

Crop Diseases and Their Management

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Chapter - 1

Disease of Rice and Sorghum

Disease of Rice

- Rice is a major staple food crop in South East Asia.
- It is affected by both biotic and Abiotic factors.
- Biotic-Fungal, Bacterial, Viral, Phytoplasma and Nematode.
- Abiotic-Khaira (Zinc deficiency).

Fungal Diseases of Rice

1. Rice Blast

Causal Organism-*Pyricularia oryzae* (Asexual Stage)

***Magnaporthe grisea* (Sexual Stage)**

Magnaporthe grisea, also known as rice blast fungus, rice rotten neck, rice seedling blight, blast of rice, oval leaf spot of graminea, pitting disease, ryegrass blast, and Johnson spot, is a plant-pathogenic fungus that causes a serious disease affecting rice.

Symptoms

It may infect young seedlings, leaves, panicles and other aerial parts of the adult plant. It is also known as leaf blast, node blast, panicle blast, or neck rot.

Leaf Blast

Leaf spots are of spindle-shaped with brown or reddish-brown margins, ashy centers, and pointed ends. Fully developed lesions normally measures 1.0-1.5 cm in length and 0.3-0.5cm in breadth. Their characteristics vary with the age, susceptibility level of the cultivar and environmental factors.

Node Blast

Nodes are infected; they become black and break off.

Neck Blast

Neck regions of panicles develop a black color and shrivel completely or partially grain set inhibited, Panicle breaks at the neck Infection of panicle base causes rotten neck or neck rot and causes the panicle to fall off.

Grain Blast

Mode of Spread

Primary source Collateral host-weeds-*Panicum ripens*, *Digitaria marginata*).

Secondary source (Air borne Conidia).

Environmental Conditions

- Temp-night-20 degree C
- Day temp-30 degree C
- Day length-14hrs
- Darkness-10hrs
- RH-92%
- Presence of drops on the leaves-germination of conidia
- Susceptible crop

It occurs in areas with low soil moisture, frequent and prolonged periods of rain shower, and cool temperature in the daytime. In upland rice, large day-night temperature differences that cause dew formation on leaves and overall cooler temperatures favor the development of the disease.

Management

- Growing of resistant variety like CO 25, IR 20, IR8, ADT 25 and CO 3.
- Avoid growing of susceptible variety such as IR 50, ADT 42, and TKM 9.
- Use of disease free seeds.
- Seed treatment with carbendazim 2g/kg or *Pseudomonas fluorescens* 10g/kg.
- Heavy application of organic manure-to improve the plant health.
- Split application of Nitrogenous fertilizers.

Foliar Spray with Chemicals

Systemic - Carbendazim 0.1% (Bavistin)

Iprobenphos 0.1% (Kitazin)

Blasticidin-200ppm

Non Systemic - Edifenphos (hinosan) 0.1%

Biocontrol - 0.25% *P. fluorescens*

2. Brown Spot of Rice

Causal Organism - *Helminthosporium oryzae* (Asexual stage)

Cochliobolus miyabeanus (Sexual stage)

Symptom

Brown leaf spot occurs in all rice-growing areas and was responsible for the Bengal famine in 1942. It causes seedling blight symptom in nursery. Uses of infected seeds then it produce the complete blight of young seedling.

Mature Plant

- Spots are mostly isolated at severe conditions these spots are collapsed.
- The disease attacks the crop from the seedling stage in the nursery to the milk stage in the field. Spots vary in shape and size and appear on the coleoptiles of the leaves, leaf sheath, and glumes. On the coleoptiles, the spots may be brown, small, and circular or oval. These Leaf spot will be brown to oval shaped look like sesame seeds so it is called as sesame leaf spot. Sometimes spots are surrounded by yellowish halos, and they may coalesce.
- Neck region-which leads to grey brown or brown in neck portion with less weakened and neck never break.
- Grains also infected and it shows black to dark brown color spot on the glumes.

Mode of Spread

Primary source (Collateral host-weeds)

Secondary source (Air borne Conidia)

Favorable Conditions

1. Temperature-25 to 30 degree C
2. Relative Humidity-90%
3. Drizzling-flowering stages of crop
4. Cloudy weather darkness-spread of the fungus

For infection to occur, the leaves must be wet for 8-24 hours. The fungus can survive in the seed for more than four years. It can spread from plant to plant through air. Major sources of brown spot in the field include:

- Infected seed, which give rise to infected seedling
- Volunteer rice
- Infected rice debris
- Weeds

Management

- Growing of resistant variety-CO 24, IR 24, Padma.
- Use of disease free healthy seeds.
- Seed treatment with Jensen hot water treatment at 50 to 54 degree C for 10 mins.
- Heavy application of organic manure-to improve the plant health.
- Split application of Nitrogenous fertilizers.
- Foliar spray with chemicals

Non systemic-Edifenphos (hinosan) 0.1%, Mancozeb 0.25%

Two fungal antibiotics

1. Griseofulvin 25mg/litre
2. Sulphanilamide 25mg/litre

Neem oil 60 EC 3% (or) NSKE 5% is recommended for the control of sheath rot, sheath blight, grain discoloration and bacterial blight.

3. Sheath Blight

Causal Organism-*Rhizoctonia solani* (Sclerotial Stage)

***Thanatephorus cucumeris* (Basidial Stage)**

Symptom

- Susceptible stage is tillering stage.
- Sheath blight disease usually appears in the later growth stages of the plant.
- Initial symptoms usually develop as lesions on sheaths of lower leaves near the water line when plants are in the late tillering or early internodes elongation stage (approximately 10-15 days after flooding) varies from place to place.
- These lesions usually develop just below the leaf collar as oval-to-elliptical, green-gray, water-soaked spots.
- Sclerotia, initially white turning dark brown at maturity, are

produced superficially on or near the lesions. Sclerotia are loosely attached and easily dislodge from the plant.

Mode of Spread

- Primary source (Sclerotia in soil)
- Secondary source (Basidiospores)

Environmental Favorable Conditions

Sheath blight occurs in areas with high temperature (28-32 °C), high levels of nitrogen fertilizer, and relative humidity of crop canopy from 85-100%. Plants are more vulnerable to sheath blight during the rainy season.

- Temp-20 to 30 degree C
- Relative Humidity-95%
- Closer planting
- Water logged conditions

Management

- Growing of resistant variety.
- Use of disease free healthy seeds.
- Seed treatment-*P. florescence* 10g/kg of seeds.
- Heavy application of organic manure-to improve the plant health.
- Carefully control of weeds, especially on the leaves.
- Split application of Nitrogenous fertilizers.
- Avoid water logged conditions.
- Foliar spray with chemicals.

Non systemic-Kitazin 0.1%, Tilt.

4. Sheath rot-*Sarocladium oryzae*

Symptoms

- Symptoms are most severe on the uppermost leaf sheaths that enclose the young panicle during the boot stage. Lesions are oblong or irregular oval spots with gray or light-brown centers and a dark reddish-brown, diffuse margin, or the lesions may form an irregular target pattern.
- The lesion is usually expressed as a reddish-brown discoloration of the flag-leaf sheath.

- The unmerged portion of the panicle rots, turning florets red-brown to dark brown. Grains from damaged panicles are discolored reddish-brown to dark brown and may not fill.
- A powdery white growth consisting of spores and hyphae of the pathogen may be observed on the inside of affected sheaths. Insect or mite damage to the boot or leaf sheaths increases the damage from this disease.

Environmental Favorable Conditions

- Temp-20 to 30 degree C
- Relative Humidity-60-80%
- Flowering stage
- Stem borer-Predisposing factor heavily to the sheath rot infection
- Rice mealy bug

Mode of Spread

- Primary source (Spread through seeds).
- Secondary source (Soil borne infection).

Management

- Growing of resistant varieties like Te-tep, ARC-7117.
- Avoid the cultivation of susceptible variety-NOVA 66, blue belly.
- In India CO 43 and hybrid rice are highly susceptible variety should be avoided.
- Use of disease free healthy seeds.
- Apply Gypsum @ 500 kg/ha at two equal splits once basally and another at active tillering stage.
- Heavy application of organic manure-to improve the plant health.
- Split application of Nitrogenous fertilizers.
- Avoid water logged conditions.
- Neem oil 3%.
- Foliar spray with chemicals: Carbendazim @ 500g/ha, Metominostrobin @ 500 ml/ha, Hexaconazole 75% WG @ 100 mg/lit 1st spray at the time of disease appearance and 2nd spray 15 days later.

5. Foot Rot or Bakanae Disease-*Fusarium moniliforme*

(*Gibberella fujikuroi*-Sexual Stage)

Symptoms

Infected seedlings in nursery are lean and lanky, much taller and die after some time. In the main field, the affected plants have tall lanky tillers with longer internodes and aerial adventitious roots from the nodes above ground level. The root system is fibrous and bushy. The plants are killed before ear head formation or they produce only sterile spikelet. When the Culm is split open white mycelial growth can be seen.

Environmental Favorable Conditions

- Temp-25 to 35 degree C
- Application of nitrogenous fertilizer
- Wet nursery

Mode of Spread

- Primary source (Externally seed borne)
- Secondary source (Air borne conidia)

Management

- Growing of resistant variety like CO 18, ADT 80 and CO 22.
- Avoid growing of susceptible variety CO 10.
- Use of disease free seeds.
- Seed treatment with carbendazim 2g/kg or 1% copper sulphate or 2% Formalin.
- Heavy application of organic manure-to improve the plant health.
- Split application of Nitrogenous fertilizers.

6. False Smut: *Ustilaginoidea virens*

Symptoms

- Only few grains in a panicle are usually infected and the rest are normal.
- Individual rice grain transformed into a mass of yellow fruiting bodies.
- Growth of velvety spores that enclose floral parts.
- Immature spores slightly flattened, smooth, yellow, and covered by a membrane.

- Growth of spores result to broken membrane.
- Mature spores orange and turn yellowish green or greenish black.

Environmental Favorable Conditions

- Relative humidity with cloudy weather during flowering to maturity stage.

Mode of Spread

- Primary source (Spores present on the collateral host and sclerotia produced ascospores for initiate the disease)
- Secondary source (Chlamydospores)

Management

- Seed disinfection can be done with cupper oxy chloride (0.1%).
- Foliar spray with cupper oxy chloride (0.25%) at flowering to maturity (2 sprays).
- Removal of collateral host.

7. Grain discolouration

- *Drechslera oryzae*, *D. rostratum*
- *D. tetramera*, *Curvularia lunata*
- *Trichoconis padwickii*, *Sarocladium oryzae*
- *Alternaria tenuis*
- *Fusarium moniliforme*, *Cladosporium herbarum*
- *Epicoccum purpurascens*
- *Cephalosporium* sp., *Phoma* sp., *Nigrospora* sp.

Symptoms

The grains may be infected by various organisms before or after harvesting causing discoloration, the extent of which varies according to season and locality. The infection may be external or internal causing discoloration of the glumes or kernels or both. Dark brown or black spots appear on the grains.

The discoloration may be red, yellow, orange, pink or black, depending upon the organism involved and the degree of infection. This disease is responsible for quantitative and qualitative losses of grains.

Favourable Conditions

- High humidity and cloudy weather during heading stage.

Management

- Pre and post-harvest measures should be taken into account for prevention of grain discoloration.
- Spray the crop at boot leaf stage and at 50% flowering with Carbendazim + Mancozeb (1:1) @ 0.2%.
- Store the grains with 13.5-14% moisture content.

Bacterial Diseases

1. Bacterial Leaf Blight-*Xanthomonas oryzae* pv. *oryzae*

Symptoms

- Seedlings in the nursery show circular, yellow spots in the margin that enlarge, coalesce leading to drying of foliage. “Kressek” symptom is seen in seedlings, 1-2 weeks after transplanting.
- The bacteria enter through the cut wounds in the leaf tips, become systemic and cause death of entire seedling.
- In grown up plants water soaked, translucent lesions appear near the leaf margin. The lesions enlarge both in length and width with a wavy margin and turn straw yellow within a few days, covering the entire leaf.
- As the disease advances, the lesions cover the entire lamina which turns white or straw coloured.
- If the cut end of leaf is dipped in water, it becomes turbid because of bacterial ooze.

Favorable Conditions

- Clipping of tip of the seedling at the time of transplanting.
- Heavy rain, heavy dew, flooding, deep irrigation water.
- Severe wind and temperature of 25-30 C.
- Application of excessive nitrogen, especially late top dressing.

Management

- Burn the stubbles.
- Avoid growing of susceptible variety TN-1.

- Tolerant variety TKM 6 and IR 42.
- Use optimum dose of fertilizers.
- Avoid clipping of tip of seedling at the time of transplanting.
- Avoid flooded conditions. Remove weed hosts.
- Grow resistant cultivars IR 20 and TKM 6.
- Spray Streptomycin sulphate and tetracycline combination 300g + Copper oxychloride 1.25 Kg/ha.
- Seed disinfection with Agrimycin 250ppm (0.025%) for 8 hrs.
- Wet table cerason @ 0.05% followed by hot water treatment 50 to 54 degree C for 10 mins.
- Foliar-COC, Cupper hydroxide 0.25% with streptomycin 250ppm.
- Application of Bacteriophages-multiply on the lab. Then mixed with irrigation channel.
- Spray fresh cow dung extract 20% twice (starting from initial appearance of the disease and another at fortnightly interval).
- Neem oil 60 EC 3% (or) NSKE 5% is recommended for the control of sheath rot, sheath blight, grain discoloration and bacterial blight

2. **Bacterial leaf streak-*Xanthomonas oryzae pv. oryzicola*** **Symptoms**

Fine translucent streaks are formed on the veins and the lesions enlarge lengthwise and infect larger veins and turn brown. On the surface of the lesions, bacterial ooze out comes form small yellow band-like exudates under humid conditions. In severe cases the leaves dry up.

Management

- Burn the stubbles.
- Use optimum dose of fertilizers.
- Avoid clipping of tip of seedling at the time of transplanting.
- Avoid flooded conditions.
- Remove weed hosts. Grow resistant cultivars IR 20 and TKM 6.
- Spray Streptomycin sulphate and tetracycline combination 300g + Copper oxychloride 1.25 Kg/ha.
- Biological Method-Spray fresh cow dung water extract 20%.
- Copper hydroxide 77 wp@1.25 kg/ha is also recommended.

Virus Disease

3. Rice Tungro Disease (RTD)-*Rice tungro bacilliform virus* (RTBV) and *Rice tungro spherical virus* (RTSV)-Vector Name Green Leaf Hopper-*Nephotettix virescens*

Symptoms: Infection occurs both in the nursery and main field. Plants are markedly stunted. Leaves show yellow to orange discoloration and interveinal chlorosis. Tillering is reduced with poor root system. Panicles not formed in very early infection, if formed, remain small with few, deformed and chaffy grains.

Management

- Grow disease tolerant cultivars like Pankhari203, BM66, BM68, Latisail, Ambemohar102, Kamod253, IR50 and Co45.
- Control the vectors in the nursery by application of Carbofuran 170 g/cent 10 days after sowing to control hoppers.

Physical Method

- Light traps are to be set up to attract and control the leaf hopper vectors as well as to monitor the population.
- Field sanitation, removal of weed hosts of the virus and vectors.
- In the early morning, the population of leafhopper alighting near the light trap should be killed by spraying/dusting the insecticides. This should be practiced every day.
- Spray Phosphamidon 500 ml or Monocrotophos 1lit/ha (2 ml/litre) or Neem oil 3% or NSKE 5% to control the vector in the main field 15 and 30 days after transplanting.
- Set up light traps to monitor the vector population.

Spray Two Rounds of any one of the following Insecticides

- Thiamethoxam 25 WDG 100g/ha
- Imidacloprid 17.8SL 100ml/ha at 15 and 30 days after transplanting. The vegetation on the bunds should also be sprayed with the insecticides

Abiotic Disorder-Zinc Deficiency (Khaira Disease)

Symptom

Usually in nursery-It produces chlorotic or yellow patches at leaf base on both sides of the midrib, restricted root growth and usually main roots turn brown.

Management

- Grow Zn-efficient varieties. Contact your local agriculture office for an up-to-date list of available varieties.
- Use fertilizers that generate acidity (e.g., replace some urea with ammonium sulfate).
- Apply organic manure before seeding or transplanting or applied to the nursery seedbed a few days before transplanting.
- Allow permanently flooded fields (e.g., where three crops per year are grown) to drain and dry out periodically.
- Monitor irrigation water quality.

Where possible: Broadcast $ZnSO_4$ in nursery seedbed and Dip seedlings or presoak seeds in a 2-4% ZnO suspension (e.g., 20-40 g ZnO L⁻¹ H₂O)/.

Diseases of Sorghum

Fungal Diseases

1. Downy Mildew-*Peronosclerospora sorghi*

Symptom

- Downy mildew Symptom-Whitish downy growth appears on the undersurface of the leaves. Corresponding upper surface it produce yellow discoloration was seen.
- Leaf shredding-Leaf shredding as the infected washed-out leaves mature they become necrotic and the interveinal tissues disintegrate to give the typical shredded leaf symptom.

Environmental Favorable Conditions

- Optimum Temperature-20 degree C.
- Relative humidity-more than 75%.
 - Cloudy weather.
 - Drizzling and intermittent rainfall.

Mode of Spread

- Primary source-soil borne oospores.
- Secondary source-Air borne sporangia.

Management

- Deep summer ploughing.
- Growing of resistant variety like CSV5, CSV 6.
- Avoid growing of susceptible variety DMS 652.
- The eradication of wild hosts near sorghum fields.
- Removal of infected sorghum plants in the field.
- Destruction of plant debris by deep ploughing and other methods.
- Growing resistant varieties and hybrids like etc.
- Seed treatment with Apron at 4 to 6 g/kg of seed or with Metalaxyl MZ @ 6 g/kg seed before sowing of sorghum.
- Foliar spray of Ridomil 0.1% or Metalaxyl MZ at 2g/liter is recommended if standing crop is infested with downy mildew.

2. Rust-*Puccinia purpurea*

Symptom: Young plants are rarely affected by rust. The typical symptoms are seen in 1.5 to 3 months old plants. Scattered purple, red, or tan flecks appear on both surfaces of leaves.

- **Rust Affected with Leaf:** Susceptible cultivars typical rust pustules develop, mainly on the lower leaf surfaces. In highly susceptible cultivars the pustules occur so densely that almost the entire leaf tissue is destroyed.
- **Pustules on Inflorescence Stalks:** The pustules may also occur on leaf sheaths and on inflorescence stalks.

Environmental Favorable Conditions

- Optimum Temperature-10-12 degree C.
- Rainy weather.
- Presence of free water.

Mode of Spread

- Primary source-Aeciospores from *oxalis* sp.
- Secondary source-Uredospores from sorghum.

Management

- Growing of resistant cultivars like PSH 1, SPH 837, CSV 17 etc. is the only solution.
- Destruction of alternate host.

- Selective fungicides that suppress the disease are usually not economical.
- Application of sulfur dust @ 25kg/ha.

3. Red Leaf Spot or Anthracnose-*Colletotrichum graminicolum*

Symptom

- Typical symptoms are small, circular, elliptical, or elongated spots appear on the surface of the leaf.
- In its severe form, anthracnose causes premature defoliation, thus reducing growth and delaying development of plants or even premature death of plants.

Environmental Favorable Conditions

- Optimum Temperature-28 to 30 degree C.
- Relative humidity more than 80%.
- Continuous rain.

Mode of Spread

- Primary source-seed borne infection and fungal spores present in the infected plant debris.
- Secondary source-Air borne conidia produced from acervuli.

Management

- Clean cultivation, elimination of weed hosts, removal of crop residues will help in controlling this disease.
- A two year crop rotation with crops other than sorghum.
- Growing resistant cultivars like SPV 462, CSV 17 etc.
- Seed treatment with captan or thiram 4g/kg of seeds.
- Foliar spray with Mancozeb @ 0.25%.

4. Leaf Blight-*Exserohilum turcicum*

Symptom

- Leaf blight is widespread in many humid areas where sorghum is grown. It produces rectangular or oval shape with brown colour spots is produced.
- If leaf blight is established on susceptible cultivars before ear head emergence, grain yield losses may be up to 50%.

- If infection is moderate or delayed until after the formation of the flower head (inflorescence), yield losses are minimal.

Environmental Favorable Conditions

- Cool moist weather.
- Relative humidity more than 90%.
- High rainfall.

Mode of Spread

- Primary source-Seed borne conidia.
- Secondary source-Air borne conidia.

Management

- Clean cultivation, elimination of weed hosts, removal of crop residues will help in controlling this disease.
- Use disease free seeds.
- A two year crop rotation with crops other than sorghum.
- Growing resistant cultivars like SPV 462, CSV 17 etc.
- Seed treatment with captan or thiram 4g/kg of seeds.
- Foliar spray with Mancozeb @ 0.25% at 40days.

5. Charcoal Rot-*Rhizoctonia bataticola* and *Macrophomina phaseolina*

Symptom

- Charcoal rot is a major disease in the dry sorghum-growing regions.
- The charcoal rot fungus infects roots of plants growing under adverse environmental conditions, particularly moisture stress or dry soil moisture during flowering phase and high temperature.
- Infected roots show water-soaked lesions that turn brown or black.
- Affected stalks are soft or spongy at the base and tend to lodge. Lodging is the most apparent symptom of charcoal rot.
- In general, charcoal rot becomes prominent near crop maturity. In some fields, particularly of hybrid sorghums, more than 50% of the plants may break at the base and lodge.

Environmental Favorable Conditions

- High soil temperature is 35 °C or more.
- Soil moisture 40%.

- Moisture stress occurs at the time of flowering to crop maturity stage.
- Heavy application of nitrogenous fertilizer.

Mode of Spread

- Primary source-Soil borne Sclerotia.
- Secondary source-Irrigation water.

Management

- Maintaining soil moisture through irrigation, if possible, during the post- flowering period can minimize charcoal rot infestation.
- Frequent irrigation should be provided at the time of flowering stage.
- A balanced fertilizer program is beneficial as with high levels of nitrogen application with low levels of potassium may lead to charcoal rot.
- High plant population should be avoided.
- Collection and burnt of infected plants.
- Growing of drought tolerant, lodging resistant like CSV 17, SPV 462 etc. can reduce yield losses from charcoal rot infestations.
- Growing resistant cultivars like SPV 462, CSV 17 etc.
- Seed treatment with captan or thiram 4g/kg of seeds.
- Foliar spray with Mancozeb @ 0.25% at 40days.
- Soil drenching with Carbendazim, Cupper oxy chloride @ 0.25%.
- Application of Biocontrol agents like *Trichoderma viride* and *Pseudomonas fluorescense*. Each 2.5kg/ha mixed with 50kg of FYM should be broadcast at the time of last ploughing and 30days after sowing.

6. Ergot or Sugary Disease-*Claviceps sorghi*-Sclerotial Stage

***Sphacelia sorghi*-Honey Dew Stage**

Symptom

- Ergot can be an economically devastating problem.
- The first symptom is droplets of liquid honeydew exude from between the glumes of infected florets.
- Honeydew may range from colorless to start with to yellow, brown

or white with a thin to thick uniformity. Afterwards black colour sclerotia are formed.

- Harvesting grain from ergot-infected fields can be difficult. Ergot contamination reduces grain quality and limits its use as a feedstock.
- Ergot or sugary disease results from the ergot fungus infects the florets in the ear head (panicle) and prevents seed set in such florets.

Environmental Favorable Conditions

- Flowering stage coincide with rainfall.
- Cool night.
- Cloudy weather.
- Temperature-20 to 25 °C.

Mode of spread:

- Primary source-Soil borne Sclerotia.
- Secondary source-Irrigation water.

Management

- Sowing of ergot free seed.
- Adjust the time of sowing.
- Deep summer ploughing.
- Soaking seeds with 5% salt solution will aid to remove ergot infested seeds, as ergot infested seeds will float in the salt solution.
- Seed treatment with fungicides such as Captan or Thiram 4g/kg.
- Control of ergot with fungicides such as Propiconazole or Tebuconazole has proved to be cost effective in seed production plots.
- Multiple sprayings at 5-7 days interval from flag leaf stage till end of a thesis are recommended to accommodate the variation in flowering within a field.
- Foliar spray with zineb or captan or Mancozeb @ 0.25% at 5 to 10% ear head emergence stage followed by 50% flowering stage.

