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Defination :→

Plant Pathology :→

It is the branch of biology which deals with the study of diseases, etiology epidemiology, resulting losses and managemen

Objectives of Plant Pathology:

i) The study of living, non-living and environmental cause of disease or disorders of the plants.

ii) To study the mechanism of plant disease developement.

iii) To study interaction between host/susceptib and the pathogen.

iv) To develope systems of management of plant diseases and reducing losses caused by them.

* Importance of plant diseases or Plant Pathology.

i) losses they cause.

ii) About 34% of the crop produce is lost annually due to diseases insect pests and weeds. on the global basis (Cramer 1967); out of which 12% is lost due to diseases (caused by fungi, bacteria or viruses), 11% due to nemafodes 7% due to insect pest and 8% due to weeds.

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* Epidemics

i) Late blight of potato caused by Pehytophthoria infestans was responsible for causing Irish famine in 1845 by destroying the potato crop, the sample food of the people.

ii) This single disease forced man to realize the importance of plant diseases and brought the science of plant pathology to lime light.

2) Other famines

i) Wheat rust epidemics occured from time to time in many countries - Wheat rusts forced farmers to change their croping pattern and wheat replaced by corn or maize or rye.

ii) Brown spot of rice caused by Helminthosporium oryzeae was responcible for Bengal Famine in 1948.

iii) Powdery mildew of grapevines caused by Hemileia vastatrix

iii) Coffee rust caused by Hemileia vastatrix forced to cut down the coffee plants in Sri lanka in 1867..

3) Losses in India :-

i) Wheat rust causes loss of Rs 400 crore annually.

ii) In the years of epidemics losses are Rs 5000 crore or more.

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Effect on society:

i) Infected grains or the fruits may contain toxins (such as aflatoxin, fumonosin) which cause insanity paralysis stomach disorder and liver cancers.

ii) The money spent on the management of plant disease is also a loss because in the absence of diseases this money could be saved.

Classification of Plant disease.

* Based on plant part affected.

1) Localised → if they affected only specific organ or part of the plant.

2) Systemic :→ if entire plant is affected or they can be classified as root diseases, stem diseases / Foliage Foliar diseases etc.

* Based on perpetuation and spread :→

1) Soil borne: when the pathogen perpetuates through the agency of soil.

2) Seed borne: when the pathogen perpetuates through seed (or any propagation material)

3) Air borne: when they are disseminated by wind e.g. rusts and powdery mildews.

* Based on the signs and symptoms produced by the pathogens.
- Disease are classified as rust, smuts, powdery mildews, downey mildews root roots wilts, blights cankers, fruits rots, leaf spots, etc. In all these examples, the disease are named after the most conspicuous symptom of the disease appearing on the host surface.

* Based on the host plants affected.
They can be classified as cereal crop diseases, forage crop diseases, flax diseases, millet diseases, plantation crop diseases, fruit crop diseases, vegetable crop disease, flowering plant diseases etc.

* Based on major causes:
They can be classified as fungal disease, viral disease, mycoplasmal diseases etc.

* Based on Infection Process.
1) Infectious: All the diseases caused by animate causes, viruses and viroids can be transmitted from infected host plants to the healthy plants and are called infectious.

2) Non-infectious: Non-infectious disease can not be transmitted to a healthy plant. Also reffered as non-parasitic disorder or

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simply physiological disorder and are incited by abiotic or inanimate causes like nutrient difficiency or excess or unfavourable weather conditions of soil and air or injurious mechanical influences.

* Classification of Animate disease in relation to their occurance.

1) Endemic diseases: which are more or less constantly present from year to year in a moderate to severe form in a particular geographic region ie country, district or location.

2) Epidemic / epiphytotic disease: which occure widely but periodically particularly in a serere form. They might be occuring in a ~~locally~~ locality every year but assume severe form only on occassion due to the favourable environmental condn occuring in some years.

3) Sporadic disease: occure at irregular intervals and locations and in relatively few instances.

4) Pandemic diseases: A disease may be endemic in one region and epidemic in another when epiphytotics become prevalent through out a country continent or the world the disease may be termed as pandemic.

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Ghost note - 4m.

* Phanerogamic Parasite :→
Phanerogaming Parasite is also called as Flowering parasite.

- Phanerogamic Parasites
  - Stem Parasite
    - Total stem parasite. e.g. Cuscuta. (Dodder) (Holoparasite)
    - Partial stem parasite. eg. Loranthus Mistletoe.
  - Root parasite.
    - Total root Parasite (Holoparasite) e.g Orobanche (Broomrape)
    - Partial root Parasite (Hemiparasite) eg Striga (witchweed)

(hemi/semi parasite)

Striga densiflora - BN - of striga.
↓
Sorghum - main host.

Orobanche cernua - BN - of orobanche
↓
main host → Tobacco and also, cabbage, cauliflower.

Loranthus → BN → Dendrophthoe falcata.
↓
host crop - Mango

Cascuta :- host → Tomato.

striga
- striga densiflora
- striga asiatica (found in asia)

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(external) Symptoms :→

Symptoms are external expression for the evidence of abnormalities to the appearance of diseased plant brought about by pathogen after host and pathogenic interaction called as symptoms.

internal → sign : → when the pathogen itself become visible on the host surface in the form of it's organ or structure is called as sign.

Syndrome : A total sum of variety of a symptoms produced by disease

Syndrome = sing + symptoms.

Flowering Parasitic Plants.

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* Root Parasites *.

(Q 1) Striga. (Witchweed).

i) Striga is an obligate root hemiparasite, although the seedlings above ground do form chlorophyll.

ii) It attacks important crops like maize, sorghum, pearl millet, rice, sugarcane and legumes (cowpea, groundnut etc).

iii) Two species, S. asiatica & S. hermonthica causes maximum damage to crops.

iv) Striga has complex life cycle. It produces thousands of 'dust' seeds that are disseminated by wind and rain.

v) The seeds after a dormant 'ripening' period of several months respond to chemical signals exuded by the host.

vi) The chemical signals enable the Striga seeds to detect the type of host and its distance from the host.

vii) The radical produces root hairs like structures that glue it to the host.

viii) Once the parasite established the distinctive seedling of striga is formed. underground, which lacks chlorophyll, possesses scale-like leaves and produces abundant adventitious roots that form additional haustoria; establishing more connections with the host.

the roots of infected host and bear beautiful Flowers, besides bracket-like leaves lacking chlorophyll.

iii) In general, Orobanche is a parasite of colder climate and need 10-20°C of temperature for seed germination.

iv) This is the reason why it attacks tobacco during winter in India but fails to infect sunflower during summer in the same field.

v) Its control is difficult due to the high longevity (more than 5 decades) of the seeds in the soil, their extremely small size (less than the thickness of human a hair, their production in extremely large number and subterranean infection.

* Characteristics of Flowering Parasitic Plants.

i) The pathogenic Flowering plants, also called parasitic angiosperms can be classified as root parasites or stem parasites.

ii) Root parasites (witchweed and broom rape) are more common and more diverse taxonomically.

iii) Stem parasites include the dodder (Cuscuta) and mistletoes (Arceuthobium).

iv) The angiospermic parasites can be also classified as holoparasite (total parasites) or the hemiparasites (semiparasites).

v) The holoparasites lack chlorophyll and are totally dependent on the host for nutrition. Thus they are obligate parasites.

vi) The hemiparasites contain chlorophyll and make their own food, and absorb water photosynthesis is negligible and the parasite draws nutrition from the host Practically, it is an obligate parasite.

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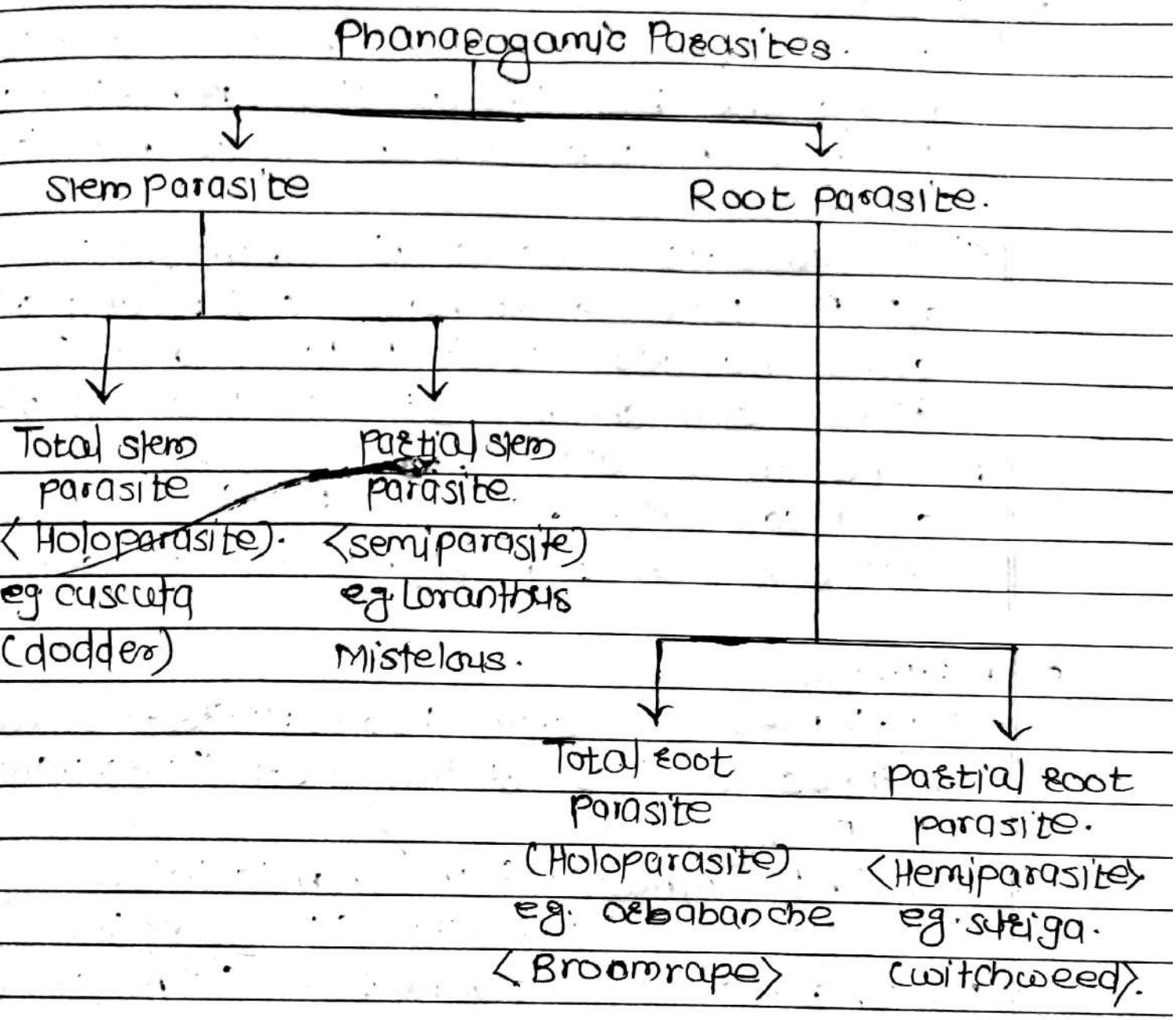

