OKRA

Integrated Pest Management

AN ECOLOGICAL GUIDE

TRAINING RESOURCE TEXT ON CROP DEVELOPMENT, MAJOR ECONOMIC PRACTICES, DISASE AND INSECT ECOLOGY, INSECT PESTS, NATURAL ENEMIES AND DISEASES OF OKRA

LOA-FNPP/GLO/002/NET with the National Crop Protection Center through the UPLB Foundation, Inc. in support of Participatory Action Research Program to Develop Okra IPM

FAO Inter-country Programme for Integrated pest in Management in Vegetables in Asia

TABLE OF CONTENTS

PREFACE

The Food and Agriculture Intercountry Programme for Integrated Pest Management for Vegetables in Asia (Phase2) assisted the National Crop Protection Center through the University of the Philippines Foundation Inc., a LOA-FNPP/GLO002NET in support of Participatory Action Research Program to Develop Okra IPM. The main objective of the program is to develop participatory action researches for okra IPM. The activities involve the conduct of baseline survey, developing a cropping calendar and curriculum for okra Farmer's Field School, conduct of field studies, refresher courses, Farmers Field Schools, workshops and meetings. Training materials such as Guide on Field Studies for Okra IPM and the Ecological Guide for Okra IPM are developed for reference materials.

The **Ecological Guide for Integrated Pest Management in Okra** has been a product of the contributions of okra farmers, trainers, agricultural technicians of exporters, the local government of Tarlac City, Lapaz and Tarlac Province and Nueva Ecija. Experiences of farmers and exporters and the field studies conducted with them are very helpful in the preparation of this ecological guide.

Appreciation is extended to okra farmers of Lapaz and Tarlac City; grower-exporter, Helen Matsuoka; agricultural technicians of the Province of Tarlac (Diosdado Rodriguez, Tess Alcantara and Rebecca Melegrito), Lapaz, Tarlac City (Judy Valete, Norma Tongol, Vilma Santos and Jorge Yesa), Nueva Ecija (Lucy de la Cruz, Aida Santos and Evelyn Santos); and researchers and staff of NCPC (Lorenzo Fabro, Godofrdo Peralta, Felomina Sta Cruz, Majella Magallona, Alfredo Ramirez, Lucita Escueta, Marides Paez, Marites Atienza, Agnes Tamayo, and Marcelino Reyes) for their assistance in the project activities and their contribution in the development of this guide.

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Introduction

The **Ecological Guide for Integrated Pest Management in Okra** is developed for the FAO Intercountry Programme for Integrated Pest Management in Vegetables for Asia. Several ecological guides developed for various commodities such as rice, cabbage, tomato and eggplant have been distributed by FAO to IPM trainers, researchers, extension workers and farmers as reference for training courses, field studies, research and any other related activities.

This ecological guide for okra includes the available technologies and experiences on okra crop production and management, harvesting and post-harvest handling. The guide covers all aspects of production from land preparation to harvesting and post-harvest handling of okra. Experiences are contributions from farmers, exporters, results of field studies and Farmers Field School and refresher courses on okra. Materials from training reports, field guides and ecological guides on other crops applicable to okra are also utilized in this ecological guide.

This guide will serve as a reference for IPM trainers, agricultural technicians and extension workers, okra growers, researchers, farmers, and even exporters. Recommendations, suggestions and experiences in the guide are useful in the preparation of training exercises, field studies and researches that can be used in training courses, follow-up activities and in addressing the needs and constraints in okra production.

INTEGRATED PEST MANAGEMENT

The FAO Intercountry Programme for Integrated Pest Management in Asia started with rice IPM. Member countries of Asia have pronouncements of IPM as a national government policy in their Ministries or Department of Agriculture. Experiences on rice IPM have become very successful leading FAO to widen its programme to more countries and commodities. The programs were on corn, vegetables, tea, cotton, mango, coconut and rice-based IPM. Problems and production constraints vary among crops or commodities but the principles and experiences in IPM hold through and are applicable to all the commodities.

Okra production in the Philippines and in other Asian countries such as Thailand is an important commodity crop for the export industry. In the Philippines, okra export contributes as much as 16 million pesos to Philippine economy annually. However, okra growers meet export restrictions from Japan because of injudicious use of pesticides. Farmers rely heavily on pesticides in managing insect pests, weeds and diseases of okra. Government agencies and researchers from the different institutions need to extend assistance to farmers to meet the demands of Japan and reduce their dependency on pesticide. Technical enhancement on the proper understanding of okra pests and provision or introduction of alternative measures for pest management will greatly help farmers, extension workers and agricultural technicians.

Japan dictates when to buy okra and what variety to buy. Japan buys okra when they cannot grow them in winter in December to March. Thus farmers start planting okra after harvesting rice in October. Japanese consumers prefer the ridged variety of okra. Local consumers want the smooth variety hence reject from their harvest is used for animal feeds. Cropping season of okra is only once a year and the timing of planting cannot be adjusted to periods when the crop is least susceptible to pest infestation. Pest population of many species such as leafhoppers, thrips, aphids, whiteflies, and mites rapidly increase during the dry season. Few species of insect pests such as stem and pod borer, fruitworm and cutworm feed on okra but cause extensive damage on pods.

A. OKRA CROP DEVELOPMENT

This section includes the origin of okra and its economic importance, growth stages and development and its susceptibility to pests. Proper understanding about the crop, its origin, crop stages and development and the critical stages of growth susceptible to pest infestation are important basis in developing an IPM strategy. Variations may be observed among locations, varieties and agronomic practices.

1. Origin and economic importance

Okra, *Abelmoschus esculentus* belongs to Family Malvaceae. Okra is also known as lady's finger in English, okra or kopi arab in Indonesia, okra in the Philippines, you-padi in Myanmar, pôôt barang in Cambodia, krachiap-mon or krachiap-khieo in Thailand, khua ngwang in Laos, and d(aaj)u b(aws)p, b(uj)b(aws)p, m(uw)(ows) p(aa)y in Vietnam.

Abelmoschus originated in Southeast Asia, however, A. *esculentus* is a cultigen of uncertain origin. It is now widely cultivated in tropical and subtropical regions but is particularly popular in India, West Africa and Brazil.

Okra is common in the Philippines, Malaysia, Thailand and Vietnam but of little importance in Indonesia and Papua New Guinea.

Okra is mainly grown for its young immature fruits and consumed as a vegetable, raw, cooked or fried. It is a common ingredient of soups and sauces. The fruits can be conserved by drying or pickling. The leaves are sometimes used as spinach or cattle feed, the fibers from the stem for cord, the mucilages for medical and industrial purposes, and the seeds as a substitute for coffee. Okra seeds contain a considerable amount of good quality oil and protein.

Besides local market, okra is grown as fresh or frozen export product to Japan by Thailand and the Philippines. Okra in brine is also a potential export to the Middle East.

A 100-gram edible portion of okra fruit contains 90 grams water, 2 grams protein, 1gram fiber and 7 grams carbohydrates. Its energy value is 145 kJ/100 grams. Okra is a good source of vitamins and minerals. It is very rich in calcium (70-90 mg/100g).

2. Growth and Development

Okra is a stout, erect annual herb that grows to 4 meters tall with spirally-arranged leaves with leaf blades up to 50 cm diameter and more or less deeply 3-5- and 7-lobed.

The general growth stages are:

- Seed

Seeds are numerous, gray to black in color and about 3-6 mm in diameter.

Seeds germinate about 5-7 days after sowing.

- Seedling stage. One to 2 weeks from seed germination.

Seedlings have at least 3-4 leaves with a height approximately 12-18 cm.

- Vegetative stage. Three to 4 weeks from seed germination.

Leaves are bigger and a plant has more than 8 leaves. Length of stem between leaves is longer. The leaves are spreading and spirally arranged.

- Reproductive stage. Plants start to flower at 5 weeks from seed germination.

Yellow solitary flowers are in the leaf axils. Okra usually flowers within 40-90 days after sowing. Flower opens in the morning.

Fruits or pods are green, cylindrical to pyramidal capsule 5-35 cm long and 1-5 cm in diameter.

It takes about 1 month from anthesis to fruit maturity. Mature green pods turn brown and dry.

On the seed crop, vegetative growth stops soon after anthesis, all assimilates being partitioned to the reproductive plant parts.

Flower initiation and flowering are delayed at higher temperatures (positive correlation between temperature and number of vegetative internodes).

Proper understanding of the growth stages and development of okra is very essential in the development IPM strategies.

2. Susceptibility of Okra Growth Stages to Pests

Okra is attacked by several species of insect pests and infected by a few diseases from seedling to harvesting (Table 1). Economic losses depend on the degree of damage, pest density, environmental condition, stage of growth and the plant part damaged by the pest.

Damping off at seedling stage does not cause losses since most of the seeds sown were treated with fungicides. Even if some seedlings are infected, there are at least 1 or more seedlings left from the 3-5 seeds sown per hill.

Leafhoppers, aphids and whiteflies attack at seedling to early vegetative stage. These insects transmit yellow vein mosaic virus in okra. Infected plants produce poor quality pods. If there is no source of yellow vein mosaic virus in the neighboring fields, the rapid increase in leafhopper population during the dry season causes hopperburn in okra. Leaves curl, turn red and eventually become dry due to feeding by high density of plant sucking insects at vegetative stage.

