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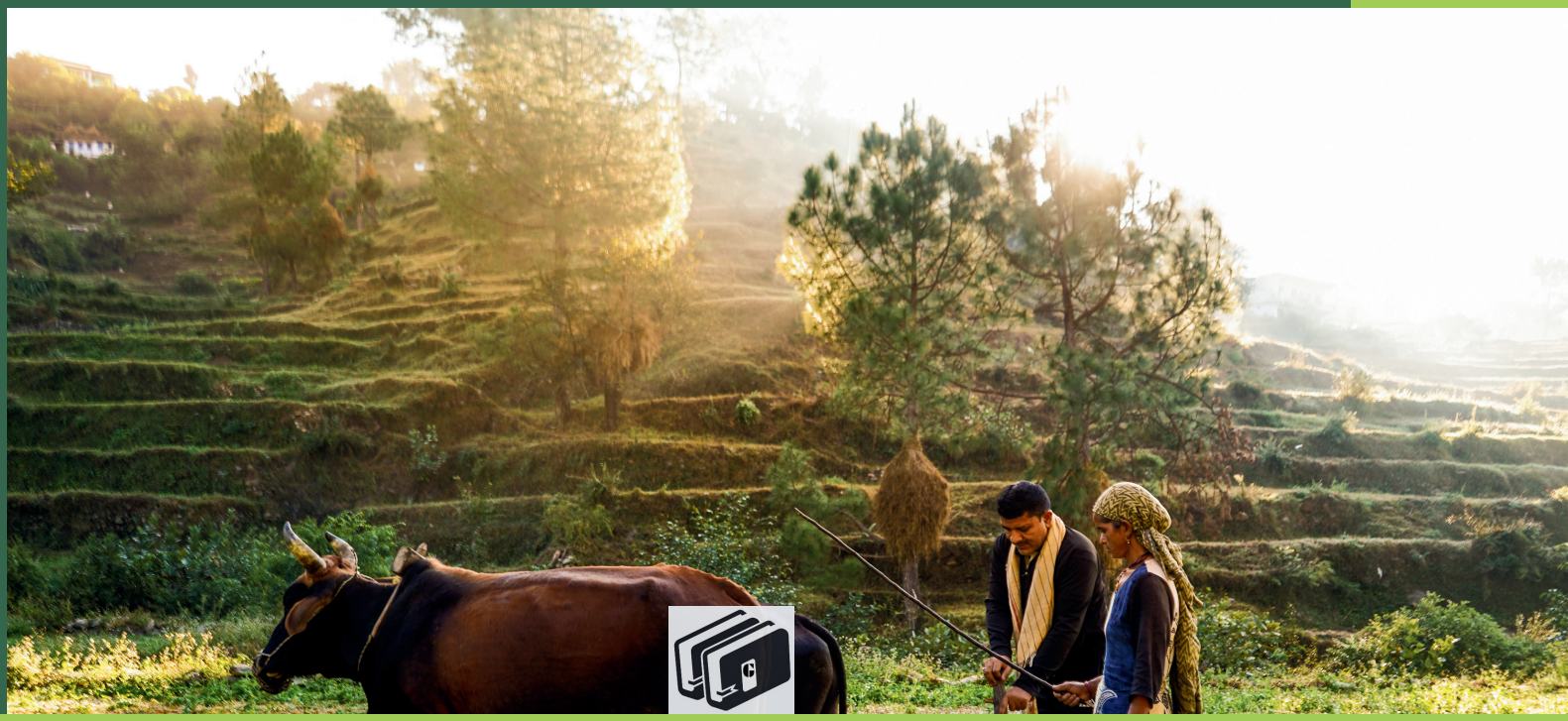