*. STEM PARASITE *

1) Cuscuta (dodder).

i) It is obligate stem holoparasite and is among the best known of all parasitic plants

ii) Dodders are the most important parasites in legumes.

iii) It causeds considerable damage to alfalfa, flax, sugarbeet onion and other crops besides fruit, fodder, and forest trees and shrubs. It also transmit viruses.

iv) The most effective means of control is seed sanitation. several herbicides are effective on c newly-germinated seeds.

2) Mistletoes.

i) Mistletoes are stem holoparasites occuring in three families of the order "santalales" as Follows.

Family Loranthaceae : showy mistletoes [Loranthus (Dendrophthoe)].

Family santalceae : sandalwood (Pyewaeia, santalum).

Family viscaceae: Dwarf mistletoe (Arceuthobium) leafy mistletoes (viscum).

ii) The seeds are covered with a sticky substance called 'viscin' that glues the seeds to the host surface.

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B) Arceuthobium (Dwarf mistletoes).

i) Arceuthobium is the most important mistletoes in item of economic losses, especially to the coniferous trees belonging to families Pinaceae and Cupressucceae.

ii) The flowers are small and unisexual, present on same (monoecious) plant or on different dioecious plants.

iii) Pollination is brought about by insects and wind.

iv) The seed which are discharged explosively from the fruit at the rate of 27 meteres per second, reach up to 16 metres.

v) The seed sticks to the surface by the viscin coating.

vi) The radicle forms a hold fast from which the haustorium emerges and penetrates the host tissue.

vii) This long life cycle is profitably used in disease management.

viii) Chemical control has also been successful with ethephon, an environmentally safe chemical.

1) Mottling: Partial destruction of chlorophyll in interveinal area.

2) Stem galls: The galls are produced due to infection of the fungal pathogens, e.g. white rust of crucifers, loranthus on mango.

3) Club roots: The malformation of roots into finger like or toe like structure due to infection of the fungal pathogen e.g. club roots of cabbage.

4) Blight: There is a general and rapid destruction of plant parts like shoots leaves blossoms twigs etc. The dead organ turn brown to black showing burnt appearance, e.g. early and late blights of potato, bacterial blight of paddy etc.

5) Spot: It is localised destruction of the tissue in a more or less circular manner. It is usually found on the leaves, and may develope on stem or fruit. The dead tissue which are in limited area give shapes as angular round or circular surrounded by yellow purple red margin eg. eye spot of jowar, tikka of groundnut, angular leafspot of cotton etc.

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6) Tar spots and streaks or stripes: Necrotic are become typically tar stained found in forest trees, palm, grasses and jowar. streaks are elongation of necrosis. eg. backeria streak of paddy and jowar.

7) Blast: same as blight but spots are distinct and spindle shaped. eg. blast of paddy.

8) Die back: Dying of plant organ especially stem and branches from the tip downward e.g. die back of citrus.

9) Exudation: secretion of sticky gum like substance due to disease eg. gummosis of citrus.

10) Anthracnose: Disruption of collenchyma and cambium tissue, lesions are sunken in the centre with raised and prominent margin eg. anthracnose of grape, chilli bean etc.

1) Black heart:→ Blackening of central portion observed in potato due to high temperature and poor ventillation in storage eg. black heart of potato

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12) Scab: Destruction of epidermal tissue in the form of scab. Infection is deep seated eg. scab of potato and apple

13) Shot hole: Decayed leaf tissues are blown away leaving holes or perforations. eg shot hole of ashok and mango.

14) Smuts: The floral parts usually the ovaries are destroyed and replaced by forming sori. eg. smuts of jowar, loose smut of wheat etc.

15) Rusts: The pustules of spore usually breaking through the epidermis are seen on the host. Pustules: o may be either dusty or compact and white, yellow red or black in colour eg. white rust of cruciferes, leaf and stem rust of wheat

16) Ergot: Normal grains are replaced by sclerotia. e.g. ergot of bajara, jowar etc.

17) Green EAR (Downy Mildew): Flowers are converted in to green and elongated diseased structures eg green ear of bajara, jowar etc.

18) Powdery mildew: Powdery growth consisting of mycelium and numerous conidia. is seen on the host surface eg. powdery mildew of pea.

19) Mummification: These are observed in fruits. The skin of the fruits becomes hard and fruits get shrivelled. such fruits are called as mummified fruits. eg. downy mildew of grape.

20) Wilts : Wilting or drying of entire plant observed in adult plants. The leaves and other succulent parts loose turgidity become flaccid and droop. It is typical vascular symptom due to plugging of xylem vessels or toxic effect. eg. wilt of tur, cotton pea gram etc.

21) Damping off: Sudden wilting and collapse of seedling observed commonly in seed beds. The stem near the soil is affected, becoming constricted and weak. eg. damping off seedlings like tobacco, tomato, cabbage chilli etc.

22) Pallor: Partial destruction of chlorophyll in the form of streaks. There is up-healthy appearance of the plant due to

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difficiency or excess of water or lack of light or reduction in chlorophyll content due to pathogenic organisms. eg. bajara seedling affected with downy mildew.

23) Rots: Partial destruction of chlorophyll in the form of streaks. There is un-healthy appearance of the plant due to difficiency or excess of water or lack of light or reduction in chlorophyll content due to pathogenic organisms eg. bajara seedlings affected with downy mildew.

23) Rots: The term is applied in cases where affected tissues decay or not. Infection of parenchyma, pith tissue and various parts. Rot imparts different colour reactions and are designated accordingly.

a) Dry rot: Decay of tissue, even after rotting may sometimes remain firm or hard. eg. dry rot of potato and corn.

b) Soft rot: Decay of soft tissues, rotting accompained by softening of the tissues. eg. soft rot of lemon, mango, tomato banana etc.

c) Red rot: Affected tissue becomes red in colour eg. red rot of sugarcane.

d) Wet rot: In addition to softening, there is slimy oozing of liquid, eg. storage rot in potato, citrus and other fruits, usually due to fungi.

e) Root rot: Destruction of parenchyma of underground stems. eg. Rhizoctonia root rot of cotton, hollow stem of jowar. Roots may be described sometimes according to plant part affected eg. stem rot (papaya), collar rot (groundnut), neck rot (paddy), rhizome rot (ginger). They are also described after the discolouration produced on infection, eg. brown rot (Potato) and black rot (cabbage), red rot (sugarcane) etc.

24) Canker :→ Deep seated infection due to destrib destruction of woody tissue and cambium tissues, cankers are raised from epidermal surface tissue and are rough to touch
e.g. guava canker etc.

Symptoms of Plant Diseases Produced by Bacterial Plant Pathogens.

1. Tumors / Galls :→
Tumors are knot like structures or even growth of the host tissue. It is bigger in size eg. tumor caused by the infestation of bacteria like Agrobacterium, radiobacter. Galls are abnormal swelling or blisters or pimples/ knot formed on plant parts. The bacteria includes formation of galls in plants by stimulating mature cells to resume meristematic growth. Galls are smaller in size than tumors.

2) Hairy Root :→
Formation of numerous fine roots eg. infestation of Agrobacterium, radiobacter var rhizogenes.

3) Wilts :→
Wilting or drying of entire plant observed in adult plants. The leaves and other succulent parts loose turgidity, become flaccid and droop. It is typical vascular symptom due to plugging of xylem vessels or toxic effect eg. bacterial wilt of tomato.

4) Blight : →
There is a general and rapid destruction of plant parts like shoots, leaves, blooms twig etc the dead organ turn as brown to black showing burnt appearance, e.g. bacterial blight of paddy.

5) Soft Rot : →
The term is applied in cases where affected tissue decay or not. Infection of parenchyma pith tissue and various parts Rot imparts different colour reactions and are designated accordingly eg. brown rot (Potato) / soft black rot (cabbage) etc.

