CHAPTER 9

OBJECTIVES

At the end of this chapter, students should be able to:
â—† state the meaning of disease.
â—† list the effects of disease on crop production.
â—† name the important disease of major crops.
â—† state the causal organism of each disease.
â—† state the preventive and control measures.

9.1 Introduction

Diseases constitute major constraints to agricultural crop production. They can attack any crop at any stage of development and growth. Attack may lead to death or drastic reduction of the potential of a crop to mature and produce yield.

9.2 Meaning of Disease

A disease is a condition of departure or deviation from the normal state of health of the crop. It is an unfavourable condition caused by infections by pathogens or deficiency or excess of some environmental factors which result in physiological and anatomical dysfunctions expressed in characteristic symptoms.

9.3 Kinds of Diseases

There are two kinds of diseases:

9.3.1 Pathogenic diseases

These are caused by infectious microorganisms called pathogens. Examples of disease pathogens:
(a) Bacteria **(b)** Fungi **(c)** Viruses **(d)** Nematodes

9.3.2 Environmental diseases

These are caused by excess supply or deficiency of some factors in the environment. This kind of diseases is otherwise called physiological diseases because they affect the normal functioning of the plants. They can be caused by any of the following:
â Excess or deficiency of some nutrient elements.
â Excess of water which causes water logging and hinders proper respiration and nutrients absorption.
â Lack of water caused by drought which results in wilting.

â Too low temperature which lowers plant metabolic rate.
â Too high temperature which causes tissue disintegration.
â Soil acidity which increases availability of trace elements and render some nutrients unavailable.
â Soil alkalinity which makes the nutrients to be available in excess causing toxicity.

9.3.2.1 Examples of environmental diseases

(i) Wilting **(ii)** Dieback **(iii)** Scotched leaves **(iv)** Chlorosis

9.4 Common Pathogenic Diseases of Plants

The four major groups of pathogens causing plant disease are as follows:

9.4.1 Fungi

â These are microscopic plants that cannot synthesize food from sunlight energy through the process of photosynthesis because they do not contain chlorophyll.
â They depend on other plants and animals for their food – saprophytes.
â They penetrate the tissues of growing plants, thereby harming the plants.

Examples of diseases caused by fungi:

i. Black pod disease of cocoa
ii. Blight of tomato and potato
iii. Soft rot of oranges
iv. Rottening of groundnut seeds
v. Fusarium wilt of tomato
vii. Root rot of rubber and kola nut trees
vii. Downy mildew.

9.4.2 Viruses

â These are very small microscopic organisms, smaller than bacteria. They can be seen with the aid of an electron microscope.
â All viruses are parasitic and although they can exist outside their host, they can grow or multiply only inside their hosts.
â Viruses cause disease in plants and animals as well as in bacteria.

Examples of diseases caused by viruses:

i. Cassava mosaic disease
ii. Yam mosaic disease
iii. Groundnut rosette disease
iv. Tobacco mosaic disease
v. Cocoa swollen shoot disease

9.4.3 Bacteria

â These are unicellular organisms which may be parasitic or saprophytic.
â Bacteria gain entry into the tissue of plants through the stomata, wounds, flower or fruits.
â Bacterial diseases are transmitted by wind, rain splash, contaminated materials or insects.
â Bacteria can be grouped in three major groups according to their cell shape and arrangement:

i. Cocci
ii. Bacilli
iii. Spirilla

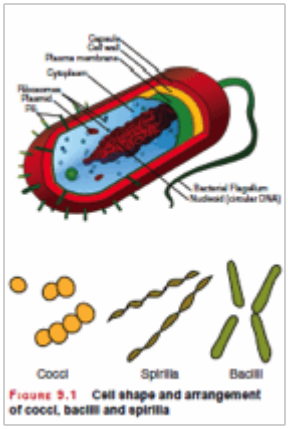


FIGURE 9.1 Cell shape and arrangement of cocci, bacilli and spirilla

Examples of bacterial disease:

i. Bacterial wilt of tomato, melon

ii. Bacterial blight of cotton

iii. Leaf blight of cassava

iv. Wilt of sugarcane

9.4.4 Nematodes

â These are small worm-like animals, but they are not true worms.

â They are usually microscopic and so their presence often goes unnoticed while they continue to do severe damages to crops.

â They injure the underground parts of plants but certain kinds of nematodes also invade stems, leaves and buds.