Cercospora leaf spot and powdery mildew are two fungal diseases at late vegetative to reproductive stage. Fungal infection spread rapidly in the field due to crowded and overlapping broad leaves of the plants. Besides the wind spreading the fungal spores to plants, people harvesting daily and passing along the okra rows are also responsible for the widespread infection in the field. Farmers remove and drop the old yellow leaves with *Cercospora* leaf spot to reduce infection but these leaves were not properly disposed, the sources being still there in the field.

Stem borers at early vegetative stage damage the shoots. The plants then develop branches to compensate for the damage by stem borers. Unlike other crops such as eggplant, development of more branches in okra is

disadvantageous. Pods from branches are less and smaller. Fruit worm, stem and pod borer feed on flowers and bore inside the pods. If flowers are damaged, no fruits or pods will be developed. Damaged pods are rejected for export. Cutworm usually feeds on the leaves. Damage by cutworm does not greatly affect the photosynthetic ability of the whole plant because okra at vegetative stage has many big and broad leaves. Cutworm also feeds on pods when they population is high.

Table 1. Incidence of major insect pests and diseases at the different growth stages of okra.

Insect pests and diseases	Growth stages of okra					
	Seedling	Early vegetative	Late Vegetative	Flowering	Fruiting	Harvesting
Damping off, *Phythium sp.*						
Melon aphids, *Aphids gossypii*						
Cotton leafhopper, *Amrasca spp.*						
Whiteflies, *Bemisia tabaci*						
Common cutworm, *Spodoptera litura*						
Stem & pod borer, *Earias vittela*						
Fruitworm, *Heliothis armigera*						
Thrips, *Thrips palmi*						
Red spider mite *Tetranychus kanzawai*						
Yellow vein mosaic						
Powdery mildew						
Cercospopra leaf spot						
Cotton stainer, *Dysdercus poecilus and D.cingulatus*						

The major insect pests and diseases at the different growth stages are shown by the dark shades. Minor pests and diseases are in lighter shades.

Pest infestation occurs in succession in okra. The critical stages when these pests occur serves as basis in designing a pest strategy to reduce damage and obtain high quality produce.
Pest incidence in okra can be determined by regular monitoring of the plants.

B. MAJOR AGRONOMIC PRACTICES

High yield of okra can be obtained if proper agronomic practices are followed. Sow F1 hybrid seeds, prepare land properly, apply the recommended rate of fertilizer, irrigate and remove the weeds when necessary. This section includes the cultural management practices from seed selection, land preparation to post-handling practices to obtain maximum yield and best quality okra pods.

1. Climate and Site Selection

Okra is usually grown in any kind of soil but it thrives well in well-drained sandy and clay loam soils. The plant is best adapted to a climate with a long, warm growing season. It grows well on a maximum average temperature of 35ºC with a minimum average above 18ºC. It may be grown at elevations from sea level up to 30 meters.

Okra is planted twice a year, from April to June and October to January. Okra for export is grown only in October to January when Japan cannot grow them in winter. It is the best alternate cash crop for rice after the first season harvest.

2. Seeds and Varietal Selection

There are several available varieties of okra farmers can select. For local consumption, smooth varieties such as Smooth Green, 4025, Clemson Spineless, Savour Selection, Emerald, and Louisiana Green Velvet are preferred. For export, Japan prefers the ridged varieties such as Native Brown, Better Five and Early Five.

Each of these varieties has their characteristics, but the market dictates what okra pods they want. The pods for export must be dark green, 5-ridged and about 10-12 cm long. Local consumers are not particular with the size and color as long as it is smooth, young, soft, and tips snap.

a. Hybrid seeds and open pollinated seeds

Hybrid seeds results from cross fertilization of two selected lines or parents with the desirable characteristics such as high yielding and resistant to pests and diseases. Seeds are often called F1. Second generation hybrids, F2 are the seeds produced from F1 seeds. The third generation hybrids, F3 are the seeds produced from the F2 seeds. F1 seeds are uniform and show the desirable characteristics of their parent lines. Plants from seeds of F2, F3, F4, and so on

are variable and undesirable characteristics usually appear. Hence, farmers always need to buy hybrid seeds for every planting or sowing.

Open-pollinated seeds are produced from natural pollination of the parent plants. Plants from open pollinated varieties show the characteristics of either parents or a combination of both parents. Farmers can multiply their own seeds from open-pollinated plants.

If farmers are producing their own seeds, they should practice proper selection. Farmer select for healthy, mature, first large-size pods from disease-free plants. Most of the time, first pods are always disease-free since most diseases show symptoms later in their growth stage. The easiest way to keep the seed is to leave it in pods until it is used.

b. Resistant variety

Varieties with long spines on leaves and pods are desirable characteristics against insect pests like leafhoppers, whiteflies, thrips, and mites. Pines on the leaves and pods deter them from moving around the pods and leaves. Pods borers, fruit worms and cutworms disliked thick pods because they cannot easily bore inside the pods. Some of these varieties are 4025 B, Better Five and Early Five.

Field studies using different available varieties can be conducted to determine the high yielding and more tolerant variety to pests and diseases. Studies indicate that varieties with spines are more resistant to leafhoppers and other insects.

c. Seed germination

Farmers do not commonly test seeds for germination. Percentage seed germination is important to know the amount of seeds needed to sow to get the desirable number of seedlings per hill. Seed should have at least 70 % germination. Packs of seeds usually indicate the % germination in their labels.

Farmers should tests the percentage germination of their own produced seeds. Seed germination test can be obtained from sowing seeds in moist tissue paper. It is important to soak seeds overnight in water to get uniform germination and good stand. It takes 5-7 days for seeds to germinate.

It is important to soak seeds overnight in water to get uniform germination and good stand. Floating seeds will not have good germination and must be discarded. Sinking seeds are those seeds with full embryo and with plenty of for reserve for proper nutrition of the germinating seed.

Cotton stainers attacking the plants during the harvesting period suck the seeds inside the pods. Feeding causes drying of seeds hence seeds float when soaked in water.

d. Seed treatments

Hybrid seeds are usually treated before packing. Locally produced seeds by farmers are not always treated. Farmers do not practice seed treatment like soaking seeds in hot water (50ºC) for 30 minutes or coating seeds with fungicides, botanical repellants, *Trichoderma* or *Bacillus subtillis* to kill fungal spores not commonly practiced by farmers.

Some of the fungal diseases that can be reduced by seed treatment are the soil-borne pathogen of damping off and other seed-borne diseases.

Soaking seeds in hot water at 50ºC for 30 minutes will kill the pathogens and soften the hard seed coat and ensure uniform germination and good stand.

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3. Soils and Soil Properties

The soil is a natural body composed of a mixture of organic and inorganic materials that is formed from the disintegration and decomposition of rocks and minerals. The soil body has dimensions of depth, width and breadth. It has physical, chemical and biological properties that are conditioned by varying degree of interactive influence of five soil-forming factors – parent material, topography, living organisms, climate and time.

As a consequence of the varying influences of the soil-forming factors, different kinds of soils evolve and develop over the earth's surface. Recognition of these differences is important to us because these reflect to a large extent the suitability and capacity of the soils for various uses.

a. The living soil

b. The soil is a dynamic living system that harbors many organisms each one having a function in the ecosystem. Earthworms, centipedes, millipedes, ground insects (such as carabids, ants, earwigs) are among the organisms thriving in the soil that can be seen with our naked eye. These insects are mostly predatory in nature. These organisms helps in the decomposition plant waste materials or

animal manure and convert them into organic matter that is then utilized by the plant. Soil insects are mostly predatory in nature. They feed on other soil insects or crawl up to the plants and feed on inset pests damaging the crop. Majority of the soil dwellers are microorganisms that may beneficial, pathogenic or nuetrals. Zooplanktons like the collembolans or springtails and cyclops are food for soil insects. Beneficial microorganisms such as bacteria, fungi, and nematodes help in the decomposition of organic waster materials. There are also soil-borne bacteria, fungi and nematodes that cause diseases and disorders in the plants.

b. Soil profile

Soil profile is the vertical section of the soil from the surface down through the different layers (horizons) and into the loose weathered rock. The soil horizon is a soil layer approximately parallel to the surface with distinct physical and chemical characteristics. The topsoil is the A horizon, the subsoil is the B horizon and the partly weathered parent material is the C horizon. The bedrock is the D horizon. The surface layer or topsoil is the zone of organic matter accumulation, darker in color than those underneath, granular structure or rounded aggregates of soil particles, and zone of removal of fine soil particles and soluble products. The subsurface layer or subsoil is the zone of accumulation of fine particles and soluble products from A horizon, usually lighter in color and has blocky structure or cube-like soil clusters. Parent material is partially weathered rock. Soil layers above were formed from this horizon. Partial weathering of the bedrock gives rise to the parent material.

c. Soil composition

The typical soil composition that is ideal for plant growth has 45% mineral matter, 5% organic matter, 25 % water and 25% air (volume percentage).

Organic matter accumulates in the topsoil where decaying plant residues are largely found. High organic matter content is beneficial to crops because it promotes granulation, increases water-holding capacity, and improves fertility of the soil, among others.

Mineral (or inorganic) matter comes from the weathering of primary and secondary minerals. It is composed of soil particles of varying sizes: sand (0.02 – 2 mm), silt (0.002-0.02mm) and clay (less than 0.002 mm). The sand and silt fractions are largely made up of primary minerals (unaltered minerals from parent rocks) while the clay fraction is made up of secondary minerals (new minerals synthesized from decomposition products of primary mineral). The mineral matter constitutes a natural reservoir of nutrients that are required for plant growth.