6) Canker : →
Deep seated infection due to destruction of woody tissue and cambium tissues. cankers are raised from epidermal surface of the tissue and are rough to touch, eg. Citrus canker tomato fruit cancer etc.

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* Symptoms of Plant disease produced by Viral & Phytoplasmal Plant Pathogens *

(B) Symptoms of viral plant pathogens.

I) Colour change in leaves. :

1) Chlorosis :→

It is known as yellowing. There is complete destruction of chlorophyll when the colour becomes white it is known as etiolation. These symptoms usually caused by viruses eg yellowing of beans.

2. Vein clearing/banding :→

clearing of veins ie they turn yellow and leaf laming remaining green, eg. yellow vein mosaic of bhendi and hibiscus.

3. Flecks : clearing of veins further turn into translucent appearance, eg. telisteza virus in kag. zi lime.

4) Mosaic :→

Mosaic caused by virus infection are highly infectious. It is due to partial loss of chlorophyll or chlorosis in uneven patches. eg papaya mosaic, tomato mosaic, chilli mosaic etc.

a) Yellow mosaic :→
Light green and yellow patches are observed in the leaf lamina. eg yellow mosaic of beans.

b) Streak:
Induction of the streaking on the infected portion mainly on the leaves eg. maize streak.

c) Mottling: Partial destruction of chlorophyll in interveinal area e.g mottle leaf of citrus.

5) Ring spots:
The formation of the characteristic chlorotic or necrotic rings on the leaves sometimes on fruit and stem eg. papaya ring spot disease.

6) Oak leaf pattern: Yellow concentric lines extending along main veins eg. Potato or aucuba mosaic virus.

7. Browning of leaf from tip downward:
eg rice tungro virus.

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II) Abnormalities of leaf shape.

1) Enation and tumors:
Dark green tumor like outgrowth appears on the upper or lower surface of leaves (enation) mosaic.

2) Leaf curl: Leaves curl upward or downward. eg. leaf curl of chilli, tobacco, papaya, baingal, tomato etc.

3) Leaf roll: Leaves roll upward or downward, plants remain stunted and have stiff upright growth, eg potato leaf roll etc.

4) Fern leaf and shoe string effect:
leaf faming between veins is poorly developed or not developed at all eg CMV on tomato etc.

5) Cupping of leaves: e.g. papaya mosaic, cowpea mosaic etc.

6) Twisting and blistering of leaves:
Uneven growth of leaf lamina eg. TMV, CMC in tomato etc.

III) ABNORMALITIES IN LEAF SIZE:.

Reduction in leaf size .eg CMV on tomato.

IV) Necrosis:

Scattered flecks or patches of dead tissues appear on infected tissue of leaves, stem, fruits eg. tomato spotted wilt virus, potato X and Y etc..

V) ABnormalities in structure and shape of plant:

i) (stunting / dwarfing (Bushy appearance):

Reduction in size of leaves, flowers, fruits shortening of internodes and height which results into stunted growth of plant .eg bunchy top of banana peg stunt etc.

ii) Hairy root and spindle tuber:

The formation of spindle tuber of tomato due to infestation of potato spindle tuber virus.

iii) Swollen shoot:

Virus ~~ied~~ inducing the swollen shoot and branches, eg. cocco swollen shoot.

VI) Symptoms on Bark and stem:

1) Bark scaling : eg. citrus xyloporosis.
2) Cracking of bark eg. Citrus exocortis.
3) Stem pitting : Pitting and grooving of the stem, eg. citrus tristeza.

VII) Symptoms on Flowers:

Colour breaking (Petal or Flower break) :→

Colour break symptoms which induces variegation in the colours of flower, eg. tulip flower mosaic; pea mosaic.

VIII) Symptoms on Fruits:

i) Mottling of fruits : eg. CMV in cucumber.
ii) Watersoaked rings : eg. Papaya mosaic.
iii) Sunblotch of fruits: eg. citrus greening in mosambi.

⑥ Symptoms of Phytoplasmal plant Pathogens.

1) Phyllody

The symptoms marked by vein clearing stimulation of the axillary buds and transformation of the flower parts into leafy structure termed as phyllody eg. sesamum phyllody..

2) Grassy shoot: Excessive tillering at the base of infected plants and grassy transformation of the growth .eg. grassy shoot in sugarcane.

3) Greening: Marked by yellowing of the midrib and lateral veins of mature leaves veins banding distortion of leaves and blotching on the fruits eg. citrus greening..

4) Little leaf: Extreme reduction in the size of the leaves and leaves become sessile, thin, soft glabrous and pale green e.g. little leaf of brinjal.

5) Sandle spikes

The symptoms are marked by severe reduction of leaf size and shorting of the internodes as a result leaves become stiff and crowded giving spiked

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appearance. eg. sandle spike.

6) Stunting and dwarfing (Bushy appearance):
Reduction in the plant size, leaf lamina, node and internodes because of the infection of the phytoplasmal plant pathogen eg. rice and barley yellow dwarf. In case of rice yellows disease induced by the phytoplasma shows profuse tillering and pronounced stunting occures.

Lecture :→

Nomenclature : Binomial system of nomenclature, Rules of Nomenclature.

Definations:

Taxonomy :→

Taxonomy is a d science that deals with the identification nomenclature (naming) and classification (systematic arrangement) of organisms.

Nomendature:

It is the system of assigning names to the taxonomic groups/ organisms according to international rules.

Systematics.

It is scientific study of organisms with the ultimate object of characterizing and arranging them in an orderly manner.

By ~~or~~ Binomial system of nomenclature was developed by carious von Linnaeus (1707 -1778) which now universally used. In this the first word indicating the name of genus in which and second word indicates the name of species.

Rules of Nomenclature

Following rules should be observed while writing of binomial.

* 1. The name of the genus should always be capitalized.
* 2. Species name should not be capitalized.
* 3. Binomial when written should always be underlined separately; when printed italicized.
* 4. The name or abbreviated name of the scientist describing the species for the first time should be written after binomial e.g. Pseudomonas syringae van Hall.
* 5. If the name is revised, the name of the original describer should be written in the bracket followed by the name of the revising scientist eg. Xanthomonas campestris pv Oryzae (Ishiyama) Dye.
* 6. To avoid confusion the same binomial should not be used to name two different species.
* 7. The year in which organism was described should be written after the name of the author/scientist.

Peinciple of Plant Disease Management.

1) Exclusion
2) Eradication.
3) Avoidance
4) Protection.
5) Immunization.
6) Therapy.

A) Exclusion

The principle of exclusion applies to management of pathogen. The aim to prevent the entry of a pathogen in a field or area.

1) Quarantine:

i) Plant quarantine aims at preventing entry of pathogens from infested areas into non-infested areas at international or national level.

ii) If in a particular area some disease is present insevious form and is likely to be disseminated by propagating materials. The govt passes necessary regulations to stop the entry of such material from infested area. For implementation of these regulation at international level proper check is maintained at the point of entry such as airport.

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iii) This is called as quarantine. Suspected material is kept under quarantine for a specific period and if found contaminated it is destroyed or effectively treated.

2) Inspection and certification :→

i) The crops grown exclusively for seed are periodically inspected for presence of disease. Necessary precaution & are taken to remove the diseased plants. The produce is then certified as seed.

3) Seed Treatment :

i) Seed tubers grafts, bulbs and other propagative materials can be given heat gas or chemical treatment to exclude the pathogen present in or on them.

ii) The method is used for exclusion by eradiction.

iii) Seed treatment reduce loss in germination and developing of the disease in the field.

4) Eradication of Insect vectors :

i) For effective exclusion of pathogens that can gain entry into a new area through insect vectors or carriers, particularly insects having long flight range, a check on these vectors is necessary.

ii) Since the flight of insects cannot be checked the crop should be given insecticidal cover before

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arrival of the vector on the plant surface.

B) **Avoidance of the Pathogen:→**

The principle of avoidance involves tactics that prevent contact between the host & the pathogen. Avoidance is not applicable to disease in which host is in a susceptible stage for a long time.

1) Choice of Geographic Area:

i) Selection of geographic area for any crop is made on the basis of suitability of climate for the crop.

eg. Bean anthracnose is common in wet where seeds produced are generally infected for seed production of bean dry dry area are always preffered.

2) Selection of field:

i) Successful cultivation of crop depends, to a great extent, on selection of proper field. If the disease caused by a soil borne pathogen has been located in the field is not put to the same crop for some time.

3) Choice of time of Planting:→

In many diseases incidence or disease severity is most serious when the susceptible stage of the plant growth coincides

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with the favourable condn of pathogen. It helps in avoiding the critical period.

4) Disease Escaping varieties :
i) In diff crops, certain varieties escape the damage by disease because of their growth character not due to their genetic constitution or resistance to the disease. eg groundnut varieties with erect habit suffers less from damage by leafy spots..

5) Selection of seed and planting material :→
Planting of disease-free seed in pathogen-free soil is often the most effective method of control of certain disease.

c) **Eradication of the Pathogen** :→
It aims at removal of the inoculum already present the field or the crop. Total eradication being not possible the aims is to reduce the inoculum density to a level where cannot cause significant damage.

Biological control of pathogen
i) The biological control aims at eradication and redn of incolum and protection of plant surface through the activity of other micro-organisms.

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ii) The antagonistic component of the microbial population may have biostatic or biocidal effect against the pathogen.

2) **Crop rotation** →

i) Crop rotation is one of the oldest method of fighting soil sickness and not diseases. The method is more effective against pathogens which have limited host range and restricted survival ability in soil.

3) **Removal and destruction of diseased plants or plant organs:**

The practice involve the removal of diseased plants or their affected organs from the field. The disease plant or portion is a continuous source of released of inoculum. Therefore they are destroyed to reduce the amount of inoculum.

