DCEBY -106

Plant Pathology and Microbiology

Uttar Pradesh Rajarshi Tandon
Open University

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Block -1
Plant Pathology

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COURSE INTRODUCTION

This course deals with plant pathology and microbiology. The pathology is concerned with the detailed study of the plant diseases, the mechanisms by which diseases develop in individual plants, and the ways by which plant diseases can be managed or controlled.

The microbiology is another most important discipline of botany. The word microbiology is made up Micro=small, Bio=Living and Logy= to study. In which we study the application of small living various microbes in the various fields like sewage treatment, improving soil fertility, increasing dairy industry for human welfare.

The whole course is divided into two block viz 1 and 2. Which are as follows:

Block 1- Plant Pathology is divided into 5 units which are as follows:

Unit 1- Covers introduction of plant pathology.

Unit 2- Covers symptoms of plant diseases caused by fungi, bacteria and virus.

Unit 3- Covers various method for control of plant diseases.

Unit 4- Covers dissemination of pathogen, epidemiology and disease forecasting.

Unit 5- Cover some important diseases of plant.

Block 2- Microbiology is divided into 3 units which are as follows:

Unit 6- Covers sewage microbiology

Unit 7- Covers soil microbiology.

Unit 8- Covers dairy microbiology.

Block-1: Plant Pathology

The plants are the primary source of various materials like food, clothes, house building materials, drugs etc. These plants or plant products may be reduced in quality by diseases in the field or during storage which can be controlled by knowledge of plant pathology.

Plant pathology deals with the detail study of the plant diseases and their control methods in the field and storage. Thus the objective of plant pathology is reducing the loss in the yield of crop to its minimum.

Keeping this in mind the present block is divided into following 5 units viz. 1,2,3,4 and 5 which are as follows:

Unit 01 - Introduction of plant pathology covers history and significance of plant pathology, pathogenicity, koch's postulates, classification of plant diseases and important Phytopathological terms.

Unit 02 - Symptoms of plant diseases covers various symptoms produced in plants by fungi, bacteria and virus.

Unit 03- Control of plant diseases cover various methods of disease control like prophylactic, therapeutic and immunisation.

Unit 04- Dissemination of pathogen epidemiology and diseases forecasting covers how pathogens are disseminated in environment and various factors of epidemiology and diseases forecasting.

Unit 05- Diseases of plants covers some important fungal diseases of crop plants.

Objective:

After studying this block you will be able to:

- Known about Koch's postulates, which help you in identifying diseases.
- Have knowledge about various symptoms produced by pathogen.
- Understand dissemination and epidemiology of pathogen for disease forecasting.
- Know various methods for control of plant diseases.

Unit-1 INTRODUCTION OF PLANT PATHOLOGY

Structure

1.1 Introduction

The term pathology is derived from the Greek words pathos = suffering and logos = study, hence pathology is the "study of the suffering". Phytopathology (phyton- plant: pathos – suffering : logos – knowledge) is the "study of suffering plant and deals with the study of nature, development and control of plant diseases. The diseased plant is the central theme to which are interlinked the pathogen, the environment and the time period. According to modern concept, disease is an interaction among the host, pathogen and environment. Diseased plants can be distinguished by change in their morphological structure or physiological processes which are brought about by unfavorable environment or by parasitic agencies. Stakman and Harrar (1957) defined plant disease as, "physiological disorder or structural abnormality that is harmful to the plant or to any of its part or products that reduces the economic value".

Objectives:-

After studying this unit you will be able to know:

- History and significance of plant pathology.
- Koch's postulates for pathogenisity test .
- Classification of plant diseases.
- Various terms required for phytopatholgical studies.

1.2 History of Plant Pathology:

The advent and progress of human civilization is intimately associated with the progress of agriculture. But ever since man started depending on plants to fulfill his nutritional needs, the enemies of plants have been causing much harm and economic losses. Fossil records of parasitic fungi date back to

Devonian period which suggests that diseases originated along with the plants.

In India mention of plant disease has been made in *Rigveda, Atharveda* (1500-500B.C.), the *Artha Shashtra* (321-186 B.C.), *Sushruta Samhita* (200-500A.D.), *Agnipurana* (500-700 A.D.) etc. In Europe, Theophrastus, while describing trees, cereals and pulses also recorded the harmful effects of wind, weather and location and believed that diseases originated from plants or from the environment, But the invention of the microscope changed the entire concept. Micheli in 1729 made an extensive study of fungi and their reproductive structures and experimentally proved that the fungi originated from spores.

Tillet (1755) demonstrated that wheat seeds dusted with bunt diseases of wheat was caused by transmission of black powder (bunt) and was contagious.

The foundation of modern plant pathology as a science was established by the French scientist Prevost (1807) who demonstrated that micro-organisms are disease causing. Working with *bunt of wheat,* he studied the germination of spores and described the life cycle of the bunt fungus in detail. An important discovery made by Prevost was the fungicidal and fungistatic properties of certain chemical. But due to the firm belief of scientists in the theory of spontaneous generation, Prevost's discoveries were acknowledge 40 years later.

The devastating *'potato disease'* in the middle of the 4^{th} century which swept over the whole of Europe and Ireland was one of the most tragic events in human history, but it was a blessing in diguise as it compelled attention of scientists on the importance of plant diseases. The causal organism of the potato disease was identified by Speerchneider and De Bary to

Phytophthora infestans, but it was believed that the fungus developed from the disease rather than that the fungus caused the disease. Few scientists, like Berkeley (1846), Morren (1845) and Van Martius (1842), however, firmly believed that the *late blight of potato* was caused by *phytophthora infestans.*

The German scientist Anton de Bary is credited for establishment of modern experimental plant pathology. He confirmed the findings of Prevost and gave the detailed description of potato late blight fungus, it's nomenclature and pathogenic nature. De Bary's outstanding contributions are his studies with rusts, smuts, downy mildew fungi, heteroecious nature of rusts and their pathogenic role. The role of enzymes in tissue disintegration was demonstrated by De Bary and the physiological era in plant pathology was initiated.

The role of fungi in disease development and the observations of the various scientists was recorded by Kuhn in 1858 in the first book of plant pathology.

A big step forward in the field of plant pathology was made by Brefeld of Germany (1875) who developed modern techniques of inoculation and the artificial culture of micro-organisms. Parasitic fungi were now being cultured in sterile synthetic media to study their physiology, nutritional requirements, sporulation and genetics.

Grape cultivation was the main industry in France for wine making. In 1878, the *downy mildew of grapevine* wiped out the crop, Professor Millardet of Bordeaux discovered that a mixture of copper sulphate and lime when sprayed on grapevine prevented the mildew disease and the Bordeaux mixture was invented. Thus, the method of chemical control of plant diseases, initiated by Prevost in 1805 was firmly established.

The variability of parasitism in pathogens and the existence of physiological races in the rust fungus was discovered by Swedish scientist Erikson in 1894. In the first decade of the 20th century, scientists studied the importance of genetics in plant disease resistance and selection of resistant lines was introduced to obtain resistant varieties (Biffer, 1903 and Orton, 1909). At the same time, Ward (1903) and Salmon (1903) discovered physiological specialization in rust and powdery mildew of cereals.

Blakeslee in 1904 reported that dissimilar nuclei take part in the life cycle of fungi. Fusion between dissimilar nuclei within a cell was demonstrated by Burgeff (1912-1914) and the term *heterokaryosis* was given to this phenomenon. Hansen and Smith (1923) established the theory of origin of physiologic races through heterokaryosis.

Flor (1955) advocated the important *gene to gene* hypothesis of disease resistance and susceptibility which stated that disease susceptibility depends on compatibility of genes between the host and pathogen.

In the early developmental stages of plant pathology scientists concentrated only on fungal diseases and bacterial association with disease was not taken into consideration. But Louis Pasteure and Robert Koch in 1876 proved that anthrax disease of cattle was caused by a bacterium. Later in 1878, Burrill reported that the *fire blight of apple and pear* was caused by a bacterium and by the year 1900 E.F. Smith firmly establish bacteria as important disease causing pathogens.

The discovery of the tobacco mosaic virus by Meyer in 1886 was the birth of the study of viruses as pathogenic agents. He demonstrated that the *mosaic* disease could be transmitted from diseased plant to healthy plants by infecting the sap of leaves showing mosaic symptoms. Ivanowski and Bijerinck are credited for starting study on the nature of viruses. In 1892, Ivanowski demonstrated that tobacco mosaic virus could pass through those filters that retained bacterial cells and suggested that viruses were smaller than the smallest bacterium. In 1998, Beijerinck coined the term *contagium vivum fluidum* (infectious living fluid) and observed that new growing tissues were more easily infected than old tissues.

In 1935, Stanley experimentally proved that viruses could be chemically treated and crystallized and still remain viable. The following year Bawden and his co-workers found that the crystalline powder of the virus contains nucleic acid and protein and in 1956 Gierrer and Schramm demonstrated that the nucleic acid fraction of the virus is actually the infectious agent.

Needham in 1743 A.D. for the first time reported the disease causing nature of nematodes, but if was a century later that Berkeley and Schacht discovered root knot nematodes and cyst nematodes of sugar beet. Now almost every crop is known to be attacked by one or more of nematodes and nematology has become a major branch of plant pathology.

Nocard and Roux (1898) discovered another group of disease incitants which was similar to viruses in size but could not be cultured. This group was known as mycoplasma: Japanese scientists (1967) discovered that mycolplasma like organisms could be responsible for most of the *yellowing diseases* supposed to be caused by viruses.

Plant pathology in the twentieth century

In the latter half of the century plant pathology progressed in several directions:

1. **Physiology of plant diseases-** The studies on physiological aspect of plant diseases was initiated by De Bary

and pursued by Jones, Brown, Gaumann, Walker and others. The important role played by fungal enzymes and toxins was established.

2. **Genetics of the host plant and the pathogen-** Inheritance of resistance and virulence is related to the genetical constitution of the pathogen. Flor (1955) explained host parasite relationship in flax rust by the *gene for gene* relationship between rust reaction in the host and pathogenicity in the parasite.

3. **Fungicide research-** Several biochemists and organic chemists joined plant pathologists in evolving new fungicides. Sisler, Cox, Ludwig and other workers explored the mechanism of fungicide reaction and in 1934, Tisdale and Williama discovered alkyldiothiacarbamates, the most widely used fungicide. The Discovery of gliotoxin by Weinding and Emerson from *Trichoderma viridar,* that prevented damping off of citrus seeding opened the field of antibiotics. Most antibiotics are bactericidal, however, **gliotoxin, petulin** and **griseofulvin** are used against pathogenic fungi.

4. **Environment in relation to disease development-** Environment is an important factor influencing disease development and includes climatic, edaphic and biotic factors.

5. **Nature of disease resistance-** Disease resistance is associated with phenols possessing antibiotic properties, Muller proposed the post infection formation of *Phytoalexin* chemicals which produced in non-hosts toward off the pathogenic fungus and provide infection by other fungus.

6. **The Biochemistry and Physiology of the diseased state of the host-** The various metabolic processes of the infected plant have been investigated to determine the sequence and extent of pathogenesis. In the diseased state, the tissues of the host disintegrates, water becomes deficient, growth and reproduction are adversely affected. Host starves and respiration rate is altered. Hence the entire physiology and biochemistry of a diseased plant changes.

7. **Tissue culture-** The technique of tissue culture enabled plant pathologists to grow organs, tissues free cells and to study the transformation of a normal cell into a tumour cell as a result of infection. The first artificial cultures of a rust fungus and microbe free culture of viruses and nematodes were done by this method.

8. **Ecological studies of plant pathogens-** Waksman in 1932 emphasized the important role of fungi in soil economy and decomposition of organic matter, Reinking and Manns (1933) coined the terms *soil inhabitants* to fungal forms occurring in all types of soil and *soil invaders* to forms restricted to few localities only. The interesting field of *rhizosphere* study was initiated by Hiltner in 1904 and Lockhead (1940) demonstrated that rhizosphere flora affected the resistance and susceptibility of plants to root infection.

In the twentieth century, plant pathology had developed into a multi-branched science, embracing all segments of biology and the entire human race is obliged to the plant pathologists for their important contribution in ensuring disease free nutritional food supply.

Heinrich Anton de bary- German surgon, botanist microbiologist and mycologist is considered FATHER OF PLANT PATHOLOGY as well as founder of MODERN MYCOLOGY.

Some important plant pathologist of India are E J Butler, B B Mundkur, K C Mehta, T S Sadasivan, R N Tandon, S P Raychaudhari, G. Rangaaswamy, S N Das Gupta etc. **Sir Edwin John Butler** an Irish mycologist and plant pathologist is considered **father of modern plant pathology in India**. He stayed in India for about twenty years and made scientific studies of most of the diseases known in India at that time. Butler left India in 1920, BB Mundkar started work on cotton wilt and started Indian Phytopatholgical Society in 1948. Sir K

C Mehta and R Prasada worked on epidemiology of cereal rust in India. T S Sadasivn established the school of Mycology and plant pathology at Madras University and laid the foundation of research on soil borne pathogen in India.

SAQ 1.

a. Bordeaux mixture was discovered by ………………………

b. Father of Plant Pathology is ……………………………….

c. Father of modern Plant Pathology in India is ………………

1.3 Significance of Plant Pathology

Plant diseases are important as they cause damage to plants and plant products. The extent of the harm caused varies with plant, the pathogen, locality, environment etc. Plant pathology is concerned with all the aspects and features of plant diseases, caused by fungi, bacteria, viruses, nematodes, parasitic higher plants etc. The study of plant pathology is of special significance as it makes us knowledgeable not only about the various kinds of diseases infecting plants but also explains about the measures of control and prevention to be taken against those diseases.

Plant pathology is not an isolated subject but is intimately associated with botany, mycology, virology, bacteriology, plant anatomy, plant physiology, genetics, biochemistry, soil science and other branches of science.

1.4 Pathogenicity

The potential capacity of infection of any pathogen is called its pathogenicity. The index of the quantitative nature of pathogenic micro-organism is called the degree of pathogenicity or virulence.

All pathogens are parasite but all parasites are not pathogen. The parasite which cause disease on the host are called pathogen.

The host pathogen interaction begins when pathogen (in the form of inoculums) comes in contact of host and ends with the expression of disease in the form of symptoms.

The inoculum causes infection when the host is susceptible and environmental conditions are favourable.

When pathogen come in contact of a susceptible host pathogensis take place.

Pathogensis is the process of infection of disease development in a plant. Infection is the establishment of a pathogen within the host, following entrance.

Thus pathogenesis is the sum of sequence of biological process in disease development from initial contact between a pathogen and its host to the appearance of first symptom of disease. A number of external and internal factors are involved in the process

The process of pathogensis can be studied under following three phases:

(1) Prepenetration Phase

(2) Penetration Phase

(3) Post Penetration Phase.

(1) **Prepenetration Phase:-** It is the host pathogen interaction before penetration of pathogen into the host. The prepenetraction in important only in the case of fungal inoculums and not in the case of viral and bacterial inoculum because, prepenetration involves germination of propogule and growth of germ tube which is a phenomenon of fungal inoculums.

Various type of spores like sporangia, conidia, oidia, chlamydospores, uredospores, ascospores etc. and produced by fungal pathogen. Some of them germinates immediately where as other germinates after a resting period.

Various **environmental factors** like moisture, pH, temperature, light, Co_2 and O_2, **Chemical factors** like host exudates, residues and biological factors like microorganisms present around the rhizosphere and phyllosphere influence the germination of spores by antagonism, competition and micro parasitism.

After encountering above factors fungal propagule germinates by germs tube and penetraters directly into the host or it grows profusely over the host surface and or infection cushion. The tip of the germ tube then form **aspersorium** from which infection thread arise and enter into the host.

Penetration Phase: It is the actual entry of pathogen into the host. The pathogen enters into the host either indirectly or directly.

Indirectly pathogen enters into the host either through natural openings present on the host surface such as stomata, lenticel hydathodes or through the wounds.

Directly pathogen penetrates through culticularised epidesmis. In this penetration pathogen has to cross morphological, biological and chemical barriers. The direct penetration is first mechanical then chemical. The germ tube of fungal hyphae develop appresorium which exact a strong mechanical pressure on the wall as a result epidermis is streached and becomes thin. The penetration take place through this thin area.

The penetraction of cuticle is purely mechanical. The appresorium exterts a presscune at the thin area due to which cuticle breaks and pathogen comes in contact of epidermal wall of the host which has pectin and cellulose. These are penetrated by enzymatic action of the hyphae due to which the cell wall become soft and pathogen penetrates into the host tissue.

At the same time pathogen has also to neutralize many toxic substances secreted by host.

Post Penetration Phase:- In this phase pathogen successfully establishes them self into the host tissue which is must for the appearance of symptoms. Various internal factors try to inhibits the growth of pathogen inside the host. The pathogen establishes themselves after over coming the internal barriers which may be morphological or biochemical. The establishment of pathogen in the host involves a close bio-chemical relationship between two (host-pathogen). Various enzymes, toxins and growth regulaters are secreted by pathogen inside the host. It brings various morphological, anatomical and physiological disturbance in the host tissue.
The physiological process, such as membrane permeability, photosynthesis, respiration and nitrogen metabolism are affected. The above disturbance are expressed on the host surface in the from of symptoms of the disease. On the basis of infection the symptom may be local in which pathogen infect the host organ or part of organ or may be systemic in which entire plant is affected. The factor that establishes infection is quantitative. Larger the dose of the infective pathogen greater are the chances of infection.

1.5 Koch's Postulats: The Pathogenecity Test

Roert Koch was a German Physician who confirmed the germ theory of disease and formulated four postulates known as Koch's Postulates. These postulates are four criteria designed to establish relationship between a microbe and disease. Koch's postulates have been critically important in establishing the criteria where by the scientific community agrees that a microorganism causes a disease.

Koch first laid down in 1882 a three step series which he said, must be fulfilled before the organism can be confirmed as the real cause of the disease. Later on a fourth step was appended to Koch's series of conditions by E.F. Smith in 1905. These four conditions are four postulates known as Koch's

Postulates universally accepted to establish a relationship between microorganism and disease. These postulates are as fallows:

1. The organism must be found associated with the disease in all the diseased host examined.
2. The organisms must be successfully isolated and grown in pure culture on nutrient media. Its growth characteristics be recorded.
3. The organisms should be isolated from pure culture and must be isolated on the healthy host on which the disease appears and it must cause the same disease on the inoculated healthy host.
4. The organism must be isolated from experimentally diseased host during the step 3 and grown in pure culture again, the organism grown in pure culture must show exactly the same characteristics of its growth which it showed during the step 2.

If all above steps of Koch's Postulates are proved to be true, the isolated organism is identified as the real pathogen responsible for the disease.

1.6 Classification of Plant Diseases:-

The plant diseases are classified in various ways on the basis of:

1. Host plant affected
2. Causal organism
3. Part of the plant affected
4. Occurrence of disease
5. Nature of dispersal medium.

1. Classification of Plant Diseases on the basis of host plant affected:

The disease is of two types:

a. **Systemic Disease** In this case whole plant is affected by pathogen and the symptom of disease appears in the whole plant.

b. **Localised Disease** When certain organ such as root, stem, leaf etc. or part of organ of the host plant is affected then it is called localized disease. In this disease the symptoms produced by pathogen on host surface are also localized.

2. Classification of Plant Diseases on the basis of Causal Organism: On the basis of nature of Causal organism, the disease is of two types:

a. Non Parasitic disease:

This disease is not caused by living organism. It is due to environmental conditions like low and very high temperature, unfavourable soil moisture, ph, presence of toxic gases in the atmosphere. Excess and deficiency of minerals in the soil also cause non parasitic disease. As there is no involvement of living organism it can not be transmitted from one diseased plant to another healthy plant. Thus the disease is non infectious.

Tip-rot or necrosis of Mango is an example of non parasitic disease. It is caused by deficiency of Boron.

b. Parasitic Disease

Parasitic disease is due to parasitic organisms like algae, fungi, bacteria, virus and nematodes. The disease is infectious and transmitted from diseased plant to healthy plant in the same field, from one field to another field and from one place to another through various agencies. White rust disease in crucifer caused by *Albugo candida* is an example of parasitic disease.

3. Classification of Plant Diseases on the basis of part of the plant affected: On the basis of part of the host plant affected disease may be classified as:

a. **Foliage Disease** when leaf of the host plant is affected by pathogen.

b. **Stem Disease** When stem of the host plant is affected by pathogen.

c. **Root Disease** When root of the host plant is affected by pathogen.

d. **Vascular Disease** When vascular region of the host plant is affected by pathogen.

e. **Fruit Disease** When fruits of the host plant are affected by pathogen.

4. **Classification of Plant Diseases on the basis of occurrence of disease:** The study of plant diseases in relation to their occurrence (interaction of populations of plants, pathogens and environment) is known as epidemiology

There may be infectious disease and contagious disease. A disease which spreads slowly and is incited by transmissible pathogen is known as infectious disease, and that which spread rapidly is a contagious disease.

On the basis of occurrence diseases are classified as:

a. Endemic Disease

A disease which constantly occur from year to year in moderate to severe form is an endemic disease. For example, the wart disease of potato caused by *Synchytrium endobioticum* is endemic to Darjeeling. In plant pathology, this term is applied to simple interest disease which are either indigenous or of ancient introduction.

b. Epidemic or Epiphytotic Disease

The disease occur widely, but periodically in a destructive form. The pathogen may be present in the locality, but the environment favourable for development of disease occur only periodically. Thus the disease is very responsive to variation of environmental conditions which actually control its incidence. Cereal rust, Powdery mildew are example of epidemic disease.

c. Sporadic Disease

The sporadic disease is rather an epiphytic disease except that it occurs only here and there at irregular intervals. In a sporadic disease pathogen affects only a few plants in a large population of host plants and others remain unaffected. Angular leaf spot is an example of sporadic disease.

d. Pandemic Disease

The disease occurs all over the world and result in mass mortality. Late blight of potato is an example of pandemic disease.

5. **Classification of Plant Diseases on the basis of dispersal medium of the pathogen:** On the basis of the dispersal medium of the pathogen diseases are classified as:

a. Soil Borne Disease

The pathogen survives in the soil and disease spread through soil. Wilt of Arhar is an example of soil borne disease as *Fusarium* sp, the pathogen of wilt disease survives in soil.

b. Seed Borne

The pathogen of disease survives in the seed therefore disease spreads through infected seed. Loose smut of wheat is an example of this disease as, the pathogen *Ustilago tritici* spreads through seed.

c. Air or Wind Borne Disease

The pathogen of disease survives in air therefore spread of disease take place through air. For example, the uredospores of *Puccinia* comes through air, infects the wheat crop and cause Black Rust disease.

SAQ 2.

a. Koch's postulates were given by……………………………..

b. In systemic disease………………………….plant is affected.

c. Parasitic disease is due to ………………………...organisms.

d. Pandemic disease occurs………………………… the world.

1.7 Phytopathological Terminology

The term used in the study of plant pathology carry definite meaning. Some such terms are as follows:

Host- On which pathogen survive.
Pathogen - A living entity which causes disease.
Inoculum – The pathogen survives from one growing season to the other in the form of spores, selerotia, dormant mycelium or in various other forms. This constitute inoculum. For example, Inoculum in bacteria is the entire cell, in virus the entire particle, in Fungi vegetative hyphae and spores. Thus the part of a pathogen which enters the host cells and causes disease is known as inoculum.
The inoculums is of two types:
(1) **Primary Inoculum:** The form of pathogen through which initiation of disease take place is known as Primary inoculum. For example in white rust of crucifer disease, the primary inoculum is oospore present in the soil
(2) **Secondary Inoculum:** After infection on the host surface pathogen produces fresh crop of spores which causes secondary spread of disease. These are called secondary inoculum. For example in the disease cycle of white rust of crucifer *Albugo candida* (pathogen) produces conidia on mustard plant (host). These conidia are secondary inoculum as they cause secondary spread of disease.
Disease: Any deviation from the healthy conditions which interferes with the normal structure and performance of vital functions of a plant is called disease. The diseased plant can thus be spotted by changes in their structure or physiological process.

Symptom: The external sign on the plant which indicate disease is known as symptom.

Simple Interest Disease: Simple interest or monocyclic disease increased mathematically- similar to simple interest on money. This disease develops from a common source of inoculum, that is, the capital which is constant. It is also known as monocyclic disease as there is one generation of infection in a season.

Compound Interest Disease: Compound interest disease is also known as polycyclic disease. This is mathematically analogus to compound interest on money and characterised by multiple generations of spores being produced in a year.

Etiology- It is the study of the living, non-living and environmental causes of plant disease.

Pathogenesis- It is the study of the mechanism of disease development by pathogens and is concerned with the processes of infection and colonization of host by the pathogen.

Epidemiology- It is the study of the spreading of the pathogen within crop areas during the growing season. Epidemiology has a wide meaning and is concerned with the interaction of crop, pathogen and environment.

Control- It is the study of the development of suitable methods of controlling the disease and reducing the losses caused by them.

Antagonism- The inhibition of growth of one organism by the other which may be due to production of antibiotics, for competition for food etc.

Biotrophs- Certain organisms obtain their nutrition from living organisms only and complete their life cycle within the living tissues are called *biotrophs* e.g. rust, smut, powdery mildew causing fungi etc.

Elicitors- Chemical signals generated by an organism to bring about metabolic shifts in another organism. The term **elicitor** is applied in phytoalexin production.

Fungitoxic- Antifungal substance which are harmful for the growth of fungi are known as fungitoxic, e.g. fungicides.

Fungistatic- Fungistats are compounds which prevent growth of fungus as long as fungus and fungistat are in contact.

Hypersensitivity- The extreme degree of sensitivity of the host plant to the pathogen, resulting in the death of the host cells in the vicinity of the invading pathogen, thus blocking the advance of pathogen.

Inoculum- The part of a pathogen which enters the host cells and is capable of causing disease. For example, Inoculum in bacteria is the entire cell, in virus the entire particle and vegetative hyphae and spores in fungi.

Infection- The establishment of nutritional relationship between the host and pathogen is known as infection. When the pathogen spreads throughout the plant in varying degrees and is associated with all phases of its life cycle. It is known as systemic infection.

Invasion and colonization- After entering or infecting the host cells, the pathogen slowly begins to attach or *invade* neighboring host cells and begins to establish itself within the host tissue by rapid division. This is known as *colonisaton.*

Incubation- The interval of time between infection and appearance of disease symptoms is known as *incubation.* Incubation period varies with host pathogens and environmental conditions.

Immune- A plant which can resist or overcome disease infection is said to be *immune.*

Latent infection- The dormant state in which a host is infected with a pathogen but does not show any symptoms.

Lesion- It is a localised area of discoloured, diseased tissue.

Mosaic- It is a viral diseased leaves characterized by intermingled patches of normal green and light green or yellow colour.

Necrotic- The term refers to tissues which are dead and discoloured.

Non-infectious disease- Disease caused by an environmental factor and not by a pathogen. This disease can not be transmitted.

Parasite- Organisms that obtain their nutritional requirements from living plants (host) are called *parasites.* Parasites may be *obligate* if restricted to living tissues only and *facultative* if growing in living or dead tissue.

Pathogen and pathogenicity- Any organism, part or entire, which can infect another organism (host) disturbing the host's metabolism is known as *pathogen* and the ability of the pathogen to cause disease is known as *pathogenicity.*

Resistance- The extent to which a plant prevents the entry, invasion and colonization of a pathogen is a measure of the plant's *resistance.* A plant is said to be *immune* when it shows *high resistance* and *susceptible* when it shows *low resistance* to the **pathogen.**

Recognition System- The earliest time when molecules of the host cell recognise the molecules of the pathogen and accept it for establishment.

Saprophytes- Organisms which derive their nutrition from dead organic matter.

Suscept- A plant that can be attacked by a given pathogen i.e. the host plant.

Susceptibility – The inability of a plant to resist the effect of a pathogen.

Symptomless carrier- A plant which produces no obvious symptoms inspite of being infected with a pathogen (usually a virus).

Systemic- A pathogen or a chemical which spreads internally throughout the plant body.

Syndrome- The set of varying symptoms characterizing a disease is termed as *syndrome.* For instance a disease may be characterized by necrosis of tissues, wilting and hypertrophy. All these symptoms collectively known as syndrome.

Phyllosphere- This term refers to the total above ground surface of plant when viewed as a habitat for microorganisms.
Rhizosphere- The soil surrounding the plant roots when viewed as a habitat for microorganism.
Antagonism- Antagonism refers to the action of any organism that suppresses or interferes with the normal growth and activity of a plant pathogen, such as bacteria or fungi.
Competition- An interaction between organisms or species in which both the organisms or species are harmed. Competition may be intra specific (among the members of same species) or intre specific (between the individual of different species)

SAQ 3.

a. Pathogen is a ……………..entity which causes disease.
b. ………………………increased mathematically similar to simple interest on money.
c. Mosaic is a ………………disease symptom.
d. Necrotic means……………………..and discoloured tissue.

1.8 Summary

- Heinrich Antonde Bary is considered FATHER OF PLANT PATHOLOGY as well as founder of MODERN MYCOLOGY.
- . Sir Edwin John Butler is considered FATHER OF PLANT PATHOLOGY in India.
- Sir K C Mehta and R Prasada worked on epidemiology of cereal rust in India.
- T.S. Sadasivan established the school of mycology and plant pathology at Madras University and laid the foundation of research of soil brone pathogen in India.
- Prof. Millardet of Bordeaux discovered Bordeaux mixture which is a mixture of copper sulphate and lime. This mixture was used to control the mildew disease of grapevine.

- The discovery of tobacco mosaic virus by Meyer in 1886 was the birth of the study of virus as pathogenic agents.
- In the twentieth century major tends in the areas like Physiological plant pathology, Genetics of host and pathogen, Fungicides, Environment in relation to plant disease, Disease resistance in plants, Biochemistry and physiology of diseased state, Tissue culture in plant pathology as well as Ecological studies of phytopathogens.
- All pathogens are parasite but all parasites are not pathogen.
- The parasite which cause disease on the host are called pathogen.
- The potential capacity of infection of any pathogen is called its pathogenicity.
- The process of pathogensis has three phases: Prepenetration phase, penetration phase and post penetration phase.
- Symptoms of disease appears on the host surface after pathogenesis.
- Four criteria of Koch's postulates are necessary in establishing relationship between a microbe and a disease (The pathogenicity Test)
- The diseases may be classified as Systemic and Localised, Epidemic or Epiphytotic, Sporadic, Pandemic, Soil Borne, Seed Borne and Air or Wind Borne.
- Host is the plant on which pathogen survives.
- Pathogen is a living organism which causes disease. Symptoms are external sign on the host plant which indicates disease.

1.8 Terminal Questions

Long Answer Questions:

1. Write a brief account of history of plant pathology.

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2. What is plant pathology? Discuss its progress achieved in twentieth centaury.

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3. Describe classification of plant Diseases.

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Differentiate Between:

a) Host and suscept

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b) Simple interest disease and compound interest disease.

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c) Non parasitic and parasitic disease.

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d) Primary inoculum and secondary inoculum.

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e) Fungitoxic and Fungistatic

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Write Short Notes on:

a) Significance of plant pathology
b) Koch's postulates
c) Inoculum

Define the following terms:

(a) Pathogenesis (b) Epidemiology

(c) Disease (d) Hypersensitivity

(e) Necrotic (f) Symptom

(g) Parasite (h) Saprophyte (i) Syndrome

1.9 Answers

SQA 1:

a) Millardet

b) Heinrich Anton de Bary

c) BB Mundkur

SQA 2:

a) Robert Koch

b) whole

c) parasitic

d) all over

SQA 3:

a) living

b) simple interest disease

c) viral

d) dead

Unit-2 SYMPTOMS OF PLANT DISEASES

Structure

2.1 Introduction

Plant Diseases: Plant disease is an impairment normal state of a plant that interrupts or modifies vital functions. A plant disease can also be defined as any problem with the plant that leads to a reduction in yield or appearance. Many plant diseases are caused by pathogens. The disease causing agents are called pathogens. A plant may be said to be diseased when there is a harmful deviation from normal functioning of physiological processes.

Objectives:-

After studying this unit you will be able to:

- Classify plant diseases.
- To known conditions necessary for pathogenic diseases.

- Identify various fungal, bacterial and viral diseases of plants by their symptoms.

2.2 Classification of Plant Diseases:

On the basis of causal agent the plant diseases are classified as:

(i) **Non Infectious Plant Diseases:** They are not associated with any animate or pathogen, so they cannot be transmitted from an infected plant to a healthy one. They are due to disturbances in the plant body caused by lack of certain inherent qualities, by improper environmental conditions of soil and air and by mechanical influences e.g.

1. Low/High temperature
2. Unfavourable O_2 level
3. Unfavourable water level
4. Rain
5. Wind
6. Air Pollution toxicity etc.

(ii) **Infectious Plant Diseases:** These are the diseases caused by pathogenic organisms or Virus, under a set of environmental conditions. Fungi, bacteria, viruses and nematodes are some pathogen. They obtain nutrients, water and everything from their host to They need host to reproduce also. Fungal and viral pathogens cause many plant diseases; bacterial and nematode pathogens cause a few. Some pathogens can infect several kinds of plants; others require a specific type of host. Pathogens such as fungi and bacteria differ in their ability to survive, spread and reproduce.

2.3 Conditions Necessary for Pathogenic Disease

Three conditions are necessary for pathogenic plant disease:

- A susceptible host plant.

- An active, living pathogen must be present.
- A suitable environment for disease development.

Sign: A sign of plant disease is physical evidence of the pathogen.

Disease Symptoms: The symptom of plant disease is a visible effect of disease on the plant. Symptoms may include a detectable change in colour, shape or function of the plant as it respond to the host.

2.4 Symptoms of Fungal Diseases.

Symptoms are visible effect which pathogen induces on the host plant. Symptoms can be divided into two categories:

(A) Symptoms due to external appearance of pathogen or some part of pathogen on the host are:

1. Mildew
2. Rust
3. Smut and Bunt
4. Sclerotia
5. White blister

1) **Mildew:-** The pathogen is seen as a superficial growth on the host surface in the form of patches of varying size. It is of two types:

(a) Downy Mildew **(b)** Powdery Mildew

a) Downy Mildew	b) Powdery Mildew
Pathogen is internal obligate parasite. The mycelium and sporangiophor are produced on the lower surface of leaves giving cottony appearance.	Pathogen is external obligate parasite. White powdery masses scattered over the surface of plant parts. The powdery appearance is due to formation of numerous conidia in the form of a coating on the host surface e.g. Powdery mildew of cucurbits caused by *Sphaerotheca* sp.