Soil water (or soil solution) carries and moves dissolved nutrients. Water is also the most active agent involved in the chemical decomposition of the mineral matter. Biological decomposition of organic residues also requires presence of optimum moisture.

Soil air has composition similar to that of atmospheric air except for the high carbon dioxide content of the former. Soil air has about 79% nitrogen, 20% oxygen, 0.5% carbon dioxide, and other gases. Among these, oxygen is vital for normal growth and nutrient absorption by plant roots. In a poorly aerated soil, plant roots "suffocate".

d. Soil texture

Soil texture is defined as the relative proportion of sand, silt and clay in a soil mass. Sand, silt and clay or soil separates are the three principal size groups of inorganic soil particles. Since the various soil separates exhibit differences in their physical characteristics and chemical composition, most of the physical, chemical and biological properties of soils are highly influenced by soil texture.

There are twelve textural classes which are recognized in soils depending on the proportions of soil separates in a soil mass. For convenience, the 12 textural classes are further divided into 3 groups, namely:

1.) Fine textured soils – clay, silty clay, sandy clay, clay loam, silty clay loam, sandy clay loam
2.) Medium-textured soils – silt, silt loam, and loam
3.) Coarse-textured soils – sandy loam, loamy sand and sand

Table 2. Effective diameter limits and some general characteristics of the different soil separates.

Soil separate	Effective diameter of particles, mm	General characteristics
Sand	2.0-0.02	Individual particles feel gritty when soil is rubbed between the fingers; non-plastic or non-sticky when moist
Silt	0.02-0.002	Feels smooth and floury when rubbed between the fingers; very slightly plastic or sticky when moist
Clay	Less than 0.002	Feels smooth, sticky when wet and plastic when moist; forms very hard clods when dry. Particles may remain suspended in water for a very long period of time.

e. Soil Structure

The arrangement of the soil particles into clusters or aggregates of different sizes and shapes is called soil structure. A usual field observation is the occurrence of granular (rounded, nonporous) or crumbs (rounded, porous) structure for the topsoil and blocky (cube-like) structure in the subsoil.

Like soil texture, the effect of soil texture on plant growth is indirect; nevertheless, it is real and important. One outstanding effect of good soil structure is the increase in total volume of pore space. Such increase in total pore is due to the increase in the number and volume of macropores (large-sized pore spaces) that form in between aggregates while maintaining the numerous micropores (small-sized pore space) within the aggregates. Macropores provide aeration, drainage and spaces for root proliferation while micropores are important in water retention.

The presence of many macropores in a soil with good structure also means that water enters the soil easily. Hence the amount of water stored in the deeper soil horizons increases; likewise, erosion and run-off decrease, particularly on sloping areas.

f. Soil moisture

Moisture is usually present in every soil no matter how dry the soil may appear. The two forms of moisture commonly found in soils in the tropics are liquid water and water vapor. Liquid water may occupy the entire space between adjacent soil particles or form thin films on such surfaces, thereby leaving some air spaces between them, or both. Water vapor mixes intimately with other components of the gaseous phase of the soil. In most cases, the amount of liquid water is much larger than that of water vapor. Liquid water is usually referred to as soil moisture.

Soil moisture content is the amount of moisture contained in a quantity of soil. Soil moisture constitutes the primary source of water for terrestrial plants. Thus it is important in crop production that soil stores adequate amount of water to satisfy the needs of the crop being grown and release the water to the crop with reasonable ease whenever the crop needs it. The capacity of the soil to store water and the ease with which it releases the stored water are therefore, the two important characteristics determining the moisture status of the soil.

g. Soil reaction and limimg

Soil reaction refers to the degree of acidity or alkalinity of the soil. Acidity is usually expressed as pH. Soil pH is a valuable diagnostic aid. It provides a

basis for deciding on the nature of other tests that should be done on the soil sample.

The effect of soil pH on nutrient availability is very important in agriculture. High concentration of hydrogen ions in acid soils has a direct effect on the availability of nutrients and consequently on the growth of crops. For instance, strong acidity increases the amount of iron, aluminum and manganese in the soil solution. If the concentration of these elements in solution becomes too high, injury to plants may result. Too high a pH, on the other hand renders these elements insoluble, resulting in decreased availability to plants.

Very strongly acidic (Ph=1) to slightly acidic soil (Ph=6) shows deficiencies of nitrogen, potassium, phosphorus, sulfur, magnesium, calcium, aluminum, iron and manganese. Slightly alkaline (pH=8) to very strongly alkaline soil (Ph=12) is hard and very compact and shows deficiencies to nitrogen, iron, manganese, copper, and zinc. Microorganisms thrive well when pH is between 5.6-7.3. Fertile soil has a pH 6-7.

On account of the effects of acidity on nutrient availability, the relationship between changes in pH and growth of the plants can be readily established. When the pH of a soil decreases much below the optimum range satisfactory for plant growth in a given soil and environment, liming must be resorted to. The primary purpose is to raise the pH for the maintenance of better nutrient availability in the soil. The materials containing Ca or Ca and Mg compounds used to neutralize soil acidity up to desired level are called agricultural lime.

Table 3. pH Values of special significance in soils**.**

PH	Soil conditions inferred from pH
Less than 4.0	Free mineral acids present, most often H_2SO_4 from oxidation of pyrite
4.0	pH of soil largely saturated with exchangeable aluminum and moderately low to very low in exchangeable bivalent cations
5.5	pH above which there is essentially no exchangeable aluminum
6.0	Soil pH suitable for a wide variety of plants
7.0	Neutral pH
8.3	Soil is equilibrium with an excess of $CaCO_3$ at the partial pressure at CO_2 in the atmosphere (0.003 atm)
Higher than 8.3	Na_2CO_3 present in the soil

Liming improves the availability of other plant food such as phosphorus, promotes bacterial activity and faster organic matter decomposition, and supplies calcium or magnesium.

Increasing soil pH through liming takes a long time. The process is affected by several conditions such soil pH, soil type, soil structure and soil organic matter.

Table 4. Amount of agricultural lime needed raise the soil pH.

Soil pH	Amount of agricultural lime (tons/ha) for soils with average organic matter content				
	Sandy soil	Sandy loam	Loam soil	Silt and clay loam	Clay soil
4.0	3.0	5.5	7.0	9.5	12.0
4.5	2.5	4.5	5.0	7.8	9.8
5.0	2.0	3.5	4.5	6.0	7.5
5.5	1.5	2.5	3.3	4.3	5.8
6.0	1.0	1.5	2.0	2.5	3.0
7.0	None	None	None	None	None
8.0	None	None	None	None	None

4. Fertilizer Management

The soil has an ability to supply nutrients in the form, amount and proportion needed for potential plant growth. These nutrients are available in the soil as soluble ions (Ca+, NO^3 , Mg $+^2$) and exchangeable ions (Mg, Ca and K).

Soil productivity is affected by several factors such as solar radiation, irrigation or water supply, pests (diseases, weeds and insects), drainage and toxicity. At high solar radiation, nutrient uptake is high. With adequate water supply, uptake of nutrients is more efficient. Pests hamper nutrient efficiency hence affects quality of pods. Temporary drainage is necessary to bring fertilizer material as close to the soil particles as possible. Generally soils with low pH encourage toxicity to plants that limits nutrient absorption.

Nutrients are lost in the soil through volatilization, denitrification, erosion or surface run off, fixation, leaching and crop removal. Volatilization is the escape of ammonia gas from nitrogen source in the soil. Urea or ammonium sulfate when applied to the soil must be covered right away to prevent volatilization. Denitrification is the conversion of nitrate to oxides of nitrogen and nitrogen gas. Erosion is the loss of particles with nutrients through the action of water, wind and other agents. Fixation is the conversion of available form into insoluble or unavailable form such as phosphate fixation. Leaching is the loss of nutrients through downward movement of water. Crop absorption is another form of nutrient loss from the soil.

Organically grown okra demands high price in Japan. A box (with 8-10 lbs pods) of organically grown okra cost 2.25 US$ while treated plants cost 1.48US$

a. Soil sampling and analysis

Proper assessment of the soil is necessary in making recommendation to improve soil fertility. Analysis of soil samples provides a clear picture of the status of your soil.

The accuracy of fertilizer recommendation depends to a large degree on the correctness of collecting representative soil samples. If the field is uniform, a sample may be taken to represent up to 10 hectares of land. One has to make as many borings as possible to cover the whole area. All the soil borings are then mixed and a one-kilogram composite sample is taken. This composite sample is sent to the laboratory for analysis. It should be noted that out of the one kilogram soil sample representing an area of as much as 10 hectares, only a few grams are used in the actual analysis.

Soil analysis can be done using simple tool such as Soil Test Kit for qualitative analysis for soil pH, nitrogen, phosphorus and potassium and the Minus One Element Technique or by running a complete chemical analysis in the Soils Laboratories. These tests are tools to help farmers approach the answer as to what the plant needs. The result of the analysis is only a piece of information used by technologists in making fertilizer recommendations. This information is not sufficient to make use for an intelligent decision. It should go hand in hand with field experiments or trials and with proper understanding of the different aspects of crop production both biotic and abiotic factors.