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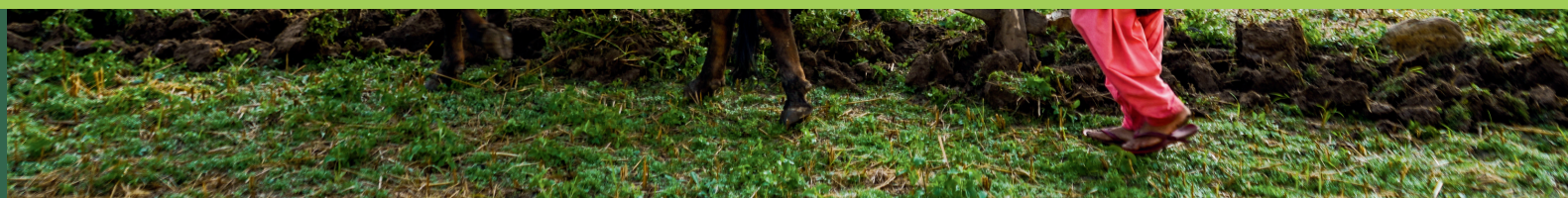

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Preface

In an era marked by environmental challenges and the imperative for sustainable development, the significance of agriculture in ensuring global food security cannot be overstated. This text book, "Text Book on Practices for Agricultural Sustainability," emerges as a beacon for students, practitioners, and researchers navigating the complex landscape of modern agriculture. At its core, the book aspires to be a comprehensive guide, offering a panoramic view of sustainable agricultural practices that can pave the way for a resilient and environmentally conscious future. Our journey through this textbook begins with a profound exploration of the principles underpinning sustainable agriculture. We delve into the intricate interplay between ecological systems, biodiversity, and crop management, laying the foundation for a holistic understanding of sustainable farming. The chapters that follow unveil an array of innovative and time-tested practices that foster sustainability in various agricultural domains. From agroecology and organic farming to precision agriculture and nano technology, each chapter meticulously examines practices that prioritize environmental stewardship, social responsibility, and economic viability. As editors, our intent is to provide a dynamic and evolving resource that reflects the dynamic nature of agricultural sustainability. It encourages readers to critically engage with the content, question conventional wisdom, and envision novel solutions to the challenges facing our global agricultural system. May this textbook serve as a catalyst for a new generation of agriculturalists committed to cultivating not only crops but also a sustainable and equitable future for our planet.

Editors

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Chapter 18	Classification of Plant Diseases, Characteristics and Symptoms on Crop Plants

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Abstract

Plant diseases create serious dangers to agriculture worldwide, resulting in significant financial losses and food security issues. Understanding disease categorization, features and symptoms is critical for effective disease control and long-term crop productivity.Plant diseases are classified primarily by their causative agents, which can be divided into three categories: fungal, bacterial and viral diseases. Each group has unique traits and means of transmission, which influence disease progression and control. Plant diseases can also be caused by non-infectious reasons such as nutritional inadequacies, stresses from the environment and inheritance issues.Plant disease symptoms on crops vary greatly depending on the causative agent. Wilting, leaf spots, cankers, necrosis, chlorosis, stunting and aberrant growth patterns are all common signs. Precisely identifying these symptoms is critical for disease diagnosis and prompt adoption of control strategies.Innovations in technology, such as remote sensing and image processing, have revolutionised disease detection, allowing for prompt action and minimising the spread of disease. Furthermore, molecular approaches allow for the rapid identification of infections, which aids in the development of precise disease management plans. The AI developing in the recent times provides an appropriate disease identification by using the various algorithms feed into it and uses these software for the analysis and management of the disease in initial stage of disease development.

Introduction

What is a disease ?

Disease is derived from the Old French word desaise, which means lack of ease or discomfort. It subsequently became the Middle English word disese, and then

disease in contemporary English. It is a broad phrase that refers to any abnormality or illness that interferes with the regular functioning of the body or mind.Generally the word disease pertains to not being well in case of humans and not growing well in case of plants. But it is not the actual term of the disease.

Plant diseases are identified by signs and symptoms (external or internal) or by the ill condition of the plant. The phrase plant disease refers to the plant's state as a result of disease or the cause of the disease. Plant disease is primarily characterised by damage done to the plant itself or its parts(Elad and Pertot, 2014).

Some other accepted definitions of plant disease are

1. Disease is a malfunctioning process of host cells and tissues that is caused by the continues irritation of the pathogen or an environment factor which leads to the appearance of the symptoms. This definition is widely accepted and it is provided in the G.N. Agrios(Agrios, 2005).

2. Disease is a defective process induced by constant irritation, which results in certain discomfort and symptoms. This definition is provided by the American Phytopathological Society (APS) and British Mycological Society (BMS).

