damping off

This is a common disease in seedlings in general caused by fungi. Seedlings will rot very close to the ground. Make sure soils are well drained and seedlings are not over crowded.

Chemical Control: Use Apron Star 42 WS as a seed dressing. Use 10g per 4kg seed. Apron Star 42 WS also controls other diseases as well as protecting seedlings from aphids for up to 4 weeks after sowing. Thiram 80 WP can be used as a seed dressing, at 100g per 50kg of seed, mixing well. This will also control some other seedling diseases. If the attack is high, drench or spray with, Apron star 42 WS, Captan, or Thiram 80 WP around the base of the seedling.

Downy mildew

This is a fungal disease. The infected plant has a white fluffy fungal growth on the underside of the young leaves. Infection will kill most seedlings. Always use healthy seedlings.

Downy mildew is a serious disease of onions attacking in cool and humid weather conditions. Control is by spraying once a week with fungicides like Dithane M45 at 30g mixed in 15L water or Ridomil Gold can control the disease in mature plants.

Early blight

This is the most common tomato disease. It appears as dark reddish brown leaf spots with round mark- ings on the bottom leaves causing them to fall off the plant. You can sometimes see the disease on the fruits as well. It appears at any time during wet weather. Prevent it by spraying with Mancozeb once a week from flowering at 20g mixed in 15L of water. For curative treatment use Folicur 250 EC at 12ml per 15L of water or Score 250 EC at 6ml per 15L water.

Late blight

This is also very common and is one of the most destructive diseases in tomatoes and potatoes. Greyish-green water soaked blisters appear on the leaves rapidly turning black. Stem blisters are dark brown and large mottled areas develop on the fruit. This disease mostly occurs during wet weather. Several chemicals are available but it is always better to prevent than to control when it has already attacked the crop. Always use clean planting material. For chemical control use Mancozeb as in Early blight, or Ridomil Gold at 190g per 15L of water or use Bravo 500 SC at 30ml in 15L water sprayed once a week. Other recommended products include Milraz, Melody Duo.

Leaf Spot

Leaf spot is another common fungal disease. It usually appears, on older leaves, as small spots with light coloured centres. It causes the leaves to turn yellow and then they drop off the plant. The disease can cause a lot of damage to tomatoes during wet weather. Use fungicides and natural pesticides.

Powdery mildew

This appears as white powder on the plant often in hot, dry weather. Chemical control is by Sulphur 80 WP and Alto at 28mls mixed in 15L of water (harvest interval three days). You can

also use Sulphur 80 WP at 30 grams per 15L water or Score 250 EC at 6ml per 15L of water or Benomyl at 7g per 15L of water. Symptoms of powdery mildew on tomato leaves.

Purple blotch

This is one of the major onion diseases we are likely to encounter, a disease caused by fungi. As is the case with insect pests, onions do not have many diseases like other crops we have discussed before. Purple blotch can cause damage when humidity (moisture in the air) and temperatures (heat) are high. Leaves infected by the disease have small irregular white patches which can enlarge to big dry patches with purplish centres. Control the disease by spraying once a week with fungicides like Dithane M45 at 30 grams mixed in 15L of water.

Sclerotinia

This disease is caused by a fungus very significant disease in both the field and storage. Symptoms include foliage that is dark brown and coated with a whitish mould. Later on, black dots will appear amid the white mould. Infected carrots become soft and watery in storage. White moulds cover the infected carrot and the black dots will follow. Control begins with crop rotation and careful handling of carrots after harvest.

Stem rot, sore shin and other soil diseases

This affects members of the cabbage family. To treat these use Quintozene 75 WP at 10g/m2 incorporated in to the soil to a depth of 50 - 100mm in the planting holes. The soil surface should be kept moist during the early post-transplanting stage. For seed-box treatment use Quintozene 75 WP at 100g/m2 well mixed into the soil and well-watered in, you can also seed dress the seed with Apron star 42 WS at 10g per 4kg seed.

Storage rots

These can affect onions. The most common type is White Bulb Rot. This is characterized by a black sooty-like mould which develops between the scales of the bulb. Remove and destroy all infected bulbs, and always inspect onion in storage.

Appendix 4: Weed control using herbicides

Lasso 48 EC can also be used at 4,0l/ha in 200 – 300L/ha water, as soon as possible after the first post-transplant irrigation. The residual effect of the herbicide will not exceed two to three months.