7. Grain Mould or Head Mould

1. Black	-	<i>Curvularia lunata</i>
2. Black	-	<i>Rhizopus</i>

3. Brown	-	<i>Helminthosporium</i>
4. Brown	-	<i>Alternata</i>
5. Pink	-	<i>Fusarium</i>

Symptom

- More than 32 genera associated with to cause the discolouration of grains and entire ear heads.
- The infected grains are covered with pink colour or black colour. Disintegration of grains occurs during threshing.
- Grain mold is a major yield-reducing disease especially in early-maturing sorghum cultivars, and in areas where the crop flowers and matures under high humidity due to continuous rains, and warm conditions.
- Yield losses range from 30 to 100% depending on cultivar type, time of flowering, maturity and soil. Molded grain may contain certain mycotoxins.

Management

- Avoidance can be practiced either by delaying sowing dates or by growing medium to late maturing cultivars such that the grain filling and maturity stages occur after end of the rains.
 - Sowing date adjustments may require irrigation, which is not always available to resource-poor farmers.
 - Reduction in mold damage is possible if the crop is harvested at physiological maturity.
 - Chemical control appears to provide some protection against grain mold, but it is neither practical nor economical except for saving valuable sorghum seed in small fields.
 - Foliar spray with Mancozeb @ 0.25% along with Aureofungin 200 ppm per liter during milky stage.
- 8. Grain Smut/Kernel Smut/Covered Smut/Short Smut-*Sphacelotheca sorghi***

Symptoms: The individual grains are replaced by smut sori. The sori are oval or cylindrical and are covered with a tough creamy skin (peridium) which often persists unbroken up to thrashing. Ratoon crops exhibit higher incidence of disease.

9. Loose Smut/Kernel Smut-*Sphacelotheca cruenta*

Symptoms: The affected plants can be detected before the ears come out. They are shorter than the healthy plants with thinner stalks and marked tillering. The ears come out much earlier than the healthy. The glumes are hypertrophied and the earhead gives a loose appearance than healthy. Symptoms the sorus is covered by a thin membrane which ruptures very early, exposing the spores even as the head emerges from the sheath.

10. Long Smut-*Tolyposporium ehrenbergii*

Symptoms: This disease is normally restricted to a relatively a small proportion of the florets which are scattered on a head. The sori are long, more or less cylindrical, elongated, slightly curved with a relatively thick creamy-brown covering membrane (peridium). The peridium splits at the apex to release black mass of spores (spore in groups of balls) among which are found several dark brown filaments which represent the vascular bundles of the infected ovary.

11. Head Smut-*Sphacelotheca reiliana*

Symptoms: The entire head is replaced by large sori. The sorus is covered by a whitish grey membrane of fungal tissue, which ruptures, before the head emerges from the boot leaf to expose a mass of brown smut spores. Spores are embedded in long, thin, dark colored filaments which are the vascular bundles of the infected head.

Management for all Smuts

- Disease can be controlled by growing resistant varieties and through the application of appropriate fungicides.
- Treat the seed with Captan or Thiram at 4 g/kg.
- Use disease free seeds.
- Follow crop rotation.
- Collect the smutted ear heads in cloth bags and bury in soil.

I. Phanerogamic parasite-*Striga asiatica* and *Striga densiflora*

Symptoms: It is a partial root parasite and occurs mainly in the rain fed sorghum. It is a small plant with bright green leaves, grows up to a height of 15-30cm. The plants occur in clusters of 10- 20/host plant. *S. asiatica* produces red to pink flowers while. *S. densiflora* produces white flowers. Each fruit contains minute seeds in abundance which survives in the soil for several years. The root exudates of sorghum stimulate the seeds of the

parasite to germinate. The parasite then slowly attaches to the root of the host by haustoria and grows below the soil surface producing underground stems and roots for about 1-2 months. The parasite grows faster and appears at the base of the plant. Severe infestation causes yellowing and wilting of the host leaves. The infected plants are stunted in growth and may die prior to seed setting.

Management

- Regular weeding and intercultural operation during early stages of parasite growth.
- Spray Fernoxone (sodium salt of 2, 4-D) at 450g /500 litre of water.

Chapter - 2

Diseases of Maize, Cumbu and Ragi

I. Diseases of Maize

1. Downy Mildew/Crazy Top-*Peronosclerospora sorghi*

Symptoms

The most characteristic symptom is the development of chlorotic streaks on the leaves. Plants exhibit a stunted and bushy appearance due to shortening of the internodes. White downy growth is seen on the lower surface of leaf corresponding upper surface we can see the yellow discoloration occurs. Downy growth also occurs on bracts of green unopened male flowers in the tassel. Small to large leaves are noticed in the tassel. All floral parts (tassel) are converted in to green leaf like structure is called as Crazy top.

Environmental Favourable Conditions

- Low temperature (21-33 °C).
- High relative humidity (90 per cent) and drizzling.
- Young plants are highly susceptible.

Mode of Spread

- Primary source of inoculums-Soil borne oospores and also dormant mycelium present in the infected maize seeds.
- Secondary source-Air borne Conidia.

Management

- Grow resistant varieties and hybrids viz. CO1, COH1 and COH2.
- Avoid growing of susceptible variety.
- Collection and destruction of infected plant debris.
- Deep summer ploughing.
- Crop rotation with pulses.
- Rogue out infected plants.

- Seed treatment with Apron at 4 to 6g/kg.
- Spray the crop with Metalaxyl + Mancozeb @ 1kg on 20th day after sowing.

2. Leaf Blight-*Helminthosporium maydis*

Symptoms

It produces small yellowish round to oval spots are seen on the leaves. The spots gradually increase in area into bigger elliptical spots and are straw to grayish brown in the centre with dark brown margins. The spots coalesce giving blighted appearance. The surface is covered with olive green velvety masses of conidia and conidiophores.

Environmental Favourable Conditions

- Optimum temperature for the germination of conidia is 8 to 27°C provided with free water on the leaf.
- Infection takes place early in the wet season.

Mode of Spread

- Primary source of inoculum-seed borne pathogen.
- Secondary source of inoculum-Air borne Conidia.

Management

- Growing of resistant variety sudan.
- Collection and destruction of infected plant debris.
- Use of disease free seeds.
- Crop rotation with non-host plants.
- Treat the seeds with Captan or Thiram at 4 g/kg.
- Foliar Spray with Mancozeb 2 kg or captan 1 kg/ha.

3. Rust-*Puccinia sorghi*

Symptoms

Circular to oval, brown colour rusty pustules are scattered over both surface of the leaves (uredospores). At matured stage, the pustules turn into brown to black teliospores.

Environmental Favourable Conditions

- Cool temperature.
- Continuous rain.
- High relative humidity.

Mode of Spread

- Primary source of inoculum-ascospores from *Oxalis* sp.
- Secondary source of inoculum-Uredospores from sorghum

Management

- Growing of resistant variety CSH 5.
- Collection and destruction of infected plant debris.
- Use of disease free seeds.
- Treat the seeds with Captan or Thiram at 4 g/kg.
- Remove the alternate hosts.
- Foliar spray with Spray Mancozeb at 2 kg/ha and Oxathin derivatives group.

4. Common Smut-*Ustilago maydis*

Symptoms

It leads to galls malformed on the ears, ear head and sheath and produces light green to brown color upon maturity, these galls rupture release large number of smut spores. The infected grains look like very long compared to healthy grains.

Mode of Spread

These smut spores are incorporated into a soil and germinate to produce the sporidia then infect the plant systematically and cause the disease.

Environmental Favourable Conditions: Fungus overwinters on crop debris or in the soil and can survive for several years; fungus usually enters the plant through wounds.

Management: Although many practices may be recommended for the control of common smut, the only method that is completely effective is to grow resistant corn hybrids.

5. Charcoal Rot-*Macrophomina phaseolina* (*Rhizoctonia bataticola*)

Symptoms

The affected plants exhibit wilting symptoms. The stalk of the infected plants can be recognized by grayish streak. The pith becomes shredded and grayish black minute sclerotia develop on the vascular bundles. Shredding of the interior of the stalk often causes stalks to break in the region of the crown. The crown region of the infected plant becomes dark in colour.

Shredding of root bark and disintegration of root system are the common features.

Favourable Conditions: High temperature and low soil moisture (drought).

Mode of Spread: The primary source of infection is through soil-borne sclerotia. The fungus over winters as a sclerotia in the soil and infects the host at susceptible crop stage through roots and proceeds towards stem.

Management

- Long crop rotation with crops that are not natural host of the fungus.
- Irrigate the crops at the time of ear head emergence to maturity.
- Treat the seeds with Carbendazim or Captan at 2 g/kg.
- Grow disease tolerant varieties viz., SN-65, SWS-8029, Diva and Zenit.

II. Disease of Cumbu

1. Downy Mildew-*Sclerospora graminicola*

Symptoms

- Infected plants exhibit dwarf due to shortening internodes and produces excessive tillering. The upper surface it produces pale chlorotic streak formed at base of the leaf to tip of the leaf. The lower surface it produces white velvety fungal growth as a results pale yellow in colour, short and also affects the ear heads.
- The floral parts are converted into green leaf like structure either partially or intercalary called green ear symptoms.

Environmental Favourable Conditions

- Drizzling
- RH-80 to 85%
- Cloudy weather

Management

- Grow resistant varieties and hybrids viz. HB 1, 5 and PHB 14.
- Avoid growing of susceptible variety.
- Collection and destruction of infected plant debris.
- Deep summer ploughing.

- Application of organic fertilizers like FYM and Neem cake to improve the plant health.
- Reduce the application of Nitrogenous fertilizer.
- Seed treatment with Apron at 4 to 6g/kg.
- Spray the crop with Metalaxyl + Mancozeb 0.1%.

2. *Smut-Tolyposporium penicillariae*

Symptoms: The pathogen infects few florets and transforms them into plump sori containing smut spores. The sori are larger than normal healthy grains and when the sori mature they become dark brown releasing millions of black smut spore balls.

Environmental Favourable Conditions

- High relative humidity.
- Successive cropping with pearl millet.

Mode of Spread

- Primary source of inoculums-pathogen survives as spore balls in the soil.
- Secondary source of inoculums-air-borne conidia.

Management: The damage caused by the fungus is negligible. Removal and destruction of affected ear head will help in controlling the disease.

3. *Ergot or Sugary Disease-Claviceps fusiformis*

Symptoms

- At the time of flowering stage small droplets of honey dew like substance exudates from infected spikelet. In contains numerous conidia carried by insects through flies, ants and beetles.
- Within 10 to 15 days, the droplets dry and harden, and dark brown to black sclerotia develop in place of seeds on the panicle.
- Sclerotia are larger than seed and irregularly shaped, and generally get mixed with the grain during threshing.

Environmental Favourable Conditions

- Conditions favoring the disease are relative humidity greater than 80%.
- 20 to 30 °C temperatures during flowering.
- Cloudy weather.

Mode of Spread

- Primary source of inoculums-germinating sclerotia which produces from ascospores.
- Secondary source of inoculums-Honeydew production promotes secondary infection caused by asexual conidia.

Management

- Growing of resistant variety CSH 5.
- Adjust the time of sowing.
- Deep summer ploughing.
- Collection and destruction of infected plant debris.
- Use of disease free seeds.
- Soaking the seed with 20% soil solution or brine solution.
- Treat the seeds with Captan or Thiram at 4 g/kg.
- Foliar spray with Spray Mancozeb at 0.25% at earhead emergence stage followed by 50% flowering stage.

4. Rust-*Puccinia penniseti*

Symptoms

Symptoms first appear mostly on the distal half of the lamina. The leaf soon becomes covered by uredosori which appear more on the upper surface. The pustules may be formed on leaf sheath, stem and on peduncles. Later, telial formation takes place on leaf blade, leaf sheath and stem. While brownish uredia are exposed at maturity, the black telia remain covered by the epidermis for a longer duration.

Environmental Favourable Conditions

- Conditions favoring the disease are relative humidity greater than 80%
- 20 to 30 °C temperatures during flowering
- Cloudy weather

Mode of Spread

- Primary source of inoculums-wind borne aeciospores and teliospores
- Secondary source of inoculums-Uredospores

Management

- Growing of resistant variety.
- Collection and destruction of infected plant debris.
- Use of disease free seeds.
- Deep summer ploughing.
- Application of organic manure like FYM and neem cake to improve the plant growth.
- Treat the seeds with Captan or Thiram at 4 g/kg.
- Remove the alternate hosts.
- Foliar spray with Spray Mancozeb at 2 kg/ha and Oxathin derivatives group.

III. Phanerogamic Parasite-*Striga asiatica* and *Striga densiflora*

Symptoms: It is a partial root parasite and occurs mainly in the rain fed sorghum, maize and cumbu. It is a small plant with bright green leaves, grows up to a height of 15-30 cm. The plants occur in clusters of 10- 20/host plant. *S. asiatica* produces red to pink flowers while. *S. densiflora* produces white flowers. Each fruit contains minute seeds in abundance which survives in the soil for several years. The root exudates of sorghum stimulate the seeds of the parasite to germinate. The parasite then slowly attaches to the root of the host by haustoria and grows below the soil surface producing underground stems and roots for about 1-2 months. The parasite grows faster and appears at the base of the plant. Severe infestation causes yellowing and wilting of the host leaves. The infected plants are stunted in growth and may die prior to seed setting.

Management

- Regular weeding and intercultural operation during early stages of parasite growth.
- Spray Fernoxone (sodium salt of 2, 4-D) at 450g /500 litre of water.

IV. Diseases of Ragi

1. Ragi Blast-*Pyricularia grisea*

Symptoms

It may infect young seedlings, leaves, panicles and other aerial parts of the adult plant. It is also known as leaf blast, node blast, panicle blast, or neck rot.

Leaf Blast

Leaf spots are of spindle-shaped with brown or reddish-brown margins, grey centers with pointed ends. Then these spots are joining together to form big spot and dried.

Node Blast

Nodes are infected; they become black and break off.

Neck Blast

Neck regions of panicles develop a black color and shrivel completely or partially grain set inhibited, Panicle breaks at the neck Infection of panicle base causes rotten neck or neck rot and causes the panicle to fall off.

Grain Blast: Black color lesions appear on the surface of glumes or grains. So it is called as grain blast.

Mode of Spread

- Primary source (Collateral host-weeds-*Panicum ripens*, *Digitaria marginata*).
- Secondary source (Air borne Conidia).

Environmental conditions

- Temp-night -20 degree C.
- Day temp-30 degree C.
- Day length-14hrs.
- Darkness-10hrs.
- RH-92%.
- Presence of drops on the leaves-germination of conidia.
- Susceptible crop.

Management

- Growing of resistant variety like CO 25, IR 20, IR8, ADT 25 and CO 3.
- Avoid growing of susceptible variety such as IR 50, ADT 42, and TKM 9.
- Use of disease free seeds.
- Seed treatment with carbendazim 2g/kg or *Pseudomonas fluorescens* 10g/kg.

- Heavy application of organic manure-to improve the plant health.
- Split application of Nitrogenous fertilizers.

Foliar Spray with Chemicals

Systemic-carbendazim 0.1% (Bavistin).

Iprobenphos 0.1% (Kitazin).

Blasticidin-200ppm.

Non systemic-Edifenphos (hinosan) 0.1%.

Biocontrol-0.25% *P. fluorescens*.

2. Seedling Blight/Leaf Blight/Leaf Spot: *Helminthosporium nodulosum*

Symptoms

- The pathogen affects both seedling and the adult plants.
- Minute, oval, light brown lesions on the young leaves and become dark brown.
- Several such lesions coalesce to form large patches of infection on the leaf blade. The affected blades wither prematurely and the seedlings may be killed.
- Linear oblong and dark brown spots appear on the leaves of grown up plants. The leaves give brightening appearance.
- Prominent brown to dark brown discoloration in the neck region and followed by weakening of neck tissue that causes it to break and the ears hanging down from the plant.
- While nursery infection causes heavy damage due to the seedling blight, neck infection causes heavy chaffiness and severe loss in grain yield.

Mode of Spread

- **Primary Source:** It is seed-borne and primary infection is through seed.
- **Secondary Source:** (Air borne Conidia).

Management

- Treat the seeds with Captan or Thiram @4g/Kg.
- Spray Mancozeb @ 1.25Kg/ha.
- Spray 1% Bordeaux mixture or Copper oxy chloride or Dithane Z-78 (2g/lit. water).

3. Foot Rot or Wilt: *Sclerotium rolfsii*

Symptom

- The infected plants remain green and stunted.
- The fungus attacks the basal stem portion and later the leaf sheath and culm.
- The infected portion becomes soft and dark brown in colour.
- The fungus is seen to grow in between the sheath and stem on the lesions.
- The plant ultimately dies.
- On the surface of lesions, small, spherical, dark coloured sclerotia are formed.

Mode of Spread

- **Primary Source:** Sclerotia contains viable hyphae and serves as primary inoculum for disease development.
- **Secondary Source:** (Air borne basidiospores).

Management

- Keeping the plants healthy and robust, and providing good drainage and other optimum soil conditions, help to avoid the disease.
- Deep ploughing before sowing and proper crop sequences involving non-poaceous crops reduces disease intensity.
- Spot drench with Copper oxychloride at 0.25 per cent for prevent spread of disease.

Chapter - 3

Diseases of Red Gram, Black Gram, Green Gram and Bengal Gram

I. Diseases of Red Gram

1. Red Gram Wilt-*Fusarium oxysporum f. sp. udum*

Symptoms

- The disease may appear from early stages of plant growth (4 to 6 weeks old plant) up to flowering and pods formation stage.

Partial Wilting or Wilting of Entire Plants

- The disease appears as gradual withering and drying of plants.
- Yellowing of leaves and blackening of stem starting from collar to branches which gradually result in drooping and premature drying of leaves, stems, branches and finally death of plant.
- Vascular tissues exhibit brown discoloration and plucking of xylem vessels. Often only one side of the stem and root system is affected resulting in partial wilting.

Mode of Spread

- Primary source of inoculums-soil borne chlamydospores.
- Secondary source of inoculums-Air borne conidia.

Environment Favorable Conditions

- Soil temperature of 17-25 °C.
- Continuous cultivation of red gram in the same field.
- Root knot nematode.

Management

- Grow resistant cultivars like Jawahar, Maruthi and Pusa-9.
- Avoid growing of susceptible variety.
- Selection of seeds from disease free field.

- Treat the seeds with *Trichoderma viride* at 4 g/kg (10⁶cfu/g).
- Avoid successive cultivation of red gram in the same field.
- Crop rotation with tobacco.
- Mixed cropping with sorghum in the field.
- Soil drenching with cupper oxy chloride (COC) 0.25%.

2. **Dry Root Rot-** *Macrophomina phaseolina*-Pycnidial stage

Rhizoctonia bataticola-Sclerotial stage

Symptoms

- The disease occurs both in young seedlings and grown up plants.
- Dry situation ideal for the occurrence of this disease.
- Sudden death of the plants occurs in patches.
- The lower leaves show yellowing, drooping and premature defoliation.
- The bark shredding occurs on the collar regions and turn into small pieces with presence of black color which represents the sclerotia and pycnidia.
- On pulling the infected plants comes out very from soil compared to healthy plants.

Mode of Spread

- Primary source of inoculums-soil borne sclerotia.
- Secondary source of inoculums-Air borne conidia or pycnidia.

Environment Favorable Conditions

- Prolonged drought followed by irrigation.
- High temperature of 28-35 °C.

Management

- Frequent irrigation at the time of flowering stage.
- Avoid growing of susceptible variety.
- Selection of seeds form disease free filed.
- Treat the seeds with carbendazim or thiram at 2g/kg or pellet the seeds with *Trichoderma viride* at 4 g/kg (10⁶cfu/g).
- Apply heavy doses of farm yard manure or green leaf manure like *Gliricidia maculata* at 10 t/ha or apply Neem Cake at 150 kg/ha.

3. Powdery Mildew-*Leveillula taurica*

Symptoms

- White powdery growth of the fungus can be seen on the lower surface of leaves.
- The corresponding areas in upper surface show pale yellow discoloration.
- The white powdery mass consists of conidiophores and conidia of the fungus.
- In severe cases, the white growth can be seen on the upper surface also.
- The severe infection of the fungus leads to premature shedding of leaves.

Mode of Spread

- Primary source of inoculums-fungus survives in the soil through cleistothecia.
- Secondary source of inoculums-Air borne conidia.

Environment Favorable Conditions-Dry humid weather following rainfall.

Management

- Growing of resistant variety.
- Avoid growing of susceptible variety.
- Selection of seeds from disease free field.
- Collection and destruction of dried leaves.
- Seed treatment with captan or thiram 4g per kg of seeds.
- Foliar spray with chemicals.

Non Systemic Fungicides

- Sulphur fungicides group-inorganic sulphur-elemental sulphur-wettable powder (sulfex, solbar) should be apply all powdery mildew disease except rose, pear and peach crops.
- Benzene group-Dinocap-karathane 0.05%.

Systemic Fungicides

- Morpholine-Tridemorph-calixin (0.1%)

- Triazole group-Propiconazole-Tilt (0.1%)
- Triazole group-Hexaconazole-cantal-(0.1%)

Virus Disease

1. Sterility Mosaic-Pigeon Pea Sterility Mosaic Virus

Vector-*Aceria cajani*-Mite

Symptoms

- Stunted growth.
- Mosaic mottling.
- Reduction of leaf size.
- Due to shortening of internodes and proliferation of auxiliary buds.
- Bushy appearance.

Management

- Selection of seeds from disease free seeds.
- Spraying of any one of the systemic insecticides at two leaf stage onwards.
- Three sprays at monthly intervals.

2. Yellow Mosaic-Red Gram Yellow Mosaic Virus

Vector-White Fly-*Bemisia tabaci*

Symptom: The infected leaves shows the bright yellow patches alternate with green patches.

Management

- Selection of seeds from disease free seeds.
- Spraying of any one of the systemic insecticides at two leaf stage onwards.

Three sprays at monthly intervals

II. Diseases of Black Gram and Green Gram

1. Wet Root Rot-*Rhizoctonia solani* and *Sclerotium rolfsii*

Symptoms

- *Rhizoctonia solani* pathogen produces reddish brown color lesions appears on the collar regions later this lesions spreads from collar region to root regions (downwards) due to this shrinkage occur in collar region and leads to death.

- *Sclerotium rolfsii*-white strand of mycelia with mustard like sclerotia appears in stem as well as around the collar region.

Mode of Spread

- Primary source of inoculums-soil borne sclerotia.
- Secondary source of inoculums-Air borne basidiospores.

Environment Favorable Conditions

- Prolonged wet conditions.
- Optimum temperature of 18-23 °C.

Management

- Avoid growing of susceptible variety.
- Selection of seeds from disease free field.
- Treat the seeds with carbendazim or thiram at 2g/kg or pellet the seeds with *Trichoderma viride* at 4 g/kg (106cfu/g).
- Soil drenching with COC (0.25%).
- Apply heavy doses of farm yard manure or green leaf manure like *Gliricidia maculata* at 10 t/ha or apply Neem Cake at 150 kg/ha.

2. Dry Root Rot-*Macrophomina phaseolina*-Pycnidial Stage (Refer Red Gram Root Rot)

3. Powdery Mildew-*Erysiphe polygoni*

Symptoms

- Small, irregular powdery spots appear on the upper surface of the leaves, sometimes on both the surfaces.
- The disease becomes severe during flowering and pod development stage.
- The white powdery spots completely cover the leaves, petioles, stem and even the pods.
- The plant assumes greyish white appearance; leaves turn yellow and finally shed. Often pods are malformed and small with few ill-filled seeds.

Favorable Conditions

- Warm humid weather.
- The disease is severe generally during late kharif and Rabi seasons.

Mode of Spread

- Primary source of inoculums-Pathogen survives as cleistothecia in the infected plant debris and usually from ascospores from perennating cleistothecia.
- Secondary source of inoculum-air-borne conidia and Rain splash also helps in the spread of the disease.