â Some are able to enter the plant and feed on the cells from inside the tissue (endoparasites) while some feed on the surface of the plant parts (ectoparasites)

â Infected plants become stunted, their leaves turn yellow and later the plants die.

Examples of nematode diseases:

i. Nematode disease of cowpea

ii. Root knot of tomato

iii. Dry rot of yam

9.5 Effects of Disease on Crop Production

1. Disease lowers the yield or quantity of crops.

2. It results in death or total loss of crops.

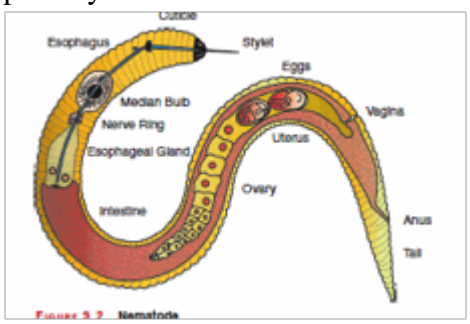
3. The quality and market value of crops are reduced.

4. It causes malformation of some parts of the plant or of the whole plant.

5. Disease results in reduced growth or stunted growth of crop plants.

6. It may result in reduced nutritive value of the crops attacked.

7. Diseases which attack the leaves of plants such as leaf spots and blight will reduce photosynthetic activities.



8. Disease which attacks fruits and vegetables makes them unattractive and unmarketable.

9. It leads to increase in cost of production unless controlled.

10. There will be reduced income for the farmer.

TABLE 9.1 Important diseases of major crops

S. no	Name of Disease	Causal Organism	Mode of Transmission	Symptoms of Disease	Prevention/ Control
Cereals					
1.	Maize smut	Fungus (*Ustilago maydis*)	• Through seeds during harvesting • Airborne spores deposited on leaves	Affected grains are converted into a large mass of black spores	• Planting of healthy or clean seeds • Seed treatment with organo-mercurial fungicides such as thiram before planting
2.	Maize rust	Fungus (*Puccinia polysora*)	• Wind carries the spores • Insects also deposit the spores	• Brown to black powdery pustules (spots) on the leaves • Leaves are destroyed, thus reducing photosynthesis	• Use resistant varieties • Early planting • Burn or bury maize plant after harvesting • Use of fungicides such as Benlate
3.	Maize streak	Virus (*Maize streak virus*)	By piercing and sucking insects (leaf hoppers)	• Chlorotic areas appear on infected plants in the form of streak parallel to the veins of the leaf	• Early planting • Use clean seeds • Use resistant varieties • Destroy insect vectors by spraying insecticides • Remove burn, or bury infected plant
4.	Maize blight	Fungus (*Helminthosporium maydis*)	By rain splash or by wind	Formation of lesions on the leaves of the affected crop	• Use resistant varieties • Application of copper-based fungicides
5.	Rice blast	Fungus (*Pyricularia oryzae*)	Through seeds and airborne spores on young leaves	• Grains do not fill • The base of the panicle is lesioned and discoloured • Dead areas on leaves • Low yield and poor grain quality	• Use of resistant varieties • Use of disease-free seeds • Proper timing of planting • Seed dressing fungicides such as Bordeaux mixture
6.	Rice leaf spot	Fungus (*Cercospora oryzae*)	By wind or rain splash	• Narrow reddish brown to dark reddish brown spots on the leaves • Spots on sheath culm and floral bracts	• Use resistant varieties • Remove infected crop residues and burn before subsequent planting
7.	False smut of rice	Fungus (*Tilletia horrida*)	Wind-/ airborne spores deposited on fruits	Grains are converted to a black mass of fungal spores	• Seed treatment with fungicides • Use resistant varieties

