SEMESTER V

16BTU501A **PLANT DIVERSITY -I** **3H - 3C**

Total hours/week: L:3 T:0 P:0 **Marks: Internal: 40 External: 60 Total: 100**

Scope:

Objectives

UNIT-I

Algae: General character, classification and economic importance. Life histories of algae belonging to various classes: Chlorophyceae – *Volvox*, *Oedogonium*, Xantho phyceae – *Vaucheria,* Phaeophyceae – *Ectocarpus* Rhodophyceae-*Polysiphonia*

UNIT-II

Fungi: General characters, classification & economic importance. Life histories of Fungi: Mastigomycontina- *Phytophthora*, Zygomycotina-*Mucor*, Ascomycotina- *Saccharomyces,* Basidomycotina-*Agaricus,* Deutromycotina-*Colletotrichum*

UNIT-III

Lichens : Classification, general structure, reproduction and economic importance. Plant diseases: Casual organism, symptoms and control of following plant diseases. Rust and Smut of Wheat. White rust of Crucifers. Late blight of Potato. Red rot of Sugarcane. Citrus Canker.

UNIT-IV

Bryophytes: General characters, classification & economic importance. Life histories of following: *Marchantia. Funaria.*

UNIT-V

Rust and Smut of Wheat. White rust of Crucifers. Late blight of Potato. Red rot of Sugarcane. Citrus Canker.

References

1. Lee, R.E. (2008). *Phycology* (4th ed.). USA: Cambridge University Press.
2. Sambamurty, (2008). *A Textbook of Bryophytes, Pteridophytes, Gymnosperms and Paleobotany*. IK : International Publishers.
3. Shaw, A.J., & Goffinet, B. (2000). *Bryophyte Biology*. Cambridge University Press.
4. Van den Hoek, C., Mann, D.J. & Jahns, H.M. (1995). *Algae: An introduction to Phycology*. Cambridge Univ. Press.
5. Vander-Poorteri, (2009). *Introduction to Bryophytes*. COP.
6. Webster, J. & Weber, R. (2007). *Introduction to Fungi* (3rd ed.). Cambridge: Cambridge University Press.

KARPAGAM ACADEMY OF HIGHER EDUCATION

(Deemed to be University Established Under Section 3 of UGC Act 1956)

Coimbatore – 641 021.

LECTURE PLAN
DEPARTMENT OF BIOTECHNOLOGY

STAFF NAME: Dr.ARCHANA.G
SUBJECT NAME: PLANT DIVERSITY SUB.CODE:16BTU501A
SEMESTER:V CLASS: III B.Sc (BT)

S.No	Lecture Duration Period	Topics to be Covered	Support Material/Page Nos
		UNIT-I	
1	1	Algae- General character, classification	T1:1-15
2	1	economic importance.	T1:67-78
3	1	Life histories of algae belonging to various classes	T1:90-94
4	1	Chlorophyceae	T1:98-101
5	1	*Volvox*	T1:111,289
6	1	*Oedogonium*, Xantho phyceae – *Vaucheria*	T1:150 T1:169
7	1	Phaeophyceae	T1:210
8	1	*Ectocarpus* Rhodophyceae- *Polysiphonia*	T1:250-264
	Total No of Hours Planned For Unit 1=8		
		UNIT-II	
1	1	General characters of Fungi.	T2:1-5
2	1	classification & economic importance of Fungi	T2:22-30
3	1	Life histories of Fungi	T2:13-14
4	1	Mastigomycontina	T2:59-70
5	1	*Phytophthora*, Zygomycotina- *Mucor*	T2:113-115

6	1	Ascomycotina- *Saccharomyces,*	T2:208-218
7	1	Basidomycotina-*Agaricus,*	
8	1	Deutromycotina-*Colletotrichum*	T2:260-271
	Total No of Hours Planned For Unit II=7 hours		
		UNIT-III	
1	1	**Lichens :** Classification, general structure, reproduction	T2:275-276
2	1	Economic importance.	T2:285-287
3	1	Plant diseases: Casual organism, symptoms and control of following plant diseases.	T2:324
4	1	Rust and Smut of Wheat.	T1:325
5	1	Red rot of Sugarcane.	T2:326-327
6	1	White rust of Crucifers. Late blight of Potato.	T2:327-330
7	1	Citrus Canker	T2:350
	Total No of Hours Planned For Unit III=7		
		UNIT-IV	
1	1	**Bryophytes:** General characters	R1:34-35
2	1	**Bryophytes:** classification	
3	1	**Bryophytes** :Economic importance.	W1
4	1	Life histories of following: *Marchantia.*	
5	1	Life histories of following: *Marchantia.*	
6	1	Life histories of *Funaria*	
7	1	Life histories of *Funaria*	
	Total No of Hours Planned For Unit IV=7hrs		
		UNIT-V	
1	1	Rust of Wheat.	W2
2	1	Smut of Wheat	

3	1	Smut of Wheat	W3:7-10
4	1	White rust of Crucifers.	W3:11-20
5	1	Late blight of Potato.	T2:326
6	1	Red rot of Sugarcane.	
7	1	Citrus Canker.	T2:330
	Total No of Hours Planned for unit V=7		
Total Planned Hours	**36**		

TEXT BOOK

1. T_1- A text book of algae. A.V.V.S Sambamurthy.2006 edition.
2. T_2- Textbook of Fungi.O.P.Sharma. 2002.

REFERENCE BOOKS:

1. R_1- Ncert.nic.in>ncerts>kebo103

WEBSITE:

1. W_1- www.biologydiscussion.com
2. W_2- www.vikaspedia.in>ipm-strategies-for-wheat.com

JOURNALS:

W_3- White rusts-An atlas of resistance-RA Mcintosh,CR Wellings and RF Park.

UNIT-I

Algae: General character, classification and economic importance. Life histories of algae belonging to various classes: Chlorophyceae – Volvox, Oedogonium, Xantho phyceae – Vaucheria, Phaeophyceae – Ectocarpus Rhodophyceae-Polysiphonia

SYLLABUS

Algae: General character, classification and economic importance. Life histories of algae belonging to various classes: Chlorophyceae – Volvox, Oedogonium, Xantho phyceae – Vaucheria, Phaeophyceae – Ectocarpus Rhodophyceae-Polysiphonia

ALGAE- GENERAL CHARACTERSTICS

Algae

Algae (singular: alga) are photosynthetic, eukaryotic organisms that do not develop multicellular sex organs. Algae can be unicellular, or they may be large, multicellular organisms. Algae can occur in salt or fresh waters, or on the surfaces of moist soil or rocks. The multicellular algae develop specialized tissues, but they lack the true stems, leaves, or roots of the more complex, higher plants.

The algae are not a uniform group of organisms. They actually consist of seven divisions of distantly related organisms. These are considered together more as a matter of human convenience, than as a reflection of their ordered, biological, or evolutionary relationships. Therefore, the term "algae" is a common one, rather than a word that connotes a specific, scientific meaning.

1. Algae are the simplest multicellular plants. Some are unicellular eg. *Chlamydomonas*
2. **Pant body:** known as Thallus and they are avascular
3. **Habitat:** Algae are usually aquatic, either freshwater or marine and some are terresterial.
4. Algae are eukaryotic thallophytes.
5. Algae are photoautotrophs.
6. **Storage form of food:** Starch

7. **Reproduction:** Algae reproduce either by vegetative, asexual or sexual method
8. **Vevetative method:** fragmentation, hormogonia
9. **Asexual spore:** zoospores, aplanospores, hypnospores, akinetes, azygospore
10. **Sexual method:** isogamous, anisogamous, and oogamous gametic fusion

CLASSIFICATION OF ALGAE

On the basis of photosynthetic pigments algae classified into three classes.

1. Chlorophyceae (green algae)
2. Phaeophyceae (brown algae)
3. Rhodophyceae (red algae).

Chlorophyta (green algae)

The Chlorophyta or green algae consist of about 7,000 species, most of which occur in fresh water, although some others are marine. Most green algae are microscopic, but a few species, such as those in the genus Cladophora, are multicellular and macroscopic. The cell walls of green algae are mostly constructed of cellulose, with some incorporation of hemicellulose, and calcium carbonate in some species. The food reserves of green algae are starch, and their cells can have two or more organelles known as flagella, which are used in a whiplike fashion for locomotion. The photosynthetic pigments of green algae are chlorophylls a and b, and their accessory pigments are carotenoids and xanthophylls.

Some common examples of green algae include the unicellular genera Chlamydomonas and Chlorella, which have species dispersed in a wide range of habitats. More complex green algae include Gonium, which forms small, spherical colonies of four to 32 cells, and Volvox, which forms much larger, hollow-spherical colonies consisting of tens of thousands of cells. Some other colonial species are much larger, for example, Cladophora, a filamentous species that can be several meters long, and Codium magnum, which can be as long as 26 ft (8 m).

The stoneworts (class Charophyceae) are a very distinctive group of green algae that are sometimes treated as a separate division (the Charophyta). These algae can occur in fresh or brackish waters, and they have cell walls that contain large concentrations of calcium carbonate. Charophytes have relatively complex growth forms, with whorls of "branches" developing at their tissue nodes. Charophytes are also the only algae that develop multicellular sex organs, although these are not comparable to those of the higher plants.

1. Chlorophyceae (Green algae)

General characterstics

- It is the largest class of algae
- They are commonly known as green Algae.
- Photosynthetic pigments: They possesses chlorophyll a, chlorophyll b and small amount of β-carotenoids.
- The chloroplasts shows various shape ie. Spiral shape in Spirogyra, cup shaped in Chlamydomonas, star shaped in Zygnema, girdle shaped in Ulothrix
- Habitat: Mostly freshwater (Spirogyra, Oedogonium, Chlamydomonas, Volvox, etc), some are marine (Sargassum, Laminaria, etc) and some are parasitic (Polysiphonia, Harvevella, Cephaleuros)
- Distribution: they are cosmopolitan in distribution

They are unicellular as well as multicellular.

Each cell is eukaryotic

Thallus: their body structure, shape and size varies.

Chlamydomonas: unicellular free living

Volvox: colonial form

Spirogyra: multicellular, unbranched filamentous form

Ulva: multicellular, parenchymatous form

Storage form of food: Starch

Pyrenoids stores starch

Cell wall has two layer: outer layer composed of pectose and inner layer is composed of cellulose

Reproduction: vegetative, asexual and sexual method

Vegetative : fragmentation

Asexual: asexual sopre (akinete, aplanospore, azygospore)

Sexual: isogamous, anisogamous, oogamous type gametic fusion

2. Phaeophyceae (Brown algae)

Paeophyta (brown algae)

The Paeophyta or brown algae number about 1,500 species, almost all of which occur in marine environments. These seaweeds are especially abundant in cool waters. Species of brown algae are macroscopic in size, including the giant kelps that can routinely achieve lengths of tens of meters. Brown algae have cell walls constructed of cellulose and polysaccharides known as alginic acids. Some brown algae have relatively complex, differentiated tissues, including a holdfast that secures the organism to its substrate, air bladders to aid with buoyancy, a supporting stalk or stipe, wide blades that provide the major surface for nutrient exchange and photosynthesis, and spore-producing, reproductive tissues. The specialized, reproductive cells of brown algae are shed into the water and are motile, using two flagella to achieve locomotion. The food reserves of these algae are carbohydrate polymers known as laminarin. Their photosynthetic pigments are chlorophylls a and c, while the accessory pigments are carotenoids and xanthophylls, including fucoxanthin, a brown-colored pigment that gives these algae their characteristic dark color.

Some examples of brown algae include the sargassum weed (Sargassum spp.), which dominates the extensive, floating ecosystem in the mid-Atlantic gyre known as the Sargasso Sea. Most brown seaweeds, however, occur on hard-bottom, coastal substrates, especially in cooler waters. Examples of these include the rockweeds (Fucus spp. and Ascophyllum spp.), the kelps (Laminaria spp.), and the giant kelps (Macrocystis spp. and Nereocystis spp.). The giant kelps are by far the largest of the algae, achieving a length as great as 328 ft (100 m).

General characteristics

Pheophyceae are called commonly known as brown algae

Photosynthetic pigments: They possesses brown colored photosynthetic pigments fucoxanthin and β-carotenoids in addition to chlorophyll a and c.

Habitat: They are almost marine, very few are fresh water eg.

Thallus: they are multicellular brown algae. No unicellular and colonial (motile or non-motile) brown algae till known.

Storage form of food: laminarin starch, manitol (alcohol) and some store iodine also.

Reproduction: vegetative, asexual and sexual methods

Vegetative: fragmentation.

Asexual: asexual spores (motile zoospores).

Sexual: isogamous or oogamous type gametic fusion.

Rhodophyceae (Red algae)

Rhodophyta (red algae)

The Rhodophyta or red algae are 4,000 species of mostly marine algae, which are most diverse in tropical waters. Species of red algae range from microscopic to macroscopic in size. The larger species typically grow attached to a hard substrate, or they occur as epiphytes on other algae. The cell walls of red algae are constructed of cellulose and polysaccharides, such as agar and carrageenin. These algae lack flagellae, and they store energy as a specialized polysaccharide known as floridean starch. The photosynthetic pigments of red algae are chlorophylls a and d, and their accessory pigments are carotenoids, xanthophyll, and phycobilins.

Some examples of red algae include filamentous species such as Pleonosporum spp., so-called coralline algae such as Porolithon spp., which become heavily encrusted with calcium carbonate and contribute greatly to the building of tropical reefs, and thalloid species, such as the economically important Irish moss (Chondrus crispus).

General characteristics

Rhodophyceae are commonly known as Red Algae

Photosynthetic pigments: They possesses Red colored photosynthetic pigments r-phycocyanin and r-phycoerythrin along with chlorophyll a, d, xanthophyll and β-carotenoid

Habitat: They are aquatic, mostly marine. Some are freshwater e.g. Batrachospermum.

Thallus: Red algae show a variety of life forms-

Unicellular- Porphyridium,

multicellular- Goniotrichum,

Parenchymatous- Porphyra,

unicellular colonies-Chroothece,

Storage form of food: Floridean starch and floridosides sugar.

Reproduction: vegetative, asexual and sexual mode

Vegetative: fragmentation

Asexual reproduction: non- motile spores(akinete, aplanospore, azygospore)

sexual reproduction: Oogamous.

Some species shows Alternation of generations in their life cycle.

Economic importance

Economic Importance of Algae

The following points highlight the economic importance of algae. They are:- 1. Algae Constitute the Link of Food Chain 2. Algae Useful in Fish Culture 3. Recreational Purposes 4. Sewage Treatment Plants 5. Water Supplies 6. Origin of Petroleum and Gas 7. Limestone Formation 8. Space Research and Other Fundamental Studies 9. Food 10. Fodder 11. Fertilizers 12. Medicine 13. Industrial Utilization.

- Algae Constitute the Link of Food Chain
- Algae is Useful in Fish Culture
- Algae is Used for Recreational Purposes
- Algae is Useful in Sewage Treatment Plants
- Algae and Water Supplies
- Algae as the Origin of Petroleum and Gas
- Algae and Limestone Formation
- Algae is Used in Space Research and Other Fundamental Studies
- Algae is Used as Food
- Algae is Used as Fodder
- Algae is Used as Fertilizers
- Algae is Used as Medicine
- Industrial Utilization of Algae

Economic Importance # 1. Algae Constitute the Link of Food Chain:

Both fresh and salt waters contain an enormous variety of algae which constitute the fundamental or primary link of many diverse food chains. Algae synthesize organic food stuffs, just as do the plants of the land. As the flesh of the land is dependent upon the activities of the green leaf, so the fish and other aquatic forms of animal life are dependent, directly or indirectly, upon algae, and fish in turn are important item in the daily diet of larger sea animals and man.

A number of aquatic algae form the food of fish either directly or indirectly. Diatoms, filamentous and some planktonic green algae, and a number of blue-green algae are very often found in the guts of various species of fresh and brackish water fish and they appear to be directly utilized as fish food.

The reserve food materials in these algae, e.g., fats and volutin in the diatoms; starch, often accompanied by oil in the green algae; sugars and glycogen in the blue-green algae; and polysaccharides in Euglena are utilized by fish.

Economic Importance # 2. Algae is Useful in Fish Culture:

That algae are fruitfully utilized in fish culture can very well be indicated from the successful culture of the Siamese fish, Tilapia mossambica which is voracious feeder of filamentous algae. This particular fish has been successfully introduced in different parts of India. A culture of Scenedesmus is often exclusively used as a daily dose of fish meal for the culture T. mossambica.

Economic Importance # 3. Algae is Used for Recreational Purposes:

Certain selected algae are grown in recreational areas like—lakes and streams along with fish.

Economic Importance # 4. Algae is Useful in Sewage Treatment Plants:

Species of Chlamydomonas, Scene¬desmus, Chlorella and Euglena are used in sewage treatment plants for providing through photosynthesis the oxygen necessary for rapid decomposition of the sewage by bacteria.

Economic Importance # 5. Algae and Water Supplies:

In the summer months the phytoplankton in ponds, lakes and reservoirs may become so abundant as to be extremely conspicuous. The water becomes cloudy and may assume a yellowish or greenish tinge. A floating mat of scum may develop.

These manifestations of algal growth are popularly termed ‘water bloom’. Such concentrations of algae are extremely objectionable, not only in public water supplies but also in waters used for bathing, fishing and other recreational purposes.

The blue-green algae are most frequently involved in the con¬tamination of water supplies, but the greens, the flagellated golden-brown, and the diatoms are also troublesome at times. Mention may be made of Prymnesium parvum, Gymnodinium veneficum and Microcystis spp. which cause mortality of fish and domestic animals that drink water infested with these algae.

The living and the dead and decaying algae impart disagreeable oily or fishy odours to the water.

Toxic protein decomposition products may be formed by blue-green algae and these are known to have caused death of cattle, sheep, and other animals which have drunk heavily infested water. In addition to the unsightly appearance and the unpleasant odours and tastes, the presence of algae in reservoirs requires a greater concentration of chlorine for bacterial control and causes difficulties in filtration.

Economic Importance # 6. Algae as the Origin of Petroleum and Gas:

The origin of oil and gas has been a matter of controversy, but it is now generally believed that, like coal, these fuels owe their energy to photosynthesis in ancient plants. Unlike coal, however, which was laid down in inland swamps, oil and gas were formed from organic matter in marine environments.

The plankton of the seas was probably of the greatest importance as a source of this organic matter. Minute marine algae captured the energy of sunlight, which was in turn transferred to the animals that fed upon them.

Organic com¬pounds derived from the plankton, both plant and animal, accumulated in mud deposits in shallow waters of the ocean floor. In the source, materials were buried by sedimentary action and, in an oxygen-free environment, gradually converted into oil and gas.

Natural gas is largely methane (CH4), which can be produced by certain kinds of anaerobic bacteria. Gas is generally associated with oil and can result from the action of methane-producing bacteria upon organic compounds.

Economic Importance # 7. Algae and Limestone Formation:

Many species of algae withdraw calcium from water, both fresh and salt, and deposit it, in the form of calcium carbonate, in their cell walls or gelatinous sheaths. The most significant forms in this category are the blue-greens and reds, but certain green algae and flagellates are also concerned.

The blue-greens are chiefly important in fresh-waters; they are responsible, for example, for the formation of extensive limestone deposits around hot springs and glaciers. The red algae are the most important calcareous algae of the seas; in particular, they play a significant role in the construction of coral reefs and islands.

Although true coral results from the activities of minute sedentary animals, it is recognized that lime-secreting red algae are almost as important in the formation of coral reefs as the coral organisms themselves. The calcareous red algae are best developed in the warmer seas, but certain species also flourish in temperate and polar regions, where they form extensive banks of limestone in coastal areas.

The algae are not only important in the present age in the formation of calcareous deposits, both in the seas and fresh waters, but also they have played a significant part in the production of beds of lime¬stone rocks, which may be 1000 feet thick.

Economic Importance # 8. Algae is Used in Space Research and Other Fundamental Studies:

In recent years Chlorella is being used in space research. Chlorella has been found very suitable for keeping the air in space vehicles pure on long interplanetary flights. The stale air in which the carbon dioxide has been concentrated is fed into a flood-lit con¬tainer containing a mixture of water and nutrient chemicals and Chlorella.

The alga restores oxygen into the space vehicle by its photosynthesis. Again species of Chlorella, Chlamydomonas, and Acetabularia are used as tools for solving fundamental biochemical and genetical problems.

Economic Importance # 9. Algae is Used as Food:

Large number of algae have entered into the diets of human beings from ancient times. The earliest records are those of the Chinese, who mentioned such food plants as Laminaria and Gracilaria in their 'materia medica' several thousand years ago.

The ancient inhabitants of Japan ate Porphyra as a healthful supplement to their rice diet. Its use became widespread, not only in Japan, but in China in course of time. Kombu, a Japanese food is prepared from stipes of species of Laminaria.

The most diversified dietary use of seaweeds was developed by the Polynesians and reached its peak in Hawaii, where during the nineteenth century at least 75 species were separately named and used regularly as food in that island world. The Hawaiians called them 'limu' and considered them a necessary staple of their daily diet.

Perhaps the best known and most widely used food alga in Western Europe in recent centuries was Irish moss, or carragheen (Chondrus chrispus), which was cooked with milk, seasoned with vanilla or fruit, and made into a highly palatable dish known, as blancmanges. The jellying qualities of Irish moss gave the alga an early food use.

Man, thus obtains carbohydrates, vitamins (algae are especially rich in vitamins A and E, and they contain some C and D), and inorganic substances, e.g., iodine (goiter is unknown among the people who eat seaweeds), not to mention the benefits of the mild laxative action of the ingested algae. Witsch (1959) stated that vitamin B value of young cultures of Chlorella equals that of lemon juice.

In Japan, powdered Chlorella ellipsoidea has been used successfully mixing with green tea.

In Germany and in the United States considerable work is being carried out on the suitability of mass cultures of Chlorella as an alternative source of animal feed and of human vegetable food.

Economic Importance # 10. Algae is Used as Fodder:

The orientals developed wide human uses for marine algae, but Europeans profited by extensive use of these plants for stock feed. In Ice¬land and Scandinavia, in the British Isles, and along the coast of France, stock has long been driven or allowed to wander to the seashore at low tide to feed on seaweeds.

Some kinds of algae, such as Rhodymenia palmata and Alaria esculenta, are favourable food of goats, cows, and sheep, and in Scotland and Ireland the stock actively hunt the shores at low tide for particular algae, especially the former.

The milk does not have any taste of algae, nor is the meat inferior because of the seaweed diet. Such animals, that have for several generations been nourished on algae, show better ability to digest it than those not so habituated.

The shortage of grain in many parts of Europe during World War I led to con¬siderable experimentation with the use of seaweeds as food for cows and horses. Stock- feed factories were established in France, Norway, Denmark and Germany, and various methods of treating and reducing seaweeds to meal or powder were developed.

The favourable results in animal husbandry in Europe led to the industrial pro¬cessing of the great Pacific-Coast kelp (Macrocystis) for animal rations. Seaweed-meal factories have been operating in the United States for several decades, providing supple¬mentary feeds for poultry , cattle and hogs.

The high mineral and vitamin G content of kelp meal has made possible its use in various poultry and other animal rations.

Economic Importance # 11. Algae is Used as Fertilizers:

The value of seaweeds in fertilizing the soil was dis¬covered early in the history of agriculture in coastal Asia, and by the ancient colonizers of the coasts and islands of North-Western Europe. In some areas of Britain, and along the coast of North-West France, the cutting of rockweeds for manure has been so inten¬sively practiced that it became necessary to regulate it by laws that have now been in effect for nearly 100 years.

In the United States, long before the recognition of their potash content, sea¬weeds were employed for fertilizers by the thrifty farmers. Not only the chemical fertilization, but also the water-holding capacity of fragments of the algae in the soil proved effective. These provided valuable small reservoirs of water in close contact with the roots of the cultivated plants.

Furthermore, the bulky organic substances decay slowly in the soil and form humus. Again yield of paddy is increased substancially when paddy field is inoculated with nitrogen fixing blue-green algae. Some of them are: Tolypothrix tenius, Aulosira fertilissima, Anabaena oryzae, Anabaenopsis arnoldii, Calothrix confervicola, Nostoc commune, and Cylindrospermum bengalense.

Economic Importance # 12. Algae is Used as Medicine:

Medicinal applications of plants are almost as old as their food uses. From earliest times the Chinese used Sargassum and various Lamina-riales for treatment of goiter and other glandular troubles. Gelidium very early became employed for stomach disorders arid for heat-induced illness.

The gentle swelling of dried Laminaria stipes upon exposure to moisture make them surgical tool in the opening of wounds. Similarly, the orientals have employed the same technique in child-birth for expansion of the cervix.

Perhaps the algae used most widely and for the longest time for medicinal pur¬poses and from which agar is extracted are the agarphytes, including Gelidium, Pterocladia, Gracilaria, and Ahnfeltia. The name ‘agar-agar’ is of Malay origin and. means ‘jelly’. This jelly was obtained by boiling up seaweeds and cooling the resulting liquid.

Agar early became useful for stomach disorders and as a laxative, and was once em¬ployed as a dietetic. It was originally produced and marketed in China, bat the Japanese took over production in about 1662 and maintained a world monopoly till 1940.

The most significant date in the utilization of agarphytes was 1881, when Robert Koch proved the value of agar in the cultivation of bacteria. Since that time is has become essential to the work of hospitals and medical research laboratories throughout the world. Besides these, Chlorella is used for the preparation of antibiotic Chlorellin.

Economic Importance # 13. Industrial Utilization of Algae:

The industrial utilization of algae may be outlined in the following manner:

(i) Kelp Industry:

Industrial utilization of seaweeds in Europe had its principal early development in the production of ‘kelp’, a name that originally referred to the ash, rich in soda and potash, derived from burning marine plants. Kelp production was begun sometimes in the seventeenth century by French peasants and spread to other parts of North-West Europe.

Drift-weeds were first used, but cutting was later resorted to Laminaria and Saccorhiza in North Britain as of major importance.

But Fucus and Ascophyllum were also widely used, and in some areas Himanthalia and Chorda. The kelp ash from these plants was widely bought by early industrialists for use in manufacture of soap, glass and alum. During the eighteenth and early nineteenth centuries the demands became considerable, and enormous quantities of seaweeds were handled in areas of rich algal growth.

Kelp extract contains a number of chemical elements, notably potassium and iodine. About 25 per cent, of the dry weight of kelp is potassium chloride. Many species of kelp are used as food for man, especially in the Orient. In Northern Europe they also serve as food for domestic animals, such as sheep and cattle.

(ii) Algin Industry:

Algin is the general term designating the hydrophilic, or water-loving derivatives of alginic acid. The most commonly known algin is sodium alginate, but other commercially important compounds are the potassium, ammonium, calcium, and propylene glycol alginates, as well as alginic acid itself.

With the excep¬tion of alginic acid and calcium, alginate, the algin products offered commercially arc soluble in water to form vis-Sous solutions.

Algin occurs generally throughout the brown algae (Laminaria, Macrocystis, Sargassum and Fucus) as a cell wall constituent. It has remarkable water-absorbing qualities that make it useful in numerous industries in which a thickening, suspending, stabilizing, emulsifying, gel-forming, or film-form¬ing colloid is required.

Thus, algin provides ice cream with a smooth texture by pre¬venting the formation of ice crystals. In automobile polishes it suspends the abrasive; in paints, the pigments; also in pharmaceuticals, the drugs and antibiotics. As a stabi¬lizing agent it serves in the processing of rubber latex .and in the printing of textiles. As an emulsifier it is widely used in such products as water-based paints, French dressings, and cosmetics.

The algin industry has become so important to such a wide variety of industries that extensive survey of kelp-bed ecology is an effort to guard against loss of this impor¬tant resource. Harvesting methods are now carefully regulated, and a huge amount of money is being spent on kelp-bed research throughout the world.

Experimental studies are continuing on the relation of pollution to kelp survival and on kelp-bed grazing organisms.

(iii) Agar Industry:

The outstanding use of the red algae, however, is in the production of agar. This is a dried and bleached gelatinous extract obtained from red algae—Gelidium nudifrons, G. pusillum, G. robustum, and Gracilaria verrucosa. Agar is used extensively in medicine, chiefly as laxative, since it is not digested and in¬creases greatly in bulk with the absorption of water.

More important than this medicinal utilization is its use as an essential ingredient in the preparation of medium for the growth of bacteria and fungi. As such it is indispensable in bacteriological laboratories, because no adequate substitute for agar is known.

Since the introduction of agar into bacteriology in 1881, the agarphytes have become increasingly industrialized and the technical uses of agar enormously expanded. Modern industry has deve¬loped such a multitude of applications that only a fraction of them can be noted here. Large quantities of agar are used as a food adjunct.

Agar serves widely as a substitute for gelatin, as an anti-drying agent in breads and pastry, in improving the slicing quality of cheese, in the preparation of rapid-setting jellies and desserts, and in the manu¬facture of frozen dairy products. The use of agar in meat and fish canning has greatly expanded, and hundreds of tons are utilized annually.

Agar has proved effective as a temporary preventive for meat and fish in tropical regions, due to the inability of most purifying bacteria to attack it.

Early industrial uses of agar in the Orient included sizing fabric, water-proofing paper and cloth, and making rice paper more durable. Modern industry has refined and expanded these uses to meet new needs in the manufacturing of such items as photographic film, shoe polish, dental impression molds, shaving soaps, and hand lotions.

In the tanning industry agar imparts a gloss and stiffness to finished leather. In the manufacture of electric lamps, a lubricant of graphite and agar is used in draw¬ing the hot tungsten wire.

The increasing applications have called for wide expansion of the collection of agarphytes, and since Japan supplied most of the world’s markets before World War II, when those supplies were cut off, a great amount of hurried research was conducted in an attempt to develop domestic agar supplies not only in the United States, but in South Africa, Australia, New Zealand and Russia.

Life histories of algae belonging to various classes: Chlorophyceae – Volvox, Oedogonium, Xantho phyceae –Vaucheria, Phaeophyceae – Ectocarpus Rhodophyceae-Polysiphonia

LIFE HISTORIES OF ALGAE BELONGING TO VARIOUS CLASSES

Class: Chlorophyceae

Volvox:

General characteristics:

Systematic Position of Volvox:

Occurrence of Volvox:

Volvox is free floating fresh water green algae. Volvox grows as planktons on surface of water bodies like temporary and permanent ponds, lakes and water tanks. During rainy season due to its fast growth the surface of water bodies become green. The Volvox colonies appear as green rolling balls on surface of water.

Volvox is represented by about 20 species:

Some common Indian species are—Volvox globator, V aureus, and V. rousseletii V. prolificus, V. africanus.

Structure of Volvox:

Volvox thallus is a motile colony with definite shape and number of cells. This habit of thallus is called coenobium.

The colony is hollow, spherical or oval in shape and the size of colony is about the size of a pin head. The number of cells in a colony is fixed. Depending upon the species of Volvox the cells can be 500-60,000. The central part of colony is mucilaginous and the cells are arranged in a single layer on periphery of the colony.

The cells of anterior end possess bigger eye spots than those of posterior end cells. The cells of posterior side become reproductive on maturity. Thus, spherical or round colony of Volvox shows clear polarity. The cells of Volvox colony are Chlamydomonas type. Every cell has its own mucilage sheath.

The mucilage envelope of colony appears angular due to compression between cells. The cells are connected to each other through cytoplasmic strands. In some species of Volvox the cytoplasmic connections or strands are not present.

The cells of colony are usually pyriform with narrow anterior end and broad posterior end. The cells are biflagellate, the two flagella are equal, whiplash type and project outwards. The protoplasm of cell is enclosed within plasma membrane.

Each cell contains one nucleus, a cup shaped chloroplast with one or more pyrenoids, an eye spot and 2-6 contractile vacuoles. In some species of Volvox e.g., in V. globator and V. rousseletii the cells are of Sphaerella type.

The cells of colony are independent for functions like photosynthesis, respiration and excretion. The movement of colony takes place by co-ordinated flagellar movement. The reproduction is common to the coenobium.

Reproduction in Volvox:

Volvox reproduces both asexually and sexually. The asexual reproduction takes place under favourable conditions during spring and early summer. In Volvox mostly the cells of posterior part of colony take part in reproduction. These reproductive cells can be recognized by their larger size, prominent nuclei, dense granular cytoplasm, more pyrenoids and absence of flagella.

Asexual Reproduction:

During asexual reproduction some cells of the posterior part of colony become reproductive. These cells enlarge up to ten times, become rounded and lose flagella. These cells are called gonidia (Sing, gonidium). The gonidia lose eye spot. Pyrenoids increase in number.

The gonidia are pushed towards interior of the colony. The first division of gonidium is longitudinal to the plane of coenobium and this forms 2 cells. The second division is also longitudinal and at right angle to the first, forming 4 cells. By third longitudinal division all the four cells divide to make 8 cells of which 4 cells are central and 4 are peripheral. These 8 cells are arranged in curved plate-like structure and are called plakea stage. Each of these 8 cells divides by longitudinal division forming 16 cells arranged in the form of a hollow-sphere. The sphere is open on exterior side as a small aperture called phialopore. The cells at this stage continue to divide till the number of cells reaches the characteristic of that species. The cells at this stage are naked and in close contact with each other. The pointed anterior end of cells is directed towards inside.

The next step is called inversion of colony. As cells become opposite in direction, their anterior pointed end has to face the periphery of colony.