3. Disease is a change in a single or several of the regulated successive series of physiological functions within a plant that results in a loss of synchronisation of energy usage as a result of constant irritation from either the presence or absence of some substance or cause.

Classification of plant diseases

The plant diseases are classified into several types on the basis of different characters. The classification is as follows:

1. On the basis of disease occurrence and prevalence

a. Epidemic: It is also known as epiphytotic disease. An epidemic is an widely occurring disease in a severe form.
Ex: Irish famine (Late blight of potato) - *Phytophthora infestans*

b. Endemic: Endemic diseases are commonly present in a particular place in moderate to destructive form(Parnell *et al*, 2017).
Ex: Black wart of potato - *Synchytrium endobioticum*(endemic to Darjeeling hills, West Bengal)
Club root of cabbage - *Plasmodiophora brassica* (endemic to Nilgiris hills)

c. Pandemic: The disease is prevalence in all parts of the world.

d. Sporadic: The occurrence of the disease is irregular and their presence is also not determined certainly and it occurs in a fewer chances.
Ex: Angular leaf spot of cucumber - *Pseudomonas lachrymans*

2. On the basis of infectious nature

a) Infectious plant diseases

i) Diseases caused by parasitic organisms: These diseases are mainly caused by the living or biotic or animate microorganisms which can initiate the development of the disease in the host and responsible for dispersing into the other individuals.

ii) Diseases caused by viruses and viroids: These are animate inside the living organisms and inert outside the body of the organisms.

b) Non-infectious plant diseases: These diseases are generally non-parasitic or physiological disorders. These are caused by the inanimate things and they do not spread from one plant to another plant(Agrios, 2005).

Symptom

The internal or external reactions or sometimes the modifications or changes produced in the plant as a result of disease is called as symptom.Each plant pathogen produces unique symptoms on the plant and some produces symptoms which are similar to the other agents and it is always difficult in case of viral diseases and nutritional disorders.

Various kinds of symptoms on crop plants

Various kinds of plant pathogens (Fungi, Bacteria, Virus, Viroids, Phytoplasma, Spiroplasma *etc.*) along with the disorders (caused by the stresses of the surrounding environment) produces different patterns on the plants which was collectively called as symptoms.

Fungal disease symptoms

1. Damping off: Damping off impacts a wide variety of plant seeds and seedlings, including crops, flowers and ornamental plants. It has the potential to destroy entire harvests. Damping off usually affects seeds and young seedlings.

a) Pre-emergence damping off: The disease can attack seedlings before they emerge from the soil, causing them to rot or germinate poorly.

b) Post-emergence damping off: After the seedlings have emerged, they may show symptoms such as wilting, yellowing and a constriction of the stem at ground level. The diseased seedlings frequently fall over and perish.

Damping off is caused mostly by a variety of soil-borne fungi, including *Rhizoctonia*, *Pythium* and *Fusarium*. These fungi thrive in cool, moist environments and can persist in soil for long periods of time(Pane *et al*, 2017).

Ex: Damping off of vegetables - *Pythium aphanidermatum*

2. Root rot: Root rot is a frequent and damaging fungal disease that damages the roots of many different plants, including trees, shrubs, ornamental plants, and crops. If left untreated, it can cause plant deterioration, withering and even death.

Root rot symptoms vary based on the plant species and the fungus responsible. However, frequent warning indicators include:Wilting, yellowing, or browning of leaves, usually beginning at the plant's base. Growth is slowed and vigour is diminished. Brown or black, soft and mushy roots with a strong odour. Dark sores on the stems or at the plant's base.

Root rot is caused mostly by soil-borne fungi, the most prevalent genera being *Armillaria*, *Phytophthora*, *Rhizoctonia* and *Fusarium*. These fungi grow in damp, ill-drained soil and can infect plant roots via wounds, weaker roots or healthy roots in saturated soil(Palmieri *et al,* 2022).

Ex: Root rot of cotton - *Rhizoctonia bataticola*

3. Collar rot: Collar rot, often referred to as crown rot or basal stem rot, is a fungal disease of plants that affects the lowest part of the stems or crowns of plants. It can have an impact on a wide variety of plant species, such as crops, ornamental plants and shrubs and trees. Collar rot can result in plant wilting, dieback and even plant mortality, making it a major problem.

