PLANT PATHOLOGY

(Introduction and classification of plant diseases based on pathogens. Symptoms, causal organism and Management)

1. **Koleroga (mahali/fruit rot)**

Koleroga is one of the major diseases of arecanut (*Areca catechu* L.). This occurs as an epidemic in the heavy rainfall areas of Karnataka and Kerala. The disease first makes its appearance after monsoon period. On severe symptoms leads to 70-90% of the yield loss.

Causal organism: *Phytophthora araceae* a fungus belongs to the of plant-damaging oomycetes (water molds).

Symptoms:

- The first symptom is the appearance of water-soaked dark green/yellowish lesions on the nut surface near the calyx.
- The patches enlarge and nuts darken and they shed in large number.
- The fallen nuts soon develop whitish mycelial mass all over. Nuts of all ages are attacked.
- Infected nuts are lighter in weight and possess large vacuoles
- As the disease advances the fruit stalks and the axis of the inflorescence rot and dry, sometimes being covered with white mycelial mats.

Inflorescence and seed of arecanut infected with *Phytophthora araceae*

Control measures:

- Spraying Bordeaux mixture (1%) twice a year, one just before the onset of South-West monsoon and another 40 days later. If monsoon is prolonged, give a third spray.
- Removal of all dried and infected bunch of last season attached to the palm for filed sanitisation.
- Remove the infected tissues from the crown and treat the wound/ cut end with 10% Bordeaux paste. Cover the treated bud with protective covering till the normal shoot emerges.

2. Late blight of Potato (Kone Angamari roga)

Late blight of potato is potentially devastating disease can infect potato foliage and tubers at any stage of crop development. The primary host is potato (*Solanum tuberosum* L.), but the pathogen also can infect other solanaceous plants, including tomatoes, petunias and hairy nightshade, that can act as source of inoculum to potato.

Causal organism: Late blight of potato caused by the fungus pathogen *Phytophthora infestans* belongs to the family of oomycetes. The first place to record this disease from Andes Mountain of South America and later on introduced to Europe and caused Irish Famine in Ireland in 1845-46. In India disease reported from Nilgiri hills between 1870-80.

Symptoms:

- The first symptoms of late blight in the field are small, light to dark green, circular to irregular-shaped water-soaked spots.
- These lesions usually appear first on the lower leaves. Lesions often begin to develop near the leaf tips or edges, where dew is retained the longest.
- During cool, moist weather, these lesions expand rapidly into large, dark brown or black lesions, often appearing greasy. Leaf lesions also frequently are surrounded by a yellow chlorotic halo.
- The lesions are not limited by leaf veins, and as new infections spread to entire leaves, petioles and stems of the plant.
- During active growth, especially in cool, wet weather, a white powder like appearance is visible at the edge of the lesions or along petioles. This is the area where the late blight pathogen actively is producing spores. As the weather changes to warm and dry, these lesions become dry, stop sporulating and become tan.
- A pale green to yellow border often surrounds the lesions. Severely infected fields often produce a distinct odour.
- Late blight infection of tubers is characterized by irregularly shaped, slightly depressed areas that can vary considerably from brown to purplish.
- Tuber lesions first appear as irregular, dark blotches. When cut open, affected tissue is water-soaked, reddish brown and extends with an irregular margin into the tuber flesh.
- Lesions may start as a superficial decay that continues to develop after tubers are harvested and placed into storage. Infected tubers are commonly invaded by secondary decay organisms such as soft-rot bacteria.

Light to dark green, circular to irregular-shaped water-soaked spots

Large, dark brown or black lesions, often appearing greasy

Surrounded by a yellow chlorotic halo

Later white mildew-appearing area is visible at the edge of the lesions

A white mildew-appearing area along petioles

Brown, dry lesions can develop following warm and dry weather

brown to purplish irregularly shaped, slightly depressed areas

reddish-brown rot found under the skin due to secondary rot

Stages of Late Blight disease in Potato

Control measures:

- Crop rotation is employed to avoid soil intrusion of conidia.
- Use a seed piece fungicide treatment labelled for control of late blight.
- *S. demissum* and *S. phureja* - used for breeding for disease resistant varieties.
- Regular spraying during growing season gives effective control- 10 to 15 days interval – Brestan 600g/ha – Zineb 0.2 % – Bordeaux mixture 1.0% – Mancozeb (2 kg/ha).
- Removal of all dried and infected branches and burnt in fire.
- Applying phosphorous acid to potatoes after harvest and before piling can prevent infection and the spread of late blight in storage.