The inversion of colony starts with formation of a constriction opposite to phialopore. The cells of posterior end along with constriction are pushed inside the sphere, till the whole structure comes out of the phialopore. After inversion, the anterior pointed end of the cell faces periphery.

The phialopore gets closed, and makes the anterior part of the colony. After inversion the cells develop cell wall, flagella and eye spot. The cells become separated due to development of gelatinous sheath around each cell. This newly developed colony is called daughter colony. The daughter colonies initially remain attached to gelatinized wall of parent colony and later become free in gelatinous matrix of parent colony. The daughter colonies are released in water after the disintegration of parent colony or through the pores. Sometimes next generation of daughter colonies develop while the colonies are still attached to the earlier parent colony.

Sexual Reproduction:

The sexual reproduction in Volvox is oogamous type. Some species of Volvox e.g., V. globator are monoecious or homothallic i.e., the antheridia and oogonia develop on same colony. Other Volvox species e.g., V. rousseletii are dioecious or heterothallic i.e., antheridia and oogonia develop on different colonies.

Monoecious species are usually protandrous i.e., antheridia mature before oogonia but some species are protogynous i.e., oogonia develop before antheridia. V aureus is mostly dioecious but sometimes can be monoecious.

Reproductive cells mostly differentiate in the posterior part of colony. These cells enlarge, lose flagella and are called gametangia. The male reproductive cells are called antheridia or androgonidia and female reproductive cells are called oogonia or gynogonidia.

Development of Antheridium:

The development of antheridium starts with formation of antheridial initial or androgonidial cell mostly in posterior side of the colony. The initial cells enlarge, lose flagella, protoplasm becomes dense and nucleus becomes larger. The antheridial initial shifts inside towards cavity and remains connected to other vegetative cells through cytoplasmic strands.

The protoplast of antheridial initial divides, longitudinally to form 16-512 elongated cells. The cells remain in plate like structure or arrange in a hollow sphere. The inversion of cells also takes place as in asexual reproduction. Each cell differentiates in antherozoid or spermatozoid.

The antherozoid is spindle shaped, elongated, bi-flagellated structure containing two contractile vacuoles, nucleus, cup shape chloroplast, pyrenoid and eye spot. It is pale yellow or green in colour. The antherozoids are released individually or sometimes in groups.

Development of Oogonium:

The oogonia also differentiate mostly in posterior side of the colony. The oogonial initials enlarge, nucleus becomes larger, protoplast becomes dense, flagella are lost, eye spot disappears and many pyrenoids appear. The mature oosphere or ovum is round or flask shaped structure. The egg is uninucleate structure, the beak of flask shape oogonium functions as receptive spot.

Fertilization of Volvox:

After liberation from antheridium, the antherozoids swim freely on surface of water. Due to chemotactic response the antherozoids reach the oogonia.

Some antherozoids enter each oogonium. Only one antherozoid enters inside the oogonium through receptive spot. After this plasmogainy i.e., fusion of male and female cytoplasm and karyogamy i.e., fusion of male and female nuclei take place. This results in formation of diploid zygote.

The diploid zygote secretes a three layered thick wall. The layers of the wall are exospore, mesospore and endospore. The outer exospore is thick. It may be smooth e.g., V. aureus or spiny e.g., V. globator.

The mesospores and endospores are thin and smooth. The walls contain nucleus pigment haematochrome which imparts red colour to the zygote. The zygotes are released by the disintegration of parent colony. Then zygotes undergo a period of dormancy.

Germination of Zygote:

The dormant zygote germinates on approach of favourable climatic conditions. The diploid nucleus of zygote undergoes meiotic division forming four haploid cells. The outer two layers of zygote burst and the inner layer comes out as vesicle. The four haploid cells migrate with the vesicle. The development of new colony from zygote differs in different species of Volvox.

In V. aureus and V. minor the protoplasm of zygote divides repeatedly until the cell number of colony is reached and new colony is formed as in asexual reproduction process. In V. campensis the protoplast of zygote divides to make many biflagellate zoospores.

Only one zoospore survives and all other disintegrate. This zoospore comes out of the vesicle it divides to make many cells which arrange to form a colony. In V. rousseletii the zygote forms a single biflagellate zoospore, the protoplast of zoospore divides and forms a colony. In all the methods the cells divide and undergo inversion to make a mature colony.

Life Cycle of Volvox:

Volvox is haploid (n) algae, the haploid gametes fertilize to make diploid zygote (2n) which divides by meiosis to make haploid cells (n) which mature into haploid Volvox colony

Oedogonium:

Systematic position:

In this article we will discuss about:- 1. Occurrence of Oedogonium 2. Plant Body of Oedogonium 3. Features 4. Cell Structure 5. Reproduction 6. Life Cycle.

Occurrence of Oedogonium:

Oedogonium (Gr. oedos, swelling; gonos, reproductive bodies) is an exclusively fresh water alga. Out of about 400 species more than 200 have been reported from India. They are very common in pools, ponds, lakes etc.

The filamentous plant body may get attached with the stone, wood, leaves of aquatic plants, small branches of dead plant remain in water etc. by their basal cell the holdfast. Some species like O. terrestris are terrestrial.

Plant Body of Oedogonium:

The thalloid plant body is green, multi¬cellular and filamentous. The filaments are unbranched and cells of each filament are attached end to end and form uniseriate row. The filament is differentiated into 3 types of cells: 1. Basal cell, 2. Apical cell and 3. Middle cells.

1. Basal Cell:

It is the lowermost cell of the fila¬ment. The cell is long, gradually narrowed and towards the basal end it expands to form simple, disc-like, multilobed or finger-shaped structure. The cell is generally colourless, which performs the function of fixation to the substratum and called holdfast.

2. Apical Cell:

It is the topmost cell of the filament. The cell is usually rounded towards apical side and green in colour.

3. Middle Cells:

All the cells in between basal and apical cells are alike. The cells are longer than their breadth i.e., rectangular in shape.

Towards the upper end of some cells a ring-like structure is present known as cap or apical cap. The cell with cap is called cap cell. The number of caps on a cell indicates the number of cell divisions in that cell.

Important Features of Oedogonium:

1. This is a common fresh water alga growing on substratum like sand particles, rocks etc.

2. The plant body is unbranched, filamentous and differentiated into apex and base.

3. Cells have reticulate chloroplasts.

4. Presence of caps on the young dividing cells.

5. Vegetative cell division is very elaborate.

6. Asexual reproduction takes place by multi- flagellate zoospore, where flagella are arranged around the beak-like apical region.

7. Sexual reproduction is advanced oogamous type.

8. The female gamete i.e., ovum, is produced singly in each oogonium.

9. The male gametes i.e., antherozoids, are very much similar to zoospores but smaller in size. Two antherozoids are produced in each antheridium.

10. Based on the size of male filament the plants are divided into two groups: Macrandrous and Nannandrous type.

11. In macrandrous type the antheridia develop into the filament of normal size. But in nan-nandrous type the antheridia develop on small and thin male filament, the dwarf male or nannandrium (remain attached with the oogonium wall or its lower cell, the suppor¬ting cell), develop on germination of andro- spore. The androspore forms singly in andro- sporangium, develop in the normal filament.

12. The androspores are smaller than zoospores (produced asexually), but larger than antherozoids.

13. The zygote undergoes meiotic division and produces four zoospores. In dioecious species two produce male and other two produce female plants.

Cell Structure of Oedogonium:

The intercalary cells are longer than their breadth and are cylindrical in outline.

The cells are surrounded by thick and rigid cell wall. The cell wall is differen¬tiated into three layers an outer chitin, middle pectin and innermost cellulosic. Just interior to the wall, cell membrane is present, which encloses the protoplast.

The protoplast consists of cytoplasm, chloroplast and nucleus. The cells contain many small or single large vacuoles situ¬ated in the centre and remain filled with cell sap. The cytoplasm lies between the cell membrane and vacuole.

The Chloroplast is single, large and reticulate, which remains embedded in the cyto¬plasm. It extends from one end of the cell to the other end. Cells are uninucleate and nucleus is generally present in the centre of the cell within the cytoplasm or it may be excentric.

Cell Division:

Growth of the filament takes place through cell division. All cells except apical and basal ones are capable of dividing through cell division though division remains restricted in some of the cells of the filament.

The steps of cell division are:

1. Initially the nucleus becomes shifted from peripheral position towards the centre and then moves slightly towards the upper half of the cell.

2. Ring-like thickening develops towards the upper part of the cell wall which gradually increases in thickness.

3. The nucleus undergoes mitotic division and form two nuclei.

4. At the end of cell division (telophase), a row of microtubules develop and accumulate as a layer between the daughter nuclei. This layer remains in floating condi¬tion which will develop the future septum.

5. The ring-like thickening gradually elongates and splits the mother wall towards the apical region. The ring expands much more and forms a concave cylindrical structure. The ring material ultimately forms the cuticle of the upper daughter cell.

6. The upper part of the ruptured mother wall remains attached to the anterior end of the new daughter cell as a cap i.e., the apical cap. The other part remain towards the basal region of the daughter cell.

7. The floating septum gradually goes up to the base of the future daughter cell i.e., at the top of the mother cell at the ruptured end and it becomes fixed. Later on it develops into mature cross wall.

8. New side wall develops between the cuticle and the plasmalemma of the upper cell. Thus the two cells are formed. It is evident that the cell with cap is the younger one which develops between the two old cells.

Reproduction in Oedogonium:

Oedogonium reproduces by all the three means: vegetative, asexual and sexual.

Vegetative Reproduction:

It takes place by fragmentation and akinete formation:

1. Fragmentation:

It takes place by accidental breakage of the filament, dying off of intercalary cells or by the formation of intercalary sporangia. The fragments are capable of developing into new filaments.

2. Akinete:

During unfavourable condition the entire protoplast of a cell becomes a thick-walled, reddish-brown, round or oval structure, the akinete. The akinete germinates during favourable condition and develops a new filament. They generally form in chain.

Asexual Reproduction:

Asexual reproduction takes place by means of zoospores. Zoospores are formed singly within a cell. Comparatively younger cell i.e., the cell with cap behaves as sporangium mother cell.

The zoospores are multiflagellate and ovoid, pyriform or spherical in shape. They are uni¬nucleate with single chloroplast and occasionally with an eye-spot.

During favourable condition, the zoospore formation begins in a cap cell of the filament. The entire protoplast of zoosporangium contracts from the wall and behave as a unit. The proto¬plast becomes round or oval in shape and its nucleus moves at one end.

Near the nucleus a semicircular hyaline area develops. Just below the hyaline area a ring of blepharoplast granules develops, connected with each other by fibrous strands (Ringo, 1967). Later on, from each blepharoplast granule, single flagellum develops. Thus a crown of flagella is present around the colourless semicircular area.

The fully developed zoospores are liberated by breaking the zoosporangium wall. The wall of the zoosporangium breaks near the cap region and the neighbouring cell bend on one side to make way for the liberation of zoospore. During liberation, the zoospore remains as a delicate mucilaginous vesicle for 3-10 minutes. After dis¬solution of vesicle the zoospore gets free and starts swimming in the surrounding water.

Germination:

The zoospore can swim for about one hour or more. Coming in contact with substratum by the anterior end, it loses flagella and starts to elongate. The lower hyaline part becomes separated by cell wall, which forms the hold fast. Through the subsequent division and re-division in a single plane, new filament is formed.

Sexual Reproduction:

The sexual reproduction in Oedogonium is an advanced oogamous type. The male gametes or antherozoides are produced in antheridium and the female gamete or egg is produced in oogonium. Male and female gametes differ both morphologically and physiologically.

Only one egg is produced in each oogonium and two antherozoides in each antheridium. Another motile structure, the androspore, is produced singly in each androsporangium. Deficiency of nitrogen and alkaline pH are the important fac¬tors for promoting sexual reproduction.

Distribution of Sex Organ in Oedogonium:

Based on the size of the male (antheridial) filament the species of Oedogonium are divided into two groups macrandrous and nannandrous type:

1. Macrandrous Type:

In macrandrous type the antheridium develops in the filament of normal size.

It is of two Types:

i. Monoecious type (homothallic or bisexual). In this type (e.g., O. fragile, O. nodulosum and O. hirnii) antheridia and oogonia are borne on the same filament.

ii. Dioecious type (heterothallic or unisexual). In this type (e.g., O. gracilius, O. cardiacum and O. aquaticum) the antheridia and oogonia are borne on the different filaments.

2. Nannandrous Type:

The nannandrous species are always dioecious (heterothallic) i.e., antheridia and oogonia are borne on different filaments. In this type the antheridia develop on a very small filament termed as dwarf male or nannandrium. In nannandrous type initially androsporangia are developed in series on normal sized filament. The andro¬spore form singly within androsporangium.

Liberating from androsporangium, the androspores swim freely in water. The androspore germinates on the oogonial wall (O. ciliatum) or on supporting cell (O. concatenatum) and forms dwarf male filament. Towards the api¬cal region, the dwarf male filament cuts off small cells as the antheridial mother cells.

Each antheridium produces two anthero¬zoides. The androspores, antherozoids and zoospores are morphologically alike but differ in their sizes. The androspores are smaller than zoospores (produced asexually) but larger than antherozoides.

They are of two types:

i. Cynandrosporous Type:

In this type (e.g., O. concatenatum) the androsporangia and oogo¬nia are borne on the same filament ii. Idioandrosporous Type:

In this type (e.g., O. setigerum, O. confertum and O. iyengarii) the androsporangia and oogonia are borne on different filaments.

Sexual Reproduction in Macrandrous Species:

The structure and development of antheri¬dium and oogonium are similar in all the species belonging to either monoecious or dioecious type. They differ only in the position of sex organs. In monoecious type both the sex organs develop on the same filament, but in dioecious type they are on different filaments.

a. Antheridium:

Any cap cell of the vegetative filament may function as antheridial mother cell (Fig. 3.75). It divides transversely into an upper smaller antheridium and a lower larger sister cell. The sister cell then undergoes repeated transverse division and form an uniseriate row of about 2-40 rectangular uninucleate antheridia.

The nucleus of the antheridium undergoes mitotic division and forms 2 nuclei. Each nucleus becomes surrounded by some cytoplasm and metamorphoses into an anthero¬zoid. Thus two antherozoids are developed from each antheridium.

The antherozoids are unicellular, uninucle¬ate, multiflagellate and yellowish in colour. Morphologically it is similar to zoospore and androspore, but much smaller in size. The libe¬ration of antherozoid is similar to zoospore formed during asexual process.

b. Oogonium:

Any cap cell of the vege¬tative filament may function as oogonial mother cell (Fig. 3.76). It divides transversely into an upper oogonium and a lower suppor¬ting cell or suffultory. The lower cell may again undergoes similar divisions in repeated sequence to form two or more oogonia with a lower supporting cell.

With maturity the oogonium becomes globose, which contains single egg. A receptive spot is present at one side of the egg. Before fertilisation a trans¬verse slit or pore develops on the oogonial wall through which the antherozoids take the entry.

Sexual Reproduction in Nannandrous Species:

The structure and development of androsporangium, antheridium and oogonium are similar in all the species either belonging to Gynandrosporous or Idioandrosporous type. They differ only in the position of androspo¬rangium. In Gynandrosporous type the androsporangia and oogonia are borne on the same filament, whereas in Idioandrosporous type the androsporangia and oogonia are borne on different filaments.

a. Androsporangium:

The mode of develop¬ment of androsporangia is alike with the antheridial development in macrandrous species. The androsporangia are larger than the antheridia of macrandrous type. The nucleus of androsporangium does not divide and the entire protoplast metamorphoses into a single androspore.

The androspores are unicellular, uninucleate and multiflagellate. The androspores are larger than the antherozoids. The andros¬pores are liberated by breaking the wall of androsporangium. During liberation each androspore remains in a mucilage envelop for few minutes and then becomes free to swim in water (Fig. 3.77A, B).

b. Germination of Androspore and Forma¬tion of Antherozoids:

After swimming for some time, it gets attached either on oogonial wall or on supporting cell (Fig. 3.77C). Then a wall develops around the andospore. The androspore elongates and cuts off a few flat cells at its apex to form the antheridia (Fig. 3.77D). The nucleus of each antheridium divides mitotically to form two nuclei.

Each nucleus with some cytoplasm metamorphoses into single antherozoid. Thus two antherozoids are formed in each antheri¬dium (Fig. 3.77E). The antherozoids are liberated in a similar way as found in macrandrous species. The antherozoids swim in water for sometime and in contact with receptive pore or slit, antherozoid enters inside the oogonium and fertilizes the egg.

c. Oogonium:

The structure and develop¬ment of oogonium are same as macrandrous species.

Fertilisation:

Antherozoids are attracted by the mature oogonium through chemical stimu¬lus. Normally only one antherozoid enters through the opening on the oogonial wall and fertilises the egg, resulting in the formation of a diploid zygote or oospore (Fig. 3.78A, B; 3.77F).

Oospore:

The zygote during further deve¬lopment retracts itself from the oogonial wall and secretes 2-3 layered outer wall (Fig. 3.78B). Later on the outermost one becomes ornamented. The zygote generally undergoes a long period of rest and becomes brown in colour.

Germination of Oospore:

The oospore germinates during favourable condition (Fig. 3.78C-G). The nucleus undergoes meiosis and forms 4 haploid daughter nuclei. The nuclei accumulate some cytoplasm and form 4 daugh¬ter protoplasts. They liberate by rupturing the oospore wall. During liberation they develop flagella and are called meiospores or zoomeiospores.

Initially they remain inside a delicate vesicle, which soon disintegrates and the zoospores get free into the environment. After swimming for some time in water they withdraw their flagella and germinate into new haoloid Oedogonium filament like zoospore in asexual reproduction. The nature of zoomeiospore development varies in monoecious and dioecious species.

In monoecious species all the zoomeiospores develop into similar Oedogonium filament.

In dioecious species out of 4 zoomeio¬spores, 2 develop into male and other 2 develop into female Oedogonium filaments.

Indian Species:

Oedogonium cardiacum, O. aster, O. elegans, O. aerolatum and O. armigerum.

Life Cycle of Oedogonium:

Fig. 3.79-3.82 depict life cycle of Oedogonium.

Vaucheria: Occurrence, Features and Reproduction

this article we will discuss about:- 1. Occurrence of Vaucheria 2. Plant Body of Vaucheria 3. Features 4. Reproduction 5. Taxonomic Status 6. Life Cycle.

Occurrence of Vaucheria:

The genus Vaucheria (named after J. P. Vaucher) is represented by about 54 species, out of which 9 species are found in India.

Most of the members are terrestrial (V. geminata, V. terrestris, K. hamata) or fresh water (V. uncinata). A member like V. sessilis is terres¬trial as well as aquatic. Species like K amphibian is amphibious in habitat. The terrestrial forms grow in winter in the form of green and thick layer on damp soil. A few species grow in brack¬ish water and some are marine (V. piloboloides). V. jonesii grows on snow.

Plant Body of Vaucheria:

Plant body of Vaucheria is filamentous, much branched, coenocytic and siphonaceous thallus (Fig, 3.83A). The coenocytic body con¬tains many nuclei. Septa may form during injury or on development of sex organ. But the filament is normally septate in V. pseudohamata.

In terrestrial species the plant body remains attached to the soil surface with much branched thread like structure, the rhizoid or hapteron. In floating members the rhizoids are either absent or ill-developed. Species like V. mayyanadensis shows well-developed rhizoid and aerial bran¬ches.

The filamentous body has a thin outer wall, which is less elastic. It is made up of outer pectic and inner cellulosic layers. In the centre of the filament a continuous vacuole is present except at the apical region, which is filled with cell sap. The protoplast is present throughout the filament between the cell wall and vacuole which contains nuclei, chromatophores and other substances.

In the protoplast, nuclei remain towards vacuole and chromatophores towards periphery Chromatophores are very small, circular, oval or elliptical in outline. Pyrenoids are absent.

Vaucheria contains the pigments like chloro¬phyll a, chlorophyll e, carotenoids and xanthophylls as in the class Xanthophyceae. The carotenoids are present in more amount than chlorophylls. The characteristic pigment of Chlorophyceae, chlorophyll b, is absent and the dominant pigment of the order Siphonales of Chlorophyceae, the siphonin and siphonoxan- thin are absent in' Vaucheria.

The reserve food material is oil, it occurs as colourless droplets in the cytoplasm. If the fila¬ments remain exposed under continuous illumi¬nation, the assimilatory product will be starch instead of oil.

Important Features of Vaucheria:

1. Plant body is filamentous, coenocytic and branched. It remains attached with the sub¬stratum by rhizoids.

2. Reserve food is fats and oils.

3. Reproduction takes place by all the three means : Vegetative, Asexual and Sexual.

4. Vegetative reproduction takes place by fragmentation.

5. Asexual reproduction takes place by compound multiflagellate zoospores i.e., synzoospores, aplanospores, hypnospores and akinetes.

6. Sexual reproduction is oogamous.

7. The oogonium contains single large, uninu¬cleate egg, while the antheridium contains many biflagellate antherozoids.

8. The oospore or zygote undergoes meiosis during germination and forms new Vaucheria plant.

Reproduction of Vaucheria:

Vaucheria reproduces by all the three means: vegetative, asexual and sexual.

Vegetative reproduction' It takes place due to accidental breakage of the vegetative filament. Septa are formed in the injured region of the filament.

Asexual Reproduction:

Vaucheria repro¬duces asexually by the formation of various types of spores such as zoospores, aplanospores and akinetes.

Zoospores:

Zoospores are formed singly inside the zoosporangium, developed at the apical region of the filament. During formation of the zoosporangia, more amount of nuclei and cytoplasm accumulate towards the apex, thereby the vacuole becomes reduced in size. The upper portion gets separated from rest of the filament by cross-wall and forms apical sporangium.

Consequently the sporangium becomes club-shaped and dark green in colour. After some time, the orientation of nuclei and chloroplast get reversed, thereby the nuclei present towards the centre of the vegetative fila¬ment come to the periphery and chloroplasts become shifted from periphery towards the centre.

Before liberation, entire protoplast of the zoosporangium contracts slightly. During libe¬ration a narrow aperture develops at the apex through which the zoospore is liberated. Flagella are formed during liberation.

The zoospores are yellowish-green, ovoid, multinucleate and multiflagellate structures, having small central vacuole and many chromatophores situated between the vacuole and peripheral nuclei. The paired flagella are unequal in length.

Single flagellum deve¬lops from a basal granule or basal body. For each pair of flagella, a pair of basal granules is present. The basal granules remain firmly attached together at the tip of the nuclei. Some algologists considered this multi-flagellate and multinucleate unit as synzoospore or compound zoospore.

After about 15 minutes of swimming the zoospore becomes sluggish, deflagellated, rounded and then secretes a thin wall around. One or more elongated siphonaceous tubes develop at different direction. One of the tubes develops into rhizoid and other one into new thallus.

Aplanospores:

Aplanospores are developed singly within aplanosporangium, during unfavourable conditions. Like zoospores, the aplanospores are developed singly inside the aplanosporangium at the apical side of the aerial hyphae. During development it also cuts off from rest of the filament by transverse septum.

The aplanosporangium is club-shaped, which deve¬lops single non-flagellate club-shaped or globose aplanospore. The aplanospore is liberated by rupturing the apical wall. After liberation the aplanospore germinates into new filament like the mother.

Rarely the protoplast of the sporangium gets separated into small units, the micro-aplanospores. On being liberated they germinate into new filaments.

Akinetes:

Akinetes are formed during unfavourable condition. During akinete forma¬tion the content of the filament divides into small segments by thick gelatinous wall. These thick walled small multinucleate portions or segments are called akinetes, also called as hypnospores or cysts. The protoplasts of akinetes are often laden with oil. During favourable condition akinete germinates into new filament.

The above stage of akinete chain looks like another alga Gongrosira and therefore this stage is called Gongrosira stage.

Sometimes the protoplast of the akinete divides into many small uninucleate amoeboid segments. After liberation by breaking the akinete wall, they develop into individual filaments.

Sexual Reproduction of Vaucheria:

The sexual reproduction in Vaucheria is of oogamous type. It takes place by antheridium, the male sex organ and oogonium, the female sex organ. Most of the species are homothallic or monoecious but a few (V. litorea, V. dichotoma and V: mayyanadensis) are heterothallic or dioecious.

Position:

In homothallic or monoecious species (V. sessilis, V. aversa) antheridia and oogonia are borne very close or adjacent on a single filament or on adjacent filament. But in heterothallic or dioecious species (V. dichotoma), they are borne on different plants.

The sex organ shows great variation in their position not only in different species but also in the same species. The sex organs are stalked or sessile (V. sessilis). In V. geminata, a short stalk bears single terminal antheridium flanked by 3-4 oogonia. In V. gardneri single, terminal elongated antheridium is surroun¬ded by a group of oogonium. In V. terrestris the stalk of antheridium and oogonium is stout, very long and well-developed. In V. bilateral is however, 2-6 oogonia are arranged bilaterally in a series and the antheridia are short-stalked and curved and open towards oogonium.

Development:

Antheridium:

Initially a short lateral branch like vegetative branch projects out. Large number of nuciei and chromatophores accumulate towards the apical region. The api¬cal region then bends like a horn and a transverse septum is laid down which differentiates the apical antheridium.

The nuclei of antheridium aggregate in the centre and divide mitotically. Each nucleus along with some cytoplasm metamorphoses into single spindle shaped biflagellate antherozoid. The flagella are unequal in length, dissimilar (one whiplash and other tinsel) and laterally inserted.

The antherozoids are generally liberated through an opening developed at the apical region of antheridium. Several pores are developed on anthridial wall in V. debaryana for the liberation of anthrozoides.

Oogonium:

Initially a small protuberance develops at or near the base of antheridial branch, due to accumulation of cytoplasm. The cytoplasm of this region is colourless which has many nuclei and without any chromatophore. This colourless multinucleate mass of cytoplasm is called wanderplasm (Oltmanns, 1895). The wall of the thalli near the wander- plasm bulges out and forms oogonial initial, which gradually enlarges and consequently many chromatophores migrate into it. With further development the oogonium initial becomes round or ovoid in shape with a beak at the apex and gets separated from rest of the filament by transverse septa.

The mature oogonium contains a large nucleus at the centre with many chromatophores and oil droplets dispersed throughout the cyto¬plasm. All the nuclei except one degenerate dur¬ing development.

According to Oltmanns (1895) all nuclei except one go back to the main thallus before separation. The protoplast along with nucleus rounds off and forms single ovum or egg. It has an hyaline area towards the anterior, known as the receptive spot. Fertilisation. Both the sex organs open almost at the same time. The tip of the beak of oogonium gelatinises and forms an aperture. Simultaneously an aperture is also formed at the apex of antheridium (the time of opening may vary from a few minutes to 2 hours).

A small drop of colourless cytoplasm oozes out through the beak of oogonium and several antherozoids coming out from the antheridium get entangled in this drop. Out of many, only one enters into the oogonium. Coming in contact with the egg it looses its flagella and enters into it.

The nucleus of antherozoid is smaller than the egg nucleus. They remain side by side, till the nucleus of the antherozoid attains almost same size of the egg nucleus. Two nuclei then fuse and form diploid (2n) zygote.

Zygote:

The zygote secretes 3-7 layered wall around it. The protoplast accumu¬lates oil droplets. Initially the zygote remains green, but later it becomes red due to breakdown of chlorophyll. It remains within the oogonium and later comes out by decay of oogonial wall. It remains dormant for long period which varies with the duration of unfavourable condition like high temperature, desiccation etc.

Germination:

During favourable condition the zygote germinates to form new thallus. The nucleus (2n) of zygote undergoes first meiotic division followed by several mitotic divisions thus forming a coenocytic condition. The zygote wall cracks at a point and inner protoplasm elon¬gates, which gradually forms lower rhizoids and an aerial hypha like the mother.

Taxonomic Status of Vaucheria:

There has been a great controversy regar¬ding the taxonomic status of Vaucheria. Fritsch (1935) included Vaucheria along with other three genera (Vaucheriopsis, Dichotomosiphon and Pseudodichotomosiphon) in the family Vaucheriaceae under the class Chlorophyceae. This was also followed by lyenger (1951) and Venkataraman (1961).

It was placed under the class Chlorophyceae, based on the following characteristics:

1. Plant body is siphonaceous filament.

2. Asexual reproduction by synzoospore or compound zoospore.

3. Sexual reproduction is oogamous type.

4. Presence of chlorophyll a.

5. Change of assimilatory product into starch, instead of oil under continuous illumination.

However, it differs from other members of Chlorophyceae, based on the following charac¬teristics:

1. Absence of macerised cellulosic cell wall.

2. Absence of pyrenoid.

3. Paired flagella of synzoospores are unequal.

4. Absence of chlorophyll b.

5. Reserve food is oil.

Later Smith (1950) followed by Greenwood et al. (1957), Prescott (1969), Round (1973), Bold and Wynne (1978) separated Vaucheria from Chlorophyceae and placed it under the class Xanthophyceae.

They shifted Vaucheria to Xanthophyceae, based on the following charac¬teristics:

1. Unequal length of flagella of antherozoids.

2. Presence of chlorophyll e, a pigment com¬mon in Xanthophyceae.

3. Absence of two xanthophylls, siphonin and siphonoxanthin.

Davis (1904), Williams (1926) and Printz (1927) observed the phylogenetic relationships between Vaucheria with fungi:

1. Presence of thalloid coenocytic plant body.

2. Similarity in the development of sex organs with oomycetous fungi.

3. Presence of both whiplash and tinsel type of flagella like some phycomycetous members.

4. Presence of similarity in external structure with some members of Monoblepharidaceae.

5. Synzoospore of Vaucheria is like the gonidium of various members of Peronos- poraceae.

For the above evidences someone believed that the Phycomycetes have been derived from Vaucheria-like ancestors. But it is very difficult to make comment on whether this similarity in characteristics is due to their real affinity or it is due to convergent evolution.

Indian Species:

Vaucheria sessilis, V. amphibian, V. geminata, V. uncinata, V. polysperma etc.

Life Cycle of Vaucheria:

Phaeophyceae- ectocarpus

In this article we will discuss about Ectocarpus. After reading this article you will learn about:- 1. Classification of Ectocarpus 2. Occurrence of Ectocarpus 3. Thallus Structure 4. Cell Structure 5. Growth 6. Reproduction 7. Fertilization 8. Life Cycle.

Classification of Ectocarpus:

Fritsch (1945) divided class Phaeophyceae into 9 orders:

1. Ectocarpales

2. Tilopteridales

3. Cutleriales

4. Sporochnales

5. Desmarestiales

6. Laminariales

7. Sphacelariales

8. Dictyotales

9. Fucales.

Smith (1955) classified Phaeophyceae into 12 classes which were grouped in three subclass on the basis of their life cycles:

Orders:

Order: Ectocarpales:

(i) The Ectocarpales include about 60 genera which inhabit cold sea of temperate and polar regions.

(ii) The thallus mostly shows heterotrichous habit with prostrate creeping disc holdfast and monosiphonous filament making erect system.

(iii) The growth is trichothallic and the cell divisions are intercalary.

(iv) The asexual reproduction takes place by zoospores formed in unilocular and plurilocular sporangia.

(v) The sexual reproduction is isogamous or oogamous.

(vi) The life cycle is isomorphic type.

Family: Ectocarpaceae:

(i) The family Ectocarpaceae is characterized by simple, heterotrichous thalli.

(ii) The sexual reproduction is isogamous.

(iii) The alternation of generation is isomorphic.

(iv) The plants are marine. Ectocarpaceae in India is mainly represented by Ectocarpus, Compsonema, Giffordia and Myrionema.

Ectocarpus:

Systematic Position:

Class: Phaeophyceae

Order: Ectocarpales

Family: Ectocarpaceae

Genus: Ectocarpus

Occurrence of Ectocarpus:

Ectocarpus is word-wide in distribution particulary in colder seas and Polar Regions. Ectocarpus is very common on sea shore of Atlantic Ocean. Ectocarpus is found attached on sea rocks.

Some species of Ectocarpus are epiphytic e.g., E. coniferus, and E. breviarticulatus grow on larger algae like Fucus and Laminaria. E. dermonematus is endophytic species. E. fasciculatus is epizoic species growing on fins of faster. In India Ectocaupus is represented by about 100 species.

Thallus Structure:

The plant body is mostly typically heterotrichous and differentiated into (a) creeping or prostrates system and (b) projecting an erect system. In some species one of the two systems may be reduced. In epiphytic forms the prostrate system is well developed and the erect system is reduced.

In many species of Ectocarpus, the thallus is sparingly to profusely branched, the cells are uniseriate, joined end to end in a row. In some species, the older portions of the main branches are corticated by a layer of descending rhizoidal branches. In many species the terminal portion of a branch may end in a colourless hair with a basal meristem.

Structure of Cell:

The cells are generally rectangular, uninucleate and the nucleus is placed in the region of the central vacuole, suspended by protoplasmic threads. The cell contains a few parietal band shaped chromatophores with irregular branches (E. siliculosus) or many disc shaped chromatophores (E. granulosus). The chromatophores contain large amount of xanthophyll's in addition to chlorophyll.

Fucosan vesicles or granules are present in large number along with pyrenoid like bodies in the cell. The reserve food material is in form of laminarin and mannitol. The cell wall is differentiated into two layers, the inner firm layer is made of cellulose and the outer gelatinous layer contains alginic acid.

