

**Subdivision: Deuteromycotina: class: Coelomycetes (Sphaeropsidales), class: Hyphomycetes (Hyphomycetales, Agonomycetales)**

**General characters**

Fungi possess branched, septate and multinucleate mycelium. They reproduce through asexual methods. the most common method of reproduction is by conidia. No sexual spores are produced. They are called as Fungi Imperfecti.

**Classification**

**Key to Classes of Deuteromycotina**

A. True mycelium lacking or not well-developed, soma is made up of yeast (budding) cells with or without pseudomycelium .. Blastomycetes. AA. Mycelium well-developed, assimilative budding cells absent ... B, BB

B. Reproduction by conidia borne in pycnidia or acervuli ... Coelomycetes BB. Reproduction absent i.e. sterile forms or takes place by conidia produced on separate hyphae or aggregations of hyphae (as synnemata or sporodochia) but not within pycnidia or acervuli ... Hyphomycetes

**Class: Coelomycetes**

The members are found both in tropical and temperate regions. They are commonly found in cultivated and uncultivated soils, leaf litter organic debris, fresh water and saline water. They may be found on other fungi and lichens. They are also pathogens of plants, insects and vertebrates. Coelomycetes is divided into two orders, Melanconiales and Sphaeropsidales. In this class conidia are produced either in acervuli or pycnidia and accordingly the members have been grouped into two orders:

- 1 Conidia produced in acervuli -Melanconiales
- 2 Conidia produced in pycnidia –Sphaeropsidales

**Order: Melanconiales**

In Melanconiales the fructifications are acervuli. It contains a single family, 'Melanconiaceae' which is characterized by the production of acervuli. Acervuli may develop subepidermally or subcuticularly. Conidia may be hyaline to cream, pink, orange or black. Acervuli develop by simple meristogenous, compound meristogenous or sympogenous methods. More than 120 genera are included in this family and they cause plant disease known as anthracnose. The important genera are

1. *Colletotrichum*
2. *Coryneum*
3. *Cylindrosporium*
4. *Entomosporium*
5. *Marssoninia*
6. *Melanconium*
7. *Monochaetia*
8. *Pestalotia*
9. *Pestalotiopsis*
10. *Gloeosporium*
11. *Sphaceloma*
12. *Didymosporium*
13. *Septogloeum*

### ***Colletotrichum***

Acervuli may be subcuticular, epidermal or subepidermal. They may be either separate or confluent. Conidiophores are hyaline to brown, septate, smooth, branched at the base. Conidia are hyaline, unicellular, falcate or lunate (sickle shaped) or cylindrical. Perfect state of the fungus belongs to *Glomerella*. The important plant pathogenic species of *Colletotrichum* are given below:

*C. capsici*-Fruit rot and dieback of chillies, anthracnose and boll rot of cotton.

*C. circinans* -Smudge of onion

*C. coffeae* -Coffee berry disease

*C. falcatum* -Red rot of sugarcane

*C. gloeosporioides* Anthracnose of citrus and banana.

*C. graminicola* Anthracnose of corn and sorghum .

*C. lindemuthianum*-Anthracnose of cowpea and *Phaseolus* spp.

*C. musae* -Anthracnose of banana (*Gloeosporium musarum*)

*C. truncatum* -Anthracnose of legumes.

### ***Pestalotia (Pestalozzia)***

The genus is characterized by the conidia which are fusiform, straight or slightly curved and five septate, with four median cells brown and end cells hyaline lacking cytoplasm. There

may be 3-9 apical, cellular, simple or dichotomously branched appendages and one basal endogenous cellular, simple or branched appendage. The conidiophores are long, branched and septate. The fructifications are dark brown.

### ***Pestalotiopsis***

*Pestalotiopsis* differ from *Pestalotia* in the production of 4 septate conidia (5 celled) with two or more apical appendages and conidiogenous cell with several proliferations. The fructifications eustromatic and cupulate. Acervuli are subepidermal and are irregularly erumpent through the epidermis or longitudinal cracks may appear. They are either found on decaying leaves. Many are important plant pathogens.

*P. palmarum* -Grey blight of coconut (*Pestilential palmarum*) and other palms.

*P. theae* -Grey blight of tea and blight of (*Pestalotia theae*) mango, palms and cotton.

*P. mangiferae* -Grey blight of mango (*Pestalotia mangiferae*)

## **Order: Sphaeropsidales**

In this order the conidia and conidiogenous cells or conidiophores are produced in pycnidia. Mycelium may be immersed in the substrate or superficial. Conidia are produced in several ways from phialides, annellides etc. Conidia are solitary, sympodial catenate etc. Sphaeropsidales is divided into four families based on the colour, shape and texture of the pycnidia. They are Sphaeropsidaceae ,Nectrioidaceae (Zythiaceae), Leptostromataceae and Excipulaceae (Discellaceae).

### **Family : Sphaeropsidaceae**

This is a large family consisting of both saprobes and a stroma. These are tough, leathery to brittle, globose, ostiolate and dark coloured. The spores are hyaline spherical or oval and often exude from the ostiole in damp weather in a worm like mass or citrus.

### ***Macrophomina***

Mycelium superficial or immersed, hyaline to brown, branched, septate, often tree like in form (dendroid). Pycnidia separate, globose, dark brown, immersed, with one cavity, thick-walled; wall consisting of an outer layer of darkbrown; thick walled, closely packed polyhedral cells, becoming hyaline towards the inside. Ostiole central, circular, papillate. Conidiophores absent. Conidiogenous cells enteroblastic, phialidic, determinate, lageniform to doliform, hyaline, smooth with aperture and minute collarette, formed from cells lining the pycnidial cavity.