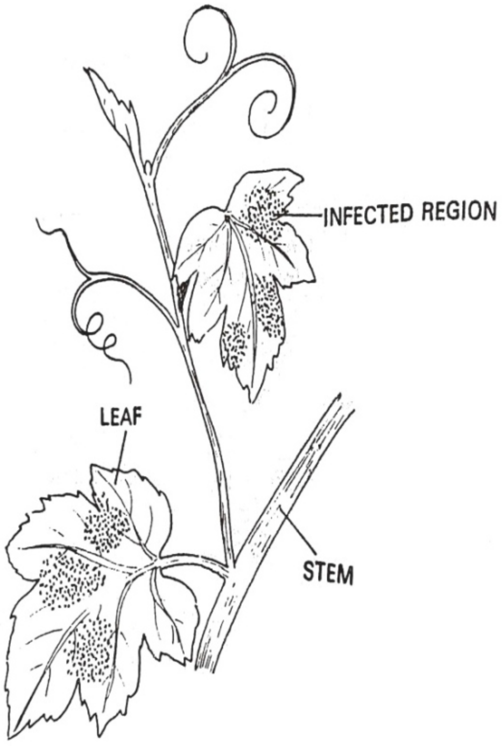

Fig.2.1.a. Symptoms of Downy Mildew

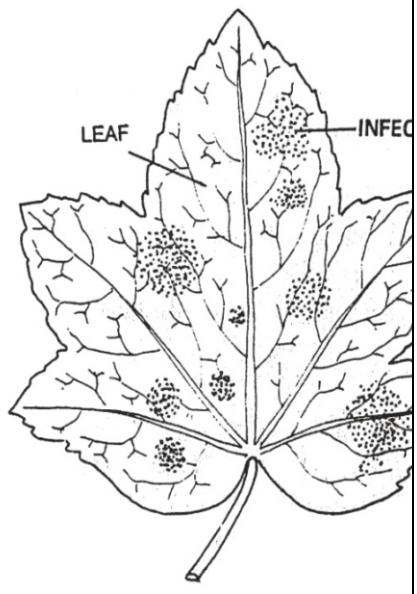

Fig.2.1.b. Symptoms of Powdery Mildew

2. Rust:- Symptoms appear as small coloured pustules on host surface. Colour may be red, yellow, black, brown and orange. These symptoms are produced due to exposure of underlying mass of spores because of ruptured epidermis. e.g. ***Black rust of wheat Caused by Puccinia graminis tritici.***

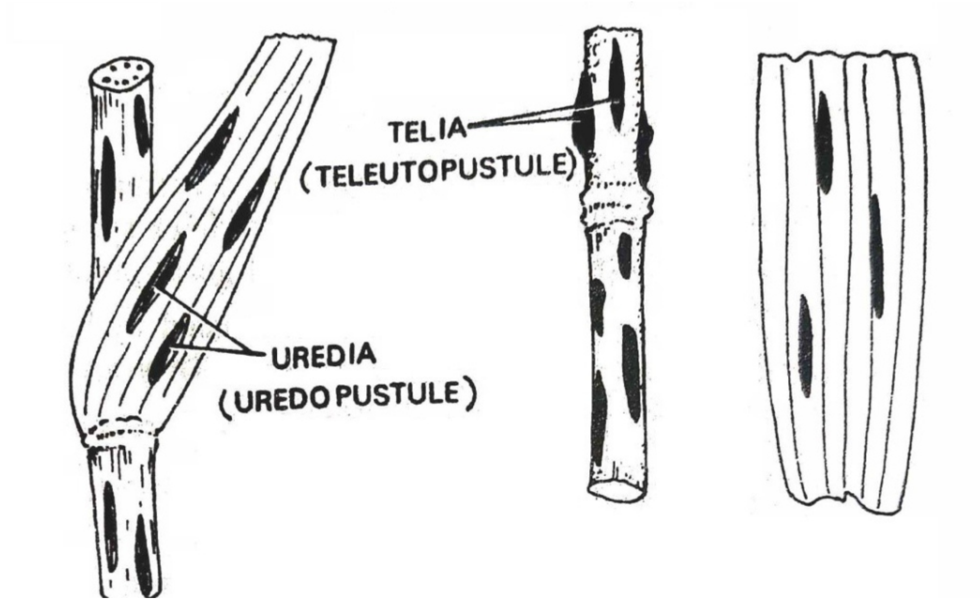

Fig. 2.2. Symptoms of Rust

3. Smut & Bunt:- Symptom of smut appears on the floral organs particularly in ovaries. The infected ear look charcoal like as the overy has black powdery mass of smut spores instead of grain. The smut is of two types-

(a) Loose Smut (b) Covered Smut

(a) Loose Smut	(b) Covered Smut
The smut spore remain covered by thin membrane in the beginning but soon it ruptures and smut spores get exposed and disseminated e.g. Loose smut of wheat caused by- *Ustilago tritici*	The smut sposes remain coved by wall of the grain and glume. They get exposed only at the time of threshing. e.g. *Covered smut of Barley caused by Ustilago hordei.*

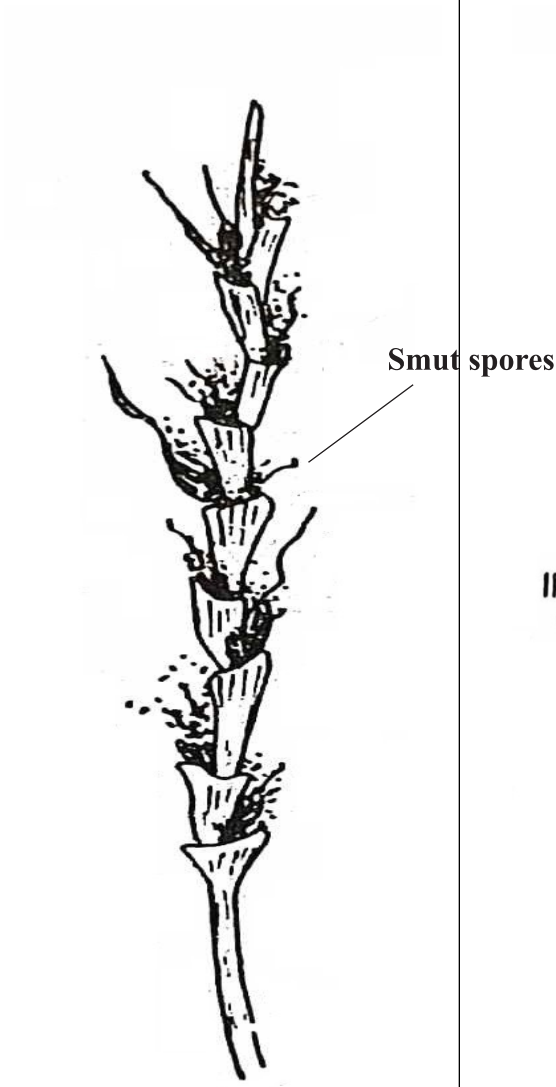

Fig.2.3.a. Symptom of Loose Smut

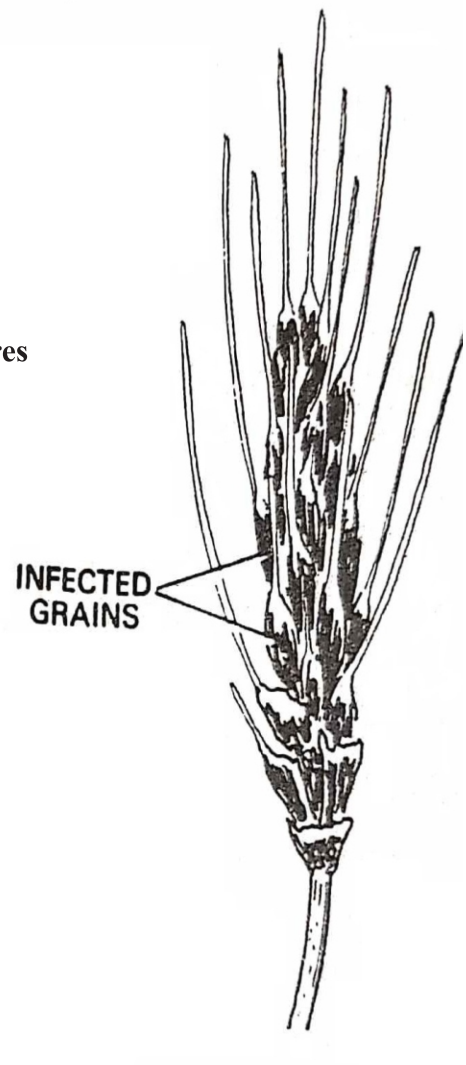

Fig.2.3.b. Symptom of Covered Smut

In case of sugar cane the whole floral axis is transformed into a black dusty whip eg. Whip smut of sugarcane caused by *Ustilago scitaminae.* In case of bunt the smutted ear has a thick Pericarp and ear given a stinking smell e.g. Bunt of wheat caused by *Tilletia foetida*

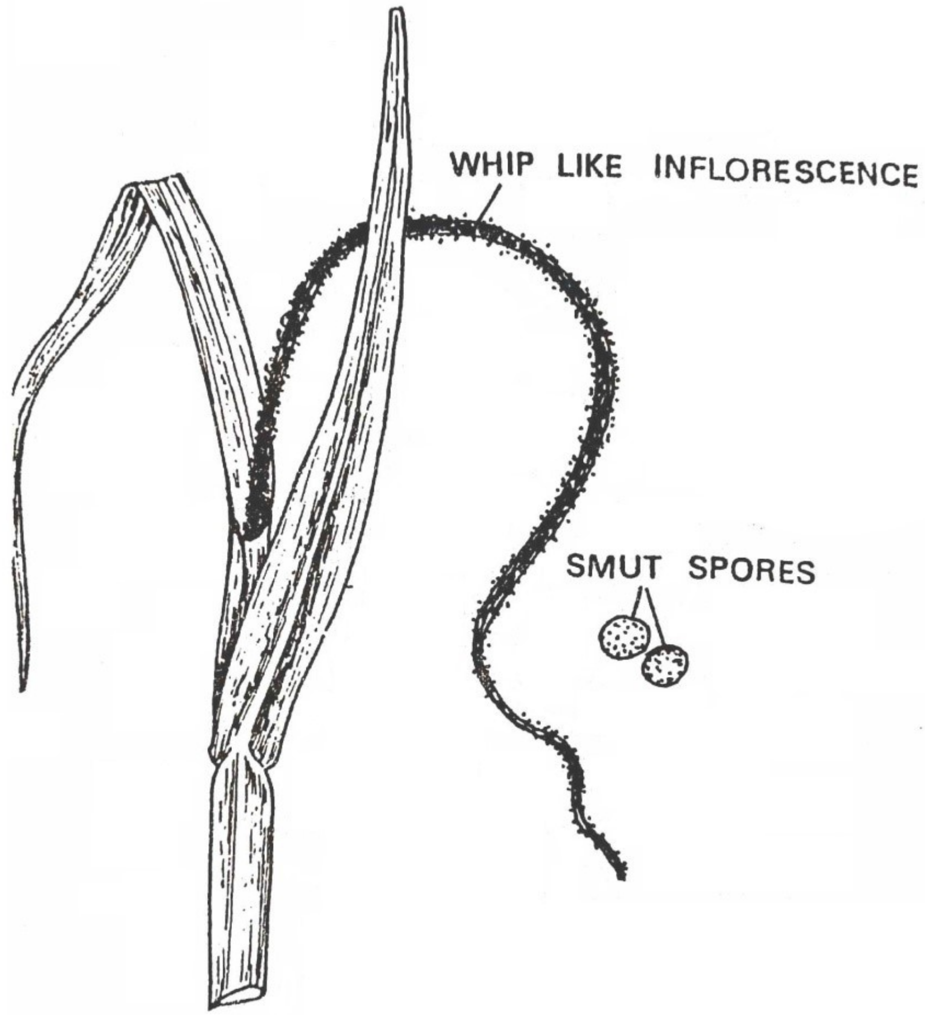

Fig. 2.4. Whip smut of sugarcane

4. Sclerotia:- It is a compact hard mass of dormant fungal hyphae which may be brown, black, gryeish, violet or purplish. In some case e.g., Ergot of rye, the selerotia are formed in the position of Kernel in the spike.

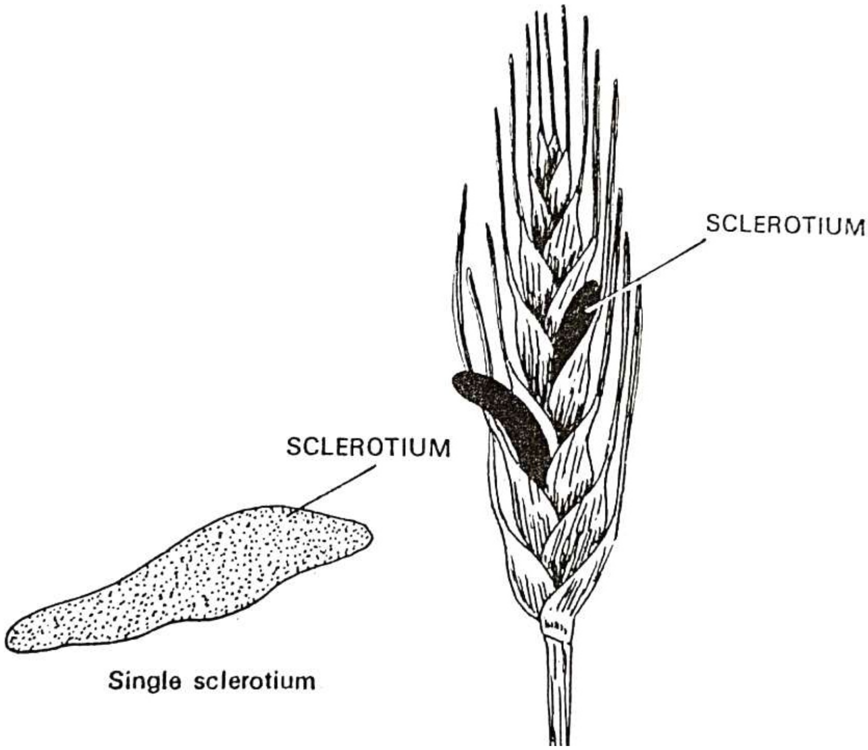

Fig. 2.5. Symptom of Sclerotia

5. White Blister:- White shiny blister like pustules are produced on the lower surface of the leaf of *Brassica* due to exposer of white powdery masses of conidia as a result of rupture of epidermis. e.g. White blister or Rust of Crucifer is caused by *Albugo candida.*

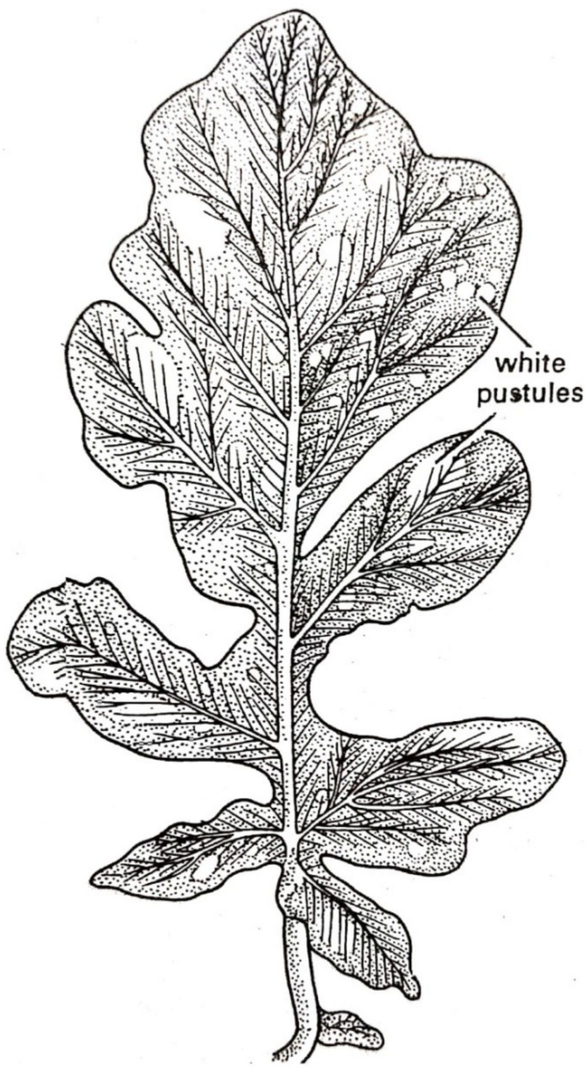

Fig. 2.6. Symptom of White Blister

B. Symptoms which are visible effect induced by pathogen on host are:

1. Necrosis

2. Overgrowth

3. Undergrowth

1. Necrosis:- In this death of host tissue take place which is induced by attack of pathogen Necrotic symptoms are as fallows:-

- **Lesions or Leaf Spot**:- In many cases necrosis is confined to small area and is called *Local Lesions*. Which may be big or small, circular, oval or irregular in shape and variously coloured.

  In many cases dead tissue of the spot may fall out leaving a hole. This is called *Shot Hole.*

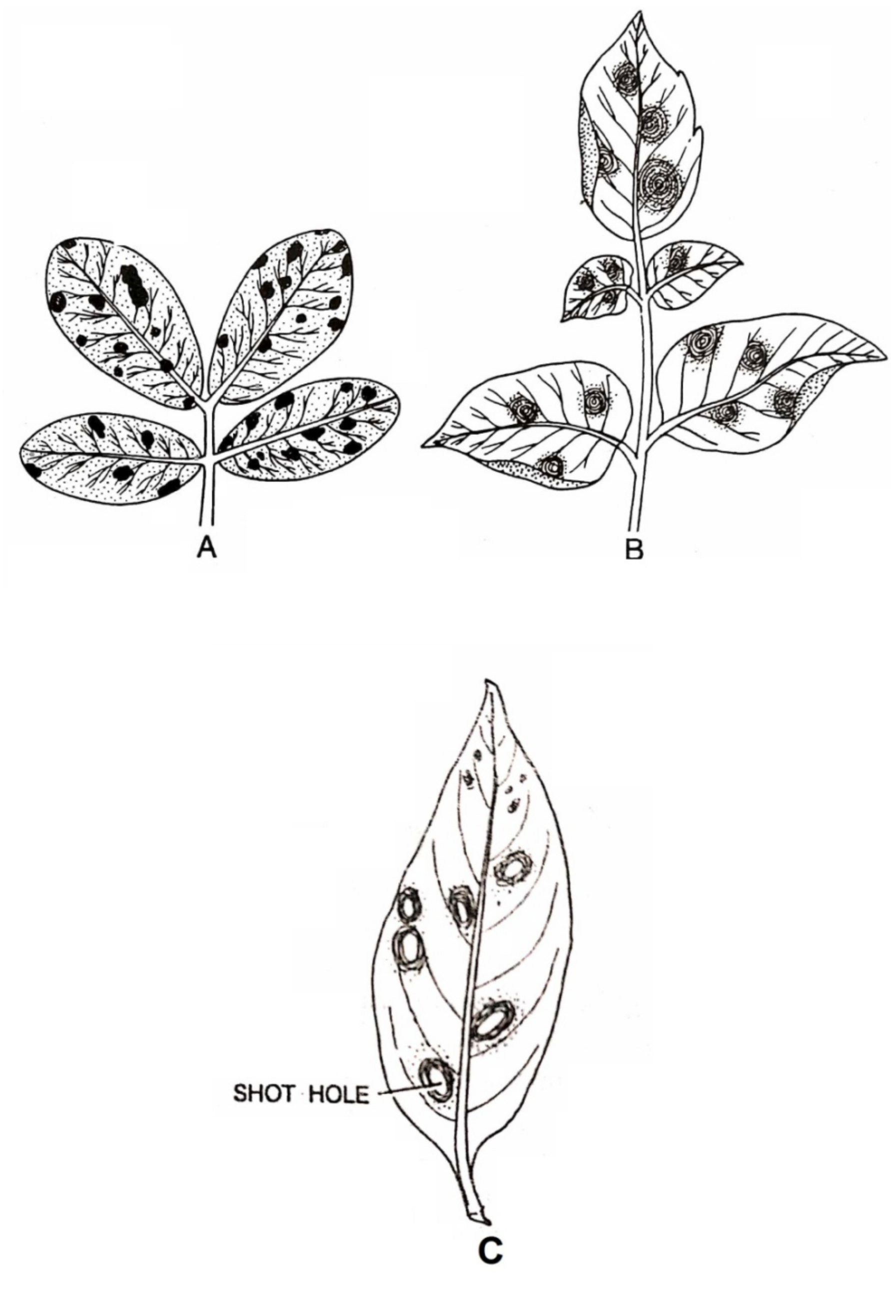

Fig. 2.7. A to C Symptoms of Lesions or Leaf Spot

- **Wilt:-** Plant show dehydration and drought. Symptom first appears in fleshy shoot and leaves. The leaves become flaccid due to loss of turgidity and result in dropping of entire plant. Pathogen attacks the root of the plant and get accumulated in the vascular tissues of stem and root. It causes obstruction to the movement of water. Tyloses are also formed in the lumen of vessel. Besides this pathogen secreates some toxic substance such as gum, gel, pectins and polysaccharides.

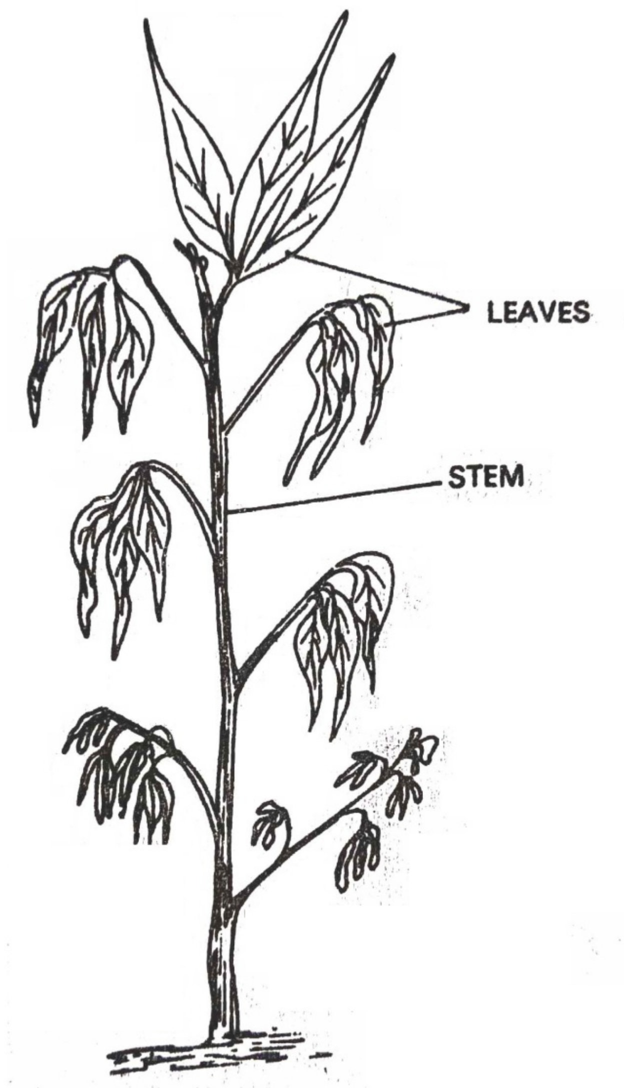

Fig. 2.8. Symptom of Wilt

- **Damping off**:- Young seedings are killed either before their emergence from the soil or after emergence. When they are killed before emergence it is called *Pre emergence Damping off* in which young radical and plummule get rot and finally die.

When newly emerged seedings are killed at ground level it is called *Post emergence damping off*. In this the pathogen attacks the base of stem (hypocotyle) usually just below the soil line. The infected tissue becomes soft and water soaked as a result the seeding topples over or collapse.

Fig. 2.9. Symptom of Damping off

- **Rot**:- In Rot the affected tissue die and undergo decay. The Rot diseases may be classified on the basis of the organ attacked such as leaf, stem, root, bud and fruit rot. In rot the death and decay is due to disintegration of cells and middle lamella by the action of enzymes. It turns black to brown. Rot may be soft and dry. When symptom is watery it is called soft rot.

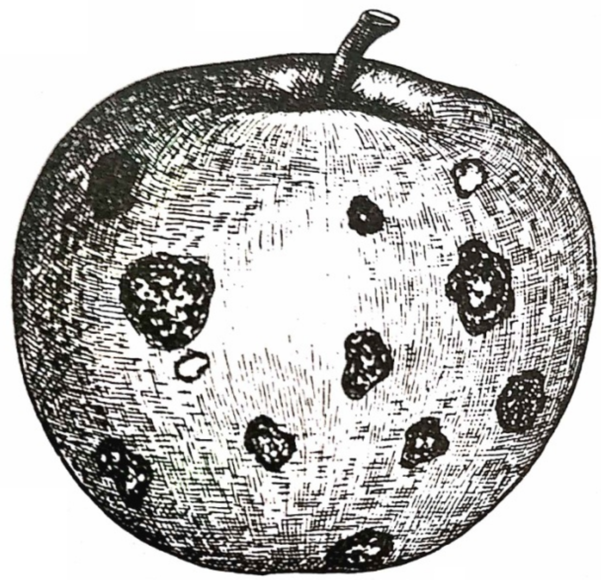

Fig. 2.10. Symptom of Rot

- **Blight**:- The symptoms give a brunt appearance. Sudden and etensive damage to the leaves and other part of plant in response to attack of pathogen. Initially symptom appear in the form of circular or irregular spot on the leaf. It increases in size and cover the entire leaf. The affected tissue become necrotic and gives burnt appearance. In severe attack leaves shrivell and fall down e.g. Late Blight of Potato caused by- *Phytophthora infestens.* Early Blight of Potato caused by- *Alternaria solani.*

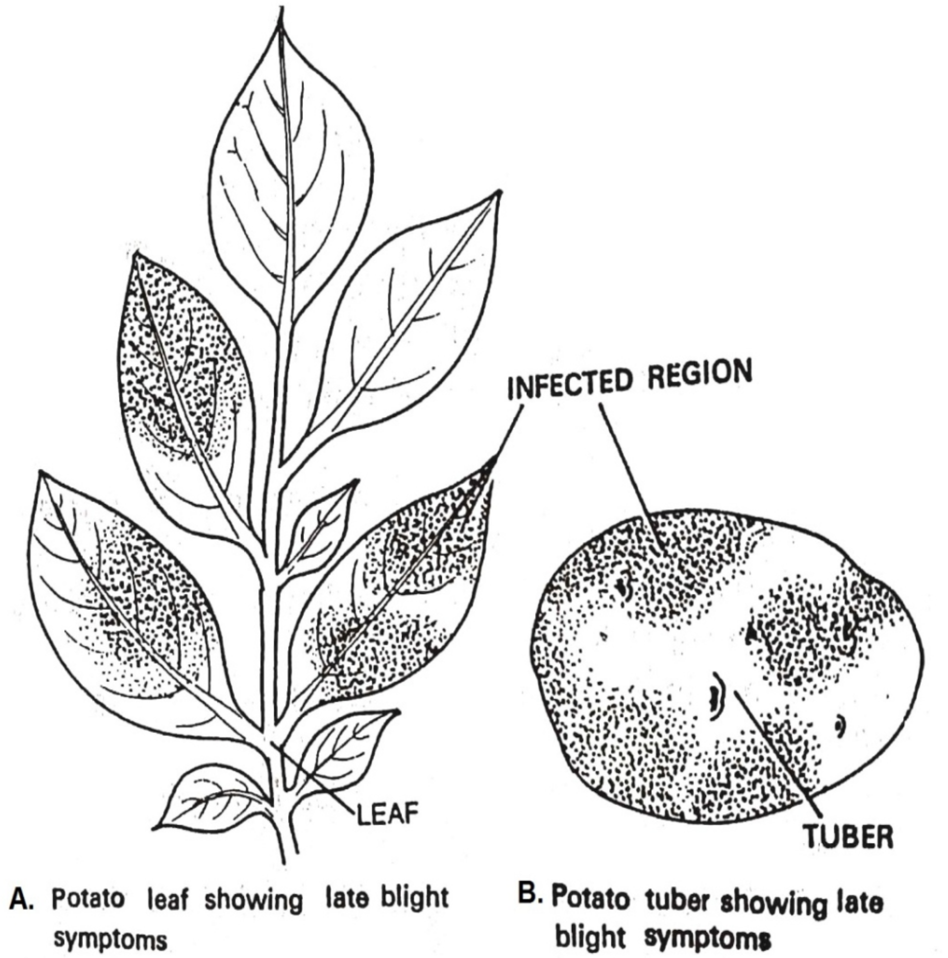

Fig. 2.11. A-B, Symptoms of Blight

2. Overgrowth:- Sometimes over growth in the host tissues are induced which may be, either due to *Hypertrophy* or due to *Hyperplasia* or due to both.

In **Hypertrophy** the abnormal increase in size of one or more organ of a plant is due to increase in cell size of host plant induced by pathogen.

In **Hyperplasia** the abnormal increase in size of one or more organ of a plant is due to increase in no. of cells of host plant induced by pathogen.

Hypertrophy and Hyperplasia causes distortions, swellings, leafcurls and gall. e.g Hypertrophy of *Brassica* caused by *Albugo.*

Fig. 2.12. Symptom of Overgrowth Showing Hypertrophy

3. Undergrowth (Atrophy):- Symptoms are characterised by undergrowth or under development of tissue. It produce *Dwarfing Symptom* in which size of leaf reduces, nodes and internodes become short. Plant fails to produce flower and fruit and finally die e.g. Little leaf of brinzal caused by *Mycoplasma*.

SAQ 1:-

a) Black rust of wheat is caused by ………………………………………..

b) Symptoms of smut appear on the floral organ particularly in ………………….

c) *Albugo candida* causes …………………….. in crucifer.

d) *Phytophthora infestens* causes ………………….. of Potato.

2.5 Symptoms of Bacterial Diseases:-

All plant pathogenic bacteria are rod-shaped and majority are flagellated. Only two genera among the six e.g. *Corynebacterium* and *Streptomyces* are Gram positive while the rest are Gram negative .

The Pathogenic bacteria enter into the plant through: (1) Root hairs, stigmas (2) Natural openings such as stomata and (3) incidental wounds. After entering into the suitable host, the bacteria may establish themselves interacellulary, intracellulary, intravscularly or in more than one combination and exhibit following types of disease symptoms;

Local Lesions:-

Local lesions or spots appear on the leaf blade in the petiole, stem etc. when such spots occur on fruits, resulting in the discolouration of fruits. The spot first appear as minute water soaked specks spreading rapidly to form irregular, angular or Circular spots. The lesions or spots become necrotic (dead).

Soft Rots-

In this case softening of host tissue occurs due to disintegration of cells and dissolution of middle lamella as a result of enzymatic action and oozing of watery secretion from the affected part. It is followed by plasmolysis and death of host cell. The bacteria grow upon this dead plant tissue.

Cankers and Scabs:-

Cankers and scabs are Corky outgrowths formed on above ground parts of the host such as leaves, twigs, fruits. These outgrowths are the result of the reaction of host tissue to the pathogen. The Canker in deep seated, local, dead lesion results in open wound sunken in the stem surrounded by living tissue. Scab on the other hand are not deep seated because it is formed by epidermal infection. Such infections are common in citrus, mango and many other fruit and forest trees e.g. Citrus canker disease is Caused by *Xanthomonas citri.*

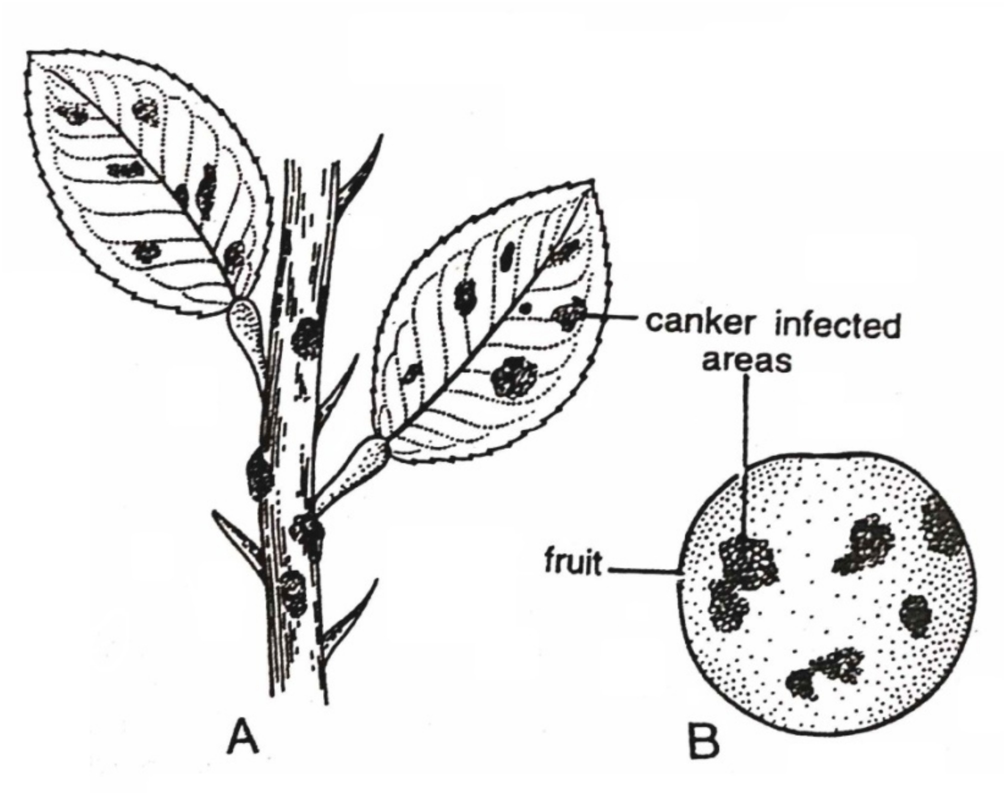

Fig. 2.13. A-B. Symptoms of Cankers

Tumours and Galls :-

In some cases invasion of bacterial pathogen result in the hypertrophy and hyperplasia of invaded tissues. This hypertrophy and hyperplasia is due to some chemicals produced in the vicinity of the host cell as a result of chain of reactions caused by pathogen. Due to this tumours and galls develop on the affected organs. Crowngall disease caused by *Agrobacterium tumefaciens* is the best example of this.

Vascular Disease:-

In some of the bacterial leaf spots pathogen moves into the vascular tissues and become systematic. In others, the invasion is concentrated in the vascular tissues, resulting in typical wilt of the affected plants. Pathogenic infection obstructs movement of water in the vessels due to depositions of gum and formation of tyloses in the lumen of vessel. The collapse of vessel also contribute to wilting.

SAQ 2:-

a) Canker is a …………………………lesion.

b) Crown gall disease is caused by ……………………….