Growth of Ectocarpus:

The growth in the prostrate system is apical and in the erect system it is diffuse and intercalary. In intercalary or trichothallic growth meristem is located at the base of a hair (E. irregularis and E. paradoxus). The growth is apical in E. lucifugus.

Reproduction in Ectocarpus:

In Ectocarpus the reproduction takes place by asexual and sexual methods.

Asexual Reproduction in Ectocarpus:

The asexual reproduction takes places with the help of biflagellate zoospores. These zoospores are produced in unilocular and plurilocular sporangia. The sporophytic diploid plant forms two types of sporangia:

(a) Unilocular sporangia

(b) Plurilocular sporangia.

These two types of zoosporangia may be produced on the same plant or on different plants. The unilocular zoosporangia form haploid zoospores and the plurilocular sprogania form diploid zoospores.

Unilocular Sporangia:

The unilocular sporangia develop singly on tips of small branchlets. The terminal cell of the branchlet gradually increases in size and becomes ellipsoidal. This cell functions as sporangial initial. The nucleus of sporangial cell first divides by meiotic division followed by many equational divisions. This results in formation of 32-64 haploid nuclei. The nuclear divisions are not followed by wall formation and the sporangium remains unilocular. Each nucleus of the sporganiuin gets surrounded by protoplast segment and ultimately transforms into 32-64 zoospores (Fig. 2 D). Each zoospore is pyriform, uninucleate with two laterally inserted unequal flagella.

The anterior flagellum is longer, pantonematic and directed forward while the posterior is shorter, acronematic and directed backward.

The zoospores discharge en-masse in gelatinous matrix through a terminal pore in sporangium. The zoospores after being discharged remain in spherical mass at the apex of sporangium. The zoospores remain inactive for 30-60 seconds then become free and swim in water. They remain motile for about 30 minutes.

These zoospores are haploid, they withdraw flagella and attach to the substratum by their anterior ends. The zoospores germinate within 2-3 hours to produce a new Ectocarpus plant which is similar to sporophytic plant in structure. These plants are called gametophytic plants as on maturity they bear plurilocular gametangia.

According to Knight (1929), Schussing and Kothbaouer (1934), rarely the zoospores released from unilocular sporangia, show pairing and fusion but the fate of such zygotes is not known.

Plurilocular or Neutral Sporangia:

Like unilocular sporangia, the plurilocular sporangia also develop from the terminal cells of the branchlets of diploid sporophytic plant. The cell which functions as sporangial initial enlarges in size and becomes spherical or elongated structure. It repeatedly undergoes transverse divisions to form a row of 5-12 cells. Then vertical divisions start in all the cells starting with the median cells of the row.

Many transverse and vertical divisions result in formation of cubical cells arranged in 20-40 transverse tiers. The cells are arranged in regular rows. This multicellular structure is called plurilocular sporangium.

The protoplast of each diploid uninucleate cell of the sporangium is transformed into a single biflagellate zoospore. The zoospores of plurilocular and unilocular sporangia are identical in structure but zoospores of plurilocular sporangia are diploid and zoospores of unilocular sporangia are haploid.

The mature zoospores are liberated from the sporangium through apical or lateral pores. The zoospores remain motile for 4-5 hours and then germinate into diploid thallus which later on bears unilocular and plurilocular sporangia.

These diploid zoospores multiply only sporophytic plants and they do not play any role in alternation of generation. The formation of unilocular and plurilocular sporangia is affected by environmental conditions like temperature and salinity of water. E. siliculosus produces unilocular sporangia at 13°C, plurilocular at 19°C and both unilocular and plurilocular at 16°C.

Sexual Reproduction in Ectocarpus:

The sexual reproduction may be isogamous, anisogamous or oogamous. Most of the Ectocarpus species are anisogamous. The gametes are biflagellate, motile and are produced in plurilocular gametangia borne on haploid or unisexual plants.

The plurilocular gametangia and plurilocular sporangia are similar in structure and development. The plurilocular gametangia are either sessile or stalked and vary in shape from ovate to siliquose. The plurilocular gametangia develop singly from the terminal cell of the lateral branchlets.

The gametangial initial divides transversely to form a row of 6-12 cells. Further divisions are transverse and vertical in these cells to make hundreds of cubical cells arranged in 20-40 transverse layers. The protoplast of each cubical cell in gametangium metamorphosis into single biflagellate pyriform gamete. The gametes are liberated in water through terminal or lateral pore in gametangium.

In E. siliculosus the gametes are morphologically similar. Hence the reproduction is isogamous but physiologically anisogamous. The fertilization occurs between gametes from separate plants. These gametes are morphologically identical but one is less active, becomes passive after a short period and behaves as female gamete. The more active gametes are considered male.

The active male gametes cluster around female gamete and cling themselves by their anterior flagellum. It is known as clump formation. In this clump formation one male gamete is able to fuse with female gamete. The gametes fuse to form a diploid zygote. In other species of Ectocarpus gametes from same plant can fuse to form a zygote showing isogamous reproduction.

In E. secundus, the sexual reproduction is anisogamous, the gametes are different in size. The smaller gametes are produced in micro-gametangia and the larger are produced in bigger mega-gametangia. The micro-and macrogametes after liberation fuse and form zygote,. In E. padinae three distinct types of plurilocular gametangia are formed. The largest mega-gametangia represent oogonia and the smallest micro-gametangia represent antheridia. The egg and antherozoids produced by the mature mega-gametangia and micro-gametangia fuse to form zygospore. The medium sized meso-gametangia give rise to medium size gametes. They do not fuse but develop new plant parthenogenetically.

Fertilization in Ectocarpus:

In isogamous species the fusing gametes are morphologically and physiologically similar. The two gametes of same gametangium or from two different gametangium of same thallus fuse to from zygospore. In physiologically anisogamous species, gametes from two filaments of different strains fuse. The female gamete after liberation secretes a volatile sexual attractant sirenine.

A large number of male gametes are attracted and cluster around female gamete to make clump formation. After sometime one male gamete fuses egg to make zygospore and other gametes detach themselves from female gamete. The zygospore germinates after 2-3 days. Its diploid nucleus divides mitotically to make diploid Ectocarpus plant.

Life Cycle of Ectocarpus:

The sexual thalli of Ectocarpus are haploid. The haploid plants bear plurilocular gametangia. The isogametes or anisogametes fuse to form diploid zygospore. The diploid nucleus of zygospore divides mitotically during germination. This forms diploid, sporophylic plants. The diploid plants bear both unilocular and plurilocular sporangia.

The zoospores formed in plurilocular sporangia are diploid and give rise to diploid sporophytic plants on germination. The zoospores formed in unilocular sporangia are haploid and on germination form haploid gametophytic thalli. In Ectocarpus the sporophytic and gametophytic plants are morphologically similar hence there is isomorphic alternation of generation.

Rhodophyceae-polysiphonia

Occurrence of Polysiphonia:

The genus Polysiphonia (Gr. poly — many; siphon — tube) is represented by more than 150 species, out of which about 16 species are reported from India. They grow in marine habitat and are cosmopolitan in distribution.

Commonly they are found in littoral and sublittoral zones. In India they are found in western and southern coasts. Commonly, they grow as lithophytes i.e., on rocks or stones (e.g., P. elongata), some species like P. urceola, P. terulacea grow as epiphytes on Laminaria. P. fastigiata grows as semiparasite on Ascophyllum nodosum.

Plant Body of Polysiphonia:

Plant body is multiaxial well branched thallus of dark brown, reddish or bluish red colouration appearing as a very small bush. The height of the bush varies from a few to several centimeters.

Most of the species are heterotrichous in habit, consisting of prostrate and erect systems.

Prostrate System:

It may be multiaxial and well developed. From the lower side of the prostrate system many unicellular rhizoids are developed. The rhizoids are much lobed at the apex and form definite attach¬ment discs (e.g., P. urceolata, P. nigrescens).

Erect System:

The erect filaments develop from the prostrate system. The erect system con¬sists of main axis and many branches. The branches are of two types: long branch and short branch

The long branches are called branches of unlimited growth or long lateral branches and the short branches i.e., branches of limited growth are called trichoblasts. The long bran¬ches develop in a spiral or radial symmetry. The trichoblasts are spirally arranged, dichotomously branched, colourless and mostly annual struc¬tures bearing sex organs. The trichoblasts may develop both from main axis and long branches.

The main axis and long branches consist of a central siphon of many elongated cylindrical cells situated in vertical row. It is surrounded by 4-20 peripheral siphons. So the plant body is polysiphonous and named Polysiphonia. Only the central siphon is present at the apical region of both main axis and the long branches.

In most of the species, peri¬central siphon is covered by 3 layers of cortical cells formed due to periclinal and anticlinal divisions of the cells of pericentral siphon. All cells of the plant body are connected with each other by pit connections (cytoplasmic connec¬tions). The short branches or trichoblasts are monosiphonous.

Cell Structure of Polysiphonia:

The cells have thick wall, differentiated into outer pectic and inner cellulosic layers. The cells are uninucleate with many discoid chro¬matophores without pyrenoids. Neighbouring cells are connected by pit connections. The cells contain large central vacuole. Reserve food is floridean starch.

Important Features of Polysiphonia:

1. Plant body is polysiphonous.

2. Apical growth takes place by single dome- shaped apical cell.

3. Sexual reproduction is of advanced ooga¬mous type.

4. Post-fertilisation stage is much elaborate.

5. Cystocarp is well-developed.

Reproduction in Polysiphonia:

Polysiphonia reproduces both asexually and sexually. Sexual reproduction is of oogamous type. In the life cycle of Polysiphonia three kinds of plants are recognised.

These are:

1. Diploid tetrasporophyte,

2. Haploid gametophyte, and

3. Diploid carposporophyte.

1. Diploid Tetrasporophyte:

It develops on direct germination of carpospore (2n = 40), thus the plant is diplsid (2n). It is an independent plant which, instead of developing sex organs develops tetrasporangia. The diploid nucleus of tetrasporangia undergoes meiosis and develops four (4) haploid (n = 20) tetraspores.

2. Haploid Gametophyte:

It develops on direct germination of tetraspore (n); thus the independent plant is haploid (n). Most of the species are heterothallic, thus the spermatangia (male sex organ) and carpogonia (female sex organ) are developed on different plants.

3. Diploid Carposporophyte:

This stage is diploid (2n) and dependent on haploid gameto¬phytic plants. The union between haploid (n) spermatium (developed inside spermatangium) and haploid female gamete (developed inside carpogonium) forms diploid (2n) nucleus inside the carpogonium.

Further development of diploid nucleus forms diploid carposporophyte. Later carpospores are formed by mitotic division of carposporangium. The carpospore on direct germination forms diploid tetrasporophyte plant.

Asexual Reproduction:

Asexual reproduction takes place by haploid non-motile tetraspores.

The carpospores (2n) on direct germination develop diploid tetrasporophytic plants. The plants are independent and polysiphonous. Some pericentral cells of the thallus near apical region develop sac-like tetrasporangia. The diploid nucleus of tetrasporangium undergoes meiosis and forms four tetraspores. The spores are arranged tetrahedrally.

Development of Tetraspores:

Tetraspores are produced in tetrasporangia. Single pericentral cell of each tier, towards apical region functions as tetrasporangial initial. This initial cell is smaller than other pericentral cells of any particular tier. This initial cell divides vertically into inner and outer cells.

The inner cell functions directly into sporangial mother cell and the outer cell further divides and forms two or more cover cells. The sporangial mother cell divides transversely into lower stalk cell and upper tetra- sporangial cell.

The latter undergoes further enlargement and develops into a tetrasporangium. The diploid nucleus of tetrasporangium undergoes meiosis and forms 4 tetraspores or meiospores. The tetraspores are arranged tetrahedrally inside the tetrasporangium.

The mature tetraspores are liberated by rupturing the wall of the sporangium. On germination they develop gametophytic polysiphonous plant. Being heterothallic, out of four tetraspores, two produce male and the remaining two pro¬duce female gametophytic plants.

Sexual Reproduction:

Sexual reproduction is of oogamous type. Plants are commonly dioecious. The male sex organs i.e., spermatangia and female sex organs i.e., carpogonia, are developed on male and female plants, respectively.

1. Male Reproductive Organ:

It is called spermatangium or antheridium.

Initially male trichoblast develops as side branch on the plant body. It becomes branched. In some species both the branches become fertile, but in others only one remains fertile and the rest undergo repeated dichotomy to form dichotomous sterile structure.

The monosiphonous fertile branch(es) of male trichome bears many unicellular and spherical spermatangia. Each spermatangium is a uni¬nucleate structure which produces single spermatium, the male gamete.

During development of spermatangium, all cells except a few basal cells, divide periclinally and form pericentral cells on both the sides. Each pericentral cell undergoes several divisions and forms spermatangial mother cells. Each one cuts off 2-4 unicellular bodies, the spermatangia. Each spermatangium develops into a single non-motile male gamete, the spermatium.

The spermatia are liberated from the sper¬matangium, through a narrow apical slit on the wall. The spermatia are dispersed through water.

2. Female Reproductive Organ:

The female reproductive organ is called carpogonium.

The carpogonium develops at the top of 2-5 celled carpogonial filament. The carpogonial filament develops on the female trichoblast. The carpogonium is a flask-shaped body, with a basal swollen region containing an egg and an upper elongated neck region, the trichogyne.

During development of carpogonium, initially a female trichoblast initial is developed on central siphon, a few cells (3-4) below the apical cell. The female trichoblast initial, then undergoes repeated divisions and forms a female trichoblast of 5-7 cells. The lowermost three cells of the female trichoblast divide vertically and form three tiers of pericentral cells.

Any one of the pericentral cells of the middle tier towards the mother axis becomes the supporting cell. The supporting cell cuts off a small initial at its outside, the procarp initial. The procarp initially undergoes repeated divisions and forms a 4-celled branch, the procarp or carpogonial filament (branch). The apical cell of the carpogonial filament functions as carpogonium mother cell. The cell further develops into a carpogonium. The carpogonium has a swollen basal region containing egg and an elongated tubular region, the trichogyne .At the later stage, the carpogonium develops two initials from the supporting cell, one at the base, the basal sterile filament initial and another at the lateral side, the lateral sterile filament initial. The lateral sterile initial divides transversely and forms two-celled lateral sterile filament. The carpogo¬nium is ready for fertilisation at this stage. The pericentral cell adjacent to the supporting cell starts growing to cover the fertilised carpo¬gonium. Later on they form sheath (the protective covering) around the fruit body, called as pericarp.

Fertilisation:

The spermatia are dispersed with the help of water. A few spermatia become attached at the tip of the. receptive trichogyne. Out of many, only one becomes successful. The common wall of successful spermatium and trichogyne dissolves at the point of contact and the male nucleus passes to the female nucleus present at the base of the carpogonium. The fusion between the nuclei results in the formation of zygote.

Post-Fertilisation Changes:

At the starting of this phase, an auxiliary cell is developed from the supporting cell situated just below the basal region of the carpogonium. Simultaneously, the lateral,.sterile filament increases in length (4-10 celled) by cell division as well as elongation and the basal sterile initial divides to form a two (2)-celled filament. The auxiliary cell has a single haploid nucleus.

A tubular connection is then developed between the auxiliary cell and carpogonium.The carpogonial nucleus (2n) divides mitotically into two nuclei, of which one is transported to the auxiliary cell and the other one remains in the carpogonium. Thus the auxiliary cell contains one haploid and one migrated diploid nuclei. The haploid nucleus (n) is degenerated. Gradually the trichogyne shrivels.

Many vegetative filaments then develop from the adjacent vegetative pericentral cells, which gradually develop the total covering. The diploid nucleus of auxiliary cell then divides mitotically and forms two nuclei. One of them then migrates into the outgrowth developed on the auxiliary cell.

This outgrowth after separating by a partition wall forms gonimoblast initial. In this way many gonimoblast initials can develop on auxiliary cell. Each initial by repeated mitotic divisions forms gonimoblast filament. The terminal cell of the gonimoblast filament develops into carposporangium, which forms single diploid carpospore inside.

During this development the auxiliary cell, supporting cell, carpogonium and some cells of basal and sterile filaments fuse together and form an irregular cell, the placental cell. The haploid nuclei (n) of the placental cell gradually degenerate and have simply a nutritive function.

The placental cell, gonimoblast filament and carpogonia are covered by many vegetative filaments and form an urn-shaped structure, the cystocarp. The outer covering of cystocarp is called pericarp. The diploid part of the cystocarp represents the carposporophyte. Some cells of basal and sterile fila¬ment along with some cells of carpogonial filament gradually degenerate.

The carposporangium develops single diploid carpospore. After liberating from the carpogonium they come out through the ostiole of cysto-carp.

Germination of Carpospore:

Coming in contact with any solid surface, the diploid carpospore gets attached and then undergoes first mitotic division and forms large upper and small lower cells. Both the cells undergo mitotic division and form 4 celled stage.

The lower most cell forms the rhizoid, the upper one functions as apical cell and the rest cells undergo further development and form the polysiphonous body. This plant body is diploid i.e., the tetrasporophytic plant, which later develops the tetraspores and complete the cycle.

Life Cycle of Polysiphonia:

Life cycle of Polysiphonia consists of three distinct phases: diploid tetrasporophyte, haploid gametophytes and diploid carposporophyte.

Out of 4 tetraspores produced in tetrasporangia on diploid tetrasporophytic plant, two tetraspores develop haploid (gametophytic) male and other two haploid (gametophytic) female plants. The male gametophytic plants develop male gametes inside spermatangia and female gametophytic plants develop female gametes inside carpogonigia.

Zygote develops inside carpogonium after gametic fusion. With gradual development gonimoblast filament, carposporangia and carpospores are developed inside a composite structure, the cystocarp. It is the carposporophytic stage. Diploid carpospore on germination produces the diploid tetrasporophytic plant again.

Possible questions

- What are the general characteristics of algae?
- Write in details about the economic importance of algae
- What are the salient features of Chlorophyceae
- Describe the cell morphology of Volvox
- What are the methods of reproduction of Oedogonium
- Write notes on the characteristic features of Xanthophyceae
- Explain the morphology, life cycle and mode of reproduction in Ectocarpus
- Explain the morphology, life cycle and mode of reproduction in Xanthophyceae family
- Explain the morphology, life cycle and mode of reproduction inRhodophytes

UNIT-II

Fungi: General characters, classification & economic importance. Life histories of Fungi: Mastigomycontina- Phytophthora, Zygomycotina-Mucor, Ascomycotina- Saccharomyces, Basidomycotina-Agaricus, Deutromycotina-Colletotrichum.

SYLLABUS

Fungi: General characters, classification & economic importance. Life histories of Fungi: Mastigomycontina- Phytophthora, Zygomycotina-Mucor, Ascomycotina- Saccharomyces, Basidomycotina-Agaricus, Deutromycotina-Colletotrichum

A fungus (plural: fungior funguses) is any member of the group of eukaryotic organisms that includes microorganisms such as yeasts and molds, as well as the more familiar mushrooms. These organisms are classified as a kingdom, Fungi, which is separate from the other eukaryotic life kingdoms of plants and animals.

A characteristic that places fungi in a different kingdom from plants, bacteria, and some protists is chitin in their cell walls. Similar to animals, fungi are heterotrophs; they acquire their food by absorbing dissolved molecules, typically by secreting digestive enzymes into their environment. Fungi do not photosynthesise. Growth is their means of mobility, except for spores (a few of which are flagellated), which may travel through the air or water. Fungi are the principal decomposers in ecological systems. These and other differences place fungi in a single group of related organisms, named the Eumycota (true fungi or Eumycetes), which share a common ancestor (form a monophyletic group), an interpretation that is also strongly supported by molecular phylogenetics. This fungal group is distinct from the structurally similar myxomycetes (slime molds) and oomycetes (water molds). The discipline of biology devoted to the study of fungi is known as mycology (from the Greek μύκης mykes, mushroom). In the past, mycology was regarded as a branch of botany, although it is now known fungi are genetically more closely related to animals than to plants.

General Characteristics of Fungi:

- Eukaryotic
- Decomposers – the best recyclers around

- No chlorophyll – non photosynthetic
- Most multicellular (hyphae) – some unicellular (yeast)
- Non-motile
- Cell walls made of chitin (kite-in) instead of cellulose like that of a plant
- Are more related to animalsthan plant kingdom
- Lack true roots, leaves and stems
- Absorptive heterotrophs -Digest food externally and then absorb it
- Lack of chlorophyll affects the lifestyle of fungi…
- Not dependant on light
- Can occupy dark habitats
- Can grow in any direction
- Can invade the interior of
- a substrate with
- absorptive filaments

Structures

- Body of fungus made of tiny filaments or tubes called hyphae .
- Contain cytoplasm and nuclei (more than 1)
- Each hyphae is one continuous cell
- Cell wall made of chitin
- A tangled mess of hyphae is called mycelium
- Rhizoids are root-like parts of fungi that anchor them to the substrate (whatever they are bonding to)
- Mycelium increases the surface area of the fungi to absorb more nutrients.

Classification of fungi:

- Fungi can be classified into 5 groups
- Fungi evolved from an aquatic, flagellated ancestor
- Chytrids
- Glomeromycetes (Mycorrhizae fungi)
- Mycorrhizae are mutually beneficial associations of plant roots and fungi
- Common and may have enabled plants to colonize land

Help create an extending network for the plant to absorb more nutrients and water

- Ascomycetes (Sac fungi)

o Truffles and yeast

- Basidiomycetes (club fungi)

o Puff ball mushroom

- Zygomycetes (zygote fungi)

Fungus Reproduction:

- Fungi produce spores in bothasexual and sexual life cycles
- Mushrooms let out spores from their pores that are carried by the wind to meet other spores and become a new fungi
- Yeast are unicellular and divide into new fungal cells (mitosis)

o In some fungi, fusion of haploid hypha produces a heterokaryotic stagecontaining nuclei from two parents (fusion of cytoplasm)

o After the nuclei fuse, meiosis produces haploid spores (can grow in fungi and are the asexual part of the life cycle)

General Fungi Reproduction Cycles:

- But fungal groups do differ in their life cycles and reproductive structures

Reproduction in Basidiomycetes:

- Basidiomycota (typical mushroom)
- ASCOMYCOTA
- **Fungi Nutrition**:

Fungi absorb food after digesting it outside their bodies

Fungi are heterotrophic eukaryotes

- Fungi use digestive enzymes to break down their food then absorb the liquid. (acquire nutrients such as nitrogen)
- Examples:
- trap nematodes (little worms who feed on fungi) and paralyze them with special juices then absorbs and digests the nitrogen out of them.

3 Modes of Nutrition

in Fungi:

- Saprophytes
- Parasites
- Mutualists (symbionts)

Saprophytes

- Use non-living organic material
- Important scavengers in ecosystems
- Important in recycling carbon, nitrogen and essential mineral nutrients

Parasites

- Use organic material from living organisms, harming them in some way
- Range of hosts from single-celled diatoms to fungi, to plants to animals to humans
- Mutualists (symbionts)
- Fungi that have a mutually beneficial relationship with other living organisms

- Mycorrhizae – beneficial relationship with fungi with plant root

o More than 90% of plants in nature have a mycorrhizal in roots (example: Truffles- expensive delicacy!)

- Lichens – associations of fungi with algae or cyanobacteria

o Food source for animals, breaking down rocks into soil

- Parasitic fungi harm plants and animals

o Parasitic fungi cause 80% of plant diseases

o Can kill plants and affect crops

- Many fungi are harmful to humans

- Can cause human diseases – allergies, athletes foot, ringworm, yeast infection

Ringworm

- A contagious fungal infection having characteristic red ring that can appear on an infected person's skin

- Can affect the scalp, the body (particularly the groin), the feet, and the nails

- Also called Tinea

Benefits of Fungi

- Fungi also form mutualistic relationships with animals

- Some animals benefit from the digestive abilities of lichens

- Lichens consist of fungi living mutually with photosynthetic organisms

o Lichens consist of algae or cyanobacteria (protists or bacteria) within a fungalnetwork

- Fungi have enormous ecological, economic and practical uses

o Ecological= fungi are essential decomposers;mycorrhizae increase plant growth

o Economic/Practical= antibiotics and food (making bleu cheese/ truffles and truffle hunting)

- More Useful Fungi:

- Yeasts – baking and brewing beer

- Antibiotics – penicillin & cephalosporin
- Production of organic acids – citric acid in Coke
- Steroids and medicines – birth control pills

MAJOR PARTS OF A MUSHROOM:

- Cap (Pileus) – The top part of the mushroom.
- Cup (Volva) – A cup-shaped structure at the base of the mushroom. The basal cup is the remnant of the button (the rounded, undeveloped mushroom before the fruiting body appears). Not all mushrooms have a cup.
- Gills (Lamellae) – A series of radially arranged (from the center) flat surfaces located on the underside of the cap. Spores are made in the gills.
- Mycelial threads – Root-like filaments that anchor the mushroom in the soil.
- Ring (Annulus) – A skirt-like ring of tissue circling the stem of mature mushrooms. Not all mushrooms have a ring.
- Scales – Rough patches of tissue on the surface of the cap
- Stem (Stape) – The main support of the mushroom; it is topped by the cap. Not all mushrooms have a stem.

Mastigomycotina- phytophthora

1. Habitat of Phytophthora:

Phytophthora (Greek phyton = plant; phthora = destruction) is represented by 48 species (Water house, 1973) which are cosmopolitan in distribution. Most of the species attack higher plants, mostly angiosperms and cause diseases of economic significance. Some species are facultative parasites and others as facultative saprophytes.

One of the most common and well known species of Phytophthora is P. infestans, causing the disease called late blight of potato or Potato blight. Cool temperature (between 22-23°C) and excess of water favours the growth of this fungus. In India P. infestans has been reported from Nilgiri Hills and Darjeeling. It also occurs periodically in the plains particularly of northern India. However, in the Indo-Gangetic plain blight of Colocosia antiquorum (Vern. arvi) caused by P. colocasiae is quite common.

2. Symptoms of Phytophthora:

The disease appears as small black or purplish black areas at the margins and tips of the leaf. These patches gradually enlarge and soon the entire crown may rot. Under favourable conditions all parts of the host undergo browning and rottening.

If the soil is very moist, tubers are also affected and may rot completely. In Colocasia anti-quorum large, circular, oval or irregular yellowish brown areas appear on leaves (Fig. 7 B). Drops of a yellow liquid oozes out from the leaf surface, and severe infection may result even in the rottening of corms.

3. Vegetative Structure of Phytophthora:

The mycelium is coenocytic, aseptate, hyaline and profusely branched (monopodial branching). The septa are formed at the time of reproduction or at maturity. The cell wall consists of glucan. Chitin is, however absent. Cytoplasm contains many nuclei, mitochondria, endoplasmic reticulum, ribosomes, dictyosomes, vacuoles and many oil globules. The mycelium is intracellular, and directly kills the invaded cells (Fig. 7 D).

However, in some cases it is intercellular, present in the intercellular spaces of the host tissue. Some of the species develop haustoria to absorb their food material. In P. infestans the haustoria are selender and finger like (Fig. 7 E). Haustoria develop as lateral outgrowths from the intercellular hyphae.

Young haustorium invaginates the host cell. It remains surrounded by an extra-haustorial sheath, an extra haustorial haustorium membranes and the cytoplasm of the host cell. Cytoplasm of haustoria contains mitochondria, ribosomes, endoplasmic reticulum and nuclei. (Fig. 8.).

4. Reproduction of Phytophthora:

The fungus reproduces by Vegetative, asexual and rarely by sexual methods.

(i) Vegetative Reproduction:

Many species of Phytophthora (P. colocasiae and P. parasitica) reproduce by means by Chlamydospores. These vegetative reproductive bodies may be terminal or intercalary. They germinate by giving rise to 3-11 germ tubes which generally develop sporangia at their tips.

(ii) Asexual Reproduction:

The asexual reproduction takes place by means of sporangia which are borne on aerial sporangiphores. Low Temperature (12-20°C) and high relative humidity (91-100%) favours the growth of sporangia. The sporangiophores arise directly from the internal mycelium and emerge out of the host singly or in clusters through stomata or by piercing through the epidermal wall Each branch of sporangiophore bears, sporangium at its tip. With the growth of the hypha below, the sporangium is shifted to lateral position and another sporangium is formed at the tip. The process may be repeated several times. Thus, the sporangiophore in Phytophthora is sympqdially branched. The sporangia may vary in shape (i.e. lemoni form, ovoid or elliptical). It is hyaline to light yellow in colour, terminally papillate and has a basal plug. In P. colocasiae the sporangia are 38-60 µ long and 18-26 µ broad. The sporangia are deciduous (fall off) and are disseminated by water or are blown by the wind. At the place of detachment of sporangia, the sporangiophores bear nodular swellings which are typical for this fungus.

On falling upon a suitable host, the sporangia germinate. The germination of sporangium is governed by two main factors i.e., moisture and temperature. At high temperature (20-30°C), the sporangium germinates directly by a germ tube.

However, lower temperature (12°C) and presence of moisture favours indirect germination i.e., by zoospore formation. The sporangia are also susceptible to dessication. They loose their viability above 20°C temperature in 1-3 hours in dry air and 5-15 hours in moist air.

Direct Germination:

In the absence of moisture and high temperature (25 °C), sporangia germinate directly by germ tube and behave as conidia. The germ tube enters through a stomata and infects the leaf.

Indirect Germination:

In the presence of moisture and lower temperature (12°C) it behaves as zoosporangium and produces zoospores. The protoplasm of the sporangium is cut off into many uninucleate polyhedral pieces. Zoospores are kidney shaped, biflagellate and possess flagella on lateral side. Of the two flagella one is of whiplash type and the other of tinsel type. The zoospores are liberated by the bursting of the sporangial wall. After swimming for some time they come to rest, encyst (Fig. 9 I) and germinate by a tube .

The germ tube adheres on the epidermis of the host and produces a flattened pressing organ i.e., appresorium, at its tip. From the appresorium a fine tubular, peg like outgrowth arises. It is the infection hypha. It peneterates the host tissue through stomata or epidermal cells.

After penetration it develops into a profusely branched mycelium. The mycelium is intercellular and develops haustoria in the host cells. Under favourable conditions numerous sporangiophores emerge from the stomata and give rise to large number of sporangia. They are again disseminated by the wind and infect new plants. Thus, under favourable conditions the pathogen can reproduce several times by asexual method in one growing season.

(iii) Sexual Reproduction:

Clinton (1911) reported for the first time the sexual stages (oospore) in P. infestans. The sexual reproduction in Phytophthora is highly oogamous. The fungus is heterothallic i.e., requires two opposite strains, + and – for sexual reproduction. The male and female reproductive organs are called antheridia and oogonia, respectively.

Antheridium:

The antheridium is of following two types:

(a) Amphigynous:

Attached to oogonium as a collar e.g., P. infestans

(b) Paragynous:

Attached laterally to the oogonium e.g. P. cactorum. The antheridium arises earlier than the oogonium showing a protandrous condition. It develops as a terminal, more or less club shaped structure on a short lateral hypha of one strain. In young stages, it is thin walled with non-vacuolar cytoplasm and possessing only one or two nuclei.

The mature antheridium is funnel shaped and forms a collar like structure at the base of the mature oogonium. The two nuclei divide mitotically and forms 12 nuclei. All nuclei disintegrate except one in mature antheridium.

Oogonium:

It is initiated laterally or below the antheridium on a hypha from other strain. The young oogonium pierces the developing antheridium from below and swells above it into a pear shaped or spherical structure. When young, it is multinucleate (up to 40 nuclei) and contains dense cytoplasm.

On maturity it becomes vacuolated and differentiated into an outer multinucleate periplasm and a central uninucleate ooplasm. The nucleus of the ooplasm divides mitotically and out of the two one survives and it functions as an egg or oosphere nucleus.

Fertilization:

The oogonial wall bulges out at one point inside the antheridium and forms the receptive papilla. Later on the wall at the receptive spot dissolves and the antheridium pushes a short fertilization tube towards the oogonium. It penetrates the periplasm and passes into the ooplasm. It’s tip opens and liberates a male nucleus and some of the cytoplasm.

However, in P. himalayensis 2 to 3 papilla like outgrowths develops from the antheridium. One of these grows upwards and establishes a connection with the oogonium. The male nucleus passes into the oogonium through papilla and brings about fertilization. The oospore may also develop parthenogenetically in some cases.

Oospore:

During fertilization, first of all the plasmogamy takes place. The fertilized oospore secretes a wall and undergoes rest. Fusion of the two nuclei is very late and occurs even until after the oospore walls are laid down. A mature oospore consists of an outer thick wall called exospore and an inner thin wall endospore. Exospore is made up of pectic substances and endospore is composed of cellulose and proteins.

Germination of Oospore:

It is of rare occurrence and observed in a few species like P. cactorum. P. palmivora etc. The fusion nucleus divides meiotically and later on successive divisions result in the formation of few or many nuclei in the oospore.

The exospore cracks and the endospore comes out in the form of a germ tube which develops a sporangium at the tip. The contents of sporangium may divide to form zoospores or sometimes may directly develop into a mycelium (P. cactorum). Thus, it completes its life cycle only within its host tissue. It has no saprophytic existence. It lives as dormant mycelium in the dead host remains lying in the soil.

5. Some Common Diseases Caused By Phytophthora:

6. Control of Phytophthora:

(1) Cultivation of resistant varieties.

(2) Spraying of fungicides like Bordeaux mixture.

(3) Destruction of the infected foliage by spraying with sulphuric acid; copper sulphate, Dithane and Fytolan.