Management: (Same as Red Gram)

4. Leaf Spot-*Cercospora canescens*

Symptoms

Small, circular spots develop on the leaves with grey centre and brown margin. Several spots coalesce to form brown irregular lesions. In severe cases defoliation occurs. The brown lesions may be seen on petioles and stem in severe cases. Powdery growth of the fungus may be seen on the centre of the spots.

Favorable Conditions-Humid weather and dense plant population.

Mode of Spread

- Primary source of inoculums-The fungus survives on diseased plant debris and on seeds.
- Secondary spread is by air-borne conidia.

Management

- Avoid growing of susceptible variety.
- Collection and destruction of infected plant debris
- Selection of seeds from disease free field.
- Seed treatment with captan or Thiram 4g/kg of seeds.
- Foliar spray with Morpholine-Tridemorph-Calixin (0.1%) followed by organic sulphur-Maneb-Mancozeb (0.25%).

5. Leaf Rust-*Uromyces phaseoli* (Syn.: *U. appendiculatus*)

Symptoms

The disease is mostly seen on leaves, rarely on petioles, stem and pods. The fungus produces small, round, reddish brown uredosori mostly on lower surface. They may appear in groups and several sori join together to cover a large area of the lamina. In the late season, teliospore appear on the leaves which are linear and dark brown or black in color. Intense pustule formation causes drying and shedding of leaves.

Favorable Conditions

- Cloudy humid weather, temperature of 21-26 °C.
- Nights with heavy dews.

Mode of Spread

- **Primary Source of Inoculum:** The pathogen survives in the soil through teliospores and as uredospores in crop debris. Primary infection is by the sporidia developed from teliospores.
- **Secondary Source of Inoculum:** wind borne uredospores.

Management

- Avoid growing of susceptible variety.
- Collection and destruction of infected plant debris.
- Selection of seeds from disease free field.
- Seed treatment with captan or Thiram 4g/kg of seeds.
- Foliar spray with Oxathin derivatives-carboxin-vitavax (0.1%).

Virus Disease

1. Yellow Mosaic Disease-*Mungbean yellow mosaic virus (MYMV)*

Vector-White Fly (*Bemisia tabaci*)

Symptoms

Initially small yellow patches or spots appear on green lamina of young leaves. Quickly it develops into a characteristic bright yellow mosaic or golden yellow patches alternate with green patches. Yellow discoloration slowly increases and leaves turn completely yellow. Infected plants mature later and bear few flowers and pods. The pods are small and distorted. Early infection causes death of the plant before seed set.

Management

- Rogue out the diseased plants up to 40 days after sowing.
- Remove the weed hosts periodically.
- Increase the seed rate (25 kg/ha).
- Grow resistant black gram variety like VBN-1, PDU 10, IC12/2 and PLU 322. Cultivate the crop during rabi season.
- Follow mixed cropping by growing two rows of maize (60x30cm) or sorghum (45x15cm) or cumbu (45x15cm) for every 15 rows of black gram or green gram.

- Spraying of any one of the systemic insecticides at two leaf stage onwards.

2. Leaf Crinkles Disease-*Urdbean leaf crinkle virus* (ULCV)

Vector-White Fly (*Bemisia tabaci*)

Symptoms

- Crinkling and curling of the tips of leaflets and increase in leaf area. Crinkling and rugosity in older leaves becomes severe and leaves thickened. Petioles as well as internodes are shortened.
- Infected plant gives a stunted and bushy appearance.
- Flowering is delayed, if inflorescence is formed, is malformed with small size flower buds and fails to open.

Management

- Use increased seed rate (25 kg/ha).
- Rogue out the diseased plants at weekly interval up to 45 days after sowing. Cultivate seed crop during rabi season.
- Remove weed hosts periodically.
- Spray methyl demeton on 30 and 40 days after sowing at 500 ml/ha.

III. Disease of Bengal Gram or Chick Pea

1. Wet Root Rot-*Rhizoctonia solani* and *Sclerotium rolfsii*

Symptoms

- ***Rhizoctonia solani***: Pathogen produces reddish brown color lesions appears on the collar regions later this lesions spreads from collar region to root regions (downwards) due to this shrinkage occur in collar region and leads to death.
- ***Sclerotium rolfsii***: White strand of mycelia with mustard like sclerotia appears in stem as well as around the collar region.

Mode of Spread

- Primary source of inoculums-soil borne sclerotia.
- Secondary source of inoculums-Air borne basidiospores.

Environment Favorable Conditions

- Prolonged wet conditions.
- Optimum temperature of 18-23 °C.

Management

- Avoid growing of susceptible variety.
 - Selection of seeds from disease free field.
 - Treat the seeds with carbendazim or thiram at 2g/kg or pellet the seeds with *Trichoderma viride* at 4 g/kg (106cfu/g).
 - Soil drenching with COC (0.25%).
 - Apply heavy doses of farm yard manure or green leaf manure like *Gliricidia maculata* at 10 t/ha or apply Neem Cake at 150 kg/ha.
2. **Dry Root Rot-*Macrophomina phaseolina*-Pycnidial Stage (Refer to Red Gram or Green Gram Root Rot)**
 3. **Wilt Disease-*Fusarium oxysporum f. sp. ciceris***

Symptoms

- The disease may appear from early stages of plant growth (4 to 6 weeks old plant) up to flowering and pods formation stage.

Partial wilting or wilting of entire plants

- The disease appears as gradual withering and drying of plants.
- Yellowing of leaves and blackening of stem starting from collar to branches which gradually result in drooping and premature drying of leaves, stems, branches and finally death of plant.
- Vascular tissues exhibit brown discoloration and plucking of xylem vessels. Often only one side of the stem and root system is affected resulting in partial wilting.

Mode of Spread

- Primary source of inoculumsoil borne chlamydo spores.
- Secondary source of inoculumsoil borne conidia.

Environment Favorable Conditions

- Soil temperature of 17-25 °C.
- Continuous cultivation of red gram in the same field.
- Root knot nematode.

Management

- Grow resistant cultivars like Jawahar, Maruthi and Pusa-9.
- Avoid growing of susceptible variety.

- Selection of seeds from disease free field.
- Treat the seeds with *Trichoderma viride* at 4 g/kg (10⁶cfu/g).
- Avoid successive cultivation of red gram in the same field.
- Crop rotation with rice.
- Mixed cropping with sorghum in the field.
- Soil drenching with copper oxy chloride (COC) 0.25%.

3. *Ascochyta Blight-Ascochyta rabiei*

Symptoms

All above ground parts of the plants are infected. On leaf surface the lesions are round or elongated bearing irregularly depressed brown spots and surrounded by a brownish red margin. Similar spots may appear on stem and pods.

Mode of Spread

- Primary source of inoculum—seed borne pathogen.
- Secondary source of inoculum—Air borne conidia.

Environment Favorable Conditions

- High rain fall during flowering stage.
- Temperature—20 to 25 °C.
- Relative humidity 60%.

Management

- Grow resistant variety.
- Avoid growing of susceptible variety.
- Selection of seeds from disease free field.
- Remove and destroy the infected plant from field.
- Seed treatment with captan 2g or carbendazim 2g per kg of seeds.
- Crop rotation with cereals.
- Expose the seed at 40 to 50 °C to reduce the survival of *A. rabiei* by about 40 to 70%.

Chapter - 4

Diseases of Groundnut and Gingelly

I. Diseases of Groundnut

1. Tikka Leaf Spots

- **Early Leaf Spot:** *Cercospora arachidicola* (Sexual Stage: *Mycosphaerella arachidis*)
- **Late Leaf Spot:** *Cercospora personata* (Sexual stage: *Mycosphaerella berkeleyi*)

Symptoms

The disease occurs on all above ground parts of the plant, more severely on the leaves. The leaf symptoms produced by the two pathogens can be easily distinguished by appearance, spot colour and shapes. Both the fungi produce lesions also on petiole, stem and pegs. The lesions caused by both species coalesce as infection develops and severely spotted leaves shed prematurely. The quality and yield of nuts are drastically reduced in severe infections.

S. No.	Early Leaf Spot	Late Leaf Spot
1.	• Symptoms seen in with in 3 to 4 weeks after sowing	• Symptoms seen in 3 to 4 weeks after sowing
2.	• Reddish brown circular spot present on the upper surface of the leaves. These spots are surrounded by yellow hallow.	• Carbon black irregular spot present on the Lower surface of the leaves. These spots are not surrounded by yellow hallow.
3.	• At severe conditions these spot also present on petiole, stem and pods and finally defoliated occurs.	• At severe conditions these spot also present on petiole, stem and pods and finally defoliated occurs. It is a highly destructive one.

Favourable Conditions

- Prolonged high relative humidity for 3 days.
- Low temperature (20 C) with dew on leaf surface.
- Heavy doses of nitrogen and phosphorus fertilizers.
- Deficiency of magnesium in soil.

Mode of Spread

- The primary infection is by ascospores or conidia from infected plant debris or infected seeds.
- The secondary spread is by wind blown conidia. Rain splash also helps in the spread of conidia.

Management

- Grow moderately resistant varieties like ALR 1.
- Remove and destroy the infected plant debris.
- Eradicate the volunteer groundnut plants.
- Keep weeds under control.
- Treat the seeds with Thiram at 2g/kg.
- Foliar spray with non-systemic fungicides-Benzene group-Chlorothalonil-Kavach (0.1%) and if necessary, repeat after 15 days.

2. Rust-*Puccinia arachidis*

Symptoms

It produces very brown raised rusty pustules on the lower surface of leaf corresponding upper surface yellow discoloration will be occurs.

Favorable Conditions

- Cloudy humid weather, temperature of 21-26 °C.
- Nights with heavy dews.

Mode of Spread

- **Primary Source of Inoculum:** The pathogen survives in the soil through teliospores and as uredospores in crop debris. Primary infection is by the sporidia developed from teliospores.
- **Secondary Source of Inoculum:** wind borne uredospores.

Management

- Avoid growing of susceptible variety.
- Collection and destruction of infected plant debris.
- Selection of seeds from disease free field.
- Seed treatment with captan or Thiram 4g/kg of seeds.
- Foliar spray with Oxathin derivatives-carboxin-vitavax (0.1%).

3. Crown Rot-*Aspergillus niger* and *A. flavus*

Symptoms

It produces 3 types of symptoms.

- **Pre Emergence Rotting:** Black colour or light green color discoloration occurs on the before germinating of seedling which leads to death of seedling will be occur.
- **Post Emergence Rotting:** Black colour or grey color discoloration occurs on the collar region on after of seedling which leads to rotting of seedling will be occur.
- **Crown Rot:** After well-established seedling rotting occurs on the collar region.

Management

- Avoid growing of susceptible variety.
- Collection and destruction of infected plant derbies.
- Selection of seeds form disease free filed.
- Seed treatment with captan or Thiram 4g/kg of seeds.
- Soil drenching with cupper oxy chloride (0.25%).

4. Stem Rot and Pod Rot-*Sclerotium rolfsii*

Symptoms

- Stem rot-it produces rotting of stem on base of the collar region.
- Pod rot-the infected pod shows reddish brown colour lesions which leads to rotting occur.

Mode of Spread

- The primary infection is soil borne sclerotia.
- The secondary spread is wind borne Basidiospores.

Management

- Avoid growing of susceptible variety
- Selection of seeds form disease free filed.
- Treat the seeds with carbendazim or thiram at 2g/kg.
- Soil drenching with COC (0.25%).
- Apply heavy doses of farm yard manure or green leaf manure like *Gliricidia maculata* at 10 t/ha or apply Neem Cake at 150 kg/ha.

- | | |
|--|---|
| 5. Wet Root Rot: <i>Rhizoctonia solani</i> and <i>Sclerotium rolfsii</i> | } Refer black
Gram and
Green gram |
| 6. Dry Root Rot: <i>Macrophomina phaseolina</i> -Pycnidial stage
<i>Rhizoctonia bataticola</i> -Sclerotial stage | |

II. Disease of Gingelly

- | | |
|--|---|
| 1. Wet Root Rot: <i>Rhizoctonia solani</i> and <i>Sclerotium rolfsii</i> | } Refer black
Gram and
Green gram |
| 2. Dry Root Rot: <i>Macrophomina phaseolina</i> -Pycnidial stage
<i>Rhizoctonia bataticola</i> -Sclerotial stage | |
3. **Leaf Spot-***Cercospora sesami*

Symptom

Small, circular spots develop on the leaves with grey centre and brown margin. Several spots coalesce to form brown irregular lesions. In severe cases defoliation occurs.

Favorable Conditions: Humid weather and dense plant population.

Mode of Spread

- Primary source of inoculums-The fungus survives on diseased plant debris and on seeds.
- Secondary spread is by air-borne conidia.

Management

- Avoid growing of susceptible variety.
- Collection and destruction of infected plant debris.
- Selection of seeds from disease free field.
- Seed treatment with captan or Thiram 4g/kg of seeds.
- Foliar spray with Chlorothalonil-Kavach (0.1%) followed by organic sulphur-Maneb-Mancozeb (0.25%).

4. Leaf Blight-*Alternaria solani*

Symptom

It produces dark brown colour irregular lesions with concentric ring occurs on the upper surface of leaves which leads to drying of leaves.

Mode of Spread

- Primary source of inoculums-The fungus survives on diseased plant debris and on seeds.
- Secondary spread is by air-borne conidia.

Management

- Avoid growing of susceptible variety.
- Collection and destruction of infected plant debris.
- Selection of seeds from disease free field.
- Seed treatment with captan or Thiram 4g/kg of seeds.
- Foliar spray with Morpholine-Tridemorph-Calixin (0.1%) followed by organic sulphur-Maneb-Mancozeb (0.25%).

5. Powdery Mildew-*Erysiphe cichoracearum*

Symptom

White powdery growth appears on the upper surface of the leaves and leads to drying occur.

Mode of Spread

- **Primary Source of Inoculum:** Fungus survives in the soil through cleistothecia.
- **Secondary Source of Inoculum:** Air borne conidia.

Environment Favorable Conditions: Dry humid weather following rainfall.

Management: Refer black gram powdery mildew

Phytoplasma

1. Sesame Phyllody-*Phytoplasma*

Vector-*Orosius albicinctus*

Symptom

- Shortening of internodes.
- Production of phylloid flowers.
- Bushy appearance.
- The flowers are converted into green leaf like structure is called as phylloid.
- In severe infection, the entire inflorescences is replaced by short twisted leaves closely arranged on a stem with short internodes, abundant abnormal branches bend down.
- Finally, plants look like witches broom.
- If capsules are formed on lower portion of plant they do not yield quality seeds.

Management

- Selection of seeds from disease free seeds.
- Spraying of any one of the systemic insecticides at two leaf stage onwards.
- Three sprays at monthly intervals.

Chapter - 5

Diseases of Sunflower, Castor and Cotton

I. Diseases of Sunflower

Major Diseases

- **Wet Root Rot:** *Rhizoctonia solani* and *Sclerotium rolfsii*
- **Dry Root Rot:** *Macrophomina phaseolina*-Pycnidial stage
Rhizoctonia bataticola-Sclerotial stage
- **Leaf Blight:** *Alternaria helianthi*
- **Rust:** *Puccinia helianthi*
- **Head Rot:** *Rhizopus* sp.
- **Powdery Mildew:** *Erysiphe cichoracearum*
- **Basal Rot:** *Sclerotium rolfsii*
- **Necrosis:** *Tobacco streak virus* (TSV)

Vector-Thrips (*Frankliniella schultzei*)

1. **Wet Root Rot:** *Rhizoctonia solani* and *Sclerotium rolfsii*
 2. **Dry Root Rot:** *Macrophomina phaseolina*- Pycnidial stage
Rhizoctonia bataticola-Sclerotial stage
 3. **Leaf Blight-*Alternaria helianthi***
- } Refer black
Gram and
Green gram

Symptoms

- The pathogen produces brown spots on the leaves, but the spots can also be seen on the stem, sepals and petals.
- The lesions on the leaves are dark brown with pale margin surrounded by a yellow halo.
- The spots later enlarge in size with concentric rings and become irregular in shape.
- Several spots coalesce to show bigger irregular lesions leading to drying and defoliation.

Favourable Conditions

- Rainy weather.
- Cool winter climate.
- Late sown crops are highly susceptible.

Mode of Spread

- **Primary Source of Inoculum:** The fungus survives in the infected host tissues and weed hosts. The fungus is also seed-borne.
- **Secondary Source of Inoculum:** The secondary spread is mainly through wind blown conidia.

Management

- Deep summer ploughing.
- Proper spacing
- Clean cultivation and field sanitation.
- Use of resistant or tolerant variety like B.S.H.1.
- Application of well rotten manures.
- Practicing crop rotation.
- Planting in mid-September.
- Remove and destroy the diseased plants
- Treat the seeds with Thiram or Carbendazim at 2 g/kg. Spray Mancozeb at 2 kg/ha.

4. Rust-*Puccinia helianthi*

Symptoms

- Small, reddish brown pustules (uredia) covered with rusty dust appear on the lower surface of bottom leaves. Infection later spreads to other leaves and even to the green parts of the head.
- In severe infection, when numerous pustules appear on leaves, they become yellow and dry.
- The black coloured telia are also seen among uredia on the lower surface. The disease is autoecious rust. The pycnial and aecial stages occur on volunteer crops grown during off-season.

Mode of Spread

- **Primary Source of Inoculum:** The pathogen survives in the soil through teliospores and as uredospores in crop debris. Primary infection is by the sporidia developed from teliospores.
- **Secondary Source of Inoculum:** wind borne uredospores.

Favorable Conditions

- Day temperature of 25.5° to 30.5 °C with relative humidity of 86 to 92 per cent enhances intensity of rust attack.

Management

- Use of tolerant and resistant varieties
- Crop rotation should be followed.
- Previous crop remains should be destroyed.
- Removal of crop residues
- Seed treatment with captan or Thiram 4g/kg of seeds.
- Foliar spray with Oxathin derivatives-carboxin-vitavax (0.1%).
- Spray Mancozeb at 2kg/ha.

5. Head Rot-*Rhizopus* sp.

Symptoms

The affected heads show water soaked lesions on the lower surface, which later turn brown. The discoloration may enlarge to stalk from head. The affected portions of the head become soft and spongy and insects are also seen associated with the petrified tissues. The larvae and insects which attack the head surface way for the entry of the fungus which attacks the inner part of the head and the developing seeds. The seeds are converted into a black powdery mass. The head finally withers and droops down with heavy fungal mycelial nets.

Favorable Conditions

- Prolonged rainy weather at flowering.
- Damages caused by insects and caterpillars.

Disease Cycle: The fungus survives as a saprophyte in host debris and other crop residues. The disease is spread by wind-blown spores.

Management

- Treat the seeds with thiram or carbendazim at 2g/kg.
- Control the caterpillars feeding on the heads.
- Spray the head with Mancozeb at 2kg/ha during intermittent rainy season and repeat after 10 days, if the humid weather persists.

6. Powdery Mildew-*Erysiphe cichoracearum*

Symptoms

This disease produces white powdery growth on the leaves. White to grey mildew appears on the upper surface of older leaves. As plant matures black pin head sized are visible in white mildew areas. The affected leaves more luster, curl, become chlorotic and die.

Mode of Spread

- **Primary Source of Inoculum:** fungus survives in the soil through cleistothecia.
- **Secondary Source of inoculum:** Air borne conidia.

Environment Favorable Conditions: Dry humid weather following rainfall.

Management

- Growing of resistant variety.
- Avoid growing of susceptible variety.
- Selection of seeds from disease free field.
- Collection and destruction of dried leaves.
- Seed treatment with captan or thiram 4g per kg of seeds.
- Foliar spray with chemicals.

Non Systemic Fungicides

- Sulphur fungicides group-inorganic sulphur-elemental sulphur-wettable powder (sulfex, solbar) should be apply all powdery mildew disease except rose, pear and peach crops.
- Benzene group-Dinocap-karathane 0.05%.

Systemic Fungicides

- Morpholine-Tridemorph-calixin (0.1%)
- Triazole group-Propiconazole-Tilt (0.1%)
- Triazole group-Hexaconazole-cantal-(0.1%)

7. Basal Rot-*Sclerotium rolfsii*

Symptoms

Initial symptoms of the disease appear 40 days sowing. The infected plants can be identified by their sickly appearance. Plants dry up due to the disease infestation. The lower portion of stem is covered with white or brownish white fungal colonies. In extreme cases the plants wilts and dies. Dark brown lesions appear on the base of the stem near ground level, leading to withering. Large numbers of sclerotia are seen.

Favorable Conditions

- Infection occurs in the crop in the month of July and August.
- The fungus survives through Sclerotia in soil and plant debris.

Management

- Deep summer ploughing.
- Complete field and crop sanitation.
- Use of resistant or tolerant varieties.
- Collect and destroy plant debris.
- Apply *Trichoderma* on seed and soil to reduce wilt.
- Apply and incorporate fungus *Coniothyrium minitans* before sowing as it invades and destroy the pathogen in the soil.
- Seed treatment with *Pseudomonas fluorescens* or *P. putida* strains protect sunflower from Sclerotinia infection during seedling stage.
- Seed treatment with captan or thiram at the rate of 3 g/kg of seed.
- Drenching the base of the plant with chestnut compound 3 g per litre of water.
- Seed treatment with carbendazim at 0.2% followed by the addition of *Trichoderma harzianum* 10 g/kg soil and spraying Carbendazim at 0.2% to 15 days old seedling.

8. Necrosis-Tobacco streak virus (TSV)

Vector-thrips (*Frankliniella schultzei*)

Symptoms: Characterized by the sudden necrosis of part of lamina followed by twisting of leaves and systemic mosaic and Advanced symptoms lead to plant death.

Management

- Removal of weed hosts
- Management of vector population
- Changing planting dates

II. Disease of Castor

Major Diseases

- Wilt-*Fusarium oxysporum*
- Rust-*Melampsora ricini*
- Leaf blight-*Alternaria ricini*
- Brown leaf spot-*Cercospora ricinella*
- Powdery mildew-*Leveillula taurica*
- Bacterial leaf spot-*Xanthomonas campestris* pv. *ricinicola*

1. Wilt: *Fusarium oxysporum*

Symptoms

- When seedlings are attacked cotyledon leaves turn to dull green colour, wither and die subsequently. Leaves are droop and drop off leaving behind only top leaves.
- Diseased plants are sickly in appearance.
- Wilting of plants, root degeneration, collar rot, dropping of leaves and necrosis of affected tissue and finally leading to death of plants.
- Necrosis of leaves starts from margins spreading to interveinal areas and finally to the whole leaf.
- Spilt open stem shows brownish discoloration and white cottony growth of mycelia much prominently in the pith of the stem.

Mode of Spread

- Primary source of inoculums-soil borne chlamydospores.
- Secondary source of inoculums-Air borne conidia.

Environment Favorable Conditions

- Soil temperature of 17-25 °C.
- Continuous cultivation of red gram in the same field.
- Root knot nematode.

Management

- Selection of disease free seeds.
- Grow tolerant and resistant varieties like Jyothi, Jwala, GCH-4 DCH-30 and SHB 145.
- Avoid water logging.
- Burning of crop debris.
- Green manuring and intercropping with red gram.
- Treat the seeds with thiram @ 2g/kg or carbendazim @ 2g/kg seed.
- Seed treatment with 4g of *Trichoderma viride* talc formulation.
- Multiplication of 2kg of *T. viride* formulation by mixing in 50kg farm yard manure.
- Sprinkling water and covering with polythene sheet for 15days and then applying between rows of the crops is helpful in reducing the incidence.

2. Rust-*Melampsora ricini*

Symptoms

- Minute, orange-yellow colored, raised pustules appear with powdery masses on the lower surface of the leaves and the corresponding areas on the upper surface of the leaves are yellow.
- Often the pustules are grouped in concentric rings and coalesce together to for drying of leaves.

Mode of Spread

- **Primary Source of Inoculum:** The pathogen survives in the soil through teliospores and as uredospores in crop debris. Primary infection is by the sporidia developed from teliospores.
- **Secondary Source of Inoculum:** wind borne uredospores.

Management

- Rogue out the self-sown castor crops and other weed hosts.
- Spray Mancozeb at 2kg/ha or Propiconazole 1l/ha.
- Foliar spray with Oxathin derivatives-carboxin-vitavax (0.1%).

