NATIONAL OPEN UNIVERSITY OF NIGERIA

SCHOOL OF SCIENCE AND TECHNOLOGY

COURSE CODE: ACP 305

COURSE TITLE: PRINCIPLES OF CROP PROTECTION

ACP 305: PRINCIPLE S OF CROP PROTECTION: COURSE GUIDE

Contents Pages

Introduction:

In nature, plants and animals exist in a dynamically balanced community. Under these conditions, the incidence of pest and diseases is uncommon. This was the situation when man survived on hunting and collecting of fruits and roots for food.

The introduction of crop husbandry by man between 15,000 and 10,000 B.C., created one of the basic causes of pests and disease development. The drastic and continual alteration of the ecological conditions led to the disruption of the biological balance in nature. The clearing of small to large areas of land which involve the destruction and alteration of natural vegetation and ecosystems, the cultivation of crops and the selection of plants for yield and human acceptability, aggravated the situation and led to the population explosion of pest and disease organisms. Also, intercontinental transport and trade brought about the introduction and establishment of new pests and diseases from other areas. Other factors that create pests and diseases include the introduction of new crops and changes in human habits and economic conditions. For instance, as the standard of living of some people rises, their taste and preference change. They are no longer willing to tolerate a few scales on the skin of fruits or vegetables or new beetle or caterpillar holes.

The course

Course aims:

This course aims to provide an understanding and appreciation of crop pests and diseases, and the practices for their management and control.

Course objectives:

In addition to the aims above, the course intends to achieve some wider objectives which have been introduced through discussions of certain peculiarities in protection.

At the end of the course, you should be able to:

i. Discuss the nature of crop pests and diseases
ii. Describe the major crop pests and diseases
iii. Appreciate the economic importance of pests and diseases
iv. Discuss the management and control strategies of plant pests and diseases.

Working through the course

This course material has been written in very simple language for your understanding. However, the course demands of you total commitment and dedication as much is still required of you. You are advised to devote time to read the material until you are convinced that you have understood the content; and do not forget to attend the tutorial sessions where you would have the opportunity of interacting with other students, and to ask questions on issues not very clear.

The course materials

For the study of this course, you will be provided with the following materials.

- Course guide
- Study units

Course overview

In addition, you are provided with a list of recommended textbooks which you may acquire to supplement the course material.

Study units:

The course has been divided into the following study modules and units:

<u>Module I: Crop pests</u>

Unit 1: Concept of crop pest

Unit 2: Insects as pests

Unit 3: Other animal agricultural pests

Unit 4: Weeds as pests

Unit 5: Pests of stored products

<u>Module II: Crop diseases</u>

Unit 1: Concept of crop diseases

Unit 2: Important diseases of Crop plants

In module 1, Unit 1, the various definitions of crop pest and the conditions which promote pests and diseases are given. You are also introduced to the categories of crop pests.

In unit 2, insect pests of cereals, legumes, root and tubers have been identified. Their economic importance, morphology and life cycle as well as control methods are also discussed.

In unit 3, special discussion is made for other animal agricultural pests. Particular mention is made of rats, mice, nematodes and birds because of their importance. Their control measures are also discussed.

In unit 4, you will learn about weeds as pests. Weeds are pants growing were they are not wanted, but are important in crop production. They have both harmful and beneficial effects. Methods of weed control are also highlighted.

Unit 5 focused on storage pests of common Nigerian crops and the damages caused by them.

In module II, units 1 and 2, the concepts of diseases and a description of the causative agents of crop diseases are given. You will be acquainted with disease symptoms and how they can be diagnosed. Important diseases which affect arable and permanent crops and methods of their management are also discussed according to crop agronomic groupings.

COURSE OVERVIEW

Module	Unit	Title of work	No. of weeks to complete them	No. of assignments
1	1	Concept of crop pest	1	5
	2	Insect pests	2	2
	3	Other animal agricultural pests	1	2
	4	Weeds as pests	1	5
	5	Pest of stored products	1	4
2	1	Concept of crop diseases	1	6

	2	Important diseases of crop plant	2	2

Textbooks

The under listed books are recommended for further reading. You will benefit by consulting these books regularly and making notes from them. They form the main reference material which will enable you to expand your level of knowledge and understanding of the various aspects of the course:

i) Anthony, Y., O.C. Ezedinma and Ochapa, C.O. (1986). Introduction to Tropical Agriculture. Longman Group Ltd.

ii) Ayo Fatubarin. Plant pathology. 2003 series

iii) I.C. Onwueme and T.D. Sinha. Field Crop Production in Tropical Africa. CTA, Wageningen, Netherland.

iv) I.C. Onwueme. Crop Science. Book 2. cassell's Tropical Agriculture Series.

v) Larry P. Pedigo. Entomology and Pest Management. Low price edition, 4th Edition.

vi) M.I.T. Norman., C.J. Pearson and P.G.E. Searle (1995). The Ecology Tropical Food Crops. Cambridge University Press.

vii) T.A. Taylor. Crop Pests and Diseases. Eds. G.C. Last and A.L. Mabogunje.

Assessment

There are three components of assessment for this course- The Tutor Marked Assignment (TMA), Students Activities (Practical), and the End of Course Examination.

The Tutor Marked Assignment is a continuous assessment component of your course. It accounts for 30% of the total score. Tutor Marked Assignments are provided at the end of each unit for you to answer. All of these must be answered before you are allowed to sit for the end of course examination. The TMA’s would be given to you by your facilitators and returned after you have done the assignment.

Students Activities for self assessments are also embedded within some units. Most of them require your personal involvement and effort to carry them out.

The end of course examination concludes the assessment for the course. It constitutes 70% of the whole course. You will be informed of the time for the examination. It may or not coincide with the university semester examination.

Summary

The course introduces and acquaints you with the commonest crop pests and diseases as well as their management strategies. It has been written in a clear, easy – to – read style. As you read through the materials, you will come across familiar, and some not too familiar crop pests and diseases. This is intended to increase your depth of knowledge about the subject matter. The additional knowledge you will acquire from studying the course will prepare you for a latter, very productive life in farming.

ACP 305: PRINCIPLES OF CROP PROTECTION

MODULE 1: CROP PESTS

Unit 1: Concept of Pests

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1.0 Introduction

Before any attempt is made to control an insect or other organism, it should first be established that it is a pest and that it would be profitable to attempt control. In this unit, you will be acquainted with the fundamentals of crop pests and the general methods for their management and control.

2.0 Objectives

At the end of this unit, you should be able to:

2.1 Define and describe crop pests
2.2 Discuss the importance of Crop pest
2.3 Categorize crop pests
2.4 Name the different types of crop pests
2.5 Discuss the damages caused by insect pests

3.0 Concept of crop pest

3.1 Definitions of crop pest:

Pests are usually defined in terms of the degree and importance of crop damage or loss. Most often, the definition of a pest depends on individuals and the prevailing conditions.

Examples of the many definitions of a pest include the following:

a) A pest is any animal or plant which harms or causes damage to man, his animals, crops or possessions, or even just causes him annoyance.
b) A pest is any organism detrimental to man, whether it is an insect, disease organism, weed, rodent, or other.

c) A pest is any form of plan or animal or pathological agent injurious or potentially injurious to plant or plant products, livestock or man.
d) An organism is a pest when the level of damage it causes is sufficient to warrant control measures.

3.2 Importance of Crop pest

Crop productivity in most of Africa is generally low. This is due to losses from pests and diseases. Therefore, the reduction of losses due to pests and diseases is an important element in increasing the efficiency of crop production. These losses occur from planting of the seeds through field phases of production to storage and processing.

3.3 Conditions which promote pests

a) Favourable climatic conditions.

The most common way in which organisms attain pest status is simply by an increase in number. Seasonal increases in pest numbers are usually controlled by climatic conditions and biological pressures. These climatic conditions include temperature, humidity, rainfall and sunlight. *Aphis gossypii* (the cotton aphid) outbreaks commonly occur on young plants in spells of dry weather, but clear up rapidly with the onset of the rains. In Great Britain, outbreak of certain aphids can be expected in years following a mild winter. The reverse is the case after a very severe winter.

b) Biological change

When the environmental conditions are favourable, an ecological change can covert a harmless organism into a pest. The major ecological reasons for an organism developing pest status include:

i) Change in cultural practices. E.g. monocultures represent a concentration of plants of the same species over a wide area and this is beneficial to the insect or organism which will thereby have little difficulty in finding its host plant.

ii) Change in the character of the food supply. Plants grown for agriculture have normally been selected for their nutritive value and therefore more attractive to pests than their wild relatives. E.g. Sorghum and maize are more attractive to stem borers than are wild grasses.

iii) Introduction to new environments. Insects and other organisms become established as pests when taken to countries where they did not previously exist. In the new country, the natural enemies (parasites and predators) and competitors for food are often absent, hence allowing the population of the new pests to increase dramatically e.g. *icerya purachasi* mask. (Cotton cushion scale) is a native of Australia but was introduced into California in 1868. By 1887, it has become a serious pest of citrus in its new environment. Most storage pests exist in small population in the field but increase economically in numbers and become serious pests in the favourable climatic and abundant food of a grain store. E.g *Sitophilu oryzae* (L) on maize cob, *Stotroga cerealella* (oliv.) on sorghum and the bruchids on cowpea.

iv) Climate in host/natural enemy relationships. The application of pesticides on a large scale in agricultural operations generally affects natural enemies more than the pests. E.g *Ascotis selenaria* (the giant cooper) is normally a minor pest of robusta coffee in Uganda. It became a serious pest of Arabica coffee in Kenya after very frequent use of parathion in coffee plantation.

v) Loss of competing species. Under monoculture conditions, there are fewer insect species than under natural conditions and many species now become pests which were not pests under natural conditions.

vi) Economic change. A pest may arise purely for economic reasons because of a change in the value of a crop. Damage that is not serious when prices are low can be very important when prices are high. If the crop is in short supply, consumers overlook a little damage.

Generally, organisms which cause significant economic loss in quantity and/or quality of crops and plant products are widely recognized as pests and disease organisms.

3.4 Categories of crop pests

Pests are categorized according to several factors, including their abundance, damage caused, etc. we have already seen that the number of organisms causing damage or loss is considered to be of great importance in determining which organisms are pests. Very often, the degree of seriousness of damage is related to numbers. However, there are exceptions, e.g. disease – transmitting organisms, which the effect of organism on crop is not directly proportional to numbers or in special quality products where a slight contamination may lead to serious financial loss. Inspite of this, the concept of economic threshold based on the population levels of organism, or level of incidence of a disease, is still the most acceptable in categorizing pests.

Economic threshold is the population density at which control measures should be applied to prevent an increasing pest population from reaching economic injury level or the population level of the organisms or level of disease incidence above which economically significant damage or loss is caused, and below which damage or loss is negligible or the population level above which it will pay the farmer to control his pests and below which it is uneconomical. The concept of economic threshold is based on the fact that organisms over a long period of time and in a relatively undisturbed environment reach a state of equilibrium with their environment. This is a dynamic state of equilibrium, which means that although population densities vary from season to season, year to year or place to place, for a particular place, there is an average population level which is reasonably stable over a long period of time. The economic threshold and economic injury level (the lowest population density that will cause economic damage or injury that will justify the cost of artificial control measures) are usually above this average population level. These levels are not constant for any pest, disease or environment, but they can be worked out from an intimate knowledge of the organisms, the crops which they are attacking and other components of the environment. Economic damage is the amount of injury which will justify the cost of artificial control measures.

On the basis of the concept of economic threshold and depending on the severity of damage caused, the number of organisms involved, frequency of occurrence and the prevailing circumstances, pests are categorized as follows:

a) Key pests (major pests, regular pests)

These are perennial pests which cause serious and persistent economic damage in the absence of effective control measures. The population of the damaging stage stamp above economic injury level.

Examples:

The variegated grasshopper *Zonocerus variegates* is a key pest of cassava, vegetables, citrus and many cultivated crops in West Africa. *Maruca testulalis,* the cowpea borer is a major pest of cowpea. *Dydercus volkerii,* the cotton stainer on cotton. Some major pests cause economic damage at low populations and are therefore called low – density pests, e.g. cocoa mirids. Other pests like locusts and grasshoppers usually occur in very dense populations and are therefore described as high – density pests. Key pests are the main target of pest control operations.

b) Minor pests

Some organisms cause economic damage only under certain circumstances in their local environment. Under normal conditions, their populations are low and the damage they cause is insignificant.

Examples:

The cocoa – pod husk minor *Marmara sp.* is a minor pest of cocoa in Nigeria and Ghana. Minor pests are usually not the focus of pest control operations.

c) Occasional pests

Populations of occasional pests are normally below the economic threshold level, occasionally rise above it.

Examples:

Many lepidopterous defoliators and stem borers occur at irregular intervals and cause economic damage to crops.

d) Potential pests

Potential pests are those species whose population level are usually far below the economic threshold but can become highly injurious under changed cultural practices or as an introduced pest.

Example:

The giant looper (*Ascotis selenari reaprocaria (*wlk) became a major pest of coffee estates in Kenya following indiscriminate and uncontrolled use of pest pesticides in the agro – ecosystem.

e) Migrant pests

These move from one area to cause damage to crops in another area. They are a special group of key pests which are classified as migrant pests. Their control normally involves international cooperation between the members countries affected.

Examples:

The African migratory locust is jointly tackled by the West Africans which form the OICMA organization with headquarters in Bamako, Mali. Army worms (*Spodoptera spp.)* are jointly monitored by the west Africa Armyworm Forecasting Programme involving many East African countries. The village weaver birds, *Queen sp*. are also migrant pests.

3.5 General methods for the prevention and control of crop pests:

1. Prevention. The best way of controlling pests is to prevent their attack. To prevent new insect pests from spreading, all animals which harbour the pests must be properly treated.

2. Chemical methods. These involve the use of chemicals to kill the pest. This method is the most effective of all the methods. The chemicals are generally called pesticides and include insecticides (for the control of insect pests), rodenticides (control of rodents), herbicides (control of weds). They may be applied inform of powder or dust, smoke of spray or may even be used as stomach or contact poison.

Examples of pesticides are Gammalin 20, Alfrex – T, Aldrin, Ventox 25, Phostoxin, Parathion, dual, Pimextra etc.

3. Physical. This involves use of scare crows, hand picking, use of trap, fencing and burning of debris.

4. Cultural method. This is the use of good cultural practices to enable crops escape the attack of pests. They are ploughing, proper tillage and disposal of refuse, regular weeding, planting of resistant varieties of crops, early planting and harvesting and practice of crop rotation.

5) Biological method. This involves the use of natural predators and parasites of the pests. Example is the use of snakes and frogs on insects, use of African marigaid for the control of nematodes, use of cats to control rodents in stores and use of tiny wasp to control bugs on cassava.

4.0 Conclusion

Pest is an all-encompassing word that includes insects, fungi, bacteria, viruses, phytoplasmas, nematodes, mollusc, vertabrates, weeds and parasitic flowering plant (striga). All organisms causing damages to crops can be regarded as potential pests, but it is usual to use the term strictly for organisms causing significant damage in quantity and or quality of crops and plant produce.

5.0 Summary

In this unit, we learnt about the different types of crop pests. We learnt about their definitions, categories, importance and conditions which promote their activities. The damages caused by pests and control methods were also discussed.

6.0 Tutor marked assignments

(a) Define crop pests

(b) Discuss the importance of crop pests

© Discuss the conditions which promote pests

(d) List the categories of crop pests

(e) List the general control measures of crop pests

7.0 References for further reading

i) Anthony, Y., O.C. Ezedinma and Ochapa, C.O. (1986). Introduction to Tropical Agriculture. Longman Group Ltd.

ii) Ayo Fatubarin. Plant pathology. 2003 series

iii) I.C. Onwueme and T.D. Sinha. Field Crop Production in Tropical Africa. CTA, Wageningen, Netherland.

iv) I.C. Onwueme. Crop Science. Book 2. cassell's Tropical Agriculture Series.

v) Larry P. Pedigo. Entomology and Pest Management. Low price edition, 4th Edition.

vi) M.I.T. Norman., C.J. Pearson and P.G.E. Searle (1995). The Ecology Tropical Food Crops. Cambridge University Press.

vii) T.A. Taylor. Crop Pests and Diseases. Eds. G.C. Last and A.L. Mabogunje.

UNIT 2: INSECT AS PESTS:

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1.0 Introduction

Insects belong to the phylum arthropods. Arthropods form a major group in the animal kingdom and constitute one of the largest and most important pests of crop plants. It is a group of animals with segmented bodies and hard skin. The following classes under which are other minor divisions are identified:

i) Class insecta. These have one pair of antennae, tracheal respiration, and three pairs of true legs, three body regions (head thorax and abdomen). Examples of animals belonging to this class are grasshopper, bee and beetle.
ii) Class arachnida. These are characterized by possession of two body regions (cephalothorax and abdomen), four pairs of legs, absence of antennae, and respiration by means of tracheae, diffusion through the body walls. Examples include the spider, mites and ticks.
iii) Class chilopoda. Insects in this group have elongated body with 15 or more pairs of legs with only 1 pair occurring on each body segment e.g. the centipede.
iv) Class diplopoda. These have elongated body with many legs usually two pairs per body segment excet for the first few at the back of the head. E.g. millipede.
v) Class crustacea. These are usually aquatic, posseses gills and have five or more pairs of legs. Examples include crabs, crayfish and lobsters.

2.0 Objectives

At the end of this unit, you should be able to:

1) Discuss the damage caused by insect pests.
2) Name and describe the insect pests of important Nigerian cereal, legume, root and tuber crops
3) Discuss the control measures of insect pests.

3.0 Insects as pests

3.1 Damage caused by insect pests

Damage by insects can be grouped into three major categories:

i) Biting and chewing

Some insects consume part of the plant with the aid of their biting and chewing mouth parts. Grasshoppers, lepidopterous caterpillars and beetles all consume whole portions of leaves, stems, flowers, fruits or roots of plants. Locust and army worm consume whole plants. The quantities of vegetation consumed can be quite high. For example, a single female locust *Schostocerca sp.* can consume 1.5g of vegetation per day and a swarm of locusts covering $10km^2$ can eat up to 2,000 tons of vegetation per day. Lepidopterous caterpillars are defoliators and can completely eat up the leaves of plants. Removal of leaves and other vegetative plant tissues interferes with growth and development of the crops, reduces photosynthetic surface of plants and reduces yield. Damage to the flowers and fruits leads to drastic reduction in the yield of crops.

ii) Piercing and sucking

The Hemiptera and Thysanoptera have mouth parts which are modified and adapted for piercing and sucking plant tissue. The Siphuculata and some Diptera have mouth parts for piercing and sucking animal tissue too. Piercing and sucking insects do mechanical damage to the tissues they pierce. They cause loss of plant sap or blood and seriously affect the growth and development of the host. In some cases, parts of the plants attacked may be distorted and rendered unfit for sale and for human consumption. Sucking insects also inject toxic saliva into plant tissues and this may cause death of such tissues. When fruits are attacked, blemishes may result and this lowers the quality of that fruits. Thrips pierce and suck cowpea flowers, cause flower abortion, and reduce fruit formation and yield. Piercing and sucking pests cause secondary damage through the introduction of pathogenic organisms, such as fungi and bacteria. These invade the wounds resulting from insect attack. For example, cocoa mired feeding lesions formed on cocoa stems are invaded by the weakly pathogenic fungus *Calonectria rigidiuscula* which causes die – back of the cocoa stem. Piercing and sucking insects also directly transmit various diseases of crops. E.g. maize streak, virus on maize leaf curl of cotton, cassava mosaic disease, ground nut rosette virus and cocoa swollen shoot virus disease. Tsetse flies (*Glossina spp)* transmit the protozoan parasite trypanosomes, which cause sleeping sickness in humans and nagana in cattle. Mosquitoes transmit the malarial parasite in humans.

ii) Boring

Some insects tunnel into the stems and fruits of crops and remain inside the tissue where they consume large quantities of the tissue. Such insects have mouth part adapted for biting and chewing. E.g, larvae of most stored products insects like *Callosobruchus maculates* on cowpea, *Tribolium spp* on cereal grains, *Ephestia cantella* on maize, *Dermestus maculates* and *Necrobia rufipes* on dried fish and *Cylas puncticollor* on sweet potato. *Maruca vitrate* (testulalis) is a major pest of cowpea where it bores into the unripe pods, while *Sesania spp* are important stem borers of maize and sugar cane plants which are bored and died quickly. Boring insects reduce the quality of timber and stored produce, thus lowering the farmer's income.