(4) Seed tubers should be obtained from areas where the disease does not occur.

(5) Tubers should be covered with a thick layer of soil. It will avoid the chances of spores coming in contact with them.

(6) Good drainage system should be maintained.

Mucor: Description, Structure and Reproduction

In this article we will discuss about:- 1. Description of Mucor 2. Vegetative Structure of Mucor 3. Reproduction.

Description of Mucor

The genus Mucor (L. muceo, be moldy) is represented by about 80 species, found through¬out the world and about 17 species from India, commonly known as mold.

They grow mostly as saprophytes on decaying fruits and vegetables, in soil (Mucor strictus, M. flavus), on various food- stuff-like bread, jellies, jams, syrups. M. mucedo, is a coprophilous species (grows on dungs of herbivorous animals like cow etc.), known as black mold.

Species like M. mucedo and M. racemosus are well-known air contaminants. M. javanica is known to cause alcoholic fermen¬tation.

List of various species of Mucor, harmful and useful to the mankind, are given below:

Vegetative Structure of Mucor:

The vegetative plant body is eucarpic, con¬sists of white cottony coenocytic much-branched mycelium. The mycelia ramify all over the sub¬stratum. The hyphae are usually prostrate, but some of them penetrate into the substratum and serve the function of both anchorage and absorp¬tion of nutrients. The hyphal wall is microfibrillar, consist mainly of chitin-chitosan. In addition, other substances like other polysaccharides, lipids, purines, pyrimidines, protein, Ca and Mg are also present. Inner to the cell wall, cell membrane is present which covers the protoplast. The proto¬plast contains many nuclei, mitochondria, endo¬plasmic reticulum, ribosomes, oil droplets, small vacuoles and other substances.

Reproduction in Mucor:

Mucor reproduces by vegetative, asexual and sexual means.

1. Vegetative Reproduction:

It takes place by fragmentation. Due to accidental breakage, the mycelium may break up into two or more units. Each unit is capable to grow as mother mycelium.

2. Asexual Reproduction:

It takes place by the formation of sporangiospore, oidia and chlamydospore (Fig. 4.28).

(a) Sporangiospore Formation:

During favourable condition, the nonmotile spores known as sporangiospores or aplanospores are formed inside the sporangium.

The sporangiophores develop singly and scatteredly on the upper side of the superficial myceli¬um. The sporangiophore is generally unbranched, however it is branched in M. brunneus and M. racemosus.

After attaining a certain height, the nuclei and cytoplasm push more and more towards the apical side, consequently the apex of the aerial hyphae swells up. The swollen part enlarges and develops into large round sporangium.

With maturity, the proto¬plast inside the sporangium is differentiated into a thick dense layer of multi-nucleate cytoplasm towards the peripheral region just inside the sporangial wall, called sporoplasm and a vacuolated portion with a few nuclei towards the centre, called columellaplasm.

A series of small vacuoles then appear between the sporoplasm and colu¬mellaplasm (Fig. 4.28E). These vacuoles become flattened and coalesce to form a continuous cleavage cavity (Fig. 4.28F).

This is followed by the formation of a septum towards the innerside of the cavity, which differentiates into inner columella and upper sporoplasm region. With further deve¬lopment, the septum becomes dome-shaped and pushes its way into the sporangium.

Protoplast of the sporoplasm then undergoes cleavage to produce many small multinucleate (2-10 nuclei) or rarely uninucleate segments. These segments transforms into globose non- motile sporangiospores.

Dehisence of sporangium takes place after maturation of spores. Minute needle-shaped crystals of calcium oxalate are formed on the external surface of sporangium wall. They imbibe water and make the wall soft. Conse¬quently, the sporangiophore secretes water around the sporangium. The unused protoplast of the sporangium absorbs water and swells up, thereby it creates pressure.

This pressure along with the pressure exerted by the bulging of the columella causes the soft wall of the sporangium to rupture. The dehisced sporangium thus shows a dome-shaped columella with attached spores at the top and remains of the sporangial wall as collar around its base. The spores are dispersed chiefly by insect and also by wind.

(b) Oidia:

Oidia are thin walled bid-like structures formed by mycelium grew in a medium rich in sugar. After detachment, the oidia increase by budding like yeast. This stage is called torula stage. Later, they develop to mycelia.

(c) Chlamydospore:

During unfavourable condition, thick-walled, nutrition rich, intercalary mycelium segments are developed by septation of mycelium which are termed as chlamydospores. They get separated from each other when the connecting mycelium dries up. In favourable condition, the chlamy¬dospore germinates and gives rise to a new mycelium.

3. Sexual Reproduction:

Sexual reproduction takes place during unfavourable condition by means of gametangial copulation. The gametangia look alike and by conjugation, they give rise to zygospore. Most of the spe¬cies of Mucor are heterothallic (M.-mucedo, M. hiemalis), but few species (M. tenuis, M. genereosis) are homothallic.

In heterothallic species, zygospores are pro¬duced by the union of two gametangia deve¬loped from mycelia of compatible strains; whereas, in homothallic species, the uniting gametangia develop from mycelia that derived on germination of a single spore.

When two mycelia of compatible strains come close to each other, the mycelia produce small outgrowth, called progametangia. The apical region of the two progametangia come in close contact. Nuclei and cytoplasm of each progametangium push more and more towards the apical region and its tip swells up with dense protoplasm.

The rear region becomes vacuolated. A septum is laid down, separating the apical regi¬on, which is called gametangium; and the basal region is called suspensor. The undi¬fferentiated multi-nucleate protoplast of the game¬tangium is called aplanogamete or coenogamete.

After maturation of gametangia, the com¬mon wall at the point of their contact dissolves and the protoplast of both the gametangia unite to form zygospore (Fig. 4.280, P). The nuclei of opposite gametangia fuse together to form diploid (2n) nuclei, unpaired nuclei gradually degenerate.

The diploid nuclei undergo meiosis before resting stage of zygospore. In heterothallic species normally 50% of the nuclei are of "+" strain and the other 50% of "-" strain.

Accordingly, the spores are of + or – type, but in M. mucedo (a heterothallic species) the spores are of either + or – type. All the nuclei except one degenerate and the surviving nucleus under¬go repeated mitosis to produce large number of nuclei of the same strain.

The young zygospore enlarges and probably secretes five layered (two in exospore and three in endospore) thick wall, of which the outer one is black and warty. The zygospore then under¬goes a period of rest.

After resting period, the zygospore germi¬nates and, on germination, the innermost layer comes out after cracking the outer walls and pro¬duces a promycelium. The content of the zygospore migrates into the tip of the promyceli¬um which swells up and differentiates into a lower stalk like germsporangiophore and the upper spherical germsporangium.

The haploid nuclei of germsporangium form haploid spores called sporangiospores inside the germsporangium. These spores are also known as meiospores. Each meiospore, after liberation, germinates like sporangiospore and forms a new mycelium like the mother thallus.

Sometimes failure of gametangial copulation results in parthenogenic development of zygospore by any one gametangium called azygospore or parthenospore. It is, however, haploid in nature and its nucleus does not under¬go meiosis before spore formation.

Basidiomycotina- agaricus

1. Habit and Habitat of Agaricus:

Agaricus is an edible fungus and is commonly known as mushroom. In old literature it is known by the generic name Psalliota. It is a saprophytic fungus found growing on soil humus, decaying litter on forest floors, in the fields and lawns, wood logs and manure piles.

It grows best in moist and shady places and is commonly seen during rainy season. It is cosmopolitan in distribution.

About 17 species of Agaricus have been reported from India. It is commonly known as kukurmutta in U.P. and dhingri in Punjab. A. campestris (field mushroom), A. bisporus (A. brunnescence; white mushroom) are common edible mushrooms. A. bisporus (cultivated mushroom) is widely cultivated for food purposes in Solan (Himachal Pradesh). Some species of Agaricus are poisonous (e.g., A. xanthoderma) and some species may cause gastrointestinal disturbances in some persons (e.g., A. placomyces, A. silvaticus).

2. Structure of Agaricus:

It can be studied in two parts:

(a) Vegetative mycelium (living inside the soil)

(b) Fruiting body or basidiocarp (present above the soil and edible in young stage)

(a) Vegetative Structure:

Vegetative mycelium is of three types:

Primary Mycelium:

It originates by the germination of uninucleate basidiospores carrying either '+' or '-' strain. The cells are uninucleate i.e., monokaryotic. It is short lived and becomes bi-nucleate by fusing of two compatible hyphae.

Secondary Mycelium:

It originates from primary mycelium. After fusion of the hyphae of two opposite strains, the nucleus from one hypha migrates to the other and later gives rise to the bi-nucleate secondary mycelium i.e., dikaryotic. It is long lived and abundant.

Tertiary Mycelium:

The secondary mycelium grows extensively under the soil and becomes organised into special tissue to form the fruiting body or basidiocarp. The fruiting body appears like umbrella above ground. It is made up of dikaryotic hyphae. These hyphae are called tertiary mycelium. The mycelium is subterranean. The hyphae are septate and branched. The cells communicate with one another by means of a central pore in the septum. It is a typical dolipore septum.

3. Fairy Rings of Agaricus:

The mycelium of the Agaricus is subterranean. It has a tendency to grow in all directions from a central point to form a large invisible circular colony. The mycelium also increases in diameter year after year and the being at all times on the outer edge, because the central mycelium dies away with age.

When the mycelium becomes mature at tips, sporophores are produced. These sporophores appear in a circle. These circles of mushrooms are commonly called "fairy rings", because of an old superstition that the mushroom growing in a ring indicates the path of dancing fairies.

The fairy rings are generally composed of dark green and light green bands of grass. The outer ring of probably luxuriant growth of grass (dark green band) is due to the fact that actively growing edge of mycelia attacks protons and other organic substances of soil liberating ammonia in excess. This is converted into nitrate by nitrifying bacteria which is subsequently absorbed by the grass leading to stimulated growth.

The inner ring of depressed growth (light green band) is due to increase in the growth of fungus within the soil, at the same place. This reduces the growth of the grass.

This is possible due to reduction in aeration and limitation of water supply to grass. Fairy rings by Agaricus campestris are less common. Marasmius oreades and Lepiota molybdites are very good examples for such type of growth. M. oreades is known to perennate for as long as a period of 400 years producing the ring every year.

4. Reproduction in Agaricus:

1. Vegetative Reproduction:

It reproduces vegetatively by its perennating mycelium.

2. Asexual Reproduction:

(a) Chlamydospores are produced which are lateral or intercalary in position. On germination, it gives rise to hyphae.

(b) Oidia may also be formed under certain conditions which are also known to have sexual function in the diplodisation.

3. Sexual Reproduction:

The sexual reproduction is mainly somatogamous or pseudogamous. The sex organs are completely absent and their function has been taken over by the somatic hyphae which are heterothallic. However, a few species of Agaricus, like A. campestris and A. bisporus, are homothallic.

(a) Plasmogamy:

It is the first step in the sexual reproduction of Agaricus. The vegetative hyphae with uninucleate haploid cells from mycelia of opposite strains (heterothallic) or from the same mycelium (homothallic) come into contact and fuse. Each of such fusion results into a bi-nucleate (dikaryotic) cell. The dikaryotic cell, by successive divisions, gives rise to the bi-nucleate or dikaryotic mycelium. This dikaryotic mycelium is perennial and produces the characteristic fruiting body of the mushroom year after year.

(b) Karyogamy:

This is the second step in sexual reproduction. This step is considerably delayed and takes place in the young basidium. In it the fusion of the two nuclei of dikaryon takes place.

(c) Meiosis:

It is the third and last step in sexual reproduction. It takes place in basidium prior to basidiospores formation. Karyogamy is immediately followed by meiosis. Thus, the basidiospores, formed after meiosis, are haploid.

Development of the Basidiocarp or Sporophore:

The development of the basidiocarp takes place from the subterranean mycelial strand known as rhizomorph. After absorbing sufficient food material mycelium produces fruiting bodies, which are very small in size and remain underground.

These tiny, pin head structures come above the soil under favourable conditions (i.e., after rain or when enough moisture is present in the soil). These are the primodia of basidiocarp. These primordia enlarge into round or ovoid structures and represent the 'button stage' of the basidiocarp.

A longitudinal section of button stage shows that it can be differentiated into a bulbous basal portion representing the stalk region and an upper, hemispherical part which at maturity forms the cap or pileus region. A ring like cavity (gill chamber) develops at the junction of stalk and pileus region.

At this stage the basidiocarp is not fully open but the young pileus is connected with stalk by a membrane known as partial or inner veil or velum. Due to rapid absorption of water and food material, the stalk further elongates. The button projects above the soil and elongates considerably. The growth is very slow at the lower portion of the button while it is very rapid at the upper portion.

As a result of such growth the button develops into umbrella like cup. Velum gets broken due to enlargement of the cap and elongation of the stalk. It exposes the hymenium or the gills. Atkins (1906) described the development of basidiocarp as hemiangiocarpic i.e., the hymenium is at first enclosed but becomes exposed at maturity.

Simultaneously, the development also takes place in the gill region. The tissue of the upper region of the gill chamber differentiates into slow and fast growing alternate bands called primordiutn of gills. Gills or lamellae are of three types i.e., long gills, half length gills, quarter length gills.

Structure and Anatomy of Basidiocarp:

The mature fruiting body can be differentiated into three parts i.e., stipe, pileus and annulus

1. Stipe:

It is the basal part of the basidiocarp. In this region the hyphae run longitudinally parallel to each other. A transverse section of stipe shows that it is made up of two kinds of tissue, i.e., (a) Compactly arranged hypahe in the peripheral region known as cortex, (b) loosely arranged hyphae (with inter spaces), in the central region known as medulla.

2. Pileus:

The stipe at its top supports a broad umbrella shaped cap called pileus. The mature pileus is 5 to 12.5 cm in diameter. From the underside of the pileus hang approximately 300 to 600 strips or plates of tissues known as gills or lamellae. The gills are white or pinkish in young condition and turns brown or purplish black at maturity.

A transverse section of the gill (T. S. of gill) shows the following 3 distinct, structures :

1. Trama:

It is the middle part of the gill. This region is made up of loosely arranged interwoven mass of plectenchymatous tissue of long, slender hyphae. These hyphae run, more or less, longitudinally.

2. Sub-Hymenium or Hypothecium:

The hyphae of the trama region curve outwards towards each surface of the gill. They end in small diametric cells forming a compact layer known as sub-hymenium.

3. Hymenium or Thecium:

It is the outermost layer and lies on the surface of sub-hymenium covering both sides of the gill. Some branches emerge out almost at right angle to the sub-hymenium and develop a palisade like layer consisting of basidia (fertile) and the paraphyses (sterile). Some of the sterile cells become enlarged and project beyond the basidial layer. They are called as cystidia.

Development of Basidium:

The basidia are spore producing bodies. The young basidia arise from the terminal, bi-nucleate cells of the sub-hymenium layer. As the basidium grows, the two nuclei of the dikaryon fuse to form the synkaryon. The diploid nucleus soon undergoes meiosis to form four haploid nuclei (Fig. 7 B 3).

Simultaneously, four narrow tube-like structures develop at the top of the basidium. These are called sterigmata (sing, sterigma). The sterigmata swell at their tips and each forms a small, single basidiospore by budding.

A large vacuole develops in the basdium due to which the cytoplasm and nucleus (one in each) migrate into the budding basidiospore. Thus, four haploid basidiospores are formed in a basidium. Out of the four basidiospores, two are of '+' strain and two are of '-'strain.

The young basidiospore is un-pigmented but it develops brown or black pigments at maturity. In A. bisporus two basidiospores are produced. The mature basidiospore is attached obliquely at the top of the sterigmata. It has minute projection at one side of its attachment called hilum or hilar appendix.

Discharge and Dispersal of Basidiospores:

Mature basidiospores are discharged by 'Water drop mechanism' or 'Water bubble method'. A drop of liquid develops at the hilum. It increases in size gradually and attains a size of about one-fifth of the spore (Buller, 1922). This drop is called Buller's drop.

At this stage the basidiospores are generally shot away from the sterigmata. According to the latest view, the liquid drop is contained in a limiting membrane. The membrane ruptures and releases a pressure at the base of the basidiospore.

According to Olive (1964) the Buller's drop is not liquid in nature but actually a gas bubble of CO2 on is made of both gas and liquid (Nicl et al, 1972). Basidiospores are shot horizontally from where they fall vertically downwards. They are light in weight and are carried away by wind. Each basidiospore is uninucleate and has a wall of chitin and chitosan.

Germination of Basidiospores:

After falling on the suitable substratum, basiodiospores germinate to produce primary (monokaryotic) mycelium which is either of '+' or '-' strain.

The mycelia of two different strains fuse to form a secondary or dikaryotic mycelium (somatogamous copulation, heterothallic). However, in homothallic species, a single basidiospore is capable to give rise to secondary mycelium. The secondary mycelium develops the basidiocarps.

Deuteromycotina- colletotrichum

Colletotrichum (sexual stage: Glomerella) is a genus of fungi that are symbionts to plants as endophytes or phytopathogens. Many of the species in this genus are plant pathogens, but some species may have a mutualistic relationship with hosts.[1]

These are fungi imperfecti which belong to artificial class of fungi. The presence of sexual stage of reproduction is controversial. There are more than 15000 species of imperfect fungi. They are septate and are unicellular. They resemble to yeast with respect to its cellular structure. Unlike basidiomycetes they have no clamp connection. Asexual reproduction occurs by formation of conidia. It includes red rot, early blight, helminthosporium, tikka disease and wilts. Red rot is caused by colletotrichum falcatum. It affects the sugarcane reduces juice content and bring about falling of leaves. Helminthosporium affects rice and causes brown life spot of rice. Bengal famine occurred due to helminthosporium. Early Blight occurs in potato and tomato and is caused by Alternaria solani. The leaves form brown spots with concentric rings. They have combination of longitudinal and transverse septa. Tikka disease is caused by crecospora which forms brown or black leaf spots. Conidia are filamentous in shape and have septa. Wilts occur due to blockage of trachery elements by fungal growth.

Morphology of Colletotrichum:

Colletotrichum:

Common Name:

Red-Rot of Surgarcane (Saccharum officinarum).

Occurrence:

It occurs commonly on the stem and leaves of sugarcane plants in every sugarcane- growing region, and causes the common red-rot disease of surgarcane. Colletotrichum capsici occurs on Capsicum anum.

Symptoms of the Disease on Sugarcane:

1. The fungus mainly attacks the stems and leaves.

2. The stems, at the high level of infection, get rotten and shrink at the nodes, and become dull in colour.

3. The upper leaves become paler and start to droop down.

4. The stem splits and many red-coloured longitudinal lines are formed on it. These lines extend through many internodes

5. The reddening is mainly in the vascular bundles and sometimes also in the pith.

6. Many white patches are also present on the stem in cross-wise direction.

7. The midrib of the leaves also becomes dark red.

Vegetative Structures of Colletotrichum:

1. Mycelium is septate, branched, hyaline and intercellular or intracellular.

2. Many oil drops are present in each cell of the mycelium.

3. Mycelium is generally present in the cells of the parenchymatous pith.

Acervulus and Conidia:

1. The fungus only reproduces asexually by forming conidia.

2. The conidia develop on conidiophore, and both these structures form the fruiting body of the fungus called acervulus

3. Acervuli are saucer-shaped, flat and black velvety structures.

4. In each acervulus, alongwith condidia and conidiophores, are present many long, branched and septate bristles called setae.

5. Conidiophores are aseptate and cut many unicellular, falcate, hyaline conidia, which, on germination, form the new mycelium

Significance

Colletotrichum species cause a disease called anthracnose. This disease affects a wide range of plants worldwide, including different types of fruits, vegetables, legumes and cereals. Anthracnose is characterized by lesions that appear on fruits, stalks and leaves. It has an economic impact because fruits and vegetables with lesions are physically disfigured and cannot be sold. Colletotrichum thrives in warm, wet conditions, and can spread to affect up to 80 percent of a crop.

Identification

A Colletotrichum lesion first appears as a soft, sunken area that is light brown in color. Later, the lesion becomes covered with concentric rings of small, pink spots . These pink spots are the fruiting bodies, called acervuli, that produce the spores that spread the disease. Black spikes, resembling short hairs, may be visible among the fruiting bodies. For the rest of its life cycle, Colletotrichum has no visible symptoms.

Asexual Life Cycle

The acervuli on the lesions caused by Colletotrichum release spores called conidia, which are dispersed by wind. Conidia can also be spread by rain, which splashes them onto other plants. When a conidium lands on a plant it can infect, it penetrates the plant's skin. Once inside the plant, the Colletotrichum grows and spreads as a mycelium, the fiberous form of the fungus. The symptoms of a Colletotrichum infection appear when the mycelium breaks through the surface of the plant and produces acervuli.

Sexual Life Cycle

Colletotrichum occasionally produces a special form called a hypha instead of a mycelium. The hypha is the sexual form of Colletotrichum. Two hyphae from different Colletotricum individuals fuse together and produce a spore through sexual reproduction. This spore is called an ascospore, and it can survive in the environment for a very long time. Sexual reproduction produces genetically diverse offspring, and this genetic diversity helps Colletotrichum survive under different conditions and environments.

Prevention/Solution

The spread of Colletotrichum can be controlled through the application of fungicides and by preventative measures. Don't bring infected plants into a field. If the disease has affected a crop, don't plant anything in the infected field for two years. Remove plant debris that may be contaminated with Colletotrichum spores from the field. Keep tools clean, because Colletotrichum spores can be passed from plant to plant on farming equipment or by workers handling infected plants.

Ascomycotina- saccharomyces

Saccharomyces

Scientific classification

Kingdom: Fungi

Division: Ascomycota

Class: Saccharomycetes

Order: Saccharomycetales

Family: Saccharomycetaceae

Genus: Saccharomyces

Meyen (1838)

Saccharomyces is a genus of fungi that includes many species of yeasts. Saccharomyces is from Greek σάκχαρον (sugar) and μύκης (mushroom) and means sugar fungus. Many members of this genus are considered very important in food production. It is known as the brewer's yeast or baker's yeast. They are unicellular and saprophytic fungi. One example is Saccharomyces cerevisiae, which is used in making wine, bread, beer, and for human and animal health. Other members of this genus include the wild yeast Saccharomyces paradoxusthat is the closest relative to S. cerevisiae, Saccharomyces bayanus, used in making wine, and Saccharomyces cerevisiae var boulardii, used in medicine

Morphology

Colonies of Saccharomyces grow rapidly and mature in three days. They are flat, smooth, moist, glistening or dull, and cream in color. The inability to use nitrate and ability to ferment various carbohydrates are typical characteristics of Saccharomyces.

Cellular morphology

Generally, they have a diameter of 2-8µm and length of 3-25µm. Blastoconidia (cell buds) are observed. They are unicellular, globose, and ellipsoid to elongate in shape. Multilateral (multipolar) budding is typical. Pseudohyphae, if present, are rudimentary. Hyphae are absent.

Saccharomyces produces ascospores, especially when grown on V-8 medium, acetate ascospor agar, or Gorodkowa medium. These ascospores are globose and located in asci. Each ascus contains 1-4 ascospores. Asci do not rupture at maturity. Ascospores are stained with Kinyoun stain and ascospore stain. When stained with Gram stain, ascospores appear Gram-negative, while vegetative cells appear Gram-positive.

History

The presence of yeast in beer was first suggested in 1680, although the genus was not named Saccharomyces until 1837. It was not until 1876 that Louis Pasteurdemonstrated the involvement of living organisms in fermentation and in 1883, Emil C. Hansen isolated brewing yeast and propagated the culture, leading to the discovery of the importance of yeast in brewing.[1] The use of microscopes for the study of yeast morphology and purity was crucial to understanding their functionality.

Use in brewing

Saccharomyces cerevisiae—the yeast most used for brewing and baking

Numbered ticks are 10 micrometres apart.

Brewing yeasts are polyploid and belong to the genus Saccharomyces. The brewing strains can be classified into two groups; the ale strains (Saccharomyces cerevisiae) and the lager strains (Saccharomyces pastorianus or Saccharomyces carlsbergensis in the old taxonomy). Lager strains are a hybrid strain of S. cerevisiae and S. eubayanus and are often referred to as bottom fermenting. In contrast, ale strains are referred to as top fermenting strains, reflecting their separation characteristics in open square fermenters. Although the two species differ in a number of ways, including their response to temperature, sugar transport and use, the S. pastorianus and S. cerevisiae species are closely related within the genus Saccharomyces.

Saccharomyces yeasts can form symbiotic matrices with bacteria, and are used to produce kombucha, kefir and ginger beer.

Saccharomyces fragilis, for example, is part of kefir cultures and is being grown on the lactose contained in whey (as a byproduct in cheesemaking) to be used as animal fodder itself.

Pathology

Saccharomyces cause food spoilage of sugar-rich foods, such as maple sap, syrup, concentrated juices and condiments.[5] Case report suggest extended exposure to S. cerevisiae can result in hypersensitivity.[6

Saccharomyces: Structure, Nutrition and Life Cycle (With Diagram)

Kingdom – Mycota – Division – Eumycota

Sub- division – Ascomycotina – Class – Hemiascomycetes

Order – Endomycetales – Family – Saccharomycetaceae

Genus – Saccharomyces – Species – cerevisiae

Saccharomyces or Yeast is saprophytic unicellular eukaryotic fungus which grows on sugary solution, grapes etc.

Structure of Saccharomyces:

In a culture of Saccharomyces 2 types of somatic cells can be seen

(a) 'Dwarf strain' yeast cells:

They are small (3 x 2μm) haploid spherical yeast cells which exist in 2 opposite mating types (+ and – strains)

(b) 'Large strain' yeast cells:

They are comparatively larger (15 x I0 μm) diploid, ellipsoidal yeast cells. Structurally both strains of Saccharomyces are unicellular, uninucleate, hyaline, holocarpic, non-mycelial thallus. In a favourable sugary medium as many as 64 cells found temporarily connected to form a pseudomycelium. The cell surface has one concave birth scar and on e or many convex bud scars. Like a plant cell, it consists of protoplast surrounded by cell wall. Cell wall composed of glucan (30-40%), mannan (30%), proteins, lipids and chitin.

The granular cytoplasm contains various organelles and reserve foods (glycogen and oil globules). The centril cytoplasm (endoplasm) contains a large vacuole with a nucleus at one end. From nucleus fine dark staining strands extend around the vacuole. The vacuole enclosed by tonoplast and fills with solution of volutin composed of RNA, lipoprotein and poly-phosphate granules.

Nutrition:

Yeast cells are facultative aerobe. They contain Zymase (an enzyme complex) which brings about alcoholic fermentation when placed in sugar solution. Alcohol fermentation is ectothermic process which goes on rapidly in absence of oxygen. Fermentation process occurs inside the cell, as zymase confined within the cells, except invertase which can diffuse out of cell.

Life Cycle of Saccharomyces:

In the life cycle of Saccharomyces cereviceae alternation of generations seen where 2 types of vegetative individuals alternate with each other's i.e. the 'dwarf strain' haploid yeasts ceils alternates with 'large strain' diploid yeast cells. The 'dwarf stain' cells represent haplophase or gametophyte phase while large strain' cells are diplophase or sporophyte phase. Saccharomyces undergo asexual cycle in favourable period and sexual cycle under unfavourable period.

(a) Asexual cycle (budding):

Under favourable conditions both 'dwarf strain' cells and 'large strain' cells multiply by asexual process called budding. During the process, near one pole cell wall softens by enzymatic action as a result an outgrowth appears. The nucleus divides mitotically and passes one daughter nucleus along with a part of vacuole into the outgrowth. The outgrowth now known as a bud that enlarges, and then constricts as a young yeast cell from the parent. Rapid budding may form pseudomycellium.

(b) Sexual cycle (Haplo- diplobiontic cycle):

Under unfavourable condition Saccharo¬myces cerevisiae undergo sexual cycle which is haplo-diplobiontic type. Here both haploid and diploid phases are equally represented. The haploid dwarf cells have two genetically distinct mating types or strains (+ and -). The haploid dwarf cells of opposite strains function as gametangia and perform gametangial conjugation. It involves plasmogamy (cytoplasmic fusion) and karyogamy (fusion of + nucleus and – nucleus). As a result of sexual fusion zygote or large yeast cell develop. In favourable period large diploid yeast cells directly act as asci and divides by meiosis to form four haploid ascospores. The ascospores upon liberation form a number of haploid dwarf cells of opposite strains by budding.

Herman (1971) and Hartwell (1974) have observed that when dwarf cells of opposite mating types (i.e. – and +) are not in contact with each other, a sex hormone is secreted. This hormone induces enlargement and elongation in the yeast cells, and consequently they grow towards the opposite mating types, and conjugation follows.

Such a fusion of cells or nuclei of opposite mating types of the same species is called legitimate copulation and the phenomenon is called heterothallism (Blakeslee, 1904). Rarely, cells of the same mating types may also fuse and depolarization takes place. Such a conjugation between the same mating types is called illegitimate copulation.

Possible Questions

- What is the general classification of fungi
- Write in details about the economic importance of fungi
- What is the common life cycle in fungi
- Explain different fruiting bodies of fungi
- What are the different types of spores in fungi
- Explain the morphology, life cycle and mode of reproduction in Agaricus
- Explain the life cycle of Phyophthora sp
- Describe asco spores
- Explain the morphology, life cycle and mode of reproduction in Colletotrichum

UNIT-III

Lichens : Classification, general structure, reproduction and economic importance. Plant diseases: Casual organism, symptoms and control of following plant diseases. Rust and Smut of Wheat. White rust of Crucifers. Late blight of Potato. Red rot of Sugarcane. Citrus Canker.

SYLLABUS

Lichens : Classification, general structure, reproduction and economic importance. Plant diseases: Casual organism, symptoms and control of following plant diseases. Rust and Smut of Wheat. White rust of Crucifers. Late blight of Potato. Red rot of Sugarcane. Citrus Cankers

UNIT – III

Meaning of Lichens:

Lichens are a small group of plants of composite nature, consisting of two dissimilar organisms, an alga-phycobiont (phycos — alga; bios — life) and a fungus-mycobiont (mykes — fungus; bios — life); living in a symbiotic association.

Generally the fungal partner occupies the major portion of the thallus and produces its own reproductive structures. The algal partner manufactures the food through photosynthesis which probably diffuses out and is absorbed by the fungal partner.

Characteristics of Lichens:

1. Lichens are a group of plants of composite thalloid nature, formed by the association of algae and fungi.

2. The algal partner-produced carbohydrate through photosynthesis is utilised by both of them and the fungal partner serves the function of absorption and retention of water.

3. Based on the morphological structure of thalli, they are of three types crustose, foliose and fruticose.

4. Lichen reproduces by all the three means – vegetative, asexual, and sexual.

(a) Vegetative reproduction: It takes place by fragmentation, decaying of older parts, by soredia and isidia.

(b) Asexual reproduction: By the formation of oidia.

(c) Sexual reproduction: By the formation of ascospores or basidiospores. Only fungal component is involved in sexual reproduction.

5. Ascospores are produced in Ascolichen.

(a) The male sex organ is flask-shaped spermogonium, produces unicellular spermatia.

(b) The female sex organ is carpogonium (ascogonium), differentiates into basal coiled oogonium and elongated trichogyne.

(c) The fruit body may be apothecia! (discshaped) or perithecial (flask-shaped) type.

(d) Asci develop inside the fruit body containing 8 ascospores. After liberating from the fruit body, the ascospores germinate and, in contact with suitable algae, they form new lichen.

6. Basidiospores are produced in Basidiolichen, generally look like bracket fungi and basidiospores are produced towards the lower side of the fruit body.

7. The growth of lichen is very slow, they can survive in adverse conditions with high temperature and dry condition.Habit and Habitat of Lichens:

There is about 400 genera and 15,000 species of lichens, widely found in different regions of the world. The plant body is thalloid; generally grows on bark of trees, leaves, dead logs, bare rocks etc., in different habitat. They grow luxuriantly in the forest areas with free or less pollution and with abundant moisture.

Some species like Cladonia rangiferina (reindeer moss) grows in the extremely cold condition of Arctic tundras and Antarctic regions. In India, they grow abundantly in Eastern Himalayan regions. They do not grow in the highly polluted regions like Industrial areas. The growth of lichen is very slow.

Depending on the growing region, the lichens are grouped as:

1. Corticoles:

Growing on bark of trees, mainly in the sub-tropical and tropical regions.

2. Saxicoles:

Growing on rocks, in cold climate.

3. Terricoles:

Growing on soil, in hot climate, with sufficient rain and dry summer.

Associated Members of Lichens:

The composite plant body of lichen consists of algal and fungal members.

The algal members belong to Chlorophyceae (Trebouxia, Trentepohlia, Coccomyxa etc.), Xanthophyceae (Heterococcus) and also Cyanobacteria (Nostoc, Scytonema etc.) The fungal members mainly belong to Ascomycotina and a few to Basidiomycotina. Among the members of Ascomycotina, Discomycetes are very common; producing huge apothecia, others belong to Pyrenomycetes or Loculoascomycetes.