3. Leaf Blight-*Alternaria ricini*

Symptoms

- All the aerial parts of plants viz., leaves, stem, inflorescences and capsules are liable to be attacked by the pathogen.
- Irregular brown spots with concentric rings form initially on the leaves and covered with fungal growth. When the spots are joining together to form big patches, premature defoliation occurs.
- The stems, inflorescences and capsules are also show dark brown lesions with concentric rings.
- On the capsules, initially brown sunken spots appear, enlarge rapidly and cover the whole pod. The capsules crack and seeds are also getting infected.

Favorable Conditions

- High atmospheric humidity (85-90%).
- Low temperature (16-20 °C).

Mode of Spread

- The pathogen is externally and internally seed-borne and causes primary infection.
- The secondary infection is through air-borne conidia.

Management

- Treat the seeds with captan or thiram at 2g/kg.
- Remove the reservoir hosts periodically.
- Spray mancozeb at 2kg/ha.

4. Brown Leaf Spot-*Cercospora ricinella*

Symptoms

- The disease appears as minute brown specks surrounded by a pale green halo.
- The spots enlarge to grayish white centre portion with deep brown margin.
- The spots may be 2-4 mm in diameter and when several spots coalesce, large brown patches appear but restricted by veins.
- Infected tissues often drop off leaving shot-hole symptoms.
- In severe infections, the older leaves may be blighted and withered.

Mode of Spread

- The pathogen remains as dormant mycelium in the plant debris.
- The disease mainly spreads through wind borne conidia.

Management

- Spraying with 1% Bordeaux mixture or Copper oxy chloride@ 0.2% may help to bring the disease under check; but where the cultures of Eri-silk worm are maintained on castor plants, spraying would not be desirable.
- Use of resistant varieties would be the most effective method for combating the disease.
- Spraying twice with Mancozeb 2g/lit or Carbendazim 500g/ha at 10-15 day interval reduces the disease incidence.
- Treat the seed with thiram or Captan 2gm/kg seed.

5. Powdery Mildew-*Leveillula taurica*

Symptoms

It is characterized by typical mildew growth which is generally confined to the under-surface of the leaf. When the infection is severe the upper-surface is also covered by the whitish growth of the fungus. Light green patches, corresponding to the diseased areas on the under surface, are visible on the upper side especially when the leaves are held against light.

Mode of Spread

- Primary source of inoculums-fungus survives in the soil through cleistothecia.
- Secondary source of inoculums-air borne conidia.

Environment Favorable Conditions-Dry humid weather following rainfall.

Management (refer black gram powdery management)

6. Bacterial Leaf Spot: *Xanthomonas campestris* pv. *ricinicola*

Symptoms

The pathogen attacks cotyledons, leaves and veins and produces few to numerous small rounds, water-soaked spots which later become angular and dark brown to jet black in color. The spots are generally aggregated towards the tip. At a later stage the spots become irregular in shape particularly when

they coalesce and areas around such spots turn pale-brown and brittle. Bacterial ooze is observed on both the sides of the leaf which is in the form of small shining beads or fine scales.

Management

- Field sanitation help in minimizing the yield loss as pathogen survives on seed and plant debris.
- Hot water treatment of seed at 58°C to 60°C for ten minutes.
- Grow tolerant varieties.
- Spray Copper oxychloride 2kg/ha or Streptocycline 100g/ha or Paushamycin 250g/ha.

III. Disease of Cotton

Major Diseases

- **Fusarial Wilt:** *Fusarium oxysporum* f. sp. *vasinfectum*
 - **Wet Root Rot:** *Rhizoctonia solani* and *Sclerotium rolfsii*
 - **Dry Root Rot:** *Macrophomina phaseolina*-Pycnidial stage
Rhizoctonia bataticola-Sclerotial stage
- Refer black
Gram and
Green gram
- **Alternaria Leaf Blight:** *Alternaria macrospora*
 - **Cercospora Leaf Spot:** *Cercospora gossypii*
 - **Grey or Areolate Mildew:** *Ramularia areola*
 - **Bacterial Blight or Black Arm:** *Xanthomonas campestris* pv. *malvacearum*
1. **Fusarial Wilt:** *Fusarium oxysporum* f. sp. *vasinfectum*

Symptoms

- The disease may appear from early stages of plant growth (4 to 6 weeks old plant) up to flowering and pods formation stage.

Partial Wilting or Wilting of Entire Plants

- The disease appears as gradual withering and drying of plants.
- Yellowing of leaves and blackening of stem starting from collar to branches which gradually result in drooping and premature drying of leaves, stems, branches and finally death of plant.
- Vascular tissues exhibit brown discoloration and plucking of xylem vessels. Often only one side of the stem and root system is affected resulting in partial wilting.

Mode of Spread

- **Primary Source of Inoculum:** Soil borne chlamydozoospores.
- **Secondary Source of Inoculum:** Air borne conidia.

Environment Favorable Conditions

- Soil temperature of 17-25 °C.
- Continuous cultivation of red gram in the same field.
- Root knot nematode.

Management

- Grow resistant cultivars like Jawahar, Maruthi and Pusa-9.
 - Avoid growing of susceptible variety.
 - Selection of seeds from disease free field.
 - Treat the seeds with *Trichoderma viride* at 4 g/kg (10⁶cfu/g).
 - Avoid successive cultivation of red gram in the same field.
 - Crop rotation with tobacco.
 - Mixed cropping with sorghum in the field.
 - Soil drenching with copper oxy chloride (COC) 0.25%.
2. **Wet Root Rot:** *Rhizoctonia solani* and *Sclerotium rolfsii* } Refer black
3. **Dry Root Rot:** *Macrophomina phaseolina*-Pycnidial stage } Gram and
Rhizoctonia bataticola-Sclerotial stage } Green gram
4. **Alternaria Leaf Blight:** *Alternaria macrospora*

Symptom

- It produces reddish brown irregular lesions with concentric ring on the leaf surface.
- When the spots are joining together to form big patches, premature defoliation occurs.

Favorable Conditions

- High atmospheric humidity (85-90%).
- Low temperature (16-20 °C)

Mode of Spread

- The pathogen is externally seed-borne and causes primary infection.
- The secondary infection is through air-borne conidia.

Management

- Treat the seeds with captan or thiram at 2g/kg.
- Foliar spray with Calixin (0.1%) followed by mancozeb at 2kg/ha.

5. Cercospora Leaf Spot: *Cercospora gossypii*

Symptoms

Small, circular spots develop on the leaves with grey centre and brown margin. Several spots coalesce to form brown irregular lesions. In severe cases defoliation occurs.

Favorable Conditions: Humid weather and dense plant population.

Mode of Spread

- Primary source of inoculums-The fungus survives on diseased plant debris and on seeds.
- Secondary spread is by air-borne conidia.

Management

- Avoid growing of susceptible variety.
- Collection and destruction of infected plant debris
- Selection of seeds from disease free field.
- Seed treatment with captan or Thiram 4g/kg of seeds.
- Foliar spray with Benzene group-Chlorothalonil-Kavach (0.1%) followed by organic sulphur-Maneb-Mancozeb (0.25%).

6. Grey or Areolate Mildew: *Ramularia areola*

Symptom

- Irregular to angular pale translucent lesions on lower surface, bound by veinlets and grey powdery growth
- Light green specks on upper surface
- In severe cases whitish grey powdery growth on upper surface. Affected leaves dry up inward, turn yellow and fall prematurely
- Growing the resistant varieties like Sujatha and Varalakshmi.

Management

- Remove and burn the infected crop residues.
- Rogue out the self-sown cotton plants during summer months.

- Avoid excessive application of nitrogenous fertilizers/manures.
- Adopt the correct spacing based on soil conditions and varieties.
- Spray the crop with Carbendazim at 250-375g or wettable sulphur at 1.25-2.0 kg/ha, repeat after a week

7. Bacterial Blight or Black Arm: *Xanthomonas campestris pv. malvacearum*

Symptoms

- Symptoms seen on all the stages of crop growth.
- It produces 5 types of symptoms which include seedling blight, angular leaf spot, vein blight, Black arm and boll rot.
- **Seedling Blight:** Initially it produces reddish brown color depressed spot appears on the young emergence leaves later it will turn into black depressed lesions it is called as Seedling blight.
- **Angular Leaf Spot:** Initially it produces water soaked lesion angular leaf spot present in between vein and vein lets later it will turn into black colour angular leaf spot.
- **Vein Blight:** The angular lesion that spread into flaking of vein and vein lets.
- **Black Arm:** The black lesion spread into down wards which leads to blackening branches.
- **Boll Rot:** Reddish brown depressed spot present on the surface of boll which leads to rotting bolls occurs.

Mode of Spread

- **Primary Source of Inoculums:** Seed borne pathogen.
- **Secondary Source of Inoculums:** irrigation water.

Management

- Seed treatment with acid delinting method (100ml H₂SO₄ per kg of seed) followed by *streptomycin sulphate* (200 ppm).
- Collection and destruction of infected plant debris's.
- Foliar spray with *Streptomycin sulphate* (200ppm) at 10 days intervals.

Chapter - 6

Diseases of Sugarcane, Tobacco and Betelvine

I. Diseases of Sugarcane

Major diseases

1. **Red Rot:** *Colletotrichum falcatum*
2. **Smut:** *Ustilago scitaminea*
3. **Sett Rot or Pineapple Disease:** *Ceratocystis paradoxa*
4. **Sugarcane Mosaic:** *Sugarcane mosaic potyvirus*
5. **Grassy Shoot:** Phytoplasma
6. **Ratoon Stunting:** *Clavibacter xyli* sub sp. *Xyli*

1. Red Rot-*Colletotrichum falcatum*

Symptoms

- The first external symptom appears mostly on third or fourth leaf which withers away at the tips along the margins.
- Typical symptoms of red rot are observed in the internodes of a stalk by splitting it longitudinally.
- These include the reddening of the internal tissues which are usually elongated at right angles to the long axis of the stalk.
- The presence of cross-wise white patches are the important diagnostic character of the disease.
- The diseased cane also emits acidic-sour smell. As the disease advances, the stalk becomes hollow and covered with white mycelial growth.

Favourable Conditions

- Mono culturing of sugarcane.
- Successive ratoon cropping.
- Water logged conditions and injuries caused by insects.

Mode of Spread

- The primary infection is mainly from infected setts.
- Secondary spread in the field is through irrigation water and cultivation tools. The rain splash, air currents and dew drops also help in the spread of conidia from the diseased to healthy plants in the field.

Management

- Adopt crop rotation by including rice and green manure crops.
- Select the setts from the disease free fields or disease free areas.
- Avoid ratooning of the diseased crop.
- Soak the setts in 0.1% Carbendazim or Triadimefon 0.05% solution for 15 minutes before planting.
- Grow resistant varieties CO 62198, CO 7704 and moderately resistant varieties CO 8001, CO8201.
- Setts can be treated with aerated steam at 52 °C for 4 to 5 hours and by moist hot air at 54 °C for 2 hours.

2. Smut-*Ustilago scitaminea*

Symptoms

- The affected plants are stunted and the central shoot is converted into a long whip-like, dusty black structure.
- The length of the whip varies from few inches to several feet. In early stages, this structure is covered by a thin, white papery membrane.
- The whip may be straight or slightly curved. On maturity it ruptures and millions of tiny black smut spores (teliospores) are liberated and disseminated by the wind. Affected plants are usually thin, stiff and remain at acute angle.
- The whip like structure, representing the central shoot with its various leaves, may be produced by each one of the shoots/tillers arising from the clump.

Favourable Conditions

- Monoculturing of sugarcane.
- Continuous ratooning and dry weather during tillering stage.

Mode of Spread

- The primary spread of the disease is through diseased seed-pieces (setts).
- The secondary spread in the Symptoms field is mainly through the smut spores developed in the whips, aided by air currents. The fungus also survives on collateral hosts like *Saccharum spontaneum*, *S. robustum*, *Sorghum vulgare*, *Imperata arundinacea* and *Cyperus dilatatus*.

Management

- Plant healthy setts taken from disease free area.
- Remove and destroy the smutted clump (collect the whips in a thick cloth bag/polythene bag and immerse in boiling water for 1 hr to kill the spores).
- Discourage ratooning of the diseased crops having more than 10 per cent infection.
- Follow crop rotation with green manure crops or dry fallowing.
- Growing of red gram as a companion crop between 2 rows of sugarcane.
- Growing of resistant varieties like Co 7704 and moderately resistant varieties COC 85061 and COC 8201.

3. Sett Rot or Pineapple Disease-*Ceratocystis paradoxa*

Symptoms

- The disease primarily affects the setts usually two to three weeks after planting.
- The affected tissues first develop a reddish colour which turns to brownish black in the later stages. The severely affected setts show internode cavities covered with the mycelium and abundant spores.
- A characteristic pineapple smell is associated with the rotting tissues. T
- The setts may decay before the buds germinate or the shoots may die after reaching a height of about 6-12 inches. Infected shoots are stunted.

Favourable Conditions

- Poorly drained fields.
- Heavy clay soils.

- Temperature of 25-30 °C.
- Prolonged rainfall after planting.

Management

- Soak the setts in 0.05% Carbendazim 15 minutes.
- Use long setts having 3 or 4 buds.
- Provide adequate drainage during rainy seasons.

4. Sugarcane Mosaic-*Sugarcane mosaic potyvirus*

Vector *Aphids-Aphis gossypii*

Symptoms

- The disease appears more prominently on the basal portion of the younger foliage as chlorotic or yellowish stripes alternate with normal green portion of the leaf.
- As infection becomes severe, yellow stripes appear on the leaf sheath and stalks. Elongated necrotic lesions are produced on the stalks and stem splitting occurs.
- The necrotic lesions also develop on the internodes and the entire plant becomes stunted and chlorotic.

Management

- Roguing of infected plants and use of disease free planting material.
- Chemical sprays to manage the insect vector population in early crop stage.
- Grow mosaic-resistant or, at least, tolerant varieties.
- Breeding mosaic-resistant varieties is needed.
- *Saccharum spontaneum* L. and *S. barberi* (Jesuit) carry resistance to mosaic and so varieties with this background must be preferred.
- Rogue out the diseased clumps periodically.
- Select setts from the healthy fields as the virus is sett-borne. Aerated Steam Therapy (AST) at 56 °C for 3hrs, for setts before planting is advised.

5. Grassy Shoot-Phytoplasma

- The pathogen is transmitted by aphid's viz., *Rhopalosiphum maydis*.

Symptoms

- The disease appears nearly two months after planting.
- The disease is characterized by the production of numerous lanky tillers from the base of the affected shoots.
- Leaves become pale yellow to completely chlorotic, thin and narrow
- The plants appear bushy and ‘grass-like’ due to reduction in the length of internodes premature and continuous tillering. The affected clumps are stunted with premature proliferation of auxiliary buds.
- Cane formation rarely occurs in the affected clumps, if formed, thin with shorter internodes having aerial roots at the lower nodes.
- The buds on such canes usually papery and abnormally elongated.

Management

- Eradication of diseased parts as soon as symptoms are seen.
- Avoid selection of setts from diseased area.
- Pre-treating the healthy setts with hot water at 52 °C for 1 hour before planting and treating them with hot air at 54 °C for 8 hours.
- Spraying the crop twice a month with insecticides.

6. Ratoon Stunting-*Clavibacter xyli* sub sp. *xyli* (Rickettsia Like Organism-RLO)

Symptoms

Diseased clumps usually display stunted growth, reduced tillering, thin stalks with shortened internodes and yellowish foliage. Orange-red vascular bundles in shades of yellow at the nodes are seen in the infected canes.

Management

- Select the setts from disease free fields or from disease free commercial nursery.
- Remove and burn the clumps showing the disease incidence.
- Treat the setts before planting, as specified for grassy shoot disease.

II. Diseases of Tobacco

1. **Damping off:** *Pythium aphanidermatum*, *Pythium debaryanum*

Symptom

- Damping off is a serious problem in tobacco nurseries both in heavy clay soils and light sandy soils.
- It is caused by several soil inhabiting fungi predominant being *Pythium aphanidermatum*, *pythium debaryanum*, *Phytophthora* sp. and some times *Rhizoctonia solani* are also involved.
- The disease may appear at any stage of the seedlings but maximum damage is observed 5-6 weeks after sowing.

Disease is noticed in Two Phases, viz.

- **Pre-Emergence Damping-off:** Seedlings are infected which die before emergence from the soil resulting in poor and uneven stand of the seedlings
- **Post-Emergence Damping-off:** Post emergence damping- off is the most destructive phase. The older seedlings show shriveling and brown discoloration of the stems near the soils and start rotting under wet soil conditions. The decayed stems collapse and seedlings topple over leaving parchment like brown crust over the soil.

Management

- Deep ploughing in summer destroys the fungus
- Preparation of raised seed beds 15 cm high with channels around to provide drainage
- Rabbing the seed bed before sowing with slow burn farm waste materials like paddy husk, tobacco stubbles and waste grass etc.,
- Use seed rate 3 g/ha only to avoid over crowding of seedlings.
- Regulate watering to avoid excessive dampness on bed surface.
- Bordeaux mixture 0.4% @ (40 gm of copper sulphate +40 gm of lime in 10litres of water) or Copper oxychloride @ 0.2% (20gm in 10litres of water) is to be applied with rose can to a bed of 10 sq. m area 2 weeks after sowing.
- Two to three spray drenchings of beds with 0.2% Metalaxyl commencing three weeks after seed sowing (20 g of Metalaxyl in 10 l of water).

2. Black Shank: *Phytophthora parasitica* var. *nicotianae*

Symptom

- It appears both in nursery as well as in the field.
- Black shank occurs sporadically in every type of tobacco and causes more damage, to tobacco grown under high rainfall or irrigated conditions in light soils.
- In nursery the affected seedlings show blackening of roots and stem near soil.
- Under such conditions large circular, black or brown water-soaked lesions appear on the basal leaves.
- In the field blackening starts at the collar region and spreads both downwards and upwards causing rotting and necrosis of the whole stem including basal leaves.
- First sign of infection seen in the vigorously growing plants is yellowing of leaves, sudden wilting and ultimately death of plants under warm weather.
- The disease appears in scattered patches in the field.
- The stems of such plants when split open show brown to black dried pith in disc like plates characteristic of black shank.

Management

- It can be checked in the nursery by rabbing the seedbeds or drenching the seedbeds with 0.4% Bordeaux mixture 2 days before sowing to minimize the initial inoculum potential.
- Subsequent application of fungicides like 0.2% Copper oxychloride is essential for checking leaf blight and seedling blight.
- At the time of transplanting, seedlings with blackened stem should be discarded to prevent spread of disease to field.
- Sanitary measures like removal and destruction of the affected plants and disinfecting the spots with 0.4% Bordeaux mixture drench will prevent spread of the disease in the main field.
- Leaf blight phase of the disease can be checked by spraying 0.2% Mancozeb.

3. Leaf Curl-*Tobacco leaf curl virus* (white fly-*Bemisia tabaci*)

Symptom

- Leaf curl, is fairly widespread in all tobacco tracts in India.
- The most characteristic symptom of tobacco leaf-curl disease is the production of leafy outgrowths known as enations from the veins on the lower surface of the leaves.
- Combined with this, is a stunting of the whole plant and twisting and curling of the leaves.

Management

- Remove and destroy the diseased tobacco seedlings before and after planting whenever they are seen in the field. Fill the gaps with healthy seedlings if it is not too late.
- Alternate weed hosts for whitefly should be removed and destroyed.
- In endemic areas *Sesbania* sp. may be grown as a barrier crop around tobacco fields.
- Install 12 yellow sticky traps (castor oil coated) per hectare to monitor the whitefly population.
- If 100-200 whiteflies stick to the trap the following insecticide schedule has to be adopted.
- 1st spray Chlorpyrifos 20% E.C. @ 25 ml. In 10 litres of water
2nd spray Monocrotophos 36%, W.S.C. @ 15 ml in 10 litres of water
3rd spray Acephate 75% S.P. @ 10 gm in 10 litres of water
4th spray Demeton-s-methyl 25% E.C. @ 15 ml in 10 litres of water
- Spraying has to be done preferably in the evening hours (4-6 P.M) with high volume spraying and it should be ensured that the under side of the leaves also is covered.
- Further the spraying schedule has to be adopted on community basis.

4. Mosaic: Tobacco Mosaic Virus (*Aphid-Myzus persicae*)

- Affected plants show leaves with molting or mosaic pattern of light green and dark-green areas.
- Primary symptoms appear on newly formed young leaves as vein clearing, greenish yellow motling.

- Infection on young plants results in stunted growth, malformation, distortion and puckering of leaves.
- Immature leaves show varying degree of yellow motling and chlorosis.
- In severe infection due to a highly virulent strain of TMV, various necrotic dark-brown spots also develop resulting into 'mosaic scorch' or 'mosaic burn' under hot sunny dry spell, damaging large areas of lamina.
- TMV is highly contagious and transmitted by sap

Management

- Best effective way is to keep the crop mosaic free.
- Infected seedlings should be removed promptly and destroyed.
- Workers should disinfect their hands with soap and running water before handling seedlings, weeding or doing other cultural operations.
- Use of tobacco (smoke, snuff, or chewing) should be prohibited strictly while working in seedbeds or field.
- Weeds (*Solanum nigrum*) and plant (Brinjal, Tomato, Chillies) susceptible to the virus should be destroyed.
- In fields showing high incidence of mosaic, rotation for 2 years should be followed.

Chapter - 7

Diseases of Mango, Banana and Grapevine

I. Disease of Mango

1. Powdery Mildew-*Oidium mangiferae*

Symptoms

- Powdery mildew is one of the most serious diseases of mango affecting almost all the varieties.
- The characteristic symptom of the disease is the white superficial powdery fungal growth on leaves, stalks of panicles, flowers and young fruits.
- The affected flowers and fruits drop pre-maturely reducing the crop load considerably or might even prevent the fruit set.
- Rains or mists accompanied by cooler nights during flowering are congenial for the disease spread. The fungus parasitizes young tissues of all parts of the inflorescence, leaves and fruits.

Mode of Spread

- Primary Source of Inoculums-fungus survives in the soil through cleistothecia
- Secondary source of inoculums-Air borne conidia

Environment Favorable Conditions-Dry humid weather following rainfall.

Management

- Growing of resistant variety
- Avoid growing of susceptible variety
- Selection of seeds from disease free field.
- Collection and destruction of dried leaves.
- Seed treatment with captan or thiram 4g per kg of seeds.
- Foliar spray with chemicals-Following three sprays of fungicides at 15 days interval recommended for effective control of the disease

Non Systemic Fungicides

- Sulphur fungicides group-inorganic sulphur-elemental sulphur-wettable powder (sulfex, solbar) should be apply all powdery mildew disease except rose, pear and peach crops.
- Benzene group-Dinocap-karathane 0.05%.

Systemic Fungicides

- Morpholine-Tridemorph-calixin (0.1%).
- Triazole group-Propiconazole-Tilt (0.1%).
- Triazole group-Hexaconazole-cantal-(0.1%).

2. Anthracnose-*Gloeosporium gloeosporioides*

Symptoms

- The anthracnose disease is of widespread occurrence.
- The disease produces leaf spot, blossom blight, dry up tip; twig blight and fruit rot symptoms.
- Tender shoots and foliage are easily affected which ultimately cause 'die back' of young branches.
- Older twigs may also be infected through wounds which in severe cases may be deadly.
- Black spots develop on panicles as well as on fruits. Severe infection destroys the entire inflorescence resulting in no setting of fruits.
- Young infected fruits develop black spots shrivel and drop off.
- Fruits infected at mature stage carry the fungus into storage and cause considerable loss during storage, transit and marketing. The fungus is responsible for on twigs and leaves of mango or other hosts.

Management

- Growing of resistant variety
- Avoid growing of susceptible variety
- Selection of seeds form disease free filed.
- Collection and destruction of dried leaves.
- Seed treatment with captan or thiram 4g per kg of seeds.
- Trees may be sprayed twice with Bavistin (0.1%) at 15 days interval during flowering to control blossom infection.

- Spraying of copper fungicides (0.3%) is recommended for the control of foliar infection.

3. Sooty Mould-*Capnodium mangiferae*

Symptoms

- The disease in the field is recognizing by the presence of a black velvety coating, i.e., sooty mould on the leaf surface.
- In severe cases the trees turn completely black due to the presence of mould over the entire surface of twigs and leaves.
- The severity of infection depends on the honey dew secretion by the above said insects.