S. no	Name of Disease	Causal Organism	Mode of Transmission	Symptoms of Disease	Prevention/ Control
8.	Covered smut of Sorghum	Fungus (*Sphacelotheca sorghi*)	Through soil or seeds	Germs turn black	• Use of clean uninfected seeds • Seed treatment with fungicides
9.	Sorghum head smut	Fungus (*Ustilago rectiona*)	Through soil or seeds	The whole head is converted into a large mass of spores	• Use of clean uninfected seeds • Seed treatment with fungicides
Legumes					
10.	Fusarium wilt (cowpea)	Fungus (*Fusarium solani*)	Air	Rottening of roots, subseq-uent yellowing of leaves and wilting of the plant	• Use resistant varieties • Plant clean seeds
11.	Cowpea leaf spot	Bacterium (*Xanthomonas phaseoli*)	• Cells dispersed by wind and rain • seeds	• Angular leaf spots • Stem and pod lesions	• Use resistant varieties • Plant clean seeds
12.	Cowpea yellow mosaic	Virus (Cowpea yellow mosaic virus)	By insect vec-tors such as beetle	• Vein yellowing • Mosaic chlorosis • Stunting	• Use insecticides to control vectors • Seed treatment
13.	Damping off (wilt)	Fungi (*Phythium* sp. and *Phytophthora* sp.)	• Soil • Soil move-ment during land preparation	• Root disintegration leading to falling over and death of the plant	• Soil disinfection • Plant resistant varieties • Crop rotation
14.	Root knot	Nematode (*Meloidogyne incognita*)	By nematode in the soil or farm tools and implements	• Galls or knots on roots • Plants bear few fruits	• Soil disinfection • Plant resistant varieties • Crop rotation
15.	Groundnut rosette	Virus (Groundnut Rosette virus)	Through aphids (*Aphis craccivora*)	• Mottling of young leaflets and chlorosis • Leaf distortion with margin rolling inward	• Early plant-ing and close spacing • Use resistant varieties • Crop rotation

S. no	Name of Disease	Causal Organism	Mode of Transmission	Symptoms of Disease	Prevention/ Control
				• Yellowish green patches on leaves • Stunted growth • Reduced flower formation	• Regular weeding • Remove and burn infected plant • Destroy insect vectors
16.	Seed rot	Fungus (*Aspergillus flavus*)	• Airborne spores • Seed	Seeds fail to germinate as a result of cold, wet compacted soils	Seed dressing with organo-mercurial compounds
Beverages					
17.	Black pod disease of cocoa	Fungus (*Phytophthora palmivora*)	• Splashing of water from diseased pods to healthy pods • Planting seeds from diseased pods • Injuries caused by aphids on stems or leaves	• Dark brown or almost black spots on the pods • Fungus develops extensively on pod walls before damping the seeds • The pod becomes completely black	• Spray fungicides such as perenox, carbide, Bordeaux mixture, cocobre-sandoz and Dithane M-45 • Remove infected pods and burn them • Regular weeding of the farm
18.	Cacao swollen shoot	Virus (Cacao swollen shoot virus (CSSV))	By nymphs of mealy bug from infected to healthy plants	• Chlorotic (green) vein but other parts of leaf become yellow • Vein clearing, i.e., veins are not green • Tissues close to the vein are green • Swollen stems • Pods are scanty and the tree may die	• Destroy infected tree • Breeding for resistant varieties • Quarantine measures • Spraying of insecticides to control mealy bugs

S. no	Name of Disease	Causal Organism	Mode of Transmission	Symptoms of Disease	Prevention/ Control
19.	Coffee rust	Fungus (*Hemileia vastatrix*)	By wind or rain splash	• Small yellow spots on the leaves • Expand to large round spots show-ing a powdery coating under surface of leaves • The pots later turn bright orange to red • Defoliation of the plants • Stunted growth • Unproductive tree that may later die	• Spraying with copper fungicides • Plant resistant varieties • Use seeds from healthy or disease-free plants
20.	Brown eye spot of coffee	Fungus (*Cercospora coffeicola*)	-	• Brown and circular spots on the leaves • Later become greyish white with a reddish brown margin • Spots on the upper side of the berry cover one-half of the surface • The affected tissue turns black and shrivels	• Spray with Bordeaux mixture when the berries are ripen-ing or with any copper fungicide
21.	Brown root disease of kola	Fungus (*Fomes noxius*)	Soil	• Golden brown felty mycelium on root covered by black crust which makes the root look black	• Clear away and burn all dead stumps • Dig out infected roots and line the hole

S. no	Name of Disease	Causal Organism	Mode of Transmission	Symptoms of Disease	Prevention/ Control
				• Roots become dead	• Dig trenches 2 ft deep around the tree
22.	Kola nut rot	Fungus (*Botryodiplodia* sp.)	-	Affected pods show a black rot, and rusty brown external spots develop on the nuts which later turn black and become hard and dry	Delay the removal of seed coat to avoid injury to the nuts
Roots and tubers					
23.	Cassava mosaic	Virus	• Transmitted by whiteflies • Planting cassava cuttings from infected plants	• Yellowing of leaves • Mottling of leaves • Leaf distortion	• Use resistant varieties • Use healthy planting material • Spray insect vectors with insecticides • Remove and burn infected plants
24.	Bacterial leaf blight of cassava	Bacteria (*Xanthomonas manihotis*)	• Rain splash and wind	• Leaves wilt or defoliate • Tip dieback accompanied by cream-yellow exudation from infected parts	• Use clean planting material, i.e., cuttings from healthy plants • Use resistant varieties • Early planting • Crop rotation • Farm sanitation
25.	Cassava leaf spot	Fungus (*Cercospora carribea*)	Air	• Small white spots with a reddish brown margin	• Use resistant varieties • Plant healthy cuttings • Crop rotation

S. no	Name of Disease	Causal Organism	Mode of Transmission	Symptoms of Disease	Prevention/ Control
				• Greyish green irregular spots with a thin margin of purplish colouration	• Farm sanitation • Early planting of crops
26.	Yam leaf spot	Fungi (*Cercospora* spp.)	-	Dead spots on the leaves	• Spray with fungicides • Use resistant varieties
27.	Yam mosaic	Virus	By aphids	• Mosaic patterns on leaves • Leaf chlorosis and small yam tubers produced	• Spray insecticides to kill insect vectors • Grow resistant varieties
28.	Yam dry rot	Nemotode (*Scutellonema bradys*)	Soilborne nematodes	• No external symptoms but on cutting open affected tubers are found to be discoloured and disintegrated • Affects stored yam tubers and wounded tubers	• Apply nematicides to affected soil before planting yam • Crop rotation • Store yam properly in barn
Fruits					
29.	Gummos (citrus)	Fungus (*Phytophthora parasitica*)	Soil	• Gum formation on the bark of the trunk • Drying and cracking of the bark • Rotting of the bark near the ground	• High budding on a resistant stock such as sour orange • Planting on mound to ensure that water does not collect at the base of trunk

S. no	Name of Disease	Causal Organism	Mode of Transmission	Symptoms of Disease	Prevention/ Control
				• Leaves become yellowish and die from tip backwards	
30.	Tristeza (citrus)	Virus	• By black aphids • By infected budwood	• Mottled chlorosis at the edge of the leaf • Leaves drying from the tip backwards • Phloem necrosis smelling and protuberance at bud union	• Uproot the affected tree and burn as soon as the disease is observed • Use resistant varieties
31.	Dieback, branch cancer and fruit rot (citrus)	Fungus (*Botryodiplodia theobromae*)		• Dieback from the top of branches • Soft fruits than usual • The fruit later shrivels lightly and becomes hard and black	• Dip the fruits in copper fungicides solution • Use resistant varieties
32.	Panama disease of banana and plantain	Fungus (*Fusarium oxysporum*)	Fungal hyphae in the soil attack the roots, spread to the tissues and the whole vascular system	• Petiole collapses • Leaves begin to wither and then fall off	• Grow immune varieties of hybrids of banana • Apply potassium fertilizer such as muriate of potash • Remove and burn infected plants
33.	Bunchy top of banana and plantain	Virus	By piercing and sucking insects	Stunted growth with crowded leaves having curled edges	• Dig out infected plants and burn • Farm sanitation

S. no	Name of Disease	Causal Organism	Mode of Transmission	Symptoms of Disease	Prevention/ Control
34.	Sigatoka disease of banana or leaf spot of banana and plantain	Fungus (*Cercospora* and *Mycosphaerella*)	Spores are transmitted by mind drops or dew	• Yellowish brown chlorotic spots on leaves • Centre of the affected area becomes greyish surrounded by reddish and outlying yellow zones	• Spray with Bordeaux mix-ture or Benlate
Fibre					
35.	Black arm of cotton	Bacteria (*Xanthomonas malvacearum*)	• Through debris of plants • Dispersed by wind and rain splash • Through infected leaves and stems near the ground	• Angular dead spots on leaves and branches (black arm) • Black lesions on older stems • Boll rot	• Disposal of crop residue after harvesting by burning • Crop rotation • Seed dressing with Agrosan 5W • Plant resistant varieties
36.	Cotton leaf curl	Virus	• By whitefly (*Bemisia* spp.) • Through grafting	• Twisted elon-gated barren plants • Stunted growth • Leaves are wrinkled and the plant may die	• Plant resistant varieties • Remove and burn infected plants
37.	Cotton boll rot	Fungi (*Botryodiplodia theobromae* or *Fusarium* spp.) Nematospora	Through boll weevil injury to the boll	Rotting of bolls	• Avoid boll injuries • Control boll weevil with insecticides