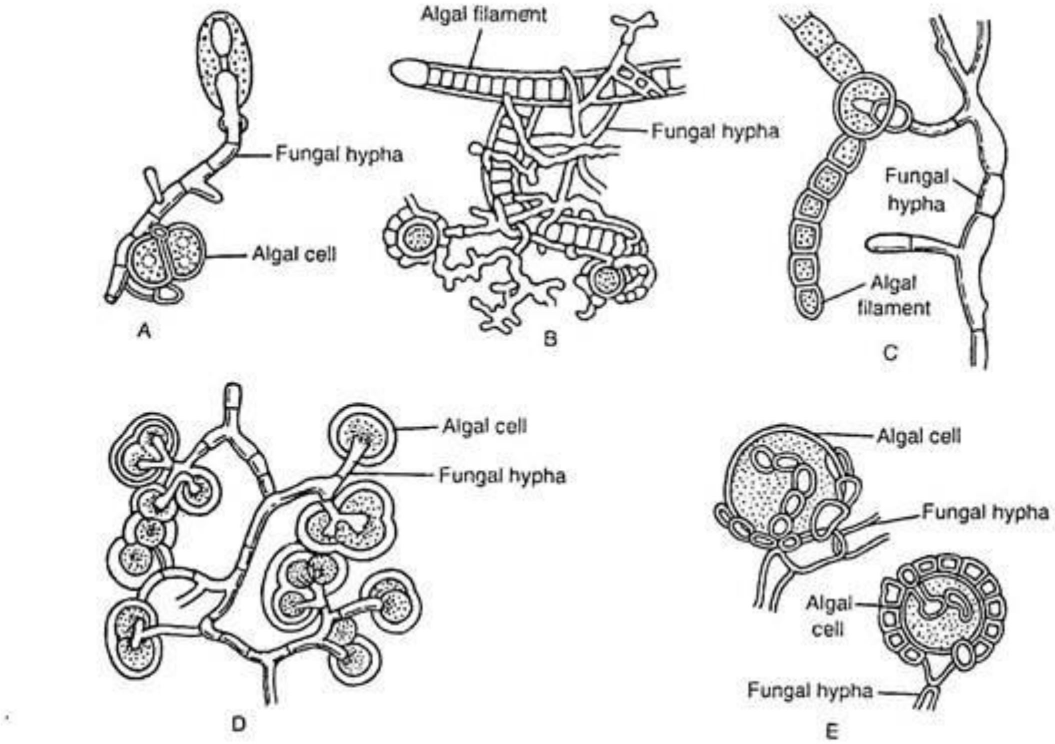


Fig. 4.111 :Lichen-forming Algae : A. *Pleurococcus viridis*, B. *Scytonema* sp., C. *Nostoc* sp., D. *Gloeocapsa* sp., E. *Pleurococcus* sp.

The members of Basidiomycotina belong to Thelephoraceae.

Nature of Association of Lichens:

There are three views regarding the nature of association of algal and fungal partners in lichen:

1. According to some workers, the fungus lives parasitically, either partially or wholly, with the algal components.

This view gets support for the following evidences:

(i) Presence of haustoria of fungus in algal cells of some lichen.

(ii) On separation, the alga of lichen is able to live independently, but the fungus cannot survive.

2. According to others, they live symbiotically, where both the partners are equally benefitted. The fungal member absorbs water and mineral from atmosphere and substratum, make available

to the alga and also protects algal cells from adverse conditions like temperature etc. The algal member synthesises organic food sufficient for both of them.

3. According to another view, though the relationship is symbiotic, the fungus shows pre-dominance over the algal partner, which simply lives as subordinate partner. It is like a master and slave relationship, termed helotism.

Classification of Lichens:

Natural system of classification is not available for lichens. They are classified on the nature and kinds of fruit bodies of the fungal partner.

Based on the structure of fruit bodies of fungal partners, Zahlbruckner (1926) classified lichens into two main groups:

1. Ascolichens:

The fungal member of this lichen belongs to Ascomycotina.

Based on the structure of the fruit body, they are divided into two series:

(i) Gynocarpeae:

The fruit body is discshaped i.e., apothecial type. It is also known as Discolichen (e.g., Parmelia).

(ii) Pyrenocarpeae:

The fruit body is flask-shaped i.e., perithecial type. It is also known as Pyrenolichen (e.g., Dermatocarport).

2. Basidiolichen:

The fungal member of this lichen belongs to Basidiomycotina e.g., Dictyonema, Corella.

Later, Alexopoulos and Mims (1979) classified lichens into three main groups:

i. Basidiolichen:

The fungal partner belongs to Basidiomycetes e.g., Dictyonema.

ii. Deuterolichen:

The fungal partner belongs to Deuteromycetes.

iii. Ascolichen:

The fungal partner belongs to Ascomycetes e.g., Parmelia, Cetraria.

Structure of Thallus in Lichens:

The plant body of lichen is thalloid with different shapes. They are usually grey or greyish green in colour, but some are red, yellow, orange or brown in colour.

A. External Structure of Thallus:

Based on the external morphology, general growth and nature of attachment, three main types or forms of lichens (crustose, foliose and fruticose) have been recognised. Later, based on detailed structures,

Hawksworth and Hill (1984) categorised the lichens into five main types or forms:

1. Leprose:

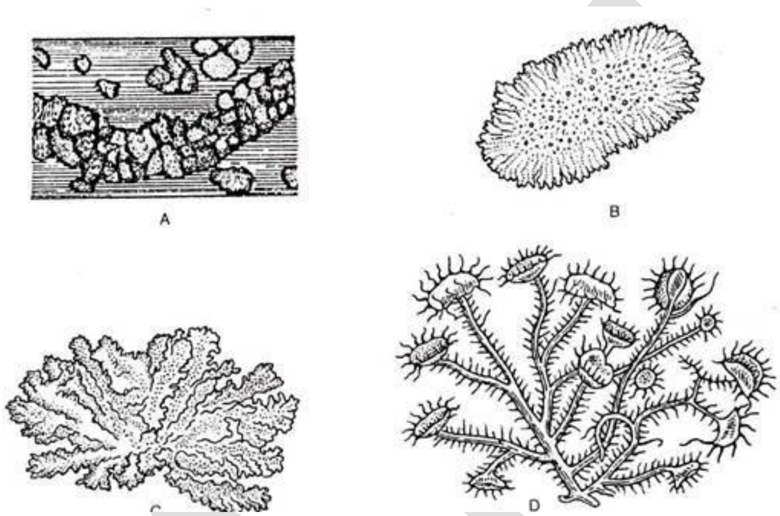
This is the simplest type, where the fungal mycelium envelops either single or small cluster of algal cells. The algal cell does not envelop all over by fungal hyphae. The lichen appears as powdery mass on the substratum, called leprose e.g., Lepraria incana.

2. Crustose:

These are encrushing lichens where thallus is inconspicuous, flat and appears as a thin layer or crust on substratum like barks, stones, rocks etc.. They are either wholly or partially embedded in the substratum, e.g., Graphis, Lecanora, Ochrolechia, Strigula, Rhizocarpon, Verrucaria, Lecidia etc.

3. Foliose:

These are leaf-like lichens, where thallus is flat, horizontally spreading and with lobes. Some parts of the thallus are attached with the substratum by means of hyphal outgrowth, the rhizines, developed from the lower surface, e.g., Parmelia, Physcia, Peltigera, Anaptychia, Hypogymnia, Xanthoria, Gyrophora, Collema, Chauduria etc.



4. Fruticose (Frutex, Shrub):

These are shrubby lichens, where thalli are well developed, cylindrical branched, shrub-like, either grow erect (Cladonia) or hang from the substratum (Usnea). They are attached to the substratum by a basal disc e.g., Cladonla, Usnea, Letharia, Alectonia etc.

5. Filamentous:

In this type, algal members are filamentous and well-developed. The algal filaments remain ensheathed or covered by only a few fungal hyphae. Here algal member remains as dominant partner, called filamentous type, e.g., Racodium, Ephebe, Cystocoleus etc.).

B. Internal Structure of Thallus:

Based on the distribution of algal member inside the thallus, the lichens are divided into two types. Homoisomerous or Homomerous and Heteromerous.

1. Homoisomerous:

Here the fungal hyphae and the algal cells are more or less uniformly distributed throughout the thallus. The algal members belong to Cyanophyta. This type of orientation is found in crustose lichens. Both the partners intermingle and form thin outer protective layer, e.g., Leptogium, Collema etc.

2. Heteromerous:

Here the thallus is differentiated into four distinct layers upper cortex, algal zone, medulla, and lower cortex. The algal members are restricted in the algal zone only. This type of orientation is found in foliose and fruticose lichens e.g., Physcia, Parmelia etc.

The detailed internal structure of this type is:

(a) Upper Cortex:

It is a thick, outermost protective covering, made up of compactly arranged interwoven fungal hyphae located at right angle to the surface of the fruit body. Usually there is no intercellular space between the hyphae, but if present, these are filled with gelatinous substances.

(b) Algal Zone:

The algal zone occurs just below the upper cortex. The algal cells are entangled by the loosely interwoven fungal hyphae. The common algal members may belong to Cyanophyta like Gloeocapsa (unicellular); Nostoc, Rivularia (filamentous) etc. or to Chlorophyta like Chlorella, Cystococcus, Pleurococcus etc. This layer is either continuous or may break into patches and serve the function of photosynthesis.

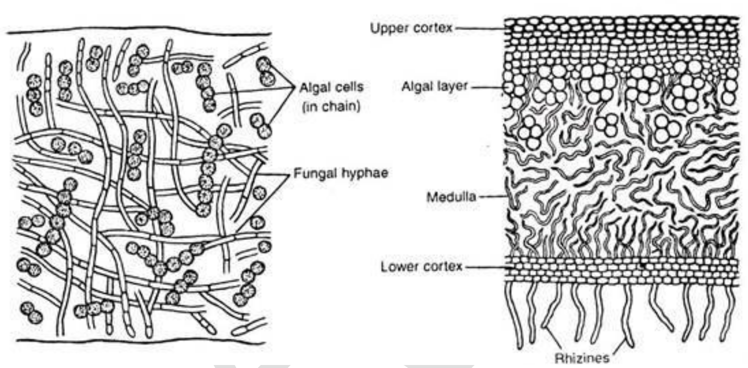
(c) Medulla:

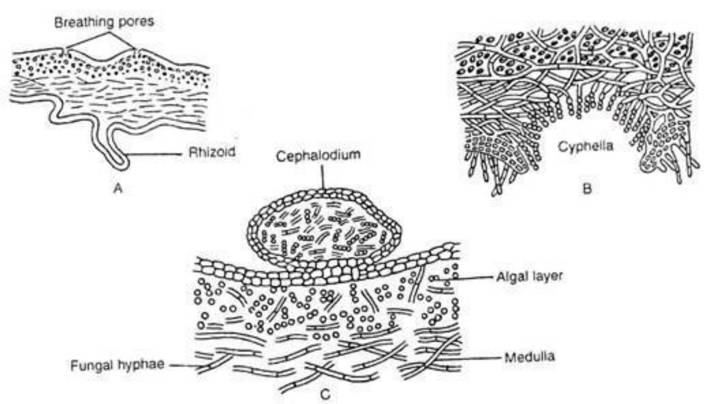
The medulla is situated just below the algal zone, comprised of loosely interwoven thick-walled fungal hyphae with large space between them.

(d) Lower Cortex:

It is the lowermost layer of the thallus. This layer is composed of compactly arranged hyphae, which may arrange perpendicular or parallel to the surface of the thallus. Some of the hyphae in the lower surface may extend downwards and penetrate the substratum which help in anchorage, known as rhizines.

The internal structure of Usnea, a fruticose lichen, shows different types of orientation. Being cylindrical in cross-section, the layers from outside are cortex, medulla (composed of algal cell and fungal mycelium) and central chondroid axis (composed of compactly arranged fungal mycelia).





C. Specialised Structures of Thallus:

1. Breathing Pore:

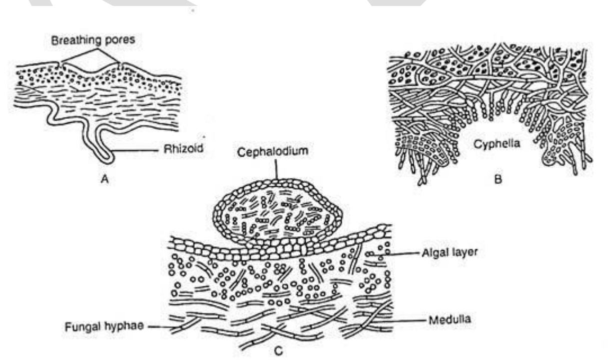
In some foliose lichen (e.g., Parmelia), the upper cortex is interrupted by some opening, called breathing pores, which help in gaseous exchange.

2. Cyphellae:

On the lower cortex of some foliose lichen (e.g., Sticta) small depressions develop, which appears as cup-like white spots, known as Cyphellae .Sometimes the pits that formed without any definite border are called Pseudocyphellae. Both the structures help in aeration.

3. Cephalodium:

These are small warty outgrowths on the upper surface of the thallus. They contain fungal hyphae of the same type as the mother thallus, but the algal elements are always different. They probably help in retaining the moisture. In Neproma, the Cephalodia areendotrophic.



Reproduction in Lichens:

Lichen reproduces by all the three means, vegetative, asexual, and sexual.

I. Vegetative Reproduction:

(a) Fragmentation:

It takes place by accidental injury where the thallus may be broken into fragments and each part is capable of growing normally into a thallus.

(b) By Death of Older Parts:

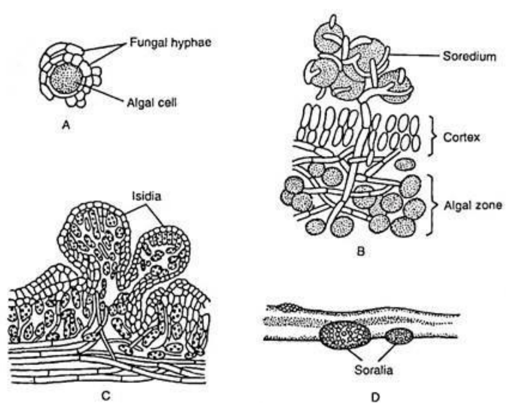
The older region of the basal part of the thallus dies, causing separation of some lobes or branches and each one grows normally into new thallus.

II. Asexual Reproduction:

1. Soredium (pi. Soredia):

These are small grayish white, bud-like outgrowths developed on the upper cortex of the thallus. They are composed of one.or few algal cells loosely enveloped by fungal hyphae. They are detached from the thallus by rain or wind and on germination they develop new thalli.

When soredia develop in an organised manner in a special pustule-like region, they are called Soralia, e.g., Parmelia Physcia etc.



2. Isidium (pi. Isidia):

These are small stalked simple or branched, grayish- black, coral-like outgrowths, developed on the upper surface of the thallus. The isidium has an outer cortical layer continuous with the upper cortex of the mother thallus which encloses the same algal and fungal elements as the mother.

They are of various shapes and may be coral-like in Peltigera, rod-like in Parmelia, cigar-like in Usnea, scale-like in Collema etc. It is generally constricted at the base and detached very easily from the parent thallus. Under favourable condition the isidium germinates and gives rise to a new thallus.

In addition to asexual reproduction, the isidia also take part in increasing the photo- synthetic area of the thallus.

3. Pycniospore:

Some lichen develops pycniospore or spermatium inside the flask-shaped pycnidium.

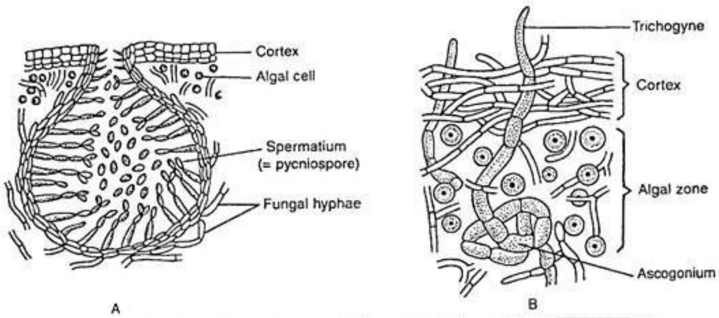
They usually behave as gametes, but in certain condition they germinate and develop fungal hyphae. These fungal hyphae, when in contact with the appropriate algal partner, develop into a new lichen thallus.

III. Sexual Reproduction:

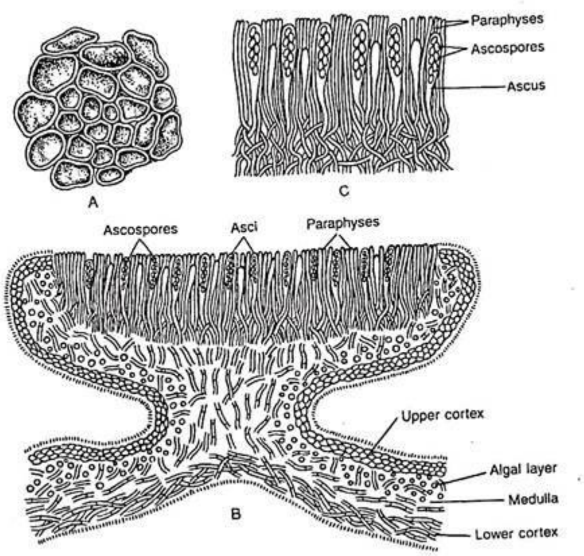
Only fungal partner of the lichen reproduces sexually and forms fruit bodies on the thallus. The nature of sexual reproduction in ascolichen is like that of the members of Ascomycotina, whereas in Basidiolichen is like that of Basidiomycotina members.

In Ascolichen, the female sex organ is the carpogonium and the male sex organ is called spermogonium (= pycnidium). The spermogonium mostly develops close to carpogonium.

The carpogonium is multicellular and is differentiated into basal coiled ascogonium and upper elongated multicellular trichogyne. The ascogonium remains embedded in the algal zone, but the trichogyne projects out beyond the upper cortex.



The spermogonium is flask-shaped and develop spermatia from the inner layer. The spermatia behave as male gametes. The spermatium, after liberating from the spermogonium, gets attached with the trichogyne at the sticky projected part. On dissolution of the common wall, the nucleus of spermatium migrates into the carpogonium and fuses with the egg.



Many ascogenous hyphae develop from the basal region of the fertilised ascogonium. The binucleate penultimate cell of the ascogenous hyphae develops into an ascus.

Both the nuclei of penultimate cell fuse and form diploid nucleus (2n), which undergoes first meiotic and then mitotic division — results in eight haploid daughter nuclei. Each haploid nucleus with some cytoplasm metamorphoses into an ascospore.

The asci remain intermingled with some sterile hyphae — the paraphyses. With further development, asci and paraphyses become surrounded by vegetative mycelium and form fruit body.

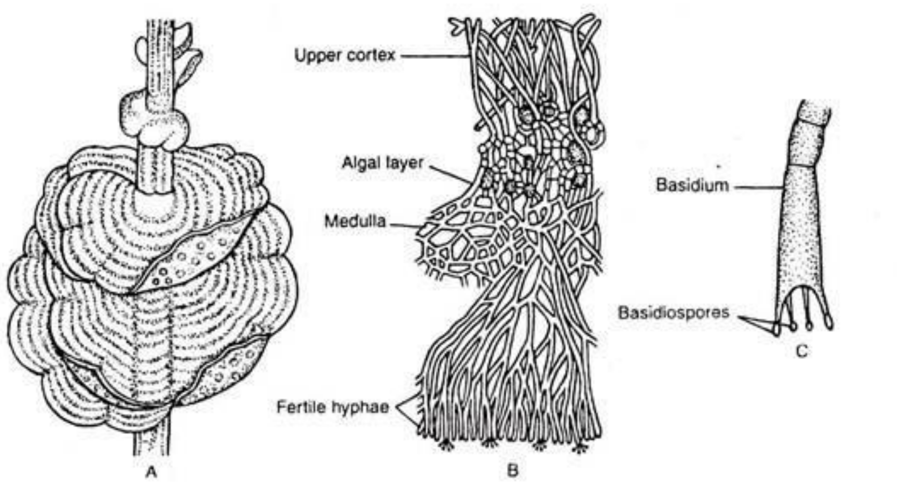
The fruit body may be ascohymenial type i.e., either apothecium as in Parmelia and Anaptychia or perithecium as in Verrucaria and Darmatocarpon or ascolocular type (absence of true hymenium), which is also known as pseudothecia or ascostroma.

Internally, the cup-like grooved region of a mature apothecium consists of three distinct parts; the middle thecium (= hymenium), comprising of asci and paraphyses, is the fertile zone covered by two sterile zones — the upper epitheca and lower hypotheca. The region below the cup is differentiated like the vegetative thallus into outer cortex, algal zone and central medulla. Usually the asci contain eight ascospores , but the number may be one in Lopadium, two in Endocarpon and even more than eight in Acarospora.

The ascospores may be unicellular or multicellular, uninucleate or multinucleate, and are of various shapes and sizes. After liberating from the ascus, the ascospore germinates in suitable medium and produces new hypha. The new hypha, after coming in contact with proper algal partner, develops into a new thallus.

In Basidiolichen, the result of sexual reproduction is the formation of basidiospores that developed on basidium as in typical basidiomycotina. The fungal member (belongs to Thelephoraceae) along with blue green alga, as algal partner forms the thalloid plant body.

The thallus grown over soil produces hypothallus without rhizines, but on tree trunk it grows like bracket fungi and differentiates internally into upper cortex, algal layer, medulla and lower fertile region with basidium bearing basidiospores



Importance of Lichens:

A. Economic Importance of Lichens:

The lichens are useful as well as harmful to mankind. The useful activities are much more than harmful ones. They are useful to mankind in various ways: as food and fodder, as medicine and industrial uses of various kinds.

1. As Food and Fodder:

Lichens are used as food by human being in many parts of the world and also by different animals like snail, catterpiliars, slugs, termites etc. They contain polysaccharide, lichenin; cellulose, vitamin and certain enzymes.

Some uses of lichens are:

(i) As Food:

Some species of Parmelia are used as curry powder in India, Endocarpon miniatum is used as vegetable in Japan, Evernia prunastri for making bread in Egypt, and Cetraria islandica (Iceland moss) as food in Iceland. Others like species of Umbillicaria, Parmelia and Leanora are used as food in different parts of the world. In France, some of the lichens are used in the preparation of chocolates and pastries.

Lichens like Lecanora saxicola and Aspicilia calcarea etc. are used as food by snails, caterpillars, termites, slugs etc.

(ii) As Fodder:

Ramalina traxinea, R. fastigiata, Evernia prunastri, Lobaria pulmo- naria are used as fodder for animals, due to the presence of lichenin, a polysaccharide. Animals of Tundra region, especially reindeer and muskox use Cladonia rangifera (reindeer moss) as their common food. Dried lichens are fed to horses and other animals.

2. As Medicine:

Lichens are medicinally important due to the presence of lichenin and some bitter or astringent substances. The lichens are being used as medicine since pre-Christian time. They have been used in the treatment of jaundice, diarrhoea, fevers, epilepsy, hydrophobia and skin diseases.

Cetraria islandica and Lobaria pulmonaria are used for tuberculosis and other lung diseases; Parmelia sexatilisfor epilepsy; Parmelia perlata for dyspepsia. Cladonia pyxidata for whooping cough; Xanthoria parietina for jaundice and several species of Pertusaria, Cladonia and Cetraria islandica for the treatment of intermittent fever.

Usnic acid, a broad spectrum antibiotic obtained from species of Usnea and Cladonia, are used against various bacterial diseases. Usnea and Evernia furfuracea have been used as astringents in haemorrhages. Some lichens are used as important ingredients of many antiseptic creams, because of having spasmolytic and tumour-inhibiting properties.

3. Industrial Uses:

Lichens of various types are used in different kinds of industries.

(i) Tanning Industry:

Some lichens like Lobaria pulmonaria and Cetraria islandica are used in tanning leather.

(ii) Brewery and Distillation:

Lichens like Lobaria pulmonaria are used in brewing of beer. In Russia and Sweden, Usneaflorida, Cladonia rangiferina and Ramalina fraxinea are used in production of alcohol due to rich content of “lichenin”, a carbohydrate.

(iii) Preparation of Dye:

Dyes obtained from some lichens have been used since pre- Christian times for colouring fabrics etc.

Dyes may be of different colours like brown, red, purple, blue etc. The brown dye obtained from Parmelia omphalodes is used for dyeing of wool and silk fabrics. The red and purple dyes are available in Ochrolechia androgyna and O. tartaria.

The blue dye “Orchil”, obtained from Cetraria islandica and others, is used for dyeing woollen goods. Orcein, the active principal content of orchil-dye, is used extensively in laboratory during histological studies and for dyeing coir.

Litmus, an acid-base indicator dye, is extracted from Roccella tinctoria, R. montagnei and also from Lasallia pustulata.

(iv) Cosmetics and Perfumery:

The aromatic compounds available in lichen thallus are extracted and used in the preparation of cosmetic articles and perfumes. Essential oils extracted from species of Ramalina and Evernia are used in the manufacture of cosmetic soap.

Ramalina calicaris is used to whiten hair of wigs. Species of Usnea have the capacity of retaining scent and are commercially utilised in perfumery. Evernia prunastri and Pseudevernia furfuracea are used widely in perfumes.

Harmful Activities of Lichens:

1. Some lichens like Amphiloma and Cladonia parasitise on mosses and cause total destruction of moss colonies.

2. Lichen like Usnea, with its holdfast hyphae, can penetrate deep into the cortex or deeper, and destroy the middle lamella and inner content of the cell causing total destruction.

3. Different lichens, mainly crustose type, cause serious damage to window glasses and marble stones of old buildings.

4. Lichens like Letharia vulpina (wolf moss) are highly poisonous. Vulpinic acid is the poisonous substance present in this lichen.

B. Ecological Importance of Lichens:

Lichens have some ecological importance.

Some of the activities in this respect are:

1. Pioneer of Rock Vegetation:

Lichens are pioneer colonisers on dry rocks. Due to their ability to grow with minimum nutrients and water, the crustose lichens colonise with luxuriant growth. The lichens secrete some acids which disintegrate the rocks.

After the death of the lichen, it mixes with the rock particles and forms thin layer of soil. The soil provides the plants like mosses to grow on it as the first successor, but, later, vascular plants begin to grow in the soil. In plant succession, Lecanora saxicola, a lichen, grows first; then the moss Crtmmia pulvinata, after its death, forms a compact cushion on which Poa compressor grows later.

2. Accumulation of Radioactive Substance:

Lichens are efficient for absorption of different substances. The Cladonia rangiferina, the 'reindeer moss', and Cetraria islandica, the 'Iceland moss' are the commonly available lichens in Tundra region. The fallout of radioactive strontium (^{90}Sr) and caesium ($^{137}C_S$) from the atomic research centres are absorbed by lichen. Thus, lichen can purify the atmosphere from radioactive substances.

The lichens are eaten by caribou and reindeer and pass on into the food-chain, especially to the Lapps and Eskimos. Thus, the radioactive substances are accumulated by the human beings.

3. Sensitivity to Air Pollutants:

Lichens are very much sensitive to air pollutants like SO_2, CO, CO_2 etc.; thereby the number of lichen thalli in the polluted area is gradually reduced and, ultimately, comes down to nil. The crustose lichens can tolerate much more in polluted area than the other two types. For the above facts, the lichens are markedly absent in cities and industrial areas. Thus, lichens are used as "pollution indicators".

Possible Questions

- Explain the different classes of fungi
- Explain the general structure, reproduction of lichens
- Explain Rust and Smut of Wheat
- Describe White rust of Cruciferae
- Write note on White blight of Potato
- Explain the casual organism, symptoms and control measures of Citrus canker
- List five plant diseases caused by fungi
- What re the economic importance of lichens

UNIT-IV

Bryophytes: General characters, classification & economic importance. Life histories of following: Marchantia. Funaria.

SYLLABUS

Bryophytes: General characters, classification & economic importance. Life histories of following: Marchantia. Funaria.

UNIT – IV

Bryophyta: Features, Classification and Economic Importance

The division Bryophyta (Gr. bryon=moss) includes over 25000 species of non-vascular embryophytes such as mosses, liverworts and hornworts.

Bryophytes are small plants (2cm to 60cm) that grow in moist shady places. They don't attain great heights because of absence of roots, vascular tissues, mechanical tissues and cuticle. They are terrestrial but require external water to complete their life cycle.

Hence, they are called "Amphibians of plant kingdom".

The fossil record indicates that bryophytes evolved on earth about 395 – 430 million years ago (i.e. during Silurian period of Paleozoic era). The study of bryophytes is called bryology. Hedwig is called 'Father of Bryology'. Shiv Ram Kashyap is the 'Father of Indian Bryology'.

Salient features of Bryophytes:

1. Bryophytes grow in damp and shady places.

2. They follow heterologous haplodiplobiontic type of life cycle.

3. The dominant plant body is gametophyte on which sporophyte is semiparasitic for its nutrition.

4. The thalloid gametophyte differentiated in to rhizoids, axis (stem) and leaves.

5. Vascular tissues (xylem and phloem) absent.

6. The gametophyte bears multi-cellular and jacketed sex organs (antheridia and archegonia).

7. Sexual reproduction is oogamous type.

8. Multi-cellular embryo develops inside archegonium.

9. Sporophyte differentiated into foot, seta and capsule.

10. Capsule produces haploid meiospores of similar types (homosporous).

11. Spore germinates into juvenile gametophyte called protonema.

12. Progressive sterilization of sporogenous tissue noticed from lower to higher bryophytes.

13. Bryophytes are classified under three classes: Hepaticae (Liverworts), Anthocerotae (Hornworts) and Musci (Mosses).

Classification of Bryophytes:
According to the latest recommendations of ICBN (International Code of Botanical Nomenclature), bryophytes have been divided into three classes.

1. Hepaticae (Hepaticopsida = Liverworts)

2. Anthocerotae (Anthocertopsida= Hornworts)

3. Musci (Bryopsida= Mosses)

Class 1. Hepaticae or Hepaticopsida:
1. Gametophytic plant body is either thalloid or foliose. If foliose, the lateral appendages (leaves) are without mid-rib. Always dorsiventral.

2. Rhizoids without septa.

3. Each cell in the thallus contains many chloroplasts; the chloroplasts are without pyrenoi.

4. Sex organs are embedded in the dorsal surface.

5. Sporophyte may be simple (e.g., Riccia) having only a capsule, or differentiated into root, seta and capsule (e.g., Marchantia, Pallia and Porella etc.)

6. Capsule lacks columella.

7. It has 4 orders:

(i) Calobryales

(ii) Jungermanniales

(iii) Spherocarpales

(iv) Marchantiales.

Class 2. Anthocerotae or Anthocerotopsid:

1. Gametophytic plant body is simple, thalloid; thallus dorsiventra without air cambers, shows no internal differentiation of tissues.

2. Scales are absent in the thallus.

3. Each cell of the thallus possesses a single large chloroplast with a pyrenoid.

4. Sporophyte is cylindrical only partly dependent upon gametophyte for its nourishment. It is differentiated into bulbous foot and cylindrical capsule. Seta is meristematic.

5. Endothecium forms the sterile central column (i.e., columella) in the capsule (i.e. columella is present). 6. It has only one order-Anthocerotales.

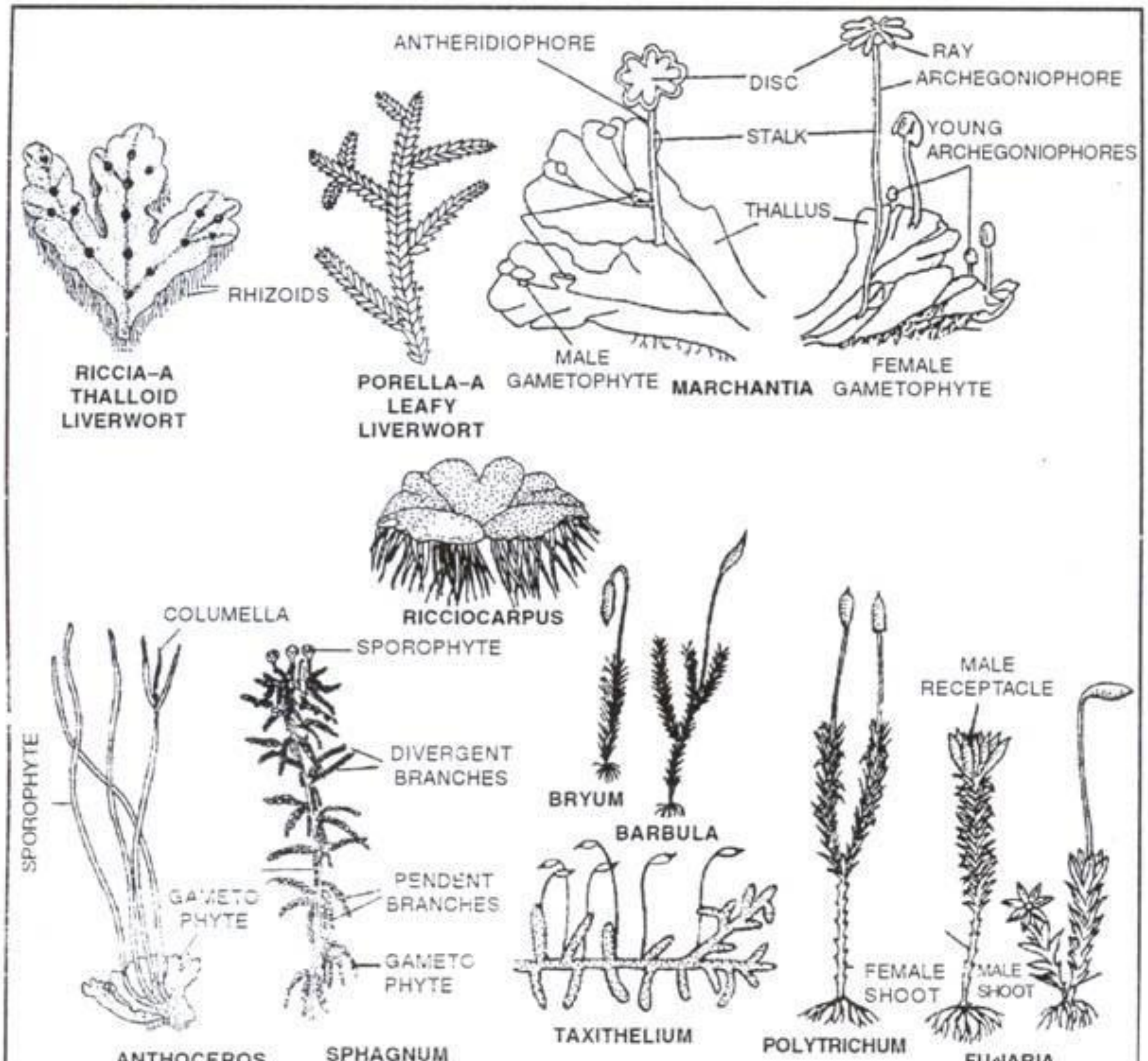


Figure 7.1 Different types of bryophytes. **Liverworts** : *Riccia, Porella, Marchantia, Ricciocarpus* **Hornwort** : *Anthoceros*: **Moss** : *Sphagnum, Bryum, Barbula, Taxithellium, Polytrichum & Funaria.*

Class 3. Musci or Bryopsida:

1. Gametophyte is differentiated into prostrate protonema and an erect gametophores

2. Gametophore is foliose, differentiated into an axis (=stem) and lateral appendages like leaves but without midrib.

3. Rhizoids multi-cellular with oblique septa.

4. Elaters are absent in the capsule of sporangium.

5. The sex organs are produced in separate branches immersed in a group of leaves.

6. It has only three orders:

(i) Bryales,

(ii) Andriales and

(iii) Sphagnales.