Management

- Pruning of affected branches and their prompt destruction prevents the spread of the disease.
- Spraying of 5 to 10 per cent starch is found effective.
- It could also be controlled by spray of Natrasul + Metacin + gumacasia (0.2% + 0.1% + 0.3%)

4. Grey Blight-*Pestalotia mangiferae*

Symptoms

- It produces irregular reddish brown color lesions with dark brown margin and white is grey centre with numerous black color spot which represents the acervulai.

Management

- Growing of resistant variety.
- Avoid growing of susceptible variety.
- Selection of seeds form disease free filed.
- Collection and destruction of dried leaves.
- Seed treatment with captan or thiram 4g per kg of seeds.
- Spraying of copper fungicides (0.3%) is recommended for the control of foliar infection.

5. Bacterial Leaf Blight-*Xanthomonas campestris* pv. *mangiferae indicae*

Symptoms

- The disease is found on leaves, petioles, twigs, branches and fruits, initially producing water-soaked lesions and later turning into typical cankers.
- The disease first appears as minute water-soaked irregular lesions on any part of leaf or leaf lamina.
- The lesions are light yellow in colour but with age, enlarge and turn dark brown to black.
- They become angular, cankerous and raised, and are surrounded by chlorotic halos.
- Several lesions coalesce to form irregular necrotic cankerous patches. In severe infections the leaves turn yellow and drop off.
- Cankerous lesions appear on petioles, twigs and young fruits.

Management

- Seedling certification, inspection and orchard sanitation.
- Three sprays of streptomycin (100 ppm) or Agrimycin-100 (100 ppm) after first visual symptom at 10-days intervals.
- Monthly sprays of Bavistin (1000 ppm) or copper oxychloride (3000 ppm) were also found effective.

Precautions

- Do not wait for appearance of the disease.
- The key to success for full control is to start application of fungicides before the infection has established.

6. Red Rust-*Cephaleuros virescens*

Symptoms

- Red rust disease, caused by an alga, has been observed in mango growing areas.
- The algal attack causes reduction in photosynthetic activity and defoliation of leaves thereby lowering vitality of the host plant.
- The disease can easily be recognized by the rusty red spots mainly on leaves and sometimes on petioles and bark of young twigs and is epiphytic in nature.

- The spots are greenish grey in color and velvety in texture. Later, they turn reddish brown.
- The circular and slightly elevated spots sometimes coalesce to form larger and irregular spots.
- The affected areas crack and scale off. In severe infection the bark becomes thickened, twigs get enlarged but remain stunted and the foliage becomes sparse and finally dries up.

Management: Two to three sprays of copper oxy chloride (0.3%) is effective in controlling the disease.

7. Phanerogamic Parasite-Loranthus (Partial Stem Parasites)

Symptoms

- Drying of plants
- It produces peg like structures for the purpose of attachment of the host. Then it produces green leaves and fruits which are light brown or red colour berries.
- The red color fruits are attracted by the insects.

Management

- Collection and destruction of infected plants.
- Burning of infected plants with parasites.

II. Disease of Banana

1. Panama Disease or Fusarial Wilt-*Fusarium oxysporum f. sp. cubense*

- This is a soil-borne fungal disease and gets entry in the plant body through roots.
- It is most serious in poorly drained soil.
- Initial symptoms are yellowing of lower leaves, including leaf blades and petioles.
- The leaves hang around the pseudo stem and wither.
- In the pseudo stem of the diseased plant, yellowish to reddish streaks are noted with intensification of colour towards the rhizome.
- Wilt is severe in poor soil with continuous cropping of banana. Warm soil temperature, poor drainage, light soils and high soil moisture are congenial for the spread of the disease.

Mode of Spread

- Primary source of inoculumsoil borne pathogen.
- Secondary source of inoculumsoil-Burrowing nematode.

Management

- Severely affected plants should be uprooted and burnt.
- Highly infected soil should not be replanted with banana at least for 3-4 years.
- Use of disease-free planting material and resistant cultivar are recommended.
- Cultural method for Corm injection – 3ml of 2% carbendazim
- Growing of paddy followed by banana for 3-5 years once or twice, use of quick lime near the base of the plant and soaking with water and avoiding sunflower or sugarcane in crop rotation helps to reduce the disease incidence.
- Dipping of suckers in Carbendazim (10g/10 litres of water) followed by bimonthly drenching starting from 6 months after planting is also recommended.
- Pairing and pralinage methods to avoid the burrowing nematode infection
- Application of bio agents, such as, *Trichoderma viride* or *Pseudomonas fluorescense* in the soil is effective.

2. Anthracnose-*Gloeosporium musae*

Symptoms

- The disease attacks banana plants at all stages of growth.
- Disease attacks the flowers, skin and distal ends of banana heads.
- The symptoms appear as large brown patches covered with a pink growth of the fungus.
- The disease fruit turns black and the fruit is shriveled.

Management

- Spraying of Chlorothalonil (0.2%) and Bavistin (1%) four times at 15 day's interval is recommended.
- Minimizing bruising; proper sanitation of handling and prompt cooling to 14 °C are essential in minimizing the disease in cold storage.

- In bunches spray with Calixin 0.1% at 30 days before harvest should be mixed with tepal for stickiness purpose.

3. Leaf Spot or Sigatoka Disease

- **Yellow Sigatoka:** *Mycosphaerella musicola*
- **Black Sigatoka:** *Mycosphaerella fijiensis*

Symptoms

- Yellow sigatoka is one of the serious diseases affecting the banana crop.
- Mature leaves are mostly affected.
- Initial symptoms appear in the form of light yellowish spindle shape on the leaf margin.
- A small number of these enlarge, become oval; the colour also changes to dark brown.
- Still later, the centre of the spot dies, turning light grey surrounded by a brown ring.
- In severe cases, numerous spots coalesce, killing large parts of the leaf. Rainfall, dew and temperature determine the spread of the disease.
- Conditions favoring mass infection are most common during the rainy season with temperature above 21 °C.

Management

- Adaptation of Pairing and pralinage method.
- Collection and destruction if infected plant debris's.
- Foliar spray with Calixin 0.1% + Tepal 1ml per liter after 15 days should be spray with Chlorothalonil-Kavach (0.25%).

4. Freckle Leaf Spot or Black Spot-*Phyllosticta musarum*

Symptoms

- Infections occur only in matured leaves.
- Numerous black raised spot present on the surface of leaves. Later the infected leaf are dried.

Symptoms

- Collection and destruction of lower leaves.

- Removal of primary inoculums.
- Foliar spray with Calixin (0.1%).

Bacterial Disease

1. Bacterial Wilt or Moko Disease-*Pseudomonas solanacearum*

Symptoms

- The young plants are affected severely.
- In the initial stages the bacterial wilt is characterized by the yellowish discoloration of the inner leaf lamina close to the petiole.
- The leaf collapses near the junction of the lamina with the petiole. Within a week most of the leaves exhibit wilting symptoms.
- The presence of yellow fingers in an otherwise green stem often indicates the presence of moko disease.
- The most characteristic symptoms appear on the young suckers that have been cut once and begin re growth. These are blackened and stunted. The tender leaves from the suckers turn yellow and necrotic.

Management

- Early detection and destruction of the suspected plants may help in preventing the spread of the disease.
- All the tools used for pruning and cutting should be disinfected with formaldehyde.
- Foliar spray with streptomycin sulphate 200 to 250 ppm.
- Soil drenching with sodium hydroxide (bleaching powder) to remove the soil borne bacteria

Viral Disease

1. Banana Bunchy top disease: *Banana Bunchy Top Virus* (BBTV)

Aphid vector-Pentalonia nigronervosa

Symptoms

- Primary symptoms of the disease are seen when infected suckers are planted. Such infected suckers put onward narrow leaves, which are chlorotic and exhibit mosaic symptoms.
- The affected leaves are brittle with their margins rolled upwards.
- Characteristic symptom of bunchy top virus is the presence of interrupted dark green streaks along the secondary veins of the lamina or the midrib of the petiole.

- The diseased plants remain stunted and do not produce bunch of any commercial value.

Management

- Systematic eradication of the diseased plants, suckers and the clumps is very essential.
- Planting materials should not be collected from places affected by this disease.
- The aphid should be controlled to check spread of the disease by spraying with Metasystox (0.1-0.5%).
- Plants adjacent to the healthy plants should also be sprayed.
- The affected plant should be killed with kerosene or herbicides such as 2, 4-D or 2, 4, 5-T.
- The rhizome should be dug out, cut into small sections and sprayed again so that no suckers can be produced which may harbour the virus.

2. Banana Bract Mosaic Disease-*Banana Bract Mosaic Virus (BBMV)*

Symptoms

The symptoms appear as yellow or pinkish green bands or mottling over an entire area of young leaves. The affected leaves show abnormal thickening of veins. Bunch development is affected.

Management

- Removal and destruction of affected plants along with rhizome.
- Growing cucurbits in and around banana field should be avoided.

3. Infectious Chlorosis or Mosaic Virus-*Cucumber mosaic virus*

- The aphid vector *Aphis gossypii* transmits the disease.

Symptoms

- The disease is characterized by typical mosaic symptoms on the leaves.
- Mosaic plants are easily recognized by their dwarf growth and mottled, distorted leaves.
- The earliest symptoms appear on young leaves as light green or yellowish streaks and bands giving a mottled appearance.

Management

- The plantation should be kept free from weeds.
- Suckers from infected clumps should not be used for planting.
- Weeds in the nearby area should be removed as the virus survives in them during offseason.
- Use of suitable insecticide to reduce spread of the disease is also suggested.

III. Grapevine Diseases

1. Downy Mildew-*Plasmopara viticola*

Symptoms

Leaves: Roughly circular yellowish discolorations present on the leaf surface are called oil spots. White colour growth present on particularly lower leaf surface. The spots turn brown with time and severely infected leaves may drop.

Shoots: Infected shoot tips curl and a white down occurs on the stem

Inflorescences: During severe infections, they can turn yellow, brown, and then dry out completely. They may also exhibit the cork-screwing observed in infected shoots.

Berries: Berries that exhibit sporulation when they are shot-size may shrivel and drop off. Infected berries of red varieties turn colour prematurely while those on white varieties acquire a mottled appearance. Infected berries tend to stay hard when the rest of the cluster starts to soften at version.

Mode of Spread

- Primarily by soil borne oospore
- Secondarily by air borne sporangiospore

Management

- Remove infected plant debris
- Spray Metalaxyl 0.1 %

2. Powdery Mildew-*Erysiphe necator*; (*Uncinula necator*)

Symptoms

Leaves: The first powdery mildew lesions are frequently found on the undersides of leaves. As the epidemic progresses, lesions become apparent on the upper sides of leaves as well. These lesions will increase in size and

number if the disease is left unchecked. Severely infected leaves may become brittle and drop off.

Shoots: Brown to black irregular blotches that can measure up to a few centimeters, follow the gradual collapse of the fungus over the way of the season.

Inflorescences and Rachis: Usually seen on rachis, powdery mildew has the appearance of a grey to whitish powder. Severe infections of the rachis can result in clusters being dropped, especially if mechanical harvesting is done.

Management

- Spray wet table sulphur 0.25% or dinocap 0.1%

3. Anthracnose-*Elsinoe ampelina*

Symptoms

Leaves: The fungus will cause small round spots which give way to small holes (leaving a 'shot-hole' appearance). During severe infections, the leaves shrivel up and drop.

Shoots: Deep elongated cankers, greyish in the centre with a black edge.

Inflorescences: Inflorescences are highly susceptible. During severe infections, they can turn yellow, brown, then dry out completely.

Berries: Deep spots, violet turning greyish in the centre, with a black edge. Severely infected berries dry up and drop prematurely.

Management

- Foliar spraying with Carbendazim 0.1 % or Mancozeb 0.1 %

4. Grey mould-*Botrytis cinerea*

Symptoms: (*Botrytis cinerea* is found in most fruit crops, including grapes)

Leaves: Although the clearest symptoms are on the berries, *B. cinerea* can infect the green leaves and cause necrotic brown spots.

Inflorescences: Inflorescences can also be infected causing the inflorescences to dry out or latent infections visible only at version.

Berries: Infected berries become covered with a greyish felt-like substance consisting of spores of the fungus. At that stage, *B. cinerea* is capable of directly infecting the berries which become more susceptible as they mature and their sugar content increases.

Chapter - 8

Diseases of Sapota, Pomegranate and Papaya

I. Diseases of Sapota

1. Leaf Spot (*Phaeophleospora indica*)

The disease is characterized by numerous, small, pinkish to reddish brown spots with whitish centers in the leaf.

Control

Spraying Dithane Z-78 or Topsin or Bavistin @0.1% at monthly intervals can control the disease.

2. Sooty Mould (*Capnodium sp.*)

- It is a fungal disease developed on honeydew-like excretion secreted by mealy bugs.
- The fungus slowly covers the entire leaf area severely affecting the process of photosynthesis.
- This results in reduced translocation of food to the fruits, which leads to reduction in their size.

Control: Spraying with 40g Zineb in 18 litres of water gives effective control.

3. Flat Leaf/Fasciation (*Botryodiplodia theobromae*)

The branches become flattened. These flattened branches are often rough, corrugated and twisted at the tip.

Control

Removing and destroying the flattened shoots can control the disease

II. Pomegranate

1. Cercospora Leaf Spot: *Cercospora punicae*

Symptoms

- Leaf spots are minute, brown with yellow halo.
- Spots are scattered, circular or irregular and become dark brown with age.

- Spots on lower side are sunken with clusters of spore bearing structures hence greyish in colour.
- Minute, circular, black spots appear on sepals of the flower.
- Fruit spots are black, minute and circular on rind.
- When grow old, become large, irregularly circular and depressed presenting an ugly look to the fruits.

Management

- Spray Thiophanate-methyl @ 1 g/l, Carbendazim 1g/l, Hexaconazole 1 ml/l or Propiconazole 1 ml/l for effective control.

2. Cercospora Fruit Spot: *Cercospora puniceae*

Symptoms

- Light zonate brown spots appear on the leaves and fruits. Black and elliptic spots appear on the twigs.
- The affected areas in the twigs become flattened and depressed with raised edge.
- Such infected twigs dry up. In severe cases the whole plant dies.
- Primary source of inoculums is infected leaves, diseased plant debris.
- Secondary source of inoculums is wind born conidia. The disease is serious during September to November.

Management

Cultural

- The diseased fruits should be collected and destroyed.
- Pruning and destruction of diseased twigs.

Chemical

- Spray the crop with Hexaconazole 5 EC or Propiconazole 25 EC or Difenconazole 25 EC @ 1 ml/lit.
- Kitazin 48 EC 2 ml/lit or Carbendazim (1g) or Chlorothalonil 75 WP (2.5 g) or Copper oxychloride 50 WP (3 g) per lit.
- Thiophanate methyl/Carbendazim @ 1g/lit were most effective.
- Among the contact fungicides Chlorothalonil @ 2ml followed by Mancozeb @ 2g were more efficacious.

3. Bacterial Blight: *Xanthomonas axonopodis* pv. *punicae*

Symptoms

- Appearance of one to several small water soaked, dark colored irregular spots on leaves resulting in premature defoliation under severe cases.
- The pathogen also infects stem and branches causing girdling and cracking symptoms.
- Spots on fruits were dark brown irregular slightly raised with oily appearance, which split open with L-shaped cracks under severe cases.

Mode of Spread

- Primary source of inoculum is infected cuttings.
- Secondary source of inoculum is Wind splashed rains.

Management

Cultural

- Wide row spacing
- Selection of disease free seedlings for fresh planting
- Pruning affected branches, fruits regularly and burning
- Give minimum four month rest after harvesting the fruits

Chemical

- Before pruning it should be sprayed with 1% Bordeaux mixture
- After Ethrel spraying or defoliation, Paste or smear with 0.5g Streptomycin Sulphate + 2.5g Copper oxy chloride + 200g red oxide per lit of water.
- Spray 0.5 g Streptomycin Sulphate or Bactrinashak +2.5 g Copper oxy chloride per litre of water.
- Next day or another day spray with 1 g ZnSO₄ +1 g MgSO₄ +1 g Boron +1g CaSO₄ per lit of water.

4. Alternaria Fruit Spot: *Alternaria alternata*

Symptoms

- Small reddish brown circular spots appear on the fruits.
- As the disease advances these spots, coalesce to form larger patches and the fruits start rotting.

- The fruits get affected which become pale and become unfit for consumption.

Management

Cultural

- All the affected fruits should be collected and destroyed.

Chemical

- Spraying Mancozeb (0.25%) or Captaf (0.25%) effectively controls the disease.

III. Papaya

1. Foot rot of papaya
2. Anthracnose
3. Powdery mildews
4. Papaya ring spot disease
5. Papaya mosaic disease
6. Papaya leaf curl disease

1. Foot Rot of Papaya

Symptoms

- It is characterized by the appearance of water-soaked patches on the stem near the ground level.
- These patches enlarge rapidly and girdle the stem, causing rotting of the tissues, which then turn dark brown or black. Such affected plants withstand strong wind and topple over and die.
- If the disease attack is mild, only one side of the stem rots and the plants remain stunted.
- Fruit if formed are shriveled and malformed. Gradually the plant dies.

Survival and Spread

- Resting spore, Oospores, germinates and release zoospores which along with irrigation water spread throughout the field.

Favorable Condition

- High relative humidity and rainy condition favors the severe disease development in sick soil.

Management

- Seed treatment with captan @ 4 g/kg
- Raise the seedlings in well drained soil and avoid water logging condition.
- Remove diseased seedlings carefully and burn
- Drench the stem base with Bordeaux mixture 1.0% or captan 0.2% or copper oxychloride 0.25% or metalaxyl 0.1% or tridemorph 0.1%.

2. Anthracnose

Symptoms

- Disease occurs both in field and in storage conditions.
- The spots on fruits first appear as brown superficial discolouration of the skin which develops into circular, slightly sunken areas and 1 to 3cm in dia.
- Gradually the lesions coalesce and sparse mycelia growth appears on the margins of the spots.
- Under humid conditions, an encrustation of salmon pink spores is released.
- Infection at early stages of fruit results in mummification and deformation.

Survival and Spread

- The disease is spread through wind-borne conidia.
- Conidia are also spread by rain splashes.
- Severity of the disease on foliage is increased under conditions of excessive moisture. Lesions develop more slowly on the immature fruits than on the mature fruits.

Favorable Conditions

- High relative humidity coupled with higher temperatures favour disease development. Maximum disease development takes place at about 26 °C under wet weather condition.

Management

- Spraying of carbendazim 0.1% or chlorothalonil 0.2% or mancozeb 0.2% or thiophanate methyl 0.1% is effective.

3. Powdery Mildew

Symptoms

- Whitish powder growth present on the lower surface of the leaves.
- On upper surfaces, leaves at the infection site show blotches of yellow or pale green usually near vein, surrounded by normally colored tissue.
- Severely infected leaves may become chlorotic and distorted before falling. Affected fruits are small in size and malformed.

Survival and Spread

- The powdery mildew fungus overwinters in dormant buds.
- Secondary spread of the disease can occur if spores are produced in these new infections

Favorable Condition

- The development of powdery mildew in papaya is favour by relative humidity around 80-85% and temperature range of 24-26 °C.

Management

- Spray wettable sulphur 0.3%/triadimefon 0.1%/carbendazim 0.1%.

4. Papaya Ring Spot Disease

Symptoms

- Infected plant initially shows chlorosis on youngest leaves followed by vein clearing, rugosity and prominent mottling of laminae.
- Malformation and reduction of the lamina which may become extremely filiform.
- Characteristically elongated dark green streak develop on petiole and upper half of the stems, infected fruits show circular concentric rings causes upto 56-60% yield loss.
- Pathogen belongs to Potyvirus group of Potyviridae family.

Transmission and Favorable Conditions

- Disease is aphid transmitted and aphids are more active during warmer conditions.
- PRSV is also easily transmitted via mechanical inoculation but there are no confirmed reports of PRSV transmission through seeds.

Management

- Use of healthy planting material.
- Periodical roguing.
- Control of insect vector using systemic insecticides.

Spray ground nut oil 1%

5. Papaya Mosaic Disease

Symptoms

- Causes leaf mosaic and stunting in papaya.
- Young seedlings in the greenhouse show vein-clearing and downward cupping of the leaves about 5 days after inoculation.
- A mottle or mosaic develops after 15-20 days.
- Symptoms appear on the young leaves of the plants.
- The leaves are reduced in size and show blister like patches of dark-green tissue, alternating with yellowish-green lamina.
- The leaf petiole is reduced in length and the top leaves assume an upright position.

Transmission and Favorable Conditions

- Papaya mosaic diseases is mechanically transmissible viruses associated with other viral disease, from papaya mosaic virus in being *aphid-borne* and restricted in host range to papaya and cucurbits.

Management

- Use of healthy planting material.
- Periodical roguing.
- Control of insect vector using systemic insecticides.

Spray ground nut oil 1%

6. Papaya Leaf Curl Disease-Spread by Whitefly *Bemisia tabaci*

Symptoms

- Curling, crinkling and distortion of leaves, reduction of leaf lamina, rolling of leaf margins inward and downward, thickening of veins.
- Leaves become leathery, brittle and distorted.

- A plant shows stunted growth.
- Affected plant does not produce flowers and fruits.
- Sometimes all the leaves at the top of the plant are affected by these symptoms. In advanced stages of the disease, defoliation takes place and the growth of the plant is arrested.
- It is not transmitted mechanically. The virus vector is the silver leaf whitefly, *Bemisia tabaci*.

Transmission and Favorable Conditions

- The virus cannot be transferred mechanical means as in the case of mosaic disease. The virus readily transmitted through grafting and white fly (*Bemisia tabaci*).

Management

- Use of healthy planting material.
- Uproot the affected plants.
- Avoid growing collateral hosts (Tomato, tobacco) near papaya.
- Insect vectors can be checked with 0.1%, dimethoate or other systemic insecticides at 10-12 days interval.

Chapter - 9

Diseases of Tomato, Chilli and Brinjal

I. Disease of Tomato

1. Damping off: *Pythium aphanidermatum*

Symptoms

- Damping off of tomato occurs in two stages, i.e. the pre-emergence and the post-emergence phase.
- In the pre-emergence phase the seedlings are killed just before they reach the soil surface.
- The young radical and the plumule are killed and there is complete rotting of the seedlings.
- The post-emergence phase is characterized by the infection of the young, juvenile tissues of the collar at the ground level.
- The infected tissues become soft and water soaked. The seedlings topple over or collapse.

Management

- Used raised seed bed.
- Provide light, but frequent irrigation for better drainage.
- Drench with Copper oxychloride 0.2% or Bordeaux mixture 1%.
- Seed treatment with fungal culture *Trichoderma viride* (4 g/kg of seed) or Thiram (3 g/kg of seed) is the only preventive measure to control the pre-emergence damping off.
- Spray 0.2% Metalaxyl when there is cloudy weather.

2. Early Blight: *Alternaria solani*

Symptoms

- This is a common disease of tomato occurring on the foliage at any stage of the growth.
- The fungus attacks the foliage causing characteristic leaf spots and blight.

- Early blight is first observed on the plants as small, black lesions mostly on the older foliage.
- Spots enlarge, and by the time they are one-fourth inch in diameter or larger, concentric rings in a bull's eye pattern can be seen in the center of the diseased area.
- Lesions attain considerable size, usually involving nearly the entire fruit; concentric rings are also present on the fruit.

Management

- Removal and destruction of crop debris.
- Practicing crop rotation helps to minimize the disease incidence.
- Spray the crop with Mancozeb 0.2% for effective disease control.

3. Fusarium Wilt: *Fusarium oxysporum* f. sp. *lycopersici*

Symptom

1. The first symptom of the disease is clearing of the veinlets and chlorosis of the leaves.
2. The younger leaves may die in succession and the entire may wilt and die in a course of few days. Soon the petiole and the leaves droop and wilt.
3. In young plants, symptom consists of clearing of veinlet and dropping of petioles. In field, yellowing of the lower leaves first and affected leaflets wilt and die.
4. The symptoms continue in subsequent leaves. At later stage, browning of vascular system occurs. Plants become stunted and die.

