B.Sc. Botany – 3rd SEM
by Dr. Raman Kumar Ravi

Alternaria

Systematic Position

Kingdom : Mycota
Sub Kingdom : Eumycotina
Phylum : Ascomycota
Sub-phylum : Euascomycetidae
Class : Ascomycetes (Teleomorphic); Deuteromycetes (Anamorphic)
Order : Moniliales
Family : Dematiaceae
Genus : *Alternaria*

Introduction

- The most common species of *Alternaria* are generally anamorphic (asexual) imperfect filamentous fungi belonging to the Class-Deuteromycetes (=The Fungi Imperfecti).
- Some perfect or teleomorphic forms (sexual) are known and belong to the class Ascomycetes and, sub-class-Pyrenomycetes (Clathrospora, Leptosphaeria, Lewia and Pleospora).
- Nearly 44 species of teleomorphic forms have been discovered, but they may be certainly close to a hundred.
- The most common anamorphic species is *Alternaria alternata*.
- In culture, the velvety colonies of *Alternaria alternata* are generally grey to black and dark, having septate branched conidiophores that bear at their ends, chains of simple or branched conidia.
- Initially, ellipsoid or clavate conidia get divided by transverse walls and soon get divided by longitudinal or oblique septae quite characteristic of different species.
- The mature multicelled conidium acquires a flask-like or club-shaped structure having indistinct or well-differentiated apical rostrum (depending upon the species), and dark-brown pigmentation.

The species of the genus *Alternaria*, are characterized by their dark pigmentation due to melanin. The melanin pigment accounts for the UV-resistance of these moulds, as the melanin pigmentation very effectively absorbs harmful UV-radiation and consequently protects the organism from fatal damage caused by the radiation. Consequently *A. alternate* has a worldwide distribution and the pigmented conidia of this species can be found distributed all over the world.

OCCURRENCE AND DISTRIBUTION

- As a saprophyte, *A. alternata* can be isolated from decaying organic material, and is predominantly found in soil. Except for the winter time conidia of *A. alternata* can be found almost everywhere in the air which accounts for the further distribution of this species by air currents.
- Apart from being pathogenic, *A. alternata* also plays a role in biodeterioration and can be isolated from building materials where it appears as dark olive spotting or staining. The minimal growth temperature of is about -20 C to 50 C, the optimal growth temperature is 200 C and the temperature maximum is *A. alternata* 320 C. *A. alternata* has a broad pH spectrum and can tolerate pH between 2 to 9.
- The species of *Alternaria* are cosmopolitan. They are ubiquitous with a number of plant pathogenic species, causing blight diseases of the cultivated plants. They can be found on various substrates such as senescent plants, vegetables, soil, food, wall of old houses, and various organic materials.
- *Alternaria* species have been isolated from various substrates and habitats including audiovisual (tapes, plate negatives, unvarnished glass), waterlogged wood, rubber, dunes, hydrocarbons, plastics, paper, parchment, paint (natural or synthetic), easel painting, murals, plants, food (fruits, vegetables, grains, nuts), soil (cultivated forests, rhizosphere of many plantations), and textile (cotton, jute, wool).
- The conidia of *Alternaria* are potent allergens, triggering seasonal reactions during the summer months, both in young and adult humans.

All species of *Alternaria* are not pathogenic or undesirable; some are used as biological agents to control invasive plants. *Alternaria alternata* saprophytic as well as pathogenic, and is a ubiquitous cosmopolitan species which flourishes in dry arid desert dunes as well as in saline lakes and moist soil along the banks of rivers and drains. *A. alternata* serves as food for moths. It is toxic and pathogenic to many crop plants. Its conidia act as allergens and can cause severe allergic respiratory diseases (asthma, chronic sinusitis, rhinitis), mycoses and leukopenia. It also causes fungal disease of skin as well as the scalp. Its mycotoxins, called alternaric acid, altenuene and alternatiol are responsible for leukopenia. It is a facultative parasite, and causes blight disease on leaves, stems and fruits of members of the family Brassicaceace (=Cruciferae) and the family Solanaceae. Diseases caused by Alternaria species are very common and are worldwide in their occurrence. Important host plants include a variety of crops such as apples, broccoli, cauliflower, carrots, potatoes, Chinese cabbage, tomatoes, bok choy,citrus,cereals, many ornamentals and a number of weeds.