Economic importance of Bryophytes:

1. Protection from soil erosion:

Bryophytes, especially mosses, form dense mats over the soil and prevent soil erosion by running water.

2. Soil formation:

Mosses are an important link in plant succession on rocky areas. They take part in binding soil in rock crevices formed by lichens. Growth of Sphagnum ultimately fills ponds and lakes with soil.

3. Water retention:

Sphagnum can retain 18-26 times more water than its weight. Hence, used by gardeners to protect desiccation of the seedling during transportation and used as nursery beds.

4. Peat:

It is a dark spongy fossilized matter of Sphagnum. Peat is dried and cut as cakes for use as fuel. Peat used as good manure. It overcomes soil alkalinity and increases its water retention as well as aeration. On distillation and fermentation yield many chemicals.

5. As food:

Mosses are good source of animal food in rocky and snow-clad areas.

6. Medicinal uses:

Decoction of Polytrichum commune is used to remove kidney and gall bladder stones. Decoction prepared by boiling Sphagnum in water for treatment of eye diseases. Marchantia polymorpha has been used to cure pulmonary tuberculosis.

7. Other uses:

Bryophytes arc used as packing material for fragile goods, glass wares etc. Some bryophytes act as indicator plants. For example, Tortell tortusa grow well on soil rich in lime.

Life histories of following: Marchantia Funaria

Gametophytic Phase of Marchantia:

External Features of Gametophyte:

The plant body is gametophytic, thalloid, flat, prostrate, plagiotropic, 2-10 cm. long and dichotomously branched.

Dorsal surface:

Dorsal surface is dark green. It has a conspicuous midrib and a number of polygonal areas called areolae. The midrib is marked on the dorsal surface by a shallow groove and on the ventral surface by a low ridge. Each polygonal area re-presents the underlying air chamber.

The boundaries of these areas represent the walls that separate each air chamber from the next. Each air chamber has a central pore. The midrib ends in a depression at the apical region forming an apical notch in which growing point is situated. Dorsal surface also bears the vegetative and sexual reproductive structures. The vegetative reproductive structures are gemma cup and develop along the midrib. These are crescent shaped with spiny or fimbriate margins and are about one eighth of a inch in diameter. Sexual reproductive structures are borne on special Stalked structures called gametophores or gamctangiophores. The gametophores bearing archegonia are called archegoniophores and that bearing antheridia are called antheridiophores.

Ventral surface:

The ventral surface of the thallus bears scales and rhizoids along the midrib. Scales are violet coloured, multicellular, one cell thick and arranged in 2-4 rows (Fig. 1 C). Scales are of two types:

(i) Simple or ligulate

(ii) Appendiculate.

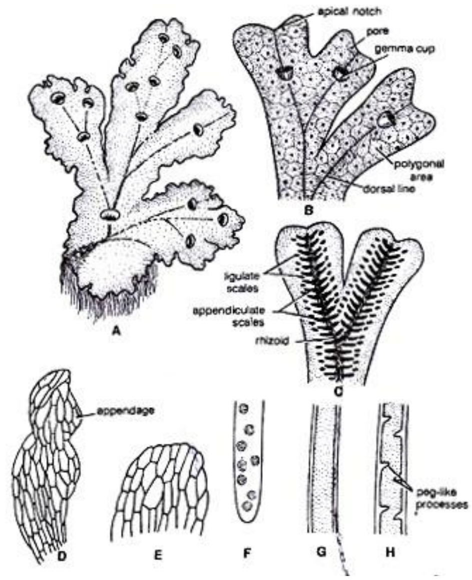
Appendiculate scales form the inner row of the scales close with midrib. Ligulate scales form the outer or marginal row and are smaller than the appendiculate scales.

Rhizoids are unicellular, branched and develop as prolongation of the lower epidermal cells. They are of two types:

(i) Smooth-walled rhizoids,

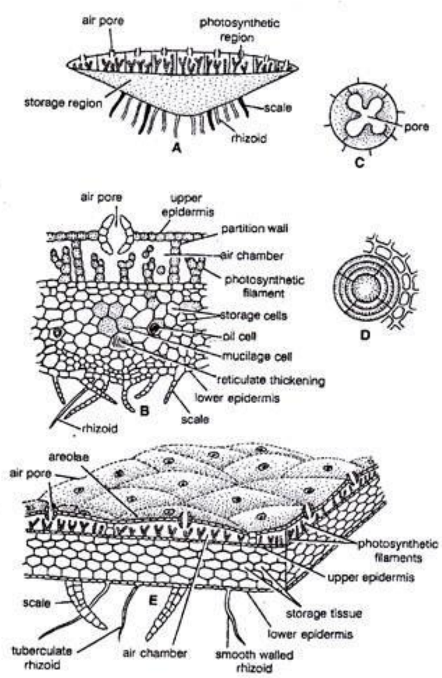
(ii) (ii) Tuberculate rhizoids.

In smooth-walled rhizoids both the inner and outer wall layers are fully stretched while in tuber-culate rhizoids appear like circular dots in surface view (Fig. 1 F). The inner wall layer modifies into peg like in growth which projects into the cell lumen (Fig. 1 H). The main functions of the rhizoids are to anchor the thallus on the substratum and to absorb water and mineral nutrients from the soil.



Anatomy of the Gametophyte:

A vertical cross section of the thallus can be differentiated photosynthetic zone and lower storage zone.



Upper Photosynthetic zone:

The outermost layer is upper epidermis. Its cells are thin walled square, compactly arranged and contain few chloroplasts. Its continuity is broken by the presence of many barrel shaped air pores. Each pore is surrounded by four to eight superimposed tiers of concentric rings. with three to four cells in each tier.

Air pores are compound in nature. The lower tier consists of four cells which project in the pore and the opening of the pore looks star like in the surface view. The walls of the air pore lie half below and half above the upper epidermis.

Just below the upper epidermis photosynthetic chambers are present in a horizontal layer (Fig. 2 B). Each air pore opens inside the air chamber and helps in exchange of gases during photosynthesis.

These are chambers develop schizogenously (Vocalized separation of cells to form a cavity) and are separated from each other by single layered partition walls. The partition walls are two to four cells in height. Cells contain chloroplast. Many simple or branched photosynthetic filaments arise from the base of the air chambers.

Storage zone:

It lies below the air chambers. It is more thickened in the centre and gradually tapers towards the margins. It consists of several lasers of compactly arranged, thin walled parenchymatous isodiametric cells. Intercellular spaces are absent.

The cells of this zone contain starch. Some cells contain a single large oil body or filled with mucilage. The cells of the midrib region possess reticulate thickenings. The lower most cell layer of the zone forms the lower epidermis. Some cells of the middle layer of lower epidermis extend to form both types of scales and rhizoids.

Reproduction in Marchantia:

Marchantia reproduces by vegetative and sexual methods.

Vegetative Reproduction:

In Marchantia it is quite common and takes place by the following methods:

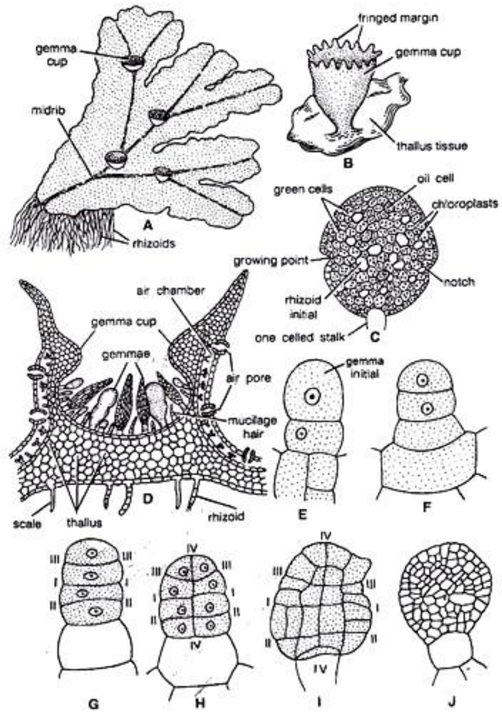
1. By Gemmae:

Gemmae are produced in the gemma cups which are found on the dorsal surface of the thallus. Gemma cups are crescent shaped, 3 m.m. in diameter with smooth, spiny or fimbriate margins.

V. S. passing through the gemma cup shows that it is well differentiated into two regions: Upper photosynthetic region and inner storage region.

The structure of both the zones is similar to that of the thallus. Mature gemmae are found to be attached at the base of the gemma cup by a single celled stalk.

Intermingled with gemmae are many mucilage hairs. Each gemma is autotrophic, multicellular, bilaterally symmetrical, thick in the centre and thin at the apex. It consists parenchymatous cells, oil cells and rhizoidal cells. It is notched on two sides in which lies the growing point.



All cells of the gemma contain chloroplast except rhizoidal cells and oil cells. Rhizoidal cells are colourless and large in size. Oil cells are present just within the margins and contain oil bodies instead of chloroplast.

Dissemination of Gemmae:

Mucilage hairs secrete mucilage on absorption of water. It swells up and presses the gemmae to get detached from the stalk in the gemma cup. They may also be detached from the stalk due to the pressure exerted by the growth of the young gemmae. The gemmae are dispersed over long distances by water currents.

Germination of Gemmae:

After falling on a suitable substratum gemmae germinate. The surface which comes in contact with the soil becomes ventral surface.

The rhizoidai cells develop into rhizoids. Meanwhile, the growing points in which lies the two lateral notches form thalli in opposite directions. Thus, from a single gemmae two thalli are formed. Gemmae which develop on the male thalli form the male plants and those on the female thalli form the female plant.

Development of Gemma:

The gemma develops from a single superficial cell. It develops on the floor of a gemma cup. It is papillate and called gemma initial. It divides by a transverse division to form lower stalk cell and upper cell. The lower cell forms the single celled stalk.

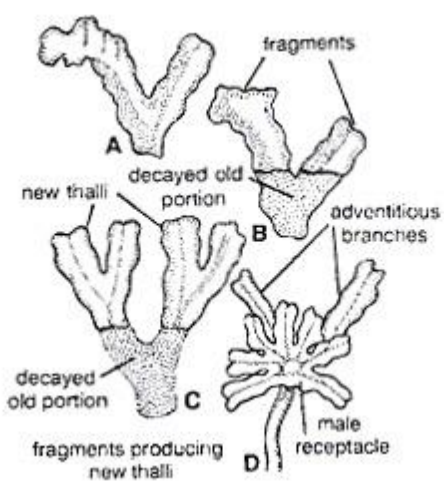
The upper cell further divides by transverse division to form two cells. Both cells undergo by similar divisions to form four cells. These cells divide by vertical and horizontal division to form a plate like structure with two marginal notches. It is called gemma.

2. Death and decay of the older portion of the thallus or fragmentation:

The thallus is dichotomously branched. The basal part of the thallus rots and disintegrates due to ageing. When this process reaches up to the place of dichotomy, the lobes of the thallus get separated. The detached lobes or fragments develop into independent thalli by apical growth.

3. By adventitious branches:

The adventitious branches develop from any part of the thallus or the ventral surface of the thallus or rarely from the stalk and disc of the archegoniophore in species like M. palmata (Kashyap, 1919). On being detached, these branches develop into new thalli.



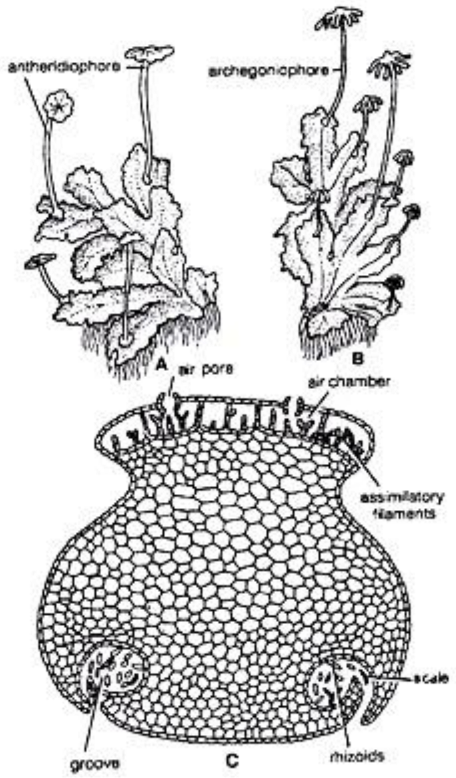
Sexual Reproduction:

Sexual reproduction in Marchantia is oogamous. All species are dioecious. Male reproductive bodies are known as antheridia and female as archegonia. Antheridia and archegonia are produced an special, erect modified lateral branches of thallus called antheridiophore and archegoniophore arpocephalum) respectively.

Further growth of the thallus is checked because growing point of the thallus is utilised in the formation of these branches. In some thalli of M. palmatci and L. polymorpha abnormal receptacle bearing both anheridia and archegonia have also been reported, such bisexual receptacles are called as androgynous receptacles.

Internal structure of Antheridiophore or Archcgoniophore:

Its transverse section shows that can be differentiated into two sides: ventral side and dorsal side. Ventral side has two longitudinal tows with scales and rhizoids. These grooves, run longitudinally through the entire length of the stalk. Dorsal side shows an internal differentiation of air chambers.

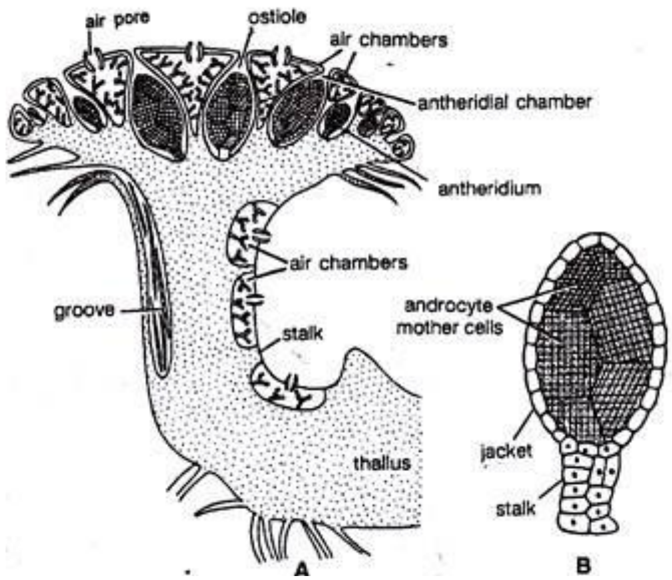


Antheridiophore:

It consists of 1-3 centimetre long stalk and a lobed disc at the apex. The disc is usually eight lobed but in M. geminata it is four lobed. The lobed disc is a result of created dichotomies.

L.S. through disc of Antheridiophore:

The disc consists of air chambers alternating with heridial cavities. Air chambers are more or less triangular and open on upper surface by n pore Called ostiole. Antheridia arise in acropetal succession i.e., the older near the center and youngest at the margins.



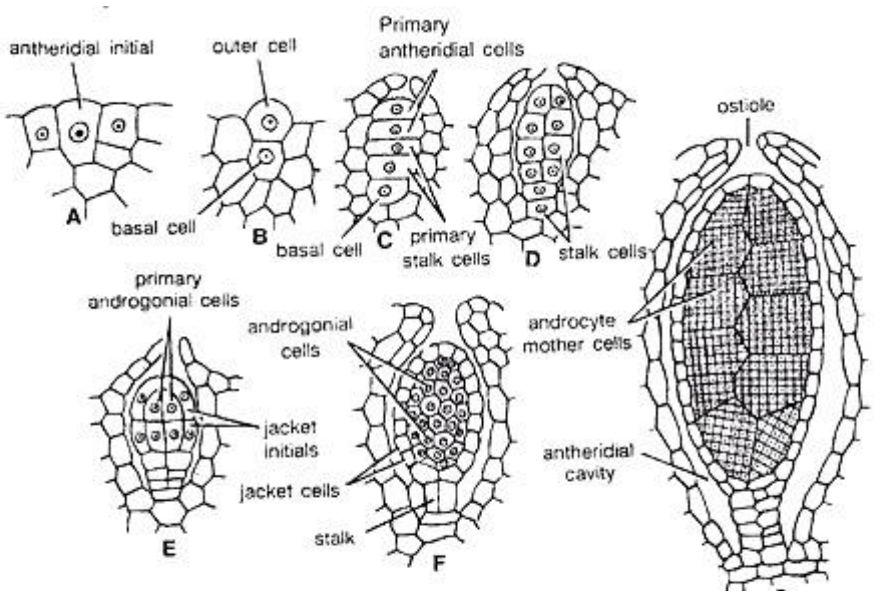
Mature Antheridium:

A mature antheridium is globular in shape and can be differentiated into two parts stalk and body. Stalk is short multicellular and attaches the body to the base of the antheridial chamber. A single layered sterile jacket encloses the mass of androcyte mother cells which metamorphosis into antherozoids. The antherozoid is a minute rod like biflagellate structure.

Development of Antheridium:

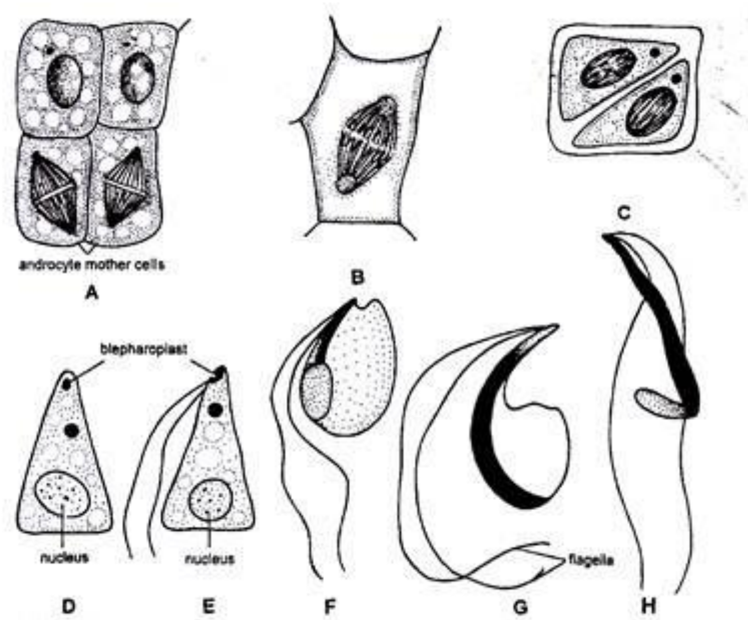
The development of the antheridium starts by a single superficial cell which is situated on the dorsal surface of the disc, 2-3 cells behind the growing point. This cell is called antheridial initial. The antheridial initial increases in size and divides by a transverse division to form an outer upper cell and a lower basal cell.

Basal cell remains embedded in the tissue of the thallus, undergoes a little further development and forms the embedded portion Of the antheridial stalk. Outer cell divides to form a filament of four cells. Upper two cells of the four celled filament are known as primary antheridial cells and lower two cells are known as primary stalk cells. Primary stalk cells from the stalk of the antheridium. Primary antheridial cells divide by two successive vertical divisions at right angle to each other to form two tiers of four cells each. A periclinal division is laid down in both the tiers of four cells and there is formation of eight outer sterile jacket initials and eight inner primary androgonial cells.



Jacket initials divide by several anticlinal divisions to form a single layer of sterile antheridial jacket. Primary androgonial cells divide by several repeated transverse and vertical divisions resulting in the formation of large number of small androgonial cells.

The last generation of the androgonial cells is known as androcyte mother cells. Each androcyte mother cells divides by a diagonal mitotic division to form two triangular cells called androcytes. Each androcyte cell metamorphosis into an antheozoid.



Spermatogenesis:

The process of metamorphosis of androcyte mother cells into antherozoids is called spermatogenesis.

It is completed in two phases:
(1) Development of blepharoplast.

(2) Elongation of androcyte nucleus.

1. Development of Blepharoplasty:
In the young triangular androcyte blepharoplast appears as a dense granule in one of the acute angles. It elongates to some extent and puts its whole body in close contact with the inner contour of androcyte. From the elongated blepharoplast emerge the flagella.

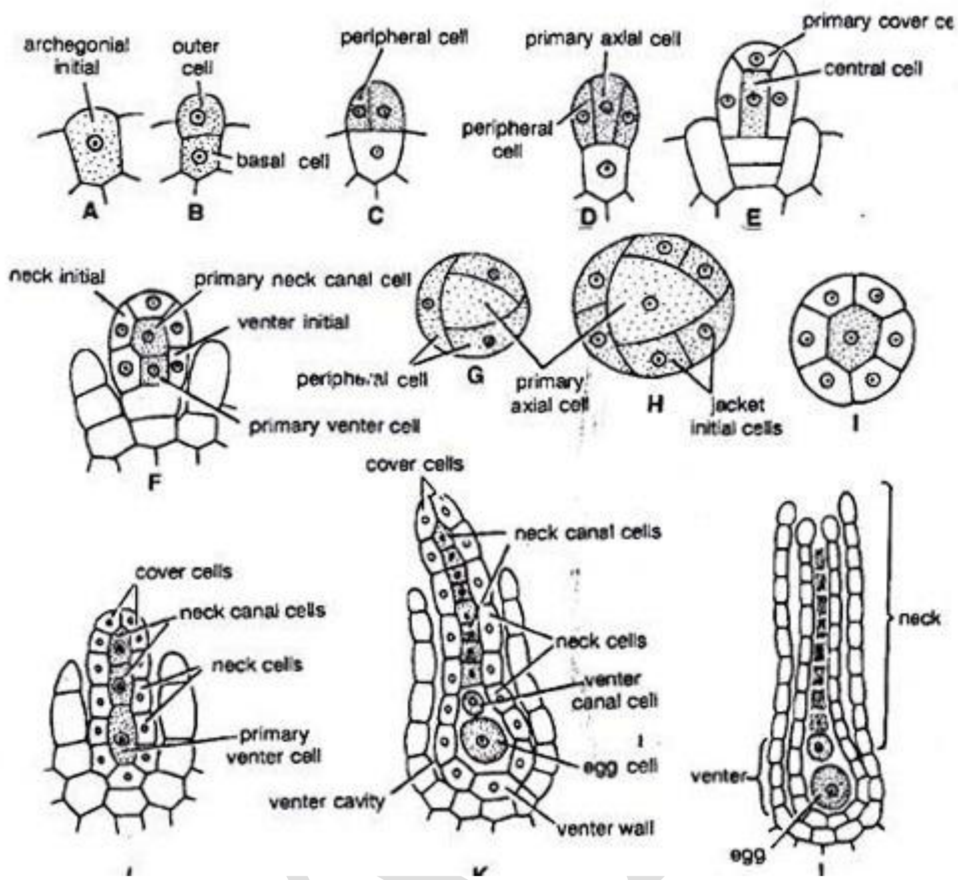
2 Elongation of Androcyte nucleus:
With the elongation of blepharoplast, the nucleus also elongates. The spline apparatus acts as a cytoskeleton for the elongation of nucleus. Spline apparatus is a multilayered structure which comprises tubules.

Archegoniophore or Carpocephalum:
It arises at the apical notch and consists of a stalk and terminal disc. It is slightly longer than the antheridiophore. It may be five to seven cm. long. The young apex of the archegoniophore divides by three successive dichotomies to form eight lobed rosette like disc.

Each lobe of the disc contains a growing point. The archegonia begin to develop in each lobe in acropetal succession, i.e., the oldest archegonium near the centre and the young archegonium near the apex of the disc. Thus, eight groups of archegonia develop on the upper surface of the disc. There are twelve to fourteen archegonia in a single row in each lobe of the disc.

Development:
The development of the archegonium starts on the dorsal surface of the young receptacle in acropetal succession. A single superficial cell which acts as archegonial initial enlarges and divides by transverse division to form a basal cell or primary stalk cell and an outer cell or primary archegonial cell.

The primary stalk cell undergoes irregular divisions and forms the stalk of the archegonium. The primary archegonial cell divides by three successive intercalary walls or periclinal vertical walls



resulting in the formation of three peripheral initials and a fourth median cells, the primary axial cell.

Each of the three peripheral initials divide by an anticlinal vertical division forming two cells In this way primary axial cell gets surrounded by six cells. These are called jacket initials. Six jacket initials divide transversely into upper neck initials and lower venter initials. Neck initial tier divides by repeated transverse divisions, to form a tube like neck.

Diversity of Algae, Lichens & Bryophytes:

Neck of the archegonium consists of six vertical rows. Each row consists six to nine cells Venter initials tier also divides by rapid transverse divisions to form a single wall layer of swollen venter. Simultaneously, the primary axial cell divides transversely and unequally to form upper small primary cover cell and lower large central cell. The central cell divides into primary neck canal cell and a lower venter cell. Primary neck canal cells divides by a series of transverse divisions to form a row of about eight thin walled neck canal cells. Primary venter cell divides only once and forms a small upper venter canal cell and a lower large egg or ovum. The primary cover cell divide by two vertical divisions at right angle to one another to form four cover cells which form the mouth of the archegonium.

Mature Archegonium:
A mature archegonium is a flask shaped structure. It remains attached to the archegonial disc by a short stalk. It consists upper elongated slender neck and basal globular portion called venter. The neck consists of six vertical rows enclosing eight neck canal cells and large egg. Four cover cells are present at the top of the neck.

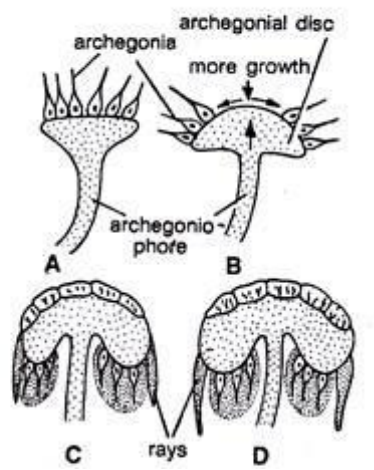
Fertilization in Marchantia:
Marchantia is dioecious. Fertilization takes place when male and female thalli grow near each other. Water is essential for fertilization. The neck of the archegonium is directed upwards on the dorsal surface of the disc of the archegoniophore. In the mature archegonium the venter canal cell and neck canal cells disintegrate and form a mucilaginous mass. It absorbs water, swells up and comes out of the archegonial mouth by pushing the cover cells apart. This mucilaginous mass consists of chemical substances.

The antherozoids are splashed by rain drops. They may fall on the nearby female receptacle or swim the whole way by female receptacle. It is only possible if both the male and female receptacles are surrounded by water.

Many antherozoids enter the archegonial neck by chemotactic response and reach up to egg. This mechanism of fertilization is called splash cup mechanism. One of the antherozoids penetrates the egg and fertilization is effected. The fusion of both male and female nuclei results in the formation of diploid zygote or oospore. Fertilization ends the gametophytic phase.

Sporophytic Phase:
Post Fertilization Changes:
After Fertilization the following changes occur simultaneously:
1. Stalk of the archegoniophore elongates.

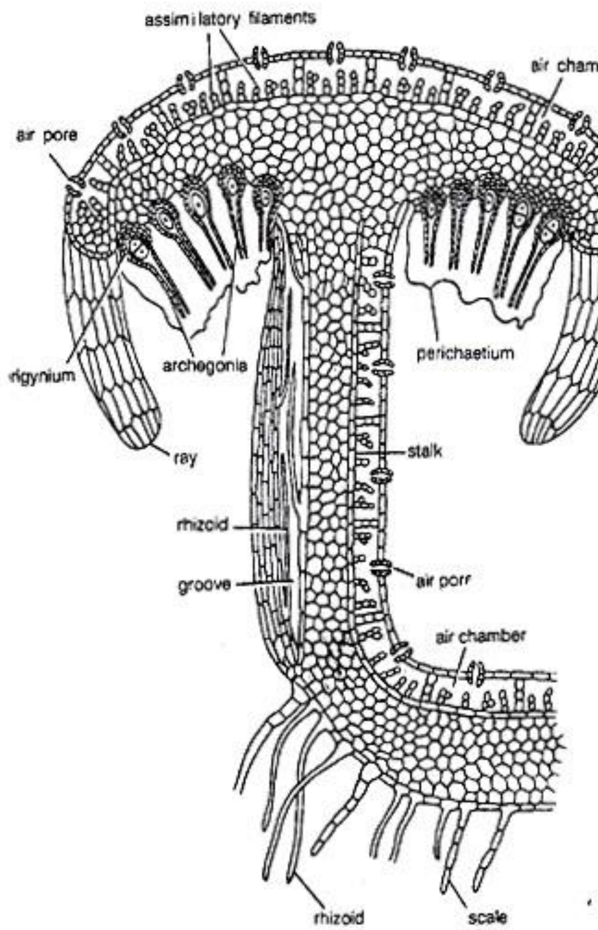
2. Remarkable over-growth takes place in the central part of the disc. As a result of this growth the marginal region of the disc bearing archegonia is pushed downward and inward. The archegonia are now hanging towards the lower side with their neck pointing downwards.



3. Wall of the venter divides to form two to three layered calyptra.

4. A ring of cells at the base of venter divides and re-divides to form a one cell thick collar around archegonium called perigynium (Pseudoperianth).

5. A one celled thick, fringed sheath develops on both sides of the archegonial row. It is called perichaetium or involucre. Thus, the developing sporophyte is surrounded by three protective layers of gametophytic origin i.e., calyptra, perigynium and perichaetium. The main function of these layers is to provide protection, against drought, to young sporophyte.



6. Between the groups of archegonia, long, cylindrical processes develop from the periphery of disc. These are called rays. They radiate outward, curve downwards and give the disc a stellate form. In M. polymorpha these are nine in number.

7. Zygote develops into sporogonium.

Development of Sporogonium:
After fertilization the diploid zygote or oospore enlarges and it completely fills the cavity of the archegonium. It first divides by transverse division (at right angle to the archegonium axis) to form an outer epibasal cell and inner hypo basal cell.

The second division is at right angle to the first and results in the formation of four cells. This represents the quadrant stage. The epibasal cell forms the capsule and hypo basal cells form the foot and seta.

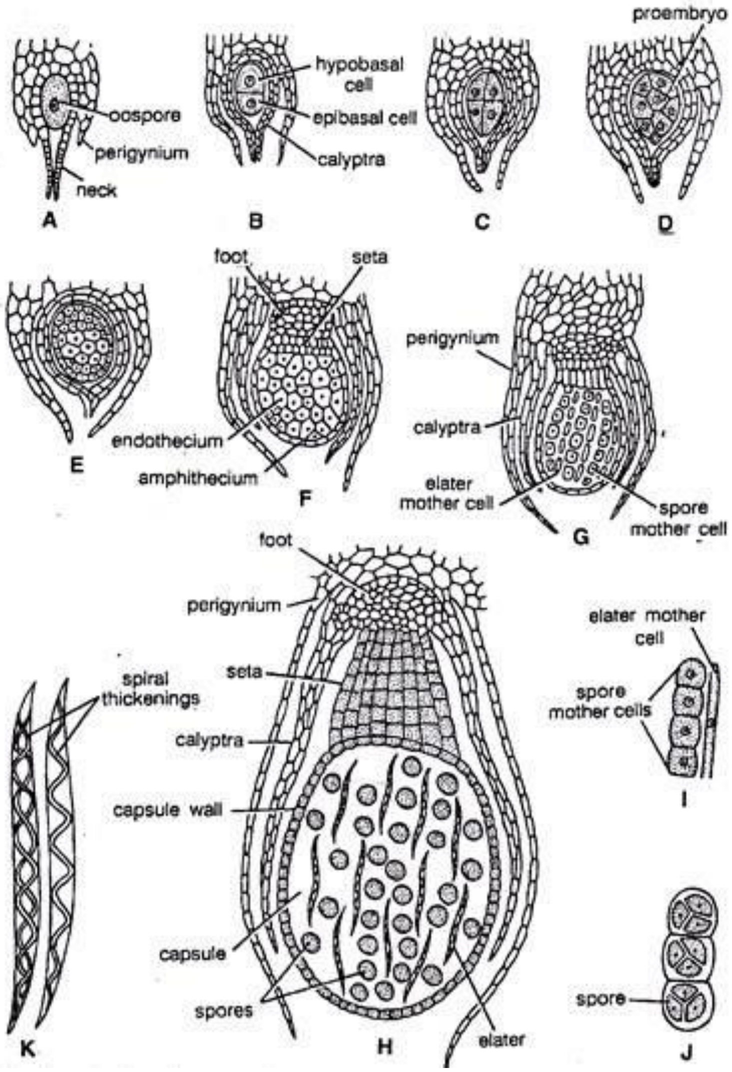
Since the capsule is developed from the epibasal cell and forms the apex of the sporogonium, the type of embryogeny is known as exoscopic. The next division is also vertical and it results in formation of eight celled stage or octant stage.