Soil samples for analysis should not represent more than ten hectares, and should include only areas which appear uniform with respect to past lime, fertilizer or manure treatments, low spots, slope and degree of erosion, cropping history, soil texture, organic matter content and color. It is also important to avoid unusual area such as gullies, bare spots, or old fertilizer bands. If sampled, do them separately. (Important: Do not mix different soils).

Soil samples for chemical analysis should provide the following information to the soil technologists: the kind of crops which were grown during the preceding 3-5 year, the crop he intends to grow, the kind and amount of fertilizers which have been used in the past, when the soil was last limed, and the slope and extent of erosion. These informations are also needed as basis for the proper fertilizer recommendation.

b. Fertilizers

A fertilizer is any organic or inorganic material of natural or synthetic origin that is added to the soil to supply certain elements essential to plant growth. Fertilizer materials are used to increase the growth rate, yield and quality or nutritive value of plants. For many decades in the past, the term fertilizers practically meant commercial fertilizers such as urea, complete, and ammonium sulfate of

nonliving origin. In recent years, however, increasing attention has been focused on organic and biofertilizers that are biological sources of plant nutrients.

Organic fertilizers or farm manures refer to composts, crop residues, animal manures, green manures, and other municipal or farm wastes that supply nutrients and improve soil physical conditions. Organic fertilizers are added to the soil in large quantities to meet nutrient demands of crops. The use of organic fertilizers is a vital component of integrated nutrient cycling systems.

Biofertilizers are microbial inoculants or groups of microorganisms that in one way or another render nutrients available to plants from sources which those plants cannot tap themselves. The nitrogen biofertilizers include *Rhizobium* (for legumes), the blue-green algae (BGA), *Azospirillium, Azotobacter*, and *Frankia* (for non-leguminous trees). The phosphorus biofertilizers are made up of bacteria and fungi that solubilize unavailable forms of phosphorus, thus converting them into available forms. Efficient phospho-bacterial isolates were identified as *Pseudomonas striata, P. rattonis* and *Bacillus polymyra*. Among the fungi, the efficient P solubilizers were observed among the *Aspergillus* and *Penecillium* groups. The mycorrhizae constitute another group of biofertilizers in that they increase the absorption of P from the soil and P-fertilizers.

Of the known essential nutrient elements that plants obtain from the soil like nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mo), sulfur (S), iron (Fe), manganese (Mn), zinc (Zn), copper (Cu) the first three are usually limiting to a greater extent than the rest**.** These nutrients are removed by plants in relatively large quantities so that their depletion proceeds at a faster rate. Besides removal by crop, the supply of these nutrients may also decrease due to leaching, volatilization and soil erosion. Thus it is inevitable that fertilizers containing them will be needed.

Field experimentation is the most reliable biological method known to determine the soil fertility. Soil and plant analyses are more effective if used in conjunction with field experimentation while the use of deficiency symptoms requires considerable experience and expertise.

The proper usage of fertilizers requires knowledge not only of their properties but also their effects on the soil. The amount of fertilizer to be applied depends on many factors which include the ability of the soil to supply nutrients, the nutrient requirement of the plant, yield potential, other management practices, capability of the farmer and other environmental factors particularly rainfall. The insufficiency of rainfall which limits potential yield for example, leads to low fertilizer use efficiency.

c. Fertilizer recommendation

The uptake of minerals is rather high in plants. Indicative figures for total nutrient uptake per hectare (crop with fruit yield of about 10 tons/ha) are 100 kg N, 10 kg P, 60 kg K, 80 kg Ca, and 40 kg Mg. The fertilizer recommendation in Indonesia is 10 t/ha of organic manure applied to the planting holes together with TSP 150 kg and KCl 150 kg, Urea 150 kg/ha or ammonium sulphate 300 kg/ha can be given in 3 split applications: at sowing after 3 weeks and again at 6 weeks after sowing. If the vegetative development at the age of 3 weeks is too luxurious, no N fertilizer should be applied anymore, otherwise the harvest will be delayed and the crop will become attractive to insects.

In the Philippines, the recommendation is 1 kg/m^2 land area together with complete fertilizer (14-14-14) at 10 g/plant during planting time. At one month after planting side dress urea (46-0-0) at the rate of 10 g/hill.

Results of soil analysis using the Soil Test Kit in Barangay Libtong, Lapaz Tarlac showed low N, P and sufficient K. The recommendation for okra based on the soil analysis is 90-60-30 NPK per hectare or 214 kg complete (14-14-14), 133.33 kg urea (45-0-0) and 150 kg superphosphate.

d. Composting and organic fertilizer application

An organic fertilizer is a decomposition product as humus which is made from constituents of plants, animal manure or their metabolic products which contain moderate percentages of N,P or K that are used to supply plants with required nutrients. The process of producing humus from organic wastes is composting.

Organic fertilizer improves the soil physical properties by promoting soil aggregation, improving soil friability and aeration. It also increases the water holding capacity, supplies essential elements, maintains or increases organic matter level, and increases soil cation exchange capacity. Organic fertilizer improves biological activities in the soil and enhances rapid multiplication of fungi, bacteria and other soil organisms.

Organic fertilizer is characterized by low nutrient content and slow release of nutrient but release maybe in time when the crop requires it most thus, less losses of nutrients. It may be carriers of disease-causing organisms if not fully decomposed and source of toxic substance and heavy metals particularly if raw materials are from industrial or urban wastes. Application of organic fertilizer

may result in nutritional deficiency in crops if material used is not fully decomposed or has a wide C:N ratio.

Sources of plant nutrients in organic fertilizer are agricultural wastes, municipal and urban wastes and others such as quano etc. Composting organic

The following are the steps in organic fertilizer preparation:

Step 1. Gather compost materials. Gather rice straw, rice hull, animal manures, garden soil and other leguminous plants such as ipil-ipil, sesbania, azolla, mungbean soybean etc. Soak rice straw and other plant origin materials for 6-12 hours before piling and chop the materials for easier decomposition.

Step 2. Prepare compost area. Level an area 2 meters wide and 6 meters long for the compost pile. Make a drainage ditch around the leveled area to prevent water from running across.

Step 3. Pile chopped rice straw/other plant materials. Pile a layer of chopped rice straw and other plant materials about 8 inches thick. Rake it smooth but do not step on the pile.

Step 4. Pile animal manures. Place and spread a layer of animal manure about 4 inches thick over the straw.

Step 5. Pile mixed garden soil and ashes. Cover the layer of manure with garden soil mixed with ashes of rice hull (2:1 ratio) of about 2 inches thick.

Step 6. Repeat steps 1 to 5 until the compost heap is about 1.5 meters. Repeat the above steps until the compost is about 1.5 meters or 5 feet high. Keep the pile fluffy so air can penetrate, insert a few bamboo poles or "breathers" with hollowed internodes and holes at the sides of the poles (about 5-7 poles at random.

Step 7. Water compost heap. Water the compost heap until it is sufficiently moist.

Step 8. Cover compost heap. Cover the compost heap with plastic sheet, used sacks, coconut or banana leaves to increase temperature and protect/prevent too much water into the compost heap that could leach the nutrients.

Step 9. Turn compost heap. After 3 weeks, remove the bamboo breathers and turn the compost pile. Water to keep the pile moist.

Step 10. Harvest compost. After 5 weeks, mix the compost, moistened, and allow to decompose for 4 more weeks. After this, the compost is ready for use.

Apply compost at the rate of 2 tons/ha after the first plowing or 3 weeks before sowing to give the compost enough time to come into equilibrium with the soil.

In composting, it is important to take precautions. Decomposing compost heap can generate heat up to 60^{o} C. Be careful in handling while mixing or turning. Wear protective gloves or boots so as not to scald your hands and feet. Composting materials and microorganisms may cause allergies. Wear mask to cover your nose and mouth, use long-sleeved clothes and wash body after working on the compost.

5. Land Preparation and Seed Sowing

a. Plowing, harrowing and furrowing

Land preparation follows right away after harvesting rice. In flooded areas farmers have to wait until the field dries up. Rice straw and hay left in the field were either burned or plowed under. After plowing, organic fertilizer is applied and mixed with the soil at harrowing. Basal fertilizer is also applied during harrowing. After 2-3 harrowing, furrows are made at 75-80 cm between rows.

Proper land preparation provides a favorable condition for crop growth and development. Breaking the soil into smaller particles through plowing and harrowing will promote better seed germination and good soil aeration.

When the soil breaks at plowing, soil pathogens and immature forms of insects (larvae and pupae) are exposed and during hot sunny days, these pathogens and immature forms of insects die. Ants also feed on the immature forms of insects when exposed. After plowing and harrowing, some farmers irrigate the soil and allow the weeds to germinate. Two weeks after, last harrowing and furrowing follow. They call this term the stable technique. This method reduces the number of weeds that will compete with the plants for nutrients, space, sunshine and water.

b. Seed sowing and plant density

Distance between rows is 75-80 cm while distance between hills is 20-30 cm. Rows in east-west direction will best capture the sunlight. Distance between rows will provide space for ease in movement during spraying, side dressing and harvesting.

Sow 2-3 seeds 2-5 cm deep. Seeding rate is 1-1.5 kg per hectare. Most farmers sow more than 3 seeds especially when they use their own produced seeds, the F2, F3 or F 4 seeds. If they use F2, F3 or F4 seeds they sow more than 5 seeds

per hill or about 5 kilos per hectare. They sow more seeds to ensure more seedlings to grow from F2, F3 or F4.