2.6 Symptoms of Viral Diseases.

(1) Leaf Curl:- Curling, distortion and reduction in the size of leaf is produced by virus. e.g. Leaf curl of papaya is caused by *Tabacco virus 16.*

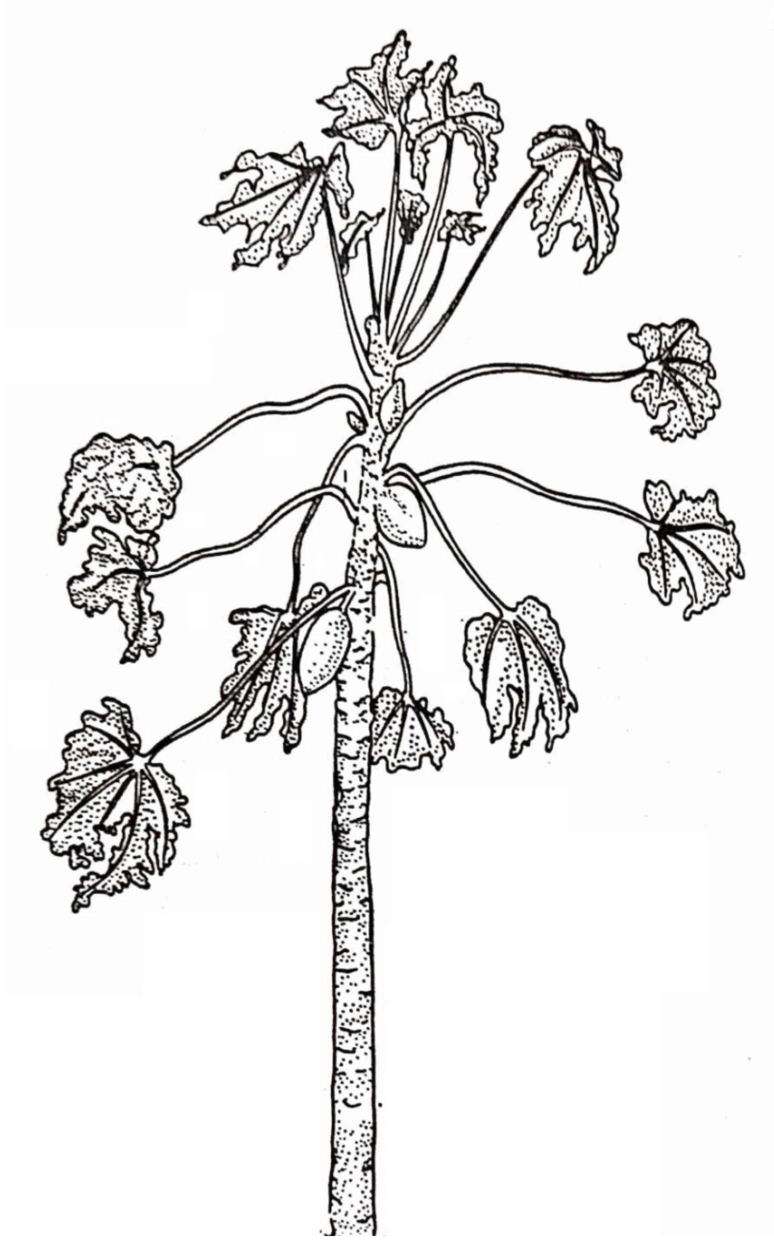

Fig. 2.14. Symptom of Leaf curl of papaya

(2) Colour Changes:- Natural colour of the plant changes due to attack of virus which are of following type-

(a) Mosaic:- Characteristic light and dark green pattern accompanied by blistered appearance of leaves due to more rapid growth of dark green tissues. It is caused by viruses. e.g. Tabacco Mosaic disease is caused by *Nicotiana virus*

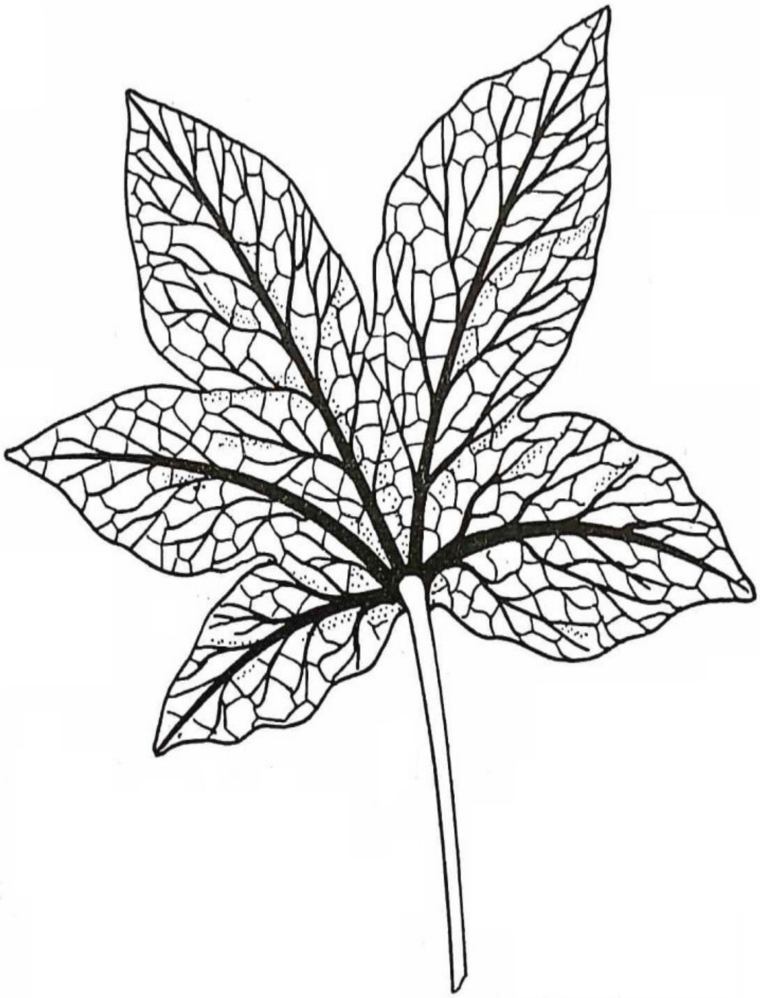

Fig. 2.15. Symptom of Mosaic

(b) Chlorosis:- In this yellowing take place in the leaf.

(c) Vcin Clearing:- In this yellowing of vein and veinlets take place as a result a yellow network of vein is formed. e.g. Yellow vein mosaic of bhindi is caused by *Hibiscus vircus* I. In this veinclearing is followed by veinal chlorosis of the leaves.

(d) Vein Banding:- The tissue close to vein remain green but the remaning tissue undergo chlorosis.

3. Local Lesion:- Symptom appears in the form of chlorotic or necrotic small area Necrosis is killing of cells and tissues and area where necrosis occur is called lesion.

4. Distortion:- The infected plants show altteration in the symmetry of leaf arrangement. Crinkling of their edges rolling and resetting of leaves by retanted growth of vains. In some cases the leaves get clerteed & wiry then called *witche's broom.*

5. Ring Spot:- Rounded spot which appears on the leaf either singly or in cluster of 4-6. The spot enclose necrotic tissue with chloreitie area against the dark green back ground.

6. Outgrowth and Tumours: In certain cases plants parts develop out growth due to attacked of virus. eg. Secondry leaves are developed on the midribs of leaves or root develop tumours.

7. Colour Break: Some viral diseases produce coloured spot or streaks on floral petals and furits. These are called *Colour Breaks'*

1. Yellow streaks in tulip
2. Pink flower of geadish
3. Chlorotic spots on fruits of tomato.

SAQ 3:-

a) Leaf curl of Papaya is a ………………………..diseases.
b) Tobacco Mosaic is caused by …………………………
c) In chlorosis ……………….take place in the leaf.

2.7 Some Important Fungal, Bacterial and Viral Diseases.

Disease	Pathogen (causal organism)	Symptom
FUNGAL DISEASES		
Damping off of seedlings	*Pythium debaryanum*	The young seedling rot from the base and topple over
Downy mildew of crucifers	*Perenospora brassicae*	Small or large purplishbrown spots on the ventral surface of leaf
Downy mildew of cucur bits	*Pseudoperanospora cubensis*	Pale yellow, angular patches on leaves.
Downy mildew of bajra	*Sclerospora graminicola*	The whole inflorescenceted into leafy bearded structures with out bearing any grains.
Powdery mildew of wheat	*Erysiphe graminis*	A grayish-white powdery growth occurs on the leaf.
Powdery mildew of peas	*Erysiphe polygoni*	The powdery whitish spots completely cover the leaves, petioles, stem and even the pods.
White rust of crucifers	*Albugo candida*	White or cream-yellow coloured pustules appear on the leaves.
Black stem rust of wheat	*Puccinia graminis tritici*	Black coloured lesions or pustules

		appear on stem, leaves and leaf sheaths.
Brown rust of wheat	*P. recondita*	Bright orange coloured pustules appear in small clusters or irregularly distributed on the leaves.
Yellow rust of wheat	*P. striiformis*	Lemon-yellow coloured oval pustules appear arranged end to end in a series, chiefly on the leaves.
Rust of linseed	*Melampsora lini*	Brown or black coloured pustules (telial stage) or orange coloured pustules (uredial stage) appear on both the surface of the leaf.
Rust of bajra	*P. penniseti*	Black coloured pustules appear on both the surfaces of the leaf, leaf sheath and stem
Loose smut of wheat	*Ustilago tritici*	The symptoms appear on the inflorescence only, the diseased ear consists of deformed spikelets filled with black, dry powdery mass

		of spores.
Loose smut of barley	*U. nuda*	Symptoms similar to loose smut of wheat.
Covered smut of barley	*U. hordei*	The symptoms appear on the inflorescence only. The smutted ear is shorter in length and every grain is replaced by a black spore mass which are held firmly by a persistent membrane.
Smut of bajra	*Tolyposporium psnicillariae*	Bright green to dirty black coloured infected grains, enlarged in size and irregularly distributed in the ear.
Whip smut of sugarcane	*U. scitaminea*	The floral shoot gets transformed into a long, whip like, dusty, black shoot, which is covered by a thin membrane.
Die-back of chillies	*Colletotricurm sapsiri*	The infection starts from the growing point of the branches and advances backward and downwards, the infected part of the stem assumes an

		enamel white colour sharply demarcated by a black line.
Mango anthracnose	*C. gloeosporioides*	On the leaves, dark brown necrotic area develop, on the twigs black necrotic areas whereas black spots appear on the older fruits.
Club root disease of cabbage	*Plasmodiophora brasicae*	The infected roots enlarge to form 'clubs' and their diameter increases 10-12 times the normal root, the leaves become pale green or yellowish in colour.
Wart disease of potato	*Synchytrium endobioticum*	The infected tubers bear dark brown, warty, tumerous out growths.
Wilt of pigeon pea	*Fusarium oxysporum f.sp. udum*	The seedling and adults wilt which is characterized by yellowing, withering and drying of leaves, branches and finally the entire plant.
Root rot of cotton	*Rhizoctonia bataticola*	The entire root system get completely rotted.

Leaf spot of groundnut	*Cercospora personata*	Dark brown to black spots, which are almost circular, 1-6 mm in size, occurring on leaves, stipules petioles.
Early blight of potato	*Alternaria solani*	In the necrotic spots, concentric rings appear on the older leaves and darkened areas on the stem giving a target-board like effect. A narrow chlorotic zone appears around the spots.
Late blight of potato	*Phytophthora infestans*	In the initial stage, purplish brown spots appear on the foliage, later the tubers get injected manifested by dry or wet rotting.
Leaf curl of peach	*Taphrina deformans*	The leaf blades become thickened and puckered along midrib, resulting in the curling of the leaves downwards. The leaves become reddish, thick and fleshy and the upper surface is covered bloom of fungal spores.

Ergot of bajra	*Claviceps purpurea*	The inflorescence gets infected and the ovaries are converted into small dark grey, hard sclerotia.
BACTERIAL DISEASES		
Citrus canker	*Xanthomonas citri*	The diseases appears as dark green spots with a raised convex surface on the leaves branches and fruits.
Yellow ear rot of Tundn disease of wheat	*Corynebacterium tritici*	Twisting of the stem distortion of the earhead and rotting of the spikelets with profuse oozing of yellow liquid containing masses of bacterial cells.
Bacterial blight of rice	*Xanthomonas oryzae*	Drying and twisting of leaf tips which extends to leaf sheaths, culms and glumes. The bacterial mass oozes out and dries on the surface.
Crown gall of stone fruits	*Agrobacterium tumefaciens*	Small outgrowths known as galls appear on stem and roots which are soft in young condition, but become hard and knotty as they grow older.

VIRAL DISEASES		
Tobacco mosaic	*Nicotiana virus 1*	The leaves develop a characteristic light and dark green discolouration pattern known as *mosaic*
Leaf roll of potato	*Solanum virus 14.*	The margins or the tips of the leaves become yellow and roll up.
Leaf curl of papaya	*Tobacco virus 16.*	Crinkling and curling of the leaves accompanied by vein clearing and reduction in the size of the leaves. In later stages, the leaves roll inwards and downwards and turn dark in colour.
Yellow vein mosic of bhindi	*Hibiscus virus I*	Vein clearing followed by veinal chlorosis of the leaves forming a yellow net work of veins.

2.8 Summary

- Symptoms are visible effects which pathogen induces on the host plant.
- Some fungal symptoms are due to external appearance of pathogen or some part of pathogen on the host, e.g. Mildew, Rust, Smut and Bunt, Sclerotia, white blister.

- Some fungal symptoms are visible effect on the host induced by pathogen e.g. Necrosis, Overgrowth and undergrowth.
- Local lesions, Softrot, Canker and Scabs, Tumours, Galls and Vascular disease are bacterial symptoms.
- Leaf Curl, Colour changes, Local lesions, Distortion, Ring spot, Outgrowth and Tumours and Colour break are viral symptoms.

2.9 Terminal Questions

Long Answer Questions:

1. Write an essay on symptoms of various plant diseases produced by fungi.

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2. Write a brief account of various symptoms produced in plants by fungi, bacteria and virus.

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3. Describe various symptoms of diseases produced in plants by bacterial and viral pathogen.

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Differentiate Between:

f) Powdery mildew and Downy Mildew
g) Rust and Smut
h) Loose smut and Covered smut
i) Hypertrophy and Hyperplasia.

Write Short Notes on:

d) Symptoms of bacterial diseases

e) Symptoms of viral diseases.

2.10 Answers

SAQ 1:

a) *Puccinia graminis tritici*

b) Overy

c) White rust

d) Late blight

SAQ 2:

a) Dead

b) *Agrobacterium tumefaciens*

c) *Xanthomonas citri*

SAQ 3:

a) Viral

b) Tabacco virus I

c) Yellowing

Unit-3 CONTROL OF PLANT DISEASE

Structure

3.1 Introduction

Plant disease play an important role in influencing the agricultural economy. Therefore, the main object of disease control is to prevent qualitative and economic losses of crops due to attack by pathogen. The aim of control measures is to save the population rather than a few individual plants. The cost of control measured used in disease control should be less than the economic value of the crop. Various types of pathogens are present in nature. Their complete eradication is impossible. Therefore plant disease control programmes are essential and should be operated in a large areas instead of smaller areas.

Objectives:-

After studying this unit you will be able to know:

- Various methods of disease control.
- Prophylectic measures for protecting plants from diseases.
- Therapeutic measures for disease control after infection.
- The immunization measures for disease control.
- To economic loss of agriculture due to diseases?

3.2 Out line of Various Methods of Diseases Control:

Various methods adopted for control of plant disease can be classified in to following categories:

Methods of Diseases Control

- Prophylactic or Preventive measures
- Therapeutic or Curative measures
- Immunisation measures

Prophylactic or Preventive measures

1- Exclusion
(i) Quarantines

2- Eradication
(i) Field Sanitation
(ii) Rouging
(iii) Eradication of alternate host
(iv) Eradication of collateral host

3- Protection
(i) Crop rotation
(ii) Selection of good quality of planting material
(iii) Condition for germination and emergence of growth

Therapeutic or Curative measures

1- Physical Therapy
(i) Sterilization of soil by heat
(ii) Hot water treatment
(iii) Hot air treatment
(iv) Low temperature treatment
(v) Treatment of radiation

2- Chemical Therapy
(i) Fungicides

Immunisation measures

1- Biological Control

2- Disease Resistance

3.3 Prophylactic or preventive measures:

Prophylactic measures are measures designed to prevent the occurrence of an adverse event, a diseases or its dissemination. Therefore these methods are applied in advance before the spread of disease. These measures are of following three types:

1. Exclusion
2. Eradication
3. Protection

1. **Exclusion:** It includes some regulatory measures to keep away the entry of pathogen in the areas where susceptible hosts are growing. This can be achieved by quarantines or quarantine regulation or Plant Quarantines.

Quarantines or Quarantine regulation or Plant Quarantines:-

Quarantine or Quarantine regulation or plant quarantiones is the legal restriction at the national and international level on the movement of agricultural commodities. The purpose of this regulation is exclusion, prevention or delay in the spread of plant pathogens and diseases in uninfected areas. Quarantine measures are of three types: (i) domestic (ii) internal and (iii) total embargoes.

The first quarantine laws were enacted in USA (1912) and are known as Federal Quarantine Acts. In 1914 India had passed in her legislature the destructive insect and pest Act (DIPACT) which subsequently supplemented by other provisions. This act has been revised eight times from 1930 to 1956 and corrected upto 1967; but it still does not fulfill the needs under prevailing conditions. The DIP Act impose restrictions on import and export of diseased plant materials and pathogen. For this purpose there are quarantine station which works at sea ports and air ports. In India there are 16 quarantine stations operating under the Directorate of **Plant Protection** and **Quarantine**. Eight quarantine stations at sea ports, six at airports and two on land frontiers (Hussainiwals in Ferozepur and Sukhia pokri in Darjeeling district).

DIP Act allows import of plant or plant material such as seed, tubers etc. from other countries only when it has a certificate from the ministry of agriculture of the exporting country stating that the plant or plant material is free from pathogen. The imported material is thoroughly checked by the trained staff at quarantine stations. In this way quarantine regulates entery of pathogen in uninfected area and prevents the disease.

Before the DIP Act following diseases are introduction in India (Table-1):

Disease	Introduced From
Leaf rust of coffee caused by *Hemileia vestarrix*	Sri Lanka

Late blight of potato caused by *Phytophthora infestans*	Europe
Flag smut of wheat caused by *Urocystis tritici*	Australia
Downy mildew of grapes caused by *plasmopara viticola*	Europe
Downy mildew of cucurbits caused by *Erysiphe cichoracearum*	Sri Lanka
Downy mildew of maize caused by *Sclerospora phillipinensis*	Java

Table-1

There are a number of lacunae in the DIP Act. As a result many diseases have been introducted in India after DIP Act. (Table-2):

Disease	**Introduced From**
Paddy blast caused by *Pyricularia oryzae*	Southeast Asia.
Powery mildew of rubber caused by *Oidium heveae*	Malaya
Black shank of tobacco caused by *Phytophthora nicotianae*	Dutch east
Crown gall of apples and pears (bacterial disease)	England
Hairy root of apple(bacterial disease)	England
Bunchy top of bananas (viral disease)	Sri Lanka
Wart disease of potato caused by *Synchytrium endobioticum*	Netherlands
Onion smut caused by *Uroevstis cepulae*	Europe
Golden nematode of potato caused by *Heterodera rostochiensis*	Europe

Table-2

In India, so for, quarantine measures exist for two insect pests e.g. Fluted scales and San Tose scale and for three diseases e.g. wart of potato, bunchy top and mosaic of banana.

2. **Eradication:-**

The primary aim of eradication is to break the “infection chain” by eliminating the pathogen.

Thus the production of initial inoculums is reduced by destroying or inactivating the sources of initial inoculums. For this the knowledge of the life cycles of the pathogens, method of perennation, host range and habit of growth are essential prerequisites for division suitable measures to prevent the disease. Eradication is done by using following methods:

(i) Field Sanitation
(ii) Roguing
(iii) Eradication of Alternate host
(iv) Eradication of Collateral Host.

(i) **Field Sanitation:** Field sanitation is a very simplest method of disease control. Pathogens survive or perennate through dormant structures in plant organs and in the soil, which act as inoculums for diseases caused by them. Hence field sanitation is must in which diseased plants are eliminated and destroyed. Destruction of diseased plant is done either mechanically or chemically. Mechanically the plant debris having inoculums and infected plant parts are burned after removal. Chemically they are treated with suitable chemical to kill or inactivate the inoculums. Infact, sanitary conditions are helpful in almost all infectious diseases. Many infectious diseases like powdery mildew of wheat and pea, downy mildew of wheat and pea, wilt of cotton and arhar, red rot of sugarcane can be controlled successfully by field sanitation.

(ii) **Roguing:-** Rouging is careful removal and destruction of infected plant parts from the fields at an early stage. This method is applied in diseases like loose smut of wheat, red rot of sugarcane, ergot of bajara, wilt of arhar, loose and covered smut of barley etc.

(iii) **Eradication of Alternate Host:-** The heteroecious pathogens complete their life cycle on two host; one the primary host and second the alternate host. This alternate host is generally wild and provides shelter to the pathogen during unfavourable conditions. The eradication of such a wild host plant breaks the chain in completing the life cycle of pathogen. For example *puccinia graminis tritici* is a heteroecious pathogen and requires two host wheat and barberry to complete their life cycle. This pathogen causes black rust disease only on wheat plant. The eradication of barberry plant, the alternate host in temperate countries breaks the chain of life cycle of pathogen. It helps in the control of black rust disease of wheat. Similarly the yellow vein mosaic of lady's finger persists on wild hosts in nature and the systemic removal of these hosts help in control of disease.

(iv) **Eradication of Collateral Host:-** Some times pathogen survives on wild perennial plants or grasses. These are called collateral host. For example Blast of rice disease is caused by *Pyricularia oryzae.* This pathogen can infect and survive on several wild species of rice and grasses, such as *Panicum repens, Digitaria marginate* and *Setaria intermedia.* Removal of these collateral host from the area eradicates the pathogen and help in disease control.

SAQ. 1

a. Exclusion can be achieved by ………………………………………..
b. In India there are ……………………quarantine stations.
c. Field sanitation is a very simplest method of …………………………..
d. Heteroecious pathogen can be controlled by eradication of ……………

3. **Protection:-**

In protection preventive measures are applied to discourage the spore germination, penetration into the host and disease development. It is achieved by using following methods:

(i) Crop Rotation
(ii) Selection of Good Quality Planting material
(iii) Condition for Germination and Emergence of plant.

(i) **Crop Rotation:** Crop rotation is an ancient farming practice that has been used by farmers since the BC Centuries. Curl (1963) has reviewed the control of plant diseases by crop rotation. Crop rotation is the practice of planting different crops sequentially on the same plot of land to improve soil health. Continuous growing of the same crop or related, crops leads to the continuous increase of soil borne pathogens in the field. These soil borne pathogens of that crop easily perenate in the soil and increases their population. Ultimately the soil becomes so heavily infested with the pathogen that it no longer supports the growth of the crop. Such soil is called "sick soil". Similar crops tend to have the same pathogens; therefore crop rotation intercepts the pathogen's life cycle and their habitat. It reduces survival rate of pathogen in the absence of the suitable host. Many soil-borne diseases such as wilt of arhar, wilt of pea, red rot of sugarcane, ergot and smut of bajra etc can be controlled by crop rotation. For example *Fusarium oxysporum* causes wilt disease in arhar. This survives in soil. To control this non susceptible other crops are sown in the field for the next 3 or 4 seasons. As a result the chain of pathogen cycle breaks due to absence of suitable host. Thus disease can be controlled. This method is also important in other aspects. If the same crop is sown year after year in the same area, the particular essential elements of the soil will be exhausted with the accumulation of toxic substances and organic acids. Thus rotation of crop helps in disease control by increasing soil nutrients and limiting the concentration of pathogen in soil.

(ii) **Selection of Good Quality Planting Material:** The seeds, tubers, cuttings of plant and grafts are used as planting material. Proper care should be taken during selection of above planting material because if planting material will be infected then the crop will be diseased.

(iii) **Condition for Germination and Emergence of Plant:** Plants should not be sown when the disease pathogen is prevelent in that area. Sowing of the seeds should be done at proper time and proper depth. The appropriate fertilizer should be given at proper time. All above result in vigorous seedling which has capability to fight the pathogens and protect them from disease. Injury in the plant should also be avoided during managing crop in the field to check the entry of pathogen. This will also protects crop from disease.

3.4 Therapeutic or Curative Measures

Therapeutic or Curative measures have been used much often to control plant diseases than in human or animal medicines. The therapeutants inhibits the development of a disease syndrome in a plant when applied for the treatment of diseased plant or plant parts. The therapy is of two types:

1. Physical Therapy
2. Chemical Therapy

1. **Physical Therapy:** In this diseased plants are treated with physical agents like temperature, radiation in the following way:

   (i) **Sterilization of Soil by Heat:-** In this method soil in the field is sterilized by steam at 82^0C or above for 30 minutes. This kills the soil pathogen. But it can not be applied in the fields of large areas. This method is effective as well economic in green houses and seeds beds where the area is small. Therefore soil pathogens of green houses and seed beds are killed by steam sterilization.

   (ii) **Hot Water Treatment:-** This method is used to eliminate seed borne diseases. The infected seeds are first soaked in the water of normal temperature. This result in activation of dormant inoculum of disease causing pathogen. Then seeds are immersed in hot water at 54^0C for 10 minutes only. This will destroy the pathogen but the embryo present in the seed remain safe. The treated seeds are dried before sowing. Thus the infected seeds become pathogen free and give rise healthy plants on sowing.

   (iii) **Hot Air Treatment:** This treatment is given to the plants after harvesting to remove moisture and protect them from fungal and bacterial attack.

   (iv) **Low Temperature Treatment:** It is given to control post harvest disease of fruits and vegetables.

   (v) **Radiation Treatment:-** Many pathogens of post harvest diseases are killed by using radiations such as ultra violet, α, β, γ and x-rays.

2. **Chemical Therapy**

In chemical therapy chemical substances are used to kill the pathogen for disease control. A variety of chemicals are available that have been designed to control plant disease by inhibiting the growth of or by killing the disease causing pathogens. Chemicals used to control bacteria (bactericides), Fungi (fungicides) and nematodes (nematicides) may be applied to seed, foliage, flowers, fruits or soil. They prevent or reduce infection by utilizing various principles of disease control.

Enormous literature is available on chemicals used for control of plant disease like principles of fungicidal action by Horsfall (1956); Fungicides, An Advanced Treatise in two volumes by Torgeson (1967, 1969); plant diseases and their chemical control discussed by Evans (1968); Role of Fungicides in modernizing agriculture in India by Metha (1971).

The use of chemical sprays, dusts or seed treatment for protecting plants from the ravages of the pathogens is not an innovation of the 20th century. In the past agriculturists used chemicals and fungicides to control plant diseases. The first recorded mention of plant disease control is in the writing of the Greek poet, Homer (1000 B.C.), who mention sulphur, which is still in use as fungicide.

Pierre Alexis Millardet (1985) showed that the downy mildew of grapes could be controlled by mixture of copper sulphate and lime. Copper sulphate had been in use even before that but its toxicity was reduced when mixed with lime in 1885. The Bordeaux mixture was used in Europe and USA for the control of many diseases. It was followed by lime sulphurs in the late 19th century and formalion, copper carbonate dusts and organomercurials as seed treatment (1913). An era of organic fungicides thiram, chloranil, dichlone were developed from the mid-1930s on wards and captan the most successful fungicide was developed only two decades ago. Many groups of chemical compounds are now available for plant disease control. This include heterocyclic nitrogen compounds, quinines, phenols and antibiotics.

SAQ 2.

(a) Soil borne diseases can be controlled by ………………………………

(b) Selection of good quality plant material helps in protecting plants from ……………………………

(c) Therapeutic measures inhibits the development of …………… in a plant.

(d) In physical therapy diseased plants are treated with physical agents like ………………….

(e) In chemical therapy ……………… are used in plants for disease control.

Fungicides: The fungicides are chemicals that kills or inhibits the development of the fungal spores or mycelium. On the basis of their uptake by the plant and mobility within plant tissues, the fungicides are classified as:

(a) Protectants
(b) Eradicants
(c) Therapeutants

Protectants: The protectant fungicides are prophylactic in their behavior and may be applied to seeds, plant surface or the soil. Fungicides of this category place a chemical barrier between the plant and the pathogen. These fungicides are not absorbed by or translocated through the plant. Thus they protect only those parts of the plant treated before invasions by the pathogen.

Eradicants: It eradicates the dormant or active pathogen from the host. Eradicants are designed to kill a pathogen that may be present in the soil, on the seeds or on vegetative propogative organs, such as bulbs, corms and tubers. They can remain effective on or in the host for some time and functions as protectant also. Therefore, this chemical can be protectant as well as eradicant.

Therapeutants:- It inhibits the development of a disease syndrome in a plant when applied subsequent to invasion by a pathogen. Usually the chemo-therapeutants are systemic in their action. They enter the plants and affect deep-seated infections.

To be successful fungicide must have following characteristics:

- To be effective against rain and dew.
- Must be nearly insoluble in water, but at the same time they must be soluble enough to function as fungicide.
- Adhesiveness is needed to enable them to stick well and last for a longer period.
- Should not be phytotoxic.

On the basis of chemical nature fungicides are divided into two categories:

(A) Inorganic fungicides
(B) Organic fungicides

(A) Inorganic fungicides:- The inorganic chemicals used as fungicides are known as inorganic fungicides which may be copper compounds, mercury compounds and sulphur sprays.

(I) Inorganic Copper Compounds:-

(i) **Bordeaux Mixture:-** It was discovered by Millardet in 1885 at university of Bordeaux- France. It is a mixture of copper sulphate lime and water. In 1882 millardet was investigating disease downy mildew of vine caused by *Plasmopara viticola.* He observed that infected leaves had bore and get defoliated. But when the leaves were sprayed with Bordeux mixture the defoliation stopped. Then millardet in collaboration with a chemist

Gayon was able to announce the successful use of copper sulphate, lime and water as fungicide against *Plasmopara viticola* (1882). The fungicidal action is due to the formation of soluble copper sulphate which is toxic to spores and sporelings in drops of atmospheric water. It is specific against downy mildew, late blight of potato, coffee rust and various leaf spot diseases. The Bordeaux mixture is sometimes phytotoxic to tender leaves and other parts and burn them.

The formulae for the Bordeaux mixture vary. The original mixture contained 15% copper sulphate and 8% lime (CaO). The proportion of these now varies according to the crop and the disease. Higher concentrations are useful in the case of woody and tough tissues, while lower concentrations are used for succulent and softer parts. The following formula (5:5:50) is regarded as a good standard type:

Copper sulphate (blue stone)	5lb (2.268 kg)
Stone or hydrated lime	5lb (2.268 kg)
Water	50 gallons

The two solutions are prepared separately in wooden or earthen vessels and the diluted solution of $CuSO_4$ is slowly poured into a concentrated lime solution in a tub with constant stirring. The resulting mixture is neutral or slightly alkaline and is not injurious. The mixture is used almost immediately after preparation and deteriorates if left for some time. To avoid this, stock solution of the two ingredients can be prepared separately and stored in wooden vessels. These can be mixed when actually required.

(ii) **Burgundy Mixture:-** Burgundy mixture is a modification of the Bordeaux mixture. It is used in cases of tender foliages, since it is less phytotoxic. In this lime is substituted by sodium carbonate and hence is sometimes called 'soda bordeaux'. The composition of burgundy mixture is:

Copper sulphate (blue stone)	10lb (4.536 kg)
Stone or hydrated lime	12.2lb (5.666 kg)
Water	50 gallons

SAQ 3.

a. Bordeaux mixture was discovered by ……………………..
b. Bordeaux mixture is a mixture of ………………., ……………….. and water.
c. Bordeaux mixture is an …………………………. fungicide.
d. Bordeaux mixture was first time used against ……………. disease.

(iii) **Cheshunt Compound:** It contains two parts of copper sulphate and 11 parts of ammonium carbonate. It is used for the control of "damping off" diseases.

(iv) **Chaubattia Paste:-** The paste is prepared by mixing copper sulphate (800g) and red lead (800g) in one litre of lanolin or raw linseed oil.

(v) **Insoluble Coppers:-** The fungicidal and bactericidal properties of copper is used in the preparation of a variety of copper dusts and sprays such as Perenox, Blitox , Cuprocide and Fytolan.

(i) **Inorganic Mercury Compounds:** Mercury compounds are highly effective as fungicides and bactericides but their use is limited because they are highly toxic to animals and human beings. Mercuric chloride ($Hg Cl_2$) and mercurous chloride (Hg_2cl_2) are used as fungicide in for seed, rhizomes, corms of vegetables and flowers to control certain bacterial and fungal diseases.

(iii) **Sulphur Sprays:-** The effective use of sulphur as a fungicide was discovered in the beginning of the 19^{th} century. Sulphur is the earliest known and widely used fungicide. The preparation of elemental suphur or curde lime suphur were used to control powdery mildew on a variety of crops and leaf curl of peach. The sulphur sprays are:

(i) **Lime Sulphur:** Chemically lime sulphur is a mixture of calcium thio sulphate and calcium polysulphides. Besides fungicide it is an insecticide also. On the tender parts it is phytotoxic hence it has only limited use.

(ii) **Self-boiled lime Sulphur:** This is less toxic than lime sulphur and made by using 8lb of sulphur flour and 8lb of burnt lime with 50 gallons of water.

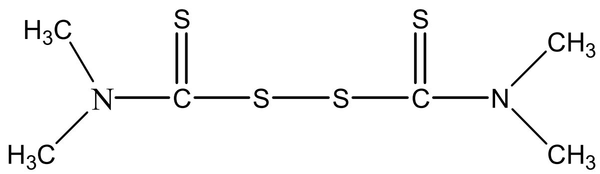
(iii) **Wettable Sulphur:** Wettable sulphurs also known as flotation sulphurs are very finely divided elemental sulphurs. It is extensively used fungicide because it causes less foliage injury.

(B) **Organic Fungicides:-** The organic chemicals used as fungicides are known as organic fungicides . Some of them are as follows:

(i) Organic compounds
(ii) Quinone and Phenolic fungicides
(iii) Heterocyclic Nitrogen compounds
(iv) Benzene Compounds
(v) Systemic Fungicides
(vi) Antibiotics

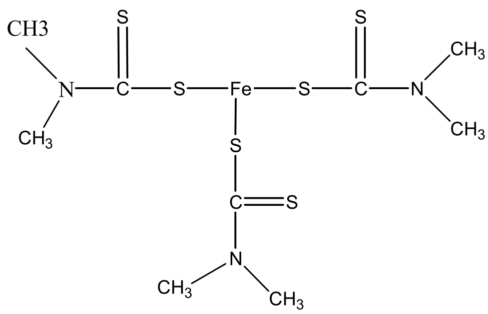
(i) **Organic compounds :-** Some organic compounds used as fungicides are:

- ***Thiram (Tetramethyl thiuram disuphides):*** Thiram is being sold under a variety of other trade names , such as 'arasan', 'tundas', 'terson', 'tulisan' etc. It is used for seed treatment. Thiram is also used in the control of foliage diseases and the soil borane pathogens such as *Pythium, Rhizoctonia, Fusarium* and *Protomyces.*



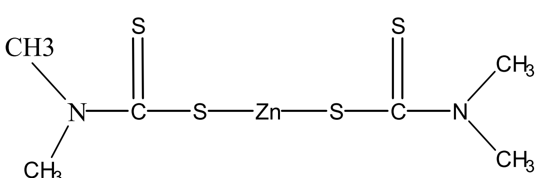
Thiram

- ***Ferbam (Ferric dimethyl dithiocarbamate):*** Its trade name is fermate or ferbam, karbam or coromet. Ferbam has been successfully used as a protectant fungicide, against a wild variety of fungal diseases of fruits and vegetables.



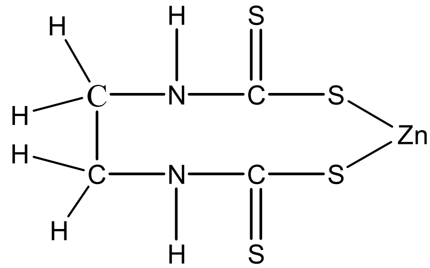
Ferbam

- ***Ziram (Zinc dimethyl dithiocarbamate):*** It's trade names are cumin, zerlate, karbam white, corozae, etc. In India, it is available under the trade name of Cuman and used against many foliar disease in field and orchard crops.



Ziram

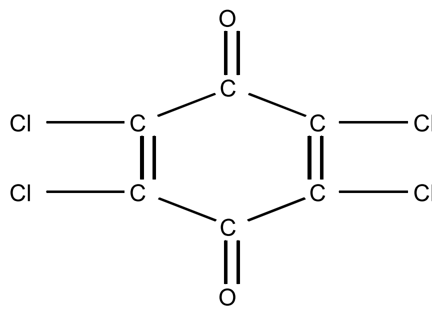
- ***Zineb (Zinc ethylene bisdithiocarbamate):*** Zineb is derived by the substitution of sodium in nabam with zinc. It is called Dithane Z-78, Parzate C or Linacol. Zineb is mainly used for foliar sprays against diseases, such as early and late blight of potatoes and tomatoes, blast of rice, leaf blight of rice.



Zineb

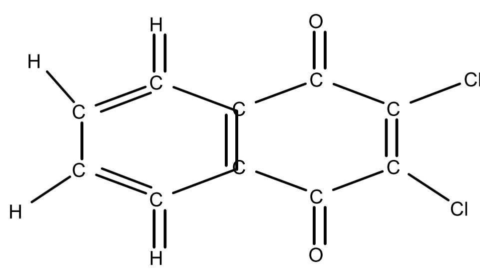
(ii) **Quinone and Phenolic Fungicides:-** Quinone and phenolic compounds are quite important as fungicides. Some important ones are:

- ***Chloranil (Tetrachloro-p-benzoquinone):*** It was reported by Cunningham and Sharvelle (1940) to give protection to lima beam seedlings from damping off. Chloranil is mainly used in seed and bulb treatment of legume flowers and vegetables.



Chloranil

- ***Dichlone (2,3 dichloro*-1,4 naphthaquinone):** It is used for seed treatment and also as a foliage spray against many plant disease.

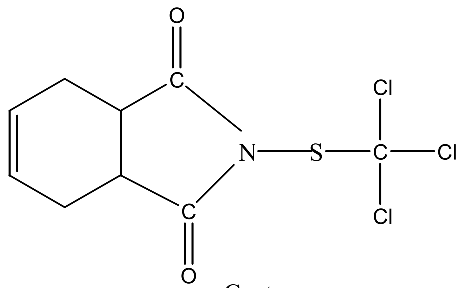


Dichlone

- ***Phenols:*** Phenols have shown exceptional qualities as bactericides, but as fungicides their use has been limited. It has been used as soil fungicides and in seed treatments.

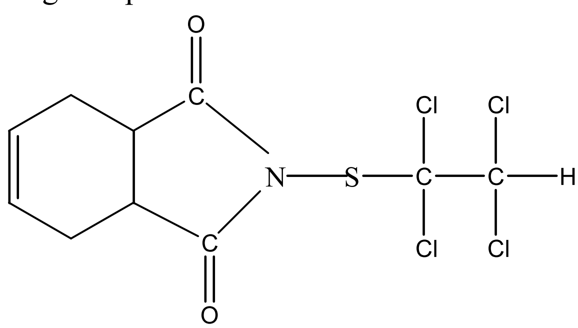
(iii) **Heterocyclic Nitrogen Compounds:-** These compounds have valuable fungicidal properties and are used as foliage protectant and eradicants of fruits and vegetables.

- ***Captan:*** Captan is the common name of N-trichloromethyl and thio-4-cyclohexene-1,2 dicarboximide. It is commercially sold as Captan 50 W and Esso fungicide 406, which acts systemically.



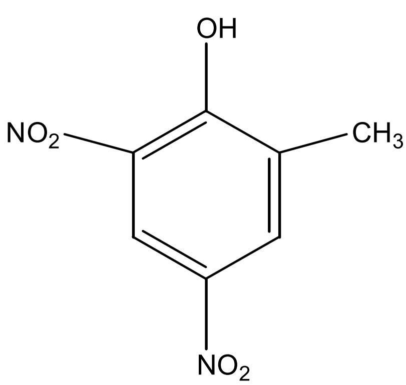
Captan

- ***Difolatan [N-*(1,1,2,2-**tetrachloro ethyl sulfenyl)-cis 4-cyclohexene 1,2-dicarboximide]** : Difolabtan has properties similar to captan. It is good fungicide for the control of early and late blight of potatoes and tomatoes.



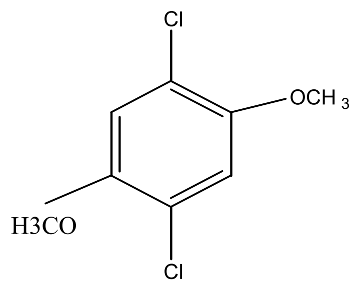
Difolatan

(iv) ***Benzene Compounds:-*** Many benzene compounds are toxic to micro-organisms and have been developed as fungicides. It is used as a dormant spray for the control of many diseases of fruit trees and ornamental plants.



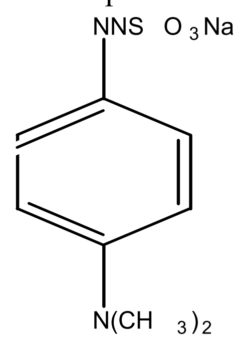
Dinitro-o-cresol

- ***Chloroneb:*** The fungicide, chloroneb, 1,4-dichloro-2,5 dimethoxy benzene, was introduced for the control of seedling disease of cotton. This is a systemic fungicide.



Chloroneb

- ***Dexon:*** This is p-(dimethylamino)- benzene-diazosodium sulfonate. It is used against soil-borne fungi causing root rot and damping off diseases of plants.

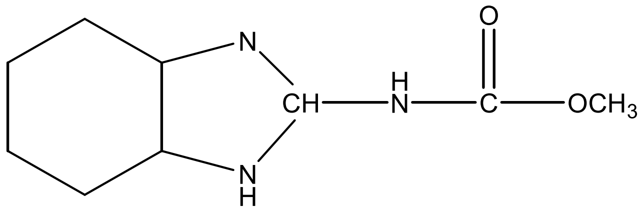


Dexon

(v) **Systemic Fungicides:-** The development of systemic fungicides such as benomyl, oxathiins, terrazole etc are used to treat many plants after infection. Systemic fungicides are absorbed and translocated within the plant, restricting the spread and development of pathogens by direct or indirect toxic effects by increasing the ability of the host to resist infection.

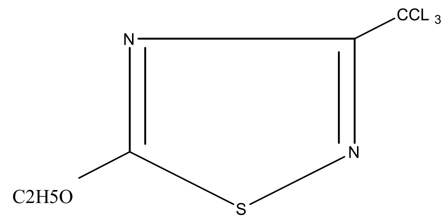
The systemic fungicides inactivate enzymes and toxins of the pathogen. Therefore, they are more specific in their action than non-systemic fungicides.

- **Benomyl:-** This is methyl- N (butyl carbomoyl)-2 benzimidazole carbamate and marketed as benlate. This fungicides is effective against a wide range of pathogens such as *Cercospora* leaf spot of sugar beet, rice, blast, apple scab, powery mildew on cucurbits, cereals and legumes. Many soil borne pathogens can also be controlled by benomyl.



Methyl Benzimidozole Corbamate (MBC)

- **Terrazole:** Terrozole-5-ethoxy-3trichloromethyl-1,2, 4-thiadiazole is systemic in action. It is toxic to phycomycetous fungi, such as *Pythium* and *Phytophthora.* It has a systemic action in plants (Al-Beldawi and Sinclair, 1969). Little is known about its fungitoxic action.



Terrozole

(vi) **Antibiotics:-** Antibiotics have been developed to control various plant diseases. Most of these drugs are absorbed by the plant and translocated like systemic fungicide. Streptomycin is used against a varity of bacterial pathogen. Tetracycline is able to control the growth of certain mycoplasmas and cycloheximides are effective in the control of certain fungal diseases.

3.5 Immunisation measures

It is based on ability to exempt infection of disease by a pathogen. It is achieved by two ways- (1) Biological Control (2) Disease resistance

(1) **Biological Control:-** The control of disease by living organism is called biological control. In biological control the survival activity of a pathogen is reduced through the agency of any other living organism except man himself. This results reduction of disease incidence caused by a pathogen. Many micro-organism parasitise, compete and antagonise other micro-organism. Biological control is based on these properties of micro-organism. It acts in following ways-

(i) **Antibiotics :** These are the chemicals secreated by the micro-organism which inhibits the growth and activity of pathogen and controls the diseases.

(ii) **Cross protection:** In this mild strain of pathogen in introduced into the host due to which resistance is developed against the strong strain of that micro-organism which can causes sever damage to the host.

(iii) **Hyper-parasitism:** Many pathogens parasitise on other pathogen it is called Hyper parasitism e.g. *Malampsora lini* (Pathogen of Rust of linseed) produces uredosposes. Which can be controlled by *Cladophora sp.* As it parasitise on uredospores of *Malampsora.* In the above example one fungus is parasitized by another one, therefore it is also known as mycoparasitism. The parasitizing fungus is called hyperparasite whereas the parasitized fungus is termed as hypoparasite.

(iv) **Antagonism:** In this one organism inhibits the growth and activity of another micro-organism eg. *Trichoderma* is antagonistic against many soil borne pathogen. There fore it is used to control many soil borne disease.

(v) **Competition:** The microorganisms compete for space, mineral and organic nutrients for proliferation and survival in their natural habitat both, rhizosphere and phyllosphere, **Rhizosphese** is "the zone of soil around plant roots characterized with intense microbial activity". **Phyllosphere** is "the niche of microbes on the surface of leaf landing from surrounding air". For the successful completion of their life cycle or infection process, the pathogen has to compete for substrate and minerals. As mineral nutrients are generally present in large quantity except nitrogen and iron in nitrogen-poor and iron-poor soils respectively. Therefore competition for substrate is most important factor than mineral nutrients. The fate of plant pathogens in competition depends on cellulolysis rate that mediates the speed of sporophytic tissue penetration. ***Trichoderma viride*** vs ***Fusarium roseum*** is an example of successful competitors competing for nutrients.

(2) **Disease resistance:-** It is the inherent ability of a plant to prevent the establishment of pathogen. If the resistance is against all the races of a pathogen it is called horizontal resistance and if it is against only few race of pathogen it is called vertical resistance.

New verities are produced by breeders. when the new verity has resistance against disease then it is recommended to the farmers.

Breeding of disease resistance is achieved by following methods

(i) **Introduction:** The new variety of plant from its place of origin is introduced into a new locality and in new environmental conditions and if it still show resistance then it is recommended to the farmers.

(ii) **Selection:** Plants having disease resistance are selected and grown along with the suceptible host and then only those plants are selected which exhibit resistance against disease. These plants are grown again for several years under different environmental conditions and when they show resistance against all conditions then they are recommended to the farmers.

(iii) **Hybridization:** The cross is made between susceptible and resistance variety and the plants of F_1 generation are grown. The plants which exhibit resistance are selected and recommended to the farmers.

SAQ 4.

a. Systemic fungicides inactivate ……………… and ………….. of the pathogen.
b. …………………….. is a systemic fungicide.
c. ……………………. are used to control certain fungal diseases.
d. The control of disease by living organism is called …………………………
e. ………………………. Is the inherent ability of a plant to prevent the establishment of pathogen.

3.6 Summary

- The main object of disease control is to prevent qualitative and economic losses of crops due to attack by pathogen.
- Prophylectic or preventive methods are applied in advance before the spread of disease.
- The aim of exclusion is to prevent new pathogen and diseases from reaching an uninfected area.
- Plant Quarantine is the legal restriction at the national and international level on the movement of agricultural commodities.
- The primary aim of eradication is to break the "infection chain" by eliminating the pathogen.
- Eradication is done by field sanitation, rouging, eradicating alternate and collateral host.
- In protection preventive measures are applied to discourage the spore germination, penetration into the host and disease development.
- Protection is achieved by rotation of crop, selection of good quality planting material and condition for germination and emergence of plant.
- Therapeutic or curative measures have been used to control plant diseases by physical or chemical therapy.
- Physical therapy is done by heat sterilization of soil, hot water treatment of infected seeds, hot air treatment of plants after harvesting, low temperature and radiation treatments.

- In chemical therapy chemical substances are used to kill the pathogen for disease control.
- The chemical may be inorganic and organic fungicides, quinines, phenols, heterocylic compounds, benzene compounds, systemic fungicides and antibiotics.
- Immunization measures are achieved by biological control and disease resistance.

3.7 Terminal Questions

1. Comment briefly on the chemical control of plant diseases.
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2. What are plant quarantines? When and where was the first quarantine act enacted?
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3. Comment briefly on various methods of disease control in plant.
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4. Discuss prophylactic or preventive measures of diseases control.
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5. Discuss therapeutic or curative measures of diseases control.
   ………………………………………………………………………………
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6. Discuss immunisation measures of diseases control.
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7. Write short notes on:
   (1) Quarantine

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(2) Biological control

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(3) Fungicides

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(4) Crop rotation

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(5) Systemic fungicide

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(6) Disease resistance

…………………………………………………………………………
……………………………………………………………………………
……………………………………………………………………………

3.8 Answers

SAQ1.

(a) Quarantines
(b) 16
(c) disease control
(d) alternate host

SAQ 2.

(a) Crop rotation
(b) disease
(c) disease syndrome
(d) temperature, radiation
(e) chemical substances.

SAQ 3.

(a) Millardet
(b) copper sulphate, lime
(c) inorganic
(d) downy mildew of vine

SAQ 4.

(a) Enzymes, toxins
(b) Benomyl
(c) cycloheximides
(d) biological control
(e) Disease resistance.

Unit-4 Dissemination of Pathogen, Epidemology and Disease Forecasting

Structure

4.1 Introduction

Dissemination or dispersal or transmission is the transport of spores or infectious bodies acting as inoculums, from one host to another host at various distances resulting in the spread of the disease. If displacement occurs on a susceptible host and environmental conditions are suitable, the pathogen grows and multiply. This is called effective dispersal. When the plant pathogen does not get any medium for it's survival it is called ineffective dissemination. The pathogen disseminate for food, nutrition, survival and to complete their life cycle.

When a pathogen spreads and affects any individual within a population over a relatively large area and within a relatively short time the phenomenon is called epidemic. Epidemology or epiphytology is the study of the outbreak of epidemic diseases, its course, intensity, cause effects and the various factors governing it. Disease forecasting is management system used to predict the occurrence or change in severity of plant diseases. The objective of forecasting is to accurately predict when the three factors – host, environment and pathogen all interact in such a way that disease can occur and cause economic losses. A good disease forecasting system must be reliable, simple, cost effective and applicable to many diseases. At the field scale forecasting is used by growers to make economic decisions about disease treatment for control.

Objectives:-

After studying this unit you will be able to know:

- How plant pathogen disseminate in nature.
- About epidemic disease and various factors that influence them.
- Pattern and development of an epidemic.
- Forecasting of plant epidemic disease.
- How can farmers protect their crops from epidemic diseases?

4.2 Dissemination of Plant Pathogen

Transport of inoculums from one host to another at various distances results in the spread of disease. This is called dissemination, dispersal or transmission of plant pathogen. The plant pathogens disseminate in two ways:

I. Direct transmission or Active dispersal
II. Indirect transmission or Passive dispersal

I. Direct transmission or Active Dispersal:

If the pathogen is transmitted along with the seeds or any other vegetative part of the plant used as a seed is known as direct transmission or active dispersal. It occurs as germinative vegetative and adherent transmission in following way:

(i) **Germinative Transmission:**

The pathogens are transmitted along with the seeds or propagule in the specific parts of the seeds such as endosperm and embryo. It remain viable and dormant inside the seed for several years. These seeds apparently look healthy. They get mixed with healthy seeds during harvesting of the crop and sown in the field. Then pathogen of disease is disseminated along with seeds. The pathogen of loose smut of wheat and barley are example of germinative transmission .

(ii) Vegetative Transmission:

The pathogens are also transmitted through the vegetative parts of the plant used as a seed such as tuber, bulb, rhizome, cuttings of the plant etc. The infected vegetative parts disseminate pathogen e.g. *Phytophthora infestens* causes late blight diseases in potato. This disease is transmitted through infected tubers used as a seed for sowing. Similarly other pathogens like *Ustilago scitaminae* causal organism of whip smut of sugarcane diseases and *Collatotrichum fulcatum* causal organism of red rot of sugar cane are transmitted through infected cane sets used as a seed.

(iii) Adherent Transmission:

The pathogens are carried over the surface of seeds or vegetative part of the plant used as seed. The sclerotia of ergot diseases, smut spores, bacterial cells get lodged on the surface of seed coat and transmitted to a long distance. For example *Telletia foetida* pathogen of bunt of wheat disease, *Ustilago hordei* pathogen of covered smut of barley and spp of *Cleviceps* pathogen of ergot diseases are transmitted over the surface of seed.

SAQ 1.

a. Transmission of pathogen with seeds and vegetative parts of the plant is ………………………
b. In germinative transmission pathogen establish themselves in the …………………. and ……………….. of the seed.
c. The pathogen of late blight of potato is transmitted through infected ……………
d. Pathogen of covered smut of barley is an example of ………………..

II. Indirect transmission or Passive dispersal

Transmission of pathogen occurs through some other agency like it may be autonomous by wind, by water, by insects, mites and nematodes, by cattle and birds and by man. The indirect transmission occurs in following way:

(i) Autonomous Transmission:

Autonomous transmission of pathogen has been discussed by Muskett in 1960. In this dispersal of pathogen take place independently without involvement of any external agency. Diseases speread to short distance by this method. For example *Fusarium* the pathogen of wilt disease is transmitted independently. Such infection occurs usually through roots of the plant and disease spreads from plant to plant in the same fields or from field to field in the same locality.

(ii) Transmission by Wind:

It is the most common method of transmission of plant pathogens and termed as anemochory. The pathogens of wind borne diseases like fungi and bacteria are transmitted by wind or air. Fungal pathogen disseminated by wind have some special qualities like they are produced in large number, light in weight, very small in size and discharged with sufficient force. The uredospores of *Puccinia graminis tritici* has been trapped in the air by means of aerospores and transmitted to very large distance through wind. They can move as high as 14,000ft above the infected grain field and travel as long as 600km distance without causing infection to other grain field. The pathogens of powdery mildew, downy mildew and smut are also disseminated by wind. The effect of air current on dispersal of spores are complex and varied. The irregular air movements are often more effective in bringing about multidirectional spread of pathogen than the strong sturdy winds.

(iii) **Transmission by water:**

Water as an dissemination or transmission agent is less important as compared to air but is an important agent of local dissemination. The plant pathogens are disseminated by water in two ways – (1) as a medium in which actively motile organisms or spores may swim about and (2) by the mechanical action of run off rain; the flowing of irrigation water or by the stream flow. The surface flow of water, heavy rain or irrigation water carry pathogen to short distances. The wilt fungus *Fusarium* and blight fungus *Phytophthora infestens* are disseminated by surface flow of water.

Splashing drops of rain and dew also help in short distance transmission. The rain drops falling on infected plant part may splash pathogen propagules in small droplets which lands on neighbouring healthy susceptible host or may be carried to long distances by air currents eg. *Xanthomonas* pathogen of black rot of crucifer. The spread of infections in red rot of sugarcane caused by *Collato- trichum_falcatum* and the dissemination of sclerotial bodies of *Sclerotium rolfsii* through soil are mainly by irrigation water.

(iv) Transmission by insect, mites and nematodes:

Insects, mites and nematodes also serve as important means of transmission of plant pathogens either on or within their bodies. They are most effective in case where pathogen produces sugary and sticky substances. Honey dew stage of ergot of bajra attracts insects and conidia of pathogen get smeared on their body parts. The same insect when visits the flowers of other healthy plant causes dispersal of pathogens. The most common and important means of transmission of virus in the field is by insect vectors like aphids, white flies, leaf hoppers, the mealy bugs and tree hoppers. The insect vectors suck the sap from the diseases plants so that the viruses reach to their mouth parts. When such insects suck the sap from the healthy plants viruses are transmitted into them. Some plant viruses multiply also within the body of insect vectors. Thus the infectively of vectors passes from generation to generations. Some viral bacterial and fungal pathogens are transmitted by nematodes. For example yellow ear rot of wheat caused by *corynebacterium tritici* is transmitted by the ear cockle nematode.

(v) Transmission by Cattle and Birds:

Cattle and birds carry the pathogens either on their bodies or within their bodies. They ingest the viable fungul propagule into their intestine through contaminated fodder. The propagule pass out as such into the dung which is used as manure. when such dung is applied in the field it act as a source of inoculums and transmit the pathogen. For example pathogens of potato scab and potato wart diseases are transmitted by manures from the dungs of horses and cows fed on diseased tubers. Some times the spores of certain pathogenic fungi mingled with the soil may be carried from contaminated fields to diseases free fields on the feet of domestic animals e.g. potato wart, club root of cabbage and onion mildew. The smut fungi are carried from field to field through alimentary canal of farm animals.

(vi) Transmission by Man:

Man also play an important role in the transmission of pathogen by his usual agricultural practices. Seeds are imported and exported. During this practice some times infected seeds many also get transmitted and thus pathogens move from one country to another. Plantation of contaminated tubers, bulbs, rhizome, bulbils etc. also helps in dispersal of pathogen. Usual farming practices such as weeding and pruning also helps in dispersal of pathogens. The workers working in the field carry the pathogen from plant to plant from field to field through their clothes, shoes, hands etc. Pathogens are also transmitted by sticking to the agricultural implements. Thus man is an agent of transportation of pathogens from continent to continent, from country to country and even from plant to plant on his own farm. In this way he repeatedly carried pathogens to the area which was free from pathogen.

Table-1

Example of some plant diseases introduced in India from other countries

Diseases	Original home
Leaf rust of coffee caused by *Hemileia vastatrix*	Sri Lanka
Late blight of potato caused by *Phytophthora infestans*	England
Flag smut of wheat caused by *Urocystis tritici*	Australia
Downy mildew of grapes caused by *Plasmopara viticola*	Europe
Downy mildew of cucurbits caused by *Erysiphe cichoracearum*	Sri Lanka
Downy mildew of maize caused by *Sclerospora phillipinensis*	Jawa

Black rot of crucifers caused by *Xanthomonas campestris*	Jawa
Powdery mildew of rubber caused by *Oidium hevea*	Malaya
Black shank of tobacco caused by *Phytophthora nicotianae*	Holland
Crowngall of apples and pears caused by *Agrobacterium tumefaciens*	
Bunchy top of banana (viral)	Sri Lanka
Hairy root of apple (viral) **Bacterial leaf streak of chillies**	England
Onion smut caused by *Urocystis eepulae*	Europe
Bacterial blight of paddy caused by *Xanthomonas oryzae*	Philippines
Golden nematode of potato caused by *Heterodera rostochiensis*	Europe

SAQ 2.

a. In autonomous transmission diseases spread to a …………….. distance.
b. Rust spores are transmitted to a long distance through ……………..
c. Wilt and blight fungus are disseminated by ………………… flow of water.
d. Viral pathogens are transmitted by …………………………..

4.3 Epidemology or Epiphytology

Some diseases periodically out break covering a large area and large population of plants. It is called epidemic. The study of epidemics and various factors that influence them is called epidemology or epiphytology.

Epidemic: Plant disease epidemics occur on most crops in many parts of the world. Some untold suffering to human due to epidemic are the Irish famine (1845, 1846) caused by late blight of potato and Bengal famine (1943) caused by brown spot of rice. Most epidemics are more or less localized and result in minor or moderate losses. Some epidemics appear suddenly extremely wide spread and become out of control.

The elements of an epidemic are susceptible host plant, virulent pathogen and favourable environmental conditions over a long period of time. The host, environmental factors and rate of multiplication of pathogen determines the capacity to spread a disease. The increase in epidemic is due to high birth rate and low death rate of pathogen. These epidemics spread very fast but can be controlled by fungicidal spray whereas the epidemic developing due to low death rate of pathogens spread slowly over a long period of time. This epidemic is dangerous because their eradication is difficult.

When an epidemic is periodic and appears after certain intervals of time it is termed cyclic. On the otherhand, when an epidemic extends over most of a continent and causes mass mortality, it is termed as pandemic. Every epidemic has a specific course. It changes, increases and becomes virulent, decline, become milder and has its own appearance and morphology. An epidemic may be in two forms quantitative and qualitative. The quantitative epidemic is incidence of the disease and qualitative epidemic is the severity of the disease. There are two extremes of epidemics i.e. explosive epidemics and tardy epidemics. The graph of explosive epidemic shows a steep rise, a short acute peak and a steep decline whereas the trady epidemic graph shows slow progress.

4.4 Factors Affecting Establishment Of An Epidemic

Establishment of an epidemic is affected by following factors:

(i) Nature of the host.
(ii) Nature of the pathogen
(iii) Environment
(iv) Human activity

(i) Nature Of The Host: There are many external and internal factors of host plant which affects the development of an epidemic. These are as follows:

(a) Susceptibility and degree of genetic uniformity of plant: Usually plants have ability to fight and defend against disease due to various genetical, physiological and structural factors. Some times few of theses factors are missed and plant becomes susceptible. The accumulation of susceptible host over a large area in aggregation is the major cause of epidemic. The host plant with vertical resistance do not allow pathogen to become established, unless a new race of pathogen develops whereas plants with horizontal resistance become infected but the rate at which epidemic develops depend on the level of resistance and environmental conditions.

(b) Types of crop and age of plants:

Type of crop and age of plant affects epidemic. The epidemics develop more rapidly i.e. in few weeks in annual crops, whereas slowly i.e. in several years in the perennial woody fruit and forest trees.

The susceptibility of diseases for plant changes with age. In some cases the hosts are susceptible during the growth period, become resistant when adult e.g. downy mildew, rusts, systemic smuts etc. The other plants are resistant while still young, become susceptible during their growth and again resistant before they are fully expanded. The diseases like late blight of potato, early blight of potato etc. there is a stage of juvenile susceptibility during the growth, followed by relative resistance in the early adult stage and then susceptibility after maturety.

(c) Introduction of new host in the area: New varities of plants are brought into a new area from their place of origin and sown there. Some times these varities of plants become more susceptible to other pathogen.

(d) Introduction of new alternate and collateral host in the area: Alternate host belongs to a different family that helps complete the pathogen life cycle and its survival. A collateral host is an additional than the usual host on which the pathogen can complete its life cycle. Thus both alternate and collateral host are important in building up the primary inoculum for the new crop. Sometimes introduction of new alternate and collateral host causes epidemic.

(ii) Nature of the Pathogen: Nature of pathogen includes its virulence level and inoculums density, reproduction cycle, ecology and mode of spread. It affects development of an epidemic in the following way:

(a) Virulence level and Inoculum density: Virulent pathogens infect host rapidly. This results in production of large amount of pathogen at faster rates when the number of pathogen propagules such as bacterial cells, fungal spores etc. are in greater number near or within the field of host plant result in greater increase of an epidemic.

(b) Reproduction cycle of pathogen: The pathogens having short reproduction cycles are polycyclic pathogen because they can produce many generation in a single growing season. This causes sudden, catastrophic disease epidemic. The pathogens which have high birth rate cause rapid epidemic as the disease spread in a compound interest manner. The pathogens which have 2-4 reproductive cycles per seasons cause localized and slower epidemics. These pathogens have low deaths rate and cause simple interest disease.

(c) Ecology of pathogen: Inoculum of pathogen is mostly produced on the aerial part of the plant. Such inoculum is dispersed easily to longer distances and results in wide spread epidemics. The vascular pathogens reproduce inside the host plant and their inoculums spread only with the help of vectors. Thus the development of epidemic depends on the active vector. The dispersal of inoculums present on plant debris lying in soil is very slow. In this way ecology of pathogen affects epidemic.

(d) **Mode of pathogens spread:** Mode of pathogens spread may be seed, soil or air which affects epidemic. The seed and soil borne pathogen have several limitations and hardly cause sudden or widespread epidemic. The air borne inoculums such as uredospores of rust can be easily dispersed by air over long distance. This causes frequent and wide spread epidemics.

(iii) Environment:

The environment affects each component of the epidemic and has a controlling influence on the development of epidemics. The environment affects the availability, growth stage and genetic susceptibility of the host. It also affects survival, multiplication rate, vigour, sporulation, dissemination of the pathogen and germination of spore and penetration. Moisture and temperature are most important environmental factor which affect disease epidemics.

Moisture promotes growth of susceptible host, increase of sporulation in fungal pathogen, facilitate release and germination of spores. In presence of high moisture all such events occur constantly and repeatedly. This results in epidemics.

Temperature favour epidemics by affecting pathogens and every stage of pathogenesis: sproe germination, penetration, growth and reproduction of pathogen, invasion and sporulation. Within a favourable range of temperature and moisture a polycylic pathogen can complete its infection cycle within a few days. Thus pathogen can produce many infection cycles within a growing season. This results into severe epidemic due to presence of abundant inoculums.

(iv) Human Activities:

Human activities like cultural practices and control measures used either favour or reduce the rate and frequency of epidemics low-lying, poorly drained, acrated fields agacent to another infected fields, tend to favour an epidemic. The propagative material having inoculums favours epidemic. Various cultural practices like continuous monoculture, planting of same variety of crop in large area, high nitrogen fertilizers, poor sanitation etc. increases the possibility of epidemics.

Various disease control measures such as chemical spray, rotation of crop, use of resistant varities reduce or eliminate the possibility of an epidemic. However, sometimes use of certain chemicals and planting of certain variety results into serious outbreak of an epidemic if the pathogen has resistance against chemical or can attack the resistant variety.

The movement of seeds, tubers, nursery stock and others propagative parts are world wide due to which new pathogens are introduced in other new areas. Such pathogens in the new area lead to severe epidemics e.g. citrus canker, chestnut blight.

SAQ. 3

(a) The study of an epidemic and various factors that influence them is called …………………...

(b) Epidemic diseases cover a large area and large population of …………………………….

(c) Type of crop and age of plant affects …………………………………

(d) Development of an epidemics require …………………………., …………………….. and ………………………… environmental conditions.

4.5 Pattern And Development Of Epidemic

The pattern of an epidemic is given by a curve called disease- progress curve that shows the progress of an epidemic over time. The disease progress curves are characteristic for some group of disease. A saturation type curve is characteristic for monocyclic disease (Fig. 4.1. a). Polycyclic diseases show sigmoid curve and disease affecting different organs show bimodal curve (Fig. 4.1. b,c) The rate of epidemic growth can be obtained from disease- progress curve.

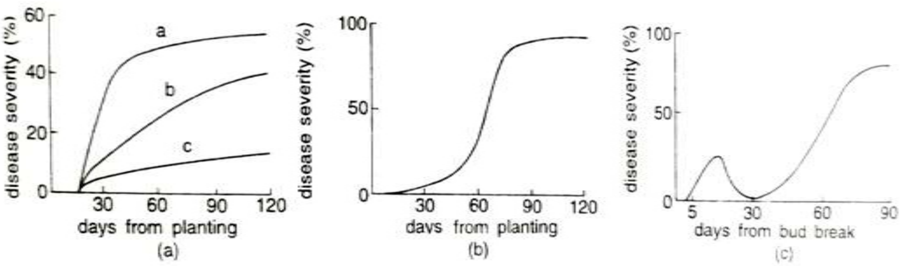

Fig. 4.1. (a) Saturation type curve, (b) Sigmoid curve, (c) bimodal curve

The pattern of an epidemic in terms of spread of disease over distance in given by another curve called disease gradient curve. The number of diseased plants and the severity of diseases decrease steepy within short distance of the source and less steepy at greater distance. (Fig. 4.2)

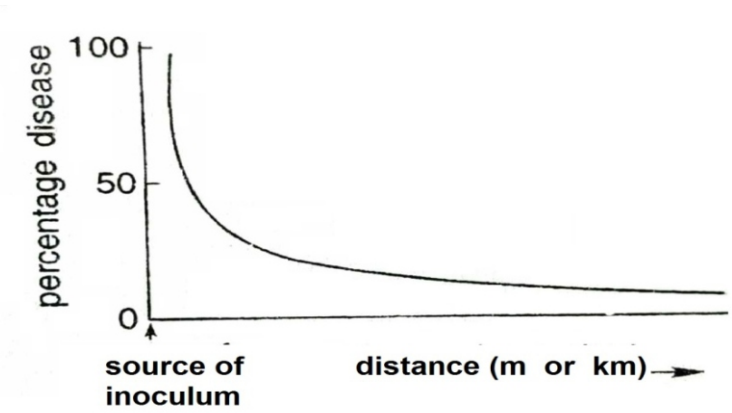

Fig. 4.2. Disease gradient curve

The following components are involved in the development of an epidemics:

- A large area planted with genetically uniform crop plant and the planted fields being close together.
- Presence of a virulent pathogen
- Combination of right sets of environmental conditions at appropriate stage of the host plant and the pathogen.
- In each new location the same set of favouralble environmental conditions must be repeated so that infection, reproduction and dispersal of the pathogen can occur as quickly as possible.

Some epidemic grow slowly while other develop rapidly. During early stage epidemics spread vigorously and after development of a saturation stage it shows decline by itself.

4.6 Information Required For Disease Forecasting

Forecasting of plant epidemic disease is means prediction for the occurrence of disease in a specific area so that suitable control measures can be undertaken in advance to avoid heavy losses. Various informations regarding host, pathogen and environment are required for forecasting of disease. These are as follows:

(1) Information regarding host:

The information regarding host are presence of susceptible varieties of host plants in the given locality, response of host at different stages of its growth to the activity of pathogen. Density and distribution of host in the given area. The dense population of a susceptible variety invites the spread of an epidemic.

(2) Information regarding pathogen:

For forecasting of an epidemic disease information of all stages of the diseases cycle or pathogen is required. These are initial inoculums, dispersal of inoculums, germination of spore, infection, incubation period, sporulation of pathogen on the infected host and redispersal of spores.

(3) Information regarding environment:

Temperature and moisture are two most important environmental factors needed for forecasting of disease. Besides this light intensity, wind velocity during crop and intercrop period should be observed for a number of years in the field.

4.7 Forecasting Of Plant Epidemic Diseases

The forecasting of plant epidemic diseases is extremely useful to formers in the practical management of crop diseases. In managing the disease of their corps, farmers must always weigh the risks, costs and benefits of numerous decisions. The pathogens and weather factors are of different type: therefore forecasting is predicted in different ways.

On the basis of data collected on weather, disease cycle and pathogen cycle certain laboratory investigations are done and correlated. Then the forecasting of disease is done by the following methods:

- **Forecasting of disease based on primary inoculum:** Forecasting of disease is done on the basis of presence of primary inoculums, its density and viability in the area where susceptible host is present.
- **Forecasting of disease based on various weather factors:** Regular monitoring of weather factors like temperature, rainfall, humidity etc. during crop and intercrop period, local weather conditions above the crop and at the soil are considered for forecasting of disease. Weather data of several years are collected and correlated with the intensity of the disease.
- **Forecasting of disease based on computer:** Computerized warning system for diseases forecasting are in use since the mid 1970s such as BLITECAST. In BLITECAST weather data collected on the farm by individual grower are transmitted to the centrally located computers. The computer then process the data, determines whether an infection period is imminent, likely to occur or cannot occur and makes a recommendation to the grower for applying control measures against epidemic disease.

  In advanced countries like USA forecasting of disease in done by computer using various environmental data.

  Computerized forecasting (BLITECAST, 1975) of late blight of potato disease can be done if:

  - A night temperature is below dew point for at least 4 hours.

- The next day should be cloudy
- Minimum temperature 10^0C or above
- At least 1mm rainfall during the next 24 hours.

SAQ 4.

a. Prediction for the occurrence of an epidemic in an area is known as forecasting of …………………………..

b. Information regarding ……………, …………. and ……………………… are required for forecasting.

c. In advance countries forecasting of disease is done by ……………………………..

4.8 Summary

- Transport of inoculums from one host to another at various distances results in the spread of disease. This is called dissemination, dispersal or transmission of plant pathogen.
- Dissemination of plant pathogens occurs in two ways: (1) Direct transmission or Active dispersal (2) Indirect transmission or Passive dispersal
- Direct transmission may be germinative, vegetative or adherent.
- Indirect transmission may be autonomous or by wind, water, insects, mites, nematodes, cattle, birds and man.
- Epidemic disease periodically out break covering a large area and large population of plants.
- Epidemology is the study of various factors that influence an epidemic.
- Nature of host and pathogen, environment and human activity affects establishment of an epidemic.
- Susceptible host, virulent pathogen and favourable environmental conditions favour an epidemic.
- Some epidemic grow slowly other develop rapidly.
- During early stage epidemic spread vigorously and after development of a saturation stage in shows decline by it self.
- Prediction for the occurrence of an epidemic disease in the area is called disease forecasting.
- For disease forecasting information regarding host, pathogen and environment is required.
- In advanced countries like USA forecasting of disease in done by computer using various environmental data.

4.9 Terminal Questions

1. Describe dissemination of plant pathogen.

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2. What is epidemic? Discuss various factors responsble for an epidemic.

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3. Describe forecasting of plant epidemic disease.

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4. Discuss direct and indirect dissemination of plant pathogen.

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5. Write short notes on:

(i) Direct transmission

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(ii) Indirect transmission

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(iii) Epidemic

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(iv) Nature of the host for an epidemic

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(v) Pattern and development of an epidemic

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(vi) Informations required for diseases forecasting.

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4.10 Answers

SAQ 1.

(a) Direct transmission (b) embryo and endosperm (c) potato tuber (iv) adherent transmission

SAQ 2.

(a) Short (b) wind (c) Surface (d) insect vector

SAQ 3.

(a) Epidemology or epiphytology (b) plants (c) epidemic (d) susceptible host, virulent pathogen, favourable

SAQ 4.

(a) Plant (b) host, pathogen, environment (c) computer

Unit-5 Diseases of Plants

Structure

5.1 Introduction

Fossil evidences indicates that plants were affected by diseases 250 million years ago. The bible and early writing mention diseases, as rusts, mildews and blight.

Any deviation from the healthy condition which interferes with the normal structure and performance of vital functions of a plant is called a disease. The occurrence and prevalence of plant diseases vary from season to season, depending on the presence of the pathogen, environmental conditions, crops and verities grown. Plant diseases are important to human beings because they are responsible for causing damage to plants and plant products. Millions of people all over the world depends on the plant products for their existence. Plant diseases can make the difference between a happy and a miserable life. During world war I, late blight damage to the potato crop in Germany may have helped end the war. This is an example of the consequences of plant diseases.

Objectives:-

After studying this unit you will be able to know:

- Pathogens and symptoms of various diseases.
- The host-pathogen relationship and environmental factors which favours disease development.

- Life cycle of various disease and their control measures.

5.2 White Rust of Crucifer

Pathogen**:** *Albugo candida* (*Cystopus candida*)
Host : Mustard plant
Systematic position of pathogen:
Class : Oomycetes
Order : Peronosporales
Family : Albuginaceae.

Distribution: Disease occurs throughout the world on a number of criufcierous plants like cabbage, mustard, turnip, cauliflower, radish, rape, toria, black mustard and many other weeds. In India disease has been reported on turnip, radish, taramira, mustard, rapeseed and weeds such as Cleome viscose. The pathogen also infects members such as capparidaceae, convolulvaceae and amaranthaceae.

Symptoms: Infection occurs in all part of the plant except root. Symptoms appear on the lower surface of leaf in the form of white shiny raised pustules. The pustules coalesce to form large irregular patches. The lower epidermis of the host in ruptured due to which white powdery mass of conidia comes out. The infected leaves become thick fleshy and reduced in size. It is followed by twisting of the stem, deformation of flower, swelling and gall formation due to hypertrophy (enlargement of host cells) and hyperplasia (increase in the numbers of host cell). The floral axis and stalk of flower become thickened and floral parts swollen, fleshy, green or violet in colour. The infected flowers become sterile. The hypertrophy and distortion of stem, axis of inflorescence and flower indicates the presence of sex organs in the host tissue.

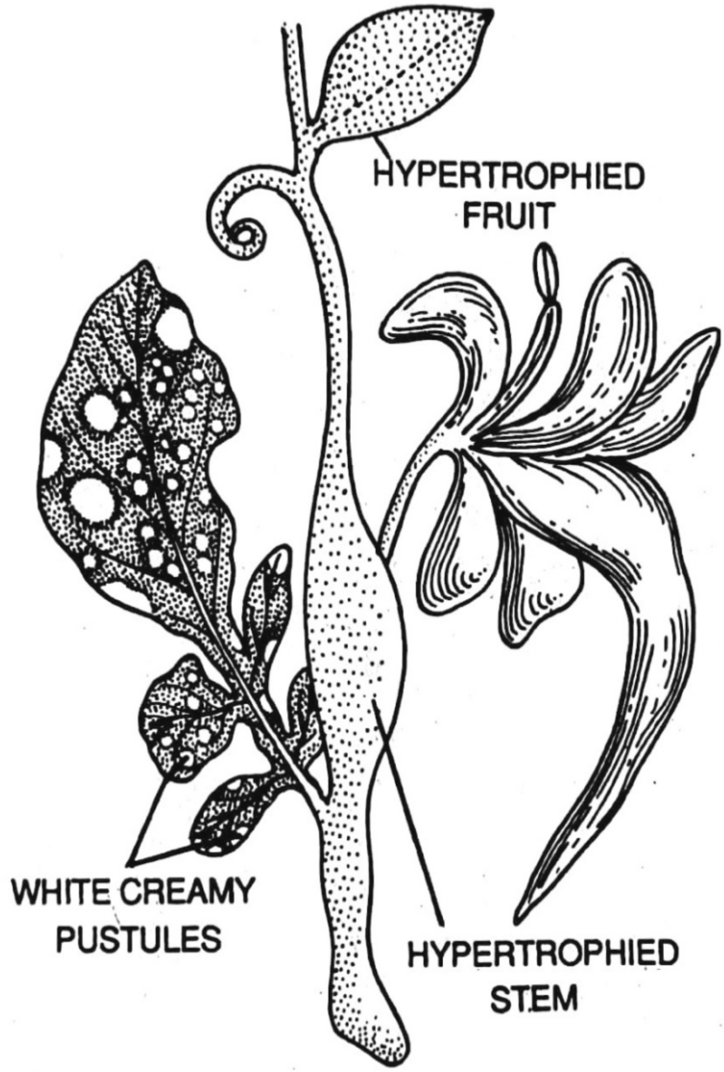

Fig.5.1. Mustard infected twig; leaf with white creamy pustules, hypertrophied stem, hypertrophied flower and fruit.

Host-Pathogen Relationship:

The pathogen is an obligate parasite which has well branched aseptate, coenocytic mycelium. The mycelium grows in the intercellular spaces of the host tissue and produces intracellular knob like haustoria. The haustoria absorbs nourishent for the pathogen from the host cell.

Disease Cycle:

The disease is soil borne as primary inoculum oospore is present in the plant debris in soil. This oospore germinates when reaches on suitable host under favourable conditions and produces zoospores. Each zoospore is naked, kidney shaped, uninucleated and biflagellated. It swims in the film of water on the host surface and come to rest. Then losses their flagella and become encysted by secreating its own cell wall. This encysted oospore germinates by giving out a germ tube which penetrates into the host through stoma and get established in the intercellular spaces.

Inside the host pathogen reproduce asexually by means of conidia produced in chain on conidiophore towards the lower surface of leaf. It exerts a pressure on the lower epidermis due to which epidermis get ruptured exposing conidial mass. As a result first sign of disease appears on the lower surface of leaf as symptom. These conidia act as secondary inoculum. They are disseminated by wind and when fall on suitable host they germinates and causes secondary infection as well as secondary spread of disease. Before the end of host plant pathogen reproduce sexually by sex organs (oogonium and antheridium). External presence of sex organs is indicated by twisting, distortion and hypertrophy in the host plant parts.

As a result of sexual reproduction oospores are produced in the host tissue. After the decay of the host tissue, the oospores are set free in the soil, enters the resting stage and tide over unfavorable period. These oospores act as primary inoculum for the next season crucifer crops.

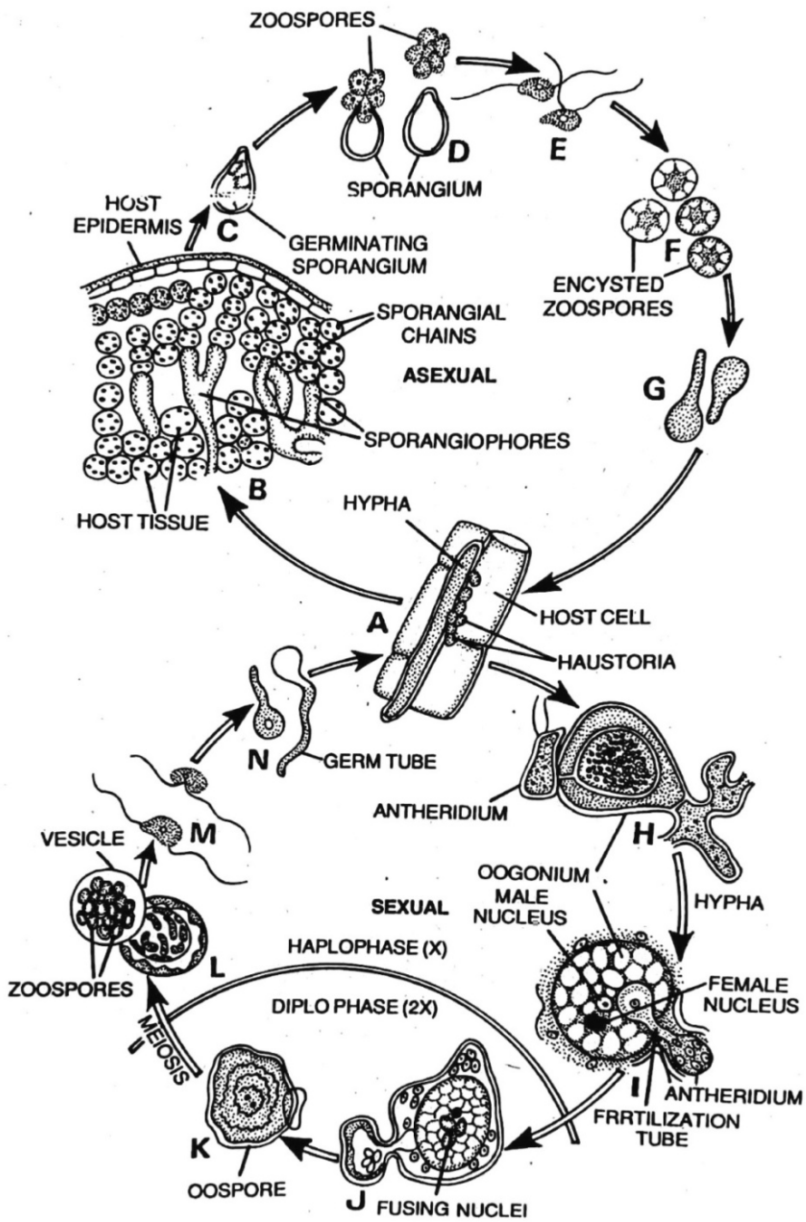

Fig.5.2. Disease Cycle of white rust of crucifers.

Control Measures:

1. Disease can be controlled by field sanitation. The diseased plant parts having oospores should be collected and destroyed. Thus, the diseases does not perpetuate.
2. Since the primary inoculum oospores survive for long time in the soil, therefore proper crop rotation for at least three years help in eradicating primary inoculums from the soil.
3. Use of disease resistant varieties of the crop.
4. Spray of Bordeaux- mixture at regular interval has been recommended.

SAQ 1

(a) White rust of crucifer is caused by ……………………………………

(b) Primary inoculum of white rust of crucifer is ………………………..

(c) White rust of crucifer is ………………….. borne disease.

(d) Secondary inoculum of white rust diseases is ……………………..

(e) …………………………… is used as control measure against white rust of crucifer.

5.3 Wilt of Arhar

Pathogen: *Fusarium oxysporum.*

Host : Arhar Plant

Systematic Position of Pathogen:

Class – Hyphomycetes

Order – Moniliales

Family – Tuberculariaceae.

Distribution: Wilt of arhar is the most severe threat to the arhar producing states in the country. This disease is responsible for severe losses in parts of Maharashtra, Uttar Pradesh, Madhya Pradesh and Bihar. More than fifty percent of the plants are succumbed to the disease in the field.

Symptoms: The young susceptible host of about five to six weeks old are attacked by pathogen. The first sign of disease appears as premature yellowing of the leaves fallowed by withering. Gradually, the wilting occurs and plants dries up. In severe infection more than fifty percent plants in the field may fall due to this disease. This wilting is different from the wilting occurring in plant due to scarcity of water or by frost. In this wilting the vascular tissue of the stem and root of host plant are plugged by dense masses of pathogen mycelia and hyphae. Tyloses are also formed in the lumen of the xylem vessels. Besides this deposition of gum also occurs there. All this interrupt the free flow of water to the leaves of host plant. As a result drooping and wilting occurs in the leaves. The pathogen also produces some toxic substances which kill the plant cells concerned in the ascent of sap. If plugging in the vascular tissue of the host plant occurs on one side only the wilting is partial.

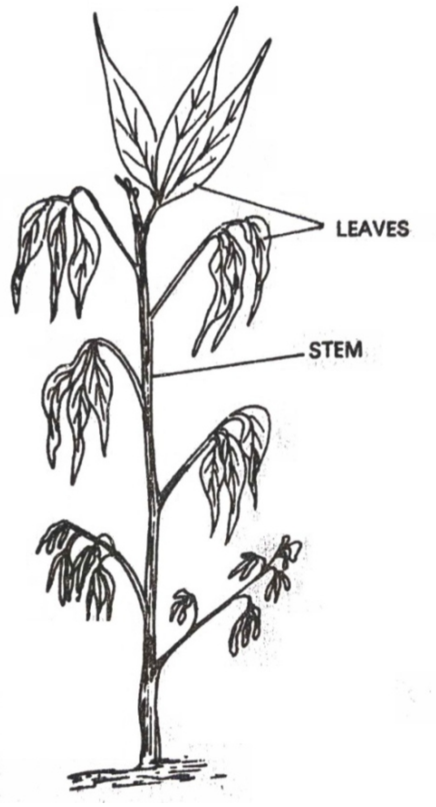

Fig.5.3. Symptom of wilt

Host- Pathogen Relationship: The pathogen is facultative parasite and can survive in soil in the absence of host plants. The mycelium is septate, branched, colourless, intercellular and intracellular restricted to the vascular tissues of the host plant. The profuse growth of mycelium within the xylem vessels completely plugs the lumen of the vessels. Macroconidia, microconidia and chlamydospores are produced by the mycelium in the host tissues.

The macroconidia are long curved backward where as, the microconidia are small, oval or curved, unicellular or 1-2 septate. The chlamydospores are round, small, thick-walled produced in chain and remain viable for a long time.

Disease Cycle:

Wilt of arhar is a soil borne disease. The microconidia, macroconidia and chlamydospores produced by *Fusarium* remain viable in the soil. When arhar is sown in the soil having inoculum get infected. The spores of pathogen present in the soil act as primary inoculum and germinates in the soil in presence of susceptible host and suitable environmental conditions. The pathogen enters into the host through roots or rootlets and establishes themselves in the vascular system of the plant. Only the roots of the plant are being infected and the infection may be carried by roots to the new area.

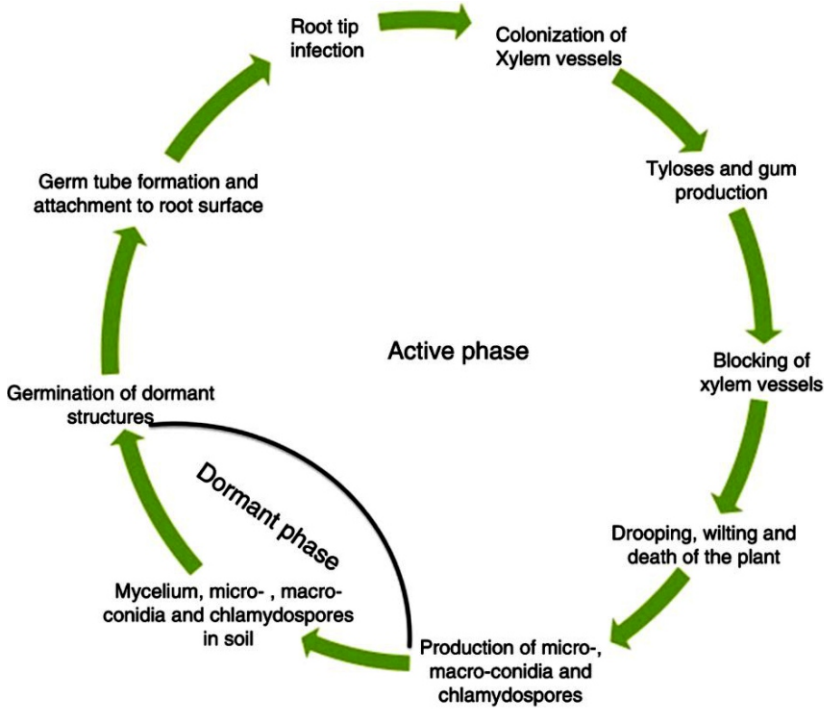

Fig.5.4. Disease Cycle of wilt of arhar (Digrammatic)

Control Measures:

1. Wilt is a soil borne disease, therefore rotation of crop for 2 to 3 years is a best method of disease control. The pathogens are host specific and when the pathogen does not get their specific host it will die and field become pathogen free.
2. Use of resistant verities such as NP (WR)-15, (NP-24 X NP-51), 15-3-3 and DDN-1 developed at 1.A.R.A., New Delhi.

5.4 Damping Off of Seedlings

Introduction

The damping-off of seedling disease was first studied in Germany by Hesse in 1874 and De Bary in 1881. In the United States this type of disease attracted attention by the end of the nineteenth century and the beginning of the twentieth century. As early as 1901 to 1905, however, the damping-off disease began to receive attention as a trouble in forest nursery seed beds.

The seedlings are attacked by soil-inhabiting fungi usually just at the soil level on to hypocotyl or upper taproot causing partial or complete rot and the seedlings suddenly topple over in a characteristic manner.

Species of *Pythium, Phytophthora, Fusarium, Rhizoctonia* are different pathogen which cause damping off of seedlings. Of the various species of

Pythium responsible for damping-off of seedlings, *Pythium debaryanum* ranks first in importance, in relation to this disease as a damping-off parasite.

This disease is encountered in seed beds where plants are propagated to be transplanted later to the field. But green houses and nursery seed beds are ideal places for outbreaks of damping-off if moisture and temperature conditions are favorable. The young, tender, succulent stage of plant may be attacked by damping-off fungi.

Causal Organism:

As mentioned above there are many pathogens of damping-off but *Pythium debaryanum* is the common cause of damping-off. It is eminently a soil-borne organism and is of common occurrence in field and garden soils, in which it survives in the form of oospores. It lives in soil as saprophyte on dead organic matter or as parasite on the young seedlings of many susceptible hosts.

Symptoms :

The most important symptom is the sudden toppling over of the seedlings. The fungus attacks the seedlings at or near the surface of the ground, according to the moisture level and depth of planting, on the hypocotyl or taproot. The cell wall of the rapidly growing seedlings is generally thin, and as such the tissue is particularly vulnerable.

In a very short time the pathogen causes invasion, rapid killing and rot of cells, and collapse of the tissue to such an extent that the seedlings suddenly fall over.

Often the damage may be complete before emergence of the seedlings above ground. After the seedlings have fallen over they may continue to decay, if the ground is wet and the air humid.

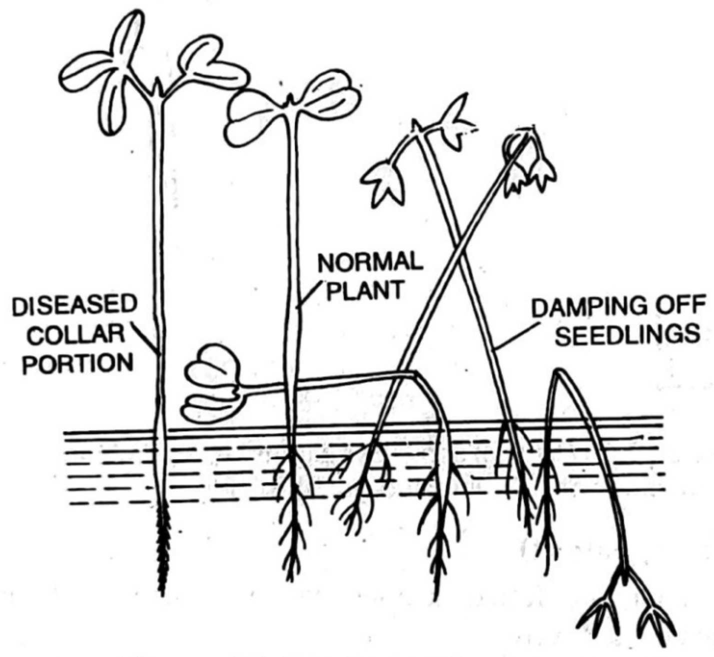

Fig. 5.5. Symptom of Damping-off of seedlings.

Damping-off of seedlings is of two types:

(i) Pre-emergence damping - off

(ii) Post-emergence damping - off.

(i) Pre-Emergence Damping-off:

The stage when the young seedlings are killed before they reach the surface of the soil when the hypocotyl has just emerged. The radicle and the plumule are destroyed as soon as they come out of the seed coat. This happens below the surface of the soil, therefore remains unnoticed.

(ii) Post-Emergence Damping-off:

During this stage the seedlings are out on the surface of the soil and on being infected by the pathogen they topple over and lie on the surface of the soil. This toppling is due to the killing of host tissue by the pathogen at or below the ground level. Initially the infected areas appear soft and water-soaked. The stem or the hypocotyl, becomes constricted and the seedlings collapse. The disease is most severe when the moisture content of the soil is medium to high. Under favorable conditions, the rapidity of onset of the disease may be to such an extent that within a very short time the seedlings of the entire seed bed may collapse.

Host - pathogen relationship:

The non-septate somatic hyphae of the organism is both intra- and intercellular without any haustoria. The organism reproduces asexually by the development of sporangia which are either terminal or intercalary on the somatic hyphae. Depending on the environmental conditions, the sporangia produce either biflagellate secondary zoospores or germ tubes. In the sporangium large number of zoospores are developed. The zoospores are biflagellate, after release the zoospores swim for some time, come to rest, round off, and germinate to produce somatic hyphae.

The sex organs, oogonia and antheridia, appear at a later stage. Fertilization occurs between antheridium and oogonium and oospore is formed in the oogonium.

On the decay of the host tissue, the oospores pass into the soil and germinate after a period of rest. At high temperatures the oospore germinates directly by germ tube which develops into somatic hyphae. At low temperatures, however, a vesicle is developed at the tip of the germ tube in which zoospores develop.

Disease Cycle:

The pathogen survives in the soil as a saprophyte on plant debris or humus in the soil, and becomes parasitic when the suitable host and proper growing conditions are present. The temperature and moisture play an important role in the severity of infection.

Abundant moisture and a fairly warm temperature are conducive to invasion of the seedlings. Soil temperatures of 20°C to 28°C. are ideal for the host infection by direct penetration. Abundance of moisture in the surface layer of the soil due to overwatering, thick sowing in the seed bed causing heavy stands, lack of aeration of the surface soil, and too much shade are conditions which favor damping-off.

Dissemination of inoculum takes place through oospores in the plant debris and mycelium remaining in the soil. A very common source of contamination in seed beds is in the soil or compost used in making up the seed beds. Sometimes these materials are obtained from an infested source and of course the organism is introduced along with the soil or compost.

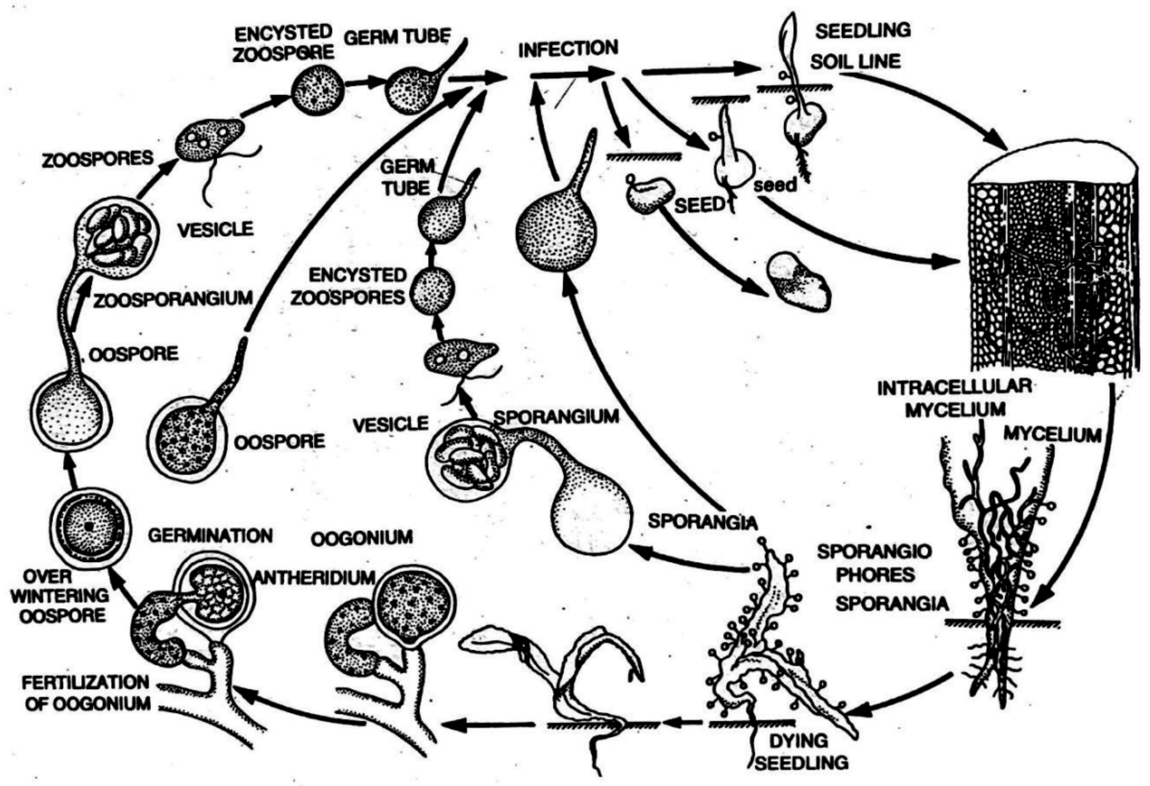

Fig.5.6. Disease cycle of Damping-Off of Seedlings

5. Control of Damping-Off of Seedlings:

Since the pathogen of damping-off trouble is soil- borne and since the temperature and moisture factors of the environment play important role in determining the severity of infection. Therefore the control measures are largely based on:

(i) Soil Preparation of Seed bed:

Every effort should be made to secure seed bed soil free from damping-off fungus. An alkaline reaction in the soil favors the growth of the fungus causing damping-off. Therefore every effort should be made to reduce alkaline reaction of the soil. Manure used in the seed bed should be well decomposed.

(ii) Treatment of Soil:

The treatment of soil is the most perfect control of damping-off. The seed bed soil should be sterilized by suitable methods. Some of the common methods are steam, dry heat, and chemicals. It makes the soil free from disease inducing fungus. Steaming of soil should be done continuously for 30 minutes.

Sterilization by dry heat is usually accomplished by burning wood upon sped bed soil. Seed bed soil can be sterilized by using formaldehyde diluted in the proportion of 1 part to 50 parts of water to be sprinkled over the loose soil in sufficient amount to soak it to a depth of at least 4 inches, which will mean one gallon for 2-3 square feet of soil.

Soil treatment with formaldehyde should be applied several days before sowing of seeds and the soil should be covered with paper, tarpaulin or other covering until ready for seed sowing.

Sulphuric acid is used in seed beds. Three-sixteenths fluid ounce dissolved in 1 to 2 pints of water is allowed for each square foot of seed bed if the soil is heavy; a little less is used if the soil is sandy. This acid treatment can be applied immediately after the seed is sown.

The formaldehyde and steam treatment are most commonly used in greenhouses and in seed beds other than in forest nurseries; the sulphuric acid is in common use in forest nurseries. Drenching of seed beds with 0.1 per cent. Captan is also recommended for soil sterilization.

Two sprayings with Bordeaux mixture at the rate of one-half gallon per square foot are also used as control one before seed germination and other as soon as the first leaves are formed and should be repeated every week as long as damping-off is likely to affect the seedlings. Disinfection of the seed bed soil and control of post-emergence damping-off can also be achieved by drenching the seed bed soil with Bordeaux mixture, Fytolan, Perenox, and Flit 406.

(iii) Treatment of Seed:

The most effective control measures of the damping off disease is the use of seed-protectants. It is a very effective measure against pre-emergence damping-off. The chemicals are applied to the seed in dry or in wet form producing a protective layer around the seed coat to enable the seedlings to grow uninterrupted.

(iv) Manipulation of Watering System:

A system of watering should be maintained to ensure that the seedlings and the surface of the seed bed soil remain dry without permitting the seedlings to suffer from lack of water. A thin layer of sand should be sprinkled over the surface of the soil. This aids in keeping the surface of the seed bed soil dry. Light irrigation at frequent intervals should be given, water-logging should be avoided.

(v) Improved Cultural Practices:

Avoid heavy seeding so that there is no overcrowding of seedlings in the seed bed and thereby no shedding effect is produced. Seedlings are liable to severe infection in poorly aerated soil and growing in shed. To avoid water stagnation, seed bed soil should have proper drainage facilities.

5.5 Late Blight of Potato

Pathogen: *Phytopthora infestens*
Systematic Position of Pathogen:
Class – Oomycetes
Order – Peronosporales
Family – Pythiaceae

Distribution: The likely home of late blight of potato is Mexico, where it is endemic on wild native species. The disease appeared in epidemic form in Europe in 1845 and led to the cause of famous famine of Ireland. Now it is a world wide distributed serious fungal disease. In India, the disease was first observed in the Nilgiri Hills, thereafter it was observed in the other parts of the country. Now the disease is of common occurrence in the plains of northern India.

Symptoms: The disease usually appears in the month of January on the above ground parts of the plant. First of all, a small dead brownish to purplish black lesion appears on the tip and margin of the leaflets, rachis, petiole and stem. In low temperature and moist weather the spot spread and cover the whole plant. As a result the host plant decay and produce a foul smell. The infection also spreads in the potato tuber which get depressed and wrinkled. The skin of the tuber becomes brown and black and decay before the harvesting of crop.

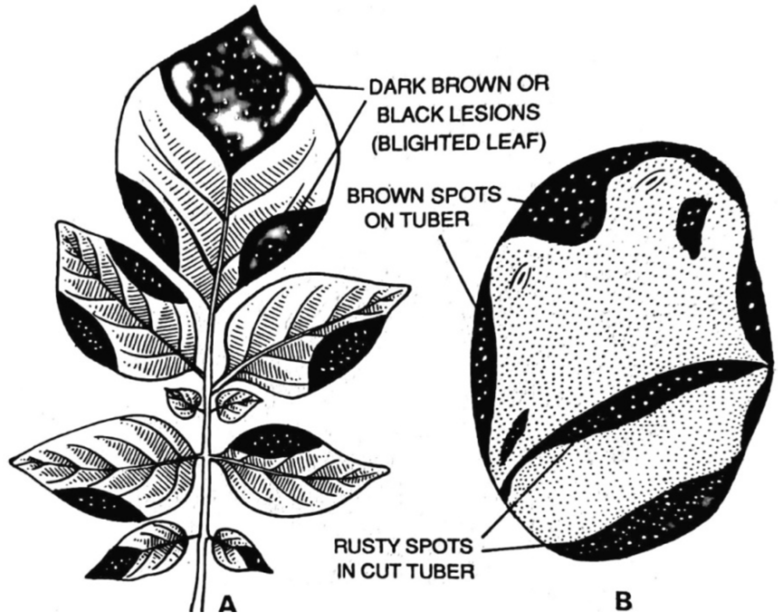

Fig.5.7. A. Affected leaf showing characteristic symptoms of disease; B. Affected tuber

Host- Pathogen relationship: The pathogen is facultative saprophyte and facultative parasite. The mycelium of the fungus is branched, hyaline, aseptate. It grows into the intercellular spaces of the host tissue and produces intracellular globular or branched haustoria which absorbs nutrients.

Environmental Relationship: Disease develops in wet conditions under high relative humidity, cloudiness, moderate rainfall and temperature between 22-23^{0}C.

Disease Cycle: The primary infection take place either through the infected tubers used as a seed or by oospore present as plant debris in the soil. Thus disease is seed borne as well as soil borne. In India the infected tubers are main source of primary infection as climatic conditions of India do not favor survival of pathogen in soil. The pathogen survives as dormant mycelium in the tuber. When such tubers are used as a seed the mycelium becomes activated. It grows in the vegetative part of the growing plant and establish themselves in the intercellular spaces.

In case of soil borne disease the oospore germinates in the soil and produces sporangium. Biflagellated zoospores are produced in the sporangium get liberated in the soil. The zoospores withdraw their flagella becomes round off and encysted. Then it germinates on host surface and produce intercellular mycelium which has intracellular haustoria.

On the host surface pathogen reproduce asexually and produces sporangia on sporangiophore which comes out through stomatal openings. These sporangia act as secondary inoculum. The sporangia are disseminated by wind and falling on healthy potato plant. It germinates and produces a number of biflagellated zoospores. These zoospores germinate on the host surface, penetrate and causes secondary spread of disease. The process is repeated as a result disease spreads during the growing season over large tracts under potato cultivation. As a result of sexual reproduction oospores are produce in the soil.

The severity of late blight disease is governed by following environmental conditions.

- Night temperature below dew point for 4 or more hours.
- Minimum temperature 10^0C or slightly above
- Mean cloudiness not below 0.8^0C on the next day
- Rainfall during next 24 hours at least 0.1mm.