3. Grain smut of Sorghum (Kernel smut / Covered smut / Short smut)

It is the devastating seed borne disease of Sorghum (*Sorghum bicolor*) commonly found in Southern India and causes about 80% of crop loss.

Causal organism: Grain smut of Sorghum is caused by *Sphacelotheca sorghi* and *S. cruenta* belongs to Basidiomycota.

Symptoms:

- The infected plants are shorter than the healthy plants with thinner stalks and marked tillering.
- The inflorescence come out much earlier than the healthier plants.
- The glumes are hypertrophied and the ear-head gives a loose appearance than healthy.
- The fungal mycelium convers entire tiller and covered with dark grey smut.
- The sorus is covered by a thin membrane which ruptures very early, exposing the spores even as the head emerges from the sheath.

Infected sorghum panicle

Control measures:

- Using of disease-free resistant cultivars (CJH-5, Nandyala, SC748-5).
- Crop rotation is employed to avoid soil born infection.
- Seed treatment with Corboxin @ 2g/kg of Seed.
- Collect smutted ear heads in cloth bags and dip in boiling water to remove inoculum.
- Spraying fungicide such as Bavistin @ 1g/kg of seed.
- Treating seeds with 5% $CuSO_4$ or 3% formalin before 3-10 min before sowing.

4. Blast disease of Rice (Benki roga)

It is the major staple food in Asia. Rice is the third highest agricultural commodity in worldwide production. Blast disease is one of the most severe diseases affecting paddy which is more severe in areas with high humidity and rainfall. Losses due to the disease may be up to 90% of the total corp.

Causal organism: Blast disease of rice caused by *Magnaporthe grisea* belongs to division ascomycota. The pathogen produces two toxins namely Pyricularin and Picolinic acid which inhibit the growth of the plant.

Spindle shaped spots with grey/ white central part with brownish border.

Shrivelled culms

Drooped panicle

Symptoms:

- The blast is a foliage disease. The symptoms also occur in other plant parts. Leaf blade, leaf sheath, petiole, rachis, stem etc. are affected by the disease.
- Brownish lesion and spots are formed on leaf blade, leaf sheath, culms and panicles.
- The spots are spindle-shaped with grey or white central part and brownish or reddish borders.
- Brown to black spots or rings is formed on the rachis of the mature inflorescence.
- Small brown or black spots on ear heads.
- Shrivelled culms in severe cases, were covered with fluffy mycelium of the pathogen.
- If the infection occurred before the grain formation, panicles droops and no grain formation.
- If the infection occurred after grain formation, the grains become small, whitish and chaffy.
- In advanced stages of the disease, necrotic rotting of neck and falling of the ears occurs.
- Plants become stunted and untimely leads to the complete death of the plant.

Control measures

- Foliar spray of fungicides is effective
- Application of Bordeaux mixture is also employed.
- Organo-meruric fungicides such as Hinosan and Blitox are also used.
- Spraying on the seeds, seedbed, tillers, and neck emerging state is done.
- Antibiotics such as Blastin and Blasticidin application are found to be effective.
- Seed treatment with organo-mercuric compounds reduces the fungal spore load on the surface of seeds.
- Field sanitation practice (removal of infected plants) can reduce the secondary spread of the disease.
- Destruction of alternate hosts in the field can be practiced.
- Use of resistant varieties is the best method to avoid the occurrence of the disease.

5. Red rot of sugar cane

Red rot of sugar cane is one of the most severe of the known diseases of sugarcane. It is widely distributed throughout the sugar-cane-growing countries of the world, and in fact it is extremely doubtful if there are any sugarcane-growing areas.

Causal organism: Red rot of sugar cane caused by *Colletotrichum falcatum* belongs to division ascomycota.

Red rot infected leaf

Reddish coloured spots of sugarcane stem

Symptoms:

- The first external evidences of disease are the drooping, withering, and finally yellowing of the upper leaves.
- The further symptoms followed by a similar wilting of the entire crown and finally the entire plant shows indications of disease and dies.
- The symptoms in moderate conditions, the eyes frequently die and blacken and the dead areas extend out from the nodes.
- Infection in the stem being internal, the presence of the disease is not visible externally. Upon splitting a diseased cane during the early stages of the disease, it will be found that the fibro-vascular bundles near the base are reddish in colour.
- The internal colour becomes brown, pith cavity become larger, greyish hyphae inside pith become visible. A sour and alcoholic smell emanates from the infected tissues.

Control measures:

Red rot is often referred as cancer of sugarcane and no effective method for its control is available yet. However, the diseases can be managed by adopting integrated red rot management practices.