3.2 Important insect pests of major crops

3.2.1. Insect pests of cereals

i) Maize aphid (*Rhopalosiphum maidis* Fitch)

Importance:

The aphid is a common and serious pest of maize. Young plants are most at risk. The pest can also be found on sorghum, millet, sugar cane, wheat and on numerous associated wild hosts. Aphids are distributed through out Nigeria. Aphids build up large numbers in colonies, on leaves and tassels. New growth becomes distorted, chlorotic and stunted. Heavily infested tassels may become sterile. Honey dew secreted by the aphids encourages growth of sooty moulds and covers the seeds in a strictly residue which makes processing difficult. These aphids transmit virus diseases of maize, such as leaf fleck and sugar cane mosaic.

The aphids vary in colour from yellow – green to dark – blue – green. They may also be covered with a thin layer of white wax or shed skins. Both winged and wingless forms may be found on the same plant.

These insects reproduce asexually (pathogenesis). Pathenogenic females give birth to living young and a generation can be completed in 8 years. They reproduce continuously throughout the year.

Non chemical control: Vigorous plants are usually tolerant of aphid attack. Natural enemies may provide sufficient control and should be encouraged.

Chemical control: Very heavy infestations may be controlled by applying an aphicide, such as pirimcarb or a systemic general insecticide such as dimethoate.

ii) Maize stem borer (*Buseola fusca* (Fuller)

Buseola fusca is probably the most important pest of maize in Nigeria, particularly in the drier savanna zones of northern Nigeria. The primary hosts are sorghum and maize, but it may also attack millet, sugar cane and rice to a lesser extent.

Larvae feed on leaves in the funnel of young plants. They scrape the inner layer of tissue away from the leaf, leaving holes while the outer layer of the leaf is left intact. In some attacks, the central leaves may die, giving the "dead heart" effect. Larvae bore into the main stems of the mature plant and later generations bore into the maize cobs and tassel. One or two larvae per maize can reduce yield by as much as 25%.

The adult moths are brown, with a wing span of 30 – 35mm. the moths are not usually seen during the day. Larvae are variable in colour, usually cream to pink, with black spots along the lower sides of the body. At maturity, they are about 30mm long. Female moths lay 30 – 150 eggs on the inner surface of the leaf sheath. Eggs hatch in 10 days and remain in clusters under the sheath. They disperse the following night to feed on young leaves in the whorl. There are 6- 7 intars and the larval stage lasts for 35 or more. larvae migrate into the plant stem where they pupate. Before pupation, they cut an exit hole ready for emergence of the adult. They can be up to 3 generations per season. The larva of the final generation goes into diapause (resting stage) at the start of the dry season. Diapause is broken by the rains, the larvae pupate and adults emerge about 2 weeks later.

Non – chemical control: Diapausing larvae can be killed by partial burning of harvested stalks before storing for fuel wood use. This burning can be done as follows: cut stalks with attached leaves and pile in the field after harvesting. The stalks are set alight and burnt for 5 – 10 minutes until the stalks become charred and cured. This can reduce diapausing population by up to 90%. Complete destruction of dry stalks by burning kills off diapausing larvae. Ploughing field after harvesting can also help reduce population while early sowing can reduce infestation.

Chemical control: Economic threshold level is 10% of plant with visible leaf whorl damage in maize. Treatment with carbofuran gramille (systemic)(wp) and deltamethrin can effectively control young larvae when used at 20 and 40 days after seedling emergence. Lambda – cylalothrin and monocrotophos are also effective when applied 5 – 7 days after eggs are found on 5% of the plants. This will allow the chemical to reach the young larvae before they enter the stem. Carbofuran must not be applied late in the season because it would residues in the grain.

iii) Leafhopper (*Cicadulina spp)*

Leafhoppers are important as vectors of maize streak virus (MSV). Host plants include maize, sorghum, pearl millet and annual grasses. *Cicadulina* is also a vector of sugar cane streak virus.

Nymphs and adults pierce plant tissue and feed on sap. High numbers of feeding insects may cause withering of the plant and leads to growth malformation. The plant may also suffer damage if females use their ovipositor to place eggs within the plant tissue. All adults and nymphal stages are able to transmit MSV. Population of leafhoppers is highest at the end of the growing season when adult migrate from older plants and wild grasses onto newly planted crops and seedlings.

Adults are 2 – 4 mm long. The head, thorax and abdomen are yellow or gold coloured with a pair of round black spots on the anterior margin on the crown. Adults are commonly found resting on the upper surface of young maize leaves. The larvae are grayish with black spots all over the body. Diapausing larvae do not have these spots.

Eggs are laid along the mid – veins of the leaves of the host plant. Each female lays 100 - 200 eggs. Egg development takes 9 – 21 days, depending on temperature. There are 5 nymphal stages lasting about 23 days.

Non – chemical control: Avoid repeating planting of maize on the same plot as this leads to a build up of the pest and MSV.

Chemical control: Treat with insecticide when 10% of plants at the edge of a row are visibly infected. A spray of carbaryl or fernitrothion and endosulfan may be effective. Application of carbofuran gramilles in the soil also protects seedling against the leafhopper.

iv) Millet stem borer (*Pennisetum americanum)*

This is a major pest attacking millet stems through all stages of plant growth. It is found through out Nigeria.

Larvae bore directly into the stem without feeding on leaves. If the population of larvae is high, plants that are attacked early may collapse and die without giving any yield. Larger plants may continue to grow but may fail to set seed. Effects are most sense on late millet.

The forewings of adult are pale yellow with dark orange lines along the length. Hind wings are white and shinny. Larvae have black oval spots on each segment. About 200 eggs are laid in batches between the leaf sheath and the stem and hatch in 9 – 12 days. Larvae bore directly into the stem where they feed. They do not feed on leaves. The life cycle is completed in 2 months and there may be 3 generations a year. At the start of the dry season, some second or third stage larvae may enter diapause within millet stem. Adults emerge about 4 weeks after the start of the rains.

Non – chemical control: Destroy all old millet stems to kill diapausing populations and clear stubbles from the field. If old stems are to be kept for fuels or building purposes, first lay them out thinly in the field in full sun to kill off diapasusing larvae. Plant gero crops early and dauwa crops later to avoid borer attack. Apply nitrogen fertilizer to gero crops once, 4 WAP to reduce stem borer damage. Natural pest control by parasites and predators is not sufficiently effective.

Chemical control: Apply granular carbofuran to the soil at the time of planting and a side dressing 6 weeks later. Spray Lambda – cyhalothrin 5 – 7 days after eggs are found on 5% of the plants and before the larvae have bored into the stalks.

v) Millet head miner (*Helioceilus albipunctella* de Joannis)

This is a serious pest of millet in the dry, Sudan & Sahelian Savannah zones of Nigeria and can cause 20 – 50% crop loss.

Larvae feed inside the millet heads on flowers and developing grains. Damage is seen as characteristic tracks over the millet head as larvae feed from the bottom of the head upwards.

Adults have a 22 – 28 mm wingspan. The forewings are red/brown in colour with a row of mall white dots near the front edge. The forewing of the male is slightly different, having 2 transparent patches near the front edge. Mature larvae are variable in colour, being dark green/brown to pale brown or green with darker dorsal and ventral stripes.

Eggs are laid on the millet floret. Larvae feed on the florets and grain, reaching maturity in 3 – 4 weeks. They then drop to the ground and burrow into the soil where they pupate and diapause through the dry season. Adult emerge at the start of the next rains.

Non – chemical control: Late planting of early – maturing millet varieties can reduce infestation. The varieties with the best resistance are those with compact heads and closed panicles.

Chemical control: Suggested economic threshold is 2 larvae per head, Deltamethrin, cypermethrin, paramethrin and carbaryl applied at 50% head emergence and again one week later can give effective control.

vi) Sorghum (*Sorgum bicolor)* shoot fly (*Altherigona soccata*)

This is prominent in the grassland areas of Nigeria. Larvae enter the plant by crawling into the funnel between the outer leaves and the new curled leaves. They feed around the whorl, severing the growing point, giving the typical dead heart symptom. The dead heart can be easily pulled out and, at the base, emits a bad smell. The young whitish yellow maggot feeds only on the decaying tissue, normally, damage occurs from 1 month after emergence. If attack occurs later, plants may produce side tillers that may also be attacked.

The adult flies are 4 – 5 mm long and resemble a common housefly. The head and thorax of the female is pale grey and the abdomen is yellow or pink with three parts of dorsal brown/black spots. The eggs are white and cigar – shaped. The larvae are 6 – 8mm long.

They are white to pale – yellow in colour. Eggs are laid singly on the undersurface of the leaves. Larvae hatch out in 2 – 3 days and feed on the stem. Larvae development is complete within 7 – 12 days. Pupation occurs either at the base of the decaying plant or, mile rarely, in the soil. The pupae are dark brown just before emergence.

Non – chemical control: Use high – yielding resistant varieties and plant early at the start of the rainy season to reduce likelihood of infestation. Also, cut back wild sorghum which acts as an alternative host for the pest.

Chemical control: Cypermethrin application is effective. Seed dressing with carbofuran will protects the plant for up to 28 days after germination.

vii) African migratory locust (*Lucusta mogratoria migratoriodes)*

In the gregarious phase, adult locusts swarm together and become a very serious, though sporadic pest. In Nigeria, the most likely outbreak area for a swarm is in the Lake Chad region, with further invasion into neighboring states.

Locusts feed upon green vegetation with a preference for grasses and cereals. Serious outbreak at migratory phase causes complete defoliation and crop loss. The solitary phase does negligible damage.

They are short – horned grasshoppers. Adult females are 35 – 40mm and males are 40 – 50 mm long. The immature solitary phase is green or brown with an arched pronotum. The migration phase is yellow – brown or grey in colour with fine dark stripes over the abdomen and a flatter pronotum. As adults mature, their general colour becomes darker. The main breeding site is the flood plains of middle Niger and Mali, from where past plagues of gregarious locust have originated. In Nigeria, the solitary phase of the locust is usually found, and has 2 generations per year – eggs are laid in pods in bare ground. There may be 18 – 72 eggs per pod and each female may produce 4 – 11 pods. The number of eggs laid varies with the phase of the locust. Eggs hatch in 10 – 25 days. There are normally 5 nymphtal in stars.

Effective control is based on regular surveys, prompt reporting and implementation of appropriate control measure. Egg laying sites should be identified, there are sites of a possible outbreak and should be observed closely. Egg masses can be dug up and exposed to the sun.

Chemical control: Lambda – cyhalothrin sprayed at the first appearance of the pest is effective.

viii) Sorghum midge (*Contarinia coquillte)*

This is a wide spread and common pest which can be serious when high population densities occur. It is a major problem in the northern region of Nigeria, especially in the early season seeding stage of the plant. It is a pest of both cultivated and wild sorghum.

Larvae feed on and destroy the developing seeds. The sorghum head becomes flattered and the seeds shrunken. A typical symptom of damage is the presence of empty spikelets and red or brown glume. One midge larva per spikelet may be sufficient to cause loss of the grain.

The adult is 1.3 – 1.6 mm long, with a white head, long brown antennae and legs, dark orange thorax and abdomen, and grey wings. The female has long ovipositor. Newly hatched larvae are white but become dark orange as they mature. They are found feeding within the grains.

Females lay 30 – 120 cylindrical eggs, 0.1x0.4 mm in size, on the flowering head, usually near the spikelet tip. Eggs hatched after 2 – 4 days and the larvae burrow into the development grain. The larval stage lasts for 9 – 11 days and pupation takes place beneath the glume. Shortly before adult emergence, the pupae case is often still visible on the spikelet of infested plants. The short life emergence, the pupae case is often still visible on the spikelet of inferred plants. The short life cycle means that up to 9 – 12 generations can be completed in one growing season, especially where the flowering times are extended by the use of a wide range of planting dates and the maturities. Diapause occurs during the larval stage in a cocoon within a spikelet.

Non – chemical control: Early and uniform planting of sorghum varieties with similar maturity dates over a large area is an effective control measure. Infested or deformed hears should be destroyed by burning, burying or compositing to kill diapausing larvae. Wild host sorghum plants surrounding the crop should be cut back. Resistant varieties are available.

Chemical control: Multiple insecticide application directed at adults is used primarily to reduce losses in late planting. The economic threshold level is 10 adults per panicle. Sprays or monocrotophos and endosulfan and dusts of endosulfan and phospsalone are effective.

ix) *Oryza sativa and O. globerrima* white stem borer (*maliarpha separatella).*

Widely distributed in all rice growing regions; it is the most important pest of upland and irrigated rice in Nigeria. Attacks only rice and is not found on other crops.

Rice plants are attacked at the full filtering stage. Larvae penetrate into and feed on the stem. They also migrate into the filters. Feeding impairs panicle ripening, leading to "white heads" and causes breakage of stems.

Adult females are about 18mm long. But the males are slightly shorter. Wingspan is 23 – 29 mm. both males and females have long pale gold – coloured forewings with a red – brown line along the costal vein, which is more pro9nounced in the male. The hind wing are shinny while. When at rest, the wings slightly overlap along length of the body. Larvae are initially white with dark brown head. Mature larvae are about 18mm long, yellow in colour and falter than the earlier stage.

Eggs are laid on the upper surface of the leaves. They are attached by cement which, on drying, contracts and causes the leaves to curl and envelop the eggs in leg tissue. Eggs are laid close together in a mass up to 1.5cm long and containing about 50 eggs. At first, they are pale, becoming darker and brown – black later. They hatch in about 7 days. Larvae then penetrate fillers just above a node. Larvae pupate in a loose cocoon at the base of the dried stubble at the end of the rice season. They may be 3 – 4 generations a year. Larvae enter a dry season disapause which can last up to 20 weeks. At the end of the dry season, pupation occurs and the adults emerge to lay eggs on the next season's crop.

Control methods:

a) Cultural control

+ Use early maturing varieties and plant early in the season so that plants mature before pest attack.

+ Remove weeds which provide alternative hosts.

+ Timely fertilizer applications order the growing period to discourage over – rapid development of the plant.

+ Destroy stubble after harvest by burning or flooding the field. This will destroy the diapausing stages of the pest thus reducing infestation in subsequent season. Avoid buying and selling seedlings for transplanting as these will often carry potential infestations that are not apparent at the time of sale.

+ Do not plant in stages (stagger), as this provides unlimited food supplies for pest population development and build up of population.

+ At harvest, do not leave tall stems in the field, particularly in early maturing varieties.

Cut the stack down to the base to destroy larvae and pupae in the stems.

+ Synchronize planting over a large area to diffuse incidence of damage and severity.

+ Host plant resistance. Use varieties that are resistant to or tolerant of stem borer attack.

b) Chemical control: the economic threshold is 2 egg mass per 20 hulls from seedling to panicle initiation or 2 egg mass per 20 hulls after panicle initiation to ripening. Chemical control is difficult, as the pest is protected inside the stem from contact with the insecticide. Systemic insecticides are necessary, but are costly. Foliar application of insecticide may kill the pest, but will also reduce population of natural enemies, leading to pest/enemy system in balance and possibly pest resurgence. Application of granola formulation can be made necessary. Recommended chemicals include monocrotophos, chropyrifo and carbofuran.

x) Stalk – eyed fly (*Diopsis spp.*)

An important, common pest of lowland rice but can also be a problem on upland rice where humidity is high. It is an early season pest which causes death of fillers. Crop losses can range from 2 to 17%, it is found throughout Nigerian.

Adults invade nurseries early in the season. They lay eggs on leaves and steams of seedlings and transplants. The larvae move inside the leaf sheath and feed on the stem tissues below the growing point, cutting off the apical part from the rest of the plant and causing dear heart symptoms. They move fresh tillers as attached ones start to decompose. Later larval stages feed on flower heads.

Diopsis is a very destructive insect. Adults are about 9 mm long with an orange head. The eyes are red – black and are held on long stalks away from the side of the head. The thorax is shiny black 2 spines projecting backwards from the posterior end. The wings appear glass – like and the abdomen and legs are red. Larvae are about 18mm long with very small heads. They are cream in colour with yellow makings on the last body segment.

The insect lives near water and prefers to feed on aquatic plants. Females lay eggs individually on the upper surface of young leaves, usually near the midrib. Each female can lay eggs out am period of 10 days. On emerging, the larvae move down the inside of the leg sheaths and feed on the developing leaves. The larval stage lasts for 25 – 33 days.

Chemical control: The economic importance of the pest is not clear and the application of pesticide may be justifiable only in severe cases.

xi) African rice gall midge (*Orseolia oryzae)*

It is a sporadic, but serious pest affecting lowland rice in Nigeria including Guinea, Sudan savanna and forest zones. Early and severe infestation can cause total loss of crop.

It survives on wild grass alternative hosts.

Attack occurs at the early filleting stage. Larva move down until they reach the apical or lateral buds to swell and form a gall. Galls are hallow, elongated tube – like structures. Which are silvery in colour. This formation is often called onion leaf or silver shoot. Infected crops show non – uniform flowering and maturing dates. Rice is most susceptible during its growth phase before panicle development. Tillers bearing galls do not produce panicles.

Adults are tiny (3 – 3.5mm long), and mosquitoes – like with strong long legs. Females have an orange – coloured abdomen. While the males have a slender brown abdomen and are generally smaller in size. Adults are nocturnal and are active in humid condition.

The midge spends the dry season on rice and grasses in wetter areas or in ratoons. At the onset of the rains, the insect population increases on the wild hosts from where transfer to cultivated rice shortly after it is planted. Females are fertilized and can lay eggs within a few hours after emergency. Eggs are laid singly on the underside of leaf sheaths and ligules. Each female can lay 100 – 300 eggs which hatch in 3 – 4 days. The young larvae creep down the leaf sheath on a film of water. At the base of the sheath, they enter the apical or lateral buds where they feed and remain until they pupate after 15 – 20 days.

Adults emerge after 2 – 3 days and may live for 1 – 5 days.

Non – chemical control: Avoid damage by planting rice as early as possible before the rains. The crop will then be mature and unsuitable as host when the pest is present. Remove alternative host plants from around the crop to prevent the initial increase in pest population.

Chemical control: Systemic insecticides, such as monocrotophos and carbofuran are effective against this pest.

xii) Sugarcane borer (*Eldona saccharina)*

This is an important pest of sugarcane. Young larvae feed on the leaf sheath while older ones bore into the base of the stem to feed. This causes dead hearts in young plants. The newly hatched larvae feed on the leaves, usually boring into the midrib. Fully grown larvae bore into the stem and destroy the plant tissue, causing dead heart symptom. They then move to another plant shoot or another plant. Presence of frass on the outside of stem is a characteristics sign of the presence of feeding larvae. Larval are usually found in the lower parts of the stem. They can be dispersed by wind from plant, by hanging from the leaves in silken threads. Stalk rots are more common on stems damages by this stem borer.