Management-Refer to Red Gram Wilt

4. Septoria Leaf Spot: *Septoria lycopersici*

Symptom

- The plant may be attacked at any stage of its growth.
- The disease is characterized by numerous, small, grey, circular leaf spots having dark border.

Management

- Removal and destruction of the affected plant parts.
- Seed treatment with Thiram or Dithane M-45 (2 g/kg seed) is useful in checking seed borne infection.

- In the field spraying with Mancozeb 0.2% effectively controls the disease.

5. Bacterial Leaf Spot: *Xanthomonas campestris* pv. *vesicatoria*

Symptom

- Moist weather and splattering rains are conducive to disease development. Most outbreaks of the disease can be traced back to heavy rainstorms that occur in the area.
- Infected leaves show small, brown, water soaked, circular spots surrounded with yellowish halo.
- On older plants the leaflet infection is mostly on older leaves and may cause serious defoliation.
- Centers of these lesions become irregular, light brown and slightly sunken with a rough, scabby surface.

Management

- Disease-free seed and seedlings should always be used and the crop should be rotated with non-host crops so as to avoid last year's crop residue.
- Seed treatment with mercuric chloride (1:1000) is also recommended for control of disease.
- Spraying with a combination of copper and organic fungicides in a regular preventative spray program at 5 to 10 day intervals or Spraying with Agrimycin-100 (100 ppm) thrice at 10 days intervals effectively controls the disease.

6. Leaf Curl: *Tomato leaf curl virus* (ToLCV)

Vector-White Fly

Symptom

- The new growth of plants with tomato yellow leaf curl has reduced internodes, giving the plant a stunted appearance.
- The new leaves are also greatly reduced in size and wrinkled, are yellowed between the veins, and have margins that curl upward, giving them a cup-like appearance.
- Flowers may appear but usually will drop before fruit is set.

Management

- Keep yellow sticky traps @ 12/ha to monitor the white fly.
- Raise barrier crops-cereals around the field.

- Removal of weed host.
- Protected nursery in net house or green house.
- Spray Imidacloprid 0.05% or Dimethoate 0.05% @ 15, 25, 45 days after transplanting to control vector.

7. Spotted Wilt: Tomato Spotted Wilt Disease (TSWV)

Symptom

- It causes streaking of the leaves, stems and fruits. Numerous small, dark, circular spots appear on younger leaves.
- Leaves may have a bronzed appearance and later turn dark brown and wither.
- Fruits show numerous spots about one-half inch in diameter with concentric, circular markings.
- On ripe fruit, these markings are alternate bands of red and yellow.
- The spotted wilt virus is transmitted through thrips (*Thrips tabaci*, *Frankliniella schultzei* and *F. occidentalis*).

Management

- The affected plants should be removed and destroyed.
- Alternate or collateral hosts harboring the virus have to be removed.
- Raise barrier crops-Sorghum, Maize, Bajra 5-6 rows around the field before planting tomato.
- Spray Imidacloprid 0.05% or any systemic insecticide to control the vector.

II. Chilli

1. Damping off: *Pythium aphanidermatum*

Symptoms

- Seedlings killed before emergence.
- Water soaking and shivering of stem.
- Factors favoring infection.
- Moist soils poor drainage 90-100% R.H soil temperature 20 °C.

Mode of Spread and Survival

- Primary source of inoculumsoil borne zoospores
- Secondary source of inoculum-irrigation water

Favourable Conditions

- High soil moisture
- Thick sowing
- Application of urea

Management

- Avoid stagnation of water
- Raised bed forming in nursery
- Reduces the seed rate
- Seed treatment with *Trichoderma viride* @ 4g/kg of seeds.
- Soil drenching with Copper oxychloride 0.25%

2. Fruit Rot and Die Back-*Colletotrichum capsici*

Symptoms

- Fungus causes necrosis of tender twigs from the tip backwards the disease is called die-back Infection usually begins when the crop is in flower. Flowers drop and dry up.
- There is profuse shedding of flowers. The flower stalks shrivels and dry up.
- This drying up spreads from the flower stalks to the stem and subsequently causes die-back of the branches and stem and the branches wither.
- Partially affected plants bear fruits which are few and of low quality. On the surface of the soil the necrotic areas are found separated from the healthy area by a dark brown to black band.

Mode of Spread and Survival

- Primary source of inoculums-seed borne.
- Secondary source of inoculum-air borne conidia.

Management

- Use of disease-free seeds is important in preventing the disease.
- Seed treatment with Thiram or Captan 4g/kg is found to be effective in eliminating the seed-borne inoculum.
- Good control of the disease has been reported by three sprayings with Ziram 0.25% Captan 0.2% or miltox 0.2%. Chemicals like

wettable sulphur 0.2%, copper oxychloride 0.25% and Zineb 0.15% not only reduced the disease incidence but also increased the yield of fruits.

- The first spraying should be given just before flowering and the second at the time of fruit formation.
- Third spraying may be given a fortnight after second spraying.

3. Powdery Mildew: *Leveillula taurica*

Symptoms

- Shedding of foliage.
- White powdery growth on lower side of leaves.

Management (Refer Pulses Powdery Mildew Management)

- Spray Wettable sulphur 0.25% or Dinocap (Karathane) 0.05%

4. Bacterial Leaf Spot: *Xanthomonas campestris pv. vesicatoria*

Symptoms

- The leaves exhibit small circular or irregular, dark brown or black greasy spots. As the spots enlarge in size, the centre becomes lighter surrounded by a dark band of tissue.
- The spots coalesce to form irregular lesions. Severely affected leaves become chlorotic and fall off. Petioles and stems are also affected. Stem infection leads to formation of cankerous growth and wilting of branches.
- On the fruits round, raised water soaked spots with a pale yellow border are produced.
- The spots turn brown developing a depression in the centre wherein shining droplets of Bacterial ooze may be observed.

Mode of Spread and Survival

- Primary source of inoculum—seed borne.
- Secondary source of inoculum—rain splash.

Management

- Seed treatment with 0.1% mercuric chloride solution for 2 to 5 minutes is effective.
- Seedlings may be sprayed with Bordeaux mixture 1 Per cent or copper oxychloride 0.25%.

- Spraying with streptomycin should not be done after fruits begin to form.
- Field sanitation is important.
- Also seeds must be obtained from disease free plants.

5. **Bacterial Soft Rot-*Erwinia carotovora* sub sp. *Carotovora***

Symptoms

- The fleshy fruit peduncle is highly susceptible and is frequently the initial point of infection.
- Both ripe and green fruit may be affected. Initially, the lesions on the fruit are light to dark-colored, water-soaked, and somewhat sunken.
- In later stages, bacterial ooze may develop from affected areas, and secondary organisms follow, often invading the rotted tissue. Post-harvest softening of stem end of fruit. The affected fruit hang from the plant like a water-filled bag.

Management

- Use chlorinated wash water to reduce populations of soft rot bacteria and to reduce the risk of infection during washing.
- This will not reduce soft rot development in fruit infected with the bacterium prior to harvest.
- Allow fruit to dry thoroughly.
- During packing and storage, the fruit should be kept clean and maintained in a cool and dry place.

Viral Diseases

1. Leaf Curl-*Chilli leaf curl virus*

Vector-Whitefly (*Bemisia tabaci*)

Symptoms

- Leaves curl towards midrib and become deformed. Stunted plant growth due to shortened internodes and leaves greatly reduced in size.
- Flower buds abscise before attaining full size and anthers do not contain pollen grains.
- The virus is generally transmitted by whitefly. So control measures of whitefly in this regard would be helpful.

Management of Viral Diseases

- The infected plants should be uprooted and burnt or buried to avoid further infection. Avoid monoculture of chilli crop.
- Selection of disease free seeds from infected field.
- Soaking seeds in a solution containing 150g Trisodium orthophosphate per litre of water for 30 minutes inhibits seed-borne inoculum.
- Treated seed should be washed with fresh water and dried before sowing. Nursery beds should be covered with nylon net or straw to protect the seedlings from viral infection.
- Raise 2-3 rows of maize or sorghum as border crop to restrict the spread of aphid vectors.
- Apply Carbofuran 3G @ 4-5 Kg/acre in the mainfield to control sucking complex and insect vectors selectively. If it is not possible spray the crop with systemic insecticides.
- Like Monocrotophos 1.5 ml or Dimethoate 2ml of Acephate 1g per litre of water. Collect and destroy infected virus plants as soon as they are noticed.

III. Diseases of Brinjal

1. Bacterial Wilt-*Pseudomonas solanacearum*

Symptoms

- Bacterial wilts symptoms on leaf surface Wilting, stunting, yellowing of the foliage and finally collapse of the entire plant are the characteristic symptoms of the disease.
- Lower leaves may droop first before wilting occurs.
- The vascular system becomes brown. Bacterial ooze comes out from the affected parts.
- Plant show wilting symptoms at noontime will recover at nights, but die soon.

Mode of Spread and Survival

- The pathogen is found to be alive in the infected plant debris for about 10 months.
- Presence of root knot nematode, *Meloidogyne javanica* increases the wilt incidence.

Management

- Use resistant variety.
- Crop rotation with cruciferous vegetables such as cauliflower helps in reducing the disease incidence. Fields should be kept clean and effected parts are to be collected and burnt. Spray Copper fungicides to control the disease (2% Bordeaux mixture.).
- The disease is more prevalent in the presence of root knot Nematodes, so control of these nematodes will suppress the disease spread.

2. Cercospora Leaf Spot-*Cercospora solani*

Symptoms

- The leaf spots are characterized by chlorotic lesions, angular to irregular in shape, later turn grayish-brown with profuse sporulation at the centre of the spot.
- Severely infected leaves drop off prematurely, resulting in reduced fruit yield.

Mode of spread and survival-The disease is spread by air borne conidia.

Management

- Pant Samrat variety is resistant to both the leaf spots. Diseases can be managed by growing resistant varieties.
- Spraying 1 per cent Bordeaux mixture or 2g Copper oxychloride or 2.5g Zineb per litre of water effectively controls leaf spot.

3. Alternaria Leaf Spot-*Alternaria melongenae*, *A. solani*

Symptoms

- Cracks appearing in leaf spot. The two species of *Alternaria* occur commonly, causing the characteristic leaf spots with concentric rings.
- The spots are mostly irregular, 4-8mm in diameter and may coalesce to cover large areas of the leaf blade.
- Severely affected leaves may drop off.
- The infected fruits turn yellow and drop off prematurely.

Mode of spread and survival-The disease is spread by wind borne conidia.

Management

- Spraying 1 per cent Bordeaux mixture or 2 g Copper oxychloride or 2.5 g Zineb per litre of water effectively controls leaf spots.

4. Collar Rot (*Sclerotium rolfsii*)

- The disease occasionally occurs in serious form.

Symptoms

- The lower portion of the stem is affected from the soil borne inoculum (sclerotia).
- Decortication is the main symptom.
- Exposure and necrosis of underlying tissues may lead to collapse of the plant.
- Near the ground surface on the stem may be seen the mycelia and sclerotia.
- Lack of plant vigour, accumulation of water around the stem, and mechanical injuries help in development of this disease.

Management

- Seed treatment with 4 g of *Trichoderma viride* formulation per kg seed will help in reducing the disease.
- Collection and destruction of diseased parts and portions of the plant.

Phytoplasma

1. Little Leaf of Brinjal-Vector Jassid-*Cestius phycitis*

Symptoms

- The characteristic symptom is the smallness of the leaves.
- The petioles are so short and the leaves appear to be sticking to the stem.
- Such leaves are narrow, soft, smooth and yellow.
- Newly formed leaves are much shorter. The internodes of the stem are also shortened.
- Auxiliary buds get enlarged but their petioles and leaves remain shortened.
- This gives the plant a bushy appearance.

- Mostly, there is no flowering but if flowers are formed they remain green. Fruiting is rare.

Management

- The severity of the disease can be reduced by destruction of affected plants and spraying of insecticides.
- New crop should be planted only when diseased plants in the field and its neighborhood have been removed.
- Methyl Demeton 25 EC2 ml/litre, Dimethoate 30 EC2 ml/ litre and Malathion 50 EC2 ml/liter has been recommended for vector control.

Chapter - 10

Diseases of Bhendi, Cucurbits, Crucifers and Amaranthus

I. Diseases of Bhendi

1. Fusarium Wilt-*Fusarium oxysporum f. sp. vasinfectum*

Symptoms

- This disease is caused by fungi, which persist in the soil for a very long time. Initially the plants show temporary wilting symptoms, which become permanent and progressive, affecting more vines.
- The leaves of the affected plants show yellowing, loose turgidity and show drooping symptoms.
- Eventually, the plant dies. In older plants, leaves wilt suddenly and vascular bundles in the collar region become yellow or brown.

Control

- Continuous cultivation of bhendi on the same piece of land should be avoided.
- In case of fields severely infected by the wilt pathogen practicing long crop rotations is useful in reducing the pathogen population.
- Three sprays of Karathane (6g in 10 litres of water) or Bavistin (1g/litre of water) immediately on appearance of initial symptoms at 5-6 days interval checks the spread of the disease.
- Leaves of fully grown plants should be thoroughly drenched during spraying.
- Soil drenching with Cupper oxy chloride (0.25%).

2. Powdery Mildew-*Erysiphe cichoracearum*

Symptoms

- The disease is found mainly on the older leaves and stems of plants. Increased humidity can increase the severity of the disease, and infection is enhanced during periods of heavy dew.
- The disease symptoms appear as subtle, small, round, whitish spots on leaves and sometimes stems.

- The spots enlarge and coalesce rapidly and a white mass resembling talcum powder becomes evident on the upper surface of older leaves or other plant parts.
- Heavily infected leaves become yellow, then become dry and brown.
- Extensive premature defoliation of the older leaves can ensue if the disease is not controlled.

Management-Refer Pulses PM Management

3. Cercospora Leaf Spot-*Cercospora abelmoschi* and *C. malayensis*

Symptoms

- *C. malayensis*-causes brown, irregular spots.
- *C. abelmoschi*-causes sooty black angular spots.
- The affected leaves roll wilt and fall. The disease causes severe defoliation during humid seasons.

Management

- Removal and destruction and of diseased plant material.
- The disease is effectively controlled by spraying with Copper Oxy chloride (0.3%) or Zineb (0.2%) starting from about a month after sowing and repeating at fortnightly intervals, depending upon the severity of the disease incidence.

4. Yellow Vein Mosaic Virus (YVMV) Vector-White Fly

Symptoms

- Initially infected leaves exhibit only yellow coloured veins but in the later stages, the entire leaf turns completely yellow.
- In extreme cases, the infected leaf becomes totally light yellow or cream coloured and there is no trace of green colour.
- At times, enations (raised structures) are observed on the under surface of infected leaf.
- Plants infected in the early stages remain stunted.
- The fruits of the infected plants exhibit pale yellow colour, deformed, small and tough in texture.

Management

- Removal and destruction of virus affected plants and planting of disease resistance varieties reduces the disease incidence.

- Controlling the whitefly population minimizes the incidence of YVMV.
- Soil application of Carbofuran (1kg a.i./ha) at the time of sowing and 4-5 foliar sprays of Dimethoate (0.05%) or Metasystox (0.02%) or Nuvacron (0.05%) at an interval of 10 days effectively controls the whitefly population.

II. Diseases of Cucurbits

1. Fusarium Wilts of Water Melon (*Fusarium oxysporum f. sp. niveum*)

Muskmelon-For *f. sp. melonis*

Symptoms

- The disease attack the plant at all stages of plant growth.
- When young seedlings are infected they damp off and die.
- In older plants the plant wilts and dies within 10 days.
- Vascular discoloration can be seen. In wet weather, pinkish or whitish fungal growth can be seen on dead stems.

Management

1. Collection and burning of infected plant.
 2. Seed treatment and soil application with *T. Viride* or *P. fluorescens*
 3. Use of disease free seeds.
2. **Root Rot of Muskmelon (*Pythium aphanidermatum*)**
 3. **Root Rot of Pumpkin and Squash (*Fusarium solani f. sp. cucurbitae*)**
 4. **Root rot of watermelon, Cucumber (*Pythium irregulare* and *P. ultimum*)**

Symptoms

- The roots of the affected plants appear water soaked with sunken darkened lesions. The crown of the plants is girdled and entire plant is collapsed. Fruits become rotted by the fungus.

Management

- As like wilt the management practice should be followed.

5. Verticillium wilt (*Verticillium albo-atrum*)

Symptoms

- The leaves of the plant become yellow from base of the plant upwards and the whole plant wilts. If the stem is cut open, brown discoloration can be seen.

6. Anthracnose (*Colletotrichum lagenarium*)

Symptoms

- Small yellowish or water soaked areas appears on leaves which enlarge rapidly and turn brown in most cucurbits but black in water melon. The affected part break and fall off or the whole leaf dries. When the infection occurs in stem, the whole vine is killed. When infection occurs in fruit pedicle, the young fruit may be darkening, shrivel and dry. Circular black cankers appear on fruits. The spots may be up to 5 cm dia based on the host and environment. In the sunken black spots salmon coloured spores can be seen.

Management

- Collection and destruction of infected plant.

7. Alternaria Leaf Spot/Target Leaf Spot/Microsporium blight (*Alternaria cucumerina*, *Cladosporium cucumerinum*)

Symptoms

- Small, circular spots appear on leaves. As the spot enlarges concentric rings can be seen on infected area. The fungus also causes fruit rot

Management

- Use of disease free seeds.

8. Cercospora Leaf Spot (*Cercospora citrullina*)

Symptoms

- Small block circular spots with grey centre appear on leaves. Severely infected leaves fall off. The fruit size is reduced.

Management

- Collection and burning of infected leaf.
- Crop rotation.

9. Downy Mildew (*Pseudoperonospora cubensis*)

Symptoms

- Symptoms resembling mosaic viz., pale green areas separated by dark green areas appear on upper surface of leaf. During wet season, corresponding lower surface is covered with faint purplish fungal growth. The entire leaf dries up quickly.

Management

- Use of bed system with wide spacing with good drainage and air movement and exposure to sun help to check the disease development.

10. Angular Leaf Spot (*Pseudomonas syringae* pv. *lachrymans*)

Symptoms

- Water soaked lesions appear on leaves which are confined to veins. The turn grey to tan and form an exudates in the lower surface. The spots loosen and fall out. Infected fruits develop a brown, circular, superficial, firm rot which causes rapid deterioration. The rot may extend into flesh.

Management

- Use of disease free seed and crop rotation.

11. Fruit Rot (*Pythium aphenidermatum*)

Symptoms

- Initially the skin of the fruit shows soft, dark green water soaked lesions which gradually develop into a watery soft rot. Cottony mycelium develop on the affected portions. The fruit in contact with the soil is attacked easily.

Management

- Keep fruits not in touch with soil

12. Other Fruit Rots of Watermelon

- a. Aspergillus fruit rot-*Aspergillus flavus*
- b. Curvularia fruit rot-*Curvularia ovoidea*
- c. Myrothecium fruit rot-*Myrothecium roridum*
- d. Rhizopus fruit rot-*Rhizopus oryzae*
- e. Diplodia fruit rot-*Diplodia natalensis* (also affects cucumber)

13. Viral Disease

- a. Cucumber mosaic virus-Vector-aphids (*A. craccivora* *M. persicae*)

Symptoms

- Mosaic mottling, leaf distortion, stunting of the plants, shortened internode and petioles. Infected plants bear only very few flowers. In fruits mottled yellowish green areas can be seen.

Management

- Removal and burning of infected plants.
- Eradication weeds hosts

Other Viral Diseases

- b. Watermelon mosaic virus-watermelon and muskmelon
- c. Squash mosaic-Squash and pumpkin
- d. Mosaic disease-Bottle gourd, snake gourd, squash, ribbed gourd

Management

- Removal and burning of infected plants.
- Eradication weeds hosts

14. Phyllody-Phytoplasma (Vector-Leaf Hopper)

- It affects bitter gourd, bottle gourd, cucumber, ridge gourd and snake gourd. The symptoms are shortening of internodes and phyllody of normal flowers. Corolla, androecium and gynoecium are transferred into green leaf like structures.

Management

1. Removal of infected plants.
2. Clean cultivation without weed host.

III. Diseases of Crucifers (Cabbage, cauliflower, turnip, broccoli are some of the important cruciferous crops)

1. Club Root (*Plasmodiophora brassicae*)

- The above ground symptoms are, yellowing of leaves, stunting and later the diseased plant die.
- Young plants die with in a short time while older plants fail to produce marketable heads.
- On roots and root lets, spindle shaped with thick centre and tapered ends giving a club shaped malformation is developed.
- The club shaped structured cells are invaded by the secondary, weakly parasitic organisms and the cells are disintegrated which produce toxins and the plants are killed.

Management

- Avoiding infected field

2. Black Rot (*Xanthomonas campestris* pv. *campestris*)

- On leaves 'V' shaped chlorotic to yellow lesions develop from the leaf margins.
- They become black later. The veins and vein let's become black. Systemic infection spreads to the root.
- The vascular bundle in the stem becomes black followed by integration of fleshy stalk.
- The attack of soft rot organisms causes further deterioration.
- The cabbage heads and cauliflower curds are invaded and become discolored.

Management

- Use of healthy seed.
- Spraying with Agrimycin 200 ppm.

3. Alternaria Leaf Spot/Black Spot/Brown Spot (*Alternaria brassicicola*)

- Small dark colored lesions up to 1.0 cm in dia appear on leaves.
- In humid condition conidiophores appear on the lesion in concentric rings.
- Linear spots also appear on petioles, stems and seed pods.
- On cauliflower curds brown discoloration occurs.
- In case of *A. brassicae* the spots are smaller in dia and lighter in colour.

Favourable Condition

- Hot moist weather, temperature 26 °C. Dew or rain for 9 hrs is essential for infection.

Management

- Hot water treatment of seeds at 50 °C for 30 minutes.
- Crop rotation, avoiding overhead irrigation.

4. Wire Stem

- Wire stem gets its name from symptoms that occur on the stem at the soil level. A dark, water soaked lesion initially appears on the stem.

- Later stems become wiry and slender at the point of the lesion.
- Diseased crucifer plants transplanted to the field grow poorly, are stunted, and may eventually die, especially if there is inadequate moisture shortly after transplanting.
- If infected plants remain alive, the stem becomes tough and woody. Plants that survive usually mature late and fail to produce a marketable head.

5. Bottom Rot

- Bottom rot is a disease of mature cabbage.
- After cabbage transplants become large enough to begin to shade the ground, the disease appears on the lower side of the head leaves that are in contact with the soil.
- The midrib is often the first part of the leaf attacked.
- Resulting lesions are sunken, black, and sharply elliptical with the long side of the lesion parallel to the side of the midrib.
- Lesions may dry out and become papery brown in appearance if the weather becomes dry.
- The surface of the lesion may be covered with a sparse, web like mycelium.
- Eventually a general black decay occurs at the base of the leaf.
- The tip of the leaf then turns yellow and then the entire leaf wilts.
- Infected leaves are shed and only a naked stalk, capped with a small head, remains.
- Bottom rot becomes a head rot if temperatures are warm and the relative humidity is high.
- A web like mycelium develops between diseased leaves.
- Infected leaves are eventually covered with small, brown, fungal structures called Sclerotia, which can persist on plant debris in the soil for long periods of time.
- The stem remains unaffected, thus, the head remains upright.

Cultural Control

- Choose a fertile, well-drained site for the plant bed. Poor drainage favors seedling disease.
- Avoid excessive amounts of nitrogen fertilizer. Succulent plants are more susceptible to infection.

- Seed crucifers when the soil temperature reaches 69°F (21°C) and seed as shallowly as possible so that germination and emergence are rapid.
- Discard transplant seedlings that show symptoms of wire stem.
- Avoid banking or throwing soil up around plants during field cultivation.
- Harvest cabbage heads early. Cabbage leaves become more susceptible the longer they stand in the field.

Survival

- Sources of the fungus include infested seeds, cruciferous weeds, and residues of cruciferous crops remaining in or on the soil.
- Survival in crop residues in soil for 3 years.

Management

- Use of disease free seed.
- Rotation with non-cruciferous crops for 4 years where the disease is severe.
- Providing adequate drainage facility.
- Soil fumigation with chloropicrin etc.

6. Cabbage Yellows/Fusarium Wilt of Cabbage (*F. Oxysporum conglutinans*)

- The plants become yellow in colour.
- The wilting of leaves may be more prominent on one side of plant than the other.
- Leaves dry up. When the infected stem is cut open brown discoloration will be seen.

Management

- Use of disease free seed. Crop rotation, field sanitation.
- Use of resistant varieties.

7. Ring Spot of Cabbage (*Mycosphaerella brassicicola*)

- Outer leaves are severely affected.
- Brown to tan spots of 1-2 cm dia. appears on leaves.
- Central portions are grey in colour with numerous fruiting bodies appear in concentric rings.

- The spots are surrounded by a green band which remains green even after the whole leaves turn yellow.
- Diseased leaves fall off. When the spot affects head, market value is reduced.

Management

- Collection and destruction of plant debris
- Hot water treatment of seeds 45 °C for 20min

8. Stalk Rots (*Sclerotinia sclerotiorum*)

- In cabbage water soaked spots appear on stem and leaves near the ground level.
- The leaves wilt and plant collapses within 10-15 days. When head is infected cottony white fungal growth is seen with numerous hard black Sclerotia.
- In cauliflower yellowing starts from tip of the leaves to downwards till the entire leaves are covered.
- The leaves shed prematurely.
- The rotting progresses to stem and the stem girdles and the stem rots up to the curd region.
- Curds are also affected. White fluffy mycelial growth with numerous Sclerotia in the affected portions can be seen.

Management

- Crop rotation with paddy

Chapter - 11

Diseases of Onion, Garlic and Potato

I. Disease of Onion

1. Purple Blotch-*Alternaria porri*

Symptoms

- Small, watery lesions with a white centre can be seen on the leaves. As the lesions grow larger, brownish purple rings containing spores are formed.
- The edges of the flecks are reddish purple and these are ringed by a yellow zone.
- If the flecks merge with each other they can affect the entire leaf, causing it to snap and die.
- Older leaves are also the most vulnerable to this disease.

Mode of Spread

- **Primary Source:** The pathogen present on the infected plant debris.
- **Secondary Source:** Air borne conidia

Prevention and Management

- Apply extensive crop rotation.
- Ensure that the leaves don't remain wet for long periods by having good drainage and by planting less densely.
- Avoid excessive irrigation.
- Fungicides can be used to control this disease.

2. Black Mould-*Aspergillus niger*

Symptoms

- Below the dried skin a powdery, black mass of spore's forms which is often invisible on the outside. The spores can be present on each of the scales.

- Infected scales first appear watery, after which white, fluffy mycelium appears on which black spores quickly form.
- In advanced stages, the bulbs will start to shrivel.

Prevention and Management

- Prevent damage and diseases on the leaf, which can allow the fungus to penetrate the onion.
- Avoid damage to the bulbs during harvesting, storage and transport.
- Keep the temperature (<15 °C) and humidity (<76% Relative Humidity) low during storage and transport.

3. Fusarium Basal Rot-*Fusarium solani*

Symptoms

- The first symptoms are the appearance of yellowing, twisted leaves.
- After this the leaves die off starting at the tip.
- The entire plant can wilt during the early stages of infection.
- Roots that have been infected turn dark brown.
- As the infection develops a white fungal growth will become visible at the basal plate of the bulb which in contrast with white rot does not contain sclerotia.
- If an infected bulb is cut lengthwise, the bottom of the bulb and the lowest part of the scales will appear to be watery and pale grey.

Prevention and Management

- Growing of high resistance to *Fusarium* basal rot should be cultivated in infected fields.
- A crop rotation cycle of 4 years or more can considerably reduce the chance of infection. Infected lots should not be stored long term.
- However if this is necessary, then the temperature should be kept below 4 °C.

4. Onion Smut-*Urocystis cepulae*

Symptoms

- Black spots or bands that are often a little swollen can be seen on the cotyledons and the first leaves. Later these split open and a huge number of spores are released.
- Infected plants suffer from retarded growth and in cases of extreme infection will die off within a few weeks.

- The symptoms remain visible throughout the entire season and will ultimately infect the bulb as well.
- Lesions on the bulbs are often the point of entry for different secondary pathogens that cause rot.

Prevention and Management

- Use healthy sets and transplants on smut-infested soil.
- This will minimize the risk of infection.

5. Anthracnose-*Colletotrichum gloeosporioides* or *Colletotrichum circinans*

The symptoms appear initially on the leaves as water soaked pale yellow spots, which spreads lengthwise covering entire leaf blade. The affected leaves shrivel and droop down.

Management

- Since the pathogen survives on crop debris, sanitation and destruction of infected crop debris helps in reducing the disease.
- Mancozeb (0.25%), Carbendazim (0.1%) or Thiophanate Methyl (0.1%) as foliar spray is effective against the disease

6. Bacterial Soft Rot-*Erwinia carotovora* sub sp. *carotovora*

Symptoms

- *Erwinia* can infect the plants in the field.
- The leaves wilt and will dry out at a later stage.
- If an infected plant is cut through, it can be seen that the middle of the new bulb is completely slimy and stinks.
- The scales are soft and appear watery.
- Later on a pale yellow to light brown slime will form. Affected bulbs are soft and watery.
- When squeezed, the bulb oozes stinking fluid or slime.

Prevention and Management

- Ensure that the soil has good structure, is well drained and is not compacted.
- Control insects and any other pathogens. Avoid extreme foliage growth.
- Don't give too much nitrogen since a lush crop is fragile and especially vulnerable to rain and wind damage.
- Don't irrigate too much after the bulb has developed.

II. Disease of Garlic

1. Pink root (*Pyrenochaeta terrestris*)

Pink root of garlic is caused by the fungus. (Hansen) Gorenz, walker and Larson *Phoma terrestris* (Hanson) it has been reported from all the garlic growing areas.

Symptoms

- The fungus attacks onion from the seedling stage onwards.
- The roots are affected and they turn pink or reddish and sometimes darken to a red or purple colour black spores form on the diseased roots which eventually shrivel and die.
- Diseased plants can be easily pulled. The above ground symptoms are shunting and yellowing tip burn and die back of the leaves.
- Affected seedlings may be killed. Older plants are not normally killed but bulb formation is affected and yields are low.
- Bulbs are not attacked although the outer scales may be penetrated.
- New roots are formed throughout the season and these may be infected and killed successively.

Spread of the Disease

The pathogen is soil borne and infection is mostly from mycelia in the soil. Optimum soil temperatures for disease development are 24-28 °C.

Management

Long rotations should be practiced to prevent build up of inoculum in the soil.

III. Disease of Potato

1. Late Blight-*Phytophthora infestans*

Symptoms

- Irregularly shaped spreading brown lesions on leaves with characteristic white fluffy sporulation at lesion margins on the underside of the leaf in wet conditions.
- In dry condition the lesions dry up and go dark brown with collapsed tissue; water-soaked dark green to brown lesions on stems also with characteristic white sporulation; later in infection leaves and petioles completely rotted.

- Severely affected plants may have a slightly sweet distinctive odor; red-brown firm lesions on tubers extending several centimeters into tissue; lesions may be slightly sunken in appearance and often lead to secondary bacterial rots.

Management

- Destroy infected tubers and any volunteer plants.
- Application of appropriate fungicide to potato hills at emergence
- Time watering to reduce periods of leaf wetness e.g. water early to allow plant to dry off during the day
- Growing of plant resistant varieties
- Apply appropriate protective fungicide if disease is forecast in area

2. Early Blight-*Alternaria solani*

Symptoms

- Dark lesions with yellow border which may form concentric rings of raised and sunken tissue on the leaves and stems.
- The lesions initially circular but become angular then leaves become necrotic but remain attached to plant and dark, dry lesions on tubers with leathery or corky texture and watery yellow - green margins.

Management

- Application of appropriate protective fungicide can reduce severity of foliar symptoms.
- Store tubers in cool environment.
- Collection and destruction of infected plant debris.

3. Verticillium wilt-*Verticillium dahlia* and *Verticillium albo-atrum*

Symptoms

- Early death of plants.
- Leaflets dying on only one side of the petiole or branching stem.
- Cut through the stem expose a discoloration of the tissue.
- Discoloration of tubers at stem-end.

Management

- Planting resistant varieties of potato is the most common method of controlling the disease.

- Cultural practices such as using furrow irrigation in place of sprinkler irrigation and avoiding overwatering plant can also reduce the severity of the disease.

4. Powdery Scab-*Spongospora subterranea*

Symptoms

- White to brown galls on the roots and stolon; raised pustules on tuber surrounded by potato skin; shallow depressions on tuber filled with brown spores.

Management

- Do not plant tubers showing symptoms of disease.
- Avoid planting potato in poorly draining soils.
- If disease occurs rotate crop away from potato for a period of 3-10 years and avoid planting tomato.

5. Common Scab-*Streptomyces* spp.

Symptoms: Raised brown lesions on tubers with corky texture; deep, pitted brown or black lesions on tuber with straw-colored translucent tissue underneath.

Management

- Avoiding planting infected tubers, using a 3-4 rotation away from potato.
- Planting less susceptible potato varieties (none are immune).
- Maintaining a high soil moisture content for 4-6 weeks after stolon tips begin to swell at the onset of tuber development; amending soil to lower pH and treating seed with appropriate fungicides when available

6. Bacterial Ring Rot-*Clavibacter michiganensis*

Symptoms: Wilting stems and leaves; dying leaves; lower leaves wilting first; ring of creamy yellow to brown rot visible when tuber is cut crossways.

Management

- Plant only certified seed potatoes - certified seed potatoes are grown in seed beds with zero tolerance of ring rot.
- Remove all crop debris from soil after harvest; sanitize tools and equipment regularly

7. Potato Leaf Roll-*Potato leaf roll virus (PLRV)*

Symptoms

Young leaves rolled and yellow or pink; lower leaves have leathery texture and roll upward; necrotic netting in vascular tissue of tuber may be present; plant exhibits an upright growth habit and growth may be stunted

Management

- Grow plants produced clonally from PLRV-free stock; harvest potato crop early in temperate regions to avoid aphid migrations late in season.
- Remove and destroy infected plants and tubers.
- Application of appropriate insecticides where available may help reduce spread.

Chapter - 12

Diseases of Coconut and Areca Nut

I. Disease of Coconut

1. Tanjore Wilt/Basal Stem End Rot/Ganoderma Wilt: *Ganoderma lucidum*

Symptoms

- Initial symptoms of Tanjore wilt (*Ganoderma* wilt) start with withering, yellowing and drooping of the outer whorl of leaves.
- This is followed by exudation of reddish brown liquid through cracks at the base of the trunk and oozing spread upward. The tissues on the bleeding spots are soft to touch.
- Decaying of tissues at bleeding point and rotting of the basal portion of the stem.
- The bark turns brittle and often gets peeled off in flakes, leaving open cracks and crevices. The internal tissues are discolored and disintegrated, emitting a bad smell.
- Bracket formation at the base of the trunk. *Ganoderma* appears at the base of the trunk. Ultimately the palm dies off.

Management

Cultural Method

- Remove and destroy all affected palms.
- Green manure crops must be raised and ploughed at the time of flowering.

Biological Method

- Apply *Pseudomonas fluorescens* (Pf1) @ 200g/palm + *Trichoderma viride* @ 200g/palm/year.
- Apply 200g Phosphobacteria and 200g Azotobacter mixed with 50kg of FYM/palm.
- Apply FYM 50kg + neem cake 5 Kg once in 6 months along with fertilizers.

Chemical Method

- Isolation of trench around the tree, 4 feet away from the base of the trunk. Apply Sulphur dust inside the trench.
- The bleeding patches in the stem may be chiseled and protected with tridemorph (5% calaxin) and subsequently with hot coal tar.
- Aureofungin-sol 2 g +1 g Copper Sulphate in 100ml water or 2 ml of Tridemorph in 100 ml water applied as root feeding. (The active absorbing root of pencil thickness must be selected and a slanting and a slanting cut is made. The solution to be taken in a polythene bag or bottle and the cut end of the root should be dipped in the solution).
- Trunk injection/root feeding with Calixin 3 ml/tree.
- Forty litres of 1% Bordeaux mixture should be applied as soil drench around the trunk in a radius of 1.5m

2. Bud Rot: *Phytophthora palmivora*

Symptoms

- The earlier symptom is the yellowing of one or two younger leaves. In the later stages the spindle withers and drops down.
- The tender leaf base and soft tissues of the crown rot into a slimy mass of decayed material emitting foul smell.
- Ultimately the entire crown falls down and the palm dies.
- The rotting slowly progresses downwards, finally affecting the meristem and killing the palms.
- This is accompanied by drooping of successive leaves. Even then, nuts that are retained on the palm may grow to maturity.

Management

Cultural Method

- Provide adequate drainage in gardens.
- Adopt proper spacing and avoid over crowding in bud rot prone gardens.

Chemical Method

- Remove all the affected tissue of the crown region and crown drenching with Copper oxychloride 0.25%.

- Spray 0.25% Copper oxychloride on the crown of the neighbouring palms as a prophylactic measure before the onset of monsoon. Palms that are sensitive (Dwarf palms) to copper containing fungicides can be protected by mancozeb.
- The infected tissues from the crown region should be removed and dressed with Bordeaux paste sprayed with 1% Bordeaux mixture as pre-monsoon spray (May and September).
- Spray with Copper oxychloride 0.25% after the onset of Monsoon.

3. Leaf Blight-*Lasiodiplodia theobromae*

Symptoms

- Leaf blight causes serious damage in seedlings and adult palms.
- Generally the adult leaves in the lower 3 to 4 whorls are affected.
- The affected leaflets start drying from the tip downwards and exhibit a charred or burnt appearance.
- Dark grey to brown lesions with wavy to undulated margins appear from the apex of the nuts.
- The affected nuts were desiccated, shrunk, deformed and dropped prematurely and resulting in nut yield loss up to 10 to 25%.
- Spores and the resting structures on the affected portion of the leaves served as inoculum for further spread through wind.

Management

Cultural Method

- Remove and burn the severely affected leaves to avoid further spread.

Biological method

- Application of 200g *Pseudomonas fluorescens* along with 50 kg of FYM+ 5 kg of Neem Cake/palm/year.

Chemical Method

- Spray 1.0 per cent Bordeaux mixture or 0.25 percent Copper oxychloride (2 times at 45 days interval during summer months).
- Root feeding of Carbendazim 2 g or Hexaconazole/Tridemorph 2 ml + 100 ml water (3 times at 3 months interval).
- Application of an additional quantity of 2kgs of MOP.

4. Stem Bleeding-*Thielaviopsis paradoxa*

Symptoms

- The progress of the disease is faster during July to November.
- Stem Bleeding is characterized by the exudation of a dark reddish brown liquid from the longitudinal cracks in the bark and wounds on the stem trickling down for a distance of several inches to several feet.
- The lesions spread upwards as the disease progresses.
- The liquid oozing out dries up and turns black. The tissues below the lesions become rotten and turn yellow first and later black.
- In advanced cases, the interior of affected trunks are hollow due to decay of interior tissues.
- As a result of extensive damage in the stem tissue, the outer whorl of the leaves turn yellow, dry and shed prematurely. The production of bunches is affected adversely.
- Nut fall is also noticed.

Management

Cultural Method

- Destroy the chiseled materials by burning. Avoid any mechanical injury to trunk.
- Along with 50kg FYM, apply 5kg neem cake containing the antagonistic fungi, *Trichoderma* @ 200g/palm/year culture to the basin during September.
- Provide adequate irrigation during summer and drainage during rainy season along with recommended fertilizer.

Chemical Method

- Chisel out completely the affected tissues and paint the wound with tridemorph 5% or Bordeaux paste. Apply coal tar after 1-2 days on the treated portion. Burn off chiseled pieces.
- Root feed with tridemorph (5% Calixin) 5ml in 100 ml water, thrice a year during April-May, September-October and January-February to prevent further spread of lesions.

II. Disease of Arecanut

1. Foot Rot or Anabe Roga: *Ganoderma lucidum*

Symptoms

- The leaf lets in the outer whorls of leaves become yellow and spreads to the whole leaf and the leaves drooping down covering the stem.
- Later, the inner whorl leaves also become yellow. Subsequently all the leaves droop, dry up and fall off, leaving the stem alone.
- Then the stem also become brittle and easily broken by heavy wind.
- The base of the stem shows brown discoloration and oozing of dark fluid.
- Bracket shaped fructifications of the fungus called 'anabe' appears at the base of the trunk.
- When infected trunk is cut brown discoloration can be seen up to one metre from ground level.

Management

- Clean cultivation
- Destruction of infected trees and stumps
- Maintaining optimal plant population without over crowding.
- Providing good drainage facility and fertilizers and manures.
- Digging trenches to avoid root contact from diseased to healthy.
- Drench 1% Bordeaux mixture at frequent intervals.

2. Mahali/Koleroga/Fruit Rot: *Phytophthora arecae*

Symptoms

- Rotting and excessive shedding of immature nuts from the trees.
- The water soaked spots initially develop at the base of the nut. Fruit stalks and rachis of inflorescence are also affected.
- Nuts show large vacuoles and dark brown radial strands.
- Very often the top of the affected trees dries up resulting in withering of leaves and bunches.
- Affected nuts fall off and show the white mycelial growth of the fungus.

Management

- Clean cultivation
- Destruction of affected trees.
- Collection and burning of fallen nuts.
- Spray with Bordeaux mixture 1% before on set of the monsoon and second spray 40-45.

3. Bud Rot: *Phytophthora arecae*

Symptoms:

- The first symptom is the change of spindle leaf color from green to yellow and then brown.
- The leaves rot and the growing bud rots causing death of the palm.
- The affected young leaf whorl can be easily pulled off.
- The outer leaves also become yellow and droop off one by one leaving a bare stem.

Management: Destruction and removal of dead palms and bunches affected by mahali disease and drenching crowns with Bordeaux mixture 1% including surrounding healthy palms.

4. Yellow Leaf Disease (*Phytoplasma*)

Symptom

Yellowing of tips of leaflets in 2 or 3 leaves of outermost whorl. Brown necrotic streaks run parallel to veins in unfolded leaves. The yellowing extends to the middle of the lamina. Tips of the chlorotic leaves dry up. In advanced stage all the leaves become yellow. Finally the crown leaves fall off leaving of a bare trunk. Root tips turn black and gradually rot.

Management

1. Growing resistant varieties like true mangala and south kanara.
2. Application of potassium and magnesium more than the recommended level.

Chapter - 13

Diseases of Coffee, Tea and Rubber

I. Disease of Coffee

1. Coffee Leaf Rust-*Hemileia vastatrix*

Symptoms

- Initially it produces small, pale yellow spots on upper leaf surfaces followed by powdery orange-yellow lesions on the lower surface of leaves.
- Symptoms commonly develop on lower leaves of plant first and then spread; infected leaves drop from the plant and twigs and branches become defoliated.

Management

- Growing of resistant varieties.
- Systemic fungicides used in coffee include pyracarbolids such as triadimefon and propiconazole and strobilurin such as azoxystrobin.
- Only one organic fungicide is widely used in coffee-triadimefon. Triadimefon is a systemic fungicide which is applied to the foliage and works to inhibit the rust infection.
- Proper pruning and training of the coffee plant help to prevent overcropping and maintain the vigor of the plant, thereby reducing its susceptibility to rust.

2. Bacterial Blight-*Pseudomonas syringae*

Symptoms

- Water-soaked spots on leaves which dry out and become brown and necrotic with yellow halos.
- Necrosis of shoot tips which spreads rapidly down branches; leaves turn black and die off but remain attached to tree

Management

Protective sprays of copper should be applied to the plants just before the onset of the rainy season and should be continued right through to the short rains.

3. **Cercospora Leaf Spot or Brown Eye Spot or Berry Blotch-** *Cercospora coffeicola*

Symptoms

- It produces brown spots on leaves which enlarge and develop gray-white center and a red-brown margin; lesions may also be surrounded by a yellow halo or may have a burned appearance if lesions are very numerous.
- Infected leaves may drop from plant prematurely
- Lesions on green berries are brown and sunken and may have a purplish halo; infected red berries may have large black sunken areas

Management

- Ensure crop is adequately fertilized as nutrient deficient plants are more susceptible to the disease.
- Remove all crop debris from field after pruning to prevent build up of inoculum good plant spacing and pruning to open up the canopy promotes good air circulation around foliage and protects against disease.

II. Disease of Tea

1. **Root Rot-*Phytophthora cinnamomi***

Symptoms

- The infected leaves turning yellow with poor plant growth
- Finally entire plant wilting and roots get discolored
- Rapid death of plant.

Management

- Application of appropriate fungicides can help to protect plants from infection.
- Collection and destruction of infected plant debris's.

2. Algal Leaf Spot-*Cephaleuros virescens*

Symptoms: It produces gray, green or tan raised spots or blotches with green margins on leaves.

Management

- Avoid overhead irrigation which can spread the disease.
- Provide adequate space between plants to maximize air circulation around foliage
- Avoid wounding plants
- Prune out diseased parts of plants by cutting 6 inches below any visible symptoms
- Application of appropriate protective fungicides should be made in Spring when old leaves drop from plants

3. Blister Blight-*Exobasidium vexans*

Symptoms

- Small, pinhole-size spots present on young leaves
- Spots become transparent, larger, and light brown in colour.
- The blisters (swelling of leaves) on lower side of leaves with dark green, water-soaked zones surrounding blisters.
- Blisters may be white and velvety or brown; young stems bent and distorted, may break off or die

Management

- Plant tea varieties which are less susceptible to the disease.
- Application of appropriate foliar or systemic fungicides to protect the plants.

III. Disease of Rubber

1. Powdery Mildew Disease-*Oidium heveae*

- On mature rubber, the disease occurs when the trees defoliate after annual wintering.
- The young brown as well as light green leaves when infected get covered with white powdery masses.
- The infected leaves shrivel, curl and fall off leaving the petioles on the plant, giving a broomstick like appearance.

- The fallen leaves form a black carpet on the plantation floor.
- The inflorescence and young fruits are also affected, thus reducing the fruit set and availability of seeds.
- Severe infection leads to die back of twigs.
- Repeated defoliation and defoliation leads to depletion of nutrient reserves and such trees may dry off.

Management-(Refer to Pulses Powdery Mildew Management)

2. Colletotrichum Leaf Disease-*Colletotrichum acutatum*

Symptoms

- Infected leaves become distorted, turn black, shrivel and fall off leaving the petioles on the plant for a short period.
- Infection usually starts at the tip of the leaves and spreads towards leaf base.
- Spots on the infected leaves are small, circular and brown with a narrow brown margin surrounded by yellow halo.

Chapter - 14

Diseases of Turmeric, Pepper, Cardamom and Coriander

I. Disease of Turmeric

1. Leaf Spot-*Colletotrichum capsici*

Symptoms

- In affected leaves, elliptic or oblong spots with yellow halo are seen.
- The centre of spots are grayish white and then with numerous black dots in centre.
- As the disease advances, the leaves dry up and give a scorched appearance.

Management

- Field sanitation
- Spray with Mancozeb 0.25% or copper oxy chloride 0.25% immediately after the appearance of symptom and at 15 days interval.

2. Leaf Blotch

Symptoms

- The disease starts as spot and later turns as a brown spot surrounded by dark brown margins and yellow.
- The lesions enlarge and adjacent lesions coalesce to form necrotic areas.

Management

- Leaf blotch controlled by spraying Carbendazim 500 g/ ha or Mancozeb 1kg/ha or Copper oxy chloride 1.25 kg/ha.
- Mix sticker solution @ 5ml/10litre of spray solution.

3. Rhizome Rot: *Pythium aphanidermatum*

Symptoms

- In infected plants, basal portion of the shoots appear watery and soft.
- The root system is very much reduced
- The leaves exhibit gradual drying along the margin
- Infected rhizomes soft, rotted, color changes into different shades of brown

Management

- Use disease free planting material.
- Providing good drainage facilities.
- Rhizome dip in copper oxy chloride or zineb (0.3%) for 30 minutes before planting.
- Soil drenching with copper oxy chloride (0.25%) in and around affected plants.
- Soil application of *Pseudomonas fluorescens* talc formulation (2.5 kg/ha).