Now the divisions are irregular and globular embryo is formed. The lower cells divide to form a massive and bulbous foot. The cells of the seta divide in one plane to form vertical rows of cells.

In upper region of capsule (when the young sporogonium is about a dozen or more cells in circumference) periclinal division occurs and it differentiates it into outer single layered amphithecium and multilayered endothecium.

The cells of the endothecium divide only by anticlinal divisions to form a single layered sterile jacket or capsule wall. The endothecium forms the archesporium. Its cells divide and re-divide to form a mass of sporogenous cells (sporocytes). Half of the sporogenous cells become narrow and elongate to form the elater mother cells. In M. polymorpha sporogenous cells divide by five successive divisions to form thirty-two spore mother cells while in M. domingensis sporogenous cells divide only by three to four divisions to form eight or sixteen spore mother cells. The elater mother cells elongate considerably to form long, slender diploid cells called elaters.

Elaters are pointed at both the ends and have two spiral bands or thickenings on the surface of the wall. These are hygroscopic in nature and help in dispersal of spores. The spore mother cell is diploid and divides meiotically to form four haploid spores which remain arranged tetrahedrally for quite some time. The spores later become free and remain enclosed by the capsule wall along elaters.



The quadrant type of development of sporogonium is quite common in many species of Marchantia (e.g., M. polymorpha) but in a few species zygote divides by two transverse divisions to form the 3-celled filamentous embryo. In it the hypo basal cell forms the foot, the middle seta and the epibasal cell develops into capsule. However, it is the rare type of embryo development in M. chenopoda.

Mature Sporogonium:

A mature sporogonium can be differentiated into three parts, viz., the foot, seta and capsule. Foot. It is bulbous and multicellular. It is composed of parenchymatous cells. It acts as anchoring and absorbing organ. It absorbs the food from the adjoining gametophytic cells for the developing sporophyte.

Seta:

It connects the foot and the capsule. At maturity, due to many transverse divisions it elongates and pushes the capsule through three protective layers viz., calyptra, perigynium and perichaetium.

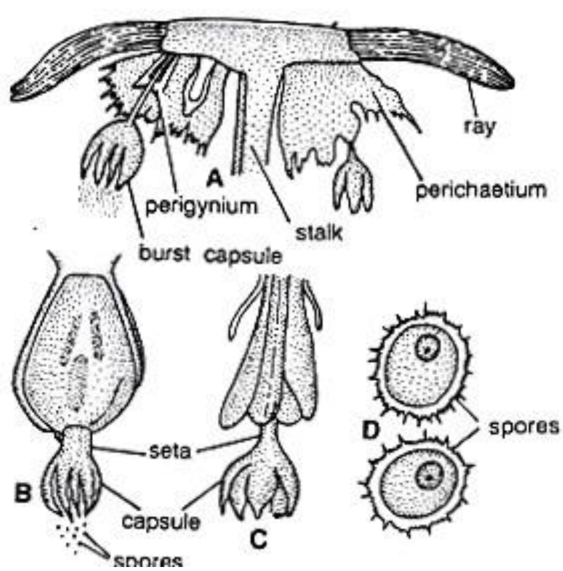
Capsule:

It is oval in shape and has a single layered wall which encloses spores and elaters. It has been estimated that as many as 3, 00,000 spores may be produced in single sporogonium and there are 128 spores in relation to one elater.

Dispersal of Spores:

As the sporogonium matures, seta elongates rapidly and pushes the capsule in the air through the protective layers. The ripe capsule wall dehisces from apex to middle by four to six irregular teeth or valves. The annular thickening in the cells of the capsule wall causes the valves to roll backward exposing the spores and elaters.

The elaters are hygroscopic in nature. In dry weather they lose water and become twisted. When the atmosphere is wet, they become untwisted and cause the jerking action. Due to this the spore mass loosens and spores are carried out by air currents.



Structure of Spore:

Spores are very small (0.012 to 0.30 mm in diameter). They are haploid, uninucleate, globose and surrounded by only two wall layers. The outer well layer is thick, smooth or reticulate and is known as exospore or exine. The inner wall layer is thin and is called endospore or intine. In M. torsana and M. caneiloba they are tetrahedrally arranged.

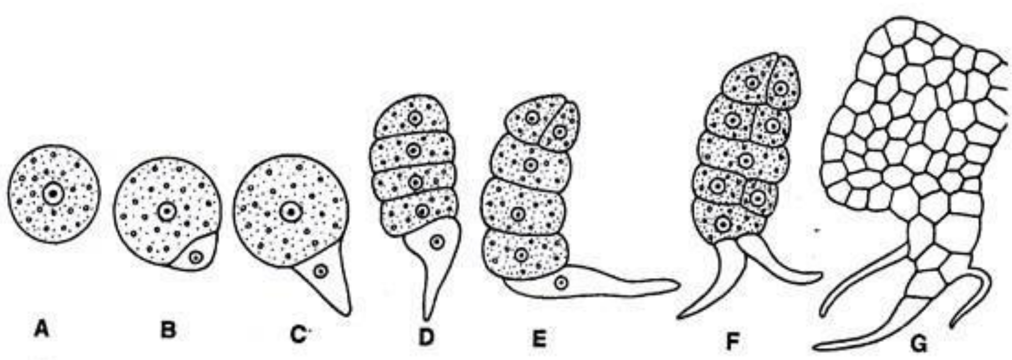
Germination of Spores and Development of Gametophyte:

Under favourable conditions, the spores germinate immediately. In first year the spore viability is approximately 100%. Before germination it divides by transverse division to form two unequal cells. The lower cell is small in size.

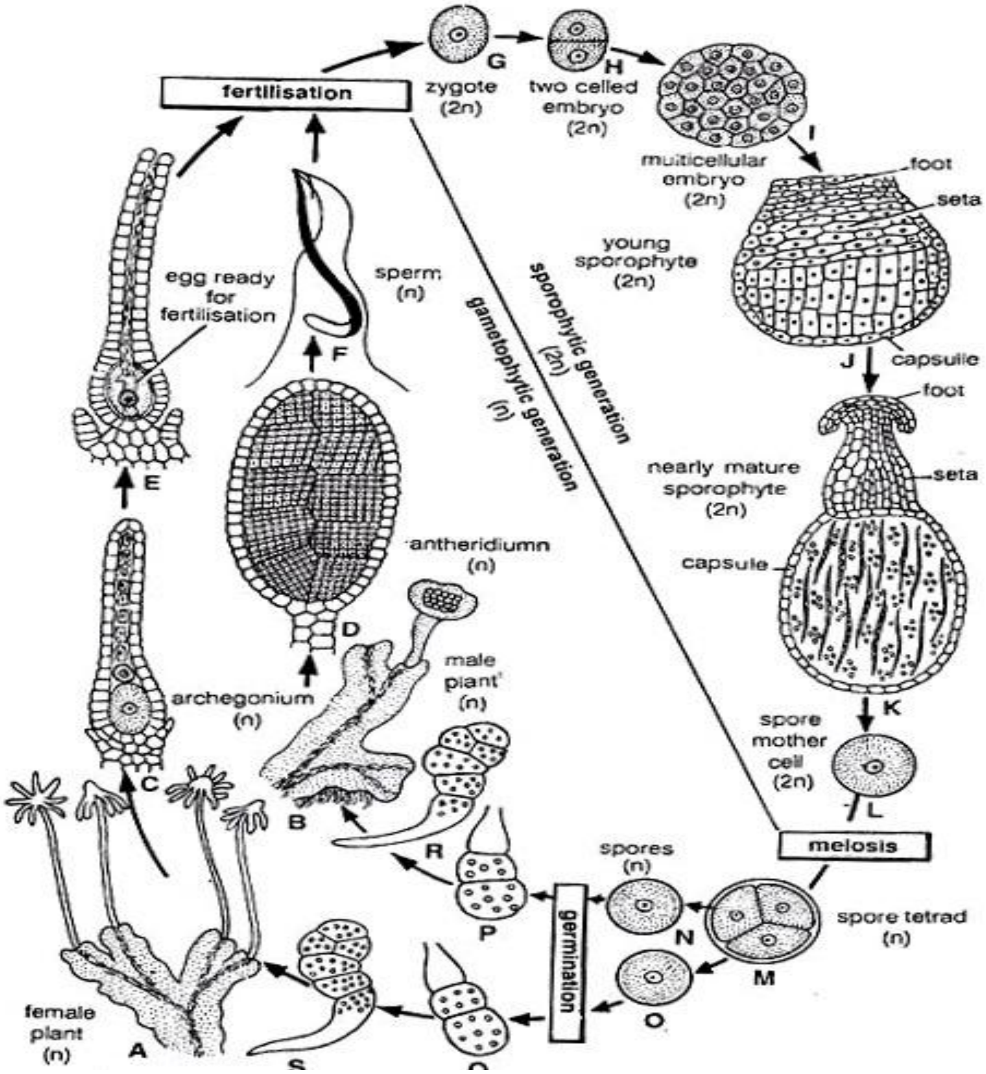
It is relatively poor in cell contents, achlorophyllous and extends to form germ-rhizoid. The large cell is chlorophyllous and undergoes divisions to form a six to eight cell germ-filament or protonema. At this stage the contents of the cells migrate at the apex.

The apex is cut off from the rest of the sporeling by a division. It behaves as apical cell. It is wedge-shaped with two cutting faces. The apical cell cuts off five to seven cells alternately to the left and right. These cells by repeated divisions form a plate like structure.

According to O' Hanlon's (1976) a marginal row of cells appears in the apical region in this plate. By the activity of these marginal cells, the expansion of the plate takes place into thallus, a characteristic of Marchantia.



Marchantia is dioecious, 50% of the spores develop into male thalli and 50% develop into female thalli.



Alternation of Generation in Marchantia:

The life cycle of Marchantia shows regular alternation of two morphologically distinct phases. One of the generations is Haplophase and the other is diplophase.

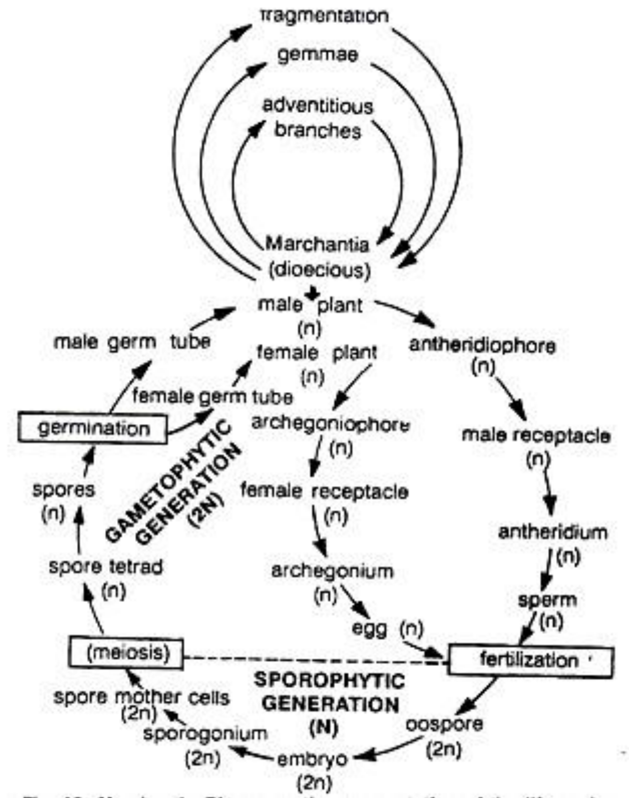
Haplophase or Gametophytic Phase:

In Marchantia this phase is dominant and produces the sex organs. Sex organs produce gametes to form a diploid zygote.

Diploid Phase or Sporophytic Phase:

Zygote develops into sporophyte. In Marchantia sporophyte is represented by foot, seta and capsule. The sporophyte produces the spores in the capsule. The spores on germination produce the gametophyte.

So, in Marchantia two morphologically distinct phases (Haplophase and Diplophase) constitute the life cycle. The life cycle of this type which is characterised by alternation of generations and sporogenic meiosis is known as heteromorphic and diplohaplontic.



Possible questions

- What are the salient features of Bryophytes?
- Explain the classification of bryophytes
- Explain the general structure, reproduction of Bryophytes
- Differentiate gametophytes and sporophyte
- Explain the morphology, life cycle and mode of reproduction in Marchantia
- Explain the morphology, life cycle and mode of reproduction in funaria
- Describe the economic importance of bryophytes

UNIT-V

Rust and Smut of Wheat. White rust of Crucifers. Late blight of Potato. Red rot of Sugarcane. Citrus Canker.

SYLLABUS

Rust and Smut of Wheat. White rust of Crucifers. Late blight of Potato. Red rot of Sugarcane. Citrus Canker.

<u>UNIT – V</u>

Loose Smut of Wheat (With Diagram) | Plant Diseases

Introduction to the Loose Smut of Wheat:

This disease is very common and widespread. It causes great damage in the wheat growing tracts of India, particularly in the Punjab, Uttar Pradesh and certain districts of Madhya Pradesh.

Luthra (1953) reported that in India, the disease causes loss of over 50 million rupees annually. In Punjab the disease is called Kangiari.

Symptoms of Loose Smut Disease:

The smutted ears emerge from the boot leaves a little earlier than the healthy ones. They bear loose, black, powdery masses of smut spores instead of flowers. All the ovaries and other floral parts except the awns and rachics are converted into masses of smut spores.

In the young spikelets before emergence each ovary has become a spore sac. It is the home of millions of spores. The spores of each spikelet are covered by a thin greyish or silvery membrane. By the time the ear emerges from the boot leaf the membrane ruptures to expose the black powdery mass of spores.

The ear is generally completely destroyed except the awns and the rachis. When the wind blows the spores are blown off and the bare rachis and central axis is left behind.

To it may cling a few spores that have not been blown off by the wind. It is not necessary that all the ears of a wheat plant may be smutted. Some may be found to be healthy and others diseased.

Causal Organism:

The causal organism of this disease is Ustilago tritici (Pers.) Rostr. and the host is Triticum vulgare. Fisher transferred U. tritici to U. nuda. Popp holds that since the two species differ in the type of teliospore germination, they should be considered as distinct species. The disease is internally seed borne. The mycelium of the fungus lies dormant in the grain.

Mycelium of Loose Smut Disease:

Ustilago tritici is an internal parasite. It has a dikaryotic mycelium. The hyphae ramify the intercellular in spaces of the host tissue. They absorb nutrition from the host cells by diffusion. The hyphae do not produce haustoria.

Spore Formation:

The mycelium grows keeping pace with the growth of the host plant. It is chiefly confined to the stem. At the time of flowering and when the inflorescence is still enclosed by the boot leaf, the mycelial hyphae enter into the ovaries of flowers.

Within the ovary each hypha grows vigorously and branches repeatedly to form a dense mass of hyphae. The latter destroy the host tissue in the ovaries and surrounding floral parts. The cells of these hyphae are binucleate.

The hyphae undergo additional septation to form short binucleate cells. These cells swell and round off to form binucleate smut spores. The smut spores are called the brand spores. Some mycologists prefer to call them teliospores.

They are spherical to oval and measure 5.9 μ in diameter. They have a finely echinulate thick spore wall which is olivaceous brown but slightly lighter on one side. The teliospores are produced in enormous numbers.

Disease Cycle:

The loose smut of wheat is a systemic disease. It is seed borne (A). As the infected grain is sown and germinates (B), the dormant fungus mycelium within the grain resumes activity. It grows best in or near meristematic tissues keeping pace with the growth of the host plant (C).

The hyphae thus grow just behind the growing point. The presence of the fungus in the meristematic tissue exercises accelerating influence on the growth of the host which matures early producing flower heads.

At the flowering time, the hyphae reach the inflorescence region (D^1) and accumulate in the floral parts chiefly the florets (D^2) which are subsequently completely destroyed. The hyphae become swollen and additionally septate.

The segments, which are binucleate, round off, separate and secrete thick walls to become smut spores which are frequently called teliospores. The teliospores serve as a means of propagating the disease during the growing season.

They are readily carried from the smutted ears (E) by air current (F) at a time when the healthy plants are in the flowering stage. There are clouds of spores in the atmosphere over the wheat fields.

The glumes of healthy flowers are wide open and the stigmas sufficiently exposed and spread in the dry weather to the spore dust. Thus the teliospores fall on the feathery stigmas of healthy wheat flowers. Under suitable conditions (warmth and moisture) the spores germinate on the stigma (G).

Before germination the two nuclei of a dikaryon fuse in the smut spore to form a single fusion nucleus or the synkaryon. The diploid teliospore represents the hypobasidium or probasidium stage. At the time of germination the exosporium ruptures.

The endosporium grows out in the form of a short tubular hypha called the promycelium or epibasidium. The diploid synkaryon migrates into, the epibasidium and undergoes meiosis, which consists of two nuclear divisions.

As a result four haploid nuclei are formed. They are arranged in a row. Two of these are of plus and two of minus strain. Walls are laid between the daughter nuclei. The epibasidium now consists of four haploid cells arranged in a row.

Each cell of the epibasidium produces a slender hypha called the infection thread. It contains a single haploid nucleus. Out of the four infection threads two contain haploid nuclei (one each) of plus strain and two of minus strain.

Basidiospores or sporidia are not produced by the basidia of Ustilago tritici. Their place is taken up by the infection threads. The neighbouring infection threads of opposite strains fuse. Consequently one of the infection threads becomes binucleate or dikaryotic.

The dikaryotic infection threads become binucleate or dikaryotic. The dikaryotic infection thread grows by elongation and clamp connections. It enters the style, grows forwards through the intercellular spaces and the channels left by the pollen tubes and reaches the ovary.

Recently Pedersen (1956) and Malik and Batts opposed this view. They hold that the infection thread pierces the young ovary wall in a week or so. From there it makes its way into the developing ovule through the integuments.

Penetration into the immature ovule occurs between the 7th and 10th day. About 10 days after infection the integuments become cutinised and resistant to infection. In the ovule the dikaryotic hypha passes into the space between the endosperm and nucellus. Here it branches freely.

The branch hyphae take about three weeks to reach the base of the raphe. Some of these pass round the bottom of the endosperm to penetrate the embryo through the scutellum. The hyphae in the scutellum are irregularly swollen and have thick and oily walls.

As the ovary ripens into the grain the fungus mycelium becomes inactive. It remains small and lies dormant in the embryo chiefly in the scutellum. The dormant mycelium within the embryo carries the fungal pathogen over seasons unfavourable to growth.

It becomes activated again at the time of germination of the grain. The presence of the dormant fungus mycelium in the grain shows no external signs of its infection.

The infected grains apparently look like the healthy ones. Ustilago tritici thus provides an excellent example of infection through the flower.

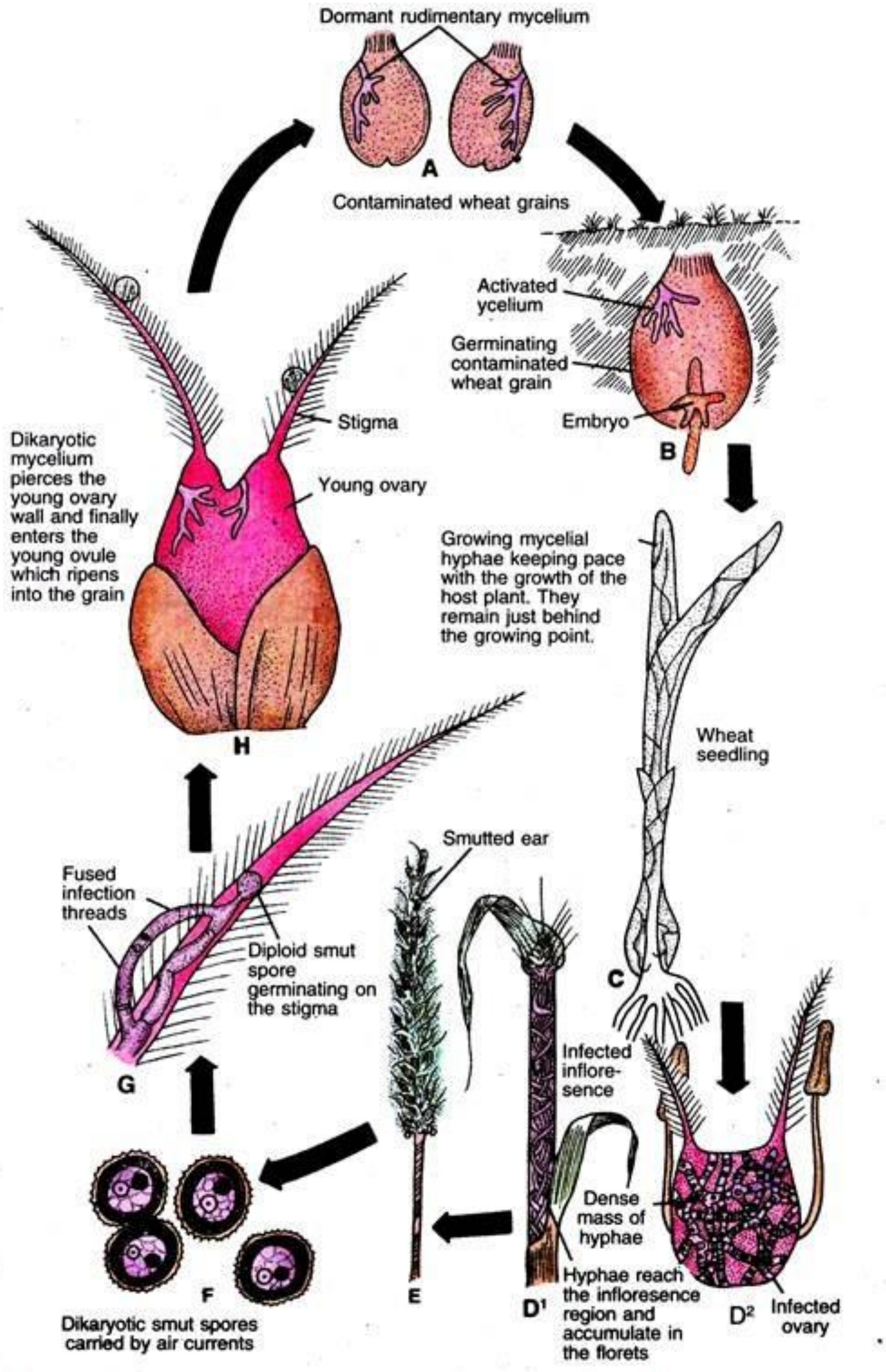


Fig. 22.14 Loose smut of wheat. A pictorial disease cycle of *Ustilago tritici*, a blossom-infecting smut.

Host-Parasite relations in Loose Smut of Wheat:

Kourssanow (1928) reported that the infected plants were generally smaller and had higher respiration rate than the healthy ones. Mather and Hausing (1960) found that the total dry weight was reduced by 33 percent, root dry weight by 32 percent, height by 11 percent in infected plants.

Gaunt and Manners (1971) reported reduction in the photosynthetic area. Expansion of successive leaves of the host plant was delayed. This reduced the availability of assimilates for the development of the infected plants which consequently showed restricted growth of the roots and the tillers.

Such effects have been attributed to:

(i) Increased respiration and decreased photosynthesis and

(ii) To the deprivation to the host by the pathogen (U. tritici) of necessary metabolates for further development.

Effect of Loose Smut Disease:

The disease results in the reduction of yield from 20 to 50 percent. Quality of the grain is, however, not affected.

Control Measures of Loose Smut Disease:

Since the mycelium of the parasite is lodged inside the grain, external application of disinfectants is ineffective. Direct attack on the fungus living deep in the tissues is very difficult. In the first instance most of the chemicals do not reach the seat of trouble.

Some which do may injure the embryo as well. The dormant mycelium in the grain is very resistant to heat. Hence in all methods of treatment the first step is to make the dormant mycelium active. In the activated condition it is vulnerable.

It is killed by the application of moist heat.

The following methods are generally employed to kill the mycelium in the embryo of the grain:

1. Hot Water Treatment:

The wheat grains are at first soaked in water kept within a range of temperature between 26°C-30°C. They are allowed to remain there for about 4-5 hours. In the softened grains the dormant mycelium becomes active.

The temperature of water is then raised and kept constant at 54°C for about 10 minutes. At this temperature the activated mycelium is killed. This method requires strict care and supervision. The temperature should be carefully controlled.

At a range a little too low, it will fail to kill the mycelium and at a degree or so too high it will kill the embryo. In this case the embryo is killed at 56°C. The margin of error either way is thus very little. After the treatment the water is drained off.

The grains should then be dried and sown. The hot water treatment was first evolved by Jensen (1888-89) against the late blight of potato. Swingle (1892) applied it against the loose smut of wheat.

2. Sun Heating:

This method is in vogue in the Punjab and U.P. Here the sun in the months of May and June is very hot. The atmospheric temperature is very high. The suspected grains are soaked in water in flat, shallow bottomed basins with water level about two inches above the level of grain.

The basins are placed in the direct rays of the summer sun for about 4 to 6 hours, say from 8 a.m. to 12 noon. During this period the dormant fungus mycelium becomes active. The water is then drained off.

The softened grains are spread in thin layers on the brick floor in the midday sun to dry. In the cooler regions the use of galvanised iron sheet to spread and dry the grain in the sun has been recommended.

This treatment kills the activated mycelium. Mitra and Taslim (1936) recommended the sun heating method for controlling the disease in North Bihar. Luthra found the solar treatment quite suitable in the Punjab where the day temperature in summer goes very high.

Bedi (1957) suggested a modification in the method. He found 4 hours presoaking period followed by one hour exposure to sun under Punjab conditions quite sufficient to kill the activated mycelium. Extra exposure to sun heat serves to dry the grain.

3. Growing Resistant Varieties:

Sowing grains of varieties of wheat which are immune from or resistant to this disease is the best method of controlling the disease. Some of the wheat resistant varieties are Np 710, Np 120, and Pb 90.

The other equally effective methods are:

4. The wheat plants with infected ears, which emerge out of the boot leaves earlier than the healthy ones, may be uprooted at once and burnt. This practice is called rogueing.

5. The grains for sowing purposes should be thrashed from uninfected wheat ears.

6. Use of systemic fungicides:

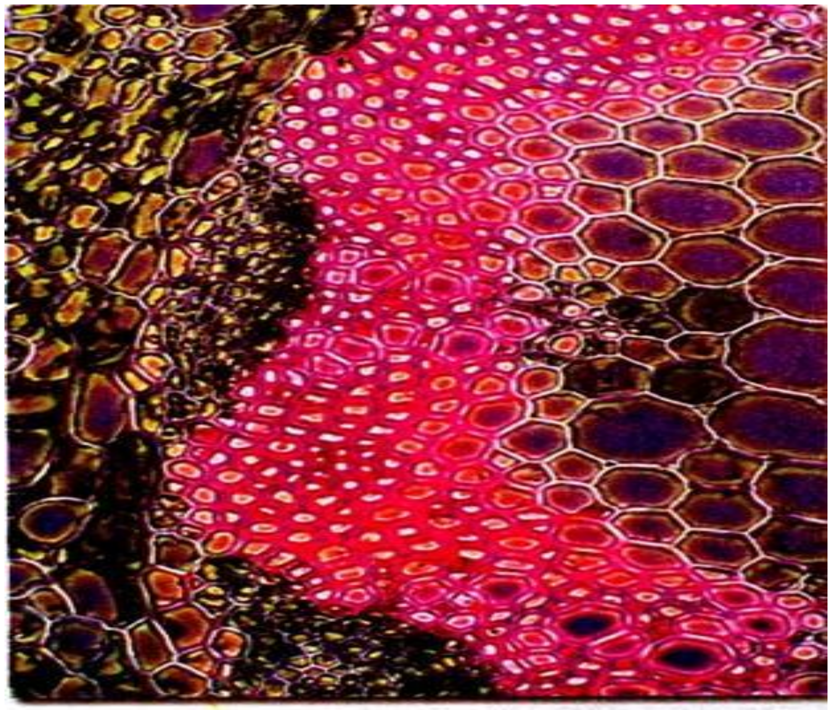
The use of fungicides, which till recently was considered impraticable to control the seed borne loose smut disease of wheat, has received much attention. Chatrath et al. (1969) found that two systemic fungicides D735 (Vitavax) and F 461 (Plantavax) give quite encouraging results when applied as seed dressing fungicides at the rate of 2.50 gm per Kg.

The use of Benomyl and Carboxin to control loose smut of wheat (U. nuda var. tritici) has been recommended by many workers. Joshi et al. (1975) reported that seed dressing with 0.25 per cent Benomyl can effectively control the disease.

Thomas and Chatrath (1975) found that a systemic fungicide thiabendazole employed as a seed treatment at the rate of 0.1 to 0.2 per cent is highly effective to control the disease without affecting germination.

White Rust of Crucifers (With Diagram)

In this article we will discuss about the white rust of crucifers caused by fungi.



Introduction to the White Rust of Crucifers:

White rust or white blisters disease is one of the common diseases of crucifer crops. It is worldwide in distribution occurring in all the areas wherever crop is cultivated. Both wild and cultivated varieties are attacked.

The disease affects a large number of crucifer crops of economic importance like Mustard, Cress, Rape, Radish, Cabbage, Cauliflower, turnip etc. In India the disease is reported on Mustard, Rape, Eruca sativa, turnip. Cauliflower and Cleome viscosa.

Effect of White Rust Disease:

Although considered unimportant in proportion to its widespread occurrence, the disease may cause serious damage in certain areas and the losses may be upto 25 percent when the floral parts get malformed and seeds are not formed at all.

The disease in association with downy mildew disease of crucifers caused by Peronospora parasitica cause severe damage to the crop.

Symptoms of White Rust Disease:

The disease affects all the aerial parts of the plant, the roots are not attacked. Symptoms may appear as a result of two types of infection: Local and Systemic.

In case of local infection, isolated spots or pustules appear on leaves or stems or inflorescence. The pustules are of variable size, measuring 1 -2 mm in diameter and are raised shiny white areas.

These may arise in close proximity and coalesce to form large irregular patches. Usually, the pustules appear in circular or concentric arrangement with one or two central areas. The host epidermis ruptures exposing white powdery mass consisting of spores of the fungus. Pustules occurring on leaves are usually confined to the lower surface only.

In systemic infections, young stems and inflorescence are infected. The fungus becomes systemic in these parts and the affected tissues are stimulated to various types of deformities. The most prominent is Hypertrophy of the affected parts. Due to Hypertrophy and Hyperplasia of floral parts, these show swellings and distortion.

The peduncle and pedicel may become enormously thickened upto 12-15 times, the normal diameter. Floral parts become fleshy, swollen, green or violet in colour, the stamens falling off early.

The petal may turn green sepal like and stamens and carpels are also converted to swollen leaf like structures. The ovules are usually atrophied as also the pollen grains resulting in total sterility. Pustules may also appear on these parts. However, the affected parts are full of oospores and starch.

When the systemic infection has taken early, the growth of the entire plant is checked, stunted and only small leaves may be formed.

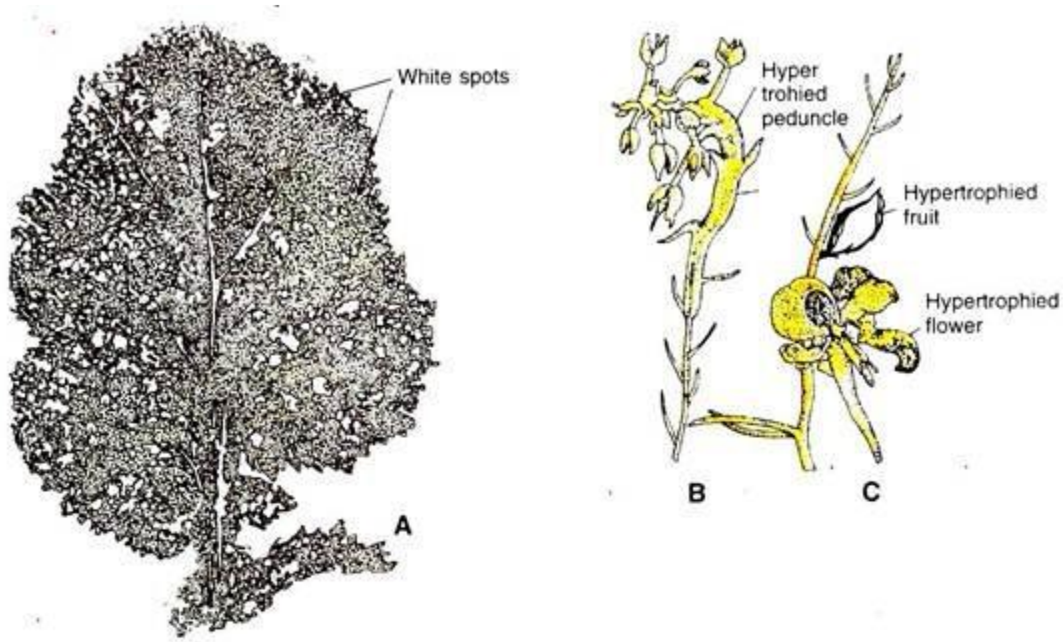


Fig. 22.3. Symptoms of white rust disease on leaves (A) and inflorescence (B and C).