- Cultivation of resistant varieties like Co 89003, Co 98014, Co 0118, Co 0238, Co 0239, Co 0124, etc can tolerate the disease.
- The disease spread through infected setts. Therefore, always select seed canes from a disease-free healthy crop. Any setts showing reddening at the cut ends or at the nodal region should be discarded.
- Raise seed crop from the seed canes treated in moist hot aerated therapy unit at 54°C for 1 hour or soak the setts overnight in Thiophanate Methyl (ROKO)+Pseudomonas.
- During rainy season, the disease spreads fast. Bunding of affected field may be done to avoid movement of pathogen through rain or floodwater.
- Roguing of diseased plants showing spindle leaf infection early during May-June and disinfecting soil around the diseased clumps with 0.1% Carbendazim solution.

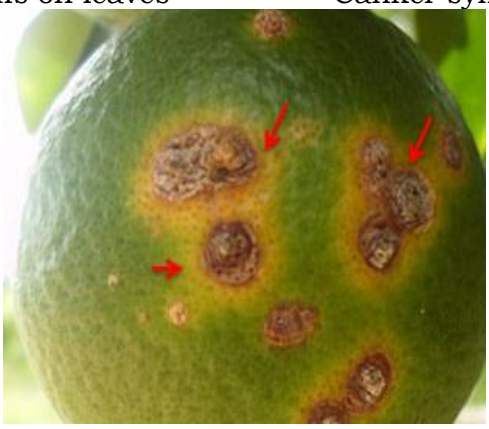
6. Citrus canker

Citrus canker is a bacterial disease, wide-spread in all the citrus growing areas. It is one of the major disease affecting citrus plants in India, China and Japan.

Causal Organism: Citrus canker is a bacterial disease caused by *Xanthomonas axonopodis* is a rod-shaped Gram-negative aerobic bacterium.

Canker symptoms on leaves

Canker symptoms on fruit



Corky spots on fruit rind with yellow halo

Symptoms:

- The canker occurs on leaves, twigs, branches and fruits.
- The lesions first appear on leaves.
- The spots first develop on the lower surface of the leaf.
- In the beginning; the lesions will be small, round and watery.
- The spots later raised and become yellowish brown.
- As the disease advances, the spot becomes white or greyish and finally ruptures.
- The spots become rough and dark black corky.
- In an advanced stage, small pots coalesce to large spots.
- Lesions are often surrounded by a yellow halo.
- The spotting in the petiole cause premature defoliation.
- Symptoms will be more prominent in young plant parts.
- Fruits also develop canker which is similar to that on leaves.
- Usually, the yellow halo is absent in fruit cancer.

- Only the fruit rind is affected (the pulp of the fruit is not affected).
- Due to the formation of corky spots on the fruits, the market value of the fruits drops.

Control measures:

Complete elimination of canker is not possible in most of the cases.

- The burning of infected plants or plant parts is done to prevent the spread of the disease.
- The use of disease-free stocks is the best method to control the disease.
- Use of resistant varieties can be done.
- Spraying plants with 1% Bordeaux mixture are found be effective.
- Control of insects using insecticides or bio-control.

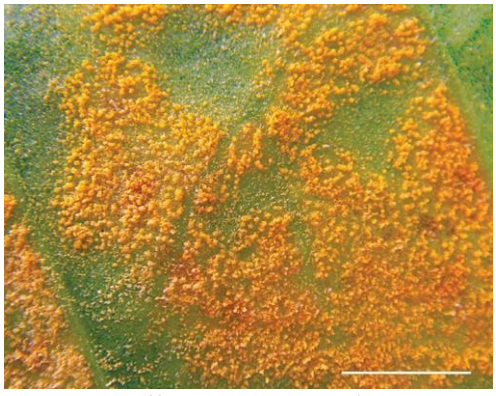
7. Coffee rust disease

Coffee rust, also called coffee leaf rust, devastating foliar disease of coffee plants. The spores of coffee rust are spread by wind or rain, and will only germinate when exposed to one to two days of continuous wetness. Coffee leaf rust infestation on a farm causes up to 50% leaf loss and up to 70% berry loss.

Causal Organism: Coffee rust disease caused by caused by fungus *Hemileia vastatrix* belongs to the phylum Basidiomycota.

Defoliation caused by severe infection

Infected coffee leaf



Coffee rust pustules

Symptoms:

- Small, pale yellow spots on upper leaf surfaces followed by powdery orange-yellow lesions on the undersides of leaves.
- Symptoms commonly develop on lower leaves of plant first and then spread.
- The rust pustules are powdery and orange-yellow on the under-leaf surface. Later the pustules turn black.
- Infected leaves drop from the plant and twigs and branches become defoliated.
- Rusted leaves drop so that affected trees are virtually bared; such trees have significantly lower coffee yields and usually die within a few years.