Depending on the plant species and the particular fungus pathogen involved in it, collar rot symptoms can change. However, typical signs include:

***Wilting*:** Plants with collar rot frequently show wilting, which begins with the lowest leaves and moves upward.

***Browning or Rotting at the Base*:** The collar or crown, which is where the stem

meets the earth, may change colour, turn brown, or rot.

Stunted Growth: Infected plants may have less vigour overall and exhibit stunted growth.

Dieback: As the disease worsens, whole branches or stems may start to wither.

Ex: Collar rot of sunflower - *Sclerotium rolfsii*

4. Stem rot: Stem rot is a broad term for a problem in plants in which the plant's stems or stalks become infected and begin to rot. This disease is frequently caused by fungi, however it can also be caused by bacterial infections or environmental stresses. Plants susceptible to stem rot include ornamentals, vegetables and trees.Environmental stressors such as too much water, inadequate drainage, high humidity and cuts or injuries to plant stems can all contribute to the development of stem rot.

Ex: Stem rot of rice - *Sclerotium oryzae*

5. Club root: It is an important of crucifers family, also known as finger and toe. The growth of swelling, distorted roots that mimic clubs or galls is the major sign of clubroot. These galls impair the capacity of plants to absorb water and nutrients, resulting in restricted growth, leaf yellowing, and wilting.

Ex: Club root of cabbage - *Plasmodiophora brassicae*

6. Wilt: Fungal wilt is produced by fungus that attacks the vascular system of plants, interfering with water and nutrient uptake and transfer. This can cause the susceptible plant to wilt, yellow and eventually die.

Fusarium wilt: Caused by various Fusarium species, affecting a wide range of plants, including tomatoes, bananas and cucurbits (cucumbers, melons, *etc.*).

Verticillium wilt: Caused by Verticillium species, impacting trees, shrubs and herbaceous plants like tomatoes and potatoes.

Ex: Vascular Wilt of Cotton - *Fusarium Oxysporum* f.sp.*vasinfectum*, Verticillium wilt of Tomato - *Verticillium alboatrum*

7. Downey mildew: Downy mildew symptoms vary based on the host plant and the oomycete species concerned. However, the following are typical *symptoms:*Yellowing of the leaves usually begins as little yellow patches on the upper surface of the leaves.White to grey fuzzy growth forms on the undersides of leaves and is sometimes referred to as "down" or "downey" mildew. Leaves can get

distorted, curl, or even perish. Infected leaves may have diminished photosynthetic ability, resulting in stunted development and lower agricultural production.

Ex: Downey Mildew of Grapes - *Plasmopara viticola*

8. Powdery mildew: The powdery, white to greyish mould development that occurs on the surfaces of afflicted plant parts is the most visible symptom of powdery mildew. Other signs and symptoms may include:Infected leaves and shoots may become deformed or stunted in growth. In severe infections, the leaves turns to yellow or brown. Significantly diseased leaves may drop early, decreasing the plant's capacity to photosynthesize.Powdery mildew can have an impact on fruit development and quality on fruit-bearing plants.

Ex: Powdery Mildew of Cucurbits - *Erysiphe cichoracearum*

9. Leaf spot: Leaf Lesions: Depending on the fungus species and the host plant, circular or irregular spots on the foliage may be brown, black, tan, grey or even purple in colour.

***Lesion Shape*:** The spots may have distinct edges and vary greatly in size and shape.

Leaf Yellowing: The tissue around the lesions frequently develops a yellow or chlorotic tinge.

***Premature Leaf Drop*:** In serious situations, the diseased leaves may fall off early, which can cause defoliation (Pane *et al*, 2017).

Ex: leaf spot of sapota -*Phavophleospora indica*

10. Anthracnose: Trees, shrubs, vegetables and ornamental plants are all susceptible to the anthracnose. Different types of fungi from the genera *Colletotrichum* and *Glomerella* are the cause. Dark, sunken lesions or patches on leaves, stems, fruits and occasionally even blossoms are typical symptoms of anthracnose.