It includes :→ * Roughing
* Eradication of alternate and collateral hosts.
* Sanitation.

a) Roughing :→ This practice involves the removal of diseased plants or their affected organs from the field.

Roughing is employed in such disease as loose smut of wheat, loose and covered smut in barley. red rot of sugarcane and wilt diseases

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b) Eradication of Alternate and collateral hosts :→
i) The primary inoculum is produced on and dispersed from the alternate or collateral host.
ii) If these wild or uneconomic host of pathogen are destroyed the source of primary inoculum is eliminated and chance of initiation of disease in crop are reduced.
iii) It is applicable in diseases cause by fungi, bacteria viruses as well as nematodes.

c) Sanitation :→
i) Field sanitation is essential for control of soil borne and facultative parasites or saprophytes.
ii) Destruction of crop debries by burning in the field decreases type of survival of pathogen in the field.
iii) Burying of crop debries deep in the soil by soil turning ploughs also inactivates inoculum of many pathogens.
iii) Sanitation is very important when diseased crop residue is left on the field as a general practice by the farmers.

4) Heat and chemical Treatment of diseased plant

→ i) The pathogen present in the plant or in its special organs can be inactivated or killed by heat or chemical treatments.

ii) Heat therapy inactivates viruses in Fruit tree seedling and grafts and destroys the exposed fungal and bacterial propagules.

iii) Bare root dip in nematocides or fungicides is a method of sanitizing the seedling before transplanting.

5) Soil Treatment :→

i) The aim of soil treatment is to inactivate or eradicate the pathogens present in the soil.

ii) It involves the use of chemicals and heat and cultural practices such as Flooding and Fallowing.

iii) In chemical treatment of soil fungicides and fumigant or granular nematicides are generally used.

iv) The fungicidal dust can be used at the time of planting of crop.

v) For small quantities of soil or for small plots heat treatment is an efficient method of eradication of pathogens.

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D) Protection

Principles of exclusion avoidance & eradication are generally inefficient or not sufficient to prevent the developement of such disease. So the plants are provided some protective cover and dusts to face the pathogens.

a) Chemical Treatment :→

The aim of most chemical sprays dust and seed treatment to form a protective layer on the host surface so that when the pathogen comes in contact with the surface it is killed or prevented from growth.

b) Control of Insect vectors :→

i) Insects are important vectors of virual and other disease The sucess of chemical control depends on speed on action, nature of pathogen and crop stage.

c) Modification of the environments:

i) Improvement of aeration under crop canopy reduce humidity on leaves and other aerial parts and thereby checks growth of fungi which flourish in humid atmosphere.

ii) Aeration through proper ventilation of the store house provides proper environment for storage of plant products especially those with succulent tissue.

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d) Modificatn of host nutrition:
i) Host nutrition often influences development of a disease in the plant. It generally acts through strengthing of the tissue.
ii) Intensity of several diseases is decreased by such micronutrients as zinc, boron, mangnease etc.

E) Immunization.
a) Selection and Hybridization :→
Selection of resistant individual with poor commercial qualities and hybridizing them with susceptible plants of high commercial qualities is the aim of developing resistance through hybridization.

b) genetic manipulation through biotechnology :→
i) Manipulation, genetic modification and multiplication of plants through such techniques as tissue culture and genetic engineering is now used in many crops.
ii) The particular plant species or in which resistance gene of the pathogen are introduced to import resistance is now possible.

f) Induction of aquired Resistance:
i) The plant aquire localize or systemic resistance during its life time through the effects of chemical or microorganisms.

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The rhizobacteria also know to induce systemic aquired resistance in die foliar parts against many disease simultaneously.

d) Resistance through chemotherapy :→
Physiological resistance in plants can be developed through chemotherapy.

e) Resistance through host nutrition:
Making available major and micronutrients through foliar sprays seed treatment or soil treatment or soil application is reported to strengthen the tissue that can ward off invasion by the pathogen.

P) Therapy of diseased plant :→

a) chemotherapy :→ Chemical treatment applied to eradicate the pathogen from tissue of the diseased plant and thus curing it are included in chemotherapy.

b) Heat or Thermotherapy :→
Plant which can tolerate the thermal inactivation or death point of the pathogen can be treated by heat to destroy the pathogen.

c) Tree surgery :→
Large size fruit trees are cleaned of infection by cutting or scrapping of the discussed part and covering the wound with a fungicidal paste.

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lect:→ Management of plant disease management.

* Methods of plant disease management.

A) Cultural Method :

1) Roughing: Roughing is the management of diseased plants. Regular removal of diseased plants from population is an important sanitary precaution and is effective against virus disease of crop.

Red rot of sugarcane, wilt of pigeonpea & cotton, smut of sugarcane downy mildew of sorghum & maize are other disease in which ~~roug~~ roguing can be adopted.

2) Eradication of alternate and collateral host:

The non-specialized pathogens o having a very wide host range from among weeds, collateral and volunteer host plants carry over the pathogens from one season to next and also provide the base for manipulation of inoculum which may reach epidemic condition.

3) Crop Rotation:

In disease control methods, growing of crops in rotation has many benefits such as.

a) Better use of nutrients.

b) weed ~~use~~ control in row crops is which in growth tillage to remove weeds would be practiced.

c) suppression of soil borne pathogens.

d) water economy.

e) Desirable effect on soil texture with deep rooted crops alternating with shallow root crops.

4) Manure and fertilizer :→

i) Role of manure and fertilizer is very important in doses or exogenous application of micronutrients reduce disease severally application of nitrogen more than the normal dose cause new succulents vegetative growth of the plant and delicious maturity.

ii) Pathogen that attack new vegetative growth of plant are favoured by level of N_2.

iii) Pathogens favoured by slow growth of the host and more severe in nitrogen difficiency.

5) Mix cropping:
Simultaneous cultivation of more than one crop in same plot. eg wheat + barley, wheat + chickpea.
Due to redn in no. of susceptible plants there is sufficient spacing between diseased leaves, roots and healthy plants. This prevents the spread of disease by contact.

6) Sanitation:
i) Field and plant sanitation is the main part of disease management through cultural practices. This step is essential even if disease or pathogen free seed has been used. eg. In wilt disease of banana.
ii) Infected plant debris not only serves as medium for survival of pathogen it serves as substrate for their source of survival and multiplication and increase the inoculum.
Removal of debris helps in decreasing disease incidence.

7) Hot weather Ploughing:
Hot weather ploughing is the heat treatment of soil up to cultivated depth is also management of top soil. Deep ploughing to turn top soil exposing it to hot summer sun is one way of killing propagules of many path[redacted] the surface of soil.

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8) Soil amendments:

i) Methods of providing organic source of nutrition to plants include use of compost, FYM and special organic amendments such as oil cakes, alfalfa, meal, wood sawdust tree bark etc.

ii) Many fungal and nematodes diseases are also supressed by organic amendments.

iii) Organic amendments are one way of promoting naturally occuring biological control of pathogens in the soil.

9) Time of sowing

Early or delayed sowing of crop enables it escape critical period of disease incidence. Thus, suitable modification of date of planting in areas where the disease is common can reduce losses. Suitable alteration in date of planting in disease like rust of wheat etc. will provide significant relief.

10) Seed rate and Plant density:

i) Host or plant density in the field is an imp. factor associated with most plant disease. Plant ~~seed~~ spacing created by seed rate or transplanting affects disease through underground closeness of roots and through aeration of a definite density of the foliage for pathogens of aerial part.

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ii) Dence canopy provides shade, increases humidity under crop delays the drying of soil under the plants prevents aeration and radiation and low temperature, these conditions favour most of foliar disease like downy mildew late blight etc.

8) Irrigation and drainage :→

i) Irrigation water is often a means of transport of inoculums through the field and to different field in the area.

ii) In papaya plantation, angular leaf spot of cotton and many pathogens occure through irrigation and drainage water in and outside the field.

B) Biological method of plant disease manggement.

→ Bolological method is one of the better, safer and cheaper mothod of plant disease manageme~~n~~t.

It can be utilise by following means:

1) Use of cross peotection.
2) Use of suppressive soil
3) Introduction of newer organism
4) Use of hypo virulent strain
5) Use of hyperparasites.

1) Cross Peotection :→

Cross peotection implies use of mildly pathogenic or non-pathogenic strain of pathogen against it's pathogenic strain since the inducer strain occupy the space in host and trigger host defence system which peotect it from the pathogenic strain. ex. Use of mild strain of virus Tristeza for cross peotection.

2) Use of suppeessive soil :→

The supressive soil are those soil which supress the developement and establishment of the pathogen in soil. The suppressive nes may be due to pH peesere of perticular clay or presence of large no of anatagonist's population.

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3) Introduction of newer antagonists:
The newer antagonists can be introduced in a particular place where it's population very limited.

4) Use of hypovirulent strain :→
Hypovirulence means subnormal virulence which include all the abnormal states where the pathogenic fitness is reduced because of presence of dRNA in the fungal body.
eg. use of diff formulation of teichoderma Bascillus sp. etc.

5) Use of hyperparasites:
Use of hyperparasite like teichoderma spp. against Rhizoctonia and sclerotinum reduces the inoculum potential of the pathogens.

c) chemical methods of plant disease management.

→ * fungicide -

The word 'fungicide' originated from two latin words, viz fungus and 'caedo' means to kill. Thus the fungicide is any agency/chemical which has ability to kill the fungus.

* fungistat: some chemicals do not kill fungal pathogens, However they simply arrest the growth of the fungus temporarily. These chemicals called fungistant.