First thinning is made when seedlings are 5 cm tall and then later at 30 cm tall.

c. Ratooning

Some farmers practice ratooning when seeds are scarce and when the buying period is extended by Japan. Instead of establishing a new crop, farmers cut the main stem of the first crop. Farmers apply herbicides to kill the weeds before applying fertilizer and irrigating. A farmer applies sodium nitrate to enhance flowering. It does not take a month to harvest from the ratoon crop. However, pods from ratoon crop are of less quality and fewer than the former crop. This is so because there are more branches per plant to provide with nutrients.

It was observed that more larvae of fruitworm and cutworrm were monitored from the ratoon crops. The larvae of these pests came from the first crop and they pupated in the soil. Ratoon crop do not require tillage so the soil is not disturbed. The duration of time from pupa to adult, egg laying and hatching of eggs into larvae coincides with that time the ratoon crop is growing more leaves and flower. Besides the larvae, other insect pests will transfer to the ratoon crops when they have no more food from the first crop in the neighboring fields.

6. Water Management

Water is a limiting factor in okra production. Cropping period is towards the dry months of the year, October to March. Farmers irrigate the field after first harrowing to allow weeds to germinate and grow. Furrow irrigation is done after sowing and then weekly if necessary. Supplemental irrigation is required to maintain the crop's growth. A full-grown crop consumes about 8 ml water per day.

Frequency of irrigation varies with soil type and cropping season. Sandy loam soil of Tarlac has poor water retention and so the plant requires more furrow irrigation more often the clay loam soil.

7. Harvesting and Post-harvest Handling

a. Harvesting Okra

For vegetable use, the fruits are picked about one week after anthesis. It takes about one month from anthesis to mature fruit. In the seed crop, vegetative growth stops soon after anthesis, all assimilates being partitioned to the reproductive plant parts. In the vegetable crop, the picking of young fruits permits sustained vegetative growth prolonging the harvest. Harvesting starts at 45-60 days after emergence or 3-7 days after flowering. Okra pods are ready for harvest when they are about 2-4 inches or 4-9 cm long or while the pod is soft and tip snaps. The pods are bright green, fleshy pod and seeds are small. The pods should be gathered everyday. They are usually handpicked and sharp knives are used to cut them from the stalks to avoid fruit damage such as bruises and discoloration.

Earlier picking depresses yields because of sub-optimal fruit weight. Delayed picking depresses marketable yields because over-aged fruits become fibrous.

Okra when harvested are immature, hence, respiration rate is high with consequent release of high heat. Skin is not well developed yet so it is very sensitive to physical damage and easily attacked by microorganisms.

Okra has trichomes that increase the surface area for moisture loss. Trichomes easily break and when broken, it serves as entry point of microorganism and exit of water vapor from okra resulting in high moisture loss.

Harvest on the day or the day before shipment (because okra has very short shelf-life; cannot be stored very long even under refrigerated conditions). Harvesting every one or two days (to minimize high percentage of over mature pods). Okra should not be harvested in the rain or when excessively wet (pods prone to deterioration because of high water content on the fruit surface). Rubber gloves (cotton) should be used during harvesting and handling to minimize cuts or physical damage to okra; provides protection to harvesters). Use ventilated, shallow field crates (to minimize heat build-up that will enhance respiration and deterioration; to minimize physical like compression and bruises due to weight loss damage). About 1 cm of stem should remain attached to the pod.

b. Post-harvest handling okra

At harvesting, field sorting or removal of reject right in the field is done (to minimize handling, reduce hauling costs and reduce contamination. Only good pods are placed in field or hauling crates. When field crates are full, keep them under the shade and dry to prevent heat accumulation that will enhance deterioration and growth of disease-causing microorganisms.

Crates are hauled from the field to the processing house. Processing facilities are either an open area with roofs and working tables. The recommended processing facilities are air-conditioned rooms to reduce heat and reduce deterioration of pods.

1.) *Selection or sorting and grading*

Pods from crates are transferred to tables lined with pieces of cloth to prevent bruising. Sorting or selection for the pods of the right size (4-9 cm long), bright green, and 5 ridged, clean and free from bruises, insect damage and disease. Grading is done by hand. Rejected pods are placed in sacks and disposed as animal feeds.

PANIQUI FEDERATION COOPERATIVE FRESH OKRA PROCESSING
(PICTURE 2)


SORTING


SIZING


SOAKING


WASHING


DRYING


DRYING

2.) Cleaning

Some exporters wash the pods to remove dirt and other organisms like eggs and immature forms of insects and microorganisms. Washing also reduces chemical residues in pods. Cleaning is by spray washing or in large water tank containing wash water with 75-100 ppm active chlorine. After washing, remove excessive water by sponge rollers or air blowers to prevent bleaching or discoloration; minimize growth of disease-causing microorganism.

AITI FRESH OKRA PROCESSING
(PICTURE 3)

SELECTION

NETTING

SEALING

PACKING

PACKING

FINAL

3.) Packing

Pods are packed in small nylon net bags.

Packing is by loose or volume packing inside ventilated cartons with net capacity of 3.5-4.5 kg (8-10 lbs); pre-packaging in perforated film (to reduce moisture loss which should not exceed 3%, otherwise toughening and blackening of the ridges set in).

Packages are well-ventilated fiberboard carton with internal dimension of fiberboard carton:
10.9 x 34 x 26.9 cm
16 x 37.3 x 27.9 cm

4.) Pre-cooling

After packing forced-air cool the packages to remove field heat prior to transport Pre-cooling lowers respiration rate and the heat evolution by the okra that brings about high rate of deterioration. The process also lowers the heat load of the transport vehicle.

Hydrocooling can also be used in conjunction to washing.

5.) Storage and transport

Okra should not be stored more than 36 hours after packing (deterioration is already starting at this time). Do not put ice on top of the packages because it causes water spots on the pods and decay. Optimum transport/storage temperature is 10-12°C. Below 10-12°C, chilling injury develops, pitting, discoloration and excessive decay.

Can be stored together with snap beans, cucumber, eggplant, pepper, potato, squash, sweet potato, and watermelons (because these commodities have the same temperature requirements as that of okra). Okra is incompatible to be stored together with tomatoes and muskmelons. These crops are ethylene producers while okra is ethylene sensitive. Exposure ethylene causes toughening and yellowing of pods and browning of skin.

If transported by aircraft where ventilation is absent, remove the okra packages from cold storage 2-3 hors prior to loading into the aircraft (to allow condensation to evaporate from the pods and reduce blackening of the ridges, mold growth and yellowing of the pods).

Cold storage is the best way of extending life of vegetables. Vegetables should be cooled soon after harvesting. This may be done before and during transit or the vegetables may be brought to the cold storage room immediately. If the delay in storing the vegetables under refrigerated storage is unavoidable, the vegetables must be kept cool by other means such as the use of crushed ice. The best temperature for storing okra is 10 °C.

Stored vegetables should not be kept for more than 3 weeks. Even under proper storage conditions, deterioration goes on.

C. MAJOR PESTS OF OKRA AND THEIR MANAGEMENT

This section includes the major insect pests of okra, their description, ecology and biology, host plants, damage, natural enemies and management.

1. Stem and Pod Borer of Okra*, Earias vitella*

Adult

Larva and damaged shoot and pods

Description

Adult: The moth is yellowish-brown, about 12 mm long with a wingspan of about 20-25 mm. Color of fore wings is variable, depending on the season of the year (temperature), i.e. yellowish white with a pink shade or brownish-yellow and with a green (sometimes brown), more or less wedge-shaped longitudinal stripe. The dorsal side of the thorax has two green stripes. Hind wings are whitish.

Egg: The eggs are about .5 mm in diameter, spherical and bluish green in color. The egg shell (chorion) has parallel longitudinal ribs forming a crown-like structure at the top. Eggs are laid singly or in small groups on young shoots, underside of the leaves, flower buds or young pods.

Larva: The fully developed (last instar) larvae are about 20 mm long, more or less spindle-shaped, greenish, dark grayish or brownish in color. The dorsal side or the back has a broad, whitish, longitudinal stripe with distinct dark spots. Two orange spots are found on the thoracic segments. Head and spiracles are black.

Pupa: It is shiny yellowish brown, about 12-14 mm long and found in a firm, yellowish-white to light grayish cocoon, shaped like an inverted boat. The pod borer pupates on top of the soil layer or on the plant, often on dried shoots and pods.

Biology and ecology

During the night after mating or within a few days, the female starts to lay eggs, singly or in small groups on young shoots, flower buds, pods, or underside of the leaves. The moths live for about 1-3 weeks. An adult lays 63-697 eggs. The incubation period is 3-7 days depending on the temperature. The young larvae feed their way into the young shoots, flower buds or pods. In the course of its life, a larva can attack a number of flower and pods one after another. The larval stage consists of 5 instars lasting from 10-16 days depending on the temperature. When the larva is ready to pupate, it prepares a cocoon on top of the soil layer or on the leaves that have dropped off. The moth hatches 1-2 weeks. Complete life cycle of pod borer is 3-5 weeks. At favorable conditions, it can produce 12 generations in one year.

Host plants

Cotton, okra and other wild malvaceous plants.

Damage

The young larvae bore and feed inside the shoots and pods. The shoots wilt and dry. The damaged plants developed branches and bears smaller pods. During the reproductive stage, the larva feeds on the flowers and bores inside the pods. A larva attacks a number of stems and pods one after another. The larva feeds and completes its larval development inside the stems and pods. Damaged plant parts can be easily detected through the fresh frass and holes on the pods. Damaged plant tissues serve as entrance for disease-causing microorganisms such as fungi. Early damage on pods also causes deformed pods.

Natural enemies

Natural enemies of stem and pod borer are egg parasitoids, *Trichogramma*, Braconid larval parasites and predators such as earwigs and ground beetles.

Management of stem and pod borer

Farmers commonly spray insecticides for stem and pod borer. They need to apply systemic compounds to kill the insects.

It is important to monitor the field for adult insects. Adults are seen on the shoots where they lay their eggs. Releases of *Trichogramma chilonis* at 30,000-50,000 adults per hectare are recommended weekly as soon as adults are observed in the field. If the plants are not sprayed and weather conditions are favorable (no heavy rains and typhoons), *Trichogramma* can establish in the field and no further inundative releases will be done towards the reproductive stage of the plant. However at very high population and damage it is best to continue weekly releases of *Trichogramma.*

Removal and proper of damaged shoots and pods will greatly reduce stem and pod borer damage in the field. Cut the shoots below the entrance hole to be sure

the larva goes with the cut shoot. Burn the damaged shoot and feed the pods to animals.

2. Okra Fruitworm, *Heliothis armigera*

Description

Adult

The body length is about 16-18 mm with wingspan of 32-38 mm. Forewings have yellowish-brown, gray-brown or copper-brown color. Several serrated transverse lines, broad sub-marginal band and reniform spot in some distances from front edge of the wind are present in the wings. Hind wings are whitish with broad, dark gray or brownish band on the edge with two light spots within the band.

Egg

Eggs are virtually round with a diameter of 0.5 mm. The eggshell has a number of longitudinal ribs. Eggs are yellowish-white and darken before larvae hatches.

Larva

When fully grown before pupation, it measures about 36-40 mm long. Head capsule, prothoracic plate and legs are brown. Spiracles are black. Body color varies from yellow, light to dark green, brown, reddish-brown, pink, orange or occasionally blackish. Dark colored larvae has usually dark, longitudinal dorsal stripes and a number of lateral stripes of different color.

Pupa

Pupa is light brown, about 15-20 mm long. It has 2 setae on tip of the abdomen.

Biology and ecology

After hatching from the pupa, the female feed on nectars of the flowers. It takes some days to mature and after mating, it begins to lay eggs. The adults are nocturnal in habit. The eggs are laid singly and can be found on all parts of the plant but mostly on the young shoots, leaves, flowers and pods. A female lays 300-400 eggs. The incubation period is 2-4 days depending on the temperature. During hatching, the larva consumes its eggshell until it starts to feed on the plant. It prefers to feed first on the flowers and then bores inside the pods. It can feed on several flowers and pods throughout the larval instars. The larval period is completed within about 2 weeks. The larvae are cannibalistic; the stronger larva feeds on the small weak larvae. Pupation takes place in the topsoil layer for 2 weeks. The adults are able to fly considerable distances. It can complete several generations in a year.

Host plants

Fruitworm is polyphagous, feeding on a wide range of plants such as corn, cotton, okra, tomato, tobacco, eggplant, pepper, cabbage, cucurbits, sorghum, legumes, weeds, and even citrus.

Damage

It is one of the most serious pests of many crops. The larva feeds on leaves, shoots, flowers and flower buds, and pods. The larva bore and feed inside the pods causing losses of pods.

Natural enemies

There are many natural enemies of fruitworm. The parasitic wasps are *Trichogramma, Microplitis manilae* and other braconid wasps. Earwigs, *Orius*, carabid beetles, mired and nabid bugs are the predators. *Bacillus thuringiensis* and Nucleopolyhedoris virus (NPV) are pathogens causing infection on fruitworm larva.

Management

Biological control using NPV and *Bacillus thuringiensis* for larvae will reduce fruitworm population. *Trichogramma evanescens* is effective in controlling eggs of fruitworm. Removal and proper disposal of pods with larva can reduce the population of fruitworm. Weeding will kill the alternate host plants of fruitworm.

3. Common Cutworm, *Spodoptera litura*

Description

Adult

Adult has a wings span of 32-38 mm. Head, thorax and abdomen are brownish. Fore wings are brown or gray-brown with a number of light stripes and spots. Tip and base of fore wings of males have clear defined bluish area. Hind wings are whitish with a brown margin.

Egg
Eggs are round, yellowish to greenish approximately .6 mm in diameter.

Larva
The larvae are usually brownish to blackish-brown when fully developed, and with one median and 2 lateral longitudinal stripes. Thoracic and abdominal segments with 4 black spots respectively. Body length is about 35-42 mm and width about 5-8 mm.

Pupa
Pupa is shiny red-brown, about 12-16 mm long and about 6 mm across. Tip of the abdomen has 2 slightly curved setae.

Biology and life cycle
The female lays eggs at night and in masses of sometimes several hundred of eggs. The egg masses are found in the under or upper side of the leaves covered with scales of the female moth. A female throughout its course of its life (about a week) can lay up to 2,500 eggs. The egg hatches within a few days and the larvae feed together on the leaves during the first 3 instars. They subsequently disperse to other plant parts at the 4^{th} to 5^{th} instars. Larval period is 14-18 days. The fully developed larva pupates in the soil where they previously spent time during daytime seeking shelter from the sun. The pupal period lasts for 7-18 days. The insect has a number of generations in a year.

Host plants
The insect is polyphagous, feeding on many crops, weeds and wild plants. The larva feeds on okra, cotton, corn, sorghum, crucifers, cucurbits, legumes, carrots, plantation crops, sweet potato, solanaceous crops, other field crops, weeds, fruit trees, and wild plants.

Damage
The young larvae feed on the underside of the leaves leaving only the epidermis of the upper side intact (windowing). The damaged leaves wither as if burnt. Feeding by older larva cause numerous holes between the main veins of the leaves. At high density, the larvae also feed on the flowers and pods.

Natural enemies
Braconids wasps parasitize the larva, while the earwigs, spiders, *Orius*, wasps, lacewing, and carabids prey on the eggs, larvae and adults. *Bacillus thuringiensis* and NPV are the disease-causing organisms of cutworm.

Management
Biological control using NPV and *Bacillus thuringiensis* for larvae will reduce cutworm population. Handpicking eggs, larvae and pupae reduces the

population. Weeding will kill the alternate host plants of cutworm. Exposure of pupae during land preparation destroys the pupae of cutworm.

4. Cotton Leafhopper*, Amrasca biguttula*

Description

Adult

An adult has long and thin body, 2.5-3 mm long, yellowish to yellowish-green in color. Fore wings are shiny and with conspicuous dark spot on the posterior half. Tibiae of hind legs are equipped with numerous strong setae.

Last nymphal instar

Last nymphal instar is about 2-2.4 mm long and.5-.6 mm broad. Body shape is similar to that of adult but smaller in size and lacking fully developed wings. The color is greenish to yellowish. Other nymphal instars are similar to last instar but smaller.

Egg

The eggs are broad-shaped, whitish to bluish-white and about .5 mm long and .1 mm broad.

Biology and ecology

Cotton leafhopper is one of the most important pests of okra in the early stages of plant growth. At daytime, the nymphs and adults remain near the base of the underside of the leaves and then run quickly sidewards when disturbed. The adults fly to other plants. In flight, they can cover long distances with the aid of the wind.

The female lays banana-shaped eggs singly and preferably in the petioles and main veins of the leaves. They prefer the young leaves. Eggs hatch after a week. The entire development takes place in about 2 weeks depending on the temperature. At high temperature, large populations can build up at favorable weather conditions.

Host plants

Cotton leafhopper is also polypahgous, feeding on cotton, okra, eggplant soybean, sunflower, beans and potato.

Damage

The damage which the nymphs and adults cause is by sucking plant sap and /or toxic effects of the saliva they inject when feeding on the leaves. In okra, severe leafcurl can be observed; the outer zones of the leaf turn yellowish to reddish and wither at a later date. Severe damage causes stunted growth, reduced yield. Field s seriously damage are easily recognized by the reddish to purple color of “hopperburn” effect.

Natural enemies
Many predators such as spiders; *Orius*; predatory wasps, dipterans and beetles prey on cotton leafhopper nymphs and adults***.*** *Beauveria bassiana* and other fungal entomopathogens cause infection on the nymphs and adults***.***

Management
Beauveria bassiana spores when applied to the plant cause infection on leafhoppers. Infection spread out in the field. At outbreaks of leafhopper population during the early stages spraying pesticides is needed. Weeding will also reduce the availability of alternate host plants.

Varieties of okra with thick and long trichomes on leaves and pods are more resistant to leafhoppers than the smooth varieties. Apply the recommended amount of fertilizer to the crop. Too much nitrogen applications make the crop susceptible to leafhoppers.

5. Whiteflies*, Bemisia tabaci*

Description
Adult
Adult whiteflies are very small insects only about 1 mm long with piercing-sucking mouthparts. It has a yellowish body, covered with secretions of a white, flour-like appearance. The male is usually smaller than the female. The wings are white, about equal in size and form in the resting white fly a kind of roof over the abdomen.