SYMPTOMS

Alternaria generally attacks the aerial parts of its host. In the leafy vegetables, symptoms of Alternaria infection typically start as a small, circular, dark spot. As the disease progresses, the circular spots may grow to 1.0 cm or more in diameter and are usually gray, gray-tan, or near black in color. Due to fluctuating environmental conditions, Alternaria does not have a uniform growth rate, thus spots develop in a target pattern of concentric rings. Where host leaves are large enough to allow unrestricted symptom development, the target board effect in the infected spots are diagnostic feature for Alternaria infection. Apart from the target board pattern, the

necrotic lesion is also often covered with a fine, black, fuzzy growth of the pathogen. This growth is because of the asexual stage of Alternaria species produced radially on the dying host tissues. Many Alternaria species produce toxins that diffuse into host tissue ahead of the growth of the fungus. Therefore, it is not uncommon to see a yellow halo that fades into the healthy host tissues that surround the infected target spot.

Fig. 1 *Alternaria solani*- symptoms on potato leaves

Alternaria infections on roots, tubers, stem and fruits are associated with the dark-brown, sunken lesions that get hardened to form cankers. The fungus may sporulate in these cankers, causing a fine, black, velvety growth of fungus representing asexual reproductive structures (conidiophores bearing conidia) on the affected area.

Alternaria Brown spot of Citrus –plants, and leaf blight of Brassicaceae is commonly caused by A. alternata, and has been reported in South Africa, Turkey, Israel, Iran, Spain, Italy, Greece, Brazil, Argentina, Peru and Colombia. On citrus plants, this disease does not affect oranges, but causes spotting on leaves and stem-branches.

On young lemon fruits, leaves and twigs, it produces brown-to-black lesions surrounded by a yellow halo. The halo is caused by a fungal toxin which rapidly kills citrus tissue. Leaf lesions are generally circular but will often have a tail, following the leaf vein which gives the lesions an eye-spot appearance. The necrosis extends along the veins as the toxin spreads in vascular tissues. On young leaves, lesions can appear as early as 36-48 hours after infection.

Leisions enlarge as leaves mature and can vary in size from 1-10 mm and will be larger if the infection occurred earlier in the season. If Alternaria brown spot is severe, the leaves may drop and entire shoot can wilt and die. Severe fruit infections, result in the drop of young fruitlets. Remaining fruit can have lesions that vary in size from dots to large pock marks on the peel. Young lesions form a corky protuberance that can be disloged as the fruit matures, leaving a light tan pock mark.