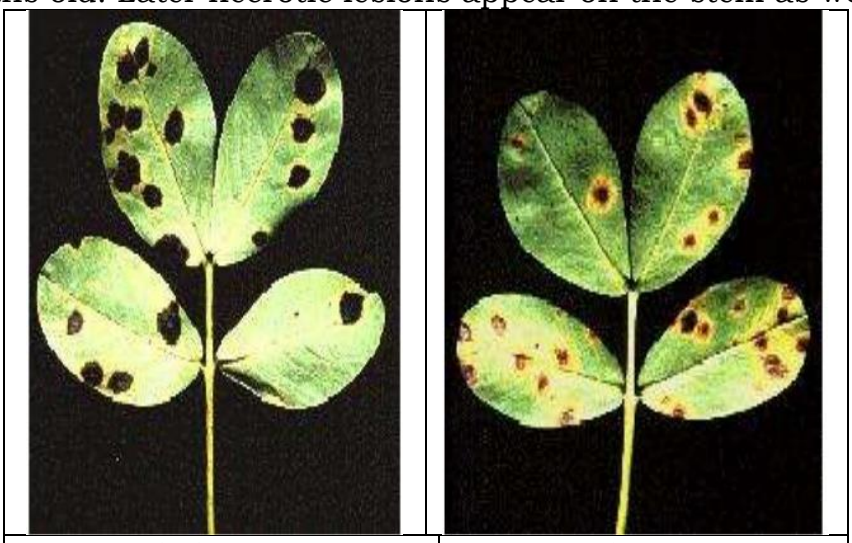
Control measures:

- Coffee rust can be partially controlled by the timely application of fungicide sprays during wet seasons.
- Growing of disease resistance cultivars.
- Removing and destroying of old and infected branches.
- Copper-containing fungicides remain one of the most effective and economical methods of controlling the rust pathogen.
- Treating the seeds with Bacillus and Pseudomonas cultures before sowing are known to produce compounds that negatively affect fungal pathogens.

8. Tikka disease

One of the best-known leaf spot diseases is that of *Arachis hypogea* L. (groundnut). Popularly it is called the tikka disease. The tikka disease is a serious disease occurring in areas where the groundnut crop is grown in India.

The spots appear on the host leaves when the plants are one or two months old. Later necrotic lesions appear on the stem as well.



Early leaf spots | Late leaf spots

Causal Organism: There are two leaf spot diseases of groundnut caused by two different species of form genus namely, *Cercospora arachidicola* and *C personata*.
Cercospora personata possesses mycelium which is entirely internal and ramifies intercellularly by developing haustoria in the palisade and spongy mesophyll cells of the host. The mycelium forms dense stroma which produces long septate to non- septate geniculate hypophyllous conidiophores.
Cerospora arachidicola has both internal and external, intera- and intercellular mycelium without haustoria. The mycelium produces scanty stroma.

Symptoms of Tikka Disease:

- **Early** and **late** leaf spots are the most common and the serious diseases of the groundnut together can cause yield loss up to 50%.
- Leaf spots can damage the plant growth and yield by reducing the available photosynthetic area and by stimulating leaflet abscission.
- **Early leaf spots** caused by ***C. archidocola*** leaf spots usually appears on the **upper surface** of matured leaves as a **brown** and **black** pin point dots. As the dots enlarge and become brown or dark brown circular spots a yellow hallow borders will appears on the outer surface of the dark brown spots.
- This disease symptoms frequently seen in the growing stages of groundnut.
- Spots in irregular shapes also may appear on the leaf petiole and plant stem which can lead to the defoliation and reduce the yield on the infected the plants.
- Leaves that falls on to the soil surface may trigger epidemics of certain soilborne diseases such as southern stem rot.
- **Late leaf spot caused** by ***C. personata*** infects on the **lower surface** of the groundnut also causes leaf defoliation in turn reduce the yield and increase the incidence of soil borne disease. As the name suggests that late leaf spot is most prevalent during the late part of the growing season.
- Lesions caused by the ***C. personata*** are usually smaller and commonly they show no yellow hallow they are more nearly circular and darker in color than that of ***C. archidocola***.

Control Measures of Tikka Disease:

- Rotation of crops, seed treatment and disposal of infected host debris by burning or burying in deep pits eliminate chances of primary infection from the soil borne inoculum. The seeds within the shells are disinfected with sulphuric acid.

- Without shells, they are soaked for half an hour in 0.5% copper sulphate solution. Agrosan GN dressing of naked seeds is equally effective.
- To check secondary spread of disease in the field, spraying with suitable fungicides is the only remedy. Among the fungicides the use of Bordeaux mixture has given good results.
- Daconil and Benlate are the two more effective fungicides than Dithane M45 for pea nut leaf spot disease control.

Biopesticides

Bio-pesticides are those biological agents that are used for control of weeds, insects and pathogens.

The micro-organisms used as bio-pesticides are viruses, bacteria, protozoa, fungi and mites. Some of the bio-pesticides are being used on a commercial scale.

Bio-pesticides are of two types: bio-herbicides and bio-insecticides.

a) **Bio-herbicides:** Herbicides are chemicals that are used for inhibiting the growth of plants in unwanted places. Herbicides used for controlling weeds in the cultivated areas are called weedicides.
   Certain crop plants do not allow the weeds to grow nearby. They are called smoother crops, e.g., Barley, Rye, Sorghum, Millet, Sweet clover, Alfalfa, Soybean, Sunflower.
   An organism which controls or destroys unwanted plant growth without harming the useful plant is called bioherbicide. The herbicide is *Phytophthora palmivora*. The fungus does not allow the Milkweed Vine to grow in Citrus orchards. Growth of *Eichhornia crassipes* (Water Hyacinth) is being controlled by *Cercospora rodmanii* in USA and *Alternaria eichhorniae* in India.
b) **Bio-insecticides:** Bio-insecticides are those biological agents that are used to control harmful insects. They include the following.
   - **Predators:** Destructive insects or plant pests can be brought under control through introduction of their natural predators.
   - **Parasites and Pathogens:** This is alternate biological control of plant pests through the search of their natural parasites and pathogens. They include viruses, bacteria, fungi and insect parasitoids.
   - **Natural Insecticides:** They are insecticides and related pesticides which are ob-tained from microbes and plants. A number of natural insecticides are available. The common ones include (i) Azadirachtin from Neem (*Azadirachta indica*).

- **Neem as biopesticide**

  In India Neem tree used as biopesticide form ancient time. Neem leaves were inserted in to the containers containing seeds, grains, cereals and millets to check the invasion of many insects.

  Advantages of neem as biopesticide

  - Wide spectrum control
  - Bio-degradable – very rapid
  - More than 200 pests controlled (Lepidoptera, Homoptera, Thysanoptera, Hymenoptera, Diptera, Coleoptera).
  - Rapid action at very low dozes
  - Very less mammalian toxicity.
  - Neem leaf not only controls pest but also Nematode, Virus and Fungus.

  Phytochemicals in neem: Phytochemicals possess bio-pesticidal properties in the neem plants are Azadirachtin, Nimbidin, Salannin and Meliantriol.

  Mode of action: Mode of action of pesticides biochemical in neem are many ways depending upon the type of insect they are, disrupting or inhibiting the development of eggs, larvae or pupae; Blocking the molting of larvae or nymphs; Disrupting mating and sexual communication; Repelling larvae and adults; Deterring females from laying eggs; Sterilizing adults; Poisoning larvae and adults; Deterring feeding; Blocking the ability to "swallow" (that is, reducing the motility of the gut); Sending metamorphosis awry at various stages; Inhibiting the formation of chitin.

- **Trichoderma as biopesticide**

  Trichoderma is a genus of fungi in the family Hypocreaceae, that is present in all soils, where they are the most prevalent culturable fungi. Many species in this genus can be characterized as opportunistic avirulent plant symbionts.

  Fungal genus Trichoderma is the most widely used biocontrol agent in the world with success against soil borne diseases, seed borne diseases, diseases in the phyllosphere and against storage rots. Trichoderma is considered as most efficient biocontrol agent and have attracted considerable scientific attention as they are considered as promising alternative to chemical fungicides against many plant pathogens.

  Mode of action: The various mechanisms include antibiosis, parasitism, inducing host-plant resistance, and competition. Most biocontrol agents are from the species *T. asperellum, T. harzianum*, *T. viride* and *T. hamatum*. The biocontrol agent generally grows in its natural habitat on the root surface, and so affects root disease in

particular, but can also be effective against foliar diseases. Major mechanisms involved in the biocontrol activity of Trichoderma spp. are competition for space and nutrients, production of diffusible and/ or volatile antibiotics and hydrolytic enzymes like chitinase and β-1,3-glucanase. These hydrolytic enzymes partially degrade the pathogen cell wall and leads to its parasitization.