The wingspan is 40 mm in adult females and 30 mm long in males. Both have pale brown forewings with 2 small dots in the centre of each. The hinderings are white. Larvae are 20 – 25 mm long. Eggs are oval and yellow. They are laid in batches of 10 – 15 in the soil surface or at the base of leaves and in cracks on stalks. Females lay 100 – 500 eggs and start laying on their second night after emergence. Eggs hatch after 5 – 6 days. The larval period is 30 – 35 days. Pupation takes place in the stem on the leaf sheath. Adults emerge after 7 – 14 days and live for 3 – 8 days.

Non – chemical control: Stubble should be burnt and crop residues buried to prevent insects from laying eggs in the dead leaf litter. Volunteer plants and other alternative host plants should be removed.

Chemical control: Endosufan or carbaryl can be effective in the early stages of attack.

iii) Leaf feeding beetle (*Ootheca spp* Coleoptera): Chrysomelidae

It is a major pest of cowpea through out Nigeria. It is the most damaging of cowpea leaf feeders. It is a polyphagous feeder and feeds on many other leguminous crops, coffee and cocoa.

Adults feed between leaf veins, making small irregular holes. Yield is reduced if attack is heavy or occurs on yo7ng plants. Heavy infestation can lead to complete defoliation of cowpea seedling and the death of the plant. Adults also cause indirect damage by transmitting cowpea yellow mosaic, cowpea mottle virus and southern bean mosaic virus.

Larvae feed on the plant roots but are minor pests compared to the adults.

Adults are about 6mm long, oval in shape & shiny black head and legs. The body colour may vary from brown to light brown or orange. Larvae are 6 – 12 mm long and are white with brown head.

There are two generations a year. Adults emerging from the dry season diaspause usually starts to lay eggs in March or April, 15 – 20 mm below the soil surface. Each female lays 200 – 500 pale yellow eggs. Hatching occurs in about 13 days. They go their 3 intars in the soil in 30 days. This is followed by a non – feeding pre – pupae stage which last for 8 – 18 days, finally developing into a yellow pupa. Adult begins to appear in July and August. There then produce a second generation which diapause in the soil until the following March.

Non – chemical control: Population are higher on cowpea that is intercropped with maize than when cowpea in grown as a sole crop.

Chemical control: One or two sprays of endosulfan, methomyl or chlorpyrifos may be effective.

3.2.2 Insect pest of legumes.

i) Pod borer *Maruca testulalis*

The larvae are a regular pest of cowpea. It damages both flowers and pods wherever cowpea is grown. Uncontrolled infestation can reduce yield by 70% the main hosts are beans and cowpeas. Alternative hosts include groundnut, castor, tobacco, rice and Hibiscus spp.

Eggs are laid on the flower buds and young leans. The young larvae bore into the flowers, feeding inside and causing the flower to drop. Young stems, terminal shoots and peduncles are also damaged. Signs of larval feeding include the webbing of flowers, leaves and pods, and the presence of frass on the shoot tips and pods. Several flowers may be attacked by one larva. Later larval stages are highly mobile and cause damage through out the reproductive cycle of the crop. Feeding on flowers and boring into green pods to feed on the developing seeds. Larvae are active at night; during the day they sheltering flowers, pods, stems and leg debris beneath the plant. Damage is more severe to pods which are located in the leaf canopy on short peduncles or those touching other parts of the plant.

The adult moth has a span of 16 – 27 mm. the following are light brown. With white markings and hind wings are white with brown margins. Mature larvae are 16mm long, whitish in colour with a black head. They have characteristic dark spots on each body segment.

Female lay over 200 oval yellow eggs on flower, terminal shoots, leaves and pods. Each hatch in 2 – 3 days and there are 5 larval stars, lasting 8 – 14 days. Pupation occurs in the pod or in a cocoon in then leaf debris beneath the plant. Adults emerge after 5 – 10 days and may live for 5 – 15 days.

Non – chemical control: Cowpea varieties with long pod peduncles and tougher pods are less susceptible. Mono – cropping should be avoided.

Chemical control: The action threshold is when 60% of flowers are damaged. Dimethoate combined with cypermethrin gives effective control. Mixture of deltamethrin + dimethoate and lambda – cyhalothrin + demethoate are also effective.

ii) Groundnut aphid (*Aphis craccivora* koch)

A widespread pest throughout Nigeria, but more common in the north, especially during dry spells when population can increase rapidly. Direct damage by feeding insect is not usually serious but the insects are important vectors of groundnut rosette virus.

The aphids primarily attack seedlings and feed on the undersurface leaves. Sap – sucking by large number of aphids may cause plant to wilt and due in hot weather and reproduction in yield. Leaves and shoots may become distorted. Sticky honeydew is also produced, encouraging the growth of moulds. Plants infected with rosette virus are stunted yellow or dark green molting on the leaves.

Adults can be winged (alate) or commonly wingless (apterous). The aphids are shiny blackish, grayish – green or brown. The cauda and sipunculi are black and the antennae are 2/3 the length of the body. They are gregarious insects, forming clusters on buds, flowers, green pods stems and the underside of leaves.

Aphids can produce either sexually or asexually. Adult females produce up to 100 young and between 2 and 20 daily. They are 4 nymphal stages, and the life cycle takes 6 – 8 days. Adults live for 5 – 15 days. When food supply is abundant, apterous forms develop in response to over crowding and lack of food. There forms are responsible for the migration of the aphids between crops.

Non – chemical control: Early sowing and close spacing of groundnut can help prevent infestation.

Chemical control: Aphid – specific insecticides, such as pirimicarle, should be prepared since they kill only aphids and allow natural enemies to survive. Other effective insecticides include lambda – cyhalothrin and monocrotophos.

iii) Termites (various species): *Amitermis sp, Odontotermes spp, Microtermis ssp*

Termites build nests around the root of the plants, feeding on the roots and may also attack foliage. They attack plants of nay age but usually established plants. Infestation intensifies as the plant matures. Attacks are more common where plants are under water stress.

Crop losses due to termites can be as high as 10 – 40% microtermes spp are a more serious pest in the Sudan savanna zone, particularly in well drained sandy soils. Damage is caused by termites penetrating into the root, stem and pegs, destroying e plant tissue which prevents transportation of water up to the plant. This causes the plant to wilt. They also scarify the pods, making them liable to crack when harvested and this may allow the entrance and growth of toxic fungus (*Aspergilus*) is aflatoxin) termites cause the plant to collapse at chewing into the main stem so weakening the plant.

Non – chemical control: Crops which mature early and are harvested early may escape attack. Seed of a uniform variety should be planted to ensure even ripening and a single harvest date.

Repeated mechanical cultivation and burying of crop residues may reduce termite population. Rotation with other crops may help prevent termite population build– up.

Chemical control: Kerosene may be poured around the base of the plant to destroy the nests. A mulch of neem cake is effective at preventing damage when groundnut is being dried in the field. The groundnuts are either mixed with the mulch or placed on top of it.

iv) Pigeon Pea Blister Beetle *Mylabris spp.*

This occurs wherever pigeon pea is grown in Nigeria. Adult beetles feed on the flowers and greatly reduce the number of pods that are set.

Mylabris postulate Thunberg in about 25mm long. Adults have obvious black and red coloration. Other genera and species are of varying sizes but are conspicuously coloured. Their name derives from the blisters on human skin caused by the exudates (containing cantharidine) which is produced by the beetles when they are disturbed.

Eggs are usually laid in the soil. The larvae of most species are generally beneficial because they feed on insects in the soil (e.g grasshopper eggs).

Non – chemical control: Blister beetle cause little damage in areas where pigeon pea is grown over large areas, because they spread across the crop. However, in small pigeon pea plots that are in the flowering stage during the period of peak adult activity most of the flower may be eaten by pest and crop loss may be substantial. The beetle can be controlled manually by picking them by hand or collecting them by insect net and crushing them, since they are slow moving. Care should be taken to protect the skin.

Chemical control: Most insecticides are not effective against these beetles, but synthetic pyrethroids work reasonably well.

v) Pod – sucking bugs *Clarigralla tomentoscicollis* stal

This is sporadic but serious pest. It is the most important pod – sucking bug on pigeon pea in Nigeria. Other are plant hosts include cowpea and other pulses.

Adults and nymps suck developing seeds through the pod wall. The seed become shriveled with dark patches. Such do not germinate and are not acceptable as human food.

Adults are about 10mm and brown – gray. They are hairy and have piercing and sucking mouthparts. There are 2 lateral projecting spines on the prothorax. The wings are held flat across the back.

Each female lays about 200 eggs in clusters on host weed plants. They hatch in 6 days. There are 5 nymphal stages and develop from egg to adult takes 20 – 25 days.

Non – chemical control: Since this insect breeds on many weed hosts on which it lays eggs, weed management is essential for its control. A solution of 9% neem seed or kernel extract (wt/vol) decreases insect survival and give effective control.

Chemical control: This is done when cowpea economic threshold level is 2 insects per 10 plants at the flowering stage, and 4 insects at the podding stage. This is yet to be determined for pigeon pea. Application of cypermethrin and dimethoate are effective.

e) Pod borers *Helicoreepa (Heliothis) armigera* Hubner

Helicoreepa is widely distributed on many host plants. This insect destroys buds, flower and pods. If flowers and pods are not available, they feed on leaflets, leaves and veins. On pods, conspicuous holes are made by the entry of the larvae. Usually, developing and partly matured seeds are eaten completely. At times, apportion of the seed and testa remains.

The large larvae are yellow, green and pink, orange, brown or black but all have characteristic light and dark stripes along each side. Adult moths are up to 19mm long with a wing span of 44mm. female insects have pale brown wings with dots near the outer margins and males are use. They are active at night.

Adults lay small eggs usually singly, on the upper and outer surface of leaves, flowers, pods, and stems. The young larvae feed by scraping green tissues and the older larvae chew voraciously into buds, flowers and pods, leaving characteristic round holes. Pupation is normally in the soil or in plant debris. One generation can be completed in 4 weeks under favourable conditions.

Non – chemical control: Natural enemies sometimes give adequate control. Some pigeon pea genotypes have considerable tolerance to the pest 80 host – plant resistance can be a useful method of avoiding damage.

Chemical control: Several insecticides including endosulfan and synthetic pyrthoids give good control especially if applied soon after the eggs hatch.

3.2.3 Important insect pests of root and tubers

i) Cassava variegated leaf hopper *Zonocerus variegates*

Occasionally, a severe pest of cassava can cause complete defoliation. Damage usually occurs between November and March. Alternative hosts include cocoa, coffee, sweet potato, millet, most vegetables and cotton which are attacked at the seedling stage.

Nymphs and adults eat the leaves. They can also feed on green stems by stripping the bark and leaving only bare wood. Their feeding can kill plants and reduce yield in older plants. Large locusts are about 40mm long. The thorax and body are yellowish – brown. The head and legs are marked with red, black and yellowish – brown. The insects have an unpleasant smell when handled.

Females lay eggs in the soil during the rainy season, usually in shady areas near cassava. There is a 6 – month egg diapause followed by 6 nymphal stages which last about 100 days. In the drier regions in Nigeria, eggs are laid at the end of one rainy season hatch at the start of the next rainy season, eggs hatch at the dry season and the instars develop over the first half of the dry season.

Non – chemical control: eggs pods should be dug up to expose the eggs and allow them to dry out and die. This must be done over large area to be effect. Flooding of egg sites will also kill the eggs. Migration of the grasshoppers into the crop can be prevented by planting physical barriers, such as trees around the field. The borders of the field should be cleared of weeds; especially chromolaena spp. locally prepared neem products are effective when applied in the dry season.

Chemical control: Insecticides such as dimethoate and fenitrothio can be used on young nymphs in November/December. Baits of bran (wheat or other cereals) mixed with mude (e.g pupoxur dust) can be lid between the rows to attract the nymphs.

ii) Cassava mealy bug *Phenacocus manohoti*

A very severe dry season tuber loss can be up to 75%. Alternative hosts include sweet potato, egg plant and tomato.

The mealy bugs initially feed on young apical cassava shoots. They inject toxic saliva which may cause deformation of the growing tissues and stunting. As the new leaves on the shoot die, infestation spread to the older leaves down the stem. Eventually, the plants show a candle stick appearance.

Adults are 1 – 3mm long and oval in shape. They are pale pink in colour but are covered in a white waxy layer.

Male insects are rare. About 400 eggs are laid together in a cottony sack. One generation takes about 22 days to complete. Adults live for about 20 days. Newly hatched larvae crawl. The insects can also be spread by the movement of infected planting material.

Non – chemical control:

a) Cultural control

Cassava plants over 7 months old are more tolerant to damage. Therefore, planting at the beginning of the rainy season will allow plants time to grow sufficiently to withstand attack. Fertilizer should be applied at the recommended rates to encourage healthy plant growth. Cuttings should be dipped for 10 minutes in hot water (25oc) before planting to kill any infestation.

b) Biological control

Biological control with an introduced parasite Epidinocarsos lopezi (De santis) is now possible in Nigeria. The parasites are available at the International Institute for Tropical Agriculture (IITA) Ibadan. Local natural enemies, such as the coccinellid Hyperaspis pumila also play a role in the biological control of the mealy bug.

c) Chemical control

Before planting, cuttings can be dipped in dimethoate or methidathrion solution for 1 minute to kill any larvae which may be present.

Other important pests of cassava are:

i) whitefly – Benisia tubaci genn homoptera: Aleyrodidae which transmit the African cassava mosaic virus and causes yield loss of 20 – 60%.

ii) Cassava green spider mite monoychellus tanajoa Aeuia:L Tetrnychidae which causes 15 – 80 % yield loss.

Activity:

Visit any crop farm and collect as many insect pests as possible. Identify them indicating their common and botanical names.

4.0 Conclusions

Insects constitute one of the largest and most important pests of crop plants. They cause damage to crops through Biting and chewing, piercing and sucking as well as boring. Damage caused by insects can be minimized or controlled through chemical and non – chemical means.

5.0 Summary

In this unit, we have studied crop pests with focus on pests of cereals, legumes, root and tubers. Their economic importance, morphology and life cycle as well as control methods were discussed.

6.0 Tutor marked assignment

(a) Name and described the insect pest of important Nigerian cereal, legume, root and tuber crops.

(b) Describe briefly the economic importance and the control measures of following pests: (i) Cassava borers of rice (ii) Groundnut aphids (iii) Termites (various species), (iv) Stem borers of rice (v) ii) Maize stem borers.

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UNIT 3: OTHER ANIMAL PESTS

Table of contents Pages

1.0 Introduction

Animal pests other than insects include nematodes, mollusks, birds, monkeys, cattle and even man. In this unit, focus is on rodents, birds and nematodes, because of their spread and importance.

2.0 Objectives
At the end of this unit, you should be able to

2.1 List the difference types of animal pests other than insects

2.2 discuss the damages caused by rodents, nematodes and birds to agricultural products

2.3 Discuss the control measures of rodents, nematodes and birds.

3.0 Animal pests

3.1 Rodents

Rodents are pests of major importance. The rodents include rats, mice, rabbit, squirrel and beaver. These are animals that gnaw things their strong teeth especially adapted for the purpose.

In the field, rodents dig out, cut, and eat young plants and attack heads of cereals. In storage, they attack grains that have been threshed and stored, contaminate food with urine and faeces, damage furniture, fittings, equipment, cause water loss and serve as carriers of diseases, e.g plague, typhus, jaundice and fever. Here, only rat and squirrel will be discussed.

3.1.1 Rats:

Damage done by rats depends on population, size and feeding habit. The rat population can increase very rapidly. Depending on availability of food, rat can breed throughout the year.

Rats commonly found in buildings and habitations

a) *Mastomys natalensis (*Multimammate rat) an *M. erthroleous.* These are also known as the 'African house rat'. They are nocturnal, need food and shelter. They are found in the swamps of Lake Chad and the black soil plains where there is no vegetation in the dry season and they hide in deep cracks in the soil. They are serious pests of stored food.

b) Black/grey rat, ship – rat or roof – rat – *Rattus rattus;*

c) Brown Norway, or sewer rat – *rattus nervegicus* – limited to Lagos, its environs and other port areas

d) The domestic mouse – *Mus musclulus* – worldwide, but limited to Lagos in Nigeria.

Important species of rats and their damage in Nigeria.

a) *Arvicanthis nilitica* (Nile harsh – furred rat) and *A. abyssinicus.* These are common in the Chad basin. Being diurnal, they avoid land without vegetation. They are found around river valleys and irrigated areas; rare in dry and sandy areas. They cause damage to cereals and dry season vegetables, cassava tubers and mango shoots.

b) *Mastomys natalensis* (Multimammate rat) and *M. erthroleous.* These are also known as the 'African house rat'. They are nocturnal, need food and shelter. They are found in the swamps of Lake Chad and the black soil plains where there is no vegetation in the dry season and they hide in deep cracks in the soil. They are serious pests of stored food. In the field, they dig out seeds, cut stems and eat grains of matured plants.

c) *Taterillus spp.* Found with *Mastomys spp.* in Lake Chad shore – line and also with *Arvicanthis spp.* in several river valleys. They did seeds at planting and groundnuts at ripening, and eat cowpea close to harvest.

d) *Gerbillus spp.* – Attained pests status at Nguru in 1975. Found to collect and store millet heads, groundnuts and seeds of okra, melons and calabash.

e) *Tatera spp*. – More numerous than before in north western Nigeria.

T. Kembi (*Kemb's gerbil*) is notorious in southwestern Nigeria for cutting young rice stems.

f) *Cricetomys sp*. – More numerous than before in north western Nigeria.

C. gambianus (The giant pouch rat) has been captured in southwestern Nigeria in rice farms (though it does not damage rice crop much), store houses and domestic premises.

Thryonomys swinderianus (the cane rat). – Common in south western Nigeria where it is the main mammalian pest of rice crop.

Fex brush furred rat (*Uranomysfoxi),* the pigmy rat (*Mus muscoloides)* and the spotted grass mouse (*Lemniscomys striatus)* are associated with rice farms in southwestern Nigeria. They dig and remove the planted seed.

g) Large Grey Dormouse (*Graphiurus hueti),* lives on trees and a major pest of cocoa.

Control measures:

1. Mechanical

a) Exclusion – Rat proofing of houses, warehouses, building, bins are very useful in preventing losses. Use of metal bins or tin containers for storing food is very effective.

Electric fence used at IRRI, Manila electrocuted some rats but it is not economical or feasible at most places. Many rats turn to unprotected fields.

b) Traps – Bow and arrow traps and spring (back – break) traps kill the rat, whereas various other traps, e.g the wonder trap, will trap them alive. Traps are especially effective when food is scarce or bait more effective than the natural food is used. 'Kosai' may be more attractive than the grain or stems or other food in the habitat.

c) Communal drives to kill rats with sticks and knives are of value not only because they supplement the menu, but also because they add to millions of rats that were killed in the Philippines when all male citizens between 16 and 60 years of age were asked to go into "action".

d) Bounties – Bounties offered for trails of rats raised public interest without adding much to control. The money is better spent on real control programme.

2. Biological control – snakes, foxes, jackals, hyenas, dogs, cats and weasels are natural enemies of rats and so are owls, falcons and hawks. Their numbers are going down due to hunting, killing, bush fires and environmental changes like cutting down of trees. Rat typhoid bacillus, *Salmonella typhimurum* was widely used in Japan to cause a fatal disease in rats, but is now prohibited.

3. Chemical control:

a) Poison baits.

i) Acute poison or single dose poison. E.g Zinc phosphide (0.75 – 3%), Thalium (Zelio grains) and Grimi (Sastrix grains). They are very popular for the control of rat. They are quick inaction and require single feeding.

Disadvantages:

a) not all rats are killed
b) bait shyness develops after some time
c) secondary poisoning can occur
d) dangerous to man
e) must be distributed widely.

ii) Chronic poison or multiple does poison. They are also called anticoagulants since they inhibit blood coagulation. Rat die of hemorrhage after 4 – 14 days as a result of the cumulative effect. The common chronic poisons used for rats are:

a) warfarin 0.02%
b) chlorophacinone 0.005% (Rafia/Caid)
c) Coumachlor 0.025% (ratilan/Tomorin)
d) Diphacinone 0.005% (Ratak)

In stores where food is plenty, these chemicals are better as liquid poison and care must be taken to make sure that only rats reach it.