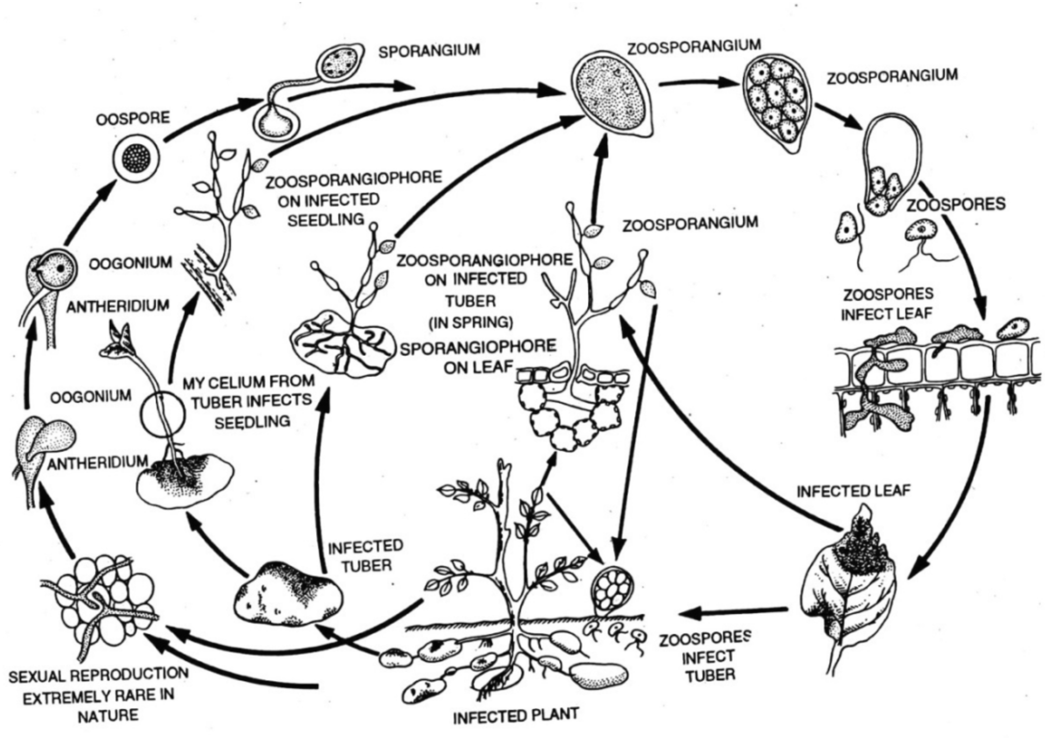

Fig.5.8. Disease cycle of Late blight of potato

Control Measures:

1. The tubers used as a seed should be disease free.
2. Use of resistant varieties such as: Kufri Naveen, Kufri Jeevan, Kufri Badshah, Kufri moti, Kufri Alankar etc.
3. Timely and repeated foliage spray of fungicides like Dithane Z-78, Dithane M-22, Bordeaux mixture, Blitox-50, Fytolan.
4. Dusting the foliage with copper lime dust is an effective control measure.
5. Destruction or proper disposal of infected potato tuber also helps in reducing incidence of disease.
6. Before storage the tubers should be dipped in 1:1000 mercuric chloride solution for 90 minutes and should be washed before use.

SAQ 2.

a. Wilt of Arhar is caused by ……………………………….
b. Damping off disease occurs at ………………….. stage of plant.
c. Late blight of potato is caused by …………………………………………
d. Late blight is a ………………………………… borne and …………… borne disease.

5.6 Early Blight of Potato

Pathogen: *Alternaria solani*
Host: Potato Plant
Systematic Position of Pathogen:
Class – Deuteromycetes
Order – Moniliales
Family – Dematiaceae

Distribution: The disease is world wide in distribution from Canda to New Zealand and Japan to South Africa. In India disease occurs in the Indo-gangetic plain and the Nilgiris.

Symptoms: It is called early blight because disease appears in the early stage when the plants are 3-4 weeks old. The disease appears in the form of small isolated scattered pale brown to dark oval or angular shaped spot. The lower leaves are infected first. The spots are covered by deep greenish blue growth of the pathogen. In older spot the necrotic area is surrounded by series of concentric ridge which give target board effect. This is the characteristic symptom of the disease.

The spots are surrounded by chlorotic zone. In severe infection spot appears on petiole and stem as well as in the tuber in the form of dark, slightly sunken, irregular or circular lesions. In severe infection the whole plant collapse.

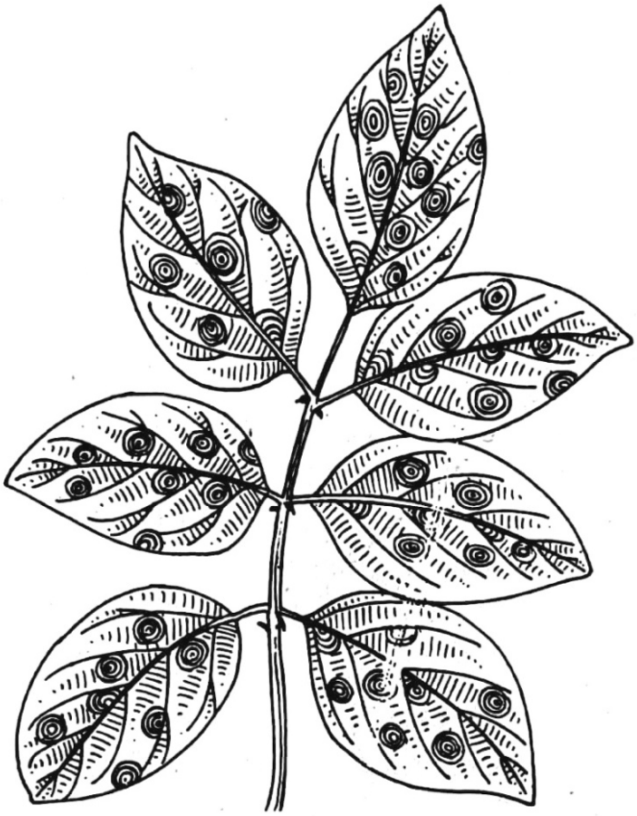

Fig.5.9.Potato leaf showing target board effect symptom

Host-Pathogen relationship- Septate branched mycelium grow in the intercellular spaces and then becomes intracellular.

The mycelium produces single conidium at the apex of conidiophore. Each conidia is muriform in shape and has transverse and vertical septa.

Environmental relationship: Heavy dew with frequent rains are essential for abundant production of conidia. The optimum temperature for germination of conidia is 28-30^{0}C. Abundant moisture and high temperature reduces the physiological vigor of the host plant and favors disease development.

Disease Cycle: The pathogen overwinters on infected plant debris in the form of mycelium or conidia. Thus disease is soil borne. Warm and humid environmental conditions are conducive to infection. The conidia present in plant debris germinates within 40 minutes under free moisture and 28-30^{0}C temperature. The germ tubes of conidia penetrates the leaf epidermis directly or through stomatal openings. Infection of potato tubers occur through wound in the tuber. Thus the primary infection in the host plant appears within 2-3 days. After infection pathogen produces conidia on conidiophores within 4-7 days.

The conidia produced on host surface act as secondary inoculum. They are disseminated mainly by wind and occasionally by splashing rain or overhead irrigation. When they fall on healthy potato plant germinate and causes secondary spread of disease. Thus early blight is polycylic with repeated cycles of new infection.

Control Measures:

1. Rotation of crop is a successful method to avoid primary infection from conidia present in the soil.
2. The plant debris should be collected and burned immediately after harvest.
3. Use of resistant varieties like: K. Naveen, K. sindhuri, K. Jeevan.
4. Timely and thorough spray of fungicides effectively controls the disease. Spray with Zineb or copper fungicide at 15 days intervals and weekly sprary of Bordeaux mixture is effective in disease control. Four to five foliar sprary of Dithane M-45, dithane Z-78, difoltan, captan and blitox-50 are also effective.

5.7 Black Rust of Wheat

Pathogen: *Puccinia graminis tritici*
Host : Wheat Plant
Systematic Position of Pathogen:
Class – Basidiomycetes
Order – Uredinales
Family – Pucciniaceae

Distribution: The disease occurs in all wheat growing countries of the world. In different parts of India the disease appears at different times. In Northern India it appears in the month of march whereas in southern and Peninsular India it appears in the fourth week of November. The disease is very destructive and causes enormous losses in all wheat growing regions of the world.

Symptoms: Symptoms appear on the stem and leaf sheath in the form of long elongated pustules. Initially the pustules are brown in colour due to uredospores but become black coloured when teleutospores are produced. The uredospores are one celled, binucleated and are exposed by the rupture of the leaf epidermis. The teleutospores are two celled unnucleated and are exposed by the rupture of underlying epidermis. In severe infection plants look sick and fail to develop normal ears.

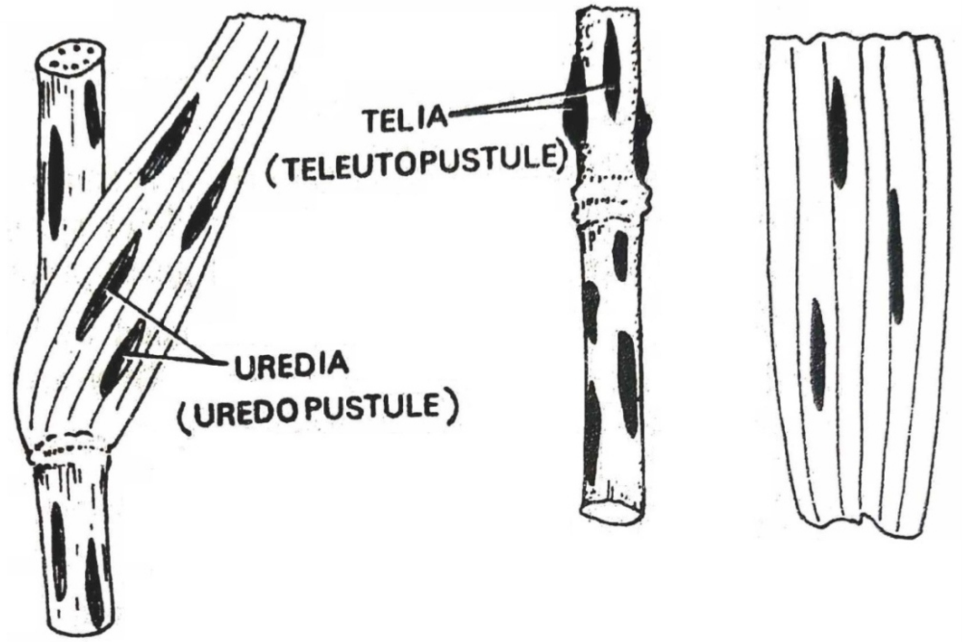

Fig. 5.10. Symptom of black rust of wheat

Host-pathogen relationship: The dikaryotic mycelium grows into the intercellular spaces of the host plant and produce button shaped intracellular haustoria by means of which absorb nourishment.

Environmental relationship: Moderate temperature and heavy rainfall favorers the disease.

Disease cycle: *Puccinia graminis tritici* is a heteroecious pathogen and requires two host wheat and barberry plant to complete their life cycle. The wheat is the primary host on which pathogen causes disease. Barberry is alternate host which is required to complete the life cycle of pathogen.

The disease is air born. The primary inoculum uredospores come to the plains of Northern India from the hills. The uredospores of the plains are killed by summer heat where as they survives on the hills due to low temperature. The uredospores when fall on the wheat plant germinates to produce mycelium and establish themselves in the intercellular space. After vegetative growth the pathogen produces uredospores in uredosori in the host below the epidermis. The epidermis ruptures and uredospores get exposed. At this stage brown streaks develop on the host surface.

The uredospores produced on the host act as secondary inoculum and are disseminated by wind. Thus secondary spread of disease occurs. After uredospores, teleutospores are produced in teleutosori on wheat plant and black streaked spots develop on host surface. After teleuto stage the life cycle of pathogen ends on wheat plant.

The teleutospore germinates in soil and forms basidium which bears four basidiospore (two of + strain and two of – strain). The basidiospores of + and – strain are dissaminted by wind and falling on alternate host barberry it germinates and produce Pycnia of + and – strain on the upper surface of leaf respectively. The + strain Pycnia has + strain receptive hypha (♀ reproductive organ) and + strain pycniospores (♂reproductive organ). On the lower surface of leaf primordia of aecidial cup is formed in which aecidiospores are produced as a result of spermatization. These aecidiospores get exposed by rupture of epidermis and disseminated by wind. Thus the life cycle of pathogen is completed.

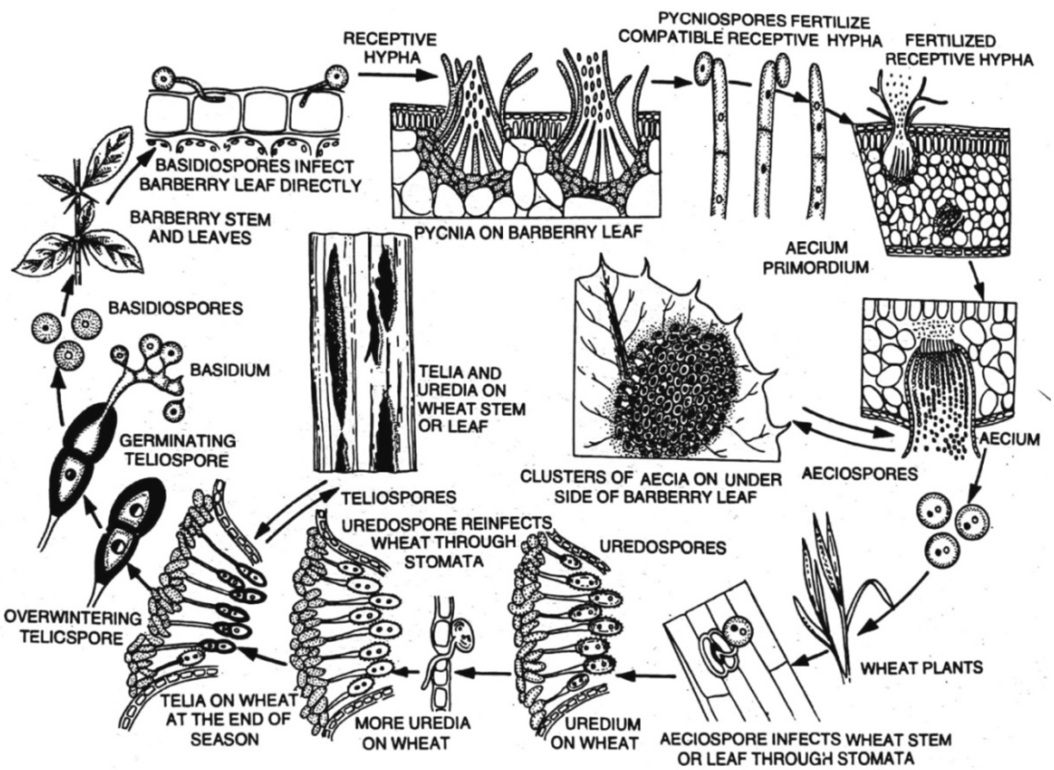

Fig.5.11. Disease cycle of Black rust of wheat

Control Measures:

1. Cultivation of resistant varieties of wheat like NP710, NP718, NP822 and NP825 helps in disease control.
2. Use of fungicides like dithane, zineb and actidione also control the disease.
3. Destruction and eradication of collateral host of hilly region on which uredospores survive there.

SAQ-3

a. *Puccinia graminis tritici* is a ………………………… fungus.
b. The primary host of *Puccinia graminis tritici* is …………….. plant.

c. Barberry leaf is the ………………………. host of *Puccinia graminis tritici*

d. Black rust of wheat is caused by …………….. …………………. ……………

5.8 Tikka Disease of Groundnut

Pathogen: *Cercospora arachidicola and C. personata*

Host: Groundnut

Systematic Position of Pathogen (Imperfect stage):

Class – Deuteromycetes

Order – Moniliales

Family – Dematiaceae

Distribution: Tikka disease is world wide in distribution and occurs in all those countries where the crop is grown. In India the disease occurs in all those states where the crop is grown. In Utter Pradesh disease is caused every year and locally known as chitwa or haldai due to characteristic symptoms on the leaves.

Symptoms: The symptom appears in the form of small pale area on the leaf surface which later on turned light brown when the causal organism is *C. arachidicola* or carbon black when the causal organism is *C. personata.*

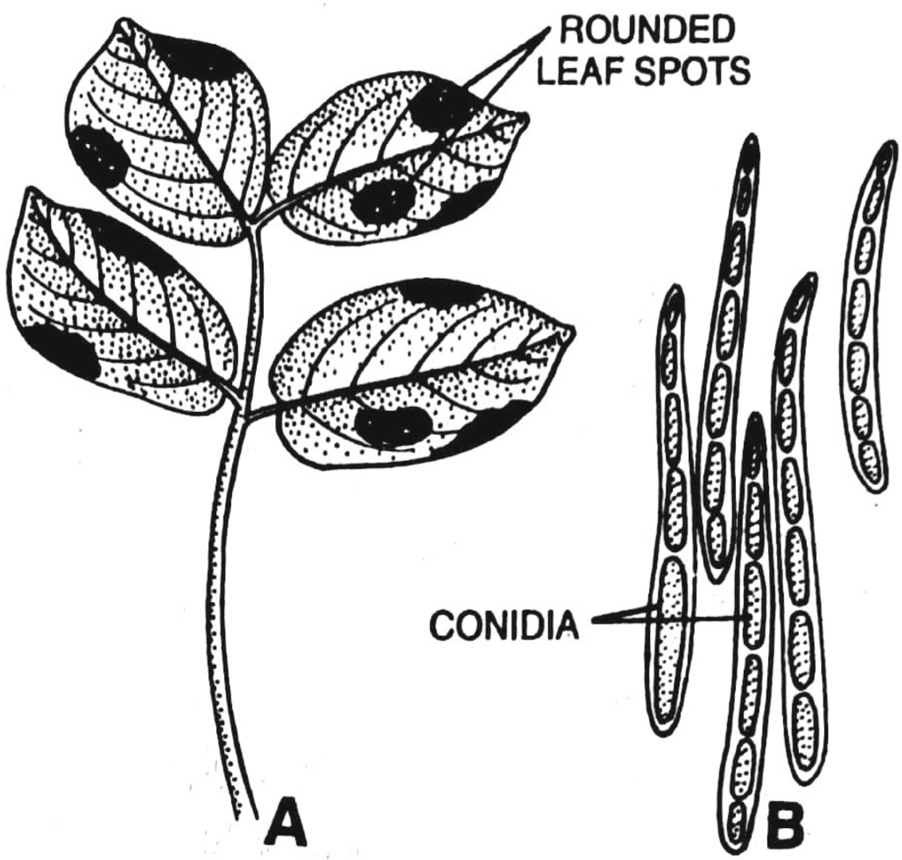

Fig.5.12. symptom of tikka disease of groundnut (*Cercospora arachidicola*). A. Leaf showing characteristic spots; B. Conidia

Host pathogen relationship: The mycelium grow in the intercellular spaces and do not produce haustoria. It kills the host tissue and then become intracellular.

Environmental relationship: Disease prevails in the month of September. Prolonged low temperature heavy dew and high humidity favors the disease development.

Disease cycle: Primary infection take place by conidia present in the infected plant Debris in soil and on seeds in the shell. The primary inoculum infects the plant when they are 2-3 months old. Mycelium establish themselves between the intercellular and intracellular spaces and produces long septate conidia which are disseminated by wind and causes secondary infection in the healthy host.

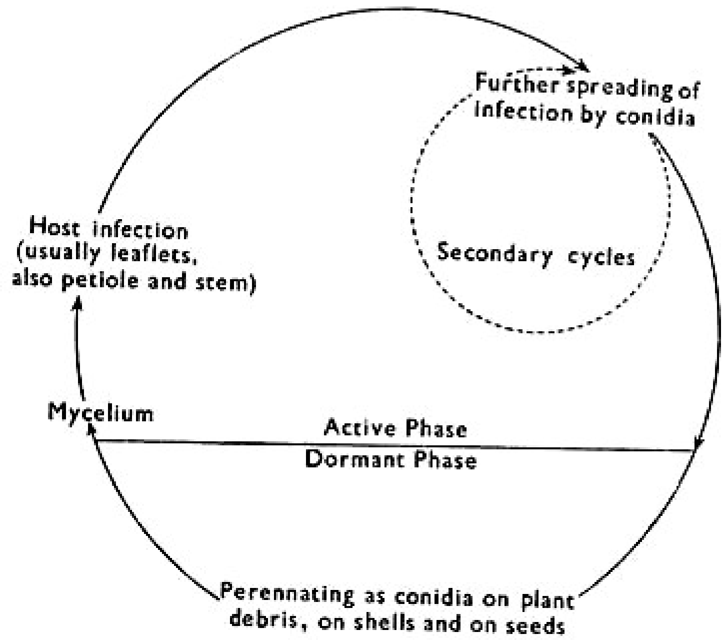

Fig. 5.13. Diagrammatic disease cycle of Tikka disease

Control Measures:

1. Rotation of crop can be used to control disease.
2. Treatment of seed and disposal of host debris by burning or burying also helps to control disease.
3. Plants are sprayed with fungicides like carbendazin, benomyl and bordeaux mixture.

5.9 Loose smut of wheat

Pathogen: *Ustilago tritici*

Host : Wheat Plant

Systematic Position of Pathogen:

Class – Basidiomycetes

Order – Ustilaginales

Family – Ustilaginaceae

Distribution: It is a common disease of India which occurs mostly in western districts of Utter Pradesh. The distribution of disease is throughout the world.

Symptoms: The symptom appears in the inflorescence. The diseased ear has powdery mass of smut spores. In the beginning the smut spores remain covered by thin silvery membrane but later on the membrane ruptures and powdery mass of smut spores get exposed.

Fig. 5.14. Smutted ear of wheat

Host-pathogen relationship: Pathogen is an obligate parasite. Septate dikaryotic mycelium grow into the intercellular spaces in the part of the plant and absorbs nourishment with the help of intracellular haustoria. The spores are produced only in the floral parts specially ovary of the flower.

Environmental relationship: Cool and humid weather at the time of flowering favors the disease development.

Disease cycle: The disease is seed borne and primary infection comes from the infected seed. The secondary mycelium grow in all the part of the plants but symptom appears in the ear when teleutospores are produced. The telutospores act as secondary inoculum and disseminated by rain or wind. They fall on the stigma of healthy overy and causes secondary infection.

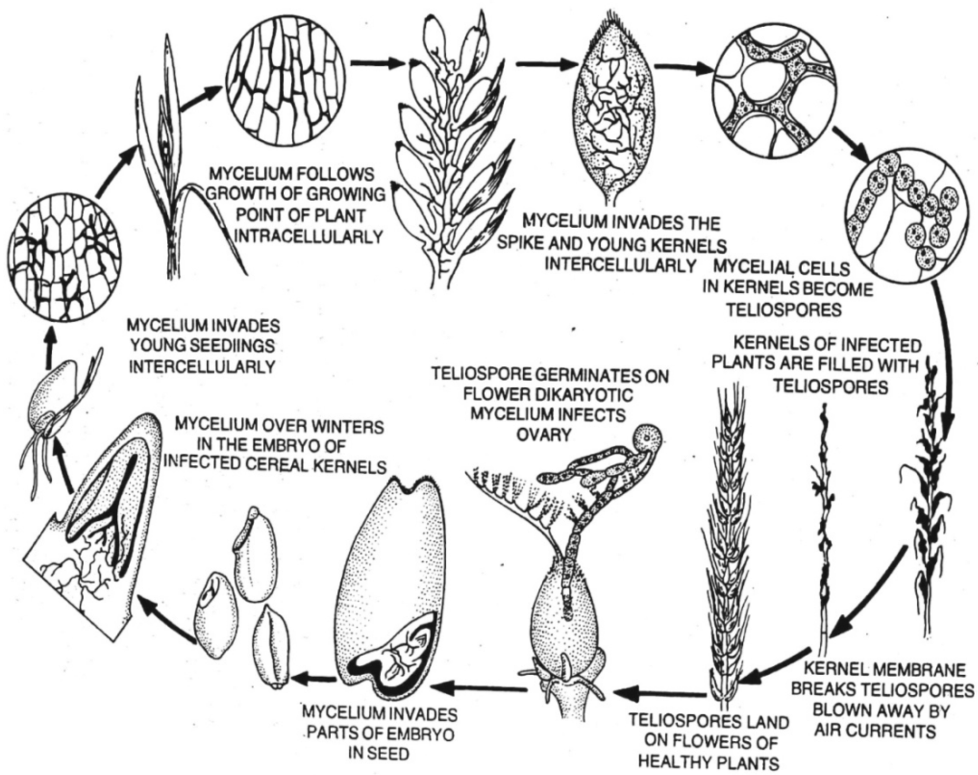

Fig.5.15. Disease cycle of Loose smut of wheat

Control Measures:

1. Seeds are soaked in cold water for few hours then they are treated with hot water (temp. 52-54^{0}C) for 10 minutes. The seeds are then dried and sown.
2. Water soaked seeds are exposed to heat of direct sunlight for about 04 hours.
3. Use of resistant varieties like NP 710, NP 718, NP 761, NP 770, MP 108, MP 144 etc.

SAQ-4

a. The host of tikka disease is ………………………………
b. The pathogen of tikka disease is ………………. …………. and ………………..
c. Loose smut of wheat is caused by …………………………….
d. Symptoms of smut disease appear in the …………………………… of the plant.

5.10 Summary

- Plant diseases are important to human beings because they are responsible for causing damage to plants and plant products.
- Millions of people over the world depends on the plant products for their existence.
- White rust of crucifer is a soil borne disease caused by *Albugo candida* or *cystopus candida.*
- Wilt of Arhar is also a soil borne disease caused by *Fusarium oxysporum.*
- Damping off of seedling is caused by species of *phythium, phytophthora, Fusarium* and *Rhizoctonia* among which *phythium debaryanum* ranks first in causing damping off diseases.
- Late blight of potato is soil borne as well as seed borne disease caused by *phytophthora infestens.* The disease appeared in epidemic form in Europe in 1845 and led to the cause of famous famine of Ireland.
- Early blight of potato is a soil borne disease caused by *Alternaria solani.*
- *Puccinia graminis tritici* is a heteroceious pathogen and completes their life cycle on two host. The primary host wheat plant and alternate host is barberry plant. On wheat plant it causes a disease known as black rust of wheat.
- Tikka disease of groundnut is caused by *Cercospora arachidicola* and *C. personata.* The disease is soil borne.
- Loose smut of wheat is a seed borne disease caused by *Ustilago tritici.* The pathogen of disease grow in all the vegetative parts of the plant but symptoms of the disease appears only in the floral parts.

5.11 Terminal Questions

1. Describe the life cycle of white rust of crucifer disease.

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2. Describe the life cycle of late blight of potato giving emphasis on the symptoms, mode of infection and methods of control.

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3. Give a brief account of black rust of wheat caused by *Puccinia graminis tritici.*

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4. Give an account of loose smut of wheat.

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5. Write short notes on:

(a) Wilt of Arhar.

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(b) Early blight of potato.

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(c) Tikka disease of groundnut

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(d) Control measures of damping off

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5.12 Answers

SAQ-1

(a) *Albugo candida* (b) Oospore (c) Soil (d) conidia (e) Bordeaux mixture

SAQ-2

(a) *Fusarium oxysporum* (b) seedling (c) *Phytophthora infestens* (d) soil, seed

SAQ-3

(a) heteroecious (b) wheat (c) alternate (d) *Puccinia graminis tritici*

SAQ-4

(a) groundnut (b) *Cercospora personata* , *C. arachidicola* (c) *ustilago tritici* (d) Infloresence

Further readings

1. **Plant Pathology by P.D. Sharma.**
2. **Fundamentals Plant Pathology by R.S. Mehrotra.**

।। सरस्वती नः सुभगा मयस्करत्।।

Uttar Pradesh Rajarshi Tandon Open University

DCEBY -106

Plant Pathology and Microbiology

Block -2
Microbiology

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Block-2: Microbiology

Microbiology is one of the most important discipline in which you study the use of small living microorganisms for human welfare in sewage treatment, improving fertility of soil and increasing dairy products.

The microorganisms are the work houses of waste water treatment system and anaerobic digesters, where they are responsible for removal of pollutants and pathogens, recovery of nutrients and energy and producing clean water.

Soil microbiology is a branch of soil science concerned with soil inhabiting microorganisms their functions, and activities within the soil ecosystem-

The bacteria present in dairy products may cause diseases or spoilage. Some bacteria may be specifically added to milk for fermentation to produce dairy products like yogurt and cheese.

This block is divided into 3 units viz. 6,7 and 8 which is as follows:

Unit 06- Sewage microbiology deals with composition and characteristics of sewage and various methods of sewages disposal.

Unit 07- Soil microbiology covers humaus and role of microbes in various cycles like nitrogen, carbon, phosphorous and sulphur occurring in soil.

Unit 08 - Dairy microbiology covers compositions of milk, sources of microbial population in milk their types and temperature characteristics, process of pasteurization and milk products.

Objectives: After studying this block you will be able to:

- Know how microbes help us to convert sewage into useful products.
- Understand role of microbes in increasing fertility of soil.
- Apply microbes in dairy industry.

UNIT 6: WATER (SEWAGE) MICROBIOLOGY

Structure:

6.1 INTRODUCTION

Water is an essential requirement of life. The microorganism present in water determines its quality and quantity. The microorganisms of water may be responsible to cause several severe diseases among the animals, humans etc. those who consume. The yield or production of plants is also affected by the quality of water they absorb. Sewage is the collection of all disposable things added in sewer line either house hold or industrial waste. The house hold sewage includes faecal matters whereas industrial sewage includes unused waste chemicals which are added to the natural water reservoirs and soil, which gets polluted.

Objectives:-

After studying this unit you will be able to:

- Know the chemical & microbial composition of sewage.

- Understand the characteristic of sewage.
- Know about various processes of small scale sewage treatment as well as large scale sewage treatment.

6.2 COMPOSITION OF SEWAGE

Though there is no fixed composition of sewage. The domestic or household sewage is depending upon the locality, area, population density and the environment whereas industrial sewage or waste is depending upon the type, quality and amount of production. Sewage includes solid, liquid and gaseous effluents. Microbial growth depends on its composition.

6.2.1 CHEMICAL COMPOSITION

The major portion of the sewage is water i.e. about 98-99% and rest of the 1-2% is metals, organic and inorganic substances remain either as suspended particles or in soluble forms. Some gases are also found present in sewage. Chemically industrial sewage contains large number of heavy metals, which are highly toxic, beside this it also contains gases like; methane, carbon-di-oxide, sulphur-di-oxide etc. The organic compounds like; celluloses, hemicelluloses, lignin, cellulobiosis etc. are generally the chief components of house hold sewage. These complex compounds which can be broken into simpler forms by the presence of microbial population present there.

6.2.2 MICROBIAL COMPOSITION

Since sewage contains organic matter and number of disease causing micro-organisms. The population of microbes in per ml of sewage calculated and found variable from few lakhs to several millions. There are both micro flora such as; bacteria, micro algae, micro fungi, and micro fauna like; protozoa, nematodes, eggs of arthropods etc. present. The common sewage microbes are bacteria like; coliform bacteria, *Clostridium perfringens*, *Streptococcus faecalis*, *Streptococcus pyrogens*, *Micrococcus proteus*, *Pseudomonas* etc. some algae such as; *Microcystis, Anabaena, Oscillatoria, Chlorella* and protozoans. There are some pathogenic bacteria which also present beside these like; *Salmonella typhi* causing typhoid fever, *Salmonella typhimurium* causes paratyphoid, *Vibrio cholerae (Vibrio comma)* for Cholera etc. Some others diseases caused by these sewage microbes are amoeboid and bacillary dysentery, poliomyelitis, jaundice etc.

SAQ 1:

a. The major portion of the sewage is …….. i.e. about 98-99% .

b. ……………causes typhoid fever.

c. Amoeboid and bacillary dysentery, poliomyelitis, jaundice etc. may be caused by ……….microbes.

6.3 CHARACTERISTICS OF THE SEWAGE

- Organic matter of sewage undergoes partial or anaerobic decomposition.
- Due to partial decomposition various gases are produced such as Methane (CH_4), Carbon dioxide (CO_2), Carbon mono-oxide (CO), Sulfur dioxide (SO_2), Hydrogen sulfide (H_2S) etc.
- These gases react with water and sewage becomes acidic having low pH i.e. 4.
- Low pH level of sewage is not suitable for microbial growth.
- Presence of heavy metals (Pb, Cr, Ni etc.) in higher concentration also affecting the growth of microorganisms.
- Due to poor illumination photosynthetic rate is reduced hence causing death of oxygen dependent aerobic microbes, plants and animals.
- BOD (Biological Oxygen Demand) becomes very high i.e. as the amount of dissolved oxygen required by the organism in a given Vol. of water at 20^0 C .
- OC (Oxygen Consumption) is also very high in sewage i.e. the amount of dissolved oxygen utilized by biotic community for oxidative decomposition of the organic matter in 1 liter of water in 1 hour.
- DO (Dissolved Oxygen) in sewage is consumed entirely by the organisms due to high demand of oxygen and low photosynthetic rate.
- Sewage water has high conductivity.

SAQ 2:

a. BOD (Biological Oxygen Demand) of sewage is ………

b. OC (Oxygen Consumption) is also very high in sewage i.e. the amount of dissolved oxygen utilized by …………..of the organic matter in 1 liter of water in 1 hour.

c. DO (Dissolved Oxygen) in sewage is consumed entirely by the organisms due to high demand of oxygen and low …………

6.4 METHODS OF SEWAGE DISPOSAL

Sewage disposal is very big problem in urban and populated areas to prevent pollution and diseases.

Sewage treatment in homes and rural areas is usually managed in small scale or single dwelling unit treatment process whereas in towns and cities managed by municipal bodies by large scale treatment processes.

6.4.1 Small Scale Sewage Treatment or Single Dwelling Unit Treatment Process

6.4.1.1 Outdoor Toilets: It has commonly in rural areas in villages where people are not aware about disposable sewer system and is not developed. Therefore people use fields and open areas. The best way is to dispose of the sewage in a pit which must be covered with soil or clay of the surrounding areas later on to avoid the spread of flies, mosquitoes, insects, animals and other pathogenic microbes to check contamination and diseases.

6.4.1.2 Cesspools: It is another method of sewage disposal of small scale treatment in many homes where human waste is dumped into cesspools. It is an underground construction consisting of cylindrical rings made up of concrete. There are many pores around the wall of rings (Fig. 6.1).

6.4.1.3 Septic Tanks: Septic tank is usually made for individual family in rural areas due to lack of public sewage system. It is made up of either metal or concrete kept underground near homes where all domestic sewage is collected through inlet pipe. The suspended organic solid sewage is accumulated at the bottom of the tank whereas liquid flows through pipes of distribution box and reaches to the surrounding soil and mixes through outlet pipes (Fig.6.2).