* Antisporulant.

Some other chemicals may inhibit the spore production without affecting the growth of vegetative hyphae and are called as 'Antisporulant'

* Antibiotic: A chemical substance produced by one organism which in low concentration can inhabit or even kill other microorganisms.

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d) Physical method of plant disease management.

i) Hot water Treatment (HWT).
The seeds are soaked in cold water at 20-30°C for 5 hrs to induce the dormant mycelium to germ. Then the seeds are immersed in hot water at 50-54°C for 10 minutes to kill the mycelium. It is very effectively used to eliminate loose smut of wheat.

ii) Hot air treatment (HAT).
Sugarcane setts are treated with hot air at 50°C for 12 hrs to eliminate mosaic virus.

iii) Aerated stem therapy (AST).
Sugarcane setts are also exposed to aerated stem at 50°C for 8 hrs to eliminate mosaic virus.

iv) Moist hot air treatment (MHAT)
This method is effectively used in sugarcane to eliminate grassy shoot disease. Initially the setts are exposed to hot air at 54°C for 8 hrs then exposed to aerated stem at 50°C for 1 hr and finally to moist hot air at 54°C for 2 hrs.

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v) Solar heat treatment (SHT).

i) A simplest treatment has been devised in India to eliminate the pathogen of loose smut of wheat.

ii) Luthr's solar energy treatment:→

The seed are soaked in cold water for 4 hrs in the forenoon on a bright summer day followed by spreading and drying the seeds in hot sun for 4 hours in the ~~afternoon. Then~~ forenoon on a bright summer day followed by spreading and drying the seeds in the hot sun for four hours in the afternoon. This method more ~~seed~~ useful for treating large quantities of the seed lots.

vi) Soil solarization:

Soil solarization is generally used for controlling soil borne pathogens like phythium, verticillium, ~~Rhizob~~ Rhizoctonia, Fusarium etc.

vii) Steam sterilization:

Steam is passed through perforated pipes at a depth of 15 cm to sterilize the upper layers of soil. It is mostly practiced under glass house and green house conditions.

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viii) Hot air sterilization:
Hot air is also passed through pipelines to sterilize the soils in the nursery areas.

ix) Hot water treatment:
It is done in pot culture studies to kill fungi and nematodes.

x) Refrigeration:
It is an accepted fact that low temperature at or slightly above the freezing point checks the growth and activities of all such pathogens that cause a variety of post harvest disease of vegetable and fruits.

xi) Radiation:
Electromagnetic radiation such as UV light X-rays as well as particulate radiation have been studied in relation to management of post harvest disease of horticultural crops.
X-rays controlled post harvest fungal infection in peaches and tomatoes.

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fungicide:

It is an chemical that is capable of killing fungi.

Systemic fungicide:

The fungitoxic compound that controls a fungal pathogen remote from the point of application and that be detected and identified called as systemic fungicide

Eg. carboxin, oxycarboxin etc.

Non systemic fungicide (contact)

The fungicide which kill or eradicate the fungus at point of application called as non-systemic fungicide eg. Mancozeb, zineb etc.

Fungicides can be broadly grouped based on their.

1) Mode of action.
2) general use
3) chemical composition.

I. Mode of action.

i) Protectant.

As the name suggests protective fungicides are prophylactic in their behaviour. Fungicide, which is effective only if applied prior to fungal infection is called a protectant

eg. zineb, sulphur

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Therapeutant:→
Fungicide that is capable of eradicating a fungus after it has caused infection and thereby causing the plant is called "chemotherapeutant" eg. carboxin, oxycarboxin, antibiotics like Aureofungin. Usually chemotherapeutants are systemic in action and affect the deep-seated infection.

Eradicants:→
Eradicants are those remove pathogen Fungi from an infection court (area of the host around a propagating unit of a fungus in which infection could possibly occure) eg. organic mercurials, lime-sulphur, didine etc. These chemicals eradicate the dormant or active pathogen from the host. They can remain effective on or in the host for some time.

II. Based on General Use:→
The fungicides can also be classified on their use in managing the disease.
Seed protectants (preplant):
eg. captan, thiram, organomercuries, carbendazim, carboxin etc.

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2) Soil fungicides (Preplant).
eg. chloropicrin, formaldehyde, vapam, dazomet etc.

3) Soil fungicides (for growing plants)
eg. Bordeaux mixture, copper oxychloride, captan PCNB, thiram etc.

4) Foliage and blossom protectants:
Eg: capton, Ferbam, zineb, mancozeb, chlorothalonil etc.

Eradicants.

5) ~~Fruit protectants:~~
Eg: organomercurials, lime sulphure etc.

6) Fruit protectants:
eg. captan, maneb, carbendazim, mancozeb

7) Tree wound dressers:
eg. Bordeaux paste, Chaubattia paste etc.

8) Antibiotics
eg. Actidione, Griseofulvin, Streptomycin, streptomycline etc.

9) General purpose sprays and dust formulations.

III Based on chemical composition:→
Non systemic fungicide

1) Sulphur fungicides:→

i) Use of sulphur in plant disease control is probably the oldest one and can be classified as inorganic sulphur. Inorganic sulphur is used in the form of elemental sulphur or as lime sulphur. Elemental sulphur can be either used as or wettable sulphur, later being more widely used in plant disease control.

ii) Sulphur fungicides emit sufficient vapours to prevent the growth of the fungal spores at a distance from the area of diposition.

iv) This is an advantages in sulphur fungicide as compared to other fungi toxicants.

v) Sulphur is a contact and protective fungicide normaly applied as sprays or as dust.

vi) This used to control powdery mildew of fruits, vegetables flowers & tobacco. It is also used against apple scab and certain rusts leaf blights of field crop and fruits disease.

2) Dithiocarbamates:

i) organic compounds of sulphur are now widely used in these days. All such compounds called as 'carbamate fungicides'

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which are derivatives of dithiocarbamic acid. Dithiocarbamates are broadly grouped into two, based on mechanism of action.

* Monoalkyl Dithiocarbamates :→

Eg: zineb (Hexathane 75% WP, Dithane z-78, Funjeb, Lonocol, Parzate C). maneb (Dithane M22, Manzate WP, MEB), mancozeb (Dithane M-45. Indofil M-45, Manzeb), nabam (chembam. Dithane A-40, Diathane D-14, Parzate liquid). and vapam (Vapam, VPM, chemvape, 4-S karbathion, Vita fume).

* Dialkyl Dithiocarbamates.

Eg, thiram (Thiride 75 WDP, Thiride 750, Thiram 75% WDP, Hexathie, Normerson, Panoram 75, Thiram, TMTD, Arasan, Tersan 75, Thylate pamarsol, Thidram).

Ferbam (coromat, feram, ferbesk, fernate Fermate D, fermicide Hexaferb 75% WP, karbam black, Ferradow).

ii) Diseases controlled :→

leaf spots, blights, anthracnose, rusts, downy mildews etc of many crops plants.

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3) Copper fungicides.

i) The fungicidal action of copper was mentioned as early as 1807 by Peevost against wheat bunt disease (Tilletia caries), but its large-scale use as a fungicide started in 1885 after the discovery of Bordeaux mixture by Millardet in France.

ii) The mixture of copper sulphate and lime was effective in controlling downey mildew of grapevine caused by plasmopara viticola. and late blight of potato.

iii) Some other sulphate of Cu preparations developed later - Bordeaux paste, chaubattia paste, Burgandy mixture and cheshunt compound. are used to control diseases.

iv) Preparation of Cu like cuprychloride (Blitox 50, cupravar 50%WP, Fytolan, Micop-D-06, Micop W-50, Blue copper 50, cuprovit, cobox, Copper bond, copper caprasol canopy, cuprax, Bilmix 4% dust, Mycop, Topguard 50%WP, Cuprous oxide and copper hydroxide.

v) diseases controlled are.

Cu fungicides are protective fungicides for foliage applicat?.

-late blight of potato, apples scab, downey mildew of grapes, damping of seedlings disease, stem cankers, leaf diseases rust & soil borne disease as like as

4)

wilt, collar rot, root rots etc. also used as wound dressers.

4) Mercury fungicides:

i) They can be grouped as organic & inorganic compounds.

ii) They are used as seed treatment chemicals against soil borne diseases. They show bacterial property. They are more toxic compounds.

iii) Due to their residual toxicity and extreme toxic nature they remain in the plants hence they are banned.
In india it is only use for seed treatment of certain crops.

- Inorganic mercury compounds :→
  eg. mercuric chloride and mercurous chloride.
- organic mercury compounds :→
  Methyl ethyl mercury chloride, ~~phybely~~ phenyl mercury chloride, ethyl mercury chloride etc.

iv) Disease controlled :→
mainly used for seed treatment and treatment of planting material. either by dry, wet or slurry method.

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5) Heterocyclin nitrogen compounds :->
i) Mostly used as Foliage and fruit protectants. Some compounds are used as a seed dressers.
some commonly used fungicides are.
captan, captafol., glyodin, ~~Siprosite~~, and Folpet etc.
ii) diseases which are controlled :->
seed and soil borned diseases in many fruits and ornamental and vegetables.
captan, glyodin and Folpet used by spraying on rusts, downy mildew, leaf spot, blights, anthracnose etc.

6) Dicarboximide compounds :->
1) Iprodione (Rovral)
2) vinclozolin (Ronilan, ornalin)
are 2 imp fungicide in this grp.
They are broad spectrum and contact fungicide and control diseases caused due to species of Botrytis, sclerotinia, Monilinia, Alternaria, Helminthosporium, fusarium, Penicillium, Rhizoctonia etc.

7) organo-phosphorous fungicides.
Edifenphos is available as Hinosan 50% EC and 2% D. It has a specific action against Pyriculoria oryzae (blast), Corticum sesakii and Cochliobolus miyabeamus in rice.

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Fungus, Somatic structure, types of fungal Thalli, fungus tissues, modification of thallus.

Fungus.

defn :- Alexopoulus and Mims (1979) defined fungus as eukaryotic / nucleated spore bearing, achlorophyllous organism generally produced by sexual / asexual method and whose filamentous branched somatic structures is typically covered by cell wall and cell wall further consist of either cellulose or chitin or glucon or some other complex organic carbohydrates.

Somatic structures.

1) Haustoria :→

i) They are nothing but organs for absorption.

ii) It is lateral growth of intercellular or superficial hyphae which will help to absorb food and nutrients from the host.

iii) They are of diff shapes and size ranging from knob like structure to simple lobbed branched coiled and they are able to penetrate only in the cell wall and not in the plasma membrane.

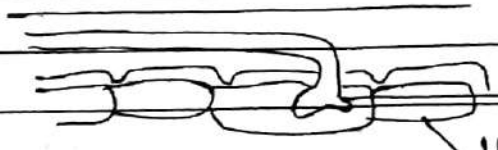

Fig: Haustoria.

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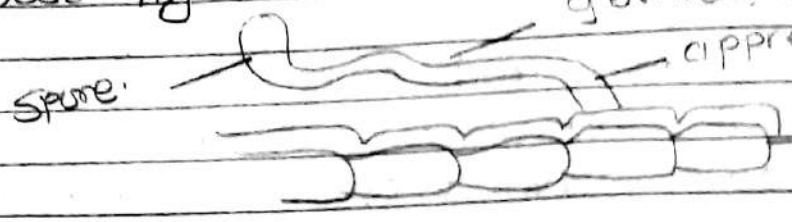
2) Appressoria < apprimere - to press against).
i) These are localized swellings of the tip of germ tube or older hyphae that develop in responce to contact with the host. In simple these are special structures for attachment in early stage of infection.
ii) From these a minute infection peg usually grows and enters the epidermal cell of the host fig.



* Types of fungal thalli.

1) Homothallic fungi.
If male and female sex organs or both the gameles are produced on the same thallus ; they are self fertile / self compatible eg. powdery mildew of Mung- Sphaerotheca fuliginea.

2) Heterothallic fungi
If male and female sex organs or both the gameles are produced on the diff thallus they are self

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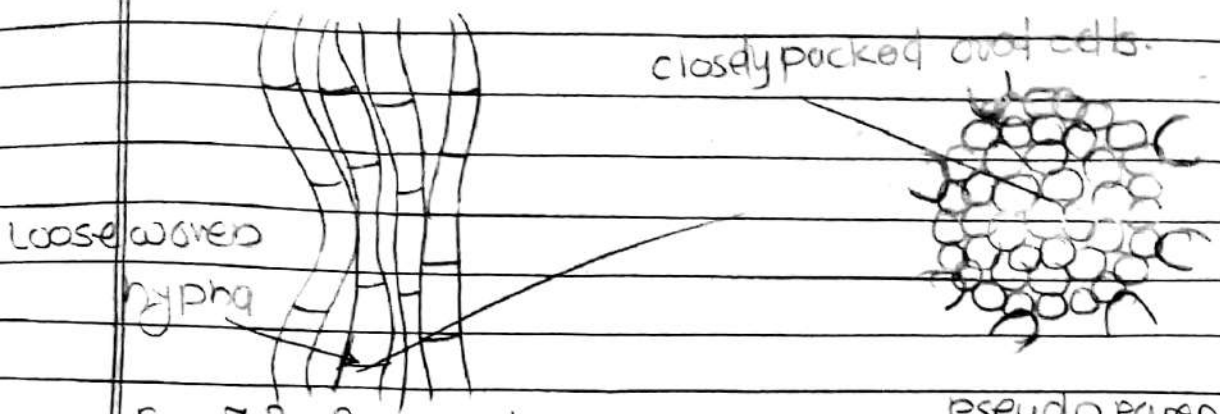
sterile or self incompatible eg. Rust fungi.

* Fungus Tissues:

1) Plectenchyma (Gr plekein - to weave + enchyma = infusion) During certain stages of fungal developement the mycelium becomes organized into loosely or compact woven tissue as against the loose hyphae ordinarily found in the mycelium. The organized fungal tissue are called plectenchyma.



The plectenchyma is of two types.

a) Prosenchyma.
b) Pseudoparenchyma.

a) Prosenchyma (Gr Pros - towards + enchyma - infusion)

a) The loosely woven tissue in which the component hyphae with elongated cells lie more or less parallel to one another is called prosenchyma.

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b). Pseudoparenchyma.

<Gr Pseudo- false + parenchyma - a type of plant tissue>.

The fungal tissue which are loosely packed, in the form of more or less isodiametric or oval cells resembling the parenchyma cells of higher plants are called pseudoparenchyma.

Both prosenchyma and pseudoparenchyma compose various types of vegetative and reproductive structure. Stroma is usually made up of prosenchyma while sclerotium is made of the pseudoparenchymatous ~~disease~~ tissue. Both stromata and sclerotia are somatic structures of fungi.

Mycelium or Thallus.

* Bacterial cell structure

Bacterial cell structure.

→ The bacterial cell is surrounded by a cell coall composed of peptrdoglycan consisting of chain of alternating N-acetyl muramic acid and N-acetyl glucosamine unite cross linked by tetrapetide and pentaglycine units.

ii) The cell wall allows the inward passage of wqste matter and digestive enzymes.

iii) All the material inside the cell wall constitute the protoplast.

iv) The protoplast contist of a cytoplasmic or protoplast membrane, which determines the degree of selective peemeability of various substances into and out of the cell.

v) The cytoplasmic membrane of bacteria eecembles those of eukaryotes but also contains respiratory and other enzymes located in the bacteria.

vi) The chromosomal DNA makes up the main body of genetic material of the bacterium and appears as a spherical, ellipsoidal dumb-bell or Y-shaped body in the cytoplasm but without any membrane.

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* Flagella

i) In bacteria flagella are the organs of locomotion.

ii) They are very dilicate and fragile and cultures are to be handled carefully for their staining.

iii) The flagella vary from 10-12 nm in width which is similar than wavelength of light. therefore cannot be seen by ordinary staining.

* Parts of Flagellum.

- **Filament:**
  It is outermost region of flagellum and is helical, composed of Flagellin with a molecular weight of 30,000-40,000 and is synthesized in the cell, which moves to the hollow core of the flagellum to the tip.
- Flagellin is protein with 14 amino acid and is characterised by higher content of aromatic amino acid and absence of cysteine in many case.

- **Hook:** Filament is attached to hook which is wider than the flagellum. This is ~~40~~ 45 nm wide and made up of different type of proteins. The hook of gram ⊕ve bacterium is longer than that of the gram ⊖ve bacterium.

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* • Basal body :→
The third part basal body consist of small central rod which is inserted into a system of rings. The gram +ve and gram -ve bacteria are different in the numbers of rings. The inner pair of rings S and M are not embeded in cell membrane and are formed in both gram positive and gram negative bacteria. L and P rings are formed only in gram -ve bacteria. S and M. rings are impotant for moment of flagella.

* • Pili
→ In some bacteria small hair like structures are also present which are called pili.
→ These are shorter than the Flagella and are thicker (3-15 nm in diameter).
→ The term fimbriae is sometime also used for pili but the term pili reserved for those which are involved in conjugation.
→ They are made up of protein sub-units pillin of molecular weight of 70,000.
→ It consist of a helically coiled fibre with a central hole of 2nm in diameter.
→ Fimbriae may be involved in attachment whenever there is infection. Both flagella and pilli stigmate from cell membrane and extend outward through the cell wall.

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Reproduction:

Bacterium multiply at a phenomenal rate by the process of binary or transverse or fission.

- As the cytoplasm and cell wall undergo division into two, the nuclear material is organised into a circular chromosome like structure which ultimately duplicates itself and gets distributed equally into 2 newly formed cells.
- Similarly, plasmids also duplicate and come into 2 daughter cells.
- The duplication occurs rapidly once every 20 minutes.
- As a result the bacterium like Escherichia coli, starting from bacterium may produce 1 million bacteria in 10 hr.
- However this no. is not reached because the gradual limitation of nutrients and toxic metabolites. Still what is achieved normally is phenomenal.
- Such ~~ece~~ bolificacy in multiplication must be of great advantage both in survival of bacterial pathogen and also for successive plant infections.

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* Fungi and their characteristics *

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- **Fungi:**

Fungi are the eukaryotic spore bearing chlorophyllus and unicellular or multicellular organism which is reproduce by asexual or sexually.

- **Characteristics of fungi.**

1) Fungir are eukaryotic.
2) They reproduce both by sexual and asexual means.
3) They or their nutrition is heterotropic. They may be a) obligate parasite or b) Saprophyte.
4) Their habitat are damping places and dead or decaying matters. They are soil born.
5) Their life cycle are both simple & complex.
6) They are Achlorophillous ie lack chlorophyll.
7) They are unicellular or multicellular.
8) They are cosmopolitian - ie distributed every where.
9) Their cell wall is made up of chitin.
10) They may be obligate parasite or saprophytes.
11) They have symbiotic relationship with other organisms and they are free living.