Conidia (Pycnospores) hyaline, aseptate, obtuse at each end straight cylindrical to fusiform, thin-walled, smooth with aperture and minute collarette, formed from cells lining the pycnidial cavity. Conidia (Pycnospores) hyaline, aseptate, obtuse at each end, straight cylindrical to fusiform, thin-walled, smooth, may be guttulate. Forming mainly sclerotia in cultures, which are black, smooth, hard, formed of dark-brown thickwalled cells. The genus *Macrophomina* is monotypic and contains the only species, *M. phaseolina*, *Macrophomina phaseolina* (syn *Rhizoctonia bataticola*). This fungus causes charcoal rot, ashy stem blight, Dry root rot, canker, damping off and leaf lesions on hosts like sorghum, pearl millet, soybean, groundnut, cotton, *Phaseolus* spp., tomato, potato etc.,

### ***Ascochyta***

It is a very large and widely distributed genus containing about 350 species. Most of them are plant pathogens. Mycelium immersed, branched, septate, hyaline to pale brown. Pycnidia are amphigenous, separate, globose, brown, immersed, unilocular and thin-walled. Ostiole central, circular, slightly papillate. Conidiophores are absent. Conidiogenous cells enteroblastic, phialidic, determinate, discrete, doliform to lageniform, hyaline, smooth, formed from the inner cells of pycnidial cavity. Conidia hyaline, thin-walled, cylindrical, ovoid, oblong to irregular, medianly one-septate, continuous or constricted at the septum. Conidia may be guttulate.

The important plant pathogens are as follows:

- A. *abelmoschi* -Leaf, fruit and stem spot of lady's finger.
- A. *caricae-papayae* -Fruit rot of papaya
- A. *fabae* -Leaf and pod spot of broad beans
- A. *melongenae* -Leaf spot of lady's finger
- A. *phaseolorum* -Leaf and pod spot of common bean and other legumes.
- A. *pisi* -Leaf and pod spot of pea.
- A. *pinodes* -Foot rot or blight of pea
- A. *rabiei* -Blight of chickpea
- A. *sorghii* -Leaf spot of sorghum

### ***Septoria***

It is a large and cosmopolitan genus with 1000 species, which are parasitic causing leaf spot diseases in plants. The pycnidia are immersed in the substratum and are either separate or

aggregated and not confluent. They are globose, ostiolate, thin walled and brown. . Conidia are hyaline, smooth, filiform (scolecospore), continuous or constricted at septa. The perfect states in Ascomycotina genera are *Mycosphaerella* and *Leptosphaeria*.

*Septoria apii* -Celery leaf blight

*S. chrysanthemella* -Black leaf spot of sweet potato

*S. bataticola* -Leaf spot of sweetpotato

*S. glycinea* -Brown spot of soybean

*S. lycopersici* -Leaf spot of tomato

*S. nodorum* -Speckled leaf blotch of wheat

*S. thespesiae* -Leaf spot of Portia tree

*S. tritici* -Leaf spot of wheat

**Family: Excipulaceae (Discellaceae) (Genera: *Excipula*, *Discula*, *Dinemosporium*, *Sporonema*)**

**Class: Hyphomycetes**

Hawksworth *et al.* (1983) classified Hyphomycetes into four orders, Agonomycetales, Hyphomycetales, Stilbellales and Tubulariales. The orders have been separated on the basis of presence of absence of conidia and the degree of aggregation of the conidiophores into specialized structures such as synnemata or sporodochia.

**Classification of Hyphomycetes**

Conidia absent except for chlamydospores - Agonomycetales or Mycelial sterilia Conidia present Conidiophores are not organized as synnemata or sporodochia- Hyphomycetales (Moniliales) Conidiophores are organized as synnemata or sporodochia.

a. Synnemata formed - **Stilbellales**

b. Sporodochia formed – **Tubulariales**

**Order: Agonomycetales or Mycelia sterilia**

1. Leaf parasites and forming sclerotia that are immersed in leaf tissue - *Dactuliphora*

2. Sclerotia not immersed in leaf tissue, if leaf parasites:

(a) Sclerotia formed of loosely woven hyphae; irregular in shape - *Rhizoctonia*

(b) Sclerotia formed of compact hyphae; large - *Sclerotium*

(c) Compact cells arranged in cluster like forms; true sclerotia absent – *Populaspora*

The fungi included in this order are referred as Mycelia sterilia as they lack even the imperfect state (spores) and reproduce only by fragmentation of mycelium. They do form sclerotia or chlamydospores, which help in perpetuation and dissemination of the pathogen. Agonomycetales may be states of Basidiomycetes, Ascomycetes or other Deuteromycetes. It has a single family Agonomycetaceae containing 42 genera. *Aegerita*, *Arbuscula*, *Dactuliothora*, *Papulaspora*, *Rhizoctonia* and *Sclerotium* are important genera.

### ***Rhizoctonia***

The form-genus *Rhizoctonia* has about 15 species. They are facultative necrotrophs i.e. they are capable of prolonged existence as saprophyte in the soil. Under suitable conditions they cause diseases like damping off and root rots. Important characters of this are the formation of sclerotia of irregular size and shape but of uniform texture brown or black, more or less loosely packed. The cells of the hyphae are barrel shaped, anastomosing frequently, branching more or less at right angles, and pale brown to brown in colour. Perfect states of *Rhizoctonia* are *Ceratobasidium* and *Thanatephorus* (of Basidiomycotina) and *Macrophomina* (Pycnidial state).  
*R. bataticola* - Dry root rot of pulses, cotton etc. (Pycnidial state: *Macrophomina phaseolina*)  
*R. solani* - Root rot of cotton. (Perfect state: *Thanatephorus cucumeris*)

### ***Sclerotium***

It is a large genus with about 100 species. They cause important plant diseases. It is characterized by hard, brown to black, fairly large sclerotia with pseudoparenchymatous rind. These are produced on sterile, cotton, white mycelium provided with clamp connections. The perfect states of *Sclerotium* are *Pellicularia* (Hymenomycetes of Basidiomycotina) and *Sclerotinia* (of Ascomycotina)

*Sclerotium cepivorum* -White rot of onion

*S. oryzae*-Stem rot of rice (Perfect state: *Magnaporthe salvinii* Conidial state: *Nakataea sigmoidea*)

*S. rolfsii* - Root rot of soybean, black pepper groundnut, cotton, cabbage tomato etc. (Perfect State: *Corticium rolfsii*(syn.*Pellicularia rolfsii*)

### **Order: Hyphomycetales (Moniliales)**

This order has important saprobes used in decomposition of organic matters. It has pathogens on plant, animal and human beings. In this order the conidiogenous cells are produced on the conidiophores, which may be either micronematous. i.e morphologically similar to

vegetative hyphae or macronematous. i.e. which are morphologically very different from purely vegetative hyphae but are always mononematous i.e. they are sporodochia. The order is divided into two families, Moniliaceae and Dematiaceae.