II. Disease of Pepper

1. *Phytophthora* Foot Rot/Quick Wilt-*Phytophthora capsici*

Symptoms

a. Die Back

- The aerial branches get infected at any point. At the site of infection of branch, the discoloration occurs and rotting progress upwards and downwards resulting in die-back symptoms.
- The lateral branches of the affected vines break off at the nodes and fall off.

b. Foot Rot or Collar Rots

- The stem near the ground level get infected and the rotting and death of vine occurs within 2-3 weeks.
- The affected portion emits bad odour.
- The necrosis progress down wards to the underground stem and to the root system.

c. **Root Rot**

The infection starts at main root or at feeder root. The leaves become yellow and defoliate.

Management

- Selection of healthy nursery material.
- Provide good drainage.
- Soil drenching with 1% Bordeaux mixture after removal of the affected plant.
- Spraying with 1% Bordeaux mixture (or) COC 0.25% (or) Alitte 0.3%.

2. **Slow Decline/Slow Wilt: *Fusarium*, *Rhizoctonia* and *Diplodia* along with nematode infection**

Symptoms

- General yellowing of lower leaves which progress upwards.
- The affected leaves become flaccid and fall off.
- Tip burn of leaves and die-back of twigs appear.
- Root knot, can be seen in the vine showing the yellowing of leaves.
- The affected vines gradually die.
- Vascular browning can be seen.

Management: Soil drenching with Copper oxychloride in May-June and September-October.

3. **Anthracnose/Pollu Disease: *Gloeosporium gloeosporioides***

Symptoms

- Symptoms appear in leaves and stems. Circular or irregular grey spots appear in the leaves.
- Concentric rings of Acervulai appear on upper surface of the leaves. On the stem the infection appear at the tips spreads downwards and kill the entire vine.
- When infections occur in leaf axils the spikes become affected and fall off.
- Berry becomes brown in colour and extends downwards from upper portion. And become chaffy (Pollu means hallow thing).

Management: Three rounds of spray with Bordeaux mixture 1%.

III. Disease of Cardamom

1. Damping off/rhizome rot/clamp rot-*Pythium vexans*/*Fusarium oxysporum*/*Rhizoctonia solani*/*Phytophthora* sp.
 2. Azhukal disease/capsule rot/fruit rot-*Phytophthora parasitica* car. *nicotianae*/*Phytophthora palmivora*
 3. Mosaic-*Cardamom mosaic virus* (CDMV)
 4. Chenthal disease/leaf blight-*Gloeosporium gloeos porioides*
1. **Damping off/rhizome rot/clamp rot:** *Pythium vexans*, *Fusarium oxysporum*, *Rhizoctonia solani*, *Phytophthora* sp.

Symptoms

- Infected leaves become pale, yellow and ultimately the young leaves die.
- Older leaves die prematurely and new shoots that arise are weak, decay and the rhizomes rot at the base of the stem.
- The diseased shoot can be pulled out easily.

Management

- Destruction of diseased clumps.
 - Providing proper drainage.
 - Changing the nursery site.
 - Drenching the nursery beds with Copper oxychloride 0.25% or Bordeaux mixture 0.5%, before 15 days of sowing.
 - Soil drenching with B.M 1% (or) PCNB 1.0%
2. **Azhukal Disease/Capsule Rot/Fruit Rot:** *Phytophthora parasitica* car. *Nicotianae*/*Phytophthora palmivora*.

Symptoms

- Symptoms can appear on tender and matured leaves. Large circular, irregular, water soaked spots with black colour appear on leaves.
- The exposed portion of the unopened leaves may rot.
- Grey patches of irregular spots with brown margin are formed at the base of the leaf sheath.
- The basal portion rots and the pseudo stem break away at the collar region.
- The infection spreads to the underground plants and the rhizomes become rots.

- Small light brown lesions appear in the green tender fruits which fall off in 3-6 days leaving the small fruit stalk.
- The tip of inflorescence also rotted.

Management

- Removal and burning of infected plants.
- Avoid moving of rhizomes from diseased areas to healthy area for planting.
- Provide proper drainage.
- Three sprays with Bordeaux mixture 1% in May, June, July.
- Soil drench with Bordeaux mixture 1% (or) Copper oxychloride 0.25%

3. Mosaic: *Cardamom mosaic virus* (CDMV)

Vector: *Pentalonia nigronervosa*

Symptoms

- General chlorosis of young leaves-parallel streaks of pale green tissues running along the veins from midrib to the margins.
- Leaf sheath also shows stitch stripes.
- In advanced stage the whole plant shows mosaic symptom.
- Rhizome shrivels and plants dies. If young clumps are attached they die before flowering.

Management

- Collection and removal of infected clumps along with rhizomes and burning.
 - Raising of nursery in diseases free areas.
 - Spray with dimethoate (or) Methyl dematan (or) Phosphamidon to kill the vector.
- ### 4. Chenthal Disease/Leaf Blight: *Colletotrichum gloeosporioides*

Symptom

- Elongated, water soaked lesions of varying size appear on the upper surface of the leaf.
- The spots become brown to dark with pale yellow hole. Leaves wither and pseudo stem wilts.

- New shoots which develop are reduced in size. Flowers fail to develop.
- The inflorescences dry up starting from tip downwards. The affected garden shows burnt appearance.

Management

- Removal and destruction of affected leaves.
- Three sprays with carbendazim 0.1% (or) Mancozeb 0.2% (or) copper oxychloride 0.25% at 30 days interval.

IV. Disease of Coriander

1. Wilt Disease: *Fusarium oxysporum* f. sp. *coriander*

Symptoms

- The disease can be easily recognized in the field by drooping of the terminal portions, followed by withering and drying up of leaves, eventually resulting in death.
- Discoloration of vascular system of the root is observed.
- Partial wilting is also found. In partially wilted plants growth is arrested.
- The leaves become pinkish yellow to yellow. Sterility is often noticed in such plants. Seeds, if formed are immature and light.
- Severe infection in the early stage results in total failure of the crop.

Management

- Deep ploughing should be done during summer season.
 - Crop rotation may also be followed. In those plots, where effect of this disease has been noticed, coriander crop should not be taken for 2-3 years.
 - Sowing should be done after seed treatment with Carbendazim 2 gm per kg seed or Thiram 2 gm per Kg seed.
- ### **2. Stem Gall: *Protomyces macrosporus***

Symptom

- Galls appear on the leaves and stems of the plants affected by this disease.
- Shape of coriander seeds change due to effect of the disease.

Management

- To control the disease, sowing may be done only after treating the seeds with 4 g Thiram and 2 g Bavistin/Kg of seeds.
 - Spray 0.1% solution of Carbendazim when the symptoms start appearing and repeat the spraying at an interval of 20 days till the disease is completely controlled.
- 3. Powdery Mildew: *Erysiphe polygoni***

Symptom

- Small, white spots appear on leaf surface and later cover the entire surface.
- Powdery growth can be seen on petiole and umbels.
- Under severe infection, plants present an ashy-white appearance.

Disease Flowers Crops (Rose, Jasmine, Tuberose and Crossandra)

I. Disease of Rose

1. Black Spot: *Diplocarpon rosae*

Symptoms

- Black lesions with feathery margins surrounded by yellow tissue are found on the leaves. Infected leaves drop prematurely.
- Purple/red bumpy areas on first year canes may be evident.
- Plants may be weakened due to defoliation and reduced flower production may be observed.

Management

- Cultural-Roses should be planted where the sun can quickly dry the night's dew.
 - Space roses far enough apart for good air circulation.
 - Avoid overhead watering and keep foliage as dry as possible.
 - Remove infected canes and burn diseased leaves.
- 2. Powdery Mildew: *Sphaerotheca pannosa***

Symptoms

- The symptom appears as grayish-white powdery substance on the surfaces of young leaves, shoots and buds.
- Infected leaves may be distorted, and some leaf drop may occur.

- Flower buds may fail to open, and those that do may produce poor-quality flower.
- It can occur almost anytime during the growing season when temperatures are mild (70 to 80 °F) and the relative humidity is high at night and low during the day.
- It is most severe in shady areas and during cooler periods.

Management

- Collection and burning of fallen leaves.
- Spray with Tilt 0.1% (or) Carbendazim 0.1% 2-3 sprays at 15 days interval is effective.
- Sulphur dust at 25 kg/ha.
- Use of sulphur at higher temperature conditions will be phytotoxic.

3. Die Back: *Diplodia rosae*

Symptoms

- Drying of twigs from tip down wards.
- Blackening of the twigs.
- The disease spreads to root and causes complete killing of the plant.

Management

Pruning should be done so that lesions on the young shoots will be eliminated. Apply chaubatia paste in the pruned area.

4. Rust: *Phragmidium mucronatum*

Symptoms

- Lemon yellow pustules appear on lower surface of the leaves and stems. Then the colour changes to blackish red.
- The affected leaves turn yellow deformed and fall prematurely.
- Die back symptom also appear due to weakening of the plant.

Management

- Collection and burning of fallen leaves.
- Spray with Wettable sulphur 0.25%.

II. Disease of Jasmine

1. Cercospora Leaf Spot-*Cercospora jasminicola*

Symptoms

- Circular to irregular reddish brown spots of 2-8 mm dia appear on the surface of the leaves.
- Later the spots become irregular covering larger areas of the leaves.

Management

- Spraying with Carbendazim 0.1%.

2. Alternaria Leaf Blight-*Alternaria jasmine, A. alternata*

Symptoms

- It produces dark brown colour spots on the leaves.
- On humid condition the spots enlarge covering large area causing blighting of leaves.
- Concentric rings can be seen in the lesions. The disease also affects stem, petiole and flowers.

Management

- Collection and removal of fallen leaves.
- Spray with Mancozeb 0.25%.

3. Collar Rot and Root Rot-*Sclerotium rolfsii*

Symptoms

- Plants at all stages are infected.
- First the older leaves become yellow followed by younger leaves and finally death of the plant.
- In the root black discoloration can be seen.
- On the infected tissues and stem surface white strands of mycelia and mustard like sclerotia are seen.

Management

- Heavy application of FYM with *Trichoderma viride*

4. Phyllody-*Phytoplasma*

Symptoms

Leaves become small malformed and bushy. In the place of flowers green leaf like malformed flowers are formed.

Management

- Selection of cuttings from healthy plants.
- Spraying insecticide to control the vector.

III. Diseases of Crossandra

1. **Wilt:** *Fusarium solani*
2. **Stem Rot:** *Rhizoctonia solani*
3. **Leaf Blight:** *Colletotrichum crossandrae*
4. **Alternaria Leaf Spot:** *Alternaria amaranthi* var. *crossandrae*

1. Wilt: *Fusarium solani*

Symptoms

- Wilt is observed in batches. In the field the disease is observed one month after transplanting.
- Leaves of infected plants become pale and droop.
- Margin of the leaves show pinkish brown discolouration.
- The discoloration spreads to the midrib in a period of 7 to 10 days.
- Stem portion gets shriveled.
- Dark lesions are noticed on the roots extending upto collar region which result in sloughing off the cortical tissue.

Management

- Affected plants should be pulled out and destroyed to reduce the disease.
 - The nematode can be controlled by soil application of Phorate at the rate of 1 g/plant on 10th day of transplanting.
 - Soil drenching with Carbendazim 0.1 per cent or Copper oxychloride 0.25 per cent on 30 days interval controls the disease.
 - The treatment may be repeated after 3 to 4 weeks if needed.
2. **Stem Rot: *Rhizoctonia solani***
 - The pathogen also causes pre-emergence damping off, Brown to black lesions develop on stem just above soil level and result in girdling of the stem.
 - The lesions extend to the upper part of the stem.
 - The lesions extend to the upper part of the stem and result in collapse of seedlings. The roots are also rotted.

Management

- Drenching with Fosesty1-A1 has been found effective in the control of the disease.

3. Leaf Blight: *Colletotrichum crossandrae*

Symptoms

- The symptoms of leaves consist of the development of brownish, depressed necrotic areas surrounded by reddish and slightly raised margins.
- Initially the spots appear as brownish specks but become darker as they expand.
- The lesions are more prominent on lower leaves and confined to the margins.

Infected leaves roll up, shrivel and drop off, leaving a barren stem with a whorl of young leaves at the top.

Management

- Spraying with benomyl 0.1% (or) Mancozeb 0.2% (or) Carbendazim 0.1%

4. Alternaria Leaf Spot: *Alternaria amaranthi* var. *crossandrae*

Symptoms

- This disease was first reported from Tamil Nadu during 1972. Infected leaves show small, circular or irregular yellow spots on the upper surface.
- They soon enlarge turn brown and develop dark brown concentric rings.
- Infected leaves become yellow and drop off prematurely.

Management

Spraying with Benomyl 0.1% (or) Mancozeb 0.2% (or) Carbendazim 0.1%.

IV. Diseases of Tuberose

1. Stem Rot

- The disease symptoms are preceded by the appearance of prominent spots of loose green colour due to rotting which extend and cover the entire leaf.

- The infected leaves get detached from the plant.
- More or less round sclerotic, brown spots are formed on and around the infected leaf.
- As a result, the infected plant becomes weak and unproductive.

Control: The disease can be controlled by soil application of Brassicol (20%) @ 30kg/hectare.

2. Botrytis Spot and Blight (*Botrytis elliptica*)

Symptoms

- The disease appears during the rainy season.
- Infected flowers show dark brown spots and ultimately the entire inflorescence dries up.
- The infection also occurs on the leaves and stalks.

Control: Spraying the plants with Carbendazim @2g/litre of water effectively controls the disease. The treatment should be repeated at 15 days interval.

3. Sclerotial wilt (*Sclerotium rolfsii*)

- The initial symptom of this disease is flaccidity and drooping of leaves.
- The leaves become yellow and dry up.
- The fungus mainly affects the roots and the infection gradually spreads upward through the tuber and collar portion of the stem.
- Both tubers and roots show rotting symptoms.
- Thick cottony growth of the fungus is visible on the rotten stem and on petioles at the soil level.

Control: Drenching the soil with 0.3% Zineb is effective in controlling the disease.

Chapter - 15

Postharvest Diseases of Fruits and Vegetables

I. Fruits: (Apple)

1. Blue Mould: *Penicillium italicum*

Symptoms

- It occurs on fruits during storage and transit.
- Affected rind of the fruits become watery.
- Watery spot increases and then entire fruit rots and emits bad smell
- Blue fungal growth is seen on the surface of the fruits.

Management

- Benomyl, Thiophanate-methyl
- 2% bleaching powder-5 minutes and 0.2% flit 406-10 minutes
- TBZ-0.1% incorporated in waxol-0-12-under refrigeration
- Pre storage dips in TBZ (500ppm) for 2-3 minutes

2. Grey Mould: *Botrytis cinerea*

Symptoms

- Infected fruits turn slightly brownish.
- The fungus advances into the inner flesh resulting in a soft, watery mass of decayed tissue contained in a slightly intact, brown skin.
- The pathogen sporulation on the surface of fruit and the typical, powdery, grey mould stage.
- The disease can spread by contact.

Management

- Sodium bisulphate which releases SO₂ when in contact with moist air can be used with packing material. Dibromotetrachloroethane, sodium-o-phenyl phenate, 2-acetyl-3-hydroxyfuran (Eckert and Sommer, 1967).
- Grey mould can be controlled by prompt cooling.

3. **Alternaria Rot: *Alternaria alternata***

Symptoms

- Typical rot symptoms of this disease are nearly round, brown to black lesions, often centred on a skin break or weakened tissue.
- The spots are firm, dry and shallow.
- The surface of spots becomes dark brown to black and in the advanced stages, the rotted tissues become spongy and the affected flesh turns black.

Management

- Practice orchard sanitation and “soft handling” of fruit.
- Harvest fruit at proper maturity.
- Careful handling during picking, washing, and packing
- Store fruits at temperatures of 0 to 4 °C.

Banana

1. **Anthracnose: *Colletotrichum musae***

Symptoms

- Small, black, circular specks on the skin- sunken & coalesce to form large spots.
- Bright salmon-coloured conidial mass appears on the spots.
- Severely infected fruits become dark due to blemishes.
- Acervuli also develop on the skin and the pulp becomes partially soft.
- Non-latent infection usually starts during or after the harvest of bunches in small peel wounds and it continues to develop without a dormant period.
- Many latent infections at the time of harvest show large number of appressoria on the surface of the peel.
- The spread of the disease is by air-borne conidia and numerous insects which frequently visit banana flowers also spread the disease.
- Temp.30 to 35 °C and RH- 85.7-100%.

Management

- Post harvest dipping of fruits in Carbendazim 400 ppm, or Benomyl 1000 ppm, or Aureofungin Sol 100 ppm.

2. Cigar-End Rot: *Verticillium theobromae*

Symptoms

- Tip of immature fruit and spreads upward.
- Ashy conidia and conidiophores cover the rotted portion.
- Imparting burnt ashy cigar-end appearance with a dark border.
- Decay may extend up to one-third of the fruit but internal tissues develop a dry rot.
- Conidia are hyaline, oblong to cylindrical, borne at the ends of tapering phialides, aggregated into rounded, mucilaginous translucent heads.
- The fungus-plant debris-microsclerotia.
- Infected plant parts-irrigation water-implements.

Management

- The principal method of control is frequent manual removal and burning of dead flower parts and infected fruits.
- Use of fungicide to control the disease is also recommended.
- In the pack house, care should be taken to cull infected fruits to avoid contaminating the washing water with spores.
- Cigar-end rot is effectively controlled by covering the flower (immediately after emergence) with a polyethylene bag before the hands emerge.

Citrus

1. Blue & Green Mould: *Penicillium digitatum* (Green Mould) and *P. italicum* (Blue Mould)

Symptoms

- Softening of damaged tissue.
- White fungal growth, which progressively turns blue or green as spores develop.
- Postharvest fungicides (Imazalil) can arrest spore development resulting in white only fungal growth.

Occurrence

- Infections develop from damaged areas.
- The growth of mould increases with storage temperatures (up to an optimum of 27 degree C).

- Late season fruit more susceptible.
- Damaged rind is more susceptible.

Management

- Careful handling reduces damage to rind.
- Good hygiene and sorting reduces spore load and infection rates.
- Sanitation destroys spores in recirculating water and packing line equipment.
- Postharvest fungicides should be applied within 24h of harvest.
- Lower storage temperatures slow down fungal development.

2. Sour Rot: *Galactomyces citri-aurantii* (formally, *Geotrichum candidum*)

Symptoms

- Very soft, watery decay.
- Distinct margin between decayed and healthy tissue.
- Sour odour detectable.

Occurrence

- Infection occurs in damaged fruit.
- Fungicide used to control blue & green moulds may not control Sour rot. (e.g., USA accepted fungicides).
- Sour rot spores in soil can accumulate in recirculating water in dips and drenches.
- Spreads by contact after packing creating nests of infected fruit in boxes.

Management

- Careful handling reduces rind damage.
- Apply Guazatine fungicide within 24hrs of harvest.
- Strong emphasis of sanitisers when Guazatine fungicide not approved for use.

Grapes

1. Blue Mould Rot: *Penicillium digitatum*

Symptoms

- Scanty growth-white and turn bluish green are seen.
- Decay the berries
- Infected tissues become soft and watery
- Infected berries emits a mouldy flavour

Management

- Avoiding injuries to the ripe berries helps to reduce soft rot.
- Clean planting stock; (ii) Disease wood removal and immediate burning; (iii) fungicide application at shoot extension and later if temperatures are cool. Sulphur is said to reduce new infections in the early Spring.

2. Blue Mould Rot: *Penicillium digitatum*

Symptoms

- Scanty growth-white and turn bluish green are seen.
- Decay the berries.
- Infected tissues become soft and watery.
- Infected berries emits a mouldy flavour.

Management

- Avoiding injuries to the ripe berries helps to reduce soft rot.
- Clean planting stock; (ii) Disease wood removal and immediate burning; (iii) fungicide application at shoot extension and later if temperatures are cool. Sulphur is said to reduce new infections in the early Spring.

3. Rhizopus Rot: *Rhizopus nigricans*

Symptoms

- Round irregular, light brown and water soaked lesion appear on fruits.
- Decaying fruits emits fermented, mouldy smell.
- Conidia aseptate, small and globose

Management

- Diphenyl sprayed on cushions is effective at 1 g and 2 g per pack in protecting the fruits upto 15 days in storage as protectant and eradicant.

Mango

1. Black Mould Rot: *Aspergillus niger*

Symptoms

- Yellowing of base-development of irregular, hazy, greyish spots.
- Mesocarp of the rotted area becomes depressed-soft.
- The fruit surface-covered-blackish fungal growth.
- Decrease in ascorbic acid.

2. Stem End Rot: *Lasiodiplodia theobromae*

Symptoms

- In fruits, the pericarp darkens near the base of the pedicel.
- The affected area enlarges to form a circular, black patch which under humid atmosphere extends rapidly and turns the whole fruit completely black within two or three days.
- The pulp becomes brown and softer.

Vegetables

I. Tomato

1. *Phoma Rot: Phoma destructiva*

Symptom

- Distinguished from other rots by the black color of this spot
- Small, black, pimple-like eruptions.
- Specks are the pycnidia or fruiting bodies of the fungus.

Favourable Condition

- Moderate temperature and high humidity.
- Most rapid decay on ripe fruits @ 21 °C, but since tomatoes ripen more rapidly at about 23 °C, the disease may be more promptly in the ripening room.

Spread and Survival

- Seed borne.
- By infected transplants or rain-splashed from infected crop debris.
- Fruits-wounds, stem scars.

Management

- Seed treatment-mercuric dust (5% ethyl mercury phosphate).
- Seed be sanitation.
- Do not harvest when plants are wet.
- To control contamination in packing process- 5% borax solution containing 0.5% liquid tar soap as washing medium.

2. Rhizopus Rot: *R. stolonifer*

Symptom

- On tomatoes, Rhizopus rot appears water-soaked and may exude a clear liquid.
- Lesion surface may be covered with thin, cotton-like fungal structures (especially under humid conditions).
- Dark sporulation may crown the white tuft of Rhizopus.
- Mycelium can infect adjacent fruit through natural openings or mechanical wounds, creating nests of mold and diseased fruit.

Spread

- Air currents pathogen grows very aggressively even on refrigerated fruit.
- Pallets and cartons, and it may survive for months in fruit residues left in picking containers and field bins.
- The length of the surface wetness period needs to be longer at the lower temperatures for disease development.

Management

- Ensure good drainage facility.
- In the greenhouse, maintain a RH of less than 80%, during the night.
- Remove decaying plant material from the plant bed.
- Avoid bruising during packing and transport.

3. Southern Blight: *Sclerotium rolfsii*

Symptom

- Hot weather disease.
- Mature plants are attacked just below the soil surface and are completely girdled.
- The tops wilt and die rapidly.
- Mycelium often grows over the diseased tissue and surrounding soil forming a white mat of mycelial threads with the typical tan-to brown, at the crown mustard-seed-sized sclerotia.
- Often the entire root system is destroyed.

Favourable Condition

- Wet periods of high temperatures (85-95 °F).

Spread and Survival

- Fungus is exceedingly destructive on ground crops and attacks the fruit where they contact the soil.
- Slightly sunken, yellow spots develop on invaded fruit, which rapidly decay, collapse, and become covered by a white fungal mass with numerous sclerotia.
- Soil borne, machinery or water-moved infested soil, survives on numerous weed and crop hosts.

Management

- Crop rotations of two years or more to a non-host crop like corn or small grains will help to prevent build-up of inoculum and disease problems
- Close plant spacing and over-irrigation promote disease development and should be avoided.

Carrot

Cottony Soft Rot/White Mould: *Sclerotinia sclerotiarum*

Symptom

- Foliage-water soaked, dark olive-green lesions associated with collapsed tissues
- Lesions expand rapidly over the entire leaf, petiole, and rosette with infected tissues

- Covered by abundant cottony, white mycelium
- At an advanced stage-affected tissues exhibit a bleached appearance, and occasionally an entire plant may collapse.
- Large black sclerotia (2 to 20mm) form externally embedded in the mycelium or internally, within the pith of the petiole.

Management

- Storage-Good ventilation.
- Use of clean containers, maintenance of temp near 0 °C.

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