3.1.2. Squirrels:

Two species of tree squirrel (*Funisciurus snerythrus),* a side stripped squirrel and the Gambian sun squirrel (*Helioscirus gambianees)* cause damage to oil palm, pawpaw and maize cobs in the field. Others known to damage crops on farmlands are the Giant forest squirrel and the red legged ground squirrel. Squirrels also damage cocoa and rubber in the south western part of Nigeria.

The control methods include the following:

i) Poisoning. This may not be suitable for tree squirrel because they are very sensitive, do not feed on harvested fruits or processed food. Camouflage and traps have been recommended for ground squirrel.

ii) Use of repellant. These are however very expensive.

iii) Trapping. Trapping using snares has been found to be effective against side – stripped squirrel and the Gambian sun squirrel. The method is cheap, efficient and free of dangers inherent in chemical control.

3.2 Nematodes.

Nematodes or eelworms are minute, multi cellular animals that exist in all most every soil and water habitat of the world. In general, they are spindle – shaped, colourless, non – segmented roundworms. Adult plant – parasitic nematode are comparatively small, 0.4 – 4mm long and 0.01 – 0.5mm in diameter. All plant – parasite nematodes possess a stylet – a hollow, protrusible, spear like structure located at the mouth entrance. They stylet connects to the esophagus and is used for performing cell walls to inject digestive juices and for drawing nutrients.

Plant – parasitic nematodes are often classified by their feeding behaviour. Ectoparasites generally feed on cells near the surface and may inert portions of their heads into the plant tissue while they feed. Endoparasites enter plants, lay eggs and feed in the plant tissues. Ectoparasites are generally larger than endoparasites. Nematodes may be classified as sedentary or migratory. Sedentary nematodes move within a host or between the host and the soil.

Nematode damage to field crops is often difficult to ascertain and may closely resemble or mimic response to drought stress, nutrient deficiencies, or other diseases and nutrient problems. A typical symptom of nematode damage is irregular areas of varying size in which the plants have an unhealthy appearance. Heavily infected plants are smaller than normal plants, are usually chlorotic, and have a tendency to wilt because of reduced or unhealthy root system. Belo ground symptoms vary, depending on the specific nematodes attacking the roots. The following symptoms are common:

a) Root knots or galls

Root tissue close to a nematode's head often becomes enlarged bulbous and distorted.

b) Root lesions

Root lesions develop when migratory endo – parasitic nematodes enter and move within the parenchyma cells of the host roots. As the nematodes feed, cavities develop, which may result in falling off of cortical tissue. Small roots often become girdled by such injuries, so that root pruning occurs. Death necrosis of root tissue is often attributed to micro organisms that enter roots via wound caused by nematodes.

c) Abnormal or reduced root development

Ectoparqsitic nematodes normally feed on root tissue near the meristematic and cell – elongation regions. Damage to or death of root cells is primarily caused by the repeated probing of the stylet into the tissue. The plant then develops short thick tissues.

Control methods:

Controlling nematodes is often complex and may not be justified unless the population exceeds the economic injury level for each nematode species. Control measures should not be initiated without an accurate diagnosis to identify the species and determine the number of nematodes at the site. Nematode control may involve numerous strategies, including the following:

a) Quarantine and sanitation

The least expensive and most efficient means of nematode control is to prevent an infestation and build up. Transportation of soil, seed, debris and vegetative plant parts is the usual means of nematode dissemination.

b) Cultural practice

Plant – parasitic nematodes may be reduced to a low levels management and cultural practices, such as following crop rotation, timing of planting, providing optimum condition for plant growth, sanitation and the use of nematode – free planting stock. Tillage implements, by disturbing the soil, may effectively reduce various nematode species.

c) Physical treatments

Steam sterilization or hot water dips effectively control nematodes in small quantities of plant propagative material, seed and soil.

d) Biological control: Plant – parasitic nematodes are susceptible to predators and parasitic, including fungi, bacteria, insects and predacious nematodes. For small areas, mulching often promotes the build up of biological – control organisms.

e) Use of resistant cultivars: The most effective and economic control is the use of nematode – resistant cultivars.

f) Chemical control: Insecticides – nematicides (carbonates and organophosphates) may be cost – effective if nematodes are implicated in crop losses.

3.3 Birds

These are the group of animals called aves. They are the most serious pests of cereals and fruits in the field. They attack cereals such as rice, millet and sorghum at the milk stage and after grain development. They also use the leaves of cereals to make their nests thereby reducing the photosynthetic ability of plants. E.g the village weaver and Quelea birds on grain crop. Their attack can lead to crop failure and increase the cost of production.

Birds can be controlled by the use of:

i) Traps
ii) Scare crows
iii) Timely harvest of the crops

4.0 Conclusions

Animals also constitute pests of major importance. For high productivity, they should be controlled, if not eliminated. Control methods may involve numerous strategies just as there are many animals.

5.0 Summary

Crop pests other than insects include nematodes, molluscks, rodents, birds, monkeys, cattle and even man. They reduce crop yield, increase cost of production, reduce market value of crops and may kill the crop. Some are vectors carrying and transmitting diseases. The general methods for controlling these pests include physical/mechanical, cultural, biological and chemical measures. In some instances, quarantine and planting of resistant varieties will serve to control pests.

6.0 Tutor marked assignments:

(a) Discuss the damages done to crops by rodents, birds and nematodes

(b) List the control measures for controlling rodents, birds and nematodes.

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UNIT 4: WEEDS AS PESTS

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1.0 Introduction

Weeds are plants growing where they are not wanted. In general, plants are considered weeds when they interfere with the utilization of the plant and water resources or otherwise adversely intrude upon human welfare. They range from grasses, legumes and other plants and constitute a serious constraint to food and fibre production world wide. Estimates of crop yield losses due to weeds in developing countries are given at about 25%. Yield losses in grain crops could be much higher.

Some of the weeds commonly found in Nigeria include goat weed (*Ageratum conyzoides),* Tridax (*Tridax procumbens),* Wire grass (*Sporonbulus pyramidalis),* Elephant grass (*Penisetum purpureum*), Siam weed (*Chromolina odoratum),* Sturbbon grass*(Sida acuta),* Pig weed (*Boerhevia diffusa),* Tete (green with horns) – *Amaranthus spinosus,* Tete (greens with no horns)- *Amaranthus viridis,* Water leaf (*Talinum triangular),* sedge plant (*Cyperus rotundantus,* Emilia sognifochia, Spear grass (Imperata cylindrical) Desmodium (*Desmodium spp.),* Guinea grass (*Panicum maximum),* Carpets grass (*Cynodon dactile),* Northern Gambian (*Andropogon gayanus),* Mucuna (*mucuna utiks)* etc.

2.0 Objectives

At the end of this, you should be able to:

a) Define weeds
b) Discuss the effects of weeds in crop production
c) Discuss the principles of weed management
d) Discuss the methods of weed management
e) Identify important herbicides in weed control

3.0 Effects of weed in crop production

3.1 Direct effects of weeds on crop

a) Competition:

Weeds compete with crops for environmental factors such as nutrient, moisture, light and space. This is because weeds like crops also require these factors for survival.

b) Chemical interactions:

Some weeds produce toxic substances in the root region which can inhibit the germination of other plants. This phenomenon is called allelopathy. E.g *Cyperus rotundus* produces substances that can inhibit germination of seeds around it. California thistle produces chemicals that inhibit germination of other seeds. This causes poor establishment of crop and high weed competition with the crop.

c) Parasitic weeds:

Parasitic weeds depend on crop plants for their food materials. For example, dodder establishes a weak root system in the soil at first. It losses the roots when fully established on the host. New roots, called haustoria are developed, and with which dodder taps food from the host. Dodder develops a massive network of stem around the host.

Striga is another parasitic weed with weak root system before it develops haustoria with which it establishes parasitic relationship on the host crops. It taps food from the host plants with the haustoria hence making the plant weak and unproductive. Striga *hermonthica ia* also known as witch weed is parasitic on sorghum and maize in Africa, India and parts of United States.

d) Reduction in crop quality through seed contamination:

The seeds of weeds contaminate crop seeds at harvest. Weeds can reduce the quality of harvested products in the following ways:

i) weed seeds in harvested grains lower market value of grains
ii) green plant parts in dry seeds can interfere with the wholesomeness of such seeds in storage and consequently lower their quality.
iii) The presence of poisonous, unpalatable or even low quality plants in forages can reduce the quality of such forages with the attendant adverse effects on the animals that graze on them.
iv) Weed control is a high cost factor in crop production. The high cost of weed control constitutes a direct loss to the farmer.

The price of seeds depends on the degree of purity, hence the more the weed seeds in crop seed lot, the lower the price of agricultural seeds. For example, in a paddy rice production, presence of *Oryza barthii* reduces the quality of Oryza sativa. The presence of striga reduces sugar cane juice in quality. Nut sedge and wild garlic in pasture field reduce the pasture quality (palatable, nutritional quality etc.).

3.2 Indirect effects of weeds

- Weeds can act as alternative hosts for diseases and pests which affect crop plants e.g *acalypha ciliate* acts as an alternate host to root known nematode; likewise, *Sida vernocaefolia.* Also, some weeds harbour polyphagous – variegated grasshopper of *Zonocerus variegates.*
- Some weeds are poisonous and can kill livestock or produce allegic susbstance that affect both man and livestock. For example *halogeton glomeratus* and black night shade are poisonous to livestock. *Mucuna utilis* and *Fleurya aestuans* produce itchy spines that affects man hence field can be abandoned in case of severe infestation by these weeds.
- They can provide food, protection and habitats for several vectors of human disease e.g *Pistia stratuites* and *Salvilia auriculata* for mosquitoes.
- Weeds can affect mechanical harvesting using combine harvester. Weesbein green can log the cutting edges of the machine thereby retarding field operations.
- Weeds also clog drainage canals, causes fire in industry sites, prevent drivers from locating right ways on roads etc. in uncultivated areas, aquatic weeds block drainage ditches and irrigation canals, thereby disturbing the flow of water at the estuaries. Aquatic weeds block flow river causing flooding of banks. They can also affect recreational activities and fishing.
- Weeds harbour rodents, birds etc. which feed on the crops, thus contributing to crop yield losses.
- Weedy plantation of permanent crops can face severe devastation in case of fire outbreak during dry season, while the damage in clean plantation would be much less.

In addition to the above, the drudgery associated with weed control limits the land area a resource poor farmer can cultivate. This limits the farm size and consequently farm revenue.

3.3 Beneficial effects of weeds

Plant considered as weeds do have some positive values. Some positive effects of weeds are examined as follows:

i) Erosion control weeds play a vital role in soil conservation. They do not only break the force of rain drops on the soil but also stabilize the soil and reduce soil movement by rain wash. Thus, the foliage act as soil covers while the roots help to hold and stabilize the soil.
ii) Addition of organic matter to the soil. Weeds eventually die and decay, thus adding organic matter to the soil.
iii) Recycling of nutrients. Nutrients are transported from deep in the soil to the surface layer by fallen leaves and earthworm activities.
iv) Food for humans. Some weeds are used as food by humans. For example, *Talinum tiangulare* is a weed that is used as vegetables in West African countries. Also the tubers of *Cyperus tuberosus* are used as food in parts of the guinea savanna zone.
v) Medicine. The leaves and roots of many weeds are important in the preparation of herbal medicines by traditional healers.
vi) Host for beneficial insects. Weeds act as hosts to beneficial insects and provide nectar for bees.
vii) Genetic materials. Some weeds are wild relative plants thus serving as a source of genetic materials for varietal development.

3.4 Management of weeds

As discussed earlier, weeds have both harmful and beneficial effects. When and where the harmful effects of weeds are greater than the usefulness, there is a need to reduce their population and growth through management practices to such an extent that the nature and extent of damage they cause are within permissible limits.

Weed management refers to the manipulation of weeds so that they minimally interfere with the growth, development and economic yield of crops and animals. Thus, efficient weed management is a vital aspect of meaningful agricultural activities. On the other hand, the cost of weed management must be less than that of the expected value of produce that will be reduced by the infestation of weeds. On many occasions weed growth and biomass development are more important than only the density of weeds. The floristic composition of weeds is more important than that of the abundance of a single species in a habitat. A specific weed management may be adopted to kill a predominant species without much or no effect on another species which may then become a predominant one (shifting flora). Thus weed management should be aimed at reducing both the population and the growth of all the species together. This is most difficult and tedious. All the species of weeds and even individuals of the same species don not emerge, grow and reproduce, simultaneously. Thus the method employed to mange weeds must have some residual effects.

To deal with problems posed by weeds some methods of management are to be adopted. Such methods are based on some basic principles. These principle are related to (i) life cycle of weeds, (ii) characteristics of weeds, (iii) mode of reproduction of weeds, (iv) habitat, location and season, (v) soil and weather conditions, (vi) area of weeds management, (vii) farming and cultural practices, (viii) availability of resources, and (ix) economic of the method.

i) Life cycle of weeds and their management.

The understanding of the life cycle of weeds determines the effective method and optimum time of weed management.

Annuals complete their life cycle within a season or year. If the introduction and seed production of annuals are prevented, they can be managed better than biennials and perennials. Annuals should be killed before flowering. It is better to adopt stale seed – bed technique (allowing germinable weed seed seeds in soil to germinate by preparing a weed seed – bed and destroying them thereafter before sowing the crops), pre- sowing irrigation pre – or post – weed emergence but pre – crop emergence application of broad spectrum translocated herbicides intercultivation to destroy annual weeds successfully. Annual in the early growth stages are easily and cheaply destroyed. Once the shoots are killed, the roots are unable to regenerate and rob water and nutrients, meant for crop growth and production.

The best time to destroy biennials is during the seedling stage of the year when they behave like annuals. Once they form underground storage organs they escape a number of management practices, and they may even multiply due to the shearing and tearing action of tillage implements. The application of translocated herbicides at the beginning of the aerial growth in second year or digging out of storage organs help destroy them.

They can also be killed by creating extreme adverse conditions, such as impounding water for a fortnight at their resumption of growth in the second year, particularly for biennials of aerobic. Heating soil by burning trashes (rabbing) after exposing the storage organs also kills the weeds successfully.

Perennials may be grouped according to forms of vegetative reproduction: simple, bulbous or rhizomatous and creeping perennials. In combating perennial weeds two problems are to be encountered (a) to check the spread or reinfestation by seeds or vegetative propagules, and (b) to destroy the established plants. They should be prevented from seeding and forming vegetative propagules by the repeated destruction of aerial shoots and underground roots by cutting, ploughing, digging, drying, and flooding during their regeneration period when food reserve tend to be exhausted.

Some rhizomatous weeds (such as imperata cylindrical and sorghum halepense) hide their storage organs well below the plough layer. Such organs and to be dug out and destroyed or translocated herbicides should be applied during their regeneration period. The burning of grown up bushes destroys the shoot and then digging or the application of translocated herbicides after the beginning of regeneration makes it easy to kill them.

If required, perennial weeds may be controlled by leaving the land uncropped for the season when several; measures, such as repeated ploughing, pudding, flooding, green manuring, digging and uprooting of storage organs, stocks and stumps, burning, grazing, and shifting of soils may be adopted. The cultivation of cleaning crops, fodder crops for repeated cutting at shorter intervals and rational cropping reduces the infestation of perennial weeds. A combination of several methods accelerates the destruction of such weeds and thus gets rid of the perennial problems posed by them.

ii) Characteristics of weeds

Predominance of a particular group of weeds (such as broad – leaved/grasses/sedges) determines the method of management. Individual species of the group may also be important in a particular habitat because of their noxious, problematic, poisonous or predominant nature. Such individual weed species may have special characteristics by which they severely react to the environmental conditions. For example, cyperus, rotundus and Ahhagi camelorum cannot tolerate waterlogged conditions. They may be killed by flooding or growing wet land rice. Some weeds (such as E. colonum, E. indica) can re- establish even if a single root is left undisturbed. Complete uprooting and feeding to cattle or composting and the application of herbicides are the possible measures to destroy them. Some weeds particularly during their grown up stages (such as Trianthema portulacastrum) take a few days to desiccate even under hot dry conditions. There should be a considered gap between mechanical uprooting and irrigation to them up completely.

iii) Mode of reproduction of Weeds

While selecting a suitable method of management detailed information regarding the production of a prevalent weed species is essential. Information pertaining to the propagation by seeds or vegetative means by both, number and time of production of propagules, the method for their dispersal, their dormancy, viability, time of germination or sprouting, association with crop plants, mode of perennation, stabilization and adaptation under adverse environmental conditions dictate the methods and the scheduling of them from their control.

iv) Habitat, Location and Season

In crop field habitat, targeted plants (weeds) are to be killed or suppressed without affecting crop plants, beneficial organisms and their activities. Such selective treatments are essential in crop fields considering the standing crop and crops in sequence and also the surrounding environment. The relative age and tolerance of crop plants and weed are to be considered. Such considerations may not be required for non – cropped areas where other factors, such as soil erosion and degradation may be considered.

The crops and weeds of uplands are quite different from those of low lands. Cultural practices and the workability of such land also differ, thus weed management practices vary.

The occurrences, composition and abundance of weeds vary from season to season and therefore suitable with management practices also differ. In the Kharif season a large number of terrestrial weeds can be suppressed by continuous submergence in water of a dept of 5cm to 10cm.

v) Soil and Weather Conditions

Soil texture and moisture are the important factor in selecting a suitable method of weed management. Light soils have a poor water holding capacity and therefore flooding can not be adopted. In heavy soil with poor drainage, mechanical weed management is impeded. Also, dry soil resists mechanical weed management. Types of weed flora differ with soil reaction and therefore weed management practices vary.

The prevalent weather condition determines the workability of the soil, the affectivity of operation and the efficiency of treatment. Continuous rain or drought, and the high velocity of wind affect filed operation. Under such conditions the management operation are either pre – or postponed or an effective method is sought for combating the infestation of weeds.

vi) Area of weed management:

In localized spots or small area (such as nursery) labour intensive but most effective methods, such as hand pulling may be adopted. In greater area (say up to two to five ha), mechanical methods and in large areas, chemical methods of weeds management may be adopted. In many cases an integrated approach may be more effective and remunerative than that of individual methods.

vii) Farming and cultural practices:

Methods of weeds management in farming with seasonal field crop differ from farming with fodder or seed production and multiplication. Similarly, weed management practices in rain fed or dry land farming differ from that of irrigated farming. Methods of weed management in mixed or intercropping differ from that of pure cropping. Weed management methods in direct seeded upland crops differ from transplanted low land crop. Management practices such as good land preparation, sowing at the optimum time and by the best method, intercultural operation, such as earthing up, insect – pest and disease management at the appropriate time and by the correct method, favour crop growth and development and at the same time suppress the population and growth of weeds.

Weed management in rations and repeatedly cut crops, differ from that in plantation crops. The best time for weed management in rations crops is the pre – regenerative stage of the crops. In green manure crop, weed population and weed management is an unnecessary expenditure and rather a loss.

In potato, groundnuts and sugar beats, earthing up and the preparation of irrigation and drainage channels are the essential intercultural operations when weed management becomes simultaneous, while in cotton and jute, inter – culture is directed mainly for weed management. Therefore, the method and time of weed management differ in these types of crops.

The method and time of weed management vary with different methods of harvesting crops. Potato, sweat potato and groundnut are harvested by digging when all the weeds are uprooted and destroyed. This is not possible with reaping, picking or uprooting methods of harvesting.