The order is divided into 2 families:

1 Conidia and conidiophores hyaline or brightly coloured -*Moniliaceae*

2 Conidia or conidiophores or both with distinct dark pigment –*Dematiaceae*

### **Form-family 1: Moniliaceae**

Most of the members in this family are saprobes in soil, dead organic matter and foodstuffs. Some are plant, human and animal pathogens whereas some others are predaceous fungi on nematodes. The members of this form-family are characterized by the production of free conidiophores or conidiogenous cells from the somatic hyphae and all the structures i.e. hyphae, conidiophores and conidia are hyaline. A key to important plant pathogenic genera is given here:

I. Conidia unicellular, globose to cylindrical, conidiophore distinct:

(a) Conidia almost similar to apical cells of conidiophores *Monilia*

(b) Conidia not as above; borne in chains; dry:

(i) Phialides in heads on simple conidiophores -*Aspergillus*

(ii) Phialides bush like; upright -*Penicillium*

(c) Conidia not borne in chains; conidiophores verticillate, phialospores in mucilaginous mass - *Verticillium*

(d) Conidiophore branching irregularly or dichotomously; conidia dry, borne on inflated **apical cells** -*Botrytis*

II. Conidia bicelled, ovoid to cylindrical:

(a) **Conidiophores** reduced to stromal cells - *Rhyncosporium*

(b) Conidiophore distinct, rarely branched, in clusters; conidia cylindrical, in short chains - *Ramularia*

III. Conidia 3 or more celled:

(a) Conidia usually of 2 types, multiseptate macroconidia canoe shaped; unicellular microconidia often present -*Fusarium*

(b) Conidiophores rarely branched, conidia simple, attenuated at the apex - *Cercosporaella*

(c) Conidiophores usually simple; conidia on denticles –*Pyricularia Aspergillus* and *Penicillium* belong here, Imperfect stages of the Erysiphales (powdery mildews) viz. *Acrosporium* (formerly known as oidium) is also placed here.

Imperfect stage of Ascomycetes -*Neurospora* and *Monilinia* and *Botryotinia* also belong here and placed in the form genera *Monilia* and *Botrytis* respectively. The genera *Verticillium* and *Trichoderma* are known to have *Trichoderma* as imperfect states. Pathogens of man and animals viz., *Microsporium* (Imperfect state: *Arthroderma*), *Trichophyton* (Imperfect state: *Nannizzia*), *Histoplasma* (Imperfect state: Ajellomyces), *Geotrichum*, *Sporothrix*, *Coccidioides*, *Paracoccidioides* and *Epidermophyton* belong to his family. *Arthroderma* (*Microsporium*), *Phymatotrichum*, Predaceous fungi like *Dactylaria*, *Arthrobotrys* and *Monacrosporium* are also included in the family Moniliaceae.

### ***Verticillium***

The genus is characterized by the production of balls of aeroospores on verticillately arranged phialides. The conidiophores are erect, hyaline or slightly pigmented and simple or branched. Chlamydospores, aleuriospores and microsclerotia are also produced by some species. *V. albo-atrum* -Wilt of cotton, tobacco, cowpea, tomato, brinjal, potato, lucerne. *V. dahliae* -Wilt of tobacco and brinjal Form-family 2: Dematiaceae.

This family is characterized by the production of dark-conidia and/or conidiophores. Conidiophores are simple and not produced in any type of fruiting body. Many members are saprobic found in soil and on dead organic matters. Others are pathogens of plants. *Alternaria* , *Bipolaris*, *Cladosporium*, *Cercospora*, *Curvularia*, *Drechslera*, *Helminthosporium* and *Pyricularia* are important genera in this family.

### **A key to important genera is given below:**

I. Conidia single celled, globose to cylindrical in shape.

(a) Conidia hyaline to sub-hyaline, *phialosporous*, endogenous; phialides often single; aleuriospores dark, borne singly or in short chains - ***Thielaviopsis***

(b) Conidia blastospores, dark, borne acropetally in long chains; ovoid to oblong, sometimes >2 celled - ***Cladosporium***

(c) Conidia dark, in short chains:

(i) Mycelium subcuticular, conidia annelospores, acute at apex, sometimes 2-celled - ***Spilocaea***

(ii) Conidia blastospores, dry, borne in apical clusters - ***Periconia***

(d) Conidiophore simple, intertwined; conidia holoblastic, spherical; in ovaries of individual grains of Gramineae - ***Ustilaginoidea***

II. Conidia usually bicelled, borne singly on conidiophores. Mycelium subepidermal, without forming stroma, apical cell of conidia narrower than basal cell - ***Passalora***

III. Conidia more than 3 celled, not borne in chains, only transversely septate.

A. Conidiophores in clusters, simple or rarely branched, conidia long cylindrical to filamentous:

(i) Stroma well developed -***Cercosporidium***

(ii) Stroma not developed -***Cercospora***

B. Conidiophores packed together, arising from a well-developed stroma. Conidia annellospores, ellipsoid ovoid -***Strigmina***