- Thallus: fungal body is called as thallus.
- septa :→ i) aseptate // ii) Septate //
- spore :→ unit of reproduction.
- my cellium :→ groups of hypae.
- hyphae :→ Thread like structure

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I. Aserual Reproduction.

i) It occures through internally or externally produced spores which also act as agents of dissemination, survival and infection.

ii) In straminopila (Oomycota) and some fungi (zygomycota), aserual spore are produced endogenously inside a sac like structure called sporangium and are released either by rupture of sporangial wall or through pore or opening in its wall.
They are either motile ~~cell~~ with one or two flagella called zoospores. or non-motile aplanospores.

iii) Sporangia are formed on specialized hyphal branches called sporangiophores.

iv) Conidia are another type of aserual spore which are cut off terminally or laterally from specialized hyphal branches called conidiophores.

v) The locomotory appendages or flagella of zoospores are of two types ie whiplash and tinsel.
The whiplash → much thinner at tip.
Tinsel (found in straminopila)[Oomycota]) have large no. of small hair like outgrowths called mastigonemes or ~~fila~~ flimmers on their entire length.

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III. Sexual Reproduction:

Sexual Reproduction involves

* Plasmogamy: fusion between two sexual cells
* karyogamy: fusion of the nuclei. It results in the formation of a diploid nucleus, which immediately or later undergoes meiosis to form 4 haploid nuclei.

fungi achieve plasmogamy by a variety of methods

i) Gametogamy
ii) Gametangiogamy,
iii) spermatization
iv) Somatogamy.

1) Gametogamy:

→ It is a fusion or copulation beth gametes.
→ Gametes are naked wall-less sex cells which copulate to form a zygote.
If the two gametes are similar in size, they are called isogamy.
→ Copulation beth two dissimilar gametes, one smaller (male) and other bigger (female) is called anisogamy.
→ The fusion beth motile male gamete and non-motile female gamete (oosphere or egg) lying in the oogonium is called heterogamy.

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ii) Gametangiogamy :→
It is fusion betn gametangia (or these sex organ) when gametangia are similar in shape and size, these are called isogametangia and are designated as ⊕ and ⊖ gametangia rather than male and female.
→ When the gametangia are diff in shape and size they are called heterogametangia
→ The male is usually smaller and clup shaped female is globular.
→ Zygospore: Fusion betn two similar gametangia.
→ The zygote formed by the fusion between morphologically distinct gametangia is called oospore and process oogamy.
→ The plasmogamy betn them is called gametangial copulation or contact eg. Mucor, Rhizophidium.

iii) Spermatization:
→ It occures in Ascomycota and Basidiomycota.
→ Spermatia (Sing. spermatium) anibute male gametes are formed like conidia or puorcing.
→ The spermatium when comes in contact with the female gametangium release the male nucleus into the female gametangia through a pore.

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iv) Somatogamy:

→ In this sex organs are not formed and somatic cells are such as gametangia and fuse together. eg. Agaricus.

→ somatogamy may occure bet^n cells of same hyphae or bet^n cells of the diff thalli.

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*** General characteristics and classification of viral plant pathogens ***

* Characteristics of viruses which separate them from other causes of plant pathogens are.
- They are acellular
- They are sub microscopic and intracellular.
- They lack lipid membrane system and energy production.
- They use host machinery for their replication.

* Structure of viruses.
→ Viron is a technical term used for the virus particle. A viron consists of nucleic acid surrounded by a protein coat.
→ The nucleic acid is called 'nucleoid' which may be either de-oxy ribonucleic acid DNA or ribonucleic acid RNA but never both, and forms the genome.
→ The protein coat is called capsid. It consists of many subunits which are similar and occasionally dissimilar and these subunits are called capsomers.
→ The combined genome and the capsid are called 'nucleocapsid'

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In many grp of viruses there is an additional protein layer bet^n the capsid and the nucleoid. This is called "virus core".

Nucleoid

- The nucleoid (nucleic acid component) is located internally within a protein coat.
- Only one type of nucleic acid, i.e either RNA or DNA is found in a virus.
- Higher percentage of nucleic acid is associated with larger DNA viruses like bacteriophages. while low content is found in animal viruses.
- Most of the viruse contain RNA, with exceptions like cauliflower mosaic virus.

* capsid

The capsid is a protein coat surrounding the nucleoid and the following functions.

→ Protects nucleic acid from unfavourable external environment.

→ It facilates nucleic acid entry into the host cell.

→ It is antigenic, and protein coat shows a complex structure and provide shape to the virus particles.

→ It interacts with the vector for specific transmission.

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Morphology of viruses

Viruses are differentiated a/c to shape and size.

i) Elongated (rigid rod & flexuous threads)
ii) spherical (isometric & polyhedral).
iii) cylindrical (bacillus-like rods).

1) 2) 3).

Some elongated viruses are rigid rods about 15 x 300nm in size but most appear as long thin, flexible threads that are usually 1-10 nm wide and 480-2000 nm in length.

Rhabdoviruses are short basillus-like cylindrical rods approximately three to five times as long as they are wide. (52-75 x 300-380 nm in size).

Most spherical viruses are actually polyhedral ranging in diameter about 17 nm (Tobacco ne. necrosis satellite virus). to 60 nm (wound tumour virus).

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Tomato spotted wilt virus is surrounded by a membrane and has flexible spherical shape about 100 nm in diameter

* composition and structure of viral proteins.
→ viral proteins like all proteins consist of amino acid.
→ The sequence of amino acid with in a protein, which is encoded by the sequence of nucleotides in the genetic material. determines the nature and properties of the protein.

* composition and structure of viral nucleic acid.
→ Most plant viruses consist of RNA, but now, a large number of ~~RNA~~ viruses have also been shown to contain DNA as its genome.
→ Both RNA and DNA are long chain-like molecules consisting of hundreds of or most of them thousands of units called nucleotides.
→ Each nucleotide consist of ~~3~~ ing compounds called the base attached to a five-carbon sugar (ribose in RNA or deoxyribose in DNA) which is turn is attached to phosphoric acid.

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* Transmission of Plant Viruses. *

→ Viruses cannot penetrate the intact plant cuticle and the cellulose cell wall plants have a barrier infection.

→ This problem is overcome either by avoiding the need to penetrate the intact outer surface. (eg) in seed transmission or by vegetative propagation. or by penetration through a wound in the surface layers. Such as in mechanical inoculation and transmission by insects.

→ There is considerable specificity in the mechanism by which any one virus is naturally transmitted.

1) Transmission via Plant material :→

a) Mechanical Transmission:

i) Mechanical transmission involves the introduction of infective viruses or viral RNA into a wound on the plant's surface.

ii) When virus establishes itself successfully in the cell, infection occurs.

iii) This form of transmission occurs naturally with a few viruses such as Tobacco mosaic virus. (TMV) and Potato virus X (PVX) that are very stable and reach high concentration in plant.

iv) Mechanical inoculation is usually done by grinding up infected leaf

tissue in a buffer usually a phosphate buffer that contains additives that control then rubbing the extract gently on the leaves of the recipient plant.

v) The gentle applicat^{n} wounds the leaf surface without causing cell death.

b) Seed Transmission:

About one seventh of the known plant virus are transmitted through the seed of at least one of their infected host plants. Virus may persist in seed for long periods so commercial distribution of a seed-borne virus over long distances may occure. examples: Pea seeds borne mosaic virus.

c) Pollen Transmission:

Some viruses are transmitted from plant to plant via pollen. As with seed transmission two mechanisms appear to operate in pollen transmission gametic infection of the embryo and direct infection of the mother plant.

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d) Vegetative Propagation:

Vegetative propagation is an important practice but it is also unfortunately, a very effective method for perpetuating and spreading viruses.

economically, imp. viruses spread systemically through most vegetative parts of the plant.

e) Grafting:

Grafting is essentially a form of vegetative propagation in which part of one plant grows on the roots of another individual where either the rootstock or the individual plant form which the scion is taken is infected systemically with a virus. the grafted plant as whole will become infected if both plants in the graft are susceptible.

2) Transmission by invertebrates:

Many plant viruses are transmitted from plant to plant in nature by invertebrate vectors. members of the insecta and arachnida classes of the Arthopoda and the Dorylaimida ordes of the Nematoda. Six of the

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order contains insects that feed by chewing. The Homoptera feed by sucking sap from plants and are numerically common vectors of plant viruses are aphids, leaf hoppers and whitefly.
7 of the 29 orders in the living insects feeding on living green plants are vectors of plant viruses and virus transmitting order are orthoptera, coleoptera, Lepidoptera, Diptera, Thysanoptera, Hemiptera.

3) Fungal Transmission of viruses:
Several viruses have been shown to be transmitted by soilinhabiting fungi. The known vectors are members of the class plasmodiophoromycetes in the division Myxomycota or in the class chytridiomycetes in the division Eumycota. species in the chytrid genus olpidium transmit viruses with isometric particles. while species in two plasmodiophorus genera, polymyxa and spongospora transmit rod-shaped or filamentous viruses.

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Characteristics of Bacteria:

1) It is a microscopic in nature.
2) Unicellular & reproduction by sexually or asexually.
3) It is prokaryotic.
4) They are motile with having. Flagella or flagellum.
5) Vary their shape- spherical rod shaped & helical.
6) Asexually reproduction of bacteria is either by binary fission or by budding.
7) Bacteria reproduce sexually by conjugation. transformation, or transduction.
8) Bacteria useful in souring of milk and are harmful which cause disease in plants and humans & animals also.
9) Good example of bacteria which are beneficial to agriculture are a) Rhizobium → which fix atmospheric N on legume root nodules symbiotically

b) Azotobacter: fix the atmos. N without the help of any plant iso it is a asymbiotic nitrogen fixation bacteria.

c) Devoid without chlorophyll.