In mechanized farming, weed infestation increases as they are not identified separately by machines. Weeds that come up in the crop rows grow and produce seeds which are harvested with crop plants and remain as an admixture with crop seeds for the next sowing. Under certain conditions mechanical weed management becomes impossible. In such cases, chemical weed management becomes indispensable, effective and cheap.

The same crop species may be grown for different purposes, such as maize, oat and cowpea for grains, fodder or seeds. Some species of weeds may be allowed to grow for fodder, still less for grain and no weed in seed crops. Therefore, weed management practices differ with the purpose of the crop grown.

viii) Availability of resources:

Farm labour, implement, power and herbicides are the major inputs in weed management. The availability and cheapness of these inputs determine the method of weed management. Although other factors such as the availability of time, the effectiveness and work ability are also contributing factors in selecting the suitable method. Agriculture in Nigeria is very dependent on the whims of nature. Therefore, the demand for labour reaches it peak during sowing, intercultural and harvesting as every farmer wants to complete such operation in a short span of time. During such period skilled labourers are in short supply; thus wage rate also high.

Apart from some hand tools, there are a few improved speedy and effective implement for weed management in the country. This also have limitation of use under the various conditions of soil and crop.

The availability of appropriate herbicides with the desirable formulation is rare in our Nigeria. Some times they are costly. The knowledge and the experience of the farmer are also lacking regarding herbicides use. The availability of resources therefore determines the method of weed management.

ix) Economics of the methods:

Most of the farmers of in Nigeria are poor and live at substance level. Even though some methods are found to be profitable, they do not care for them. The level of production is in general, low and therefore the use of costly inputs for weed management becomes risky. Except in areas with commercial crops, farmers prefer multi – purpose traditional operations such as hoeing which improves the physical conditions of the soil, earthing up and the incorporation of top dressed manures and fertilizers, and at the same time weed management which on apportioning the cost is found to be the least expensive and most effective, though time consuming and tedious. In the recent past, the introduction of integrated weed management involving non – monetary, less monetary and monetary inputs becomes popular, effective and less risky.

3.5 Methods of weed management and control

A weed management system is a functional unit of integrated weed control or methods. Weed control refers to those actions that seek to restrict the spreads of weeds, destroy and reduce their population so that they do minimum harm in a given location. On the other hand, weed eradication refers to the complete removal or elimination of all weeds and propagation of single species from an area. This is a very difficult task. This is difficult to achieve on a large scale, and it is uneconomical in most cases. Except in serious cases of noxious weeds menace, weed eradication is not a major objective in arable and permanent crop production.

Four weed management systems have been identified. They are as follows:

a) Cultural system
b) Biological system
c) Chemical system
d) Preventive systems

a) Cultural system

Cultural methods are those practices adopted by farmers to minimize weed problem without being necessarily directed toward weed control. Some involve mechanical weed control methods and these include hand pulling, hoeing, slashing and cultivation. In all cases, the aim is to destroy established weed stands. For it to be effective, operations must be carried out regularly and it is labour intensive and very expensive. The cultural methods of weed control include the following practices:

i) Manipulation of seeding rate: sparse plant population gives room for weed development. It is better to plant at optimum plant populations.
ii) Crop rotation: certain weeds with similar physiological requirements as the crop plants tend to get associated with them. Growing these particular crops yearly creates favourable conditions for such weeds, but there will be reduction in this weed population with the planting of another crop of different requirements e.g. Striga are more associated with sorghum.
iii) Mulching: involves the use of dead mulch or plastic sheet. This prevents sunlight from reaching the germinating weed seeds, but it is only possible on a small scale and not very important to field or tree crops. It also creates some inconveniences in farm operations like fertilizer application.
iv) Hand weeding: this involves hand pulling of weeds, hand slashing with cutlass and hand hoeing.
v) Flooding of farmlands.

b) Biological method:

This involves the use of living organisms or biological agents (live mulch or insect) to control weeds. It also implies using natural enemies of the weeds such as man, parasites, pathogens or predators to destroy the weeds. It must be ensured that these enemies will not be enemies of the crop. Under agronomic conditions, this approach has not found much use, but on national bases e.g use of Cactoblastis esctorum to control Opuntia species in Australia.

Biological system of weeds control includes the following weed control methods:

- Use of live mulch
- Use of insects
- Microbial control
- Plant canopy manipulation
- Allelopathy.

c) Chemical system:

The chemical system involves the use of chemicals to eradicate the weeds. The chemicals are called herbicides. Herbicides can be systemic i.e stops the normal function of plant system. The action is gradual and total control is achieved with the use of “round up” and Atrazine. Contact herbicides on the other hand destroy weeds on contact. E.g gramazone. Herbicides can also be very selective in destroying either grass or broad leavese e.g. Gramozone.

d) Preventive system:

These are measures to prevent the introduction of weeds that are not common to an area e.g. Siam weed - *Chromolaena odorata* can be introduced to a new area by using it as packaging material.

In the preventive weed management system, the following weed control methods are used:

- Sanitation measures especially non – crop area on the farm.
- Use of clean seed lots as planting material. Such seed lots must be free from weed seeds and other propagules.
- Quarantine of animals.
- Screening of irrigation water.
- Roughing of isolated weeds.
- Enforcement of laws designed to prevent the seed or propagules of certain plants from entering a country.

Perennial weeds tend to be more under permanent crops. Annual weeds tend to be more frequent in arable crop fields. There is no water – light distribution of perennial and annual crops. Weeds like *chromolaena odorata* and *Imperata cylindrical* which are problems under tree crops are also found in arable fields. Perennial weeds like *cyperus spp.* and *Cynodon dactylon* are also highly associated with arable crops, irrigated and wetland vegetable production. Striga species are clearly in association with arable crops. It should therefore be understood that both agro – ecological effect and nature of crop influence the weed types.

For maximum yields, crops need to germinate and become established in a weed – free environment. Crops face competition from weeds after establishment and early growth. In weed management, the goal is to focus on the limited weed management resources on the crop growth stages at which weed interference is most critical.

Subsistence farmers in Africa, depend mainly on the cultural system, followed by chemical and biological systems for weed management in arable crops. Specifically the practice is mainly hand weeding followed by the use of herbicides, live mulch and canopy effect. A minimum of 2 – 3 hand weeding are carried out in arable crops production, usually between the 2nd and 8th week after planting. In farming systems involving crop mixtures, the weeding recommendation for the base crop shall be applied to the mixture. Vegetable and food legumes may be grown along the alley ways during the early years of tree crop establishment. Thereafter, cover crop or grass leys may be maintained.

3.6 Herbicides in weed control.

Herbicides are highly crop specific. The rates of these specific herbicides to be use in any given situation vary with the soil type and growth stage of the weeds. Herbicides are either soil or foliar applied. Soil acting herbicides help crops to establish and begin early growth in weed free environment. Foliar acting herbicides on the other hand, help to reduce the vigor and population of growing weeds, thus placing the crop at an advantage with respect to resource use.

Below are some herbicides recommended for different crops in Nigeria.

Crop	Herbicides	Rate Kg a.i/ha	Weeds	controlled
Maize				
	Atrazine + Metolanchlor (Primagram)	2.5	Post emergence	Most annuals
	Atrzine + Alachlor (Lasso atrzine)	3.0	-//-	-//-
Rice				
	Butachlor	1.5	-//-	-//-
	Propanol + Oxidation (Ronstar PL)	2.5	-//-	-//-
	Propanol + bentazone (Lasso atrazine)	3.0	-//-	-//-
	Thiobencarb (tamarice)	3.5	-//-	-//-
Sorghum				
	Atrazine + terbuthylazine (Gadoprim A)	1.5 – 2.0	-//-	Most annual weeds except sedges and striga
	Atrazone + Propanol	1.0 + 2.5	-//-	-//-

<u>Millet</u>			
Atrazine + terbuthylazine			
(Cardoprim A)	1.5 – 2.0	-//-	Most annuals
<u>Cowpea</u>			
Metolachlor + Metobromuron			
(Galex)	2.5	-//-	-//-
Linuron + Pendimethalin			
(Panther)	2.0	-//-	-//-
Imazaquin	0.2 – 0.025	-//-	-//-
<u>Soybean</u>			
Metolachlor + Metobromuron	2.5	Post emergence	Most annuals Except sedges
(Galex)			
Metolachlor + Prometyrne			
(Codal)	2.0	-//-	Most annuals
Metolarchlor + metribuzine	1.25 -2.5	-//-	except witch grass
<u>Groundnut</u>			
Same as for soybean			
<u>Cassava</u>			
Atrazine + metolachlor	3.0	-//-	Most annuals
(Primextra)			
Pendimethalin	3.0	-//-	-//-
(Trazastomp)			
Fluometoran + metolachlor	2.0 – 3.0	-//-	-//-

(Cotoran multi)

<u>Yam</u>

Same as for cassava

<u>Maize/cassava mixture</u>

Atrazine + metolachlor	3.0	-//-	-//-

Maize/soybean mixture

Metolarclor + Prometryn (Codal)	2.5	-//-	-//-
Metolarchlor + Matobromuron	2.5	-//-	-//-

<u>Oil palm</u>

Diuron	2.0-2.5	-//-	-//-
Diuron + Paraquat	1.0	Preplant In nursery	All emerged weeds
Atrazine	2.0	Post emergence in nursery	-//-

<u>Cocoa</u>

Paraquat	0.8	Post emergence	All annual weeds

<u>Rubber</u>

Same as for cocoa

Activity:

Visit any school laboratory or crop farm and do the following:

i) Collect as many weeds as possible. Identify them with their common and botanical names.
ii) Identify the herbicides used to control the weeds
iii) Identify the type of sprayers used (knapsack, boom, pneumatic etc). Take note of their maintenance and precautions in the use of chemicals and sprayers.

4.0 Conclusions

Weeds have both harmful and beneficial effects. When and where the harmful effects of weeds are greater than the usefulness, there is a need to reduce their population and growth through management practices to such an extent that the nature and extent of damage they cause are within permissible limits. The understanding of the life cycle of weeds determines the effective method and optimum time of their management.

5.0 Summary

In this unit, we studied weeds as pests and discussed their importance in crop production. Weeds are plants growing where they are not desired and they are different kinds of them. The principles and methods of weeds control have also been highlighted.

6.0 Tutor marked assignments

a) Define weeds

b) Discuss the effects of weed management

c) Discuss the principles of weed management

d) Discuss the methods of weed management

e) Identify important herbicides in weed control.

7.0 References and further readings

i) Anthony, Y., O.C. Ezedinma and Ochapa, C.O. (1986). Introduction to Tropical Agriculture. Longman Group Ltd.

ii) Ayo Fatubarin. Plant pathology. 2003 series

iii) I.C. Onwueme and T.D. Sinha. Field Crop Production in Tropical Africa. CTA, Wageningen, Netherland.

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v) Larry P. Pedigo. Entomology and Pest Management. Low price edition, 4th Edition.

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UNIT 5: PESTS OF STORED PRODUCTS

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1.0 Introduction

On – farm storage is usually practiced by farmers. Staple foods and grains for family consumption are stored on – farm for many months. Most cash crops are also stored on – farm for a while and later moved into warehouses or silos in town and cities. Damage to stored grains, seeds and foodstuff is of particular importance because it occurs post harvest, and cannot be compensated for. Post harvest crop losses in Nigeria are often very high, averaging about 20 – 30%. Cowpea, sorghum and other small grain (rice and wheat, especially) often suffer very badly in storage. The more susceptible varieties show deterioration after only 3 – 4 weeks in storage and in some instances, 100% losses occur after only 50 days.

2.0 Objectives

At the end of this unit, you should be able to discuss the following:

2.1 Categories of storage pests

2.2 Damages caused by storage pests

2.3 Storage pests of some common Nigeria crops

2.4 Rodents as storage pests and control measure

2.5 Precautionary measures for the control of pests in stored products.

3.0 Pests of stored products

The more important pests of stored products are a few moths in the family *Pyralidae,* a few mites (*Aerina),* beetles belonging to a diversity of families, rats and mice. The produce is usually grain of many types, dried pulses (usually shelled), nuts of other seeds, some dried fruits and berries, dried leaves and dried roots and tubers.

3.1 Categories of storage pests

The pests may be categorized on the basis of their feeding behaviour as follows:

1. Primary pests: These insects are able to penetrate the outer coats of grains and seeds, and include *Ephestia spp. Trogoderma, Rhizopertha, Cryptolestes* and *Sitophilus spp.,* as well as rat and mice.

2. Secondary pests: These are only able to feed on grains already damaged by primary pests or physically damaged during harvest e.g. *Oryzaephilus spp.*

3. Fungus feeders. A number of insects (mostly beetles) that are regularly found infesting stored products are usually feeding on the fungi growing on the moist product. Some species, however, may be both fungus feeders and secondary pests, e.g. some *Psocopetera*.

4. Scavengers. These are polyphagus, often omnivorous, casual or visiting pests. These include cockroaches, crickets, ants, some beetles, rats and mice.

Some pests are clearly more specific in their dietary requirements than others. For example, the Bruchidae only attack pulse grains; some caterpillars and beetles attack dried fruits, some beetles attack only grains, some only in flours and processed products. Many are confined to animal products and dried proteinaceous materials.

3.2 Damages caused by storage pests

The relative importance of the different species of storage pests depends on the nature of damage done.

1. Direct damage:

This is the most obvious typical form of damage. It is often measured as a direct loss of weight or reduction of volume. However, neither is accurate since although produce is eaten, there is an accumulation of frats, faeccal mater, dead bodies, etc. all the insects, mites and rodents are responsible for such damage.

2. Selective eating:

Some insects prefer the germ region of seeds and grains. Thus a fairly low level of damage will severely impair germination of stored seeds. In stored food grains, there will be serious reduction in quality resulting from the loss of the protein, minerals and vitamins that occur in the germ region. This preference is shown particularly by Ephestia larvae and Cryptolestes.

3. Heating of bulk grain:

When grain or any other similar produce is stored in bulk, stagnant air trapped within the produce becomes heated by the insect metabolism and "hot spot" develop. The moisture from the insects' bodies and the stored grains condense on the cooler grain at the edge of the "hot spot". The condensed waster causes caking, leading to fungal development and may even cause some rains to germinate.

4. Webbing by moth larvae

The pyralid larvae in stored products all produce silk webbing which if present in large quantities may dog machinery and otherwise a nuisance.

5. Contamination

For export crops and produce to be sold, the presence of insects and dead bodies, exudate, frass, faeces, urine, hairs etc causes a general loss of quality and value. Export crops are mostly destined for Europe and America where infestation control legislation is particularly stringent. Many consignments have been rejected at the point of entry owing to presence of rodent hairs, urine or faecal matter, certain insect pests or residue of insecticides. In Nigeria, many consignments of sorghum and maize grain have been rejected by breweries for similar reasons.

3.3 Important pests of stored products

a) Cowpea bruchid *allosobruchus maculates*

It is wide spread in Nigeria and the most important pest of stored cowpea in Nigeria. Alternative hosts include soybean, pigeon pea, green grains, chickpea and other pulses.

The larvae bore into and feed on the beans. Infestation usually start from the farm and are laid on maturing pod in the field. The infested pods are harvested and taken into the farm stores where further development takes place.

Adults are 2.5 – 3.5mm long brownish beetles. The females have obvious dark patches in the centre of each side of the elytra and at the anterior and posterior tips. These markings are less distinct in the males. There is a tooth on the apical end of the hind femur, larvae are usually found only within the bean.

Females lay up to 90 eggs singly, attached to pods or seeds. The eggs are round, small and grey – white. They hatch in about 6 days and the larvae bore into and feed within the seeds. Each larva develops within a singly seed only. Pupation occurs in the seed about 26 days after the eggs were laid. Adults emerge after 7 days and do not feed. The whole life cycle takes about 4 – 5 weeks and there may be 6 –m 7 generations per year.

Non – chemical control: Dried bean stored in pods are more resistant to attack. Crops should be grown at least 1km from the nearest cowpea store. Prompt harvesting in areas at risk will also reduce attack levels. Treatment of cowpea seeds with fresh or refined palm oil and vegetables oil can reduce infestation of *C. maculates* by reducing e.g. laying. Mixing cowpea with dried powder of hot pepper, ash, sand, neem, kernel powder also gives protection. Small quantities of cowpea stored in the house for consumption can be protected against *C. maculates* by heating to 64^0C for 10 minutes and then cooling and storing in insect – proof jugs. Similar control can be achieved by storing cowpea in smoky conditions such as in the kitchen.

b) Rice weevil *Sitophilus oryzae* and maize weevil *Sitophilu zaemais.*

They are some of the most destructive pests of stored grains. They can damage grains beyond use. They are most active under warm – humid conditions. *S. zeamais* primarily a pest of maize, but will attack rice, sorghum and other stored grains. Infestation can begin in ripening crop in the field and continue in store. *S. oryzae* is primarily a pest of rice, but will also attack maize, various cereals and their products. E.g biscuits and pulses. It is less likely than *s. zeamais* to infest ripening crops in the field. Both have been found in dried cassava.

Adults and larvae fed on grains. Attack may start in the field and continue in the store. Larvae tunnel and fed within the grain. After pupation, adult cuts 1.5mm diameter circular hole in the grain through which they emerge. Attack leaves the product susceptible to moulds. The grains are also contaminated with insect excreta.

S. zea mais and *S. oryzae* are similar in appearance, both are dark red – brown to brown – black inclour with four pale red – brown oral spots on the elytra, but these are often indistinct. Adult *S. oryzae* are 2 – 3.3mm long and adult *S. zea mais* are 3 – 3.5mm long.

Females lay up to 150 eggs and drop a single egg in the hole they have dug in the grains. The hole is then sealed with a gelatinous fluid. Eggs hatch after about 8 days and larvae develop over 6 – 8 weeks within the grain. They mould from pupation occurs in the grains and last 5 – 16 days. The adult may live up to 6 months and there may be up to 7 generations per year.

Non – chemical control: *Sitophilus* can not breed when grain moisture is 9% or less. Therefore, grains stored in clean dry conditions are less likely to suffer attack. Seed treatment with wood ash or refined palm oil also suffers less attack. Early harvesting will reduce infestation. Infestation can also be reduced by storing maize as unhusked cobs. Storage space should be free of weevils before new grains are stored there.

c) Rodents. These have been well discussed in module I unit 3. The most important of these are the rats and mice.

3.4 General precautionary measures for control of pests in stored products.

For the control of pest in stored products, the following should be done:

a) Harvesting: The grain should be harvested as soon as they are mature to avoid infestation in field

b) Drying: The grains should be dried properly, below 15% moisture level before storage.

Dry grains are less easily attacked. Suggested levels are groundnut – 9%, maize, sorghum and millet – 12%, rice and wheat – 14%, beans, cowpea etc – 15%. Moist grains are readily attacked by *Aspergilus and penicillin.*

c) Good building: All holes or cracks in the wall, floor, roof, window and doors should be repaired and prevent access to rats, mice and insects. The building must be sealable if fumigation is contemplated.

d) Use of sealable container: On a large scale, this would include silos that are long – term grain storage as part of the national strategic reserves. Some of these silos are her metrically sealed. Some of the non – farm stores may be built of bricks or may be small plastic sack or jerry cans or large earthen ware jars. If reasonably airtight, they may be fumigated after being packed. Wooden sac, cloth or thin gauge polythene should not be used as they fail to cult off oxygen and may allow penetration of moisture into the grain.

e) Store hygiene

Activity

Visit grain stores and observe the general sanitation of the storage environment. Carry out assessment of damages to stored products by pests.

4.0 Conclusions

Post harvest crop losses due to storage pests are often very high and cannot be compensated for. To increase the shelf life and increase market value of stored products, proper control measures should be put in place.

5.0 Summary

Storage pests are categorized into primary pests, secondary pests, fungus feeders and scavenges based on their feeding habits. Some effects of storage pests include direct and selective eating of grains, bulk heating of grains, webbing of produce by moth larvae and general contamination. Description of some storage pests damages done and control measures were also given in this unit.