C. Conidiophores single; stroma absent:

1. Conidia porosporous.

(i) Conidia borne apically -***Corynespora***

(ii) Conidia borne laterally and apically -***Helminthosporium***

2. Conidia sympodulospores.

(i) Conidia typically bent, middle cell enlarged -***Curvularia***

(ii) Conidia straight, sometimes curved slightly

(a) Conidial germination by any of its cells -***Drechslera***

(b) Conidial germination by end cells only -***Bipolaris***

IV. Conidia several celled, longitudinal as well transverse septa present.

(a) Conidia borne in acropetal chains -***Alternaria***

(b) Conidia borne singly, apical, sub-globose, obovate or broadly ellipsoid - ***Stemphylium***

***Alternaria***

It is a polyphagous fungus and occurs most frequently as a saprobe on dead and decaying organic materials, on or in seeds and is responsible for causing leaf spots of economically important crop plants. Conidiophores are dark, septate, sometimes inconspicuous, simple or branched, bearing conidia at the apex. Conidia (Porospores) solitary or more often produced in acropetal succession to form simple or branched chains, muriform, darkly pigmented, ovate to obclavate, tapering abruptly or gradually towards the apex, smooth or roughened.

Important plant diseases caused by *Alternaria* spp. are

*Alternaria alternata* - Black point disease of wheat grains

*A. brassicae* - Leaf spot of crucifers  
*A. brassicola* - Leaf and pod spot of Crucifers  
*A. carthami* - Leaf spot of safflower  
*A. cucumerina* - Leaf spot of cucurbit  
*A. citri* - Black rot of oranges, fruit rot of lemons and tangerines, leaf spot of rough lemon and mandarin.  
*A. longipes* - Brown spot of tobacco  
*A. macrospora* - Leaf spot of cotton  
*A. padwickii* - Stackburn, seedling blight or leaf spot (=*Trichoconis padwickii*) of rice  
*A. porri* - Purple blotch of onion  
*A. solani* - Early blight of potato and leaf spot of tomato, chillies and tobacco  
*A. triticina* - Leaf blight of wheat

*Cercospora*: They are weak parasites on dead or drying plant tissues or pathogens of plants or human beings. This genus is characterized by long, hyaline or pigmented conidia borne in acropetal succession from a usually simple, sympodially extending, cicatrized (i.e. with conspicuous scars), pigmented conidiophores which are frequently aggregated in fascicles. The conidia are filiform and several celled.

*Cercospora apii* - Leaf spot of celery  
*C. arachidicola* - Early leaf spot of groundnut  
*C. beticola* - Leaf spot of sugar beet  
*C. coffeicola* - Leaf spot of coffee and spinach  
*C. nicotianae* - Frog -eye spot of tobacco  
*C. kikuchii* - Purple stain of soybean  
*Cercospora musae* - Sigatoka leaf spot  
*C. personata* - Late leaf spot of groundnut

### ***Helminthosporium***

Colonies effuse, dark and hairy. Mycelium immersed stromata usually present. Conidiophores often in fascicles, erect, brown to dark brown. Conidia develop laterally, often in verticils, through pores beneath the septa of the conidiophore while the tip of the conidiophores continues to grow but growth cases with the formation of terminal conidia. Conidia sub-hyaline to brown, usually obclavate, pseudoseptate and frequently with a dark brown to black protruding

scar at the base. This genus contains approximately 20 species. *Helminthosporium* imperfect state is produced in *Pseudocochliobolus* belonging to the Dothideales.

#### **List of *Helminthosporium* transferred to *Drechslera***

<i>Helminthosporium</i> sp.	<i>Drechslera</i> sp.	Ascigerous state
<i>H. carbonum</i>	<i>D. zeicola</i>	<i>Cochliobolus carbonum</i>
<i>H. gramineum</i>	<i>D. graminea</i> (Leaf stripe of Barely)	<i>Pyrenophora graminea</i>
<i>H. heveae</i>	<i>D. heveae</i> (Birds eye spot of rubber)	
<i>H. maydis</i>	<i>D. maydis</i> (Leaf blight of corn)	<i>Cochliobolus heterosporus</i>
<i>H. nodulosum</i>	<i>D. nodulosus</i>	<i>C. nodulosus</i>
<i>H. oryzae</i>	<i>D. oryzae</i> (brown leaf spot of rice)	<i>C. miyabeanus</i>
<i>H. sacchari</i>	<i>D. sacchari</i> (seedling blight of sugarcane)	
<i>H. sativum</i>	<i>Bipolaris</i>	<i>C. sativum</i>
<i>H. sigmoideum</i>	<i>Nakataea sigmoidea</i>	<i>Leptosphaeria salvinii</i>

#### **Drechslera**

It is characterized by the sympodially extending conidiophore, which produces an acropetal succession of multiseptate porospores, which are cylindric in shape and germinate from any or all cells. Conidiophores are indeterminate, extending by sympodial growth. The cells of conidium are capable of germination. Conidiophores are brown and produce the conidia singly at the apices. Conidia are cylindrical, multiseptate and dark. *Cochliobolus*, *Pyrenophora*, *Pleospora* and *Trichometasphaeria* are imperfect states of *Drechslera*.

#### **Bipolaris**

*Bipolaris* is characterized by germination of conidia from the end cells only. Conidiophores brown, producing conidia through an apical pore and forming a new apex by growth of the sub-terminal region. Conidia fusoid, straight or curved, germinating by one germ tube from each end cell. Exosporium smooth, rigid and brown. Endosporium hyaline, amorphous, separating cells of the mature phragmospores. They are pathogenic on members in grass family. The perfect state is *Cochliobolus*.

### ***Pyricularia***

There are only few species, which are causing important plant diseases. Conidiophores are more or less erect, simple or rarely branched, septate, hyaline to lightly pigmented, ultimate cells sympodulae. Conidia borne singly and terminally at the apex of conidiophore with successive conidia being produced in acropetal succession by sympodial extension of the sporogenous cell. Abscission of conidia leaves pronounced denticles on the spore-bearing apex. Conidia ellipsoid or more often pyriform, broader and truncated at the attachment point, tapering towards the distal end, mostly one septate or two septate, hyaline to lightly pigmented.