S. no	Name of Disease	Causal Organism	Mode of Transmission	Symptoms of Disease	Prevention/ Control
Latex crop (rubber)					
38.	Mouldy rot	Fungus (*Ceratostomella fimbriata*)	Through contaminated equipment such as knife, collecting cups etc.	• Depressed and discoloured spots on the panel • The spots darken and are covered with greyish mould	• Use of clean tapping tools and materials • Treat infected panel with fungicides • Farm sanitation • Adequate aeration
39.	Black thread or black stripe disease	Fungus (*Phytophthora* spp.)	• High humidity spreads the fungus • Deposition of spores on tapping area	Presence of black pencil like lines in the cortex and wood	• Use of resistant varieties • Use of appropriate fungicides • Pruning/farm sanitation
40.	Root diseases a. White root b. Brown root c. Red root	Fungus (*Fomes lignosus, Fomes noxius, Ganoderma pseudoferreum*)	Soilborne fungus	• Foliage becomes thin • Leaves become unhealthy and turn brown • Branches dieback	• Treat affected plants with fungicides, e.g., captan or Bordeaux mixture • Farm sanitation/ regular weeding
Oil palm					
41.	Freckle	Fungus (*Cercospora elaeidis*)	Through airborne spores dropping on leaves	• Brown spots surrounded by yellow holes • Dryness of the tissues	• Use appropriate fungicides • Plant resistant varieties • Farm sanitation
42.	Blast (root disease)	Fungus (*Pyricularia* spp.)	• Transmitted by soilborne mycelium attacking the roots	• Soft and dull leaves • Olive green to yellow or brown leaves • Root decay • Seedlings wilt and die	• Spray affected plants with captan at regular intervals • Regular watering of seedlings • Mulching of nursery beds

S. no	Name of Disease	Causal Organism	Mode of Transmission	Symptoms of Disease	Prevention/ Control
43.	Galadema	Bacteria (*Fusarium oxysporum*)	Through the soil by insects or nematodes	• Rapid wilting of fronds • Death of plants	• Soil sterilisation
44.	Anthrac-nose	Fungus	Air	• Dark necrotic lesions on the leaves of seedling • Brown patches on leaves of seedlings	• Use fungicides such as captan, ziram and perenox
45.	Brown germ	Fungus (*Aspergillus* spp.)	• Hyphae spreads on palm fruits	• Shiny and rotten parts or tissues • Brown spots on emerging buttons	• Treat seeds with fungicides • Use dry heat method of germi-nating seeds
Vegetables (Tomato, Melon, Okra and Amaranthus)					
46.	Damping off	Fungus (*Fusarium* spp., *Pythium* spp., *Phytophthora* spp.)	By soil movement during land preparation	• Disintegration of tissues and seedling wilt • Plants tall over and die	• Grow resistant varieties • Crop rotation • Spray with Dithane M-45 fortnightly
47.	Fusarium wilt	Fungus (*Fusarium oxysporum*)	Soilborne fungus	• Gradual dropping of leaves • Wilting and drying of whole plant	• Soil treatment with copper fungicides or formalin to kill spores
48.	Root knot	Nematode (*Meloidogyne* spp.)	Soil nematode	• Roots develop knots • Plants bear few fruits	• Soil fumigation with Nemagon • Plant resistant varieties • Crop rotation
49.	Tomato fruit rot	Fungus	Soil	• Rottening of the fruits • Low yield	Staking to prevent the fruits from touching the ground

S. no	Name of Disease	Causal Organism	Mode of Transmission	Symptoms of Disease	Prevention/ Control
50.	Mosaic	Virus	By insects	• Mottling of leaves • Vein clearing • Stunted growth • Loss of vigour and yield	• Use resistant varieties • Spray with insecticides to kill insect vectors
51.	Bacteria wilt	Bacteria (*Pseudomonas solanacearum*)	-	• Sudden dropping of leaves • Wilting and death of plant	• Crop rotation • Avoid infested soil
Stored produce					
52.	Moulds	Fungi	Air	• Sour taste • Mouldy seeds as in cocoa beans • Black mould on seeds • Pungent odour • Seed and fruit decay	• Ferment and dry cocoa beans well before storage • Avoid dampness in storage area • Fumigate stored produce

9.6 General Control Measures of Disease of Crops

â Crop rotation

â Burning of infected crops or crop residues

â Soil treatment or sterilisation

â Roguing or uprooting of infected crops

â Timely and regular spraying of crops with pesticides against vectors of disease
â Use of resistant varieties of crops
â Farm hygiene or sanitation
â Timely planting and harvesting of crops
â Spraying of recommended chemicals to control particular disease

Activities

1. Make a field trip to the nearby farms in your locality, observe and identify different types of field and stored crop diseases. Record your observations in your record book.
2. Demonstrate the use of chemicals to control crop diseases in school farm with the aid of a sprayer. List the names of common chemicals in the locality and the type of disease they control.
3. Draw a sprayer in your farm record booklet and label the parts correctly.