6.0 Tutor marked assignments

a) List the categories of storage pests

b) Discuss the damages caused by storage pests

c) List three pests of storage products

d) Discuss the precautionary measures for the control of pests in stored products

7.0 References and further readings

i) Anthony, Y., O.C. Ezedinma and Ochapa, C.O. (1986). Introduction to Tropical Agriculture. Longman Group Ltd.

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MODULE II: CROP DISEASES

UNIT I: CONCEPT OF CROP DISEASES

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1.0 Introduction

The study of plant disease is called plant pathology. Diseases are defined as disorders or physiological disturbances of the normal function of plants caused by physical, chemical or biological factors. The biological factors are those referred to mainly as *Pathjogens.* In other words, diseases are caused mainly by the low forms of plant life such as fungi, bacteria and viruses, but some diseases or disorders in crop plants are caused by other physical or soil factors. The visible morphological expressions of diseases condition are referred to as *symptoms.* Decision on the importance of crop disease and the need for control are usually based on economic considerations.

Generally, a plant is diseased when it is continuously disturbed by some casual agents that results in an abnormal physiological process that disrupts the plant's normal structure, growth, function or other activities. This interference4 with one or more plants essential physiological or biochemical systems elicits characteristic pathological conditions or what is known as symptoms.

The malfunctioning processes due to inroads of a foreign factor or due to some other biotic causes should make the plant abnormal on the sense that it is losing its economic value. However, if there is some malfunctioning or abnormality, even if caused by some biotic or abiotic factor, which does not cause loss of economic value or enhances the beauty or value of the plant it should not be called a disease in general sense. For example, the “broken tulips’ in Holland which were actually due to viral infection but they fetched very high market price because of their beauty. Variegation on ornamental perennial is another example.

2.0 Objectives

At the end of this unit, you should know:

2.1 What diseases are

2.2 Causes of plant diseases

2.3 The damages caused by diseases

2.4 The categories of plant diseases

2.5 The general symptoms of Plant disease

2.6 How to control plant diseases.

3.0 Crop diseases

3.1 Causes of plant diseases

A pathogen is always associated with a disease. A pathogen is any agent or factor that incites “pathos” or disease in an organism. Thus in strict terms, the pathogens do not necessarily belong to living or animate groups. They may be non – living or in – between the living and non – living (such as viruses). The plant pathogens are thus grouped under the following categories.

a) Abiotic factors: These include mainly the deficiencies or excesses of nutrient, light, moisture aeration abnormalities in soil conditions; atmospheric impurities etc. Examples of diseases caused by these factors are described below:

i) Nutrient deficiencies. The deficiency of major elements as nitrogen, potassium, phosphorus and sulphur is generally characterized by yellowing of leaves and poor plant growth. Magnesium deficiency is characterized by mottling or chlorosis, as well as cupping of leaves and necrotic spotting. Calcium deficiency results in irregular, distorted, brown scorched leaves and necrotic spotting.

ii) Insufficient light. This slows down chlorophyll formation and leads to a condition known as etiolation – lean growth with long internodes, pale green leaves and premature abscission of leaves and flowers.

iii) Too high temperature. The side of the fruit facing the sun dries up (sun scald disease) below the skin and becomes dicoloured and water – soaked.

iv) Low soil moisture. The symptom is generally poor growth. In maize, the leaves turn brown and the crop hardly flowers. When severe, the plant wilts and dies.

v) Air pollution. Dusts settling on leaves could lead to chlorosis and poor growth. Phytotoxicity may result when some dissolve in rain water.

vi) High soil moisture. Waster logging of soils causes root decay due to reduced oxygen. The situation if prolonged could lead to the collapse of the root cells and death of the plant.

vii) Pesticides toxicity. Leaf burn may result from a pesticide spray n that is too highly concentrated.

b) Mesobiotic causes: These are disease incitants which are neither living nor non – living. They are considered to be on the threshold of life. They include (i) the viroids which are naked infectious strands of nucleic acid. Spindle tuber of potato and tomato bunchy are some of the examples (ii) viruses which are infectious agents made up of one type of nucleic acid (RNA or DNA) enclosed in a protein coat. Examples of virus diseases of plants are leaf roll of potato, leaf curl of tomato and chili, mosaic diseases of many crops.

c) Biotic causes: This category includes diseases by animate or living organisms.

3.2 Damage caused by diseases.

Disease in crop plant is usually due to the disruption of form, function and energy usage and is caused mainly by pathogens. The effect of diseases may range from complete destruction or loss of crop stands (as in tomato wilt or maize stalk rot), to inconspicuous damage which nevertheless results in the depression of yields or loss in quality (as in root rots of sugar cane, maize and other cereals, the leaf spot of legumes cotton and other fibre and oil seed crops, and virus diseases of cassava, sweet potatoes and a wide variety of cultivated crops). Often, the signs of infection are hidden underground and there may be a tendency to ignore the diseases (as in nematodes attack).

In many other cases the effect if disease is in reducing the quality and market value of the crop or crop products. This is particularly important in perishable farm products, such as vegetables, fruits, seeds and tubers. The blemish caused by bacteria or fungi on tomatoes, bananas, oranges, etc and the rots on tubers largely contribute to the lowering of the market value of such products.

3.3 Categorization of plant diseases.

A disease may be localized if it affects only specific or parts of the plant. It may be systemic if it affects the entire plant. The diseases are called soil – borne or seed – borne when the causal agent inciting the disease perpetuate through the agency of the soil or seed (or any propagating material). However, a "disease" is never soil – borne. It is casual agent that is soil borne. Similarly, a "disease" is seed – borne only when the seed carrying its causal agent is infected and the pathogen is seed – borne, not the disease. The pathogens may be air – borne if they are disseminated by wind. Often, in this case also, a disease is called air – borne which is technically incorrect.

The symptoms or signs which appear on the affected parts or the entire plant also form a basis for grouping of plant diseases. Thus, we fund diseases known as rusts. Smuts, root rot, wilt, blight, canker, mildew, fruit rot, leaf spots etc. In all these examples, the name of the diseases is derived from the most conspicuous symptoms of the disease appearing on the host surface.

According to the host plants, the disease can be grouped as cereal, forage crop, flax, millet, root crop and plantation crop diseases.

Diseases caused by animate and virus pathogens are often classified in relation to their occurrences under the following groups:

a) Endemic diseases:

The word "endemic" means prevalent in, and confined to, a particular country, district, or location. These diseases are natural to one country or part of the earth. When a disease is more or less constantly present from year to year in a moderate to severe form in a particular geographic region, it is classified as endemic to that area. The causal agent is well established in the fields or in the locality by virtue of its ability to survive through soil or other means for long durations and environmental conditions are not adverse to its survival all those disease which become persistent through their survival on alternate or wild hosts from one crop season to the next are also included in this group.

b) Epidemic or epiphytotic diseases:

The term “epidemic” is derived from a Greek word meaning “among the people” and in the true sense was applied to those diseases of humans which appear very violently among a large section of the population. To carry the same sense in the case of plant diseases the term “epiphytotic” was coined. However, in general usage, the term epidemic is used for plant diseases also. An epiphytotic disease is one which occurs widely but periodically. It may occur in the locality every year but assumes severe form only on occasions. This may be because the environments or conditions favourable for severe occurrence occur only periodically. It is also possible that the environments are favourable but the pathogen is irregular in its occurrence or its inoculums concentration has not reached the desired level to cause the disease in the plant population.

When epiphytotics become prevalent throughout a country, continent or the world, the disease wanes, and, unless the host species has been completely wiped out, the disease subsides to a low level of incidence and becomes endemic. This balance may change dramatically by conditions that favour as renewed epiphytotic. These conditions are weather (mainly temperature, moisture) very favourable for multiplication, spread and infection by the pathogen, introduction of a new and more susceptible host, development of a very aggressive race of the pathogen, and change in cultural [practices favouring disease.

c) Sporadic diseases:

Sporadic diseases occur at very irregular intervals and locations and in relatively few instances. A given disease may be endemic in one region and endemic in another.

d) Infectious and non – infectious diseases:

Plant diseases may be infectious or non – infectious. All diseases caused by animate and virus and viroid pathogens under a set of suitable environments are infectious. Association of a definite pathogen is essential with such disease. In non – infectious diseases, no animate, virus or viroid pathogen is associated and, therefore, they remain non – infectious and cannot be transmitted from a diseased plant to a healthy plant. These disorders are due to disturbances in the body caused by lack of proper inherent qualities, by improper environmental conditions of soil and air, and by injurious mechanical influences.

3.4 General symptoms of pant diseases

Sign or evidence of disease or disorder as shown by plant or any objective evidence or bodily is called symptoms of the disease. Symptoms are seen on the plant either due to character and appearance of the visible pathogen or its structure or organs, or due to some effect upon or change in the host due to interaction between the host and the pathogen.

a) Symptoms due to character and appearance of the visible pathogen:

A parasite is present in all parasitic host tissues, but in most cases the growing vegetative portion of the parasite is within the host tissues and invisible. However, they usually form reproductive or resting structures either outside the plant organs or partly emerging from the host tissues. In either case they become visible provided they are of sufficient size or in sufficient mass. In some diseases, almost the entire body of the parasite including both vegetative and reproductive portions is external to the host and is, then readily seen, partly on account of its mass.

In some diseases, large structures of the pathogen constitute the most prominent symptom. Several of these symptoms are described below:

i) Mildew: Mildews are plant diseases in which the pathogen is seen as a growth (mildew) on green surfaces of the most. These growths appear as white, gray, brownish or purplish patches of varying size. In down mildew the superficial growth is a tangled, cottony or downy layer. In powdery mildews enormous numbers of spores are formed on the superficial growth of the fungus giving a dusty or powdery appearance. Black minute fruiting bodies of the fungus may also develop in the powdered mass.

ii) Rust: the rust disease appear as relatively small pustules of spores, usually breaking through the host epidermis. The pustules may be either dusty or compact and red. Brown, yellow, orange, or black in colour.

iii) Smut: The word “smut” means a sooty or charcoal – like powder. In plant diseases known as smut the affected part of the plant shows a black dusty mass composed of the fungus spores. These symptoms appear in floral organs, particularly the ovary part (ovariculous smuts). The pustules are usually considerably larger than those of the rust. Smut symptoms may also be found on leaves stems and even roots (culmiculous smuts).

iv) White blisters: On leaves of crucifers and many other plants there may be found numerous white, blisters – like pustules which break open and expose white powdery mass of spores. These pustules resemble rust pustules in texture but are white. Such diseases have, therefore, been often called white rust.

v) Scab: the term scabs refer to a roughened or crust – like lesion or to a freckled appearance of the diseased organ. In some diseases of this type the parasite appears at a certain stage, in others it is never seen. Thus, this term may be listed in both major groups of symptoms.

vi) Sclerotia: a sclerotium is a compact, often hard, mass of dormal fungus myceluium. In some cases, as in ergot of masses, the sclerotium assumes a characteristic shape; in others the shape may be variable. Sclerotia are most often black, or they may be buff or dark brown of purplish in colour.

vii) Blotch: This symptom consists of a superficial growth giving the fruit a blotched appearance as in sooty blotch and fly – speck disease of apple fruits.

viii)Fruitring bodies: the wood rotting fungi develop relatively large spore bearing structures (sporophores) which are either fleshy or woody. The parasite can be identified by means of the characteristics of these sporophores.

ix) Erudations: In bacterial, such as in bacterial blight of rice and fibre blight of pomes fruits, mass of bacterial cells oozes out to the surface of the affected organ where it may be seen as drops of various size or as a thin smear over the surface.

x) Tar spots: There are somewhat raised, black coated fungus bodies with the appearance of a flattened out drop of tar on leaves.

b) Symptoms due to some effect on, or change in the host plant:

As a result of disease, there may be a marked change in the form, size, colour, texture, attitude or habit of the plant of some of its organs. Such changes are usually readily observed and often constitute the most prominent symptom of the disease. Two or more of these changes may occur in the same host organ as effects of the same disease. In most diseases, these changes are brought about by the presence and activity or life processes of the pathogen and reaction of the host tissue to such activity. The pathogen may be found within the affected tissue or upon the surface or in some cases it may develop certain structures internally and other structures externally. Fruiting bodies or other structures of the pathogen may thus accompany the more striking changes in the host organs.

i) Colour changes: change of colour from normal, mostly green, is one of the most common symptoms due to the effect of a disease in plant. Thje green pigment may disappear entirely and its place may be taken by a yellow pigment. When the loss of green colour is due to prolonged exposure to darkness the condition is called etilation. A similar condition may be brought about by virus disease or from disturbances caused by fungal or bacterial pathogens. In these cases the yellowing is known as chlorosis when the green pigment is replaced by red, purple or orange pigment the condition is known as chromosis. In some diseases, the leaves are devoid of any pigment. This condition is known as albinism.

ii) Overgrowth or hypertrophy: The most apparent effect in some diseases is the abnormally increase in size of one or more organs of the plant or of the plant or of certain portions of them. This is usually the result of stimulation of the host tissues to excessive growth. It may be brought about by either or both of two processes, hyperplasia and hypertrophy. Hyperplasia is the abnormal increase in symptoms. Spots, streaks, strips, canker, blight, damping – off, burns, scald or scorch and rot are as a result of necrosis of tissues size of a plant organs due to an increase in number of cells of the organ. In hypertrophy the increase in size of the organ is due to increase in size of the cells. Both these conditions may be simultaneously present. In some disease the increase in size s of the plant organ is due to increase in size of the cells and also due to presence of fungus structures. Galls, knots, leaf curl, pockets and bladders, witches' broom, and hairy root are all the result of some form of overgrowth.

iii) Atrophy, hyperplasia or dwarfing: in many diseases one of the results is inhibition of growth in stunting or dwarfing. The whole plant may be dwarfed or only certain organs may be so affected. Sometimes hypertrophy and atrophy both are present in the same organ.

iv) Water – soaking is water – soaked, translucent condition of tissues caused by water moving from host cells into intercellular spaces due to damage to cell walls by enzymes and toxins of the pathogen.

v) Necrosis: This term is used to indicate the condition in which the death of cells, tissues, or organs has occurred as a result of the parasitic activity. The characteristic appearance of the dead area differs with different hosts and host organs and with different parasites so that there are different types of necrotic symptoms, spots, streaks, stripes, canker blight, damping – off, burns, scald or scorch and rot are result of necrosis of tissues.

vi) Anthracnose: This term is derived from Greek word meaning ulcer. Ulcer – like lesions, on twigs, stems, pods, and fruits constitute anthracnose disease caused by a specific group of fungi. Anthracnose is also a type of necrosis.

vii) Die – back: Die – back is also result of necrosis of terminal tissues of twigs in which the twigs and branches start dying from the tip backwards.

viii) Wilt: In many diseases the most striking effect of the disease is drying or wilting of the entire plant. The leaves and other green or succulent parts lose turgidity, become flaccid, and droop. This effect is usually seen first in some leaves. Later, the young growing tip or the whole plant suddenly or gradually dries. Wilting may be the result of injury to the root system, to partial plugging of water conducting vessels or to toxic substances secreted by the pathogen and carried with water to delicate tissues.

ix) Humidification: stage in certain fruit rots in which the dried, shriveled and wrinkled fruit is called a "mummy". The stage is brought about by loss of moisture due to permeation of the flesh by fungus hyphae.

x) Miscellaneous symptoms:

    (i) Alteration in habitat and symmetry can occur under the influence of some pathogens. Plants which, under normal conditions, are prostrate or creeping become ascending or even erect. Leaves become lobed from being simple. Inflorescence is changed from a head to a spike

(ii) Premature dropping of leaves, blossoms, fruits twigs occurs in many parasites. In smut the entire inflorescence or individuals flowers are completely destroyed.

(iii) Organs are transformed or replaced by new structures. The floral organs can be transformed into a mass of leafy structures. Ovaries may be transformed into sclerotia.

3.5 Diagnosis of plant disease

Rapid and accurate diagnosis of diseases is necessary before proper control measures can be suggested. It is the first step in the study of any disease. Diagnosis of plant disease is a field science and practice is the soundest method of identifying a disease in the field. Many illustrated guides and charts are available which can help in tentative identification. It is easy to identify such disease as ruts, smuts, downy mildews and powdery mildews because the structures of the pathogen are prominently visible to the naked eye. However, in many diseases for example, chlorosis or yellowing of leaves is a symptom which can be caused by a virus, fungus or a bacterium or even nutritional deficiency without association of a parasite. Similarly, plants may wilt due to fungal infection or bacterial infection. For effective and economic management of any disease, accuracy in diagnosis is important because some diseases such as damping off may be caused by many fungi and same treatment may not work against all the fungi. Accurate diagnosis requires systematic field observations (symptoms, structures of the pathogen if any pattern of occurrence) and some laboratory studies.

In those cases where symptoms are such that may be caused by a variety of living or non – living disease incidents, the first step is to determine whether the incitant is infectious or non – infectious. This can be done by observing the pattern of development of the disease in the plant population and the possible spread of symptoms on other plants. If the disease is spreading in the plant population it is infectious. An infectious disease may be caused by fungi, bacteria, viruses, or nematodes. These can be determined by visual observation of the affected parts for presence of fungal structures, bacterial exudates, or nematodes cysts or females and then by laboratory studies. If present on the host and examined under the microscope, the fungal structure may reveal presence of a particular fungus. If the fungus is not a biotroph and can be cultured, isolation on an artificial medium and tests for Koch's postulates can pinpoint the actual cause of the disease. Bacteria can also be detected in similar manner. Examination of cut pieces of the affected part in water under microscope reveals streaming of bacterial cell masses in water. The bacteria can be isolated on suitable media and Koch's postulates proved. Nematodes, if present can be seen on the host or in the tissues examined under the microscope. By separating them from the host and multiplying them, under aseptic conditions, such as chlorosis. However, nutritional deficiency is non – infectious, while virus disease symptoms spread in the plant population. If in artificial cultures no pathogen is obtained and in tissues examination, no fungal structure of a biotroph or structures of nematodes are seen but the disease is infectious, it can be expected that the disease is caused by a virus or mycoplasma – like organism (phytoplsma). Transmission tests by grafting sap inoculation or use of insect vectors can help in final diagnosis. The differentiation between virus and MLO can be made by electron microscopy and by spraying tetracycline antibiotics which mask symptoms of MLO disease but not of virus disease.

Developments in microscopy, serology and immunology, molecular biology, and laboratory instrumentation have resulted in many new and sophistication laboratory procedures for the identification of plant pathogen, particularly bacteria, viruses and vitroids

3.6 General control methods of plant diseases:

Crop diseases can be controlled using the cultural, biological and chemical methods.

a) Cultural method. The agronomic measures a farmer may adopt include the adoption of crop rotation, proper and timely land tillage, changes in the time of planting, destruction and burning of crops residues, regular and timely weeding, seed dressing before planting, use of diseases free seeds for planting, ;planting of resistant crop varieties and harvesting at the right time.

b) Biological control. This involves the use of natural enemies to control the diseases.

c) Chemical control. This is the most effective method of crop diseases control. Although certain side effects are associated with this method, it remains the most effective means of reducing plant pathogens. The type of chemicals used depend on the pathogens responsible for the disease. As a result, the following are used to control plant diseases:

i) Fungicides are used for the control of fungal diseases e.g copper, Bordeaux mixture, lime, captan etc.
ii) Viral diseases are controlled with viricides. It should be noted that viral diseases are difficult to eradicate, but the vectors transmitting the diseases can be controlled using insecticides.
iii) Bacterial diseases are controlled with antibiotics like cuprous oxide, Agrosan etc
iv) Nematicides are used to control nematodes. Examples include Nemagon, Vapan D.D and Methyl bromide.