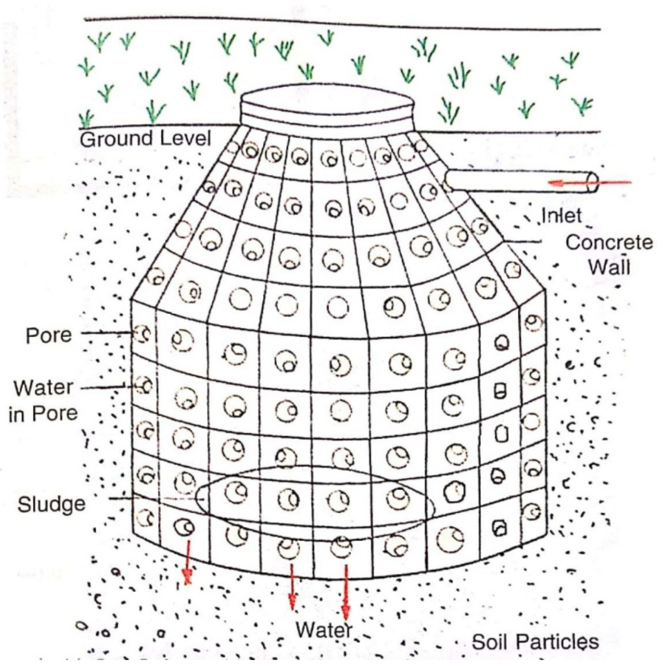


Fig.6.1: Cesspool

Waste water enter through inlet and passes into surrounding soil via pores and solid sludge accumulates at bottom

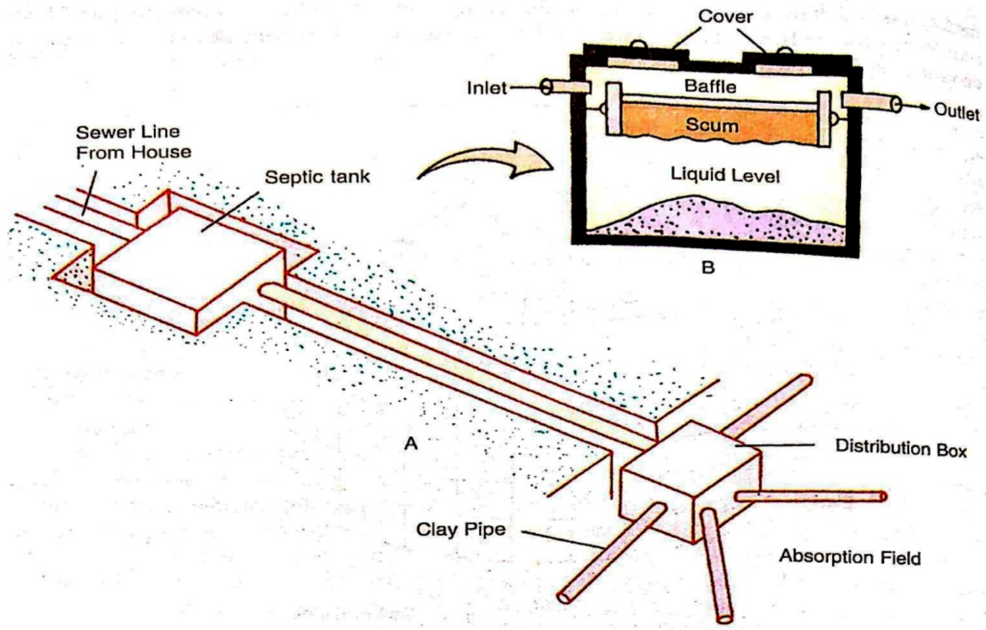


Fig.6.2: Septic Tanks in Small Towns

The collected organic materials further decomposed by anaerobic microbes and releasing some by-products such as sugars, alcohols, organic acids, amino acids fatty acids, glycerols and various gases e.g. H_2, H_2S, CH_4, CO_2 etc. after decomposition some material remains left undigested called sludge. Sludge is utilized in field as manure in the form of humus. In small towns sewage is collected in large ponds known as oxidation lagoons where it is oxidized by aerobic microbes and further sediments get decomposed by anaerobic microbes.

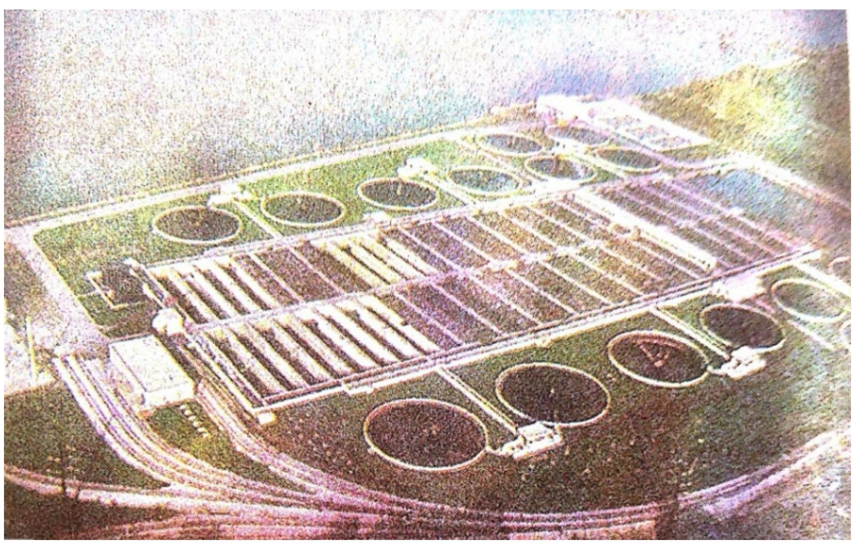


Fig.6.3: Modern Conventional Sewage Treatment Plant
(Aerial View)

6.4.1.4 Imhoff Tank: The Imhoff tank named after a German engineer Karl Imhoff (1876-1965) is a chamber suitable for the reception and processing of sewage. It is relatively simple anaerobic system used to treat waste water before heated digesters were developed. It is still commonly used for small communities of small capacity. Imhoff tanks is used for clarification of sewage by simple setting and sedimentation, along with anaerobic digestion. This is made up of metal, fixed underground at any place away from the community. It has two chambers placed one upon another. The upper chamber is smaller called as flow chamber which receives raw sewage. Then sewage flows into larger chamber called digestion chamber and is anaerobic inside. During anaerobic digestion gases like methane (CH_4), carbon dioxide (CO_2), Nitrogen (N_2), Hydrogen (H_2) etc. are released and may be utilized as biogas. The liquid waste is placed above and solid particles settle down. Both solid sludge and liquid effluent can be taken out by suction pump. Solid part is dried and may be used as manure whereas liquid effluent is spread over in the field and may be used for irrigation.

SAQ 3:

a. ……is an underground construction consisting of cylindrical rings made up of concrete with many pores around the wall of rings.

b. In small towns sewage is collected in large ponds known as ……..where it is oxidized by aerobic microbes.

c. The Imhoff tank named after a German engineer ………., is a chamber suitable for the reception and processing of sewage.

6.4.2 Large Scale Sewage Treatment or Municipal Sewage Treatment

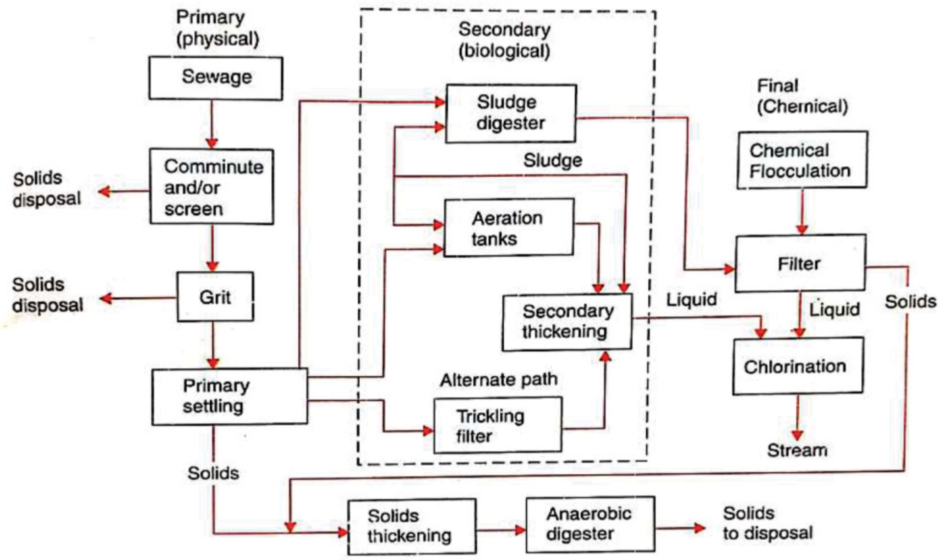
Large scale sewage is used mainly for larger communities in city or town, managed by municipal bodies. The municipality has sets several sewage treatment plants in cities (Fig.6.4). This treatment is done in following steps:

1. Primary or Mechanical Treatment
2. Secondary or microbial biodegradation Treatment
3. Tertiary or Final or Chemical Treatment

1. Primary or Mechanical Treatment: The separation of solid and liquid waste from raw sewage done mechanically is first step. The collected sewage is passed through graded filters by which solid coarser particles from liquid effluents. Solid part settles down whereas liquid sewage passes further to settling tanks. After that both solid and liquid wastes are treated separately and processed for next step.

2. Secondary or Biological Treatment: Secondary treatment involves two different steps:

a. *Aerobic Digestion of liquid sewage*
b. *Anaerobic Digestion of Solid sludge*



<u>Fig. 6.4:</u> Flow Chart Showing Large Scale Sewage Treatment Or **Municipal Sewage Treatment**

a. *<u>Aerobic Digestion</u>:* The liquid waste passes through different process of treatments:

   i. *Trickling filters*:
   ii. *Oxidation Ponds*
   iii. *Bio-disc System or Rotating Biological Contractor*
   iv. *Activated Sludge Process*

i. *Trickling filters*: In the secondary treatment the liquid waste is processed by adding aerobic microbes, these microorganisms digest the soluble organic matter and water passes through trickling filters. The water is separated from these aerobic microorganisms like *Chlorella, Oscillatoria, Clostridium, Lyngbya* etc. which are grown in the tank and converting the complex organic forms into simpler forms. The separated water further passes out while the sedimented material flows into sludge tank.

ii. *Oxidation Ponds*: The liquid is spread into secondary settling tank along with the air blown inside the tank which is known as oxidation pond. The BOD is reduced during this process and aerobic microbes may grow faster. The liquid becomes more clear and transparent in this step.

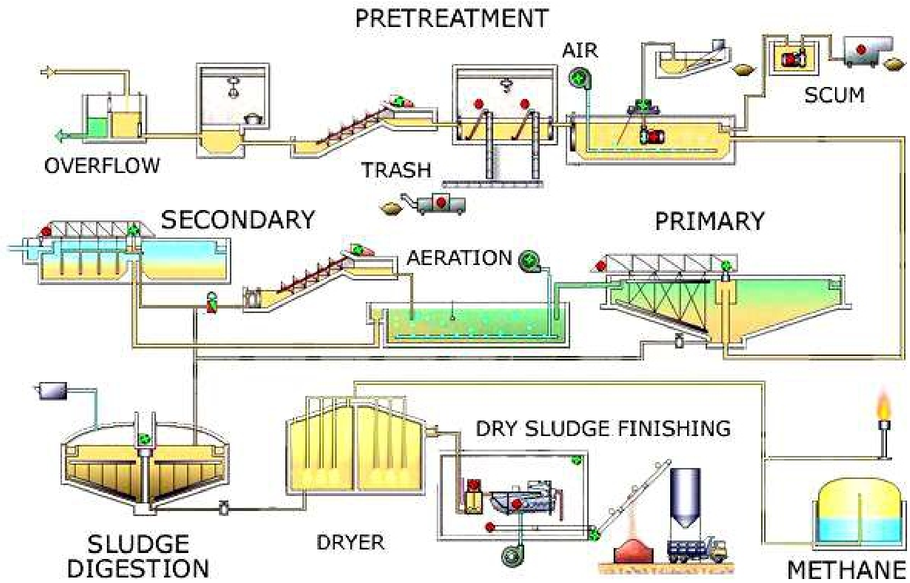


Fig.6.5: **Schematic Presentation of Sewage Treatment Plant in Town or City**

iii. *Bio-disc System or Rotating Biological Contractor*: Bio-disc is the only packaged sewage treatment plant utilizing Rotating Biological Contractor technology for small domestic applications. This process involves allowing the waste water to come in contact with bacteria which grow on bio-discs and digest the pollutants in the waste water before discharge of the treated waste water to the environment and also offers inherent cost and performance benefit with low carbon footprints.

iv. *Activated Sludge Process*: The liquid is filled in a tank where oxygen is blown so that this liquid becomes clearer and more oxygenated. The solid portion settles down. The clear liquid is sending for tertiary step.

b. *Anaerobic Digestion of Solid Sludge*: The solid portion of sludge collected during aerobic digestion after primary and secondary settling tanks from filter in a closed container is kept for several weeks and treated by anaerobic methods by adding anaerobic micro-organisms. The anaerobic bacteria break down the sludge into usable form of gases and dried digested sludge. Gases may be used as bio-gas, utilized as fuel and energy production on one hand whereas solid portion used as manure in agriculture.

3. Tertiary or Final or Chemical Treatment: The clear liquid is further purified destroying pathogenic and harmful micro-organism by treating with chlorine and used for irrigation or collected ponds or reservoir as a natural habitat.

SAQ 4:

a. The municipality has sets several sewage treatment plants in cities in which first step treatment is ……………

b. In the secondary treatment the liquid waste is processed through Trickling filters by adding ………microbes

c. During tertiary or final or chemical sewage treatment…….gas .is blown to destroy pathogenic and harmful micro-organism.

d.……or ………..is the only packaged sewage treatment plant utilizing technology for small domestic applications.

6.5 SUMMARY

- Sewage is chemically composed of approximately 99% water and 15 inorganic and organic matters in suspended and soluble forms.
- The sewage of towns in our country contains on an average 350 ppm biodegradable organic compounds, 52 ppm Nitrogen, 45 ppm Potassium and 16 ppm phosphorus.
- Cesspool or soak pit is an underground container for temporary storage of liquid and solid waste sewage.
- Septic tank is an underground chamber made of concrete, fiber glass or plastic.
- A septic tank allows waste water to flow into field where it undergoes filtration process in contrast to cesspools which is a cemented lined pit made up of concrete or cement.
- In large scale or municipal sewage treatment in town as sewage enters into plant for treatment and flows through screen, which removes large floating objects such as rags and sticks that may clog pipes or damage equipment. The sewage passes into grit chamber after screening where sand and other solid particles settle down to the bottom.
- Municipal sewage treatment is done in three steps: a. Primary or mechanical treatment b. Secondary treatment or microbial biodegradation c. Tertiary or Final or Chemical treatment

6.6 TERMINAL QUESTIONS

Multiple Choice Questions:

1. The working conditions in imhoff tanks are:
   a. Anaerobic only
   b. Aerobic only
   c. Aerobic in upper compartment and anaerobic in lower compartment
   d. Anaerobic in upper compartment and aerobic in lower compartment

2. The unit in which both sedimentation and sludge digestion process takes place simultaneously is:
   a. Imhoff Tank b. Skimming Tank c. Digestion Tank d. Detritus Tank
3. The sewage treatment units in which biological decomposition of organic matter takes place are called:
   a. Sludge sedimentation tanks
   b. Trickling filters
   c. Imhoff tanks
   d. None of above
4. Which of the following is not employed as an oxidation method?
   a. Oxidation Pond
   b. Trickling Filters
   c. Contact Aerators
   d. All of these-
5. The filtering medium of trickling filters is coated with microbial flora, known as:
   a. Zoological Film
   b. Geological Film
   c. Zooglocal Film
   d. None of these
6. The cleaning of environment with the help of microbes is called;
   a. Pasteurization
   b. Fermentation
   c. Bioremediation-
   d. Bioplastics
7. The bio-gas production process takes place at……..teperature
   a. Less than 25^oC
   b. 25^oC-40^oC
   c. 45^oC-60^oC
   d. All of these-
8. Advanced treatment is generally used to treat waste water to:
   a. Removal of coarse solid part
   b. Remove settled solid
   c. Reduce BOD
   d. Removal of additional objectionable substances
9. Treatment of municipal water supplies is based on:
   a. Coagulation, Filtration, Chlorination
   b. Chlorination, Coagulation, Filtration
   c. Filtration, Chlorination, Coagulation
   d. Coagulation, Chlorination, Filtration
10. An anaerobic digester is:
   a. Microbes grow in colony

b. Microbes that decompose hazardous waste
c. Which can convert agricultural waste to bio-gas
d. Which are used in food industry

11. Activated sludge contains large no. of:
    a. Zooplanktons
    b. Phytoplanktons
    c. Bacteria, Yeast, Mold, Protozoan
    d. Flies and mosquttoes
12. Which is not the form of biomass:
    a. Incineration of solid waste sewage
    b. Composting to produce waste
    c. Production of ethanol and methanol for auto fuel
    d. Photovoltaic production of Hydrogen
13. Oxidation ponds are generally designed at depth of:
    a. 2-40 feet
    b. 1- 5 feet
    c. 1-3 feet
    d. 5-8 feet
14. Which is not referred to sewerage system generally:
    a. Sanitary Sewage
    b. Storm Sewage
    c. Combined Sewers
    d. Solid Sewers
15. The magnitude of BOD of waste water is related to:
    a. Bacterial Count
    b. Amount of organic matter
    c. Bacteria and protozoas count
    d. Amount of inorganic matter
16. Bio-gas production is:
    a. Temperature dependent process
    b. Temperature independent process
    c. Oxygen dependent process
    d. Oxygen independent process

Short Answer Type Questions:

1. What is the difference between cesspool and septic tanks?

…………………………………………………………………………

…………………………………………………………………………

…………………………………………………………………………

…………………………………………………………………………

2. What is septic tank and how does it works?

……………………………………………………………………………

……………………………………………………………………………

……………………………………………………………………………

……………………………………………………………………………

3. Which process occurs in imhoff tanks?

……………………………………………………………………………

……………………………………………………………………………

……………………………………………………………………………

……………………………………………………………………………

Long Answer type Questions :

1. What do you know about sewage microbiology?

……………………………………………………………………………

……………………………………………………………………………

……………………………………………………………………………

……………………………………………………………………………

2. What is the composition of Sewage?

……………………………………………………………………………

……………………………………………………………………………

……………………………………………………………………………

……………………………………………………………………………

3. What are small scale sewage treatments?

……………………………………………………………………………

…………………………………………………………………

…………………………………………………………………

4. How does municipal or large scale sewage treatment in town works?

…………………………………………………………………

…………………………………………………………………

…………………………………………………………………

6.7 ANSWER

SAQ1:

a. Water *b. Salmonella typhii* *c.* Sewage

SAQ 2:

a. Very high *b.* biotic community for oxidative decomposition *c.* photosynthetic rate

SAQ 3:

a. Cesspool *b.* Oxidation lagoons *c.* Karl Imhoff

SAQ 4:

a. Primary or Mechanical Treatment *b.* aerobic *c. Chlorine* *d,* Bio-disc, Rotating Biological Contractor

Multiple Choice Questions:

1.c 2.a 3. c 4.d 5.c 6.c 7.d 8.d 9.a 10.c 11.c 12.d 13.a 14.d 15.b 16.a

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UNIT 7: SOIL MICROBIOLOGY

Structure:

7.1 INTRODUCTION

Soil is basic substratum for plants providing nutrients, water, oxygen etc. on one hand as well as support and strength to stand against gravity other hand. According to Treshaw (1970) soil is a complex of physical and biological system.

The study of soil is known as 'Pedology'. Soil is the upper layer of earth's surface its depth may vary from inches to over feet. It is composed of inorganic and organic matter, soil air, soil water etc. The organic matter consists of living and non living being. The soil is an excellent media for microbial growth. The micro-organisms present in soil are usually found in upper 6-10 inches of soil and may decrease with depth.

Objectives : After studying this block you will be able to:

- Microbial population present in the soil.
- Process of humus formation and their significance.
- Various mineral cycles occurring in soil by micro- organisms.
- Role of microbes in improving fertility of soil.

SAQ:1

a. The study of soil is called……….

b. The micro-organisms present in soil are usually found in upper …… inches of soil.

c. ……… in …… defined soil as 'a complex of physical and biological system'.

7.2 MICROBIAL POPULATION IN SOIL

The microbial flora may be categorized as: Bacteria, Fungi, Algae, Protozoa and Virus.

- **Bacteria:** The bacterial flora found in soil is found in maximum number as compared to other groups of micro-organism. These bacteria may be aerobic and anaerobic. Soil bacteria are usually rod shaped and flagellated. These are capsulated and improve the crumb structure of soil by connecting mineral particles and humus. There are many aerobic bacteria which consume soil oxygen rapidly and anaerobic condition arises and enhances the growth of anaerobic microbes even in aerated soil. Soil bacteria have both autotrophic and heterotrophic mode of nutrition. Some common species of soil bacteria are: *Nocardia*, *Streptomyces*, *Micromonospora* etc. and others like *Actinoplans*, *Arthrobacter*, *Pseudomonas*, *Agrobacterium*, *Micrococcus*, *Streptococcus* etc.

- **Fungi:** It constitutes the major portion of microbial biomass of soil. It may occur as free living or in symbiotically associated with plant roots called mycorrhiza. The common soil fungi belong to the members of Deuteromycotina (Fungi Imperfecti) mostly and the members of Ascomycotina and Basidiomycotina also found as parasites on the higher plants. These micro-fungi may be unicellular or multicellular along with the complex forms such as *Xylaria.* It can tolerate and modify acidic soil. Soil micro-Fungi decompose plant tissues. Decomposition of major constituents of plant tissues namely cellulose, lignin, pectin, hemicelluloses etc. brought about by them e.g. *Aspergillus*, *Penicillium*, *Fusarium*, *Alternaria*, *Chaetomium*, *Mycothecium* etc. Mold mycelia present in soil improve the physical structure. Fungal association with roots of higher plants has great nutritional significance for soil. Some saprophytic forms of fungi present in the soil are *Mucor*, *Agari*cus, *Amentia* etc.

- **Algae:** Algae requires sufficient light to perform photosynthesis therefore generally found on surface of soil. The members of Cyanophyceae (Blue-green Algae), Chlorophyceae (Green Algae), Bacillariophyceae (Diatoms) are common soil algae and genera of Rhodophyceae (Red Algae) mainly found in saline soil. Cells of diatoms form diamataceous earth and make the soil porous. Aeration of soil improves by the presence of algal growth. Some chemicals and other compounds may be added by secretion or death of organisms. Some soil microalgae like *Chlorella* secret antibiotic like Chlorellin in soil which may prevent the growth of other harmful soil microbes. The other chief soil Blue-green algae are *Nostoc*, *Anabaena*, *Scytonema* etc. grow on thick substratum and have capable to reclaim user soil. The pH of alkaline soil may reduce from 9.7-7.6 and water holding capacity also increased up to 40%. The blue-green algae i.e. the members of Cyanophyta or Myxophyta secret mucilage in soil to keep soil moist and can resist long spells of drought when remoist may develop soon. It has been also found that Heterocystous cyanophyceae found to fix atmospheric nitrogen in soil and increasing soil fertility such as *Nostoc commune* and some other members of Cyanophyta helps to increase organic matter and N_2 content in the soil. *Phormidium tenue* grows in paddy fields and secrets growth promoting substances which increase the yield as well as protein content of rice. Several other substances like carbohydrate, nitrogenous substances, organic acids, vitamins, phenolic compounds etc. are also secreted by various soil algae.

Some common soil algae are: Chlorophyceae: *Chlorella*, *Scenedesmus*, *Lyngbya* etc. Cyanophyceae; *Oscillatoria*, *Anabaena, Nostoc, Scytonema* etc.

- **Protozoa:** Different types of protozoan are found in soil. These are mainly flagellates and amoebae. There number may ranges from few hundred to several thousand which depends upon the physical condition of the soil. They lie either in vegetative or cyst form. They may consume living bacteria as well as dead and decaying organic matter. It also helps in maintaining equilibrium of bacterial flora of soil by their partial consumption.

  Though there are certain plant and animal viruses reported to be present in soil.

SAQ:2

a. Soil bacteria are usually ……. and…… shaped.

b. The antibiotic like Chlorellin is secreted by ………., a green algae.

c. Protozoan in soil normally lie either in ……….or…….form.

7.3 FUNCTIONS OF MICROBES IN SOIL

The soil microbes which are generally found growing near the roots of higher plants. This region is known as *rhizosphere*. The root surface alongwith closely adhering soil particles is called *rhizoplanes*. The emerging young roots secret some organic compounds which promotes the germination and growth of bacterial and fungal spores which are present in soil. The effect of root exudates on soil micro flora is called as *rhizosphere effect.* The growth of various symbiotic, pathogenic and other types of micro-organism depends on the nutrients available in soil. Thus there is competition for uptake of nutrients and only those microbes may survive which secret antibiotics and can resist antibodies (to inhibit the growth of other microbes) are found to flourish well and grow fast. Therefore one can see rhizosphere establishes a complex biological system.

SAQ:3

a. The soil microbes which are generally found growing near the roots of higher plants is known as ………

b. The root surface along with closely adhering soil particles is called ………

c. The effect of root exudates on soil micro flora is called as ……………

7.4 HUMUS

The Humus is known as **fat of the land**. It is formed by the death and decay of organic matter which is deposited on soil year after years. It is a mass of resistant residual organic matter under the atmospheric condition of soil. It is dark coloured amorphous substance. The basic components of humus are made up of H, O, N, P, S and carbon. The composition of humus varies greatly depending upon the following factors:

a. The material by which it is made i.e. the components of living or dead plants and animals which is involving in formation of humus.

b. The inter-conversion of materials by the types of micro-organisms involving in the disintegration and decaying process.

c. The physical environmental or atmospheric condition during which the interaction occurs among them such as temperature, moisture, aeration etc. and their mutual impact and reactions.

7.4.1 PROCESS OF HUMUS FORMATION:

The original plants and animals may be transported by soil fauna. After initial breakdown mostly the saprophytic micro-organism like bacteria, fungi, actinomycetes etc. attack, increase rapidly and the original material gradually vanished off. Its labile components like sugar, polysaccharides, protein, fat etc. leaving residues of more resistant lignin and lignin derivatives. Thus maximum part in humus is derived from the joint activity of soil fauna and micro-organisms along with available organic matter. The processing is done by input and soil metabolism by the activities of decomposers. The decomposers are of two types: a. Primary Colonizers b. Secondary Colonizers

The chemical nature of the substances determines the qualitative nature of micro-flora. Thus after decomposition of organic matter the humus is formed. The mature humus shows differences and variation in their composition and their rate of formation and maturity is controlled by the types of micro-organisms and physical condition of the soil such as temperature, moisture, pH of soil on one hand as well as deposition and collection of organic debris of plants and animals.

The fungal flora usually appears in a particular succession mode shown below in (Fig.7.1):

Senescent Tissue	**Dead Tissue**		
Primary colonizers		**Secondary colonizers**	
Stage I	**Stage I a.**	**Stage II**	**Stage III**
Weak Parasites	Primary Saprophytes sugar fungi living on sugar and carbohydrates	Cellular decomposers and associated secondary saprophytic sugar fungi, showing products of cellulose decomposition	Lignin decomposers and associated fungi
	Mucoraceous Mastigomycotina	Some **Mucorales** and **Ascomycotina**	**Basidiomycotina** and others
	Succession → → →		

Fig.7.1 : Schematic Representation of Humus Formation showing Succession of Soil Micro-Fungi

7.4.2 SIGNIFICANCE OF HUMUS:

Humus is an important part of the soil and has a great value in agriculture. The physical and chemical properties are influenced by the presence of different types of humus.

- **Physical Properties:** It improves the quality of soil physically by changing soil texture, friability, water holding capacity, soil moisture, porosity etc. Humus also resist soil erosion and saves the loss of minerals and nutrients present in soil which is beneficial for production of any crop and may enhances quantity as well as quality of yield.

- **Chemical Properties:** The chemical properties of soil such as the solubility, pH, oxidation- reduction potential and its buffering capacity is also affected by the presence of humus.

- Humus is also found as the store house of food materials for higher plants. Since it holds and slowly releases essential elements and gases through the microbial action and thus considered as *'Great store house'* for plants.

SAQ 4:

a. The Humus is known as …….. of the land.

b. The decomposers are of two types ……… colonizers and ……… colonizers.

c. Secondary colonizers are mostly……….mode of nutrition.

7.5 NITROGEN CYCLE

The nitrogen cycle is a series of processes that converts Nitrogen gas into organic substances and back to the nature. Microorganisms play an important role in improving soil fertility and involved in all aspects of nitrogen cycle including N_2 fixation, assimilation, ammonification, nitrification and denitrification. They decompose plant residues, soil organic matter and releases inorganic nutrients that is consumed by the plants (Fig 7.2).

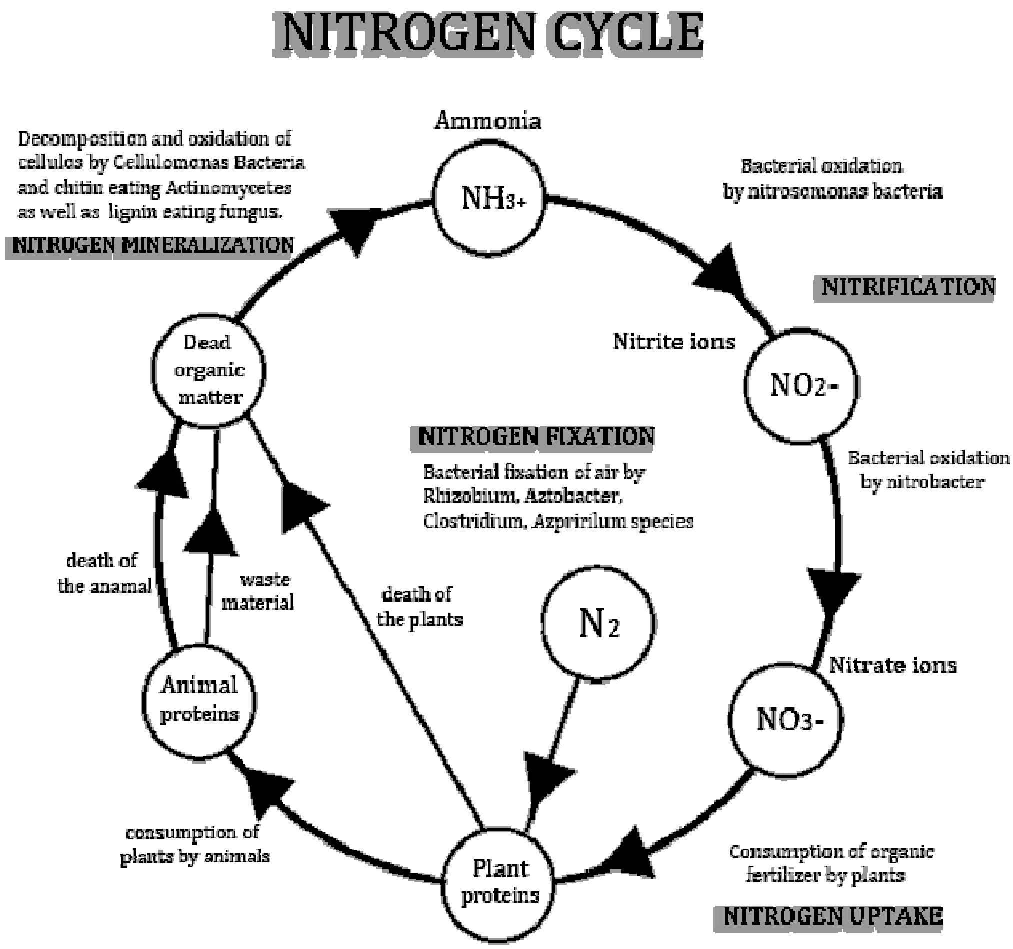


FIG 7.2: Nitrogen Cycle

- ***Nitrogen Fixation:*** The conversion of nitrogen from atmosphere into biologically acceptable form or any nitrogenous compound is called nitrogen fixation. This process is of two types: physiochemical or non-biological nitrogen fixation and biological nitrogen fixation. Biological nitrogen fixation is carried out by some prokaryotes and blue-green algae. The symbiotic nitrogen fixing microbes like *Rhizobium* inhabiting the root nodules of leguminous plants whereas some other blue green algae like *Nostoc, Anabaena* etc. showing symbiotic relationship with non leguminous plants like *Anthoceros, Azolla,* Coralloid roots of *Cycas.* The microbes use energy from the plants to fix nitrogen that is made available to the host plants and other plants of community. There are some free living nitrogen fixing bacteria available in the soil e.g. *Azotobacter, Clostridium* etc.

- ***Nitrogen Assimilation:*** Inorganic nitrogen in the form of nitrates, nitrites and ammonia is absorbed by green plants and converted into ammonia which combines with organic acids to form amino acids which is used in synthesis of various proteins, enzymes, hormones etc.

- ***Ammonification:*** The dead organic remains of plants, animals and their excreta get decayed by the action of micro-organisms especially Actinomycetes and *Bacillus* sp. these microbes utilize organic compounds in their metabolism and release ammonia.

- ***Nitrification:*** Certain bacteria such as *Nitrosomonas, Nitrococcus, Nitrospira* etc. in oceans and soil converts ammonia into nitrites and then into nitrates. These bacteria primarily use the energy of dead organic matters in their metabolism.

$$2NH_4^+ + 2O_2 \rightarrow NO_2^- + 2H_2O^+ \text{ Energy}$$

Several microbes like *Penicillium* sp., *Nitrobacter, Nitrocystis* etc. help in conversion of nitrites into nitrates.

$$2NO_2^- + O_2 \rightarrow 2NO_3^+ + \text{Energy}$$

- ***Denitrification:*** Nitrates and Ammonia are converted into nitrogen, is called denitrification by some microbes like *Thiobacillus* sp., *Micrococcus* sp., *Pseudomonas* sp. etc. There are denitrifying bacteria. Thus nitrogen reverts back to atmosphere.

$$2NO_3^- \rightarrow N_2 + 3O_2$$

- ***Sedimentation:*** Nitrate of the soil are washed down to sea or leached deep into earth. Thus Nitrates are absent in soil and preserved in rocks i.e. sedimentation of nitrogen (Fig.7.3)

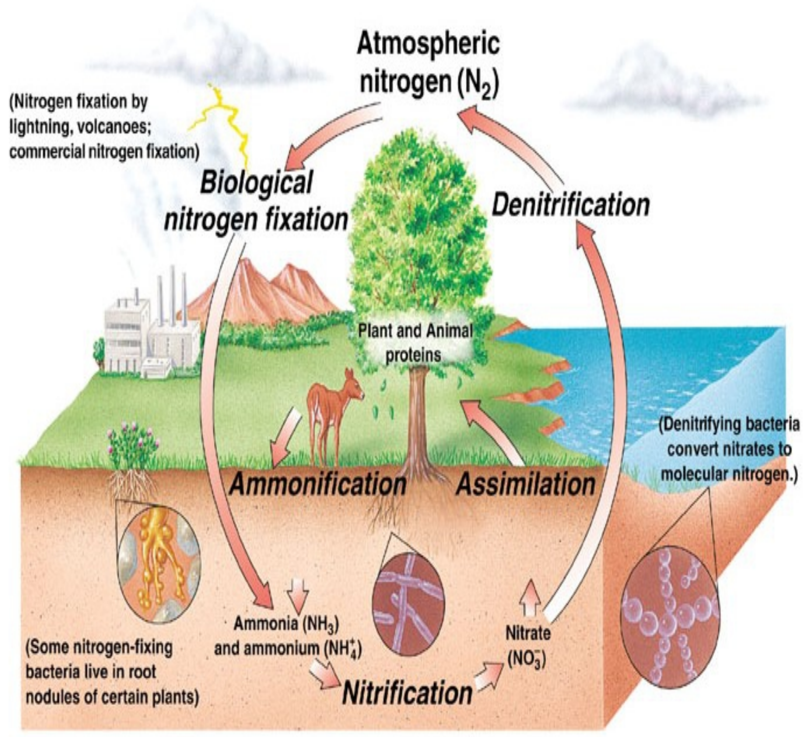


Fig.7.3: Nitrogen Cycle in Atmosphere

So that maximum nitrogen is fixed up and stored in plants, animals and microbes.