*Pyricularia oryzae* -Blast of rice

*P. setariae* -Blast of fox-tail millet

*P. grisea* -Blast of ragi / finger millet

### **Order: Tubulariales**

The characteristic features of this order is the production of sporodochia (sing. sporodochium; Gr. spora = seed + dochien = container) in which the spore mass is supported by a superficial, cushion -like (pulvinate) mass of conidiogenous cells or short conidiophores. The order contains a single family, Tubulariaceae that has more than 160 form-genera. Following genera are important:

I. Conidia unicellular, hyaline to bright coloured.

(a) Sporodochia stromatic, parasitic on grains -*Sphacelia*

(b) Sporodochia pulvinate, sometimes with prominent, hyaline setae, Conidia in chains, usually greenish in mass -*Myrothecium*

II. Conidia multicellular, long slender, setae absent in sporodochia.

(a) Macroconidia canoe shaped -*Fusarium*

(b) Conidia curved with short side branches -*Ramulispora*

III. Conidia dictyospores, dark, globose to subglobose.

(a) Sporodochia pulvinate -*Epicoccum*

(b) Sporodochia convoluted -*Cerebella*

*Fusarium*, *Tubularia*, *Volutella*, *Epicoccum* and *Exosporium* are important genera.

## Fusarium

The macroconidia (phialospores) are produced on conidiophores, which may be solitary and simple or aggregated (sporodochia) and with complex branching and the ultimate branched terminating in sporogenous cells. The sporogenous cells. The sporogenous cells are phialides, sometimes with an apical collarette. In addition to macroconidia in some fusaria another type of conidia, i.e. microconidia are produced.

Microconidia are non-septate or one-septate, ovoid to short cylindric, gathering in short chains or more commonly in spore balls. Thick walled chlamydospores are also produced either terminally or intercalarily on the somatic hyphae. The mycelium, microconidia, macroconidia and sporodochia are bright in colour. Perfect state of *Fusarium* is found in Ascomycetes in the family Hypocreaceae in which the genera, *Nectria*, *Calonectria*, *Gibberella* and *Micronectriella* are found. The genus *Fusarium* contains about 50 species, which are widely distributed in soil and organic substrates. Some of the species, which are serious plant pathogens are listed below.

*F. avenaceum* ( syn. *F. roseum*) -Damping off of seedlings, seedling blight, foot and root rot, ear blight of wheat, barley, oats, corn etc.

*F. coeruleum* -Dry rot of potato

*F. moniliforme* -Foot rot of rice

*F. oxysporum* f.sp. *batatae* -Wilt of sweet potato

*F. oxysporum* f.sp. *betae* -Wilt of beetroot

*F. oxysporum* f.sp. *carthami* -Wilt of safflower

*F. oxysporum* f.sp. *cepae* -Wilt of onion

*F. oxysporum* f.sp. *ciceris* -Wilt of chickpea

*F. oxysporum* f.sp. *conglutinans* -Cabbage yellows

*F. oxysporum* f.sp. *coriandri* -Wilt of coriander

*F. oxysporum* f.sp. *cubense* -Panama disease of banana

*F. oxysporum* f.sp. *cucumerinum* -Wilt / foot rot of cucumber

*F. oxysporum* f.sp. *cumini* -Wilt of cumin

*F. oxysporum* f.sp. *fabae* -Wilt of broad bean

*F. oxysporum* f.sp. *glycines* -Wilt of soybean

*F. oxysporum* f.sp. *lagenariae* -Wilt of bottlegourd

*F. oxysporum* f.sp. *lathyri* -Wilt of *Lathyrus sativus*

*F. oxysporum* f.sp. *lentis* -Wilt of lentil  
*F. oxysporum* f.sp. *lini* -Wilt of linseed  
*F. o. f.sp. lycopersici* -Wilt of tomato  
*F. o. f. sp. Melongenae* -Wilt of brinjal  
*F. o. f.sp. phaseoli*-Dry rot or wilt or *Phaseolus vulgaris*  
*F. o. f.sp. pisi*-Wilt of pea  
*F. o. f. sp. psidii* - Wilt of guava  
*F. o. f.sp. sesame* - Wilt of sesame  
*F. o. f.sp. sesbaniae* - Wilt of *Sesbania aegyptiaca*  
*F. tracheophilum* - Wilt of cowpea  
*F. o. f.sp. vasinfectum* - Wilt of cotton, banana, citrus, tomato and cucurbits, Damping off of tomato.  
*F. semitectum* - Storage rot of groundnut  
*F. solani* - Root rot and wilt of legumes, citrus and coffee  
*F. solani* f.sp. *aurantifolia* - *Citrus aurantifolia*  
*F. solani* f.sp. *batatae* - Wilt of sweet potato  
*F. solani* f.sp. *coeruleum* - Wilt of clusterbeans.  
*F. solani* f.sp. *cucurbitae* - Wilt of *Cucurbita* spp  
*F. solani* f.sp. *enmartii* - Wilt of potato  
*F. solani* f.sp. *faba* - Wilt of *Vicia faba*  
*F. solani* f.sp. *phaseoli* - Wilt of *Phaseolus* spp.  
*F. solani* f.sp. *piperis* - Wilt of black pepper  
*F. solani* f.sp. *pisi* - Wilt of peas  
*F. udum* - Wilt of pigeonpea  
*F. udum* f.sp. *crotalariae* - Wilt of sunnhemp

### Symptoms

Enlargement of roots, club-shaped roots due to hyperplasia and hypertrophy, gradual and inconspicuous stunting, yellowing and wilting of plant.

## **Symptoms of leaf spots, leaf blights, root rots and wilts and disease cycles of *Alternaria*, *Helminthosporium*, *Colletotrichum*, *Pyricularia*, *Macrophomina* and *Fusarium***

### **Leaf Spot**

In leaf spot a well marked necrotic area of grey, brown, purple or black tissues in green leaves.

#### **i. Blast of rice - *Pyricularia oryzae***

##### **Systematic position**

Sub-kingdom : Mycota

Division : Eumycota

Sub-division : Deuteromycotina

Class : Hyphomycetes

Order : Moniliales

Family : Moniliaceae

Genus : *Pyricularia*

Species : *P. oryzae*

**Symptoms:** Spindle shaped spots on the leaves (leaf-blast); spots are with dark brown margin and grey centre; spots on the node and neck are black; breaking of neck of earhead (neck blast) and nodal regions in stem (nodal blast). Grain infection shows brown spots on the seed coat.

**Pathogen:** Mycelium is septate, branched and hyaline to olivaceous, both inter-and intra-cellular. Conidiophores emerge through stomata or by rupturing the cuticle, single or grouped (2-3), 2 to 4 septate, geniculate and olivaceous. Conidia borne sympodially, hyaline to pale olive, pyriform, three celled with a small basal appendage called **hilum**.

**Disease cycle:** The conidia are spread through wind and cause infection. The grasses like *Panicum repens*, *Digitaria marginata*, *Echinochloa crusgalil*, etc. act as collateral hosts (alternative hosts) and help in perpetuation of the disease and act as primary source of inoculum. The conidia from the grasses on the bunds help on initiation of the disease in the nursery or main field.

**ii. Brown spot of rice- *Helminthosporium oryzae* (syn. *Bipolaris oryzae*, *Drechslera oryzae*;** Perfect stage: *Cochliobolus miyabeanus*)

**Systematic position**

Sub-kingdom : Mycota

Division : Eumycota

Sub-division : Deuteromycotina

Class : Hyphomycetes

Order : Moniliales

Family : Dematiaceae

Genus : *Helminthosporium*

Species : *H. oryzae*

**Symptoms:** Oval shaped, dark brown to black spots on the leaves; black spots on the grains.

**Pathogen:** Mycelium is brown, septate, branched, inter are and intracellular.

Conidiophores are long, septate, darker and geniculate. Conidia are borne singly, 2 to 12 are celled, brown, slightly curved with a bulge in the middle and tapering towards the ends. Perithecia are globose, dark yellowish brown with ostiolar beak. Ascii are cylindrical, slightly curved and bear 4-6 ascospores. Ascospores are hyaline, long, cylindrical and 6-15 septate

**Disease cycle:** The fungus overwinters in infected plant parts. The fungus survives on *Cynodon dactylon*, *Echinochloa colona*, *Digitaria sanguinalis* (collateral hosts) from which the conidia spread to rice crop in the nursery. Ascospores from perithecia found on dead straw in heaps, which also serve as source of infection. In the field wind-borne conidia cause secondary infection.

**iii. Sigatoka leaf spot of banana- *Cercospora musae* (Perfect stage: *Mycosphaerella musicola*)**

**Systematic position**

Sub-kingdom : Mycota

Division : Eumycota

Sub-division : Deuteromycotina

Class : Hyphomycetes

Order : Moniliales

Family : Dematiaceae

Genus : *Cercospora*

Species : *C. musae*

**Symptoms:** Yellowish green streaks are formed on interveinal areas; the streaks enlarge into cylindrical spots with grey centre, brown margin and each spots surrounded by yellow halo. The lesions coalesce and leaves dry up.

**Pathogen:** Mycelium is hyaline, septate and branched. Conidia are elongated, narrow and multiseptate. Perithecia are dark brown to black and ostiolate. Ascii are oblong and clavate. Ascospores are hyaline, two celled, obtuse to ellipsoid

**iv. Early leaf spot of groundnut - *Cercospora arachidicola* (Perfect stage: *Mycosphaerella arachidis*)**

#### Systematic position

Sub-kingdom : Mycota

Division : Eumycota

Sub-division : Deuteromycotina

Class : Hyphomycetes

Order : Moniliales

Family : Dematiaceae

Genus : *Cercospora*

Species : *C. arachidicola*

**Symptoms:** Spots are irregular or circular, 1 to 10 mm in diameter (bigger), brown; chlorotic halo around the spots present; lower surface of the spot is light brown; premature shedding of leaves.

**Pathogen:** Mycelium is septate, branched, inter and intracellular. Conidiophores are multi septate, yellowish brown and dense. Conidia are hyaline, obclavate, 3 to 12 septate, fascicles base rounded and tip sub-acute. Perithecia are black, globose, ostiolate. Ascii are cylindrical, stipitate and bitunicate. Ascospores are two celled, (upper cell larger, slightly curved), hyaline and 8 in an ascus

**v. Late leaf spot of groundnut - *Phaeoisariopsis personata***

(syn. *Cercospora personata*; Perfect stage: *Mycosphaerella berkeleyii*)

#### Systematic position

Sub-kingdom : Mycota

Division : Eumycota

Sub-division : Deuteromycotina

Class : Hyphomycetes

Order : Moniliales

Family : Dematiaceae

Genus : *Cercospora*

Species : *C. personata*

**Symptoms:** Spots are smaller (1-6mm), **circular and black** in colour yellow halo absent; premature defoliation.

**Pathogen:** Conidia are olivaceous, obclavate, usually straight or slightly curved, rounded at the apex, base shortly tapered with a conspicuous hilum, mostly 3 to 4 septate, shorter than *C. arachidicola*. Perithelial characters are similar as in *C. arachidicola*.

#### **vi. *Alternaria* leaf spot of cotton - *Alternaria macrospora***

##### **Systematic position**

Sub-kingdom : Mycota

Division : Eumycota

Sub-division : Deuteromycotina

Class : Hyphomycetes

Order : Moniliales

Family : Dematiaceae

Genus : *Alternaria*

Species : *A. macrospora*

**Symptoms:** Circular to irregular brown leaf spots with concentric rings; spots coalesce resulting in blight symptom.

**Pathogen:** Mycelium is dark, septate, branched. Conidiophore is single or in groups, erect, simple, septate, brown. Conidia are produced singly or in chains of two, obclavate with a narrow beak (twice the length of the body), reddish brown; or with both horizontal and vertical septa (muriform conidia)

#### **Leaf Blights**

Necrosis of a larger area of leaf lamina including veins is called leaf blight.

**i. Early blight of potato and tomato - *Alternaria solani***

**Systematic position**

Sub-kingdom : Mycota

Division : Eumycota

Sub-division : Deuteromycotina

Class : Hyphomycetes

Order : Moniliales

Family : Dematiaceae

Genus : *Alternaria*

Species : *A. solani*

**Symptoms:** Circular to irregular, brown spots with concentric rings; spots coalesce leading to blighting, drying of leaves and defoliation of leaves.

**Pathogen:** Mycelium is light brown to dark, septate, branched and inter-and intracellular. Conidiophores are dark coloured, emerge through stomata. Conidia are beaked, muriform, dark coloured, borne singly or in chains and are with 5 to 10 transverse and a few longitudinal septa

**ii. Late blight of potato and tomato - *Phytophthora infestans***

**Systematic position**

Sub-kingdom : Mycota

Division : Eumycota

Sub-division : Mastigomycotina

Class : Oomycetes

Order : Peronosporales

Family : Pythiaceae

Genus : *Phytophthora*

Species : *P. infestans*

**Symptoms:** Brown to purplish black water-soaked lesions; enlarge rapidly; lower surface shows whitish mildew growth, severe defoliation; potato tubers show purplish, slightly sunken lesions leading to **dry rot**.

**Pathogen:** Mycelium is endophytic, coenocytic, hyaline, branched, inter-cellular. Haustoria club shaped. Sporangiophores are hyaline, branched, indeterminate, thick walled, arise through stomata on leaves or lenticels on tubers. Sporangia are multinucleate, thin-walled, hyaline, oval

or pear shaped with a definite papilla at the apex. Zoospores are reniform, biflagellate (anterior tinsel and posterior whiplash). Oospores are thick-walled and smooth.

**Disease cycle:** Primary infection is through use of infected tubers. Mycelium spreads into shoots produced from infected tubers and reaches the aerial parts of the plant. Sporangiophore emerges through stomata on stem and leaves and produce sporangia, which are spread by rain to wet potato leaves or stems and cause disease. Large number of asexual generation in a growing season kills the foliage rapidly. The zoospores found in the soil germinate, penetrate through lentils or wounds into the tubers and send intercellular mycelium and haustoria into the cells and cause infection.

**iii. Northern corn leaf blight of sorghum - *Exserohilum turcicum*. (syn. *Helminthosporium turcicum*; Perfect stage: *Trichometasphaeria turcica*)**

#### **Systematic position**

Sub-kingdom : Mycota

Division : Eumycota

Sub-division : Deuteromycotina

Class : Hyphomycetes

Order : Moniliales

Family : Dematiaceae

Genus : *Exserohilum*

Species : *E. turcicum*

**Symptoms:** Narrow, **elongated spots** develop initially, later turns to **straw coloured**, lesions with **reddish brown margin**; matured spots are with several cm long; later coalesce and cause extensive drying of leaves.

**Pathogen:** Mycelium is inter or intracellular, multinucleate and septate. Conidiophores emerge through stomata in clusters, simple, olivaceous, septate and straight or bent. Conidia are long, spindle shaped, straight or slightly curved and 3-7 septate. **Pseudothecia** are black and globose. Ascii are clavate and bitunicate. Ascospores are hyaline, fusoid, straight or slightly curved and four celled.

**iv. Grey blight of mango - *Pestalotiopsis mangiferae***

#### **Systematic position**

Sub-kingdom : Mycota

Division : Eumycota

Sub-division : Deuteromycotina

Class : Coelomycetes

Order : Moniliales

Family : Melanconiaceae

Genus : *Pestalotiopsis*

Species : *P. mangiferae*

**Symptoms:** Minute brown spots develop at the margin and tip of the leaf initially. They gradually increase in size and become dark brown. Black dots appear at the centre of the spots represent the acervuli.

**Pathogen:** Mycelium is branched, septate and brown. Acervuli are black. Conidiophores are short, simple or branched, septate, hyaline and smooth. Conidia are five celled, oblong to **clavate**, upper two cells are slightly darker than the lowest olivaceous cells. Upper cell has three setulae.

#### **Grey leaf blight of coconut - *Pestalotiopsis palmarum***

**Symptoms:** Minute yellow spots surrounded by greyish margin appear on leaf lets, which enlarge to become elliptical with greyish white centre, dark brown margin and yellow halo. Large number of globose / ovoid, black acervuli appear on the upper surface of the spots as black dots. Many spots coalesce into irregular grey necrotic patches. Complete drying and shrivelling of leaf blade occur giving a blighted / burnt appearance.

**Pathogen:** Mycelium is septate, branched, light brown, inter and intra cellular. Fungus produces acervuli as it's asexual fruiting body during sporulation. Acervuli are black, cushion shaped, sub epidermal and break open to expose conidia and black sterile structures called setae. Conidiophores are hyaline, short, simple and bear a conidium at the tip. Conidia are five celled, middle three cells are coloured, basal and tip cells are hyaline. Tip cells have 3 -5 slender elongated appendages.