4.0 Conclusions

Crop losses due to diseases cannot be overlooked, hence the need for a detailed study of the nature of plant diseases and their causative agents. This will help prevent any form of outbreak that will result in economic loss to the farmer.

5.0 Summary

A disease is a departure from normal state of health presenting marked symptoms or outward visible signs. Some effects of plant diseases include malformation of plants and sometimes death of the plant, low yield and reduction in crop quality. Diseases symptoms include mildew, rust, smut, white blisters, exudation, scab, sclerotia, blotch, overgrowth or hypertrophy, atrophy, chlorosis (colour change), necrosis etc. crop diseases are caused by abiotic (nutrient deficiencies, insufficient light, too high temperature, low soil moisture, air pollution, high soil moisture and chemical toxicity), mesobiotic (viroids) and biotic factors (bacteria, fungai, virus and nematodes). Rapid and accurate diagnosis off diseases is necessary before proper control measures can be suggested. Diseases of crops are controlled through cultural, biological and chemical methods.

6.0 Tutor marked assignments

a) What is a disease?

b) List the casual organisms of plant diseases

c) State the damages caused by diseases

d)List the categories of plant diseases

e) Describe the symptoms of major plant diseases

f) Discuss the general control measures of plant diseases.

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UNIT 2: IMPORTANT DISEASES OF CROP PLANTS

Table of contents Pages

1.0 Introduction

Micro- organisms often cause diseases on plant products in the field and during storage. The most important of these are bacteria, fungi, viruses and nematodes. Although their effects may not cause total destruction of produce, the loss in quality due to spoilage and contamination are often significant. In this unit, diseases of economic importance which affect arable and permanent crops and methods of their management are discussed.

2.0 Objectives

At the end of this unit, you should be able to:

2.1 List and describe the organisms that cause plant diseases.

2.2 Describe the symptoms of diseases caused by bacteria, virus, fungal and nematode

2.3 Name and describe diseases of important field, vegetables and permanent crops

2.4 Discuss the control methods of crop diseases.

3.0 Important diseases of crop plants

3.1 Bacterial diseases:

Bacteria seem to be the most primitive living organisms. The bacterial cells are very small, infact so small that in some, such as in mycoplasma, the individual cells are not seen in the light of optical microscope which can magnify an object up to 200 to 300 times. Cellular size of bacteria (including mycoplasmas) varies with the stage of life cycle, nutritional status, mode of cell division, and many other factors. The size is variable more in length than in width. The ordinary bacterial cell is about 1 to 5 microns long and 0.5 pm wide (1 micron = 1/1000mm). The known range of size extends from 0.1 to 0.4 microns (nm = 1/11000 microns).

The association of bacteria with animal disease anthrax had been known since 1850. The first evidence of bacteria being responsible for plant diseases was reported in 1882 when association of bacterium (now known as Erwinia amylovora) was established with the fire blight diseases of pear. Since then the number of plant diseases identified as caused by bacteria has risen rapidly. Examples of bacteria diseases include the following.

1) Blights

a) Cassava bacterial blight (CBB)

It is the most wide spread bacteria disease of cassava in Africa and ccurs in all cassava growing areas of the world. The pathogen is *Xanthomona campestris pv. Manihoti.* Symptoms are angular water – soaked leaf spots. Spots enlarge and coalesce with time resulting in leaf blighting, wilting, defoliation, and die back. Severe defoliation leads to bare stem referred to as 'candlesticks'. Bacteria exudates on lower leaf surface, petioles and stems occur in highly susceptible varieties in periods of high humidity e.g early morning hours. It is a systemic disease characterized by vascular necrosis (usually brown in colour) of stem and roots. CBB symptoms appear in the rainy season. It survives in the cassava canopy, vascular tissues of stems seeds and dry crop debris.

Use of sanitation measures such as destroying plant debris to ashes with fire is effective in the control of CBB. Also effective are ploughing and ridging of the plot before the next crop, avoiding unclean cutting, insect – infested cutting or mechanically damaged cutting and the use of improved resistant varieties such as those mentioned under ACMV.

b) *Xanthomonas campestris* (a bacterium) also caused leaf blight in rice especially in Asia, but was found recently in West Africa. Symptoms are chlorotic water – soaked lesions along the leaf margin. Young lesions may have bacterial exudates.

c) Halo blight is caused by *Pseudomonas phaseolicola* (a bacterium) on *Phaseolus vulgaris.* Symptom is small necrotic flecks surrounded by chlorotic areas on the leaf. It survives in soil, seed and diseases vines. Control is by use of resistant varieties; so also is the use of disease – free seeds. Control can also be by applying seed – dressing with bactericides or fungicides which have bactericidal properties at 2 – 3g/kg of seed.

3.2 Fungi diseases

The fungi are plants without green pigments necessary for photosynthesis. Many of them can be seen with the naked eyes. They are either saprophytic – feeding on dead decaying organic matter (facultative parasites) or parasitic, attacking and feeding at the expense of a living host (obligate parasite).

Most plant diseases are caused by fungi. Out of 10,000 described species, more than 8000 species are of plant pathogens. Fungal diseases such as the mildew, heat rust in cereals have been known from the Roman times. Today, fungi diseases have risen to greater economic and scientific prominence. Examples of fungi diseases include the following:

1) Downy Mildew.

This is an important fungi diseases characterized by pale chlorite patilies or streaks on leaves, and a downy white sporulation (of conidial state of the fungus) on leaf underside especially on mornings, when there is a lot of dew. There is also necrosis, retarded development and sometimes sterility.

Downy Mildew is caused by *Peronosclerospora sorghi* on maize and sorghum and by *Sclerospora gramunicola* on millet. On wheat, it is caused by *Erysiphe gramunis* in temperate countries. On peas, Downy mildew is caused by *Personosphore viciae,* while mycelium of the fungus appears on lower leaf as in cereals. Upper leaf surface becomes yellowish, then darkens and dries up.

Control is by the use of resistant varieties and crop rotation. Infected plants should be destroyed immediately as the symptoms appear, to avoid spread. Early planting with the first rains is recommended in maize (susceptible in the first 4 weeks). When the rains increase and humidity increases, the fungal spores multiply and spread fast. The chemical “Apron – plus” may be used as seed treatment. Resistant maize seeds such as DMR and DMR – ESR (W&Y) may be obtained from

NSS. Commercial seed companies and state ADP's in Nigeria. Crop sanitation and rotation is recommended in sorghum.

2) Rusts

Rusts are caused by the basidiomyceters of the fungal order *Uredinales. Puccinia sacchari* and P. kuehnii on sugar cane, *Puccinia polysora* on maize, *Puccinia graminis* on wheat (very destructive) and *Puccinia* on millet.

Rusts are characterized by small rusty brown pustules on leaf surface with yellow uredospores within. Leaves become chlorotic and dry up when severe. On millet, the pustules are elongated and orange in colour. Spread of rusts is mainly by wind – borne spores. They are also spread by rain and animals. In the infected plant, they reduce the rate of photosynthesis and increase respiration. Photosynthates produced are diverted to infected tissue, thus yield and quality of grain produced are reduced. Losses caused by rust may amount to 10% of world grain crops. It is one of the most destructive plant diseases affecting mostly leaves and stems, sometimes flowers and fruits. They occur mostly on cereal crops but also affect tree crops and ornamentals.

The method of control is by the use of resistant varieties.

3) Smuts

Smuts like rusts are caused by *bacidiomycetes* of the fungal order *Utillaginales.* They are characterized by dark powdery masses of spores which look like soot/smut. They are as economically important as rusts and also attack mainly cereals, but also infect onions and ornamentals, causing significant reduction in yield of kernels. As they develop, the plant tissue is destroyed and replaced by a mass of block spores covered by thin membranes referred to as sori (singulars; sorus). Example – In head smut caused by *Spaceiotheca reliana* in maize, sori take over the inflorescence. Also, in the covered kernel smut of sorghum caused by *Spacelotheca sorgi,* grains are replaced by sori. Seeds should be treated with fungicides such as thiram and carboxin to prevent seedling infection. In the latter, the seed – borne fungus develops in the growing seedling, infecting the inflorescence as it is formed. Sometimes, infected tissues are stimulated to divide and enlarge into galls (hyperplasis), and then they are destroyed and replaced by a mass of black spores. Examples: common smut in maize caused by *utilago maydis,* where gall – like growths occur in the aerial part of the plant. Galls are more commonly formed in the cobs. In some cases, smuts may cause local infection only on leaves and stem. Spores of smuts are usually spread by the wind when the covering enclosing them is broken during harvest or threshing. Survival is usually by spore known as telisporea in solid plant debris or on contaminated seed. Some may survive as mycelium in infected kernels or infected plant.

Control is achieved by planting of resistant varieties. However, as meiosis (genetic recombination) takes place in every generation of smut fungi, new races of the pathogen are constantly being produced, therefore breeding for resistant varieties to keep pace with this must be continuous. The latter is not very easy.

4) Blast disease of rice.

It is caused by a fungus called *pyricularia oryza.* Dryness predisposes plants to infection. Thus it is the most serious disease of upland rice. At the early storage of the crop, it causes seedling blight, later in the development of the crop, it causes leaf blight. At the reproductive stage (formation of heads) it causes neck rot, thus yield is lost. Symptoms are necrotic spots on leaves which develop brown margins with grey centres. Spots latter merge and leaves becomes brown and shriveled. Humidity of over 90%, temperature of 24 – 27^{0}C and excessive nitrogenous fertilizer favours the disease. It is seed and airborne. Best control is by the use of resistant varieties. Fungicides such as isopothiolane and antibiotics such as blasticin are economical only on seeds.

5) Stalk and ear rot

It is caused by *Diplodia maydis* (fungus) which also causes seedling blight in maize. Symptoms of stalk rot are yellowish brown on lower nodes. The stalks become brittle and break. Dark conidia are usually present under the epidermis. Other fungi causing stalk and ear rots include the following: *Fusarium graminearum (*Gibberrella zea – Ascomycete) and *Fusarium moniliforme (G. fujikuroi –* ascomycete) in sorghum. Infected tissue is reddish or brown coloured in sorghum. A characteristic pin mould is formed on infected maize grains especially in wet weather.

Seed – borne infection can be controlled with seed dressing fungicides. Use of resistant varieties (e.g flint) rather than dent varieties are ideal; so also crop rotation.

6) Ergot (Sugary or honeydew disease)

Caused by Clavicepts *fusiformis* – Ascomycete (Spacelia sorgi = imperfect state) in millet and sorghum. Young flowers infected with the conidia of the fungus usually produce a creamy sweet tasting liquid in the ovary. The liquid attracts sooty mould and darkens up. The disease derives its name from the sclerotia or ergot (about 5mm long) produced when the flowers mature. The ergots stick out among the grains and are normally harvested along with the grain. They are known to be poisonous when eaten (along with the grains) by man or livestock.

Control is by early planting (in late planted crop, stress sets in and plant flowers early in order to complete life cycle) and ploughing to bury sclerotia/ergots and reduce incidence. Research on use of resistant varieties is still at the development stage.

7) Leaf Spots

Brown spot of rice is caused by *Cochliobolus miyabeanus* (*syn. Helminthosprium orzea.* Leaf spots are also caused by *Cercospora orryzae* on rice (narrow leaf spot), *Cercospora sorghi* on sorghum (grey leaf spot) and *Curvularia penniseti* on millet. Disease is seed – borne and control is by burning infected crop residue; Also seed – dress with fungicides.

8) Anthracnose.

It is caused by *Celletotrichus spp.* in different crops. For example, the disease is caused by *celletotrichum gramminicolum* on sorghum. Symptoms are red/purple spots on leaves, and also red rot on stem leading to stem lodging. Leaves dry up and grains are not well developed. It also causes leaf spots on maize, as well as reddish brown sunken spots on leaves and stem of sorghum. Control is by the use of resistant varieties.

In *Vigna spp.,* it is caused by the fungus *collectrichum hindermuthianum* where the symptoms are lesions red in the centre, with acervali and brown to purple margin. It usually infects the aerial parts of the plant. It is responsible for the well – known blotch disease of cowpea which causes the purplish brown discoloration of petioles, leaf veins, stems, peduncles and especially pods. Infected pods become distorted. Pod loss makes it an important disease of cowpea. *C. capsici and C. truncatum* also affect cowpea. On seeds, the lesions are brown in colour.

Control is by the use of crop rotation and resistant variety as well as clean certified seeds. Seed dress with fungicides like benomyl, captan or agrosan. Also 2 or 3 applications of benomyl at 15g/10 litres of water are recommended from flowering. Alternatively, dithiocarbarmae at 1kg/ha in 500 to 1000 litres of water can be used.

The disease is also caused by the fungus *Collectotrichum gloeosporiodes(Glomerella cingulata)* on yam and *G. manitholits* on cassava. In this case, dark brown to black lesions appear on leaves, petioles and stems of yam. If humidity is high and temperature is between 28 and 30^0C, the lesions enlarge and coalesce, giving rise to extension necrosis of stem leaves and stem die – black. Symptom is depressed brown oval lesions especially on cassava stem. Later lesions become raised, fibrous and deep cankers. It survives on crop debris, soil and tubers.

Use of resistant varieties is best control. Mixed cropping and staking reduces disease incidence. The uses of crop rotation disease – free cuttings are also effective in control.

9) Fusarium wilt

It is caused by a special form of *Fusarium omysporum* on cowpea and pigeon pea. It is reported on cowpea in Asia, Australia, North and South America but in Africa, it has been reported only in Nigeria and Uganda. It is soil and seed – borne. It is characterized by gradual or sudden wilt, yellowing and drying of foliage, then plant collapse and die. In young plant, the wilt is rapid, leading to death. Older plants are stunted with symptoms mentioned above. The disease is systemic, evidenced by necrosis of the vascular tissue in cowpea or blacking of stem base and internal root rot in pigeon pear. Control by using clean seeds, resistant varieties and crop rotation are effective against the disease.

10) Blight

Helminuthosporium turcicum (a fungus) causes leaf blight in maize and sorghum. It is widespread and destructive. Symptoms include linear elliptic brown water – soaked lesions on leaves and leaf shealthies. Leaves are destroyed when severe. Main source of innoculum is crop residue. Control is by the use of resistant varieties.

Leaf blight caused by *Helminthosphorium maydis* also occurs in maize. Symptoms are reddish brown lesions, smaller than those of H*. turcicum* between the veins. Control is by seed dressing with fungicide.

Rhizoctonia solani causes leaf blight in millet and sorghum and sheath in rice. Sheath blight which is important in paddy rice is characterized by grey elliptic lesions on the sheaths at water level. Lesions develop into irregular elongated botches with pale centre. Schlerotia are formed under the sheaths. Infection may extend to leaves or stem. Survival of the pathogens is as dormant mycelium on the water. Best form of control is host plant resistance. Cultural control method includes adequate spacing, destruction of innoculum sources and avoidance of excessive nitrogenous fertilizer.

Blight is caused by *Coricium solani (Rhizoctonia solani, Thanatephorus cucumeris)* on cowpea and referred to as web blight. It is characterized by small red – brown spots on leaves which become surrounded by irregular water – soaked areas. Lesions coalesce rapidly in humid weather and mycelium is present on the undersurface of leaves and young stems. It is an economically important disease in West Africa where crop loss may be total in periods of heavy rains. This pathogen survives in soil and crop debris.

Control is by use of clean seed. Also avoid dense sowing in periods of high rainfall.

Blight caused by *Sclerotium rolfii* is characterized by brown sunken lesion on leaves and stems and white mycelium near the roots; Sclentia varieties are also present in infected areas. Infected plants wilt and die. Control by use of resistant varieties and crop rotation with cereals are affective.

Taro leaf blight on cocoyam is caused by *Photophthora colocasiae.* Symptoms are circular purple – brown lesions with yellow halos/surroundings on leaves. Later, lesions coalesce to give extended leaf blights leading to leaf death and poor corn development. Sometimes there is plant collapse. The fungus survives in infected materials.

Phytophthora infestans causes late blight of potato. The water – soaked spots on the leaves coalesce resulting in large blighted areas. Stems and tubers also become infected. In favourable (cool) weather, infected caves shrivel and die, while tuber infection advances in storage. *Phytophoria infestans* also cause leaf blight, stem blight and die back in tomato and Amaranthus.

Control is by gathering and burning crop refuse and alternate hosts. Well – timed fungicidal spray of Dithane M45 at 20g/10 litres of water weekly, or Difolatan at 18ml/10 litres is also effective. Also use resistant varieties and rogue blighted plants.

11) Rusts

Rust disease is caused by *Uromyces spp., U. appendiculatus* on phaseolus spp. and Vigna spp., and U. cajani on cajanus cajan. Symptoms are red – brown pustules with yellow chlorotic surrounding halo on leaves which later become dark brown or black. When severe, there is defoliation. Spores are wind – borne and survive as teliospores on volunteer/alternative legume crops and crops debris. Control is by the use of resistant varieties.

12) Coffee rust disease

This is caused by the fungus *hemilieiu vaststrix* and it an important disease the world over. It is characterized by orange – yellow powdery spots on the leaves. Spots enlarge, coalesce and turn brown, then dry and fall prematurely. Yield is reduced. Infected trees may die later.

Bordeaux mixture at 2 to 3 week interval should be applied during the rainy season as control measure.

13) Leaf and Pod Spot

It is caused by *Ascochyta pisi* on peas. Small purple spot appear which enlarge and turn brown or black. Leaves shrivel and dry. The disease is both soil and seed - borne. Control is by seed dressing with argrosan at 2 – 3g/kg of seed, use crop rotation.

a) Angular leaf spot is caused by *Phaeisariosis griseola on Phaseolus spp and Vinra spp.* Small grey angular spots limited by vein on leaves are formed, which later become dark – ash colour. Lesions appear on stems and pods. The fungus survives in seed and crop debris. Control is by seed dressing with argosan at 2 – 3 g/kg of seed and use of crop rotation.

b) Brown leaf spot of cassava is caused by *Cercosphora henningsii.* Spots are round and brown on leaves. They then expand, coalesce and become angular due to delimitation by small veins. Infected leaves become chlorotic/turn yellow, dry and drop. Survival is in seeds or as black stomata (compact mycelial structure) in infected leaves. Leaf spots may lead to about 20% yield loss in areas where rainfall exceeds 120mm.

c) Leaf spot of groundnut. It is caused by Cercospora personatum and C. aracnidicola.

Losses caused by these fungi are equal to half of that caused by other diseases on groundnut. Symptoms are circular spots with yellow hale, later changing to reddish brown or black. Symptoms usually appear when crop is 4 – 8 weeks old and persist till harvest time. There could be complete defoliation with heavy spotting. Conidia are wind – blown and survive in crop debris. Use of resistant varieties is the best control. Crop rotation and seed dressing with fungicides are also effective.

d) Plantain and Banana (*Musa paradisiacal and M. sapientium)* Sigatoka or Banana leaf spot disease. This is caused by the fungus *Mycosphaerella musicola* (an ascomycere). It is one of the most destructive diseases of Banana and plantain and sistribution is worldwide. Symptoms are light yellow spots parallel to the side viens ofn the leaf. The spots enlarge and become dark brown. The centres of the spot die becoming grey in colour. A yellow chlorotic area surrounds each spot and this is in turn surrounded by a brown ring. Steaks occur on the petioles also. When severe, the spots coalesce and large areas of leaf die. Number, size and quality of fruit in terms of taste are reduced. Also, there is premature ripening. Where diseases reduces the number of leaves on plant to less than 12, fruits may not fill out, are undersize or may drop.

The best control is with application of fungicides such as benormyl and manczed, suspended in an oil – water emulsion, applied as frequently as forthigntly or monthly. Plant spacing to reduce disease incidence is also effective. A cercespora state of the fungus exists, which produced spores at the brown spot stage. These are dispersed by water splash. Perithecia containing asci are produced in the grey centres of the lesions. From these ascospores are forcibly released in wet weather and carried in then air to long distances.

e) Tobacco (*Nicotiana tabacum)* Cercospora leaf spot disease

spots are small, brown and roughly circular with reddish purple borders. Centre of spots later become grayish, thin and brittle often, falling out. Causal fungus is *Cercospora nicotianae.*

As a control measure, apply thiabendazole fungicide as a spray at 30 to 120g. a.i. per 100 litres of water weekly or biweekly at first sign of disease.

14) Rots. Examples include the following:

i) Black rot of potato is caused by *ceratocystis fimbriata (*Ascomycte). Undwerground plant tissues such as rootss and tubers usally affected. Symptoms are sunken black leions. The spread of infection to the stem results in the characteristics “blank shrank” or a black necrosis of the stem. The fungus survives in the soil and infected tubers. Control is by the use of crop rotation and use of disease – free material. Corm rot in cocoyam is caused by *Phythium spp and Phythophora spp.*

ii) Cassava soft root rot is caused by*Phytophora spp; Phytium spp and Fusarium spp.*

Symptoms are brown necrotic lesions on roots tube. As the latter decays, plant wilts and dies. A characteristic foul odour is emitted from infected roots. Survival is in infected roots and soil. Yield loss may be up to 80% in high rainfall areas. Mature tubers are predisposed to infection when harbvest is delayed. Control is effective by crop rottationm with non – host crops. Also, avoid continous monocropping of cassava in high rainfall areas.

iii) Sclerotum rot is the most common cassava tuber rot disease but yield loss has not been quantified.

a) Citrus foot rot (gummosis) is caused by *Phylophtora spp.* The tree trunk is infected at or below ground level resulting in death of the cortex. Infection is accompanied by gum exudation. Control is by planting of resistant varieties.

ii) Stem rot of tobacco caused by *Scolerotinia sclerotiorum.* Fungus is soil borne and may affect any part of the plant at seedling stage. In the field, fungus causes stem rot resulting in the stem tilting to the ground and thus infection of the leaves touching the soil.

Control is by applying thiabendazole 60 WP, at 400 – 900 a.i per hectare, 30 - 50 days after transplanting, then weekly according to disease severity. The thiabendazole may also be used at 60g i.a dry or as a water suspension per 100kg completely dry tobacco to control mould by Aspergillus and pennicilium in storage. For young plants, (3 to 4 leaves) in seed beds, thiabendazole 60 WP may be applied 10g per $50m^2$ at 7 – 10 day intervals for about 30 applications. The leaf spots and field spot and disease of tobacco are world – wide.

a) Cocoa (*Theobromae cacao)* black pod diseases. Black pod disease is caused by *Phytophthora palmivora* and is the most widely distributed disease of cocoa. It is characterized by a dark brown or black rot of the pod. Internally, the beans are partially or wholly destroyed. The fungus also attacks seedling, flowers, cushions and the stem cankers. It is spread by wind, insects and splashes of rain from diseased to healthy pods.

It survives in the soil and diseased tissues.

Control is by spraying Bordeaux mixture at monthly intervals before pods reach maturity. Perenox (Cuprous oxide) may also be used. Infected pods should be removed as soon as they are noticed in the field.

15) Damping – off

Damping – off of seedlings may be caused by fungal genera such as *Pythium, Rhizoctonia, Sclerotium, Phytophthora and Fusarium.*

Control: destroy crop debris and alternative hosts. Use Dithane M45 or use Difolatan as seed – dress or Benormyl at 4.5gm/11 of water.

3.3 Viral diseases

The word "virus" comes from the Latin and means a poison. More than 300 plant viruses are known. Viruses are microscopic and visible only with an electron microscope. They are infectious, obligate parasites that need living cells in which to replicate.

Viruses are transmitted from diseased to healthy plants through wounds caused or animals, including insects, other arthropods, and nematodes. Viruses can also be transmitted by fungi, parasitic seed plants, contaminated seeds and pollen contact or friction between plants and through in juries caused by people and machine. The morphology of the virus particles is varied. They may be polyhedral, bullet rod – shaped. Rod – shaped various vary in length fro 100 – 1200nm, and polyhedral vary in diameter from 18 to 70 nm.

Plant viruses are identified by their host range, mode of transmission, and physical and chemical properties. They are named in the vernacular, usually with a compound of the names of the first host on which the virus was observed and the type of symptom noted e.g maize dwarf mosaic virus. Not all viral names however are associated with the name of the causal virus.

The effect of viruses is systemic and leads to the occurrence of such symptoms as yellowing, mottling, leaf curl, excessive branching gall formation or stunting in infected crops. Severe infection leads to death or reduction in yield. Examples of viral diseases include the following:

1) Cassava mosaic disease.

Cassava mosaic disease is caused by African cassava mosaic virus (ACMV). It is the most wide spread disease of cassava in tropical Africa and India. Vector is the *Bemisia tabasi (*white fly). Symptoms are mosaic pattern on leaves. Also there is pucketing, distortion and reduction on leaves. When severe, the plant is stunted and leaves reduced to veins. ACMV may move down to the shoot but is not always fully systemic. Yield loss of between 20 to 60% is usual on crops. Use of resistant varieties is the best. Examples are TMS 3057, 30555 and 30573, Anti – ota. Ofege (MS – 6), Idiogbayepe (MS –

20). Quarantine, sanitation and manipulation of planting date to avoid period of high spread are also recommended.

2) Streak disease of maize

It is caused by maize streak virus and characterized by narrow chlorotic streaks along the leaf veins. Usually the schlorotic streaks are distributed over all the leaves and this makes it distinguishable. Transmission is by leafhoppers of the *cicadulina sp.*

Control is by the use of resistant varieties such as TZSR, TZERS, and DMR – ESR.

Sugarcane mosaic virus disease also affects maize.

3) Tristeza disease

Tristeza virus disease (or quick decline disease) cause stunting, stem pitting and death of the tree. Control by using resistant or tolerant nursery stocks, or tolerant scion – stock combination. It is recommended for economic reasons that susceptible trees be removed when infected and replaced by resistant combinations.

4) Swollen shoot disease of cocoa – caused by cocoa swollen shoot virus. It has produced great losses in West Africa. There is abnormal growth of the vascular tissues so the shoot becomes swollen. In addition, there is mottling, vein flecking and leaf mosaic. Also, there is leaf fall, die – black and subsequent death of the tree. Infected trees lose vigour and there is loss in yield.

Removal and burning of infected trees has been the means of control so far, but it is expensive as it represents depletion of resources. Chemical control of vectors give only partial control. The mealy bugs *Pseudococcus njalensis* and *Planococcus citri* transmit the virus.

3.3.1 Control of plant viral diseases:

There are various methods of approaching the control of the spread of plant viruses; they are not applicable in the same way to the various diseases. These methods can be classified under the following six headings:

1). Elimination of the sources of virus infection. The following are important for note:

a) Weeds, woody shrubs and trees are frequently host to viruses, many of which are transmitted through the seeds of such plants.

b) Viruses which have a fairly wide host range can be brought to one crop from another cultivated crop. For example, clover is the host of several viruses which affects peas and beans; moreover, the chief aphid vector over – winters on clover. It is therefore advised to grow perennial leguminous crop in close proximity to susceptible annual crops.

c) Remnants of the previous year's crop are frequently important sources of virus.

d) with vegetative propagated crops, such as cassava, it is extremely important to start with a virus free crop.

e) Any obviously virus – diseased plants should be rogued out as early as possible while the plants are still small.

2) Avoiding the vectors.

This can be achieved in various ways, by isolation, by breaking the cycle of the vector, virus and host plant, and by artificial barriers to exclude the vector. For example, it is possible to raise virus – free seed potatoes in areas where the temperature is too high for the aphid vector by early sowing e.g. early sowing of maize avoids high infestation of *Cicadulina*, the vector of the maize streak virus. Barriers can be insect – proof cages or barrier crop like maize or sun flower.

3) Direct attack on the vector

Virus diseases transmitted by aphids and leafhoppers can be controlled by applying insecticides, especially persistent and systemic insecticides. It is not sufficient to kill the insects which have been bred in a crop; they must be killed as they enter a crop. However, insecticides can neither present the introduction of a virus nor its spread within the crop. This is because when an infective insect lands on a sprayed, it can infect plants before it dies. Also, non – infective insects arriving upon a sprayed crop could acquire and transmit certain viruses before dying.

4) Breeding resistant varieties of crop

This is one of the most promising methods of control. Some varieties of cassava are resistant to the cassava mosaic virus while several varieties of maize are resistant to the maize streak virus. These varieties have reduced the importance of the two diseases in Nigeria.

5) Cure of virus – infected plants

Viruses can be eliminated from infected plants by inactivating the viruses by heat or with chemicals. For example, Ratoon stunt, a serious virus diseases or sugarcane, is controlled by exposing the sets for 2 hours in hot water at 50^0C.

6) Special method of propagation

By taking advantage of the rate, or lack, of movement of a virus in plant, it is sometime possible to propagate from tissues which are temporary free of invading virus. This is a useful technique in cases of valuable plants or where it is desired to build up virus free done of a particular variety since some viruses fail to invade the growing point, the apical meristem may be cut off and grown in a tissue culture.

3.4 Nematode diseases:

Nematode as pest has been discussed in module 1, unit 3. Typical symptoms of nematode damage is irregular areas of varying size in which the pants have been unhealthy appearance. Heavily infected plants are smaller than normal plants, are usually chlorotic, and have a tendency to wilt because of reduce or unhealthy root system. Below ground symptoms vary, depending op the specific nematode attacking the roots. The following diseases symptoms are common.

a) Root knots or galls. Root tissue close to a nematode's head often becomes enlarged bulbous and distorted.

b) Root lesions

Lesions develop when migratory endo – parasitic nematode enter and move within the parenchyma cells of the hosts roots. As the nematodes feed, cavities develop, which may result in falling off of cortical tissue. A small root often become girdled by such injuries, so that root pruning occurs. Death necrosis of root tissue is often attributed to micro – organisms that enter roots via wounds caused by nematodes.

c) Abnormal or reduce root development

ectoparasitic nematodes normally feed on root tissue nears the meristematic and cell elongation regions. Damage to or death of root cells is primarily caused by the repeated probing of the stylet into the tissue. The plant then develops short thick tissues.

Nematode diseases of important crops include the following:

1) Root – knot and cyst nematodes diseases of legumes.

They casue the greatest yield losses on most legumes. On cowpea, root – knot nematodes casue root galling and floss of yield of cowpea in Nigeria. *NM. Incognita, M. aouta and M, javanica* are the major root – knot species found on cowpeas in most areas. *M. incognita* also causes serious galling of winged bean roots and tubers as well as pigeon pea.

The above ground symptoms resulting from damaged roots are yellowing, stunted growth, wilting, nutrient deficiency symptoms, poor yield and early senescence. These symptoms often appear in early defined patches, in the field and are more obvious in adverse growing condition, e.g drought, and in sandy soils. Yield losses in the tropics have been estimated at 8 – 35% for pigeon pea and 10 – 43% for cowpea.

Cyst nematodes *Helerodera cajani* are also common to pigeon pea, cowpea and other legumes. On several infected plants, the mature, swollen white females are clearly visible covering the surface of the roots. Brown cyst containing valuable eggs can survive in the soil for many years. Field symptom on susceptible legume host attacked by Heterodera appear as yellowing.

2) Root – knot and cyst nematodes diseases of cereals

The disease manifest as stunted roots and poor developmenmt in maize and other cereal crops – *Trichodorus, Belonolanimus, Xiphinema.* The cereal cyst nematode *Heterodera avenae* causes deformed root and poor development in wheat.

3) Nematode diseases of roots and tubers:

a) *Scutellonama bradys.* Internal symptoms are small yellowish lesions under the tuber skin which later turn dark – brown to black. Then lesions coalesce forming a continuous dark, dry – rot layer which may girdle the whole tuber. External symptoms are slight deep cracks in the tuber skin or flaking – off of epidermal layer exposing the internal dry rot when infections is severe. Tubers are also malformed. Storage losses as high as 80% have been recorded in Nigeria. It reduces edible portion of tuber and their market values.

b) Lesion nematode in Yam – *Pratylenchus spp.* Infected tuber shows severe necrosis resulting in a dry rot and deep cracks in the outer tissues, skin splitting and corky patches.

Edible portion and market value of infected tubers are reduced.

iii) Root knot nematodes infecting yams – *Meloidogyne spp.* Symptoms are slight to severe galling of yam roots which later results in irregular knobby tuber. Infected seedlings are stunted with galled roots and foliar necrosis. *Meloidogyne* reduces yam growth and caused yield losses in then filed. It lowers quality and market values of infected tubers.

3.4.1 Control methods of root knot and cyst nematode diseases:

a) Chemical method: Nematicides are the most effective means of reducing yield losses by root – knot nematodes, but always the most economic. The following have been recommended for the control of nematodes on cowpea.

i) Methyl bromide injected by chisel application at 20cm depth at 224kg/ha under polythene covers.

ii) Ethylene dibromide at 17kg/ha as a pre – plant fit.

iii) DBPC injected 2 weeks before planting at 5 – 7.5 ha a.i/ha.

iv) Aldicarb as a 30cm band pre – planting and side band post – emergence application at 1kg a.i/ha.

b) Cultural methods

i) Rotation of crops is recommended but selection of poor or non host crops should only be done after careful screening. Susceptible legume varieties should not be grown successively on the same land, and an ideally an interval of 2 – 3 years is recommended. Planting of legumes and other susceptible crops (e.g. solanaceous, cucurbitaceous and other vegetables). Crops which have been shown to reduce root – knot population include cereal (sorghum, millet, maize, wheat, rice) cruciferous (cabbage, cauliflower), onion, garlic, groundnut. Cotton and rosette (Hibiscus sabdariffa) the use of crop will depend on the root – knot species or race present. For example, groundnut and cotton are susceptible hosts of *M. arenaria* and *M. acuta,* respectively. *Crotalaria* has been recommended in Brazil in rotation with cowpea to control *M. Hapla.*

ii) Some intercropping plant species are known to produce root exudates which are toxic to root – knot nematodes, e.g. tangerine marigold (*Tagetes patula)* and sesame (*Sesamum indicum)*and these have been used with limited success by intercropping with root – knot susceptible crops.

iii) A fallow period before planting a susceptible crop will greatly reduce root – knot, but weeds can also be hosts for the nematodes and a bare fallow is recommended turning the soil during the fallow will give additional kill of the nematodes.

iv) Resistant varieties

The use of nematode – resistant crop varieties is recommended as an economic means of managing root – knot nematodes. Many cowpea varieties and breeding line have been found resistant to *meloidogyne spp*.

Control of nematode diseases in root and tubers is by planting nematode – free tubers in soils where nematode population has been eliminated or is in minimal, as infection starts from field. The latter are soils which are left fallow for appropriate periods. Avoid intercropping or rotation with crops which are alternate hosts such as vegetables and legumes.

3.5 Diseases of stored products

Fungi and bacteria may infect fruits, vegetables, cereals and legumes in the field. In storage, fruits and vegetables deteriorate further as a result of the action of these pathogens or others. Penetration of this pathogen is enhanced where cuts and bruises exist on the commodities. In seeds and legumes, however, their action is inhibited mainly because of the drying of these products to low moisture content for storage purposes.

Diseases of fruits and vegetables in storage are mainly caused by fungi belonging to the gebnera *Fusarium, Penicillin, Alternaria, Geotrichum* and bacteria of the genera Erwinnia and Pseudomonas. Stored seeds and legumes are mainly infected by fungi in the genera Aspergillus, Penicvillin spp. May also casue disease in the fruits (orange, mango etc) and vegetable (tomato, pepper, onion etc) and tubers in Nigeria include Curvularia, Aspergillus, Rhizopos, Botryodiplodia, Colletotrichum, Cladosporium, Staphylococcus and Lactobacillius.

Storage disease reduces both quality and quantity of produce which in turn lower their nutritional and market values. Effects on the quality of stored produce include (i) discolorations, shriveling and rotting, (ii) reduction of germinability, (iii) selection of toxin which make produce unfit for consumption by man or livestock.

Note that heating is a sign of microbial activity in stored produce. This results from the growth and respiration of fungi. Moisture is also produced during respiration which enhances bacterial activity.

3.5.1 Control of diseases of stored products:

a) Ensure stored produce are free of diseases, insects and pests provides entry points for microbial pathogens which cause decay. Such pests may be controlled by use of chemicals.

b) Harvesting and other handling practices should be done with care to minimize bruises, cuts etc. fruits and vegetables should be harvested in cool, dry weather and should not be squashed or wounded.

c) Seeds and grains should be dried to a moisture content level below the minimum required for growth of common storage fungi.

d) Proper ventilation should be maintained in stores/storage structures to prevent temperature build – up and subsequent condensation of water on produce. A high level of hygiene is also important.

e) Storage temperature of seeds and grain should be low i.e 12^0C to 15^0C as grains respire slowly at low temperature. Also, growth of storage fungi is slow at low temperatures, while insects and mites activity is reduced. Storage temperatures for fruits and vegetables should also be low. However, temperature should not be low as to cause chilling injury for stored products.

f) Curing at 28^{0}C to 36^{0}C for about 2 weeks may be necessary for some produce e.g. onion and sweet potato, for healing of wound by wound periderm formation and suberization as well as reduction of surface moisture. (Farmer normally field air – dry onion for 7 to 10 days after harvest).

g) Store at 'Safe' moisture content.

4.0 Conclusions

Diseases of plant products are often caused by micro- organisms, particularly bacteria, fungi, viruses and nematodes. Their effects may cause loss in quality or even total destruction of produce. Management strategies should therefore be in place to reduce their effects to the barest minimum.

5.0 Summary

In this unit, important disease of cereals, legumes, root and tubers, vegetables, fruits, beverages, medicinal, oil crops and stored products have been discussed. Their causal organisms, symptoms, mode of spread and control measures are also highlighted.

6.0 Tutor marked assignments

a) State the causal organism, symptoms and control measures of the following diseases:

i) Swollen shoot disease of cocoa (ii) Cassava mosaic disease (iii) Downy mildew of maize (iv) Smuts disease of maize (v) Root – knot disease of yam.

b) Explain how diseases of stored products can be controlled.

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ACP 305: PRINCIPLES OF CROP PROTECTION

TUTOR MARKED ASSIGNMENTS

1 (a) Define crop pests

(b) Discuss the importance of crop pests

© Discuss the conditions which promotes pests

(d) List the categories of crop pests

(e) List the general control measures of crop pests

2 (a) Name and describe the insect pests of important Nigerian cereal, legume, root and tuber crops.

(b) Describe briefly the economic importance and control measures of the following pests: (i) Cassava mealy bug (ii) Groundnut aphids (iii) Termites (various species) (iv) Stem borers of rice (v) ii) Maize stem borers.

3(a) Discuss the damages done to crops by rodents, birds and nematodes

(b) List the control measures for the control of rodents, birds and nematodes.

4(a) Define weeds

(b) Discuss the effects of weeds in crop production

© Discuss the principles of weed management

(d) Discuss the methods of weed management

(e) Identify important herbicides in weed control

5(a) List the categories of storage pests

(b) List three pests of storage products

© Discuss the damages caused by storage pests

(d) Discuss the precautionary measures for the control of pests in stored products

6(a) What is a disease?

(b) List the causal organisms of plant diseases

(c) List the categories of plant diseases

(d) State the damages caused by diseases

(e) Describe the symptoms of major plant diseases

(f) Discuss the general control measures of plant diseases.

7(a) State the causal organism, symptoms and control measures of the following diseases:

(i) Swollen shoot disease of cocoa (ii) Cassava mosaic disease (iii) Downy Mildew of maize (iv) Smuts disease of maize (v) Root – knot diseases of yam.

(b) Explain how diseases of stored products can be controlled.

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