SAQ 5:

a. The conversion of atmospheric nitrogen into biologically acceptable form or any nitrogenous compound is called ………..

b. The symbiotic nitrogen fixing microbes inhabiting the ……… of leguminous plants.

c. Nitrates and Ammonia are converted into nitrogen, is called ……….

7.6 CARBON CYCLE

Carbon is an element which is the basis of life of earth. It is found in rocks, oceans and atmosphere. The same carbon atoms are used repeatedly on earth.

They cycle between the earth and the atmosphere. Plants Use Carbon Dioxide from the atmosphere and use it to make food by photosynthesis. The carbon also becomes part of the plant (stored food).

Animals directly or indirectly depend on plants. When organisms eat plants, they take in the carbon and some of it becomes part of their own bodies. After the death of plants and animals most of their bodies are decomposed and carbons atoms are returned to the atmosphere. Some are not decomposed fully and end up in deposits underground in forms of oil, coal, etc. (Fig.7.4)

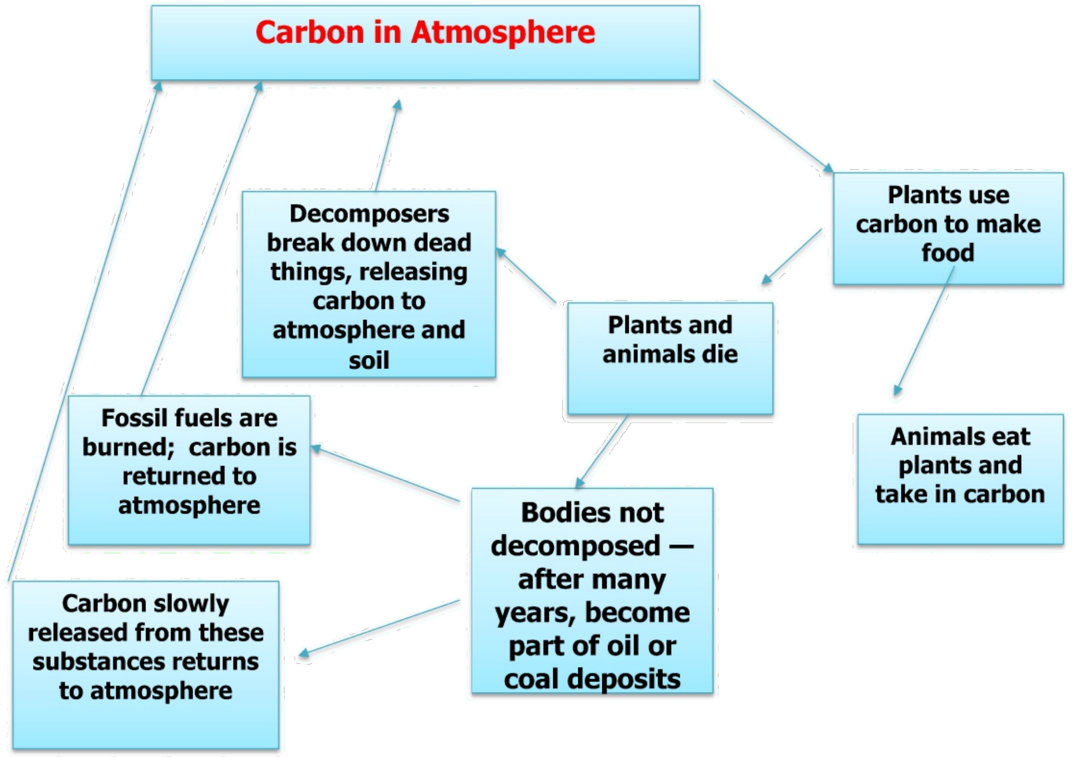


FIG.7.4: Carbon Cycle in Atmosphere

Carbon Slowly Returns to Atmosphere (Fig.7.5). Carbon in rocks and underground deposits is released very slowly into the atmosphere and carbon substances are deposited at the bottom of the ocean. This process takes many years. Additional carbon is stored in the ocean. Many animals pull carbon from water to use in shells, etc. Oceans contain earth's largest store of carbon.

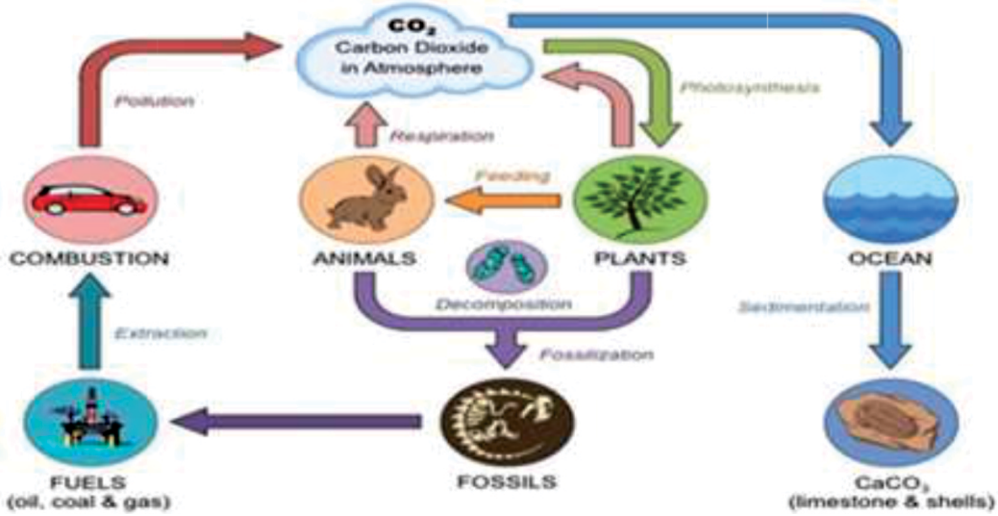


FIG.7.5: Carbon Cycle in Nature

Human Impact on Carbon Cycle:

- Burning fossil fuels or anything like coal, wood etc. release more carbon into atmosphere especially fossil fuel.
- Cutting green plants, trees which may absorb carbon dioxide in atmosphere increases global warming.

We should promote plant life, especially trees to reduce the emission of CO_2 in atmosphere.

SAQ 6:

a. Plants Use Carbon Dioxide from the atmosphere and use it to make food by …………

b. Global warming is caused by increase in………

c. Green plants may reduce………from atmosphere.

7.7 PHOSPHORUS CYCLE

Phosphorus is an essential and important constituent of protoplasm in all energy transfer and energy fixation. ATP and ADP are involved in biological system. Major store house of phosphorus is rock deposited through erosion.

The process of formation of soluble phosphate their application to crop field sum off and transportation rate has become faster but the opposite direction return to land proportionally increased.

The phosphorus cycle is not really balanced from plant and other organism like animal and on their death microbes.

Complex organic compounds are reduced by phosphating bacteria to dissolve phosphate which are partly recycled and biological system and partly leached away in water (Fig.7.6).

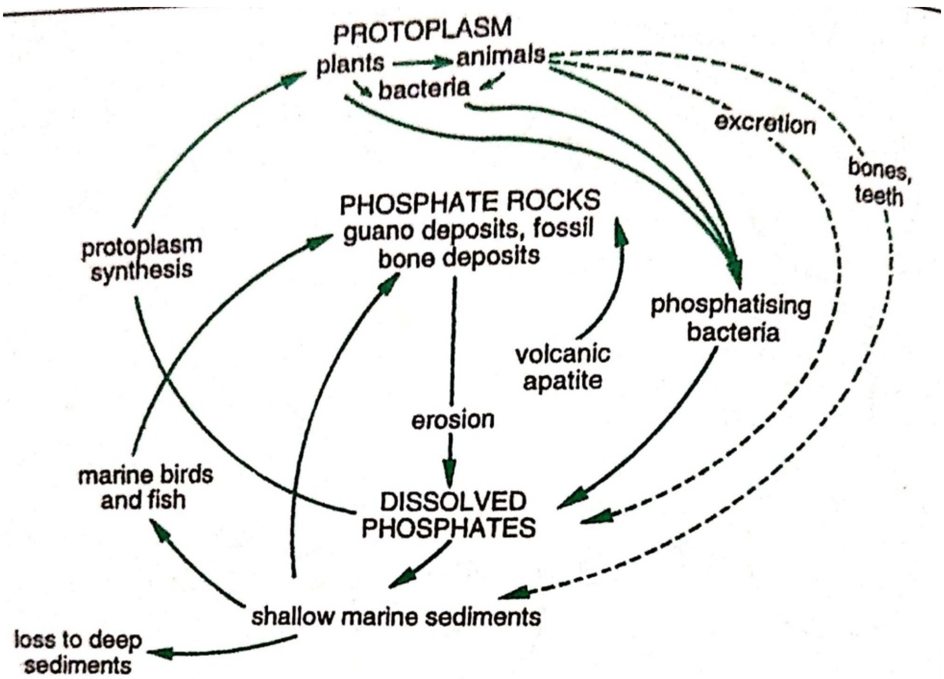
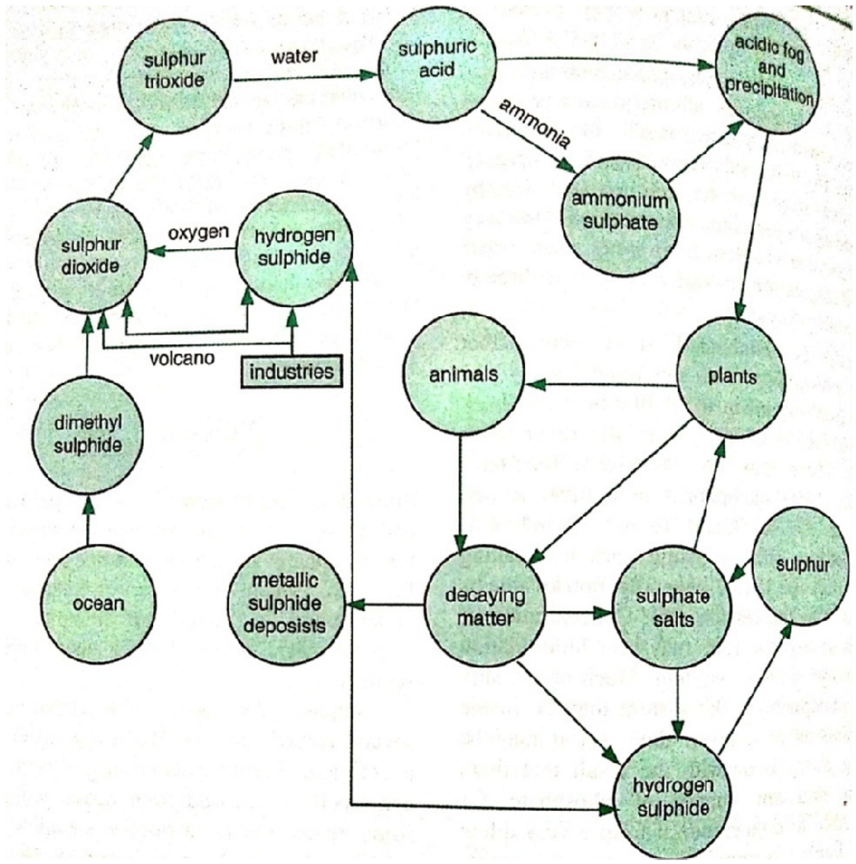


Fig 7.6 . Phosphorus Cycle

Human Impact on Phosphorus Cycle:

- Large quantities of phosphate rocks to make commercial inorganic fertilizers and detergents.
- Reducing available phosphates in soil by cutting trees and deforestation.
- Disrupting aquatic system with phosphate forms by runoff of animal wastes, fertilizers and as well as industrial and domestic sewage disposal.

7.8 SULPHUR CYCLE



FIG,7.7: Sulphur Cycle

In sulphur cycle essential element does not moves in nature but, in oxide form sulphur and sulphate which are largely responsible for the movement of sulphur is converted into other form of sulphur. Which is, obtained from water on land in the form of sulphate . Accumulate water bodies some portion of atmospheric sulphur gets converted into natural fertilizer by the action of rain. Due to the some industrial pollutant, atmospheric sulphur is also converted into acid which falls in acid rain. These acid rain destroy the vegetation. Sulphur is also important for both plants and animals. It forms a part of various amino acid which are important for growth and development (Fig.7.7).

7.9 SUMMARY

- Soil microbiology is the study of micro-organisms in soil and their activities in the soil. They also affect soil texture, properties, fertility and nutrients.

- The soil micro-organisms may be classified into five categories: Bacteria, algae, Fungi, Protozoan and viruses.

- Humus is a dark organic material that forms in soil by the decaying of organic matter like dead plants and animals with the processing of micro-organisms.

- Humus is rich in nutrients act as store house and also known as fat of the soil.

- Biogeochemical Cycles are of two types:

  1. Gaseous - Nitrogen, Carbon, Oxygen &water

  2. Sedimentary - Phosphorus, Sulfur and Calcium.

- **Nitrogen Cycle:** It is the biogeochemical cycle by which nitrogen is converted into multiple chemical forms as it circulates among atmosphere.In nature N_2 gas in atmosphere near about 78%. Soil contains NH_4^+ , NH_3 and Nitrogen containing waste nitrite (NO_2^-), nitrate (NO_3^-).

- **Carbon Cycle:** In the carbon cycle carbon is exchanged among the pedosphere, geosphere, hydrosphere and atmosphere. It shows the movement of carbon atom and its recycling.

- **Phosphorus Cycle:** The movement of phosphorus through the lithosphere, hydrosphere and biosphere.

- **Sulfur Cycle;** It is the circulation of sulfur in different forms through nature. Sulfur occurs in all living matter in the form of certain amino acids. It is abundant in soil and in proteins. Through microbial activities it converts into sulfates, used by the plants.

7.10 TERMINAL QUESTION

MULTIPLE CHOICE QUESTIONS:

Q.1. The study of soil is called:

A. Limnology

B. Pedology

C. Soil biology

D. Geology

Q.2.Which of the following is soil micro-flora:

A. Actinomycetes

B. Nematodes

C. Paramaecium

D. Earth worm

Q.3. .... is free living nitrogen fixing bacteria:

A. Cyanobacter

B. Azotobacter

C. Rhizobium

D. Osccillatoria

Q.4. Which of the following is not biofertilizers producing bacteria:

A. Nostoc

B. Anabaena

C. Clostridium

D. None of these

Q.5. Which of the following is capable of oxidizing sulphur to sulphate;

A. Thiobacillus thiooxidants

B. Desulfotomactum

C. Rhodospirillum

D. Rhodomicrobium

Q.6. Which one of these use H_2S as the electron donor to reduce carbo-di-oxide:

A. *Chlorobium*

B. *Chromaticum*

C. Both A and B

D. Rhizobacterium

Q.7. The algal population in soil is ....that of either bacteria or fungi:

A. Generally less than

B. Generally more than

C. Equal to

D. None of these

Q.8. The microbial conversion of nitrates to gaseous nitrogen is known as:

A. Nitrification

B. Denitrification

C. Nitrogen fixation

D. Ammonification

Q.9. In nitrogen fixation atmospheric nitrogen into:

A. Ammonia

B. Glucose

C. Nitrate

D. Protein

Q.10. The physical structure of soil is improved by accumulation of:

A. Mold mycelium

B. Minerals

C. Water

D. All of these

Q.11. The transformation of rocks into soil is mainly by:

A. Cyanobacteria

B. Nitrifying bacteria

C. Denitrifying bacteria

D. Fungal mycelium

SHORT ANSWER TYPE QUESTIONS:

Q.1. What is rhizosphere and rhizoplane regions?

Q.2. What is humus?

Q.3. How many types of soil micro-flora known to you?

Q.4. Write about phosphorus cycle.

Q.5. What is a biogeochemical cycle?

Q.6. What is the process of humus formation?

Q.7. Write about sulphur cycle.

LONG ANSWER TYPE QUESTIONS:

Q.1. Write an essay on the factors affecting the soil-microorganisms.

Q.2. What are gaseous biogeochemical cycles? Describe carbon cycle in nature.

Q.3. What is the role of various bacteria in nitrogen cycle?

Q.4. What is atmospheric nitrogen fixation? What do you know about symbiotic and non-symbiotic microbes?

7.11 ANSWER

SAQ:1

a. Pedology **b.** 6-10 **c.** Treshaw, 1970

SAQ:2

a. Capsulated, rod **b.** *Chlorella* **c.** vegetative or cyst

SAQ:3

a. *Rhizosphere* **b.** *rhizosphere* **c.** *rhizosphere effect*

SAQ 4:

a. Fat **b.** Primary, Secondary **c.** Saprophytic

SAQ 5:

a. Nitrogen fixation **b.** root nodules **c.** denitrification

SAQ 6:

a. Photosynthesis **b.** Carbon-di-oxide **c.** Carbon-di-oxide

MULTIPLE CHOICE QUESTIONS:

1. B **2.** A **3.** B **4.** C **5.**A **6.**C **7.** A **8.** B

9. A **10.** A **11.** A

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Unit 8: DAIRY MICROBIOLOGY

Structure:

8.1 INTRODUCTION

Milk is said to be a complete and perfect food for human. Milk and it's by products are rich source for microbial growth. It contains maximum part of water than any other element and its P^H is about 7.0.

Composition of Milk: Milk is basically composed of following components :

S.N.	Main Constituents	Range %	Average %
1.	Water	85.5-89.5	87.0
2.	Total solids	10.5-14.5	13.0
i.	Fat or Lipid	2.5-6.0	4.0
ii.	Protein	2.9-5.0	3.4
iii.	Lactose	3.6-5.5	4.8
Iv	Minerals and others	0.6-0.9	0.8

Table 8.1: Basic Constitution of Milk

These constituents of milk may vary according to the type of cattle such as cow, buffalo, goat etc. Buffalo's milk contains more fat and less water than the cow and goat's milk.

Objectives:

After studying this unit you will be able to known:

- Composition of milk
- Various sources of contamination in milk by microbial population.
- Types of microbes present in the milk
- Process of pasteurization and various dairy products.

SAQ 1:

a. The P^H of pure milk is usually..........

b. Normally milk contains..........% water and..........% other substitutes.

c. The milk of buffalo possesses more part of.......than the milk of goat.

8.2 SOURCES OF MICROBIAL POPULATION IN MILK

Milk get contaminated by the micro-organisms of various sources during handling and distribution to the consumers. The microbes may grow on the milk which has been left open after milking for longer time. The different sources of microbial growth in milk are listed below:

8.2.1 DAIRY CATTLES:

Cattles themself are the chief source of contamination whose milk is consumed. The pathogenic microbes like *Streptococcus, Staphylococcus* etc. and various diseases like tuberculosis, brucellosis fever etc. may be transmitted through contaminated milk of animal to the consumers. Therefore cattle selected for milking must be healthy and clean. At the time of milking there are no. of micro-organisms which may range from hundreds to thousands per ml. of milk by the infected cattle.

8.2.2 MILKING AREA:

The milking area is also a big source of contamination. The areas where animals are kept must be cleaned properly. There may be air borne microbes too, though the air has less no. of microbes to contaminate. The area must be cleaned form dung and other garbage surrounding animal and area. Some air borne microbes are *Pseudomonas* sp., colifrom bacteria, *Aspergillus* sp., *Penicillum* sp., *Geotrichum* sp.etc. may be transferred through dirty environment.

8.2.3 MILKMAN:

The most important person who handles the milk is milkman, who should be healthy and not be suffered from any disease. At the time of milking, handling and distribution of milk he must wear mask and should not have sneeze or cough. The microbes like *Vibrio cholrae, Mycobacterium tuberculosis, Salmonella typhii, S. typhimurium* etc. may be transferred from milkman to consumers. Therefore he must wash his hands properly by soap or detergents or sanitize by any alcohol based sanitizer.

8.2.4 MILKING EQUIPMENTS:

The equipments like milking tubes, containers, measuring containers etc. may spoil the milk. It should always be washed thoroughly by soap and hot water and cool them immediately after use. Hot water kills temperature characteristic bacteria such as *Streptococcus thermophilus*, *S. stereothermophilus*, *Candida lipolyticum*, *Alcalygens* etc. These micro-organisms may survive at very high temperature hence treating with hot water and sharp cooling helps to remove them and cleans properly.

8.2.5 MILK ADULTERATION:

Water mixing is very common practice and causing adulteration in milk. The water added may also be impure and contaminate milk and source of micro-organisms to develop and grow to deteriorate the quality.

SAQ 2:

a. The chances of contamination of milk by …… microbes enhances due to dirty milking area.

b. ………types of microbes may be killed by heat treatment.

c. The main component of adulteration in milk is ………

8.3 TYPES OF MICROBES IN MILK

The texture and smell of milk becomes changed due to the contamination and growth of microbes. There are so many sources to contaminate milk by microbes i.e. various types of bacteria and fungi as discussed above may be categorized as follows:

1. Biochemical type 2. Temperature characteristic type 3. Pathogenic type

8.3.1 BIOCHEMICAL TYPE:

The biochemical types of milk contaminating microbes are categorized as: i. Acid Forming ii. Gas producing iii. Ropy milk bacteria iv. Lipolytic type v. Proteolytic type

8.3.1.1 Acid Forming: These bacteria ferment lactose and casein into lactic acid. Due to this milk tastes and smell becomes sour. The contamination of milk by these bacteria may be due to adulteration of water or other food content and sometimes may be due to dirty container. Some of the acid forming bacteria are *Streptococcus lactis*, *S. cremoris*, *Lactobacillus lactis*, *L. brevis*, *L. plantarum*, *L. fermentum*, *Micrococcus variens*, *M. freudenreichii*, *Escherichia coli*, *Enterobacter aerogens etc.*

8.3.1.2 Gas producing: The gas producing bacteria are especially coliform bacteria. CO_2 and H_2 gases are usually produced due to the presence of these bacteria such as *Clostridium butyricum*, *Enterobacter aerogens*, certain species of Yeast e.g. *Torula cremoris*, *Candida pseudotroipicalis*, *Torulopsis sphaerica* etc. are also found in milk and ferment it into lactose and producing CO_2.

8.3.1.3 Ropy milk bacteria: The casein part of the milk coagulates by bacteria and the fluid gets separated. The texture and smell of milk changes. The microbes present in milk secrets mucilage or slime therefore the surface of milk has thread like appearance and becomes viscous or sticky called ropy fermentation. The ropy fermentation is mainly due to the presence of some bacteria such as *Alcaligens viscolactis, Enterobacter aerogens*, *Micrococcus, Mycobacterium viscolactis, Bacillus* etc.

8.3.1.4 *Proteolytic type:* These types of bacteria coagulate protein part of milk in presence of Protease enzyme which is secreted by Proteolytic type of micro-organisms i.e. chiefly the species of *Bacillus* and *Pseudomonas* such as *B. cereus* var. *mycoides, B. subtilis, P.viscosa, P. putrifaciens* and *Proteus* species etc. These microorganisms spoil the quality of milk by taste, texture and smell of the milk.

8.3.1.5 *LiPolytic type:* these bacteria ferment fat part of milk. Lipolytic microbes like some bacteria are *Pseudomonas flouroscens, Achromobacter lipolyticum* , yeast like *Candida lipolytica* and molds such as *Penicillium sp., Geotrichum candidum* etc.

8.3.2 TEMPERATURE CHARACTERISTIC TYPE:

The various types of microorganisms found in milk which is responsible to spoil may be categorized as follows on the basis of their temperature characteristics:

8.3.2.1 *Psychrophilic:* When the microbes are growing well at very low temperature is categorized under psychrophilic type. These type of bacteria may grow at very low temperature. They may survive and may grow up to 0^{o} C e.g. *Pseudomonas sp., Achromobacter sp., Flavobacterium, Alcaligens* etc. as well as some coli form bacteria are also psychrophilic.

8.3.2.2 *Mesophilic:* These bacteria may generally grow at moderate temperature i.e. from 10^{o}C to 45^{o}C usually and found best growth between 25^{o}C-40^{o}C. These bacteria are mainly acid producing type e.g. some coliform bacteria, *Streptococcus lactis* var. *maltigens, Pseudomonas icthyosoma* etc.

8.3.2.3 *Thermoduric:* This category of bacteria may survive at a very high temperature and are able to endure the heat during pasteurization. The best growth is observed in between 45^{o}C to 60^{o}C e.g. *Bacillus subtilis*, *Streptococcus thermophilus, Micrococcus lactis, Mycobacterium lacticum* etc.

8.3.2.4 *Thermophilic:* These microbes are also known as temperature loving and has no effect of pasteurization. They grow well at 55^{0}C-65^{0}C. Sometimes it may grow even at 40^{0}C and up to 80^{0}C e.g. microbes spoil milk casein and fat, ferment into acids.

8.3.3 PATHOGENIC TYPE:

There are many serious diseases caused by microbes present in milk and its product such as tuberculosis brucellosis, Q fever etc. The bacteria viz. *Mycobacterium tuberculosis, M. bovis* etc. sometimes present in milk, passes through intestine to blood and spreads into other organs when consumed. Some other diseases like Brucellosis caused by *Brucella abortus* i.e. gram negative bacteria and Q fever caused by *Coxella brucella.* Other disorders like altypical pneumonia, toxoplasmsis, anthrax, streptococcus infections etc. are also caused by micro-organisms present in milk and its product.

SAQ 3:

a. Acid forming bacteria ferment lactose and casein into……

b. Mesophilic bacteria may generally grow at moderate temperature i.e. from …….to…….

c. When microbes may survive and grow up to 0^o C is categorized as……….

d. Brucellosis caused by …………,a gram ……. Bacteria.

8.4 PASTEURIZATION

Pasteurization is a process in which packaged and non packaged foods are treated with heat. The term named after the French chemist Louis Pasteur (1864) for eliminating the bacteria present in wine. Now Pasteurization is defined as the process of heating milk or milk product to properly design and operated equipment to any of the specified pasteurization time - temperature combination. There are few top methods of pasteurization which are as follows:

A. Low temperature Long Time (LTLT) or Holding Method:

It is an old conventional method in which milk is heated in large tank at 145^oF or 62^oC for 30 minutes. To ensure uniform heating the milk is constantly stirred and followed by rapid cooling and packaging.

B. High temperature Short Time (HTST) or Flash Method:

It is commonly used and modern method. It involves metal plates and hot water to raise the temperature of milk up to 161^oF or 71^oC for 15 seconds.

C. Ultra High Temperature (UHT) or Ultra Pasteurization:

This is new method and used in dairy industry. Milk is boiled at 82^oC for 3 seconds only. Cooled immediately and packed.

Pasteurization destroys the pathogenic bacteria.

8.5 MILK PRODUCTS

In India Dairy industries are well flourished and holding first rank in milk production and contributing 23 percent global milk production. Some chief milk products produced at dairy industries are as follows:

- ***Yogurt:***

  It is prepared by fermenting milk. The fermentation of milk is done by mixing the mixture of *Lactobacillus bulgaricus* and *Streptococcus thermophilus* at 40^{o}C. It is flavored by accumulation of lactic acid and acetaldehyde.

- ***Cream:***

  Cream is composed of approximately 72% milk fat and 28% milk fluid. Milk fluid consists of 20-22 % water, 2-2.5 % Protein and Casein 4-5% out of 28% of total fluid part. It is usually prepared by centrifugation of milk by which fat part of milk gets separated from the fluid part called whey. In centrifugation machine centripetal and centrifugal force works to separate them. The heavier particles collected at margin and fluid remains left.

  The cream may be of two types: *Sweet Cream* and *Sour Cream*

  1. *Sweet Cream*: This type of cream is inoculated by bacteria *Leuconostoc citrivo* by which the carbohydrate portion gets hydrolyzed and sweet is developed.
  2. *Sour Cream*: It is inoculated by *Leuconostoc citrivorum* and *Streptococcus lactis.* The sour flavor depends upon the ratio of both bacteria.

- ***Butter:***

  Butter is usually composed of 87% fat, 6-7% protein, 4-5% carbohydrate and 5-6 % water. The production of butter in dairy industries is passed through following steps;

  i. *Production of Cream*: The fresh milk is centrifuged as discussed above by which fluid or whey portion gets segregated from fat. Fat part is isolated and collected for manufacture of butter.

  ii. *Pasteurization of Cream*: For the removal of unwanted harmful microbes pasteurization of cream is done to maintain quality and its flavor. The Low Temperature Holding (LTH) method of pasteurization is found best, because the casein and fat is separated from cream at high temperature i.e. 62.8^{o}C for about 15 minutes and cooled sharply. The High Temperature Short Time (HTST) method is applied and to kept cream at 67.8^{o}C for 4-5 minutes and then cooled immediately.

  iii. *Ripening of Cream*: The pasteurized cream is inoculated with bacteria *Strptococcus dextranicum* and fungi *Geotrichum candidum.* Both of these coagulate the fat and casein part of milk and slightly porous texture is created in the cream. Precautions are also taken to avoid destruction of fat due to long duration exposure of these micro-organisms.

iv. *Salting and Packaging*: Before packaging yellow color and flavor is added. For removal of microbes present in butter little bit of salt is added and microbial growth is inhibited due to exosmosis. Finally small cubic pieces are prepared and packed.

- ***Cheese:***

Cheese is prepared from curd. In cheese portion of casein is more in cheese as compared to butter whereas fat is less. Cheese may be prepared in following steps:

i. *Curdling in Milk:* The fresh milk is converted into curd by inoculating bacteria viz. *Streptococcus lactis, Lactobacillus lactis, Streptococcus cremoris, S.thermophilus* etc. After inoculation the milk is slightly heated to maintain the temperature from 40^{o}C-50^{o}C, which is most suitable temperature range for the faster growth of inoculated microbes. During this acid is produced and milk is converting into curd.

ii. *Separation of Milk Curd:* Milk fluid or whey is separated by sieving and filtration.

iii. *Ripening of Milk Curd:* After separation of whey, the thickened or solid portion contains fat and casein. This part is inoculated with proteolytic and lipolytic bacteria such as *Streptococcus subtilis, Proteus sp.* and a fungi *Geotrichum sp.* etc. The protein and fat content is then coagulated.

iv. *Salting and packaging:* Excess water is removed and salt is added to remove microbial population and this solid portion is cut down into pieces and packed finally.

8.6 SUMMARY

- The study of microorganisms that are associated with milk and milk products in all aspects is defined as 'Dairy Microbiology'.
- Sources of contamination in milk by microbial population are; i. Dairy Cattles ii. Milking Area iii. Milkman iv. Milking Equipments v. Milk Adulteration
- There are so many types of microbes in milk (bacteria and fungi) may be categorized as: 1. Biochemical type 2. Temperature characteristic type 3. Pathogenic type
- The biochemical types of milk contaminating microbes are categorized as: i. Acid Forming ii. Gas producing iii. Ropy milk bacteria iv. Lipolytic type v. Proteolytic type
- Temperature characteristic type microbe are catagorised as: i. Psychrophilic ii. Mesophilic iii.Thermoduric iv.Thermophilic

- Pathogenic type: There are many serious diseases caused by microbes present in milk and its product such as tuberculosis brucellosis, Q fever etc.
- Pasteurization is a process in which packaged and non packaged foods are treated with heat.
- There are few top methods of pasteurization which are as follows: Low temperature Long Time (LTLT) or Holding Method, High temperature Short Time (HTST) or Flash Method, Ultra High Temperature (UHT) or Ultra Pasteurization:
- Dairy products or milk products are also called as lacticinia are food products prepared by milk. The most common dairy animals are cow, buffalo, goat etc. The chief milk products which are commonly used and prepared in dairy industries are yogurt, cream, cheese, butter etc.

8.7 TERMINAL QUESTION

MULTIPLE CHOICE QUESTIONS:

Q.1. The chief type of spoilage in sweetened condensed milk may be:

a. Mold colonies growing on the surface.
b. Gas forming by sucrose fermenting yeast
c. Thickening caused by micrococci
d. All of these

Q.2. Fishiness in butter is caused by:

a. *Pseudomonas synxantha*
b. *Pseudomonas syncyanea*
c. *Aeromonas hydrophila*
d. *Streptococcus lactis*

Q.3.Bacterial ropiness in milk is caused by:

a. Slimy capsular material from the cells usually lipids
b. Slimy capsular material from the cells usually proteins
c. Slimy capsular material from the cells usually gums or mucus
d. None of these

Q.4. An alkaline reaction in milk is caused by the alkali formers bacteria as:

a. *Pseudomonas fluorescens*
b. *Acetobacter viscolactis*
c. Both (a) &(b)
d. None of these

Q.5. A yellow colour in the creamy layer of milk may be caused by:

a. *Pseudomonas fluorescens*
b. *Pseudomonas syncyanea*
c. *Pseudomonas synxantha*

d. All of these

Q 6. The yogurt is made from:

a. *Lactobacillus bulgaricus*
b. *Strptococcus thermophilus*
c. *S. cremoris*
d. Mixed culture of (a) &(b)

Q.7. Cheese cancer of Swiss and similar cheese is caused by:

a. *Oospora crustacea*
b. *Oospora caseovorans*
c. *Oospora aurianticum*
d. None of these

Q.8. Bulgarian butter milk is made with the help of:

a. *Lactobacillus bulgarricus*
b. *Streptococcus lactis*
c. *Streptococcus thermophilus*
d. *Streptococcus cremoris*

Q.9. Swelling of the can is caused by;

a. Gas forming anaerobic spore formers
b. Gas forming aerobic spore formers
c. None of these
d. Both (a) & (b)

Q.10. Which of the following is not the source of contamination:

a. Milker and animal
b. Litter
c. Milking area
d. Heat

Q.11. Lactic acid bacteria ferment:

a. Sucrose
b. Lactose
c. Glucose
d. Fructose

12. Which of the following group of bacteria not occurs in milk;

a. Lactic acid bacteria
b. Coliform Bacteria
c. Putrefying bacteria
d. Carboxylic acid bacteria

13. Coliform bacteria leads to:

a. Off flavor and smell
b. Gas formation
c. Off flavor, smell and gas formation

d. Fruity taste

14. Presence of coliform bacteria in milk pipelines after pasteurization indicates:
   a. Excessive hygine
   b. Poor sanitation and reinfection
   c. Rusting
   d. Coating

15. Bacteria known as the 'Cheese destroyer':
   a. Propionic acid bacteria
   b. Coliform bacteria
   c. Lactic acid bacteria
   d. Butyric acid bacteria

SHORT ANSWER TYPE QUESTIONS:

Q.1. What is dairy microbiology?

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Q.2. What are different types of milk products?

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Q.3. What is pasteurization?

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Q.4. What is whey? Which microorganisms are used in production of cheese?

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Q.5. What is the composition of milk?

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LONG ANSWER TYPE QUESTIONS:

Q.1. How do the microorganisms play role in dairy industries?

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Q.2. How does the milk and its products contaminated?

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Q.3. Describe the important steps of cheese production?

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Q.4. Describe microbial flora of milk and other dairy products and how to minimize contamination?

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Q.5. How are the different types of microorganisms in milk categorised?

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8.8 ANSWERS

MULTIPLE CHOICE QUESTIONS:

1. d 2. c 3. c 4. c 5. c 6. d
7. b 8. a 9. a 10. d 11. c 12. d
13. c 14. b 15. d

SAQ 1:

a.7.0 ***b.*** 85.5-89.5, 10.5-14.5 ***c.*** Fat

SAQ 2:

a. air borne ***b.*** Thermophilic ***c.*** water

SAQ 3:

a. lactic acid ***b.*** 10^{o}C to 45^{o}C ***c.*** Psychrophilic

d. *Brucella abortus ,* negative

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Notes