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* Causes of Plant Diseases *

* Abiotic (Inanimate) factors:
They include mainly the deficiency or excess of nutrients, light, moisture aceration, abnormality in soil condition, atmospheric impurities etc. Examples are Black tip of mango (due to SO_2 toxicity), khaira disease of rice (due to Zn difficiency), whiptail of cauliflower (Mo deficiency) hollow and black heart of potato (due to excessive accumulations of CO_2 in storage), bitter pit of apple (due to Ca defficiency).

* Mesobiotic causes:
These are the disease inoculants which are neither living nor non-living. They are considered to be on the threshold of life. They are
1) Viruses: They are infections agents made up of one type of nucleic acid (RNA or DNA) enclosed in a protein coat. Examples of viral diseases of plants are: potato leaf roll, leaf curl of tomato and chillies and mosaic disease of many plants.

2) Viroids: They are naked infectious strands of nucleic acid. They cause disease like potato spindle tuber, citrus exocortis, chrysanthemum stunt, cadang cadang of coconut palm, stor crack of apple etc.

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Biotic (Animate) cause:
This category include the pathogens which are animate or living or cellular organisms. They are.

-> Prokaryotes like bacteria which are unicellular prokaryotic microorganisms lacking true nucleus. Example of diseases caused by true bacteria are bacterial rot or wilt of potato, soft rot of potato and vegetables. citrus canker etc.

- phytoplasma are wall less prokaryotes and cause disease like peach. X.
- ii) Fastidious bacterium, xylella fastidiosa cause almond leaf scorch pierce's disease of grapevine.

- Eukaryotes are the organisms with true nucleus
- i) fungi :-> Potato wart, powdery mildew, rust, smuts, red rot of sugarcane (nearly 80% of plant disease are caused by fungi)
- ii) straminopiles (oomycetes): Downy mildews, late blight of potato, white rust of crucifers damping off etc.

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* History of Plant Pathology India. *

During 1850-1875 DR. cunningham and A. Barclay started identification of fungi in India. Cunningham made special study of rust & smuts.

1) K.R. Kjetikar : was the first Indian scientist who collected and identified the fungi in the country.

2) E.J. Butler : who is is known as the father of plant Pathology in India. Initiated an exhaustive study of fungi and diseases caused by them in 1901 at Imperial Agricultural Research Institute at Pusa (Bihar).

He made a scientific study of mostly fungal plant diseases known in India at that time. He also studied for first time plant disease known in India at that time. The diseases studied by him for the first time include wilt of cotton, pigeon pea, different diseases of rice, toddy palm sugarcane, potato and rusts of cereals.

He wrote a monograph on Pythiaceous and Allied fungi and a classic text book: Fungi and diseases in plants in 1918.

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3) J.F. Dastur :→ (1896-1971), a colleague of butler, was the 1st indian plant pathologist who is credited with a detailed studies of fungi and diseases in plants. He also studied gene phytophthora and disease caused by it in castor and potato. He is known for the establishment of phytophthora parasitica from castor.

4) G.S. kulkarni. — published exhaustive information on downy mildew and smuts of sugar cane and pearl millet.

5) B.B. Madhukar - started work on control of cotton with through varietal resistance.

6) Dr. K.C. Mehta of Agra college investigated the life cycle of cereal rusts in India during the first half of 20th century.

7) Dr R. Prasada : trained by Dr K.C. Mehata continued the work on rust. and added to the knowledge of linseed rust.

8) Luthra and Sattar (1953) developed the solar heat treatment of wheat seed for the control of loose smut. SN Dasgupta carried out exhaustive studies on black tip of mango.

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9) T.S. Sadasivan - worked out the mechanism of wilting in cotton due to Fusarium oxysporum f.sp. vasinfectum.

10) M.K. Patel, V.P. Bhide and G. Rangaswami pioneered the work on bacterial plant pathogens in India..

11) M.J. Thirumalachar conducted exhaustive studies on rusts and smuts, and developed a number of antibiotics for controlling plant diseases in India.

Notable contributions included the works of B.L Chong on sugarcane disease and Agnihotbrudy in tea disease, R.K Agrawala on apple disease and G.S. Saharan on oilseed plant disease to name a few.

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Definations and concepts:

1) Disease : A/C to horsfall and diamond (1956) disease may be defined as malfunctioning process that is caused by continuous irritation by a pathogen and /or environmental factor resulting in some suffering producing systems.

2) Disorder: The disease caused by the deficiency of nutrients or unfavourable environmental are sometimes termed as disorder or physiological disorders.

3) Pathogen: It is the agent responcible for inciting 'pathos' ie ailment or damage.

4) Parasite: These are the organisms which derive the food materials needed for their growth from other living organisms. All the pathogens are parasites but all the parasites are not pathogens. As some of the parasites live on their hosts without causing any damage to them as symbiotic relationships. eg Rhizobium bacterium in legume roots, mycorrhizae and lichens.

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5) Biotrophs :- Are the organisms which regardless of the ease which they can be cultivated on artificial media obtain their food from living tissues only in which they complete their life cycle). They were earlier also called obligate parasites. eg. rusts, smuts, powdery mode of nutrition. mildews etc.

6) Saprophytes / saprobes. - are the organisms which derive their nutrition from the dead organic matter. Some parasites and saprophytes may have the faculty or (ability) to change their mode of nutrition.

7) Facultative saprophytes: are ordinarily parasites which can grow and reproduce on dead organic matter under certain circumstances. They are also called hemibiotrophs which attack the living tissue in such a way as biotrophs but continue to grow and reproduce after the tissue dead.

8) Necrotroph: A parasite is called necrotroph when it kills the host tissue in advance of penetration and then lives saprophytically, eg. sclerotium rolfsii and pythium species

aggesiveness of pathogen is called as virulance.

Similar to necrotrophs are facultative parasites which lives as saprophytes but under favourable conditions they can attack living plants and become parasites. The necrotrophs are also known as perthotrophs or perthotophytes.

9) Pathogenicity is the ability of a pathogen to cause disease under a given set of environmental cond^{n}.

10) Pathogenesis is the chain of events that leads to development of a disease in the host.

11) Parasitism is a phenomenon by which a plant parasite ~~because~~ becomes intimately associated with the plant; it draws nutrition and multiplies and grows at the expense of the plant host.

12) Virulence: It is a measure or degree of pathogenicity of an isolate or race of the pathogen. The term aggressiveness is often used to describe the capacity of a pathogen to invade & grow in the host plant and to reproduce on or in it.

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18) Immunity: Immunity of a plant against a disease is absolute quality. It denotes the freedom of plant from disease, when the pathogen cannot establish parasitic relationship with the host. High resistance and low suspectibility approach immunity.

14) Disease resistance: It is the ability of an organism to overcome completely or in some degree the effect of a pathogen or other damaging factor, whereas susceptibility in the inability of the plant to resist the effect of the pathogen or other damaging factor.

15) Hypersensitivity is the extreme degree of susceptibility in which there is rapid death of the cells in the vicinity of the invading pathogen. It halts the further progress of the pathogen. Thus hypersensitivity is a sign of very high resistance approaching immunity.

16) Infection: It is the establisment of the parasitic relationship between the pathogen and host following entry or penetration.

17) Incubation period: is the time elapsing between penetration and completion of infection ie development of the disease symptoms.

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Invasion and colonization : is the growth and multiplication of the pathogen through the tissue of the host varying extent.

Classification of Plant disease.

* Based on plant part affected.

1) Localised. → if they affected only specific organ or part of the plant.

2) Systemic :→ if entire plant is affected or They can be classified as root / diseases stem diseases / Foliage Foliar diseases etc

* Based on perpetuation and spread :→

1) soil borne: when the pathogen perpetuates through the agency of soil.

2) seed borne: when the pathogen perpetuates through seed (or any propagation materials)

3) Air borne: when they are disseminated by wind e.g. rusts and powdery mildews.

* Based on the signs and symptoms produced by the pathogens.

• Disease are classified as rust, smuts, powdery mildews, downey mildews root roots wilts, blights cankers, fewits rots, leaf spots, etc. In all these examples, the disease are named after the most conspicuous symptom of the disease appearing on the host surface.

* Based on the host plants affected.

They can be classified as cereal crop diseases, foeage crop diseases, flax diseases, millet diseases, plantation crop diseases, fruit crop diseases, vegetable crop disease, Floweering plant diseases etc.

* Based on major causes:

They can be classified as fungal disease, viral disease, mycoplasmal diseases etc.

* Based on Infection Process.

1) Infectious: All the diseases caused by animate causes, viruses and viroids can be transmitted from infected host plants to the healthy plants and are called infectious.

2) Non-infectious: Non-infectious disease can not be transmitted to a healthy plant. Also reffered as non-parasitic disorder or

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simply physiological disorder and are incited by abiotic or inanimate causes like nutrient difficiency or excess or unfavaurable weather conditions of soil and air or injurious mechanical influences.

* Classification of Animate disease in relation to theie occursance.

1) Endemic diseases: which are more or less constantly present from year to year in a moderate to severe form in a particular geographic region ie country, district or location.

2) Epidemic / epiphytotic disease: which occure widely but periodically particularly in a severe form. They might be occuring in a ~~locally~~ locality every year but assume severe form only on occassion due to the favourable environmental condn occuring in some years.

3) Sporadic disease: occure at irregular intervals and locations and in relatively few instances.

4) Pandemic diseases: A disease may be endemic in one region and epidemic in another when epiphytotics become peevalent through out a country continent or the world the disease may be termed as pandemic.

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