#### **Root Rot**

Root rot is disintegration or decay of part or all of the root system of a plant. Pathogen belonging to *Aphanomyces*, *Pythium*, *Phytophthora*, *Rhizoctonia*, *Sclerotium*, *Phymatotrichum*, *Thielaviopsis*, *Macrophomina*, *Helicorbasidium*, *Ophiobolus*, *Armillaria*, etc. are reported to cause root rot disease in various crop plants.

i. Root rot of pulses/ oilseeds/ cotton. - *Macrophomina phaseolina* (Pycnidial stage) *Rhizoctonia bataticola* (Sclerotial stage)

**Systematic position: *Macrophomina phaseolina***

Sub kingdom : Mycota

Division : Eumycota

Sub-division : Deuteromycotina

Class : Coelomycetes

Order : Sphaeropsidales

Family : Sphaeropsidaceae

Genus : *Macrophomina*

Species : *M.phaseolina*

**Systematic position: *Rhizoctonia bataticola***

Sub kingdom : Mycota

Division : Eumycota

Subdivision : Deuteromycotina

Class : Agonomycetes

Order : Agonomycetales

Family : Agonomycetaceae

Genus : *Rhizoctonia*

Species : *R.bataticola*

**Symptoms:** Sudden and complete wilting of plants in patches; rotting of entire root system except taproot and few laterals; shredding of barks of roots; presence of minute black bodies on the surface of the infected bark of roots/stem which represents the sclerotia of the pathogen; stem near the soil level shows large number of black pycnidial bodies.

**Pathogen:** Mycelium is septate, branched, stout and brown; lateral branches from main hypha are constricted at the point of origin. Sclerotia are dark brown or black, round, mustard-like. Pycnidia are small, dark brown, globose, ostiolate, found on stem, erumpent, solitary or gregarious. Pycnidiospore are hyaline, obovoid, single celled and borne on hyaline, cylindrical conidiophores (phialides).

**Disease cycle:** It survives as sclerotia in the infected debris in soil. Primary spread is through seed-borne and soil-borne sclerotia. Secondary spread is through wind-borne pycnidiospores.

Surviving sclerotia or pycnidia in the soil or in the seed initiate the infection. They germinate and penetrate the host directly. Fungus produces cellulolytic, pectinolytic and other enzymes, which kill and disintegrates the tissues in advance of penetration, resulting in rotting of tissues. It is a facultative saprophyte and it lives saprophytically in the dead tissue and produce greyish white, inter and intracellular, septate, thick walled mycelium, which branches at right angles near the septum. During asexual reproduction, it produces dark brown, globose **pycnidia** with an ostiole on the surface of the stem above ground level. Inner wall of the pycnidium is lined with **pycnidiophore** and pycnidiospore.

**Pycnidiophores** are hyaline, short and rod shaped. **Pycnidiospores** are hyaline, single celled, oval shaped and thin walled. Pycnidia will act either as secondary inoculum for the spread within the field or as primary inoculum for the initiation of the disease after period of survival in the seed or plant debris. At the end of the growing season the fungus produces spherical, black and smooth walled **sclerotia** (resting bodies) on the inner walls of the root bark. At this stage the roots exhibit bark shredding with numerous sclerotia. Sclerotia survive and initiate new infection.

### Stem Rot

In stem rot the stem tissues show disintegration and decay

i. **Stem rot of rice - *Sclerotium oryzae* (perfect stage: *Leptosphaeria salvinii*)**

#### Systematic position

Sub-kingdom : Mycota

Division : Eumycota

Sub-division : Deuteromycotina

Class : Hyphomycetes

Order : Agonomycetales

Family : Agonomycetaceae

Genus : *Sclerotium*

Species : *S. oryzae*

**Symptoms:** Initially small, blackish, irregular lesions are observed on the outer leaf sheath near water line at later growth stages of plant. The lesions enlarge as the disease advance, the fungus penetrates the inner leaf sheath and finally the leaf sheath rots and sclerotia are formed. Later, the infection spreads to stem. One or two internodes of the stem rot and collapse. These infected

stems lodge. Small black sclerotia are seen near on the inner side of the culm amidst greyish weft of mycelium.

**Pathogen:** Mycelium is hyaline, septate and branched. Sclerotia are spherical, smooth and black. Perithecia are globose and black. Ascii are clavate and short stalked. Ascospores are eight in each ascus, fusiform, three septate, middle cells larger and dark and the end cells lighter.

**Disease cycle:** The fungus is found to survive under unfavorable conditions in the sclerotial stage. The sclerotia germinates from rice stubbles under favorable conditions and is carried from field to field by irrigation water. The sclerotia can cause primary infection .

### **Foot-Rot**

In foot rot the basal portion of the stem is infected and shows rotting.

**Foot-rot of rice - *Fusarium moniliforme*** (Perfect stage: *Gibberella fujikuroi*)

#### **Systematic position**

Sub-kingdom : Mycota

Division : Eumycota

Sub-division : Hyphomycetes

Class : Deuteromycotina

Order : Moniliales

Family : Tubulariaceae

Genus : *Fusarium*

Species : *F. moniliforme*

**Symptoms:** The most conspicuous and common symptom is the bakanae, an abnormal elongation of the plants in the nursery of the field. The infected plants are taller than normal plants, lean lanky and yellowish green. A whitish or pink fungus growth may appear on the lower portion of the drying plants. The basal portion of the infected plant becomes black and rotten. The infected seedlings reveal formation of aerial adventitious roots from the nodes above the ground level. Root system becomes fibrous and bushy. Infected seedlings die in large numbers in patches. In the transplanted crop the plants are killed before earhead formation or even if the inflorescence is formed it will be sterile. If the culm is split open brown discolouration of spongy tissues in nodular region is seen.

**Pathogen:** Mycelium is hyaline, septate and well branched. Microconidia are hyaline, single celled or two celled, oval and borne in chains. Microconidia are hyaline, 3-5 septate, sickle -

shaped formed on sporodochia. Chlamydospores are absent. Perithecia are dark blue, spherical or ovate. Ascii are cylindrical, piston shaped and 4-6 spored. Ascospores are two celled.

**Disease cycle:** The diseases are externally seed-borne and the seeds contaminate with the spores form the primary source of infection. It is also soil-borne (survives for four months as hyphae are macro conidia). The fungus mycelium and micro conidia infect seedlings at an early stage of their development. It becomes systemic in the plants infection also takes place through conidia and mycelium left in the water used for soaking seeds. The funguses in the seedling grow upward and produce mycelium and conidia and infected plant parts. The fungus infects hosts like sorghum, maize, sugarcane, *Panicum miliaceum* and *Andropogon sorghum*.



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