***Leaf spots*:**They have oddly shaped lesions with a distinct edge that are frequently dark in colour.

Fruit rot: Anthracnose can cause sunken, discoloured, and frequently wet-looking lesions on fruits.

***Twig dieback**:* The fungus can occasionally infect stems and branches, resulting in dieback and cankers.

***Defoliation**:* Serious diseases may cause leaves to drop too soon, weakening the plant.

Ex: Anthracnose of Sorghum - Colletotrichum graminicola

11. Rust: Pustules with a rusty or orange colourare frequently seen on the underside

of leaves or other plant parts.Affected areas may eventually die and fall off, and infected leaves may turn yellow.Serious infections can cause growth stunting and lower crop production.

Ex: Linseed rust - *Malampsora lini*

12. Smut: Smut fungus frequently cause infected plants to develop galls or hypertrophy development. These galls may include spores that are dark and powdery.Smut diseases are characterized by the bursting of infected plant tissues, which releases masses of dark, dusty spores.Infections that are severe might cause plants to grow slowly and lower the yield of crops.

Ex: Loose Smut of Wheat - *Ustilago nuda tritici*

13. Gummosis: Gummosis can be recognised chiefly by the existence of resinous, sticky, or gummy substances coming from the plant's bark, typically on the trunk or branches. The gum might be transparent amber, brown, or black, among other colours. Other signs may involve wilting, leaf yellowing, and branch dieback on the affected areas.

Ex: Gummosis of citrus - *Phytophthora parasitica*

14. Sugary disease: It is also known as ergot. The presence of this disease is prevalence in cereal crops like sorghum, pearl millet and others. Seed heads with ergot infection display certain symptoms:

***Dark, elongated sclerotia**:* These formations, which frequently range from dark purple to black and are hard, replace the seeds.

***Distorted seed heads**:* Damaged seed heads may seem enlarged or lengthened.

***Production of alkaloids**:* Alkaloids produced by the fungus include ergotamine and ergonovine, which can have a number of negative effects when consumed.

Ex: Ergot of Bajra - *Claviceps fusiformis*

15. Fruit rot: There are many signs of fruit rot, including discoloration (darkening

or water-soaked spots), softening, lesion formation, visible mould growth (grey, black, pink or orange), foul odours in the later stages, production of spores on the skin, quick growth, potential internal deterioration and fruit wrinkling as decay advances.

Ex: Fruit Rot of pomegranate - *Aspergillus foetidus*

16. Die back: The progressive loss of plant branches or other parts as a result of a

fungus infection is a classic sign of fungal dieback. The most typical symptoms include wilting, browning, or yellowing of the leaves, followed by a die-off of the branches that begins at the tips and moves towards the centre of the plant.

Ex: Die back of rose - *Diplodia rosarum*

17. Bunt: The major symptoms of bunt are:

Blackened Kernels: Because to containment of a powdery mass of fungal spores, infected wheat kernels appear dark black or grey and frequently develop shape distortions. The grain is replaced with this.

Bad Odour: One of the distinguishing characteristics of wheat bunt is the bad odour given off by the infected kernels. This stench, which is sometimes compared to a fishy or sulphurous smell, can be rather potent.

Grain quality and yield reduction: Wheat infected with the disease is unfit for consumption or milling, which severely reduces grain quality. Wheat bunt also causes decreased crop yields.

Ex: Karnal bunt of wheat – Neovossia indica

18. Leaf curl: Due to the proliferation of tissues in a specific area of the leaf, leaves are deformed and puckered, among other features of the plant.

Ex: Leaf curl of peach – *Taphrina deformans*

19. Necrosis: Necrosis generally refers to the death of the tissues. Plants suffering from fungus necrosis exhibit lesions, withering, and death of tissues. It frequently causes browning or darkening of the damaged plant parts and can cause the production of cankers in woody plants or fruit rot in plants that bear fruit.

Ex: Wilt of castor - *Fusarium oxysporum* f.sp. *ricini*

20. Discolouration: The loss of original colour of the plant and plant tissues that

are infected display aberrant colours that frequently look as patches, streaks or blotches. These hues can be any combination of brown, black, yellow and red. Some fungal diseases cause localised darkening or blackening of plant components, which changes the way the plant looks generally. For the disease to be managed effectively, the specific fungus must be identified accurately.

Ex: Banded leaf and sheath blight of maize - *Rhizoctonia solani*

Bacterial disease symptoms

1. Leaf blight: Reduced Yield: Bacterial leaf blight can significantly reduce crop

yields, impacting agricultural production, especially in crops like rice. Management strategies involve planting disease-resistant varieties, practicing good sanitation, and using copper-based or antibiotic sprays to control bacterial spread. Early detection and prevention are essential to mitigate the disease's impact(Buttimer *et al,* 2017).

Ex: Bacterial leaf blight of rice - *Xanthomonas oryzae* pv. *Oryzae*

2. Soft rot: Several types of plants, including vegetables like potatoes, carrots, and cucumbers, are susceptible to the widespread disease known as bacterial soft rot.Infected plant tissues produce lesions that are slick, slimy, and frequently smelly. These lesions may have a dark, moist border around their typically pale centre.As the disease worsens, the damaged tissues deteriorate and mush up, causing plant material to quickly deteriorate. This may cause a serious loss in the structure and quality of the plant.The decomposing plant material emits a terrible, pungent odour that is one of the telltale symptoms of bacterial soft rot and is often described as unpleasant and resembling a rotten stench.Advanced stages of the condition can cause the damaged tissues to turn black or brown, which is a sign of widespread disintegration and tissue death.

Ex: Soft rot of potato - *Erwinia caratovora* subsp *caratovora*

3. Wilt: The symptoms of bacterial wilt, which is brought on by pathogens such *Ralstonia solanacearum*, are as follows: This condition begins with the plant suddenly wilting, generally in a single branch or portion, and gets worse over time. Infected leaves frequently show yellowing or browning, which starts at the leaf margins and moves within.Cutting the stem may reveal vascular tissues that are discoloured, with brown or black streaks. The plant may develop stunted development as the disease progresses, causing the leaves to droop and perish prematurely. Bacterial wilt can kill plants and is extremely destructive, making

early detection and disease treatment crucial.

Ex: Bacterial wilt of solanaceous crops - *Ralstonia solanacearum*

4. Canker: On the stems, branches, or trunks of diseased plants, elevated, corky lesions or canker sores may appear. Usually dark brown to black in colour, these cankers can be depressed or broken.Infected branches or limbs may display dieback, in which the affected areas' foliage wilts, turns brown, and eventually dies. This can cause the plant to gradually deteriorate.Bacterial canker can generate irregularly shaped leaf spots on some plants. These spots are frequently black, necrotic (made of dead tissue), and encircled by a yellow halo.The disease can impact growing blossoms and fruit on fruit-bearing plants, resulting in their discoloration, scarring, or deformation.A bacterial exudate, which resembles a slimy ooze, may be seen on the cankers or other damaged plant parts in damp conditions.

Ex: Citrus canker -*Xanthomonas axonopodis* pv *citri*

5. Scab: The appearance of elevated, corky, rough-textured patches or lesions that resemble scabs on the damaged plant parts surfaces is the most recognisable sign. These lesions may seem tan, brown, or black, and their sizes can vary. The aesthetic effects can degrade the quality of harvested food, making it less appealing for sale or consumption. Lesions caused by bacteriacan serve as entrance routes for other pathogens, resulting in secondary infections that can worsen the plant's condition.

Ex: Apple scab – *Venturia inaequalis*

6. Galls and tumours: Infected plant tissues generate aberrant, frequently spherical, swellings or growths that are bigger than adjacent healthy tissues. These enlargements can arise on stems, leaves, roots and even flowers.Galls or tumours may show discoloration, such as browning or alterations in pigmentation, according to the host plant and the individual bacterial pathogen. Gall development may lead the plant's impacted parts to deform, resulting in distorted or malformed leaves, stems or roots.Depending on where the galls or tumours are located, the plant's functionality may be impacted. Galls on roots, for example, may obstruct water and nutrient intake(Bozkurt *et al,* 2023).

Ex: Crown gall of apple – *Agrobacterium tumefaciens*

Viral disease symptoms

1. Stunting: Stunting in plants is a disease in which a plant's growth and development are restricted or hindered, leading to smaller, undeveloped or less vigorous plants when compared to healthy plants.