Grasses

Fusilade Forte can be sprayed after weeds have emerged over the top of the crop will control all annual and, at the higher rates, perennial grasses as well. It is applied at the rate of 1.0 – 1.3L/ha depending on the weed species present, their stage of growth and the type of control or suppression required. Apply early before emergence of grass weeds and of crop. Will not affect emerged seeded onions or seedlings so may safely be sprayed "over the top". It is applied at the rate of 0.5 - 1.5 L/ha in a convenient volume of water. Established perennial grasses will require higher rates. It will not control broadleaf weeds nor sedges. Contact with the crop will not cause damage. Do not plant maize, sorghum, wheat, barley or oats within four months of applying Fusilade Forte. DO NOT mix with other chemicals.

Afalon(R) 50 WP is registered for the control of pre- and early post-emergent weeds in carrots. It should not be used on sandy soils or if heavy rain is eminent. It may be sprayed at 1.5 – 2.0 kg/ha on annual grasses and broadleaf weeds immediately after sowing for pre-emergent control and after the 4-leaf stage for post-emergent control.

Agile 100EC is registered for the post-emergent control of annual and perennial grasses. The rate is 1.0 – 1.5L/ha, depending on weed height and species.

Gallant super®: is registered for the post-emergent control of annual and perennial grasses. The dose rate depends on weed height and species.

Trifluralin 48EC can be applied from three to four weeks to immediately prior to sowing. It must be mechanically incorporated within 10 minutes of application. It is used mainly against annual grasses, but will also control some few broadleaf weeds.