Egg
The eggs are pear-shaped with a pedicel spike at the base, approximately .2 mm long.

Larva
The larvae are yellowish-white scales, .3-.6 mm long.

Pupa
The pupa is flat, oval shape, .7-.8 mm long. On a smooth leaf, the puparium lacks enlarged dorsal setae, but if the leaf is hairy, 2-8 long setae are present on its back.

Biology and ecology
Whitish eggs are laid usually in circular groups on the underside of the leaves with broad end touching the surface. The eggs turn brown when ready to hatch after 5-9 days. A female lay up to 169 eggs. The first instar crawlers are flat, oval-shape and scale-like. It is the only mobile larval stage. It moves to a suitable feeding area on the underside of the leaves and remains sessile throughout its remaining nymphal stage. The first 3 nympal stages is 2-4 days. Pupation lasts for 6 days. Adults emerge through a T-shape rupture in the puparium. Mating begins after 12-20 hours after emergence and takes place several times throughout the life of the adult. A female lives for 60 days longer than the males that are 9-17 days. Some 11-15 generations can occur in a year.

Host plants
It is also a polyphagous feeding on many crops like cotton, okra, tomato, Gerbera, bell pepper, tobacco, sweet potato, crucifers, cassava, legumes, cucurbits, solanaceous crops, and cutflowers.

Damage
The feeding of adults and nymphs causes chlorotic spots to appear on the surface of the leaves. Feeding leaves honey secretions on the leaves and when colonized by moulds will reduce the photosynthetic ability of the crop. At heavy infestations, it causes stunted growth and reduces yield and quality of pods.

Whiteflies transmit the yellow vein mosaic virus in okra. Infected plants show symptoms of yellowing vein, inter-vein yellowing, leaf yellowing, yellow blotching of leaves, yellow mosaic of leaves, leaf curling, leaf crumpling, leaf vein thickening, leaf enations, leaf cupping, stem twisting and plant stunting.

Natural enemies
Several species of *Encarsia* parasitize whiteflies while coccinellids, lacewings, predatory bugs; wasps attack the nymphs and adults. *Bacillus thuringiensis* and *Beauveria bassiana* are pathogens causing infection on whiteflies.

Management
Injudicious use of pesticides led to resistance development in whiteflies. Thus continous spraying of pesticides may worsen the situation. The most effectiove

control for whiteflies is the application of biological control agents such as *Beauveria* and releases of parasitoids, *Encarsia.*

6. Melon Aphids*, Aphis gossypii*

Description

Wingless female has oval body, about 1.2-1.5 mm long and .8-.9 mm across. Color is blackish-green, dark green, yellowish-green or yellow. The width of head is bigger than the length. Antennae are considerably shorter than the body. First, second and final joints of antennae are dark-gray to black, remaining joints yellow. Cornicles are cylindrical, long and blackish in color.

Winged female is about 1.2-1.4 mm long and .6-.7 mm broad. Head and thorax are dark gray to dark brown. Abdomen is blackish, blackish-green, yellowish-green or yellow. Antennae are shorter than the body. Cornicles are blackish and wings are transparent. Apart from being smaller, nymphal instars are similar to adult insects.

Biology and ecology

The winged aphids usually develop on heavily infested cultivated or wild plants (weeds) and can cover considerable wide distances through the aid of the wind. The aphids that settle on the younger, softer, well-nourished parts of the plants are usually darker in color while those on the older leaves are yellowish in color.

Reproduction by aphids is by parthenogenesis (produces offspring without mating). At high temperatures, aphids develop many generations. A wingless female can produce 150 nymphs while the winged form has less.

Aphids feed on the phloem of the host plant. They secrete honeydew why they are attended by ants.

Host plants
Melon aphids feed on cotton, okra, cucurbits, legumes, solanacoeus crops, crucifers, legumes, citrus, guava, coffee and cacao..

Damage
Melon aphids suck the sap of the phloem. It secretes honeydew that is being colonized by sooty molds. Sooty molds reduce the photosynthetic ability of the plants. At heavy infestations, leaves curl and growth is stunted. The aphids also transmit virus diseases.

Natural enemies
Coccinellid larvae and adults and syrphid larvae are voracious feeders of aphids. Other predators include spiders, predatory bugs, wasps, beetles. Parasitic wasps also attack aphids.

Management
Natural enemies such as the predatory beetles, syrphids and bugs reduce aphid population. Irrigation and application of recommended rate of fertilizer will also help manage the aphid population. Botanical pesticides will also exert control on aphid population.

7. Cotton Thrips*, Thrips palmi*

Description
Adult
Adults have body elongate, slender shape and yellowish in color. Females are 1.2-1.3 mm while males are 1-1.1 mm. First and second joint of antennae is light. Wings are narrow with long numerous setae. It has asymmetrical piercing-sucking mouthparts.

Nymphs
Nymphs are similar to adults but are smaller and without fully developed wings.

Biology and ecology
The females lay eggs singly in the tissue of the attacked plants by its ovipositor. The nymphs hatch after few days and begin to feed. Only the first two instars are found on the plants while the two pupal instars do not feed and are found in the

soil. During warm weather, development is completed in 7-18 days. They reproduce parthenogenetically as males are rare.

Host plants
Thrips attack plants like okra, cotton, onion, garlic, cucurbits, solanaceous crops, tobacco and many other field and ornamental crops.

Damage
The adults mainly attack the lower portion of the leaves and feed along the main veins and later on the other parts of the leaves. The damaged leaves become silvery and turn to bronze after sometime. Heavy infestation causes leaf curling and stunted growth.

Natural enemies
Predatory bugs, beetles and Eulophid wasps are some of the natural enemies of thrips.

Management
Botanical pesticides such as neem extract, biological control agents like *Beauveria* and *Orius* can keep down the population of thrips. Early planting, irrigation and application of the recommended amount of fertilizer are important in the reduction of thrips population.

8. Red spider mites, Tetranychus sp.

Description
Adult
Body is more or less oval in shape. Length of adult female is .5 mm long and .3mm wide while the male is smaller. Color is pale orange-yellow or reddish dark purple with legs lighter in color.

Larva
First larval instar has 3 pairs of legs, all further instars with 4 pairs. Legs and dorsal side of the body has long hairs. Protonymph (2^{nd} instar) and deuteronymph (3^{rd} instar) resembles each other apart from smaller size compared to adults.

Biology and ecology
The females lay their eggs singly on the leaves. The incubation period lasts 1-2 days. After hatching, the six-legged larvae begin feeding on the parenchymatic plant cells. The last larval instar is called the resting period during which the first molt takes place. Resting periods follows both the second instar and the 3rd instar. The mite becomes adult after the 3^{rd} instar. The development of one generation can take place within a week. Many generations develop within a year.

Host plants

Red spider mites attack many plants, field crops, vegetables, plantation crops, horticultural crops, ornamentals, weeds and wild plants.

Damage

Red spider mites cause small whitish or yellowish spots on the leaves. If infestation is high the damage on the leaves merge and appear brownish-red. Leaves wither and fall. Damage by mites resembles to that of thrips and leafhoppers. At high temperature, the mites reproduce rapidly. They spin webs used for mobility in the leaves.

Natural enemies

There are predatory species of mites that reduces red spider mite population. Other predatory bugs, beetles, wasps and spiders feed on red spider mites.

Management

Red spider can easily develop resistance to pesticides so other strategies should be used. Botanical pesticides such as neem extract, removal of weeds, application of recommended fertilizer and irrigation help in reducing spider mite population. Heavy rains or sprinkler irrigation will wash off the red spider mites from the plants.

D. MAJOR DISEASES OF OKRA AND THEIR MANAGEMENT

This section includes the causal organism, symptoms, and management is of the three major diseases of okra: the yellow vein mosaic virus*, Cercospora* leaf spot and powdery mildew.

1. Yellow Vein Mosaic Virus of Okra

Yellow vein mosaic of okra is a virus disease transmitted by whiteflies and leafhoppers. If there yellow vein mosaic in the area, whiteflies feeding on the infected plants will carry or transmit the virus through its feeding on healthy plants. A plant with yellow vein mosaic virus has yellowish mosaic on the leaves, prominent yellowish veins and curling leaves. If infection is severe, plants become stunted and pods are of low quality.

Controlling the vector will reduce the spread of the disease in the field. Whiteflies can easily develop resistance to pesticides so other pest management strategies must be implemented. An easy method is planting varieties with plenty of long trichomes on the leaves, stems and pods. Trichomes deter the movement of insect in the leaves. Other methods such as application of botanicals like neem extract can reduce whitefly population in the field. Rainbird type of irrigation will kill the small soft-bodied insects. Application of the recommended rate of fertilizer will promote growth and better crop stand. Too much nitrogen will make the plant more susceptible to whitefly and leafhopper attack.

2. *Cercospora* Leaf Spot

Cercospora leaf spot is a fungal infection caused by the pathogen, *Cercospora abelmoschi.* Spores from the infected field or plants are carried by the wind to other plants. The spores that stick on the leaf surface grow. The plants show signs (mycelial growth) on the underside of the leaves. Symptoms are observed on the old maturing leaves such as yellowing and brown spots on the underside of the leaves. At serious infection, the leaves turn brown and become dry.