SUMMARY

A disease is a condition of departure or deviation from the normal state of health of the crop.
â—† Diseases attack crop plants at any stage of growth and development.
â—† Plant diseases attack all parts of the plant, that is, stems, roots, leaves, fruits or seeds.
â—† The effects of disease on crop production may include:
âœ§ Crop failure
âœ§ Reduction in yield or quantity of produce
âœ§ Loss of quality and market value
âœ§ Malformation of parts, reduced or stunted growth
âœ§ Increase in the cost of production
â—† Symptoms of the common diseases of crop may include
âœ§ Yellowing of leaves (chlorosis)
âœ§ Red spots (rust)
âœ§ Collapse of seedling (damping off)
âœ§ Stunting or dwarfing and
âœ§ Wilting
â—† Examples of important diseases of major crops: maize streak, maize 8 nut, rice blast, cowpea leaf spot, groundnut rosette, black pod disease of cocoa, coffee rust, cassava mosaic, gummosis (citrus), yam leaf spot, cotton leaf curl, (freckle) oil palm, root knot (tomato) and mould (stored grains).

REVISION QUESTIONS

Essay Questions

1. (a) State the meaning of disease.
(b) Mention five general effects of infection on crop production.
(c) List four disease-causing organisms.
2. (a) List four ways by which diseases are spread on a crop farm.
(b) State three symptoms and three control measures of each of the following diseases:
i. Root knot of tomato
ii. Black pod disease of cocoa
iii. Cassava mosaic (WASSCE 2006)
3. (a) In a tabular form, name one fungal disease and one viral disease of any four of the following crops

i. Citrus
ii. Banana
iii. Tomato
iv. Yam
v. Groundnut
(b) State six general control measures of disease of crops.

4. Write short notes on the following plant diseases.
(a) Black pod disease of cocoa
(b) Leaf blight of cassava
5. State two symptoms and two control measures of the following plant diseases.
(a) Cassava mosaic
(b) Groundnut rosettes
(c) Root knot of okra
(d) Bacterial blight of cotton

Objective Questions

1. The twisting, wrinkling and mottling of leaves are symptoms of
(a) nematode attack.
(b) viral diseases.
(c) water deprivation.
(d) fungal attack.
2. Mould growth in cereal grains stored in damp conditions is caused by
(a) bacterium.
(b) fungus.
(c) virus.
(d) nematode.
3. Which of the following combinations of practices best control groundnut rosette disease?
(a) Late planting and spraying of insecticide
(b) Early planting and spraying of nematicide
(c) Late planting and spraying of fungicide
(d) Early planting and spraying of insecticide
4. Golden brown lesions on peeled yam tuber indicate infection by
(a) bacteria.
(b) virus.
(c) fungi.
(d) nematode.
5. The eradication of mealy bugs is an effective control of
(a) corn smut.
(b) swollen shoot of cocoa.
(c) groundnut rosette.
(d) rice blast.
6. Mosaic disease affects
(a) cotton and cocoa.
(b) groundnut and tomato.
(c) cassava and tobacco.

(d) mango and orange.

7. Which of the following is a symptom of black pod disease of cocoa?

(a) Diseased leaves fall prematurely

(b) Characteristic swellings appear on young stems and roots

(c) A small brown spot first appears on the pod

(d) Veins of diseased leaves become red in colour

8. Rosette disease of groundnut is transmitted by

(a) an ell worm.

(b) a grasshopper.

(c) a whitefl y.

(d) an aphid.

9. Streak disease of crops commonly attacks

(a) millet.

(b) sorghum.

(c) maize.

(d) rice.

10. Viral disease of crop plants are best controlled by

(a) applying insecticides.

(b) flooding farmlands.

(c) planting resistant varieties.

(d) applying fungicides.

Answers to Objective Questions

1. b 2. b 3. d 4. d 5. b 6. c 7. c 8. d 9. c 10. a