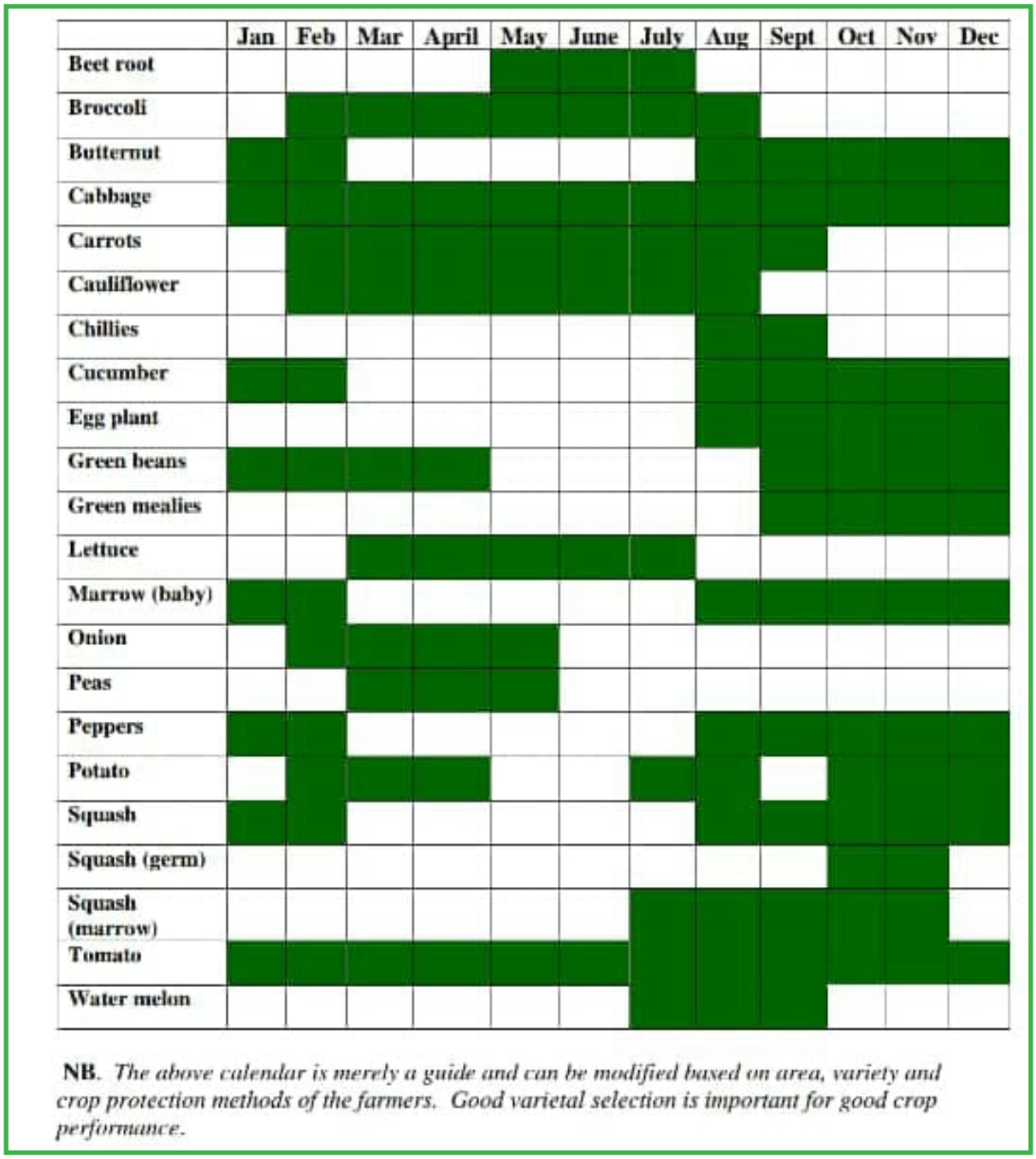
Grasses and broadleaf weeds

Goal 24 EC: Controls many annual broadleaf weeds and some annual grasses pre-emergence. Can affect nutsedge. Rate/ha – 3L in 250L of water applied 10 - 18 days after transplanting only to well-established actively growing transplants, preferably before weed emergence.

Trifluralin should be thoroughly and evenly mixed into the soil to a depth of 100 - 120mm before transplanting. It should be applied at the rate of 1.1 - 1.6 L/ha, depending on the clay percentage of the soil. The higher the clay content, the higher the rate. It will persist in the soil for about three months and so it should not carry over to the following crops.

Ronstar - this is effective for controlling weeds of onions. For direct seeded onions: Apply 4 -5L/ha. Apply only after emergence of onion seedlings and not before the 3 - 4 leaf stage. For set planted onions apply 4 – 5L/ha either before or after emergence of the onion sets. Apply after transplanting onions, preferably while the weather is hot and sunny. Irrigate immediately after application.

Appendix 5: Zimbabwe Vegetable Planting Calendar



	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Beet root					■	■	■					
Broccoli		■	■	■	■	■	■	■				
Butternut	■	■						■	■	■	■	■
Cabbage	■	■	■	■	■	■	■	■	■	■	■	■
Carrots		■	■	■	■	■	■	■	■			
Cauliflower		■	■	■	■	■	■	■				
Chillies								■	■			
Cucumber	■	■						■	■	■	■	■
Egg plant								■	■	■	■	■
Green beans	■	■	■	■					■	■	■	■
Green mealies									■	■	■	■
Lettuce			■	■	■	■	■					
Marrow (baby)	■	■						■	■	■	■	■
Onion		■	■	■	■							
Peas			■	■	■							
Peppers	■	■						■	■	■	■	■
Potato		■	■	■			■	■		■	■	■
Squash	■	■						■	■	■	■	■
Squash (germ)										■	■	
Squash (marrow)							■	■	■	■	■	
Tomato	■	■	■	■	■	■	■	■	■	■	■	■
Water melon							■	■	■			

NB. *The above calendar is merely a guide and can be modified based on area, variety and crop protection methods of the farmers. Good varietal selection is important for good crop performance.*

Definition of key terms (Glossary)

Basal fertiliser: Fertiliser applied during land preparation before planting

Bolting: When a plant unexpectedly produces a flower-head usually in response to sudden hot temperatures

Compost: A stable material, containing high levels of organic matter, made from decayed plant or animal material

Compound fertiliser: A fertiliser containing several minerals

Evaporation: Water lost, from the soil or a plant, into the air

Harvest interval: The amount of time we must wait, after spraying a crop, before harvesting the product

Herbicide: A chemical developed to kill weeds

Hygiene: Keeping yourself or an area clean to prevent the spread of disease

Larvae: The young stage of an insect

Mulch: Material placed on the surface of soil to reduce evaporation

N**itrogen:** A mineral that all plants need in order to grow

Nutrient: A substance that living things require in order to be healthy

Oedema: Swelling caused by water

Organic matter: Material from decayed plants or animals used to improve the soil

Perennial: A plant that lives for several years

Pesticide: A chemical developed to kill pests

Petiole: The stalk that joins a leaf to a plant

Phosphorus: A mineral required for plant growth

Physiological disorders: Distortion to a plant or fruit structure caused by lack of nutrients, soil moisture stresses or unfavourable environmental conditions.

Potassium: A mineral required for plant growth

Predators: An animal that hunts and eats another animal

Systemic pesticide: A pesticide that is absorbed into the tissues of a plant

Variety: A type of plant that has been developed for certain characteristics through crop breeding

We Effect was created by the Swedish cooperative movement in 1958. It is an international NGO with its HQ in Stockholm Sweden. Its development cooperation is founded on the principle of help for self-help and thrives towards the vision of a world free from poverty and injustice. We Effect works with partners of mostly member based organizations to ensure members empower themselves with knowledge and skills to alleviate poverty and injustice. We Effect works in various countries globally with Regional offices in Southern Africa, East Africa, Latin America and Eastern Europe and works in the sectors of sustainable rural development, habitat and rural finance.

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