Removal and proper disposal of old yellowing leaves with *Cercospora* leaf spot reduces the infection in the field. Burning the leaves is the easiest way of disposing the infected leaves. After removal of the leaves, spray fungicides on the underside of the okra leaves. Less fungicide is required than when the leaves are not yet removed. Spray fungicides late in the afternoon.

3. Powdery mildew

One of the causal organisms of powdery mildew is *Erysiphe cichorocearum* in okra. *Erysiphe* also infects other plants isuch as cucurbits, potato, tobacco, tomato, sunflower, and lettuce. Okra infected by powdery mildew has whithite powdery growth on the upperside of the leaves. Dark spots are all over the infected leaves. This hinders the photosynthetic ability of the plant resulting to stunted growth. The leaves turn brown and eventually become dry.

Application of fungicide late in the afternoon can control the infection. It is important to monitor the adjacent field for the infection so that preventive application of fungicides can be done. Since the spores are carried by the wind, refrain from planting in the area towards the direction of the wind from the source of infection.

E. MAJOR WEEDS OF OKRA

This section includes the important weeds in okra, their description, means of propagation and management.

1. Broad Leaf Weeds of Okra

The broad leaf weeds of okra are the giant pigweed, *Trianthema portulacastrum*; spiny amaranth, *Amaranthus spinosus*; morning glory, *Ipomoea triloba; Ageratum conyzoides, Synedrella nodiflora* and *Cleome rutidosperma*.

Trianthema or the giant pigweed is a succulent, prostrate annual herb. The stem is flat, fleshy 10-40 mm long, much branched, green or purplish. The leaves are arranged opposite in unequal pairs, ovate to almost circular, glabrous, with slightly wavy margins, narrowed at the base to a petiole 3-10 mm long with an inflated sheating base. The flower is solitary, axillary, sessile, white or pale pink to purple. Fruit is a capsule, 3-4 mm in diameter, with 1 awn at the tip, opening around the middle, containing 6-8 seeds. The seeds are rough, kidney-shaped reddish brown to black, about 1.3mm in diameter. Propagation is by seed. The habitat is in dryland field crops, vegetable crops and pastures.

Farmers observed *Trianthema* to harbor small larvae that may also feed on their okra. Several larvae were collected and an insect zoo was set up. The adults that emerged from the pupa are unknown microlepidoterans. Other larvae were given okra leaves but the larvae were observed not feeding on okra.

Ipomoea triloba or morning glory is a crawling or twining vine. The stem is herbaceous, slender glabrous somewhat pubescent, rarely rooting at nodes and 100 cm long. The leaves are broadly ovate to orbicular in outline, 2-10 cm long, entire, coarsely dentate tapering at the tips to concave. The flowers are axillary, usually sub-umbelliform cymose, rarely solitary, pink to purple, commonly up to 3 cm in diameter, corolla about 1.5 cm long and 1-12 cm long peduncles. The fruits are spherical, hairy capsule, 5-6 mm long and brown. Seeds are hairless and 3-3.5 mm long. Propagation is by seeds and the habitat is in dryland field crops and vegetables.

Celosia argentea is an annual herb up to 2 m high. The stem is fleshy and branched. Have alternate leaves, linear-lanceolate to narrowly linear, 5-15 cm long and 0-1.3 cm wide. The flower is a pink or white dense, many-flowered spike, tapered at the end, terminal on the stems and branches, 3-10 cm long with peduncle up to 20 cm long. The fruits are 1-seeded capsule, ovoid to almost globular and 3-4 mm in diameter. The seeds are black, round, shiny and .5-1.5 mm in diameter. It propagated by seeds and lives in the dryland field crops.

Corchorus olitorius is an erect; much- branched annual up to 1 m high with tough stems. The stem is woody at the base with jointed nodes. The leaves are alternate, ovate-lanceolate up 20 cm long, 3-7 cm wide, with hair-like projections about 1 cm long on each side of the square or rounded base; margin finely toothed, stalk hairy, 1-2.5 cm long. The flowers are yellow, 6-8 mm in diameter, solitary or paired on very short stalks in the axils of the upper leaves. The fruits are 5-valved, transversely ridges inside, 3-6 cm long, 5 mm wide, abruptly narrowed at the tip to a short beak. The seeds are numerous, small, dark,

angular, about 2 mm wide. Propagation is by see and found in the dryland field crops.

Ageratum conyzoides is an ascending to erect annual, .2-1 m high with a strong odor. The stem is hairy and branched; leaves are simple, opposite, ovate, with serrated margins, tip acute, narrowing abruptly at the base to a hairy stalk up to 5 cm long. The flowers are pale blue or white, in clusters of 4-18 flower heads, sparsely hairless acute bracts. The fruits are slender, lanceolate, pentagonal black achene with brown to white base. It is propagated by seeds and live in dryland fileld crops, plantation crops, vegetable crops and pastures.

2. Sedges

The most common sedge in the okra field is *Cyperus rotundus* or purple nutsedge.

Purple nutsedge is an erect, rhizomatous, tuber-forming perennial 15-50cm high. The above ground stems are erect, unbranched, smooth, triangular, with swollen tuberous base. Rhizomes are spreading, slender, white and fleshy, covered with scales when young, brown and fibrous or woody when old. Tubers are irregularly shaped, 1-2.5 cm long, white and succulent when young, turning coarse, fibrous, brown or black when old and open produced in chains. The leaves are linear, dark green, basal and 5-15 cm long. The flowers are terminal umbels, subtended by 2 or 4 leafy bracts with overlapping reddish brown florets. The seeds are achene, ovate or oblong-ovate, 1.5 mm long, 3-angledand blackish when ripe. Seeds, rhizomes and tubers propagate it. It lives in the dryland field crops, plantation and vegetable crops.

3. Grasses

There are many grass species in the okra field but the most common are stargrass, *Cynodon dactylon*; crow'sfoot grass, *Eleusine indica, Echinochloa colona* and *Dactyloctenium aegyptium.*

Echinochloa colona is a smooth, tufted annual, 30-75 cm high, usually decumbent and rooting at the lower nodes. The stems are flattened, open reddish-purple at the base, usually swollen at the nodes. The leaves are smooth, margins free in the upper part, basal portion often tinged with red; blade smooth, flat and up to 2-25 cm long. The flowers are green to purplish, ascending panicle, 6-12 cm long, with 4-8 simple, short, compact branches, 1-3 cm long. Spikelets are ovate, acute, 2-3 cm long, closely crowded in about 4 rows along one side of the branch, nearly sessile, sometimes with an awn point about 1 mm long. Fruits are caryposis and elliptical. Propagation is by seeds and habitat is in the dryland field crops, vegetable and plantation crops and in wetland rice.

Crow's foot grass is slightly hairy, tufted, prostate to ascending annual up to 60 cm high, profusely branching at the base and occasionally rooting at the lower nodes. The stems are laterally flattened, whitish or pale green, smooth or with a few long hairs along the edges. The leaf sheath is 6-9 cm long, flattened laterally with a few long hairs at the collar, blade flat or folded, 10-30 cm long, with parallel margins and blunt tip, ligule membranous, auricle absent. The flowers are digitate, with terminal whorl of 3-6 spikes, spikelets numerous, sessile, and awnless. Fruits are caryopsis about 1.5 mm long, reddish-brown, oblong-ovate, with conspicuous ridges. It is propagated by seeds and lives in the dryland field crops and plantation crops.

Cynodon dactylon, or stargrass is an extensively creeping, much-branched perennial grass with underground rhizomes. The stems are flattened, usually prostate but sometimes upright, flowering stalks 10-40 cm high. An extensive system of rhizomes produced below ground, long runners above ground, with roots and tufted shoots arising from the nodes. Leaves are small, linear, 2-20 cm long and 4 mm wide, blue-green smooth on the lower surface, hairy on the upper, margins rough. Sheaths on aerial stems are overlapping with a few long hairs at the junction of the sheath and blade. The flowers are terminal, 4-5 slender digitate spikes, 1-6 cm long, 1-2 mm wide, each bearing many spikel;ets; spikelets sessile, flattened, closely overlapping in rows along one side of the spike. Fruits are caryopsis, flattened, elliptical, reddish brown. Seeds, runners and rhizomes propagate it. It lives in the dryland cield crops, plantation and vegetable crops.

4. Weed Management

Weeds are difficult to manage because they have several means of propagation such as by seed, rhizomes, tubers or stem. They produce many small seeds that can be carried by the wind, animals and by farm tools.

Handweeding is the most practical method of controlling weeds. Remove the weeds from the field when they are still small. Do not allow them to flower and have mature fruits or seeds to prevent the spread of more seeds in the field. In okra, the stable technique (as named by the farmers) allows the weeds to germinate from the first harrowing to last harrowing. These weeds die at the last harrowing and furrowing. At 3-4 weeks after sowing, side dress fertilizer and follow with off barring to cover the fertilizer and kill the weeds between rows. This will reduce the weeds and will be easier to handweed.

Water management, proper land preparation, application of recommended rate of fertilizer and crop rotation are among the cultural management practices that can help reduce weed density in the field.

Farmers commonly apply herbicides to control the weeds. They apply broad-spectrum herbicides causing death of okra seedlings from herbicide drift. Phytotoxicity always happens in the okra field due to over reliance to herbicides in weed control. They still consider herbicide application as the easiest and least expensive method of weed control.

It is necessary to control the weeds because they compete with okra for nutrients, space, sunshine and water. They also serve as alternate host for pests and diseases in okra.