Ex: Purple Leaf of Beet virus

2. Leaf curl: The most visible symptom in leaf curling is upward (cupping) or downward (rolling) contingent upon the virus and host plant.Leaves that are infected frequently exhibit aberrant forms, such as deformation, puckering, or narrowing.Leaves may change colour, showing yellowing (chlorosis) or mottling, that may negatively impact their visual appeal.It can cause minimised plant growth because infected plants may devote fewer resources to growth and more to defence mechanisms. It can lower fruit output and quality in fruit-bearing plants, reducing crop yields.Some viruses that cause leaf curl can also cause systemic symptoms that affect the entire plant. Stunted growth, yellowing of younger leaves, and general plant weakening are some of the signs.

Ex: Papaya leaf curl

3. Mosaic: Infected leaves are frequently mottled, with light and dark green patches or streaks. This discolouration is caused by a disruption in chlorophyll production, which inhibits the plant's capacity to efficiently photosynthesize. Leaves infected with mosaic might become twisted, wrinkled, or puckered. They may also have a mosaic of light and dark patches.In some circumstances, the mosaic pattern emerges on leaves in the form of a concentric ring or circular pattern, which is known as “ring mosaic” (Hemmati et al, 2023).

Ex: Tobacco Mosaic

4. Vein banding: The lamina of the infected plant leaf discolours exhibiting yellow in colour while the veins and midrib are in green colour.

Ex: Strawberry vein banding

5. Necrosis: Death of tissues is called as Necrosis. Detailed explanation of necrosis is giving in above symptoms.

Ex: Mild mosaic of potato

6. Enations: Enation is a plant viral infection indication that is characterised by the formation of tiny, leaf-like structures on the veins of leaves. These constructions are typically green and come in a variety of sizes and shapes.

Ex: Pea enation mosaic

7. Rosetting: Rosetting occurs when the foliage of a diseased plant cluster firmly in a circular or spiral pattern in the plant's centre, like a rosette. In addition, the

afflicted leaves may be smaller, deformed, or discoloured.

Ex: Groundnut rosette

8. Colour breaking: The affected sepals and petals of the flowers of affected plant show loss of colours at some points resulting in the uneven colour of the flower. Due to this colour breaking, the tulip flowers in the early centuries were sold at higher prices and gained importance in the development of virology.

Ex: Tulip colour breaking

9. Vein clearing: The veins and midrib of the infected plant subjected to chlorosis resulting in the loss of green colour from the veins by showing yellowish in colour while the lamina retains its green colour.

Ex: Okra yellow vein mosaic

Others

1. Little leaf: The affected plant leaves are smaller in size. Petioles are get reduced

and appears to be attached to the plant. The newly formed leaves are curled, deformed and yellow in colour. The internodes size gets reduced and making the plant shortened. Axillary buds enlarged in size giving them bushy appearance.

Ex: Little leaf of brinjal - Phytoplasma

2. Phyllody: The leaves grow deformed and bushy. Green leaves form in the place of flowers, like deformed flowers.

Ex: Sesamum phyllody - Phytoplasma

3. Grassy shoot: The disease is distinguished by the development of multiple lanky tillers from the base of the infected shoots. The leaves turn pale yellow to fully chlorotic, becoming thin and narrow. The plants seem bushy and 'grass-like' due to shorter internode lengths and early and persistent tillering.

Ex: Sugarcane grassy shoot - Mycoplasma/Phytoplasma

Conclusion

In modern agriculture, a thorough understanding of plant diseases, their classification, characteristics and symptoms on agricultural plants is critical. It forms the basis for successful disease management measures, which are critical for nutritional safety and sustainable agricultural practices. This classification aids in

disease diagnosis and the selection of effective control methods.It enables early detection, which is critical for timely response. With the global concerns of climate change, new pathogens and rising agricultural productivity demands, knowledge of plant diseases has become critical. It helps farmers, researchers and agricultural professionals to take preventive actions, choose resistant crop types and use tailored treatments to reduce the monetary and environmental impact of plant diseases. Finally, this knowledge is critical to guaranteeing agriculture's and food production's long-term viability and resilience.

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