The stem and the axis of the inflorescence may get twisted appearing in a zigzag sequence. Normal dormant buds are stimulated and grow into lateral shoots.

Causal Organism:

The causal organism Albugo Candida (Lev.) Kunze or Cystopus candidus Lev. is an obligate parasite.

Disease Cycle:

The primary infection occurs due to oospores perennating in the soil or due to mycelium perennating on perennial hosts. These serve as primary inoculum when the environmental conditions are favourable.

Oospores germinate in presence of water to form a vesicle in which a large number of zoospores are formed. These zoospores swim in a film of water and land on the suitable host, germinate by germ tubes, enter the host and establish infection. The mycelium in the host is intercellular with globose haustoria.

Soon the mycelium after absorbing nutrients and food materials from the host, accumulates below the lower epidermis. Conidiophores, which are clavate, and formed at the tip of hyphae, begin to produce conidiosporangia in basipetal succession. The pressure of these breaks open the lower epidermis and white rust symptoms become apparent on the leaves.

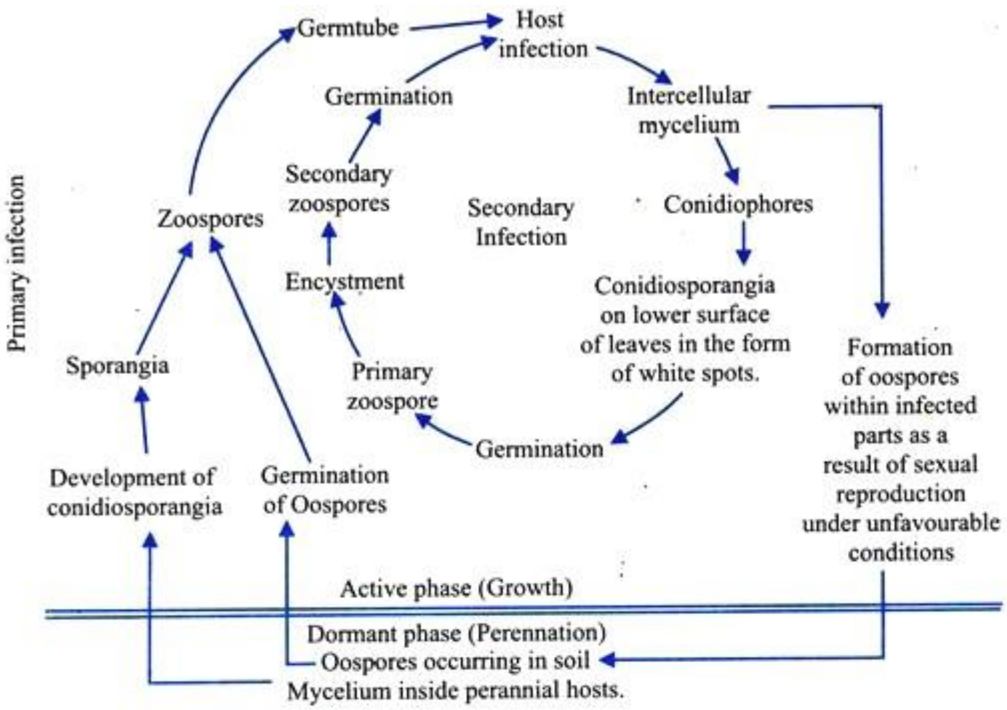


Fig. 22.4. White rust of crucifers–Disease cycle.

The conidiosporangia produced during early phase of the growing season cause secondary infection in the host. These are blown away by wind or any other agency, land on the host surface and germinate to form zoospores.

The zoospores germinate by formation of germ tubes which enter the host and cause secondary infection. If the conditions are favourable, this is repeated.

When the conditions become unfavourable or during the later phase of the growing season, the fungus begins sexual reproduction producing oospores. These oospores, being thick-walled, can withstand the unfavourable conditions.

During harvesting of the crop, the diseased hypertrophied portions of the plant are generally left in the field where they perennate waiting for the favourable conditions to return back.

Control Measures of White Rust Disease:

The disease may be controlled by the following methods:

(i) Clean cultivation and destruction of weed should be practised.

(ii) Crop rotation will avoid the soil borne primary inoculum.

(iii) Spraying with 0.8 percent Bordeaux mixture or Dithane M-45 (0.2%) may be undertaken to check the spread of the disease.

(iv) Disease resistant varieties be preferred.

Late Blight of Potato (With Diagram)

In this article we will discuss about the late blight of potato caused by fungi.

Introduction to the Late Blight of Potato:

Late blight is a serious fungal disease of potatoes. It is worldwide in its distribution. It occurs in potato growing areas of the world. Winter is the main potato growing season in India. It is followed by hot summer months in the plains. The drought and high temperature kill the fungus in the soil.

The late blight epidemics are thus rare in the plains in India. It is destructive to the crop grown in the rainy season. The disease occurs annually in the cooler Himalayan regions extending from Assam to Kashmir at an altitude of 6,000 ft. or more as the crop is grown in the rainy season.

Moreover, the temperature during the day is never above 22°-23°C which is favourable for the appearance of disease. The crops grown in the plains have been usually free from the epidemics of late blight because the chief predisposing factors (temperature and moisture) that render potato plants susceptible to disease are absent during the period of their growth.

The temperature is high for the development of the disease. Now it has established itself in the Indo- Gangetic plain and occurs annually in the states of Punjab, Uttar Pradesh, Bihar, and W. Bengal. The disease is also destructive to tomatoes.

Effects of Late Blight:

The damage caused by the disease is frequently very high. Severe damage to the foliage shortens the growing season. Consequently the tubers remain small and reduced in weight.

They are produced in smaller numbers. This results in the reduced yield. In severe cases of infection there is complete loss of the crop, Infection also results in the decay of tubers in the field and storage.

Symptoms of Late Blight:

The disease first appears on the tops of the plants generally after the blossoming period but mostly in the month of January. It may appear as well at any time during the growth period of the plant. The conditioning factor is the favourable environment.

The disease makes its appearance as small, dead, brownish to purplish black areas or lesions. These appear on the tips and margins of the leaflets, rachis, petiole and stem. Under favourable conditions (low temperature and high humidity) the lesions rapidly increase in size involving the whole surface of the leaf.

The disease generally first attacks the leaves, and petioles near the ground and the lesions appear on the lower surface of the leaflets on individual plants and then spreads upwards.

Finally, a rapid and general blighting of foliage occurs. The blighted leaves curl and shrivel in dry weather. Under moist conditions they decay and emit a characteristic offensive odour.

Examination of the lesions on the lower surface of the leaf on a dew morning reveals a delicate growth of the fungus parasite in the form of whitish powdery bloom. It consists of sporangiophores and sporangia (.. 22.7 E) of the pathogen pushing out through the stomata. The sporangia serve to spread the disease in the growing season.

Potato tubers are often infected in the field after the tops have been blighted. They get separate infections while in the hill. There is brownish discoloration of the skin of those parts of the tubers which lie nearest the surface of the soil.

These dry rot spots remain firm and extend to about half an inch below the surface. During storage, the bacteria assist to set in the wet rot phase. In cool and dry conditions the progress of the disease is slower and the wet rot phase is generally checked.

Under moist conditions hyaline mycelial hyphae and sporangiophores push out through the lenticels and appear on the surface of infected tubers.

Causal organism and over-wintering:

The causal organism is Phytophthora infestans (Mont.) De Bary. The mycelium is aseptate conenocytic, hyaline and branched. The hyphae are both intercellular and intracellular.

They form rudimentary haustoria in the host leaf cells but in the tubers the haustoria are more common and elaborate (club-shaped, hooked or spirally twisted). According to De Bary (1876), the mycelium overwinters in the infected tubers.

Melhus (1915) confirmed De Bary’s observation. De Bruyn (1926) opined that the fungus overwinters in the soil but this remains unconfirmed. Kaung (1956) stated that in the temperate regions the fungus perannates in soil in the form of sporangia and germ tubes.

Disease Cycle:

The infected tubers (A) are generally considered as the main source of primary infection in India. The survival of the fungus in the soil in the Indian climatic conditions in any form appears remote. According to the widely held view, the fungal parasite overwinters as a dormant mycelium in the infected tubers.

It becomes activated at the time of germination of the diseased seed tubers among the planting stock or waste tubers in dump heaps or infected tubers remaining in the ground after a previous crop. The activated mycelium invades the healthy sprouts (B).

The second view is that the thick-walled resting oospores which are found in abundance in the infected tubers are the important overwintering structures. They play a significant role as the source of primary infection.

At the planting time, the resting oospore germinates. The germ tube after emergence usually ends in a terminal sporangium. The contents of the latter divide to form zoospores. The released zoospores invade the healthy sprouts and bring about infection.

According to some, the sexual phase seems to play no role in the life history of the pathogen. The infected sprouts emerge above ground and produce shoots which contain the mycelium (C).

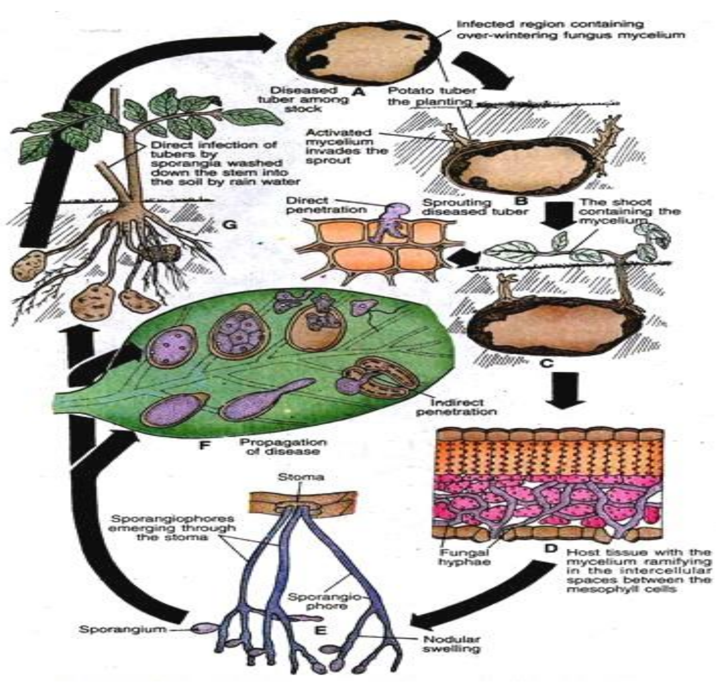
It grows and ramifies in the intercellular spaces absorbing nutrition by putting haustoria into the host cells (D). Under suitable conditions of temperature and humidity, the mycelium pushes out hyahne, branched, indeterminate sporangiophores through the stomata of the host leaves (E).

The thin-walled, ovoid or lemon-shaped sporangia, each with an apiculate tip, are borne singly at the tips of sporangiophores or their branches. As the sporangium reaches maturity, the supporting hyphal branch immediately below it swells slightly and continues to grow turning the attached sporangium to the side.

The elongation of the branch proceeds and a new sporangium is formed. The process is repeated. A fertile branch or sporangiophore is thus characterised by 9 or 10 such swellings occurring at intervals.

Each nodular swelling marks the point where the sporangium was borne. The mature sporangia are readily detached and spread by splashing rain or air currents to new potato plants (F_1 and a). Grosier (1934) who studied the biology of Phytophthora infestans reported that the sporangia are formed within a temperature range of 3° to 26°C with an optimum of 18° to 22°C. The minimum relative humidity required is 91 percent with an optimum of 100 percent.

On reaching a suitable host (potato), the sporangia germinate on the leaves (F). Germination is influenced by moisture and temperature conditions.



(a) Indirect Germination:

In cool moist weather the sporangia function as zoosporangia (F_{1-3}). The optimum temperature for the formation of zoospore is 12ºC (54°F). In the indirect germination the protoplasmic contents of sporangium divided to form a number of (usually 8) biflagellate zoospores (F_3).

They are liberated in a group through terminal pore formed by rupture of the apical papilla. The released zoospores, after a brief period of activity in rain water or dew come to rest. Each retracts its flagella and secretes a wall around it.

The clothed zoospores (cyst) then germinates by pushing out a germ tube or infection thread (F_4). The zoospores germinate rapidly at 12° to 15°C. Cool and moist nights are thus favourable for the formation and germination of zoospores. The germ tubes show rapid growth at 21°C . After infection they grow best at a slightly higher temperature.

(a) Direct Germination:

Under dry and warmer conditions no zoospores are formed. The sporangium functions as a conidium (F_a). It directly puts out a germ tube or infection thread (F_b). The optimum temperature for this direct germination of sporangia is about 24° or '25°C.

The indirect method of germination of sporangia by the formation of zoospores in a terrestrial late blight fungus is an instance of retention of an ancestral primitive character which was normally used by its aquatic ancestor.

(b) Spread of the Disease (Secondary Infection):

The infection thread produced on the surface of the host leaf in either of the two above-mentioned methods enters the host tissue (leaves or stem). It makes its entry occasionally through the stoma but more often it penetrates directly through the cuticle by a penetration hypha arising from an appresorium (F_4).

The lower surface of the leaf is more susceptible than the upper. The infected leaves produce another crop of sporangia. These are carried by wind to the healthy plants which are thus infected. This constitutes secondary infection. The process is repeated.

As a result the disease spreads during the growing season over large tracts under potato cultivation. The disease spreads quickly when cool and wet nights alternate with warm moist days. Low temperature and high humidity favour the spread of the disease.

Field infection of Potato Tubers:

The tubers get separate infections (G). It is caused by zoospores produced in foliage lesions (blighted tops) or present in the contaminated soil. Sporangia and zoospores come in contact with the tubers in two ways.

Firstly, by contact freshly lifted healthy and wounded tubers with diseased haulms and contaminated soil.

Secondly, during crop growth, the zoospores and sporangia washed down the stems into the soil by rain come in contact with the tubers.

Tuber infection is dependent on the germination of sporangia, release and motility of zoospores. The released zoospores have to move through soil to the infection sites. The longer the zoospores continue to swim and greater their number, the greater are the chances of infection. The germ tubes gain entrance through the eyes, wounds and lenticels.

According to Sato (1979), wet cool soil promotes infection but wet warm soil lowers it because cool water at 16°C or below 12-14°C favours indirect germination of sporangia and prolongs motility of zoospores. The sexual phase seems to play no significant role in the life history of the pathogen.

The severity of late blight infection is governed by environmental conditions.

The chief among them are:

(i) Night temperature below dew point for 4 or more hours,

(ii) Minimum temperature 10°C or slightly above,

(iii) Mean cloudiness not below O.8°C on the next day,

(iv) Rainfall during next 24 hours, at least 0.1 mm.

Control Measures of Late Blight:

Various methods of control of the disease are known.

These are:

1. Selection of Seed (Planting) Tubers:

The seed tubers should be free from the disease. This requires strict seed tuber inspection at the cutting time. This measure will eliminate direct infection.

2. Storage of Tubers at 40ºF or below:

Storage of potato tubers in cold storage rooms reduces or even checks the progress of the rot.

3. Growing Disease Resistant Varieties:

Considerable success has been achieved in the perfection of resistant varieties of potato at the potato breeding station, Simla. Growing these will provide an increasing opportunity to combat the disease.

4. Use of Fungicides:

Resistance alone has not effectively checked the disease. Therefore the complete control of blight is accomplished by the application of protectant fungicides. These are applied before infection for effective control in two ways namely by spraying or dusting as follows:-

4a. Spraying:

The best method of control is the timely and repeated foliage spray schedule with copper fungicides such as Perenox, Blitox-50 and Fytolan. Dithane Z-78, and Dithane M-22 have proved more effective than the copper fungicides. The spraying should start when the plants are 8 inches tail.

It should continue until the harvest time at 10 days' interval. Both the surfaces of foliage should be properly protected by adequate spraying delivered with a considerable force in the form of fine mist.

Roy and Das (1968) found Brestan 60, Dithane M-45 and Zineb useful for the control of late blight in Assam. Mistiming of sprays may have serious consequences for late blight control in N.E.U.S.A.

Mancozeb and Chlorothalonil are the major fungicides which are presently used. Both fungicides inhibit sporangial and spore germination but has little effect on the mycelium in the leaf tissue.

4b. Dusting:

Some people claim that dusting the foliage with copper-lime dust is a more effective control measure. Dusting is done in the morning when the plants are wet with dew.

5. Sanitation:

Destruction or proper disposal of potato tuber refuge from pits and store houses IS another practical measure to reduce the incidence of disease.

6. Tuber treatment before storage:

The tubers should be dipped in 1: 1,000 mercuric chloride solution for 90 minutes before storage. Before use they should be washed.

7. Avoidance of injuries to tubers at harvest is also important.

8. In cool humid areas killing of foliage a few days before harvest proves beneficial. This is accomplished by spraying with herbicides or flame throwers or by the use of mechanical vine beaters.

Red Rot of Sugarcane: Symptoms and Control | Plant Diseases

In this article we will discuss about:- 1. Introduction to Red Rot of Sugarcane 2. Symptoms of Red Rot of Sugarcane 3.Causal Organism 4. Disease Cycle 5. Control.

Contents:

1. Introduction to Red Rot of Sugarcane:

This is one of the most severe of the known diseases of sugarcane. It was first described from Java by Went in 1893. It is widely distributed throughout the sugarcane-growing countries of the world, and in fact it is extremely doubtful if there are any sugarcane-growing areas where it does not exist, although it may be much more destructive in some places than others.

The disease was very widespread and virulent in North Behar and Eastern part of the United Provinces during 1939 and 1942. It was so destructive that it almost whipped out the sugarcane plantations in those areas.

2. Symptoms of Red Rot of Sugarcane:

The first external evidences of disease are the drooping, withering, and finally yellowing of the upper leaves. This is followed by a similar wilting of the entire crown, and finally the entire plant shows indications of disease and dies. When not severe, the eyes frequently die and blacken and the dead areas extend out from the nodes.

Infection in the stem being internal, the presence of the disease is not visible externally. Upon splitting a diseased cane during the early stages of the disease, it will be found that the fibro-vascular bundles near the base are reddish in colour. The host tissue reacts vigorously to the presence of the fungus and some kind of reaction or change sets in the host cells in advance of the hyphal invasion.

The protoplasm changes colour and a gummy dark-red material oozes out of the cells filling the intercellular spaces. The soluble pigment present in this ooze, is absorbed by the cell wall producing the characteristic red rot appearance.

However, the presence of a red colour in the fibro-vascular bundles is not necessarily an indication of this disease, since the colour may be due to any one of many other causes. As the disease advances the red colour spreads to the surrounding tissues extending through many internodes and irregular discoloured blotches are formed, which may be reddish or yellowish or white with red margins (.. 374A).

These white areas with red margins are a positive proof of the disease. When the stem is completely rotted inside, the natural bright colour of the rind disappears and turns dull as it shrivels. Black specks appear on shrivelled rind. The stem shrinks at the nodes (.. 374C). Split cane gives sour smell and shows red tissue with white cross-bands.

About this time the upper leaves of the stem turn pale and gradually droop down. These leaves then wither at the tips and along the margins. Ultimately the entire plant withers and droops down. In areas where the disease appears in a severe epidemic form, the entire crop withers and droops resulting in a complete loss of crop.

Though the fungus attacks all parts of the host above ground, stems and midribs of leaves are more susceptible to fungal attack. Infection in the leaves is visible along the midribs as dark-reddish zones having tendency to elongate rapidly turning blood-red enclosed by dark margins (.. 374B). When the infection becomes old, the central blood-red colour changes to straw colour.

The hyphae after ramifying in the infected host tissue collect beneath the epidermis and form a stroma of densely packed cells and ultimately an acervulus is developed resulting in the rupture of host epidermis. The acervulus bears long septate setae along with short conidiophores on which falcate (sickle-shaped) conidia are borne (.. 374D to F).

After growing for a period within the host tissue, the hyphae produce a large number of chlamydospores in the pith parenchyma. The chlamydospores persist in the soil for a long time.

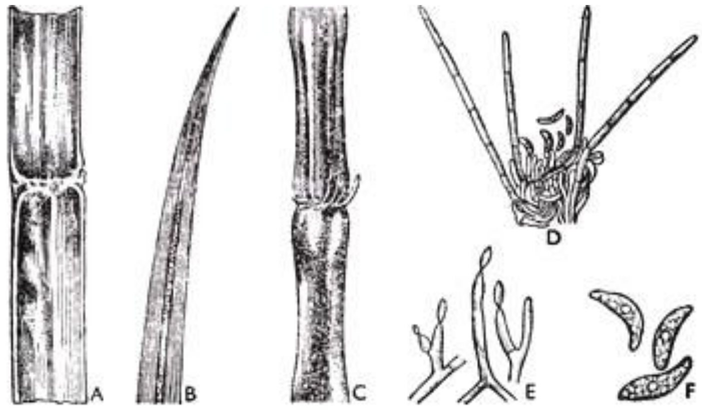


Fig. 374. Red Rot of sugarcane. A—C. Disease symptoms. A and C. On stem. B. On leaf. D. An acervulus. E. Conidiophores producing conidia. F. Conidia.

An examination of the diseased tissues with a microscope will reveal more or less mycelial threads of the fungus, or if the diseased canes are split and put in a moist chamber the fungus will develop readily and be easily recognized.

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3. Causal Organism of Red Rot of Sugarcane:

Red rot of sugarcane disease is caused by Colletotrichum falcatum Went, the perfect stage of which is Glomerella tucumanensis (Speg.) Arx and Muller. There has been considerable difference in opinion as to the nature of the fungus that causes this disease. Some insisted that this fungus is more strictly saprophytic than parasitic, and that it cannot attack healthy canes.

Others said that it cannot attack mature canes except through wounds, but that it can attack young plants. However, the young canes are usually protected by the leaf sheaths. In some places the fungus has been reported to grow on the dead canes only and the disease is not known.

The mycelium of the fungus grows both inter- and intracellularly in the parenchymatous cells of the host tissue. The hyphae are colourless, slender, freely branched and septate. Acervuli appear just above or below the nodes along the depressions or ridges.

They are black velvety bodies, develop in clusters. Acervuli are cuspidate with irregularly arranged setae (.. 374D). Aseptate conidiophores 20µ long and 8µ wide, on which one-celled falcate conidia are borne. Conidia are 16 to 48μ long and 4 to 8μ broad. They bear large oil globule in the centre. Chlamydospores are terminal or intercalary.

The perfect stage was reported from India under cultural condition in 1952 and under natural conditions on sugarcane leaves in 1953. It comprises of perithecia which are globose superficial with bottom embedded in the host tissue. Asci are numerous, clavate and paraphysate bearing 8 ascospores which are aseptate, hyaline and elliptical.

4. Disease Cycle of Red Rot of Sugarcane:

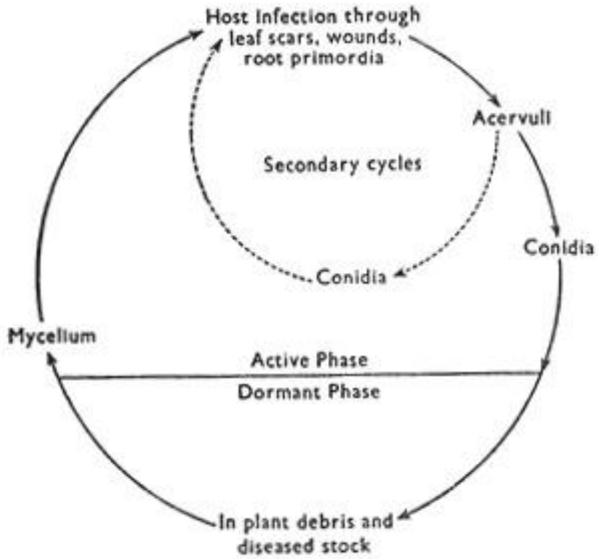
The sources of primary inoculum are the old fragmented stalks and leaves and other rubbish on which the fungus grows saprophytically; and unknowingly planted diseased stock during cultivation. Ratoon crops also serve as a source of primary inoculum. Opinions differ whether the fungus is strictly saprophytic or parasitic.

The conidia that are produced in the acervuli developed along the midribs of the diseased leaves during primary infection, form the secondary inoculum. They are disseminated by wind, rain splashes, irrigation water and also by insects. The conidia germinate readily by germ tube which on coming in contact with any hard surface, e.g., soil particles or plant parts, forms appressorium from-which infection hypha is produced.

The pathogen may gain entrance through the nodes at the leaf scars, through any kind of wound, through root primordia and seed-cuttings. The diseased canes are frequently found to be injured by insects, especially borers, and no doubt these wounds facilitate the entrance of the fungus, which in turn does much more damage than the insects.

Red rot is not a root disease, though roots are often infected by the fungus. High humidity due to water-logging, weak growth of host plant for want of proper cultural operations, continuous cultivation of the same variety of sugarcane in a particular locality, and cultivation of susceptible cane variety in the neighbouring areas are some of the aspects that help disease incidence and often to epiphytotic.

Disease cycle of Red Rot of sugarcane is presented in .ure 375.



5. Control of Red Rot of Sugarcane:

Red rot of sugarcane is hard to control because the stalk from which seeds are prepared has been largely affected from the time of planting, and fungicides cannot reach the infected tissues inside a diseased seed sett. Therefore careful selection of red rot-free seed setts is recommended for planting. Seed should always be taken from disease-free nurseries examined regularly by the cane protection staff.

Before planting, each seed sett should be carefully examined and those setts which show reddening should be discarded.

The spread of the red rot can be prevented during the growing season by timely rogueing and burning of the affected clumps with utilization of the green leaves for cattle fodder. In no case ratoons of sugarcane should be kept in the red rot affected fields. Attention should always be given to sanitation by digging out stubbles of diseased canes and burning them with other trash in the field.

Where facilities are available for hot water treatment of seeds, they can be utilized for controlling red rot of seed (treat in water at 50°C., for two hours). Treating seed with fungicides like Arasan (0.25 per cent.) is often effective.

The use of sugarcane varieties resistant to red rot is also recommended. Some of the resistant varieties are: Co. 975, 1148, 1158, 1336 and 6611; Co. S 561, 574; B.O. 3, 10, 47.

The possibilities of an epidemic is very much minimized with the practice of long crop rotations (2 to 3 years) where planting is done in plots.

One of the best ways to reduce the incidence of the disease is to raise healthy stock for planting in plots especially fertilized, cultivated, and kept disease-free by constant care.

Citrus Canker Disease (With Diagram)

In this article we will discuss about the citrus canker disease caused by bacteria.

Host: Citrus sp.

Pathogen: Xanthomonas sp.

Introduction to the Citrus Canker Disease:

Citrus Canker is a bacterial disease of worldwide distribution occurring wherever citrus is grown. It is a serious menace to our most valued citrus orchards causing objectionable blemishes on the fruit. The disease causes serious damage in India, China, Japan and Java.

The pathogen incites severe canker disease in a number of citrus species on stems, leaves and fruits. The disease attacks most of the species/varieties of citrus. The most susceptible species are the acid lime plants, the sweet orange and the grape fruit.

Symptoms of Citrus Canker Disease:

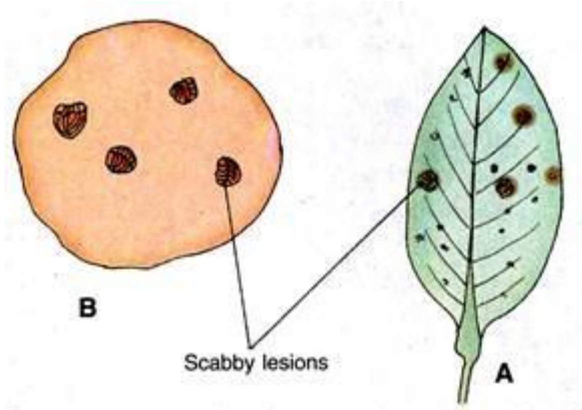
Crast-like disease lesions or scabby spots and small cankers (open wounds or dead tissue surrounded by living tissue) appear on all over ground parts of the plant such as leaves, young branches and fruits. The trees are, however, not commonly killed.

The lesions on the foliage, at first, appear on the lower surface as small round raised spots. These are translucent and of yellowish brown colour. Later the spots turn white or greyish and finally rupture. The older lesions are corky and brown, sometimes purplish.

The necrotic brownish canker regions are surrounded by a yellowish brown to green raised margin and distinct watery yellow halo region. The yellow halo region is free from the pathogen. The cankerous lesions contain the pathogen in millions.

Mairie suggested that the halo regions are formed due to the response of the host tissue to a diffusible metabolite of the pathogen. Padmanabhan et al. (1975) reported accumulation of malic acid in the halo region due to increased respiration in this region.

The lesions on the twigs are usually irregular in form. The lesions on the fruit are similar to those on the leaves but lack the yellow halo.



Causal Organism:

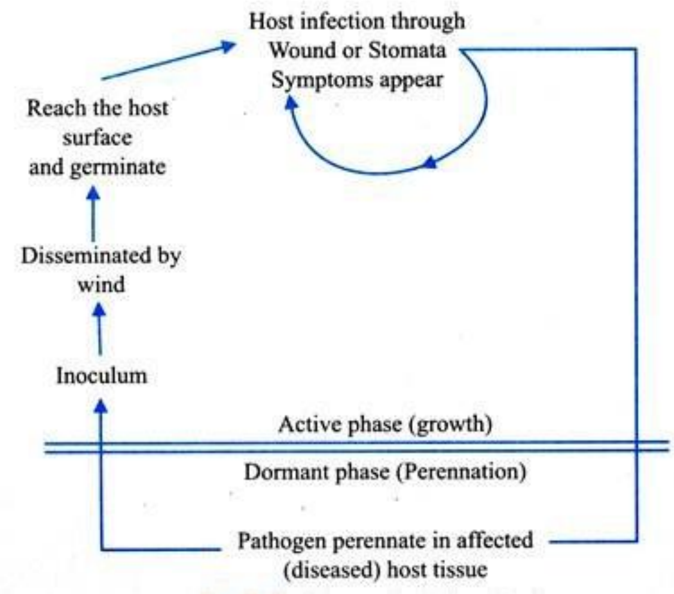
The causal organism is the bacterial pathogen Xanthomonas citri, now called X. campestris pv. citri (Hasse) Dowson. It consists of a short, motile rod (1.5-2.0 x 0.5- 0.75 µ) furnished with a single polar flagellum (monotrichous). It lacks endospore formation. It is a gram negative, aerobic form surrounded by a mucilaginous capsule. It forms chains.

The climate factors which favour the disease are the mild temperature and wet weather. The most suitable range of temperature appears to be 20ºC to 30ºC.

Disease Cycle:

Infection takes place through the stomata and wounds. The disease is not soil borne. The pathogen perennates in the old lesions on the twigs still attached to the host plant.

From there it is carried by driving rains and by insects to new localities. Man functions as the chief agent of dissemination by planting infected nursery stock in new localities.



Control Measures of Citrus Canker Disease:

To combat the disease in order to prevent economic loss or to reduce to a low level following measures can be suggested:

1. Eradication:

The disease is controlled by the eradication of diseased trees. This is accomplished by removing the trees with advanced infection and burning them.

2. Pruning:

The infected trees may be cured by removing the diseased foliage and branches with pruning scissors and then spraying the trees with one percent Bordeaux mixture at regular intervals.

3. The use of disease free nursery stock for planting is the best method of controlling the disease.

4. The fallen infected leaves and twigs should be collected and burnt.

5. Spraying:

Spraying with Bordeaux mixture and lime sulphur is a useful measure to protect the fruit. It should be done during the first three months after the beginning of fruit formation. Spraying should commence before the onset of rains and repeated during the rainy season.

6. Citrus nurseries should be raised in places away from the regions of heavy and protracted rainfall. There should be no **"khatti"** hedge around the nurseries.

7. Rangaswamy (1957) reported that the use of antibiotic sprays is useful in controlling the disease. Streptomycin sulphate and Phonomycin have been found to be effective. Vaheeddudin (1959) found that spraying with neem-cake is effective in controlling citrus canker.

References

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6. Webster, J. & Weber, R. (2007). Introduction to Fungi (3rd ed.). Cambridge: Cambridge University Press.

Possible Questions

- Explain the general characteristics of plant disease caused by fungi
- With the help of neat diagrams explain Rust and Smut of Wheat
- Explain in details about the White rust disease in Cruciferae
- Explain White blight of Potato
- Describe in details about the casual organism, symptoms and control measures of Late blight of potato

- Explain the economic aspects of plant diseases caused by different fungi
- What re the economic importance of lichens
- What is citrus canker? Describe in details about the casual organism, symptoms and control measures