Thallus structure and anamorphic (asexual) stage of *Alternaria*

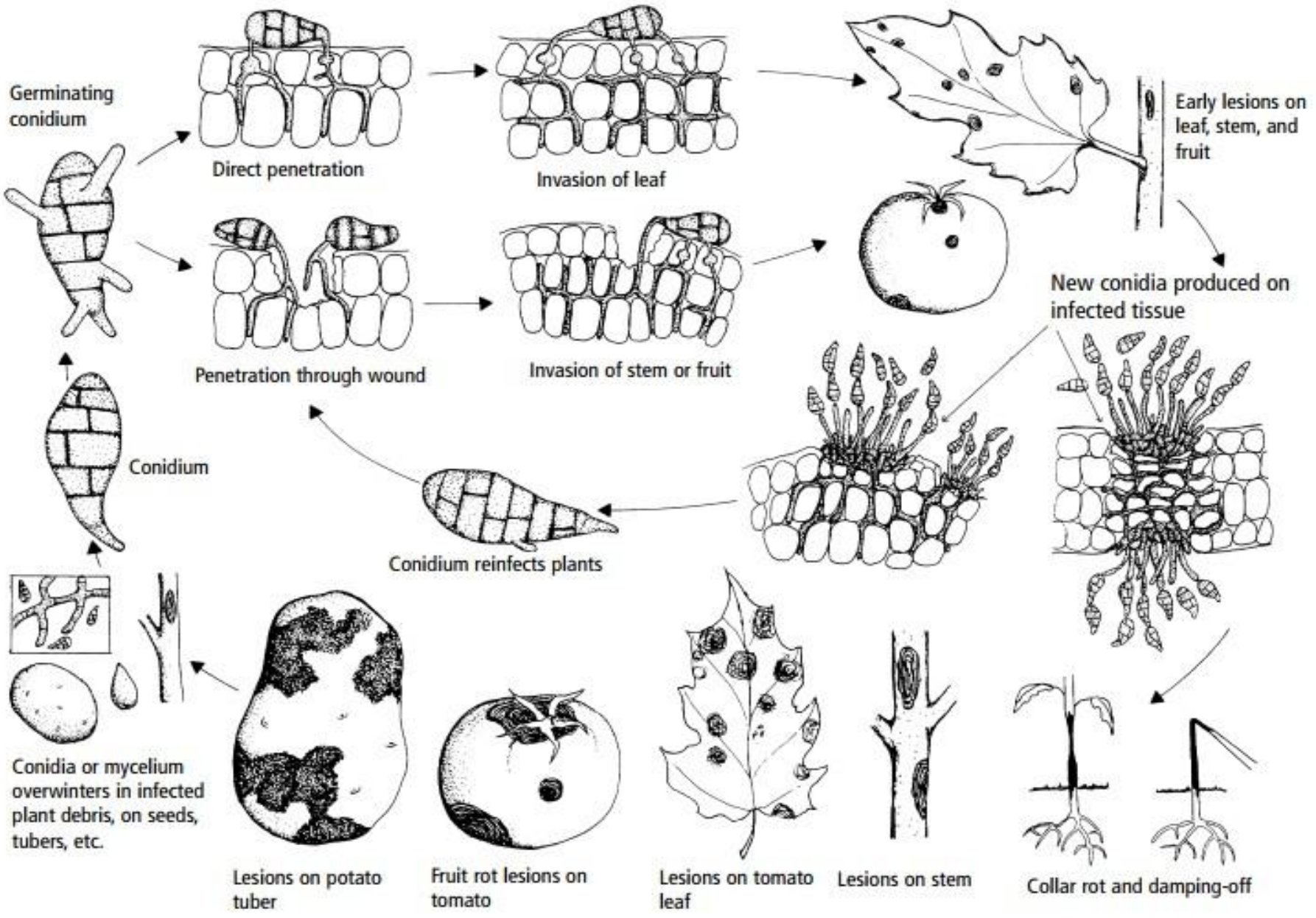
The thallus of species of Alternaria consists of multicellular branched brown coloured mycelium that multiplies vegetatively under normal conditions. It produces multicellular branched conidiophores that bear at their terminal ends or tips of branches, multicellular conidia singly or in chains. The conidia of Alternaria species are often beaked and always multicelled, having longitudinal and transverse septae. The conidia are dark coloured due to melanin pigment and borne singly or in chains.

Plant pathogenic

Alternaria species survive between crops in the form of conidia and dormant mycelium in infected plant residue or in soil, and on seeds. If the fungus is seedborne, it may attack seedlings, causing damping –off, stem lesions, or collar rot . Most often, however, the fungus grows and sporulates on plant residues during periods of rain, heavy dew or under conditions of good soil moisture. Spores are windblown or splashed onto plant surfaces where infection occurs. The spores must have free moisture to germinate and infect. Penetration of the host can be direct, through wounds or through stomata. Tissues that are stressed, weak, old or wounded are more susceptible to invasion as compared to healthy and vigorous tissues.

Anamorphic (Asexual) stage of *Alternaria*

The conidia of Alternaria species borne on multicellular branched conidiophores, are thick-walled, multicellular and pigmented and thus tolerate adverse conditions like dry weather. In citrus plantation, they are produced on leaves 10 days after symptoms appear, primarily an old lesions on mature leaves. Spore production continues up to 50 days after infection. In addition, conidia are produced in lower numbers on fruit and twigs remaining on the tree as well as on leaf litter. When there is no susceptible tissue available, such as over the winter, the fungus survives on mature leaves, twigs and fruit. Spore production is greatest when relative humidity is above 85%. Spores are air-borne and release into the air is triggered by rainfall or by a sharp change in relative humidity. Once the spores are released, they are moved by wind to susceptible tissue where they are able to infect. When temperatures are favorable (20 -29oC), the length of the wetting period required for infection is about 8-10 hours. When temperature drops below 170 C or rise above 32oC respectively, the fungus requires extended leaf wetness durations (>24 hrs) to cause significant infections. On highly susceptible cultivars, as little as 6 hours of leaf wetness can result in infections. Most of the infections probably follow a rainfall event, but dew can be sufficient to bring about infection.


Germinating conidium
Direct penetration
Invasion of leaf
Early lesions on leaf, stem, and fruit
Penetration through wound
Invasion of stem or fruit
New conidia produced on infected tissue
Conidium
Conidium reinfects plants
Conidia or mycelium overwinters in infected plant debris, on seeds, tubers, etc.
Lesions on potato tuber
Fruit rot lesions on tomato
Lesions on tomato leaf
Lesions on stem
Collar rot and damping-off

Teleomorphic (Sexual) Stage of *Alternaria*

Several teleomorphic genera having their anamorphic form as *Alternaria*, such as Clathrospora, Lewia, Leptosphaeria and Pleospora, are known, however, for convenience, we are describing the characteristics of Lewia hordeicola and L. infectoria isolated from cereals. Both Lewia hordeicola and L. infectoria are homothallic, and produce fertile ascomata (Spherical perithecia with ostiole) on synthetic medium after long incubation at 40 C in the dark. The two species differ from each other in the shape and size of ascospores, the conidial sporulation patterns, and the shape, size, septation pattern and roughness of the conidia. Both the species are reported to act as spoilage agent in stored barley, wheat, rice, maize and oats. The studies were made based on separate cultures raised from single ascospores of each of the above named Lewia species. In both the cultures, the fungal colonies were lanose to loosely cottony that were initially yellowish tan and then, turned brownish grey with age. In both the cultures conidial stage appeared within 14 days.

Additional structural differences in the above-named anamorphic and teleomorphic stages are as follows:

The peridium of ascomata (perithecium) is multicellular consisting of not more than two-layered pseudoparenchyma. The asci are sub-cylindrical and bear eight uniseriately arranged multicellular ascospores. The ascospores are ellipsoid, usually tapered at both ends, rarely short-clavate and inequilateral. The young ascospores have 5-transeverseseptae and mature ascospores develop a longitudinal septum in the middle so that both the terminal ends of each ascospore have one-celled compartment. The asci mature at different times and release their ascospores one by one after emerging through the ostiole of perithecium. The ascospores, after dispersal by wind or water germinate to produce branched multicellular mycelium on suitable substratum on a specific host or any organic material.

DISEASE CONTROL

Control of Alternaria diseases can be accomplished in several ways. It is important to remember to grow plant cultivars that have disease resistance. When seed may be carrying the fungal spores, raising of crop using disease-free seed or seed that has been treated by fungicide, can greatly reduce disease incidence. Rotating crops so that susceptible crops follow non-host crops is useful in reduing disease incidence. Crop residue destruction by burning, and weed control also helps reduce disease. Ultraviolet light has been shown to be essential for spore formation in *Alternaria* species. Therefore, under greenhouse growing conditions, the use of ultraviolet light-absorbing film can greatly reduce the incidence of some diseases of *Alternaria*. Finally, there are a number of fungicides that have activity against *Alternaria* species. The commonly used fungicides are Chlorothalonil, captan, fludioxonil, imazalil, iprodione, meneb, mancozeb, thiram, mercuric chloride, and selected copper fungicides (Bordeaux mixture) which have varying degrees of efficacy against *Alternaria* species. Invitro studies reveal that *A. alternata* is susceptible to amphotericin B, fluconazole, itraconazole and ketoconazole. Fungicides are the primary means of controlling Alternaria brown spot of Citrus plantations. The plantations should be raised by using resistant varieties. The saplings should be planted at a wider spacing to promote rapid drying of the leaf canopy that makes the disease more manageable. In existing plantings, it is

important not to promote excessive vegetative growth. Over watering and excessive nitrogen fertilization should be avoided. Frequent light hedging should be done, rather than less frequent severe hedging. The best time to hedge to control *Alternaria* brown spot of Citrus fruits, is late March. The number of fungicide applications needed for control varies greatly with the susceptibility of the cultivar and the severity of the infestation. The first spray should be applied when the leaves are at the stage of expansion to prevent build up of *Alternaria* on the spring flush. The second and subsequent applications may need to be made as often as every 10 days to achieve good control on fruit and foliage.

ECONOMIC IMPORTANCE

Some species of *Alternaria* are obligate saprophytes and have an important role in degradation of organic matter in soil. Because of this property, they are responsible for spoiling, damaging and deteriorating our items of daily utility such as audiovisual item, wood, plastics, paper, paint and paintings, food and textile-products. The conidia of *Alternaria alternata* have been reported to act as allergens leading to severe allergic respiratory diseases (asthma, chronic sinusitis, rhinitis), mycoses and leucopenia. *A. alternata* also causes disease of skin as well as the scalp. Leukopenia is caused by toxins (altenuene, alternatiol and alternaric acid) produced by *A. alternata*. Many species of Alternaria have acquired the property of inhabiting living tissues of crop- plants, thereby causing great economic loss to agriculturists and horticulturists.

Some important diseases caused by Alternaria species

Carrot leaf blight caused by *Alternaria dauci*

Black rot of Carrot caused by *A. radicina*

Leaf spot of crucifers caused by *A. brassicae* and *A. brassicicola*

Early blight of potato and fruit-rot of tomato caused by *A. solani*

Broccoli head rot caused by *A. brassicae* or *A. brassicicola*

Fruit spot on peppers caused by *A. tenuis* and *A. alternate*

Brown spot of Citrus plants caused by *A. alternata*

***Alternaria* SP.**

Habit and Habitat of *Alternaria*

Alternaria is represented by about 50 species. Several form-species are found as saprobes on dead and decaying plant parts and in the soil while some form-species are facultative parasites, infecting a large number of higher plants.

The conidia are picked by the wind from the soil and invade laboratories and houses. In laboratories, conidia contaminate the cultures and in houses these conidia are responsible for allergies, skin diseases and hay fever. The most commonly occurring disease of potato early blight is caused by *Alternaria solani*.

Symptoms of *Alternaria*

Alternaria shows the symptoms of blight. Early symptoms appear in the form of yellowish-brown spots on the leaves, which enlarge in size and become round to form the concentric rings. If we study these spots with the handlens, they appear like the 'target boards' and hence the symptoms are called target board effect (Fig. 1). In severe infection entire lamina, petiole, stem and even tubers are badly damaged. Edible parts of the tuber turn brown.

3. Vegetative Structure of *Alternaria*

The mycelium is endophytic, profusely branched and septate. In parasitic species, it is both inter—and intracellular, geniculate, light brown and without haustoria. Each cell of the hypha is usually multinucleate (Fig. 2).

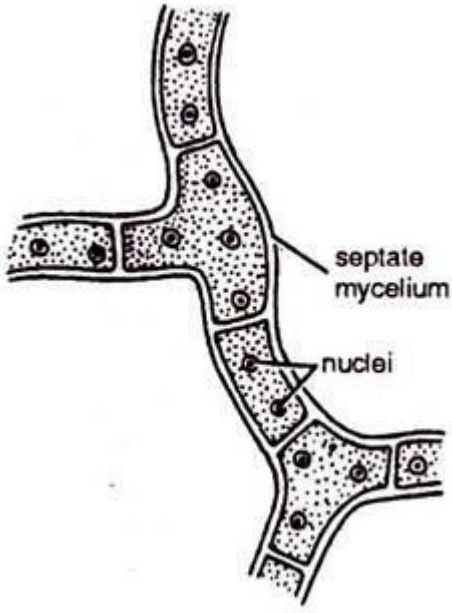


Fig. 2 *Alternaria* Mycelium

4. Reproduction in *Alternaria*:

Alternaria reproduces only by conidia which are produced at the tips of conidiophores. The endophytic mycelium grows out as erect and aerial hyphae through the stomata or ruptured

epidermis of the infected host tissue. The conidiophores are short, dark coloured, aerial, septate structures and cannot be easily distinguished from the somatic hyphae.

A conidium develops as an apical bud from the uppermost cell of the conidiophore. The young conidium first divides by transverse septa and some of its cells divide by longitudinal septa. Conidia with transverse and longitudinal septa are called ‘muriform or dictyospores (Fig. 3).

Conidiophore gives rise to one or two conidia exogenously at the tip, but in synthetic media chains of conidia may be produced (Fig. 3). Sometimes branching of the conidial chain is also observed. Any lower ceil of the condium produces a bud which develops into conidium.

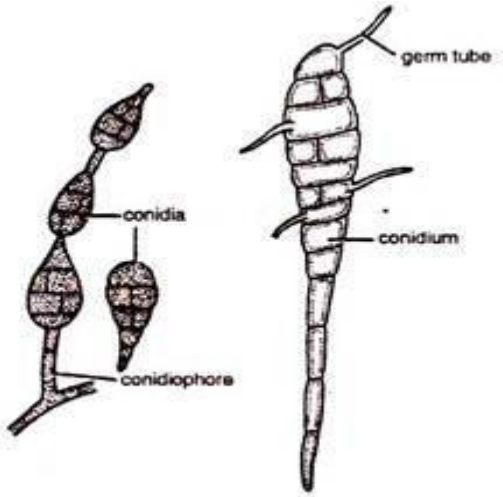


Fig 3 *Alternaria* - Conidia in acropetal chain and germinating conidium

A mature conidium is multicellular, obclavate, elliptical or beaked, about 30-12 µ long, 12-30 µ broad and has transverse and longitudinal septa (Fig 3). It is surrounded by two layered wall of which the outer wall is pigmented and the inner wall is hyaline. The conidia are readily disseminated by wind.

In the presence of moisture and suitable temperature each conidium germinates by producing 5-10 germ tubes at a time (Fig 3). The germ tubes infect the host plant through stomata or, epidermal cells or injuries caused by insects. The perfect stage of Alternaria belongs to Pleaspora infectoria of Loculoascomycets fungus (Fig. 4).

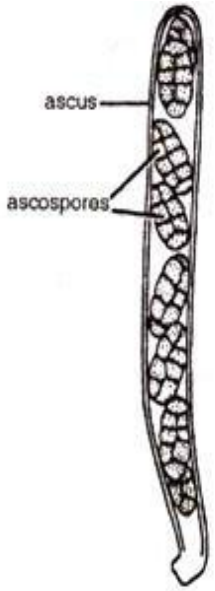
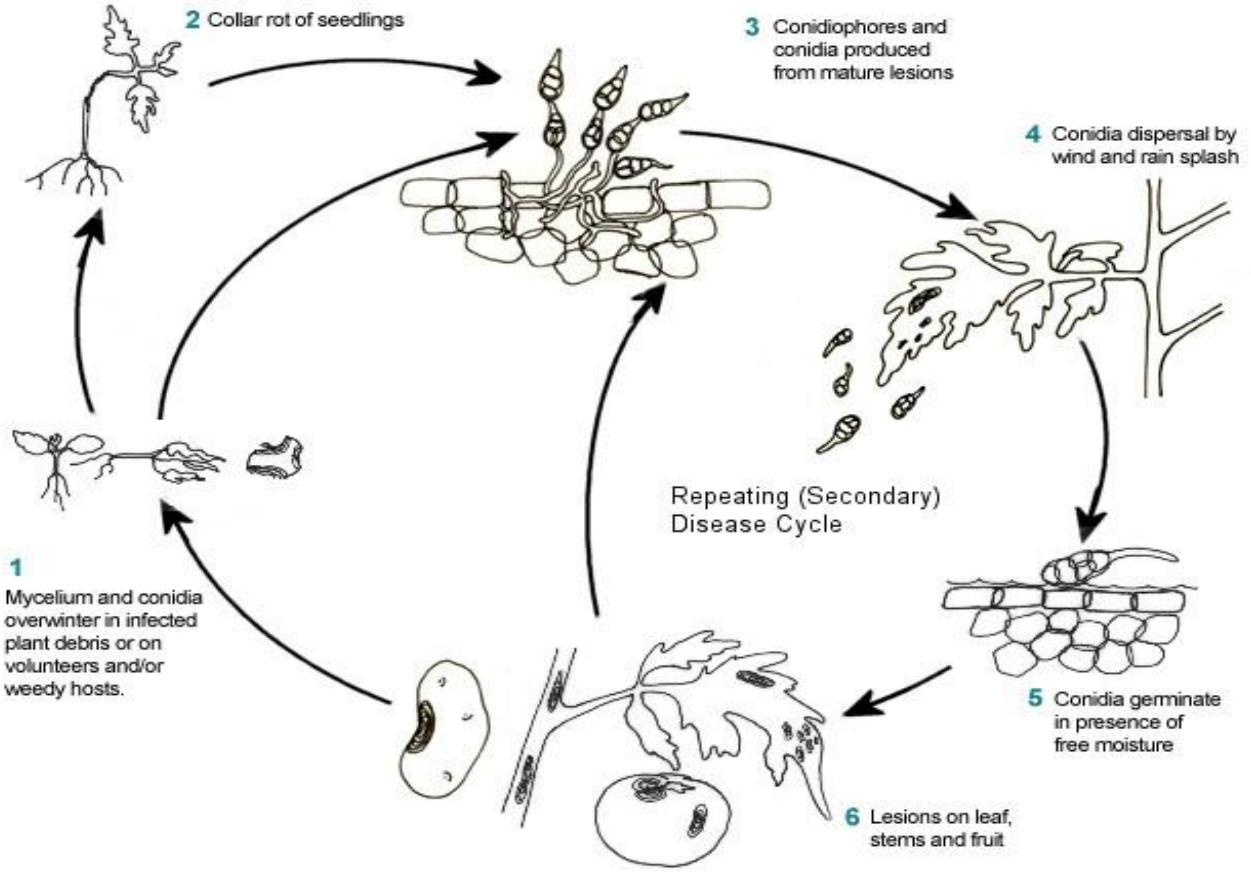
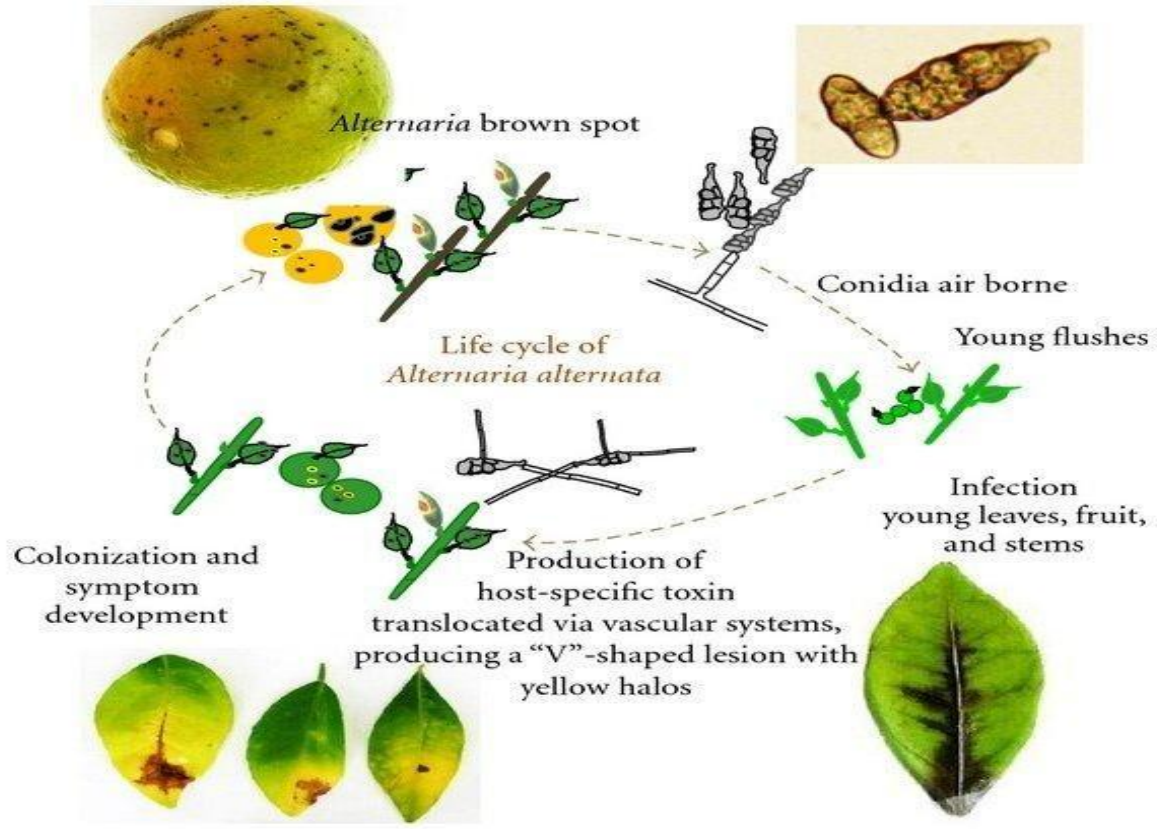


Fig. 4 *Alternaria*. Ascus of *Pleospora infectoria* representing the stage of *Alternaria*

Life Cycle





Early blight of potato*	*Alternaria solani*
Black point disease of wheat	*A. alternata* (= *A. tenuis*)
Leaf blight of wheat	*A. triticina*
Leaf spot of crucifers	*A. brassicae*
Leaf spot of cucurbits	*A. cucumerina*
Leaf spot of tobacco	*A. longipes*