COURSE: MSc Part -1

PAPER – 2

TOPIC- Fungi(Various topics)

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Topic-1

Par asexual cycle in Fungi

In most of the plants the life cycle is completed by adopting two distinct stages called as 1) Vegetative phase and 2) Reproductive phase. Reproductive phase in Fungi is completed as vegetative reproduction , asexual reproduction and sexual reproduction. During sexual reproduction the two mating types having haloid status fuse to form a diploid structure. The diploid structure is capable to tide over unfavourable condition and with return of favourable condition germinates. Germination begins with meiosis where genetic recombination also occurs. A new method of Genetic recombination was noticed by Pontecarvo and Roper of University of Glasgow in 1952 in *Aspergillus nidulans*, the imperfect stage of *Emericella nidulans*. This cycle hence force was called as Parasexual Cycle where true sexual cycle comprising of nuclear fusion and meiosis is absent.The Parasexual Cycle is defined as a cycle in which plasmogamy, karyogamy and meiosis (haploidisation) take place but not at a specified time or at specified points in the life-cycle of an organism.

Generally parasexual cycle occurs in those fungi in which true sexual cycle does not take place. The members of class Deuteromycetes (Deuteromycotina) in which sexual cycle does not occur, exhibit parasexual cycle. This cycle has not only been reported in members of Deuteromycetes but also in fungi belonging to Ascomycetes and Basidiomycetes.

Steps Involved in Parasexual Cycle:

According to Pontecarvo (1958), parasexual cycle in *A. nidulans* involves the following steps:

(i) Formation of heterokaryotic mycelium

(ii) Fusion between two nuclei (Karyogamy)

(a) Fusion between like nuclei

(b) Fusion between unlike nuclei

(iii) Multiplication of diploid nuclei

(iv) Occasional Mitotic crossing over.

(v) Sorting out of diploid nuclei

(v) Occasional haploidisation of diploid nuclei, and

(vii) Sorting of new haploid strains.

A brief account of these steps is being presented below:

(i) Formation of heterokaryotic mycelium:

Heterokaryotic mycelium is formed in several ways. The most common is by the anastomosis of somatic hyphae(Homokaryotic mycelium) of different genetic combinations.

The foreign nucleus or nuclei introduced into a mycelium multiplies and its progeny spreads through the mycelium rendering it heterokaryotic. Mutation in one or more nuclei of a homokaryotic mycelium also makes it heterokaryotic.

It happens in some of the fungi belonging to Ascomycetes. Still a third way is by the fusion of some of the nuclei and their subsequent multiplication and spread among the haploid nuclei. In this type of heterokaryotic mycelium a fixture of haploid and diploid nuclei occur.

(ii) Fusion between two nuclei (Karyogamy):

The fusion of nuclei in the mycelium has been demonstrated. The nucelar fusion may be of two types:

(a) fusion between like nuclei and

(b) fusion between unlike nuclei.

The nuclear fusion results in the formation of homozygous or heterozygous diploid nucleus respectively.

If the genotype of unlike nuclei present in the heterokaryotic mycelium is A and B, then five types of nuclei can be formed by their fusion: two types of haploid nuclei (A and B), two types of homozygous diploid nuclei (AA and BB) and one type of heterozygous diploid nucleus (AB).

(iii) Multiplication of diploid nuclei:

The above mentioned five types of nuclei multiply at about the same rate but the diploid nuclei are present in much smaller number than the haploid nuclei. Pontecarvo (1958) estimates a proportion of one diploid heterozygous nucleus to 1000 haploid nuclei.

(iv) Occasional mitotic crossing over:

During multiplication of diploid nuclei, mitotic crossing over may take place. This results in the formation of new gene combinations. These recombinations, which are dependent on the existence of heterokaryosis, give the fungus some of the advantages of sexuality within the parasexual cycle.

According to Pontecarvo's (1958) estimates, the amount of recombinations which may be expected to occur in an ascomycete through its parasexual cycle is 500 times smaller than through its sexual cycle.

However, in Penicillium chrysogenum and Aspergillus niger, diploidisation and mitotic crossing over occur more frequently indicating the importance of parasexual cycle in evolution of new strains.

(v) Sorting out of Diploid nuclei:

In those fungi which produce uninucleate conidia, sorting out of the diploid nucleus occurs by their incorporation into conidia which germinate to produce diploid mycelia. Diploid strains of several important imperfect fungi have been isolated.

Roper (1952) first synthesized and isolated diploid strains of *Aspergillus nidulans*. The conidia of diploid strains are somewhat larger than those of haploid strains.

(vi) Occasional haploidisation of the diploid nuclei:

Occasionally, some hyphae of diploid mycelium form haploid conidia which form haploid mycelia on germination. The formation of haploid conidia by diploid mycelium indicates that haploidisation occurs in some diploid nuclei.

(vii) Sorting of new haploid strains:

Some diploid nuclei undergo haploidisation in the mycelium and are sorted out by incorporation of haploid nuclei in the uninucleate conidia. Some of these haploid strains are genotypically different from their parents because of their mitotic recombinations.

Thus, after the parasexual cycle has operated for some time, the mycelium may contain the following types of nuclei:

(a) Haploid nuclei like those of both the parents,

(b) Haploid nuclei with various new genetic recombinations,

(c) Several types of diploid homozygous nuclei,and

(d) Several types of diploid heterozygous nuclei.

Significance of Parasexual Cycle:

Parasexual cycle is of importance in industrial processes. Several fungi which are used in various industrial processes belong to fungi imperfecti or Deuteromycetes and in these fungi only parasexual cycle operates.

New and better strains of these fungi are obtained by mutation through parasexual cycle. The strains of desirable characters can be developed through mitotic recombinations.

Parasexuality can also be applied in the analysis of genetic and physiological processes of perfect and imperfect fungi. Parasexual cycle has also been successfully employed in genetic control of pathogenicity and host-range in several species of Fusarium.

Topic-2

HETEROTHALLISM IN FUNGI

Homothallic is the condition of having both male and female reproductive structures on the same thallus whereas heterothallic is the condition of having male and female reproductive structures in different thalli.Homothallic and heterothallic are two conditions of sexual reproduction found in fungi and some algae. In a homothallic condition, the resources for sexual reproduction occur in the same organism while in a heterothallic condition, sexual reproduction requires the presence of two compatible partners.

The term Heterothallism was first used by an American geneticist A.F. Blakeslee in 1904 when he observed that zygospores could develop in some spp. only when two mycelia of different strains were allowed to come in contact with each other.

Blakeslee made these observations as a result of his studies on zygospore formation in Mucorales. He found that in some species of *Rhizopus*, zygospores were formed freely while in others like *R. nigricans* zygospores were formed rarely.

In *Mucor hiemalis*, too zygospores were formed rarely. On the basis of his studies, he divided the various species of Mucorales into two groups:

Heterothallic and **Homothallic**.

Thus heterothallic species are those which require mycelia of two different strains to interact to enable the zygospores to be formed while the homothallic species are those which require mycelia of only one strain to interact for the formation of Zygospores.

According to Blakeslee (1904) Heterothallic condition is "essentially similar to that in dioecious plants and animals and although in this case the two complimentary individuals which are needed for sexual reproduction are in general not so conspicuously differentiated morphologically as in higher forms, such a morphological difference is often distinctly visible."

He concluded that the Zygospore formation is a sexual process. In homothallic species, the mycelium is bisexual while the mycelium in heterothallic species is unisexual, (+) and (-) strains represent the two different sexes.

Heterothallism may therefore be defined as the condition in which Zygospore formation takes place only when mycelia arising from asexual spores of two genetically different mating types (+) and (-), are allowed to interact.

On the other hand the condition, in which one individual originating from a single asexual spore is capable of forming zygospores independently, is known as Homothallism.

Blakeslee proved the phenomenon of heterothallism on the basis of the experiments he conducted using several species of Mucorales. He inoculated spores of two different strains of *Mucor hiemalis* on a petridish containing synthetic agar medium.After a few days it was observed that the zygospores were formed along the zone of contact of two mycelia. In another experiment he inoculated spores of only one strain on a petridish containing synthetic agar medium and after some time it was observed that absolutely no zygospores were produced in this experiment.From these experiments, he concluded that zygospores could be formed only when mycelia of two different strains were allowed to come in contact.

Blakeslee and his coworkers (1928) examined different genera of Mucorales to test whether these were homothallic or heterothallic. Most of the genera tested were homothallic while only a few genera were found to be heterothallic.

In heterothallic species of *Mucor mucedo*, the zygospores upon germination produced germsporangia which contain spores of only one strain (either + or -).In this case, zygospores could be formed only when mycelia formed from spores of (-) strain formed in germsporangia produced on germination of zygospores are allowed to come in contact with the mycelia produced from the spores of (+) strain.

But in the heterothallic species of *Phycomyces nitens* Spores of (+) and (-) strains are produced in the same germsporangium. Blakeslee thus regarded the (+) and (-) strains of heterothallic species as differing in sex and the term heterothallism may therefore be treated as equivalent to dioecism in haploid organisms.

Since the discovery of heterothallism in Mucorales by Blakeslee, the phenomenon has been reported in several groups of fungi. Though variations may occur, but all heterothallic species share one common feature of inter mycelial contact.

While in *Dictyuchus monosporous* it is dioecism, in *Ascobolus magnificus*, it is expressed as self-sterility or self-incompatibility. Both the fungi resemble the heterothallic Mucorales in that sex-organs or gametangia are formed only when opposite strains come in contact.

In *Dictyuchus monosporous* the two sex-organs are formed by different strains but in *Ascobolus magnificus*, each strain produces sexorgans but these are self-sterile.

On the basis of these observations, the heterothallism may be of two types:

Morphological heterothallism and Physiological heterothallism.

Morphological heterothallism:

Morphological heterothallism may be defined as the condition when morphologically different male and female sex organs are produced in two closely associated mycelia.

The two sex organs or gametes are so morphologically different that it is easier to term one of them as male and the other as female-examples of such type of morphological heterothallic fungi are: *Achlya ambisexualis, A. bisexualis, Blastocladiella variabilis, Dictyuchus monosporus, Phytophthora palmivora and Peronospora parasitica*

However, in *Blastocladiella variabilis* the male and female gametangia are morphologically distinct, the male being smaller than the female. Whitehouse (1949) also used the term haplodioecious for morphologically heterothallic species of fungi.

Physiological Heterothallism:

In physiological heterothallism, the interacting thalli differ in mating type or incompatibility, irrespective of the presence or absence of the sex organs or gametes. This means that sexual reproduction takes place by two morphologically similar but physiologically different hyphae in physiological heterothallism.

The gametangia as well as gametes do not show morphological differentiation but physiologically they behave differently.

Physiological heterothallism may be of two types:

(i) **Two Allelomorphs or Two-Allele Heterothallism**:

When nuclei of both the mating types are different in genetic characters, this type of Heterothallism is known as Two-Allele heterothallism. In these types compatibility is governed by a pair of Alleles represented by A and a located at single same locus of the chromosome.

(ii) **Multiple Allelomorph or Multiple Allele Heterothallism**:

In this type of heterothallism, more than two (multiple) alleles determine the sexual compatibility. These may be located at one (bipolar) or two (tetrapolar) loci.Because of the larger number of alleles involved in this type of heterothallism, chances of mating of compatible strains increase.

As stated above, the multiple allele heterothallism may be of two types:

(a) **Bipolar Multiple-allele heterothallism**

(b) **Tetrapolar multiple-allele heterothallism.**

(a) Bipolar Multiple-Allele Heterothallism:

This type of heterothallism is controlled by multiple alleles at a single locus, instead of a pair of Alleles. For example, if the locus is named as L, the multiples alleles will be designated as L1, L2, L3, L4—Ln and these are present on the single locus L.

(b) **Tetrapolar Multiple Allele heterothallism**:

This type of heterothallism is characteristic of Basidiomycetes except rusts. In this type of heterothallism, which is very similar to bipolar multiple allele heterothallism, compatibility is determined by two loci.

Multiple allele—the compatible factor is present on two loci L1 and L2 of two Chromatids of a chromosome. At the time of meiotic division, both the loci are separated with chromatids.

According to Garrett (1963), "heterothallism promotes the out-breeding and therefore subserves the same end as the sexual process, which it renders most efficient. Hetrothallism is not the same as sex, it is refinement super imposed upon it."

Topic-3

METHOD OF MUSHROOM CULTIVATION

Mushrooms are fleshy, edible fungi that are a low-calorie food and a good source of Vitamin B. Shiitake, porcini and chanterelle are some types of mushrooms. The edibility of mushroom depends on the absence of poisonous effects on humans and the desirable taste and aroma. They are somewhat meaty in flavor and taste and are also a great source of Vitamin D.

Usage

The use of edible mushrooms is since hundred years BC in China, where they were used for its medicinal value as well as for food. They can be purchased fresh or dried and preserved.

Mushroom powder, made from dried button mushrooms is popularly used as a flavoring agent in soups, stews, dips and sauces.Since mushrooms already contain so much water, they do not require any soaking.Though its medicinal value has not yet been acknowledged by science it is traditionally used in Japan, Korea and China for radial treatments and chemotherapy.

Nutritional Value

1. They do not contain cholesterol or fat but the fibers and enzymes present in them help lower cholesterol levels.

2. Due to its high protein content, mushrooms help maintain cholesterol levels and so protect against cardiovascular diseases like stroke and heart attack.

3. They are very good for diabetic patients as they have no fat, no cholesterol, and very low level of carbohydrates but high protein content.

4. Some compounds that are present in mushrooms are responsible for proper functioning of the liver and pancreas.

5. They contain various polysaccharides that have anti carcinogenic effect. Mushrooms are therefore helpful in preventing breast and prostate cancer.

6. Mushrooms are a good source of iron and are hence suggested for a good diet incase of anemia.

7. Being a good source of Vitamin C and D it is good for bone health and a good metabolism.

8. A powerful antioxidant called Ergothioneine that is present in mushrooms, protects the body from free radicals and boosts the immune system.

9. Shiitake mushrooms can fight tumors, white mushrooms are very good for weight loss and maitake mushrooms are very good breast cancer preventives.

The six steps of mushroom farming:

Phase I

1. Composting

Phase II

2. Composting

3. Spawning

4. Casing

5. Pinning

6. Cropping

These steps are described in their naturally occurring sequence, emphasizing the salient features within each step. Compost provides nutrients needed for mushrooms to grow. Two types of material are generally used for mushroom compost, the most used and least expensive being wheat straw-bedded horse manure. Synthetic compost is usually made from hay and crushed corncobs, although the term often refers to any mushroom compost where the prime ingredient is not horse manure. Both types of compost require the addition of nitrogen supplements and a conditioning agent, gypsum.

The preparation of compost occurs in two steps referred to as Phase I and Phase II composting. The discussion of compost preparation and mushroom production begins with Phase I composting.

Phase I:

1. Making Mushroom Compost

Mushroom requires nutrient rich substrate for proper growth and development. There must be adequate moisture, oxygen, nitrogen, and carbohydrates present throughout the process, or else the process will stop.Nitrogen supplements and gypsum are spread over the top of the bulk ingredients and are thoroughly

Mixed.. Heat, ammonia, and carbon dioxide are released as by-products during this process.

Mushroom compost develops as the chemical nature of the raw ingredients is converted by the activity of microorganisms, heat, and some heat-releasing chemical reactions. These events result

in a food source most suited for the growth of the mushroom to the exclusion of other fungi and bacteria.. This is why water and supplements are added periodically, and the compost pile is aerated as it moves through the turner. Gypsum is added to minimize the greasiness compost normally tends to have. Gypsum increases the flocculation of certain chemicals in the compost, and they adhere to straw or hay rather than filling the pores (holes) between the straws. A side benefit of this phenomenon is that air can permeate the pile more readily, and air is essential to the composting process. The exclusion of air results in an airless (anaerobic) environment in which deleterious chemical compounds are formed which detract from the selectivity of mushroom compost for growing mushrooms. Gypsum is added at the outset of composting at 40 lbs. per ton of dry ingredients.

Nitrogen supplements in general use today include brewer's grain, seed meals of soybeans, peanuts, or cotton, and chicken manure, among others. The initial compost pile should be 5 to 6 feet wide, 5 to 6 feet high, and as long as necessary. A two-sided box can be used to form the pile (rick), although some turners are equipped with a "ricker" so a box isn't needed. The sides of the pile should be firm and dense, yet the center must remain loose throughout Phase I composting. As the straw or hay softens during composting, the materials become less rigid and compactions can easily occur. If the materials become too compact, air cannot move through the pile and an anaerobic environment will develop.

Turning and watering are done at approximately 2-day intervals, but not unless the pile is hot (145° to 170°F). Turning provides the opportunity to water, aerate, and mix the ingredients, as well as to relocate the straw or hay from a cooler to a warmer area in the pile, outside versus inside. Supplements are also added when the ricks are turned, but they should be added early in the composting process. The number of turnings and the time between turnings depends on the condition of the starting material and the time necessary for the compost to heat to temperatures above 145°F.

Water addition is critical since too much will exclude oxygen by occupying the pore space, and too little can limit the growth of bacteria and fungi. As a general rule, water is added up to the point of leaching when the pile is formed and at the time of first turning, and thereafter either none or only a little is added for the duration of composting. On the last turning before Phase II composting, water can be applied generously so that when the compost is tightly squeezed, water drips from it. There is a link between water, nutritive value, microbial activity, and temperature, and because it is a chain, when one condition is limiting for one factor, the whole chain will cease to function.

Phase I composting lasts from 7 to 14 days, depending on the nature of the material at the start and its characteristics at each turn. There is a strong ammonia odor associated with composting, which is usually complemented by a sweet, moldy smell which result in a food rather exclusively used by the mushrooms. As a by-product of the chemical changes, heat is released and the compost temperatures increase. Temperatures in the compost can reach 170° to 180°F

during the second and third turnings when a desirable level of biological and chemical activity is occurring. At the end of Phase I the compost should: a) have a chocolate brown color; b) have soft, pliable straws, c) have a moisture content of from 68 to 74 percent; and d) have a strong smell of ammonia. When the moisture, temperature, color, and odor described have been reached, Phase I composting is completed.

Phase II:

2. Finishing the Compost

There are two major purposes to Phase II composting. Pasteurization is necessary to kill any insects, nematodes, pest fungi, or other pests that may be present in the compost. And second, it is necessary to remove the ammonia which formed during Phase I composting. Ammonia at the end of Phase II in a concentration higher than 0.07 percent is often lethal to mushroom spawn growth, thus it must be removed; generally, a person can smell ammonia when the concentration is above 0.10 percent.

Phase II takes place in one of three places, depending on the type of production system used. For the zoned system of growing, compost is packed into wooden trays, the trays are stacked six to eight high, and are moved into an environmentally controlled Phase II room. The most recently introduced system, the bulk system, is one in which the compost is placed in a cement-block bin with a perforated floor and no cover on top of the compost; this is a room specifically designed for Phase II composting.

Phase II composting can be viewed as a controlled, temperature-dependent, ecological process using air to maintain the compost in a temperature range best suited for the de-ammonifying organisms to grow and reproduce. The growth of these thermophilic (heat-loving) organisms depends on the availability of usable carbohydrates and nitrogen, some of the nitrogen in the form of ammonia..

A high temperature Phase II system involves an initial pasteurization period during which the compost and the air temperature are raised to at least 145°F for 6 hours. This can be accomplished by heat generated during the growth of naturally occurring microorganisms or by injecting steam into the room where the compost has been placed, or both. After pasteurization, the compost is re-conditioned by immediately lowering the temperature to 140°F by flushing the room with fresh air. Thereafter, the compost is allowed to cool gradually at a rate of approximately 2° to 3°F each day until all the ammonia is dissipated. This Phase II system requires approximately 10 to 14 days to complete.

In the low temperature Phase II system the compost temperature is initially increased to about 126°F with steam or by the heat released via microbial growth, after which the air temperature is lowered so the compost is in a temperature range of 125° to 130°F range. During the 4 to 5 days

after pasteurization, the compost temperature may be lowered by about 2°F a day until the ammonia is dissipated.

It is important to remember the purposes of Phase II when trying to determine the proper procedure and sequence to follow. One purpose is to remove unwanted ammonia. To this end the temperature range from 125° to 130°F is most efficient since de-ammonifying organisms grow well in this temperature range. A second purpose of Phase II is to remove any pests present in the compost by use of a pasteurization sequence.

At the end of Phase II the compost temperature must be lowered to approximately 75° to 80°F before spawning (planting) can begin. The nitrogen content of the compost should be 2.0 to 2.4 percent, and the moisture content between 68 and 72 percent. Also, at the end of Phase II it is desirable to have 5 to 7 lbs. of dry compost per square foot of bed or tray surface to obtain profitable mushroom yields. It is important to have both the compost and the compost temperatures uniform during the Phase II process since it is desirable to have as homogenous a material as possible.

3. Spawning

Mushroom compost must be inoculated with mushroom spawn (Latin expandere = to spread out) if one expects mushrooms to grow.. Microscopic spores form within a mushroom cap, but their small size precludes handling them like seeds. From the germinating spores, the mushroom arises from thin, thread-like cells called mycelium.Specialized facilities are required to propagate mycelium, so the mushroom mycelium does not get mixed with the mycelium of other fungi. Mycelium propagated vegetatively is known as spawn, and commercial mushroom farmers purchase spawn from any of about a dozen spawn companies.

Spawn is distributed on the compost and then thoroughly mixed into the compost. For years this was done by hand, broadcasting the spawn over the surface of the compost and ruffling it in with a small rake-like tool. In recent years, however, for the bed system, spawn is mixed into the compost by a special spawning machine which mixes the compost and spawn with tines or small finger-like devices. In a tray or batch system, spawn is mixed into the compost as it moves along a conveyer belt or while falling from a conveyor into a tray. Once the spawn has been mixed throughout the compost and the compost worked so the surface is level, the compost temperature is maintained at 75°F and the relative humidity is kept high to minimize drying of the compost surface or the spawn. Under these conditions the spawn will grow –

producing a thread-like network of mycelium throughout the compost. The mycelium grows in all directions from a spawn grain, and eventually the mycelium from the different spawn grains fuse together, making a spawned bed of compost one biological entity. The spawn appears as a white to blue-white mass throughout the compost after fusion has occurred. As the spawn grows

it generates heat, and if the compost temperature increases to above 80° to 85°F, depending on the cultivar, the heat may kill or damage the mycelium and eliminate the possibility of maximum crop productivity and/or mushroom quality. At temperatures below 74°F, spawn growth is slowed and the time interval between spawning and harvesting is extended.

The time needed for spawn to colonize the compost depends on the spawning rate and its distribution, the compost moisture and temperature, and the nature or quality of the compost. A complete spawn run usually requires 14 to 21 days. Once the compost is fully grown with spawn, the next step in production is at hand.

4. Casing

Casing is a top-dressing applied to the spawn-run compost on which the mushrooms eventually form. Clay-loam field soil, a mixture of peat moss with ground limestone, or reclaimed weathered, spent compost can be used as casing. Casing does not need nutrients since casing act as a water reservoir and a place where rhizomorphs form. Rhizomorphs look like thick strings and form when the very fine mycelium fuses together. Mushroom initials, primordia, or pins form on the rhizomorphs, so without rhizomorphs there will be no mushrooms. Casing should be pasteurized to eliminate any insects and pathogens it may be carrying. Also, it is important that the casing be distributed so the depth is uniform over the surface of the compost. Such uniformity allows the spawn to move into and through the casing at the same rate and, ultimately, for mushrooms to develop at the same time. Casing should be able to hold moisture since moisture is essential for the development of a firm mushroom.

Managing the crop after casing requires that the compost temperature be kept at around 75°F for up to 5 days after casing,throughout the period following casing, water must be applied intermittently to raise the moisture level to field capacity before the mushroom pins form.

5. Pinning

Mushroom initials develop after rhizomorphs have formed in the casing. The initials are extremely small but can be seen as outgrowths on a rhizomorph. Once an initial quadruples in size, the structure is a pin. Pins continue to expand and grow larger through the button stage, and ultimately a button enlarges to a mushroom. Harvestable mushrooms appear 18 to 21 days after casing. Pins develop when the carbon dioxide content of room air is lowered to 0.08 percent or lower, depending on the cultivar, by introducing fresh air into the growing room. Outside air has a carbon dioxide content of about 0.04 percent.

The timing of fresh air introduction is very important and is something learned only through experience. Generally, it is best to ventilate as little as possible until the mycelium has begun to show at the surface of the casing, and to stop watering at the time when pin initials are forming. If the carbon dioxide is lowered too early by airing too soon, the mycelium stops growing

through the casing and mushroom initials form below the surface of the casing. As such mushrooms continue to grow, they push through the casing and

are dirty at harvest time. Too little moisture can also result in mushrooms forming below the surface of the casing. Pinning affects both the potential yield and quality of a crop and is a significant step in the production cycle.

6. Cropping

The terms flush, break, or bloom are names given to the repeating 3- to 5-day harvest periods during the cropping cycle; these are followed by a few days when no mushrooms are available to harvest. This cycle repeats itself in a rhythmic fashion, and harvesting can go on as long as mushrooms continue to mature. Most mushroom farmers harvest for 35 to 42 days, although some harvest a crop for 60 days, and harvest can go on for as long as 150 days.

Air temperature during cropping should be held between 57° to 62°F for good results. This temperature range not only favors mushroom growth, but cooler temperatures can lengthen the life cycles of both disease pathogens and insects pests. It may seem odd that there are pests which can damage mushrooms, but no crop is grown that does not have to compete with other organisms. Mushroom pests can cause total crop failures, and often the deciding factor on how long to harvest a crop is based on the level of pest infestation. These pathogens and insects can be controlled by cultural practices coupled with the use of pesticides, but it is most desirable to exclude these organisms from the growing rooms.

The relative humidity in the growing rooms should be high enough to minimize the drying of casing but not so high as to cause the cap surfaces of developing mushrooms to be clammy or sticky. Water is applied to the casing so water stress does not hinder the developing mushrooms; in commercial practice this means watering 2 to 3 times each week. Each watering may consist of more or fewer gallons, depending on the dryness of the casing, the cultivar being grown, and the stage of development of the pins, buttons, or mushrooms. One can estimate how much water to add after first break has been harvested by realizing that 90 percent of the mushroom is water and a gallon of water weight 8.3 lbs. If 100 lbs. of mushrooms were harvested, 90 lbs. of water (11 gal.) were removed from the casing; and this is what must be replaced before second break mushrooms develop.

Outside air is used to control both the air and compost temperatures during the harvest period. Outside air also displaces the carbon dioxide given off by the growing mycelium. The more mycelial growth, the more carbon dioxide produced, and since more growth occurs early in the crop, more fresh air is needed during the first two breaks. Farmers lightening and Ventilation is essential for mushroom growing, and it is also necessary to control humidity and temperature. Moisture can be added to the air by a cold mist or by live steam, or simply by wetting the walls

and floors. Moisture can be removed from the growing room by: 1) admitting a greater volume of outside air; 2) introducing drier air; 3) moving the same amount of outside air and heating it to a higher temperature since warmer air holds more moisture and thus lowers the relative humidity. Temperature control in a mushroom growing room is no different from temperature control in your home. Heat can originate from hot water circulated through pipes mounted on the walls. Hot, forced air can be blown through a ventilation duct, which is rather common at more recently built mushroom farms. There are a few mushroom farms located in limestone caves where the rock acts as both a heating and cooling surface depending on the time of year. Caves of any sort are not necessarily suited for mushroom growing, and abandoned coal mines have too many intrinsic problems to

be considered as viable sites for a mushroom farm. Even limestone caves require extensive renovation and improvement before they are suitable for mushroom growing, and only the growing occurs in the cave with composting taking place above ground on a wharf.

Mushrooms are harvested in a 7- to 10-day cycle, but this may be longer or shorter depending on the temperature, humidity, cultivar, and the stage when they are picked. When mature mushrooms are picked, an inhibitor to mushroom development is removed and the next flush moves toward maturity. Mushrooms are normally picked at a time when the veil is not too far extended. Consumers in North America want closed, tight, mushrooms while in England and Australia open, flat mushrooms are desired. The maturity of a mushroom is assessed by how far the veil is stretched, and not by how large the mushroom is.

Consequently, mature mushrooms are both large and small, although farmers and consumers alike prefer medium- to large-size mushrooms.Picking and packaging methods often vary from farm to farm. Freshly harvested mushrooms must be kept refrigerated at 35° to 45°F. To prolong the shelf life of mushrooms, it is important that mushrooms “breathe” after harvest, so storage in a nonwaxed paper bag is preferred to a plastic bag.

TOPIC-4

Development of Ascus and Ascospore

The Ascus and the Ascospore develop in three types of fruiting body found in members of Ascomycetes. They are known as Apothecia, Cleistothecia and Perithecia.

The fruiting body is also known as ascocarp. There are four types of ascocarps:

Cleistothecium- The fruiting body is spherical and remains tightly closed, e.g. *Aspergillus*

Perithecium- The fruiting body is flask-shaped with one external opening, e.g. *Neurospora*

Apothecium- The fruiting body is cup-shaped and asci are present in hymenium, e.g. *Peziza*

Ascostroma- There is no differentiated fruiting body. Asci are present in the stroma, e.g. *Mycosphaerella*

1. The female sex organ of Ascomycetes is called as Ascogonium containing a female nucleus.

2. The male nucleus is transferred during fertilization to bring about Plasmogamy.

3. A mycelial structure known as Ascogenous hyphae emerges from the Ascogonium.

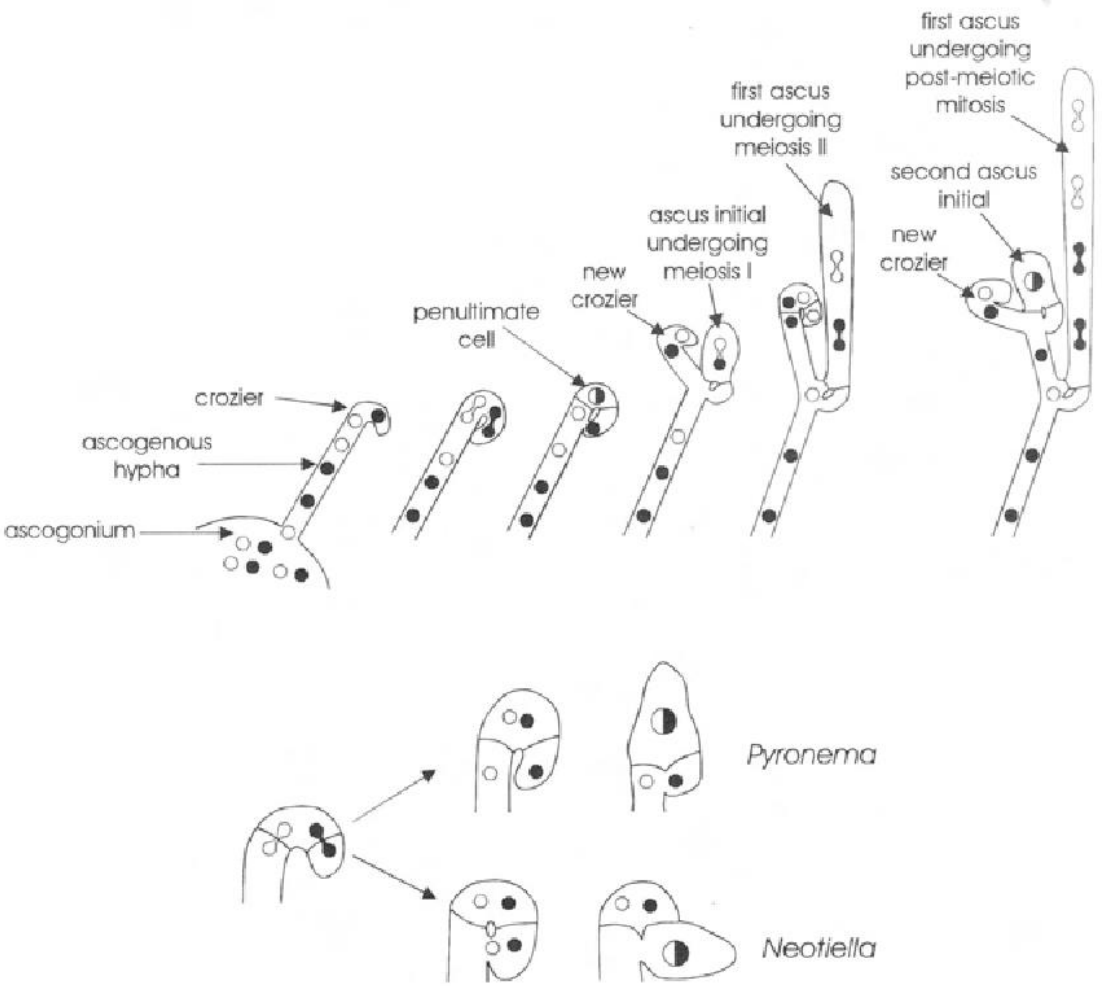
4. The tip of the Ascogenous hyphae bends at the tip to be called as crozier, which contains a male and female nucleus which fuse. This step is called as karyogamy.

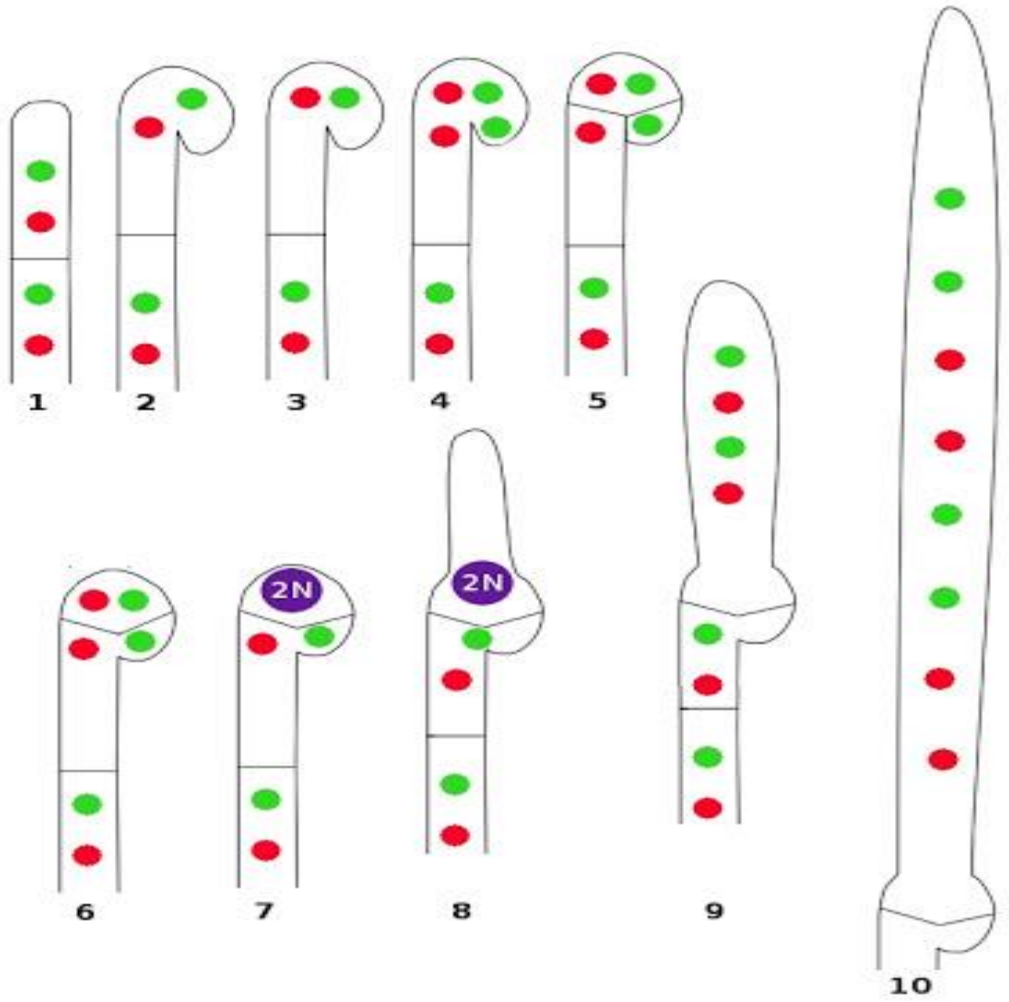
5. Soon the crozier gets differentiated into two regions known as Penultimate cell containing one male and one female nucleus and tip portion as Anti Penultimate cell containing only one nucleus.

6. The penultimate cell ultimately acts as Ascus containing Ascospore.

7. In the Penultimate cell the diploid nucleus divides first by meiotic division into four and then by mitosis into eight nucleus. Each nucleus soon gets transformed into Ascospore.

8. Additional croziers can appear from the side of the Ascogenous hyphae to give rise to another Ascus.


first ascus undergoing post-meiotic mitosis
first ascus undergoing meiosis II
second ascus initial
ascus initial undergoing meiosis I
new crozier
new crozier
penultimate cell
crozier
ascogenous hypha
ascogonium
Pyronema
Neotiella



Sequential development of Ascus and Ascospore in Ascomycetes

TOPIC-5

SEX HORMONES IN FUNGI

These hormones are produced by cells as very specific molecules that have

profound morphogenetic effects on other cells of the same or closely related species.

They regulate the temporal and spatial coordination of the sequence of events

leading to the sexual pairing and fusion of nuclei from two cells. The hormones

are released from their site of synthesis, and by their diffusion they define the cells

that will be involved in the sexual interactions. With one notable exception they

are produced in very small amounts and are active in very small amount.

Chemical communication is essential for coordination of activities in a multicellular organism. Hormones play an essential role in this communication as chemical signaling molecules. Hormones are substances produced in one portion of an organism and transported by any means, including diffusion, to other portions of the same individual or other individuals of the same species where they induce specific responses. These chemical communication are described below:

Chemical communication in aquatic fungi mediated by Sirenin

A number of water moulds included amongst the lower fungi like some of the Chytridiomycetes and those distant relatives, the oomycetes, are known to produce chemoattractants involved in growth processes leading up to sexual reproduction. These can quite properly be described as sex hormones. The aquatic chytridiomycete *Allomyces* produces uniflagellate motile gametes which are differentiated as male and female although they arise on the same haploid thallus and have the same genotype. The female gametes and gametangia produce a substance called sirenin to which the male gametes show strong chemotaxis.. The hormone is active at concentrations of about 10-10 M and it works by regulating the movement of male gametes. Female gametes are only sluggishly motile but male gametes swim in random smooth arcs interrupted by stops after which the cell swims in a different direction. Sirenin organises the direction of swimming by shortening the run between interruptions if the cell moves away from the source of hormone and diminishing the number of stops if the cell is moving towards the source. Inactivation of the hormone by the male gamete is essential to the overall activity but it is not known whether this

results from enzymic breakdown or irreversible binding to some component of the cell. This chemotaxis thus leads to cell contact which is a prelude to plasmogamy.

The female sex hormone of another water mould, *Achlya* (which is not a true fungus but belongs to the Chromista), has also been characterised in some detail. This material, called **antheridio**l, is a steroid the activity of which can be detected by bioassay in 10-11 M solution.

The mating sequence reported consisted of: development of antheridial hyphae on the male; production of oogonial initials on the female; growth of antheridial hyphae towards oogonial initials; formation of cross-walls separating oogonia and antheridia; and, after the two made contact, the antheridium grew through a lysed portion of the oogonial wall, after which its own wall was dissolved. **Antheridi**ol is produced continuously by the female and under the influence of the hormone, branches on the putative male thallus which might otherwise grow out as vegetative branches are caused to elongate rapidly and differentiate into antheridia.

The male is also induced to excrete a second hormone**, oogoniol** or **hormone** B (also a steroid), and it is in response to this that the female initiates oogonial differentiation and amplifies antheridiol levels to those which attract antheridial hyphal growth. There are thus at least two contributors to this hormonal 'conversation'; the female produces antheridiol but takes up very little itself and does not synthesise oogoniol though it does have a receptor for this hormone. On the other hand, the male makes no antheridiol but is sensitive to it, and one of the responses is to produce oogoniol to which the male is insensitive.

Chemical communication in the Mucorales mediated by Trisporic acid

The only other fungi in which the activity of known hormones has been well characterised are some members of the Mucorales. These are filamentous, terrestrial, lower fungi with mycelia typically composed of unbranched coenocytic hyphae. A little way behind the advancing hyphal tips of vegetative mycelia asexual sporangiophores are produced. However, in the vicinity of a mycelium of opposite mating type, sporangiophore formation is suppressed and sexual differentiation takes place, involving formation of sexual hyphae (zygophores) which grow towards each other, fusing in pairs to form gametangia. Zygophore formation is determined **by trisporic acid**; if this chemical is added to pure, unmated, cultures sporangiophore formation ceases and zygophores form instead. Although there are a number of trisporic acid-related compounds, some of them corresponding to intermediates in the pathway, both mating types produce and respond to the same hormone.

The trisporic acids are synthesised from β-carotene: the molecule is cleaved to retinal, a C-2 fragment is lost, and then there is a series of oxidations. The complete reaction sequence occurs in vitro only when both plus and minus mating types are grown in mixed culture or in an experimental apparatus in which they are separated by a membrane permeable to small molecules. Both mating types have the genetic capacity to produce the enzymes of the complete

pathway, but the alleles which determine the mating type repress complementary steps in the later stages of trisporic acid synthesis.

Thus, in plus strains synthesis of enzymes needed to form the 4-keto group is repressed by the MT+ allele while enzymes involved in forming the 1-carboxylic acid group are repressed by MT-. Each mating type thus produces a precursor which only the opposite mating type can convert to trisporic acid. The precursors diffuse between the strains and have the status of prohormones which stimulate trisporic acid synthesis. Early steps in the pathway are repressed to a rate-limiting level by a mechanism which allows activation by trisporic acid. When plus and minus strains come together, therefore, the complementary synthesis of trisporic acid consequent on the co-diffusion or the prohormone precursors leads to derepression of the early part of the pathway and amplification of overall trisporic acid synthesis.

The increasing gradient of prohormone diffusing from each zygophore induces a chemotropic response. The zygophores can grow towards one another from distances of up to two millimetres. When the zygophores make contact they adhere firmly in a way that implies that mating type-specific and species-specific substances are formed on the zygophore surface. These features are clearly an aspect of the mating type phenotype and are necessary for completion of the mating programme, without adhesion the zygophores continue unproductive extension growth, but the nature of the substances involved is unknown.

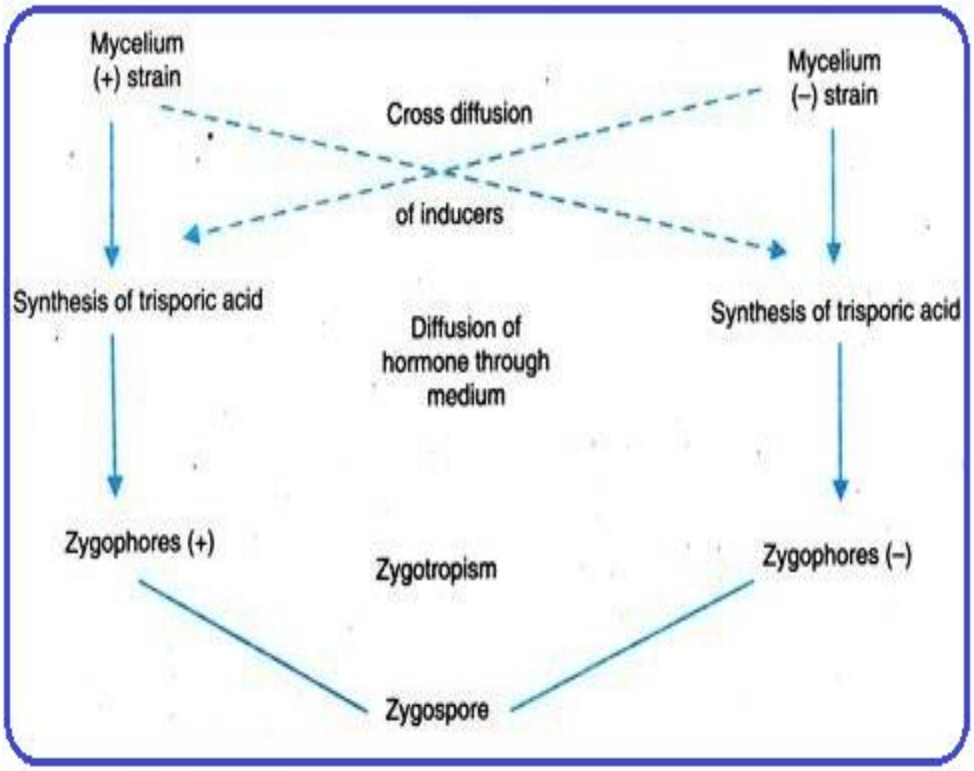
Chemical communication in yeasts mediated by Pheromone

In higher fungi, mating through the activity of hormones is well documented in ascomycetous and basidiomycetous yeasts and there is some evidence that diffusible factors also have a role in inducing ascogonial and trichogyne formation in some filamentous ascomycetes. These observations provide some idea of the sorts of molecules which might be involved in cell to cell contact. Many yeasts release diffusible sex hormones (‘pheromones’) as a prelude to the cell fusion that leads to conjugation.

Mating type factors in the yeast *Saccharomyces cerevisiae* are responsible for production of peptide hormones and **pheromone**-specific receptors. In animals, pheromones are chemicals emitted into the environment by an organism as a specific signal to another organism, usually of the same species. Effective at minute concentrations, pheromones often have important roles in regulating social behaviour of animals, being used to attract mates, to mark territories, and promote social cohesion in communities. Yeast pheromones were named by analogy to the animal hormones because they organise the mating process.

Pheromones cause their target cells to elongate into projections but have no effect on cells of the same mating type or on diploids. In *Ustilago maydis*, conjugation tube formation in the yeast-like sporidia is induced by mating-type-specific pheromones released by haploid cells. These

pheromones are short lipopeptides: 11–15 amino acids with a C-terminal cysteine residue to which a farnesyl group (a 15-C isoprenyl moiety) is attached.



An account of Synthesis of Trisporic acid in Mucorales

Topic-6

Economic importance of Fungi

Fungi are one of the most important groups of organisms on the planet. This is easy to overlook, given their largely hidden, unseen actions and growth. They are important in an enormous variety of ways.

Biological Insecticides

Fungi are animal pathogens. Thus they help in controlling the population of pests. These fungi do not infect plants and animals. They attack specifically to some insects. The fungus Beauveria bassiana is a pesticide that is being tested to control the spread of emerald ash borer.

Reusing

These microbes along with bacteria bring about recycling of matter by decomposing dead matter of plants and excreta of animals in the soil, hence the reuse enriches the soil to make it fertile. The absence of activities of fungi can have an adverse effect on this on-going process by continuous assembly and piling of debris.

Importance in Medicine

Metabolites of fungi are of great commercial importance.

Antibiotics are the substances produced by fungi, useful for the treatment of diseases caused by pathogens. Antibiotics produced by actinomycetes and moulds inhibits the growth of other microbes.Apart from curing diseases, antibiotics are also used fed to animals for speedy growth and to improve meat quality. Antibiotics are used to preserve freshly produced meat for longer durations.Penicillin is a widely used antibiotic, lethal for the survival of microbes. The reason it is extensively used is since it has no effect on human cells but kills gram-positive bacteria.Yield-soluble antibiotics are used to check the growth of yeasts and bacteria and in treating plant diseases.Administration of Griseofulvin results in the absorption by keratinized tissues and are used to treat fungal skin diseases(ringworms).Ergot is used in the medicine and the vet industry. It is also used to control bleeding post-child-birth.LSD – Lysergic acid, is a derivative of ergot and is used in the field of psychiatry.

Importance in Agriculture

The fungi plant dynamic is essential in productivity of crops. Fungal activity in farmlands contributes to the growth of plants by about 70%.

Fungi are important in the process of humus formation as it brings about the degeneration of the plant and animal matter.They are successively used in biological control of pests. Plant pests are used as insecticides to control activities of insects. For example – *Empausa sepulchralis*, *Cordyceps melonhae*. Use of fungal pesticides can reduce environmental hazards by a great extent.

Fungi are also used in agricultural research. Some species of fungi are used in the detection of certain elements such as Copper and Arsenic in soil and in the production of enzymes. For instance, biological and genetic research on fungi named Neurospora led to the One Gene One Enzyme hypothesis.The fungi live in a symbiotic relationship with the plant roots known as mycorrhiza. These are essential to enhance the productivity of farmland. 80-90% of trees could not survive without the fungal partner in the root system.

Importance in Food industry

Some fungi are used in food processing while some are directly consumed. For example – Mushrooms, which are rich in proteins and minerals and low in fat.

Fungi constitute the basis in the baking and brewing industry. They bring about fermentation of sugar by an enzyme called zymase producing alcohol which is used to make wine.

Carbon dioxide- a byproduct in the process, is used as dry ice and also in the baking industry to make the dough (rising and lightening of dough).

Saccharomyces cerevisiae is an important ingredient in bread, a staple food of humans for several years. It is also known as the baker's yeast.

Ciclosporin, an immunosuppressor is derived from the fungus Tolypocladium niveum. It is used in organ transplants and autoimmune diseases

Many organic acids and enzymes are produced by ascomycetes, e.g. citric acid, gluconic acid, amylases, proteases, etc.

Different kinds of cheese are prepared from different Penicillium species, e.g. Camembert, Brie, Roquefort, etc.

Aspergillus is used to prepare soy sauce and to prepare other Asian alcoholic beverages

Morels. Truffles and lobster mushroom are used as fungal delicacies.

Topic-7

Classification and characters of Basidiomycetes

Basidiomycetes constitute the most important group among Fungi. This group of Fungus represents members which has important role to play as disease causing agents represented by Rust Fungi and Smut Fungi. These fungus damages the most important crop represented by Wheat, Barley, Maize, Pennisetum and Jowar . The damage caused by this Fungus is so severe that it can cause a drought like situation. The disease caused is Endemic to Epidemic. Yet another group of this Fungus is represented by Mushroom which forms a important delicacy all over the world also known as poor man's Protein supplement.

The group is represented by following Classes

1 Uredinomycetes.

2. Ustilaginomycetes:

3. Basidiomycetes

1. Class Urediniomycetes:

The class Urediniomycetes includes the rust fungi, that cause rust diseases of plants,.The two types of fungi are placed in two orders, Uredinales and Septobasidiales, respectively:

Order Uriedinales:

The order includes the rust fungi, which are characterised by the formation of first uredospore and then teliospores that originate from the terminal cells of the dikaryotic hyphae during onset of favourable condition .These two important stages are concerned with damage to the Primary host Wheat, Barley etc. The teliospores on germination, give rise to basidiospores formed on short, pointed sterigmata and -discharged explosively.

. The genera of the rust fungi are identified by the structure of their teliospores. There are five families in the order. Family Pucciniaceae .

Family Pucciniaceae: This is represented by genus Puccinia

Genus Puccinia:

Puccinia is an obligate parasite and is extremely host-specific. In defined culture media they do not form spores known as Uredospore, teleutospores which can be formed easily on the natural hosts. This could be due to the change from parasitic to saprobic mode of life in the culture tube. The organism, in nature however, lives only as an obligate parasite.

The fungus causes 'rust' disease of several economically important plants.Some of the important species are as follows:

1. P. graminis- It has 6 sub-species or formae specialis, which attack only one particular host of Graminae; but basidiospores of all sub-species infect Berberis, the alternate host.

P. graminis tritici infects wheat.

P. graminis avenae infects oats.

P. graminis hordei infects barley.

P. graminis secalis infects rye.

The life cycle of Rust can be completed on one host(Autoecious) or on two different host(Heteroecious)

Stage 0: Pycnium bearing spermatia and receptive hyphae- On Barberry

Stage I: Aecium bearing aeciospores,- On Barberry

Stage II: Uredinium bearing urediniospores.- On Wheat(Source of Primary infection)

Stage III: Telium bearing teleospores- On Wheat(Source of Secondary infection

Stage IV: Basidiospores- On soil.

Most of the stage of the life cycle is spent as dikaryotic ycelium like Uredo stage, Teleuto stage, Aecial stage.Monokaryotic stage is noticed in Basidial stage and in Pycnial stage.

Sexuality in Rust

While Basidiospores and pycnium producing spermatia and receptive hyphae are uninucleate, it was Craigie (1927) who discovered that Pycnium is the gametic stage bearing sex cells which are self-sterile.It is the stage where plasmogamy and dikaryotisation take place when spermatia and receptive hyphae of the compatible mating type come in contact.

2. Class Ustilaginomycetes:

Genus Ustilago:

Ustilago causes smut diseases of several economically important plants. Some of the important species and the diseases they cause are – U. tritici (loose smut of wheat), U. nuda (loose smut of barley), U. avenae (loose smut of oats), U. maydis (smut of maize), U. scitaminea (smut of sugarcane), and U. occidentalis (smut of cyanodon).

In all smut diseases, except the smut of maize, the hyphae become systemic in the host tissue, but the sori of teliospores are formed only in certain parts of host, usually the ovary or the inflorescence. The sori are covered by a host membrane. This is a distinguishing feature of this genus.

In loose smut of wheat, barley and oat, the ears are transformed into a black mass of spores, which after the rupture of host membrane, become free and are blown by the wind in such huge amounts that something like a smut cloud can be seen. In smut of sugarcane, the whole floral axis becomes a black, sooty whip-like structure due to its transformation into smut spores. The smut of maize is different and smut sori are formed on any part of the host.

The Plant Body

The mycelium is of two types. The primary mycelium, consisting of uninucleate cells, is formed by the germination of basidiospores and is of very short duration.. The secondary mycelium is dikaryotic, i.e., the hyphae consist of binucleate cells. It extends practically through the entire life.The uninucleate cell is represented by Monokaryotic mycelium which of short duration and has strain difference known as + strain and – strain . he Monokaryotic mycelium of different strain meet to bring about Plasmogamy. The two nuclei remain together in the compartment to be called as Synkaryon. Karyogamy takes place to develop a diploid nucleus.

The mycelium grows intercellularly and draws nutrition from host cells through haustoria (except U. maydis). The mycelium grows extensively and is present in every part of the host. Eventually, at the end of the host season, the hyphae accumulate in the part where smut sori are to be formed. The binucleate cells round up to form thick-walled teliospores.

Reproduction:

Asexual Reproduction:

Budding of basidiospores is the most common method of asexual reproduction. Fragmentation, and in some species, conidia are the other means of asexual reproduction.

Sexual Reproduction:

There is a complete degeneration of Sexuality in Smut Fungi.Sex organs are absent. But the sexual reproduction, represented by Plasmogamy, to karyogamy followed by meiosis, does occur and brings about the genetic recombination. The function of sex organs is taken up by somatic cells which transform into teliospores. They represent absolute heterothallism. The karyogamy takes place in the Promycelium emerging out of Smut spores. The diploid zygote nucleus in the Promycelium undergoes meiosis to form four haploid nuclei, two of each mating type.The promycelium is divided into four cells by horizontal septa. A bud arises from each cell into which one nucleus passes. In some species the promycelium may continue forming the basidiospores. In some species, e.g., U. maydis, the basidiospores themselves by budding form sprout cells (= daughter basidiospores or secondary sporidia). In U. tritici there are no basidiospores; the cells of the promycelium form infection threads which fuse to establish a dikaryotic hypha that grows and develops into the secondary mycelium.

3. Class Basidiomycetes:

Order Agaricales:

Family Agaricaceae (Genus Agaricus):

Habitat:

The fungus grows in lawns, fields and forests round the year. The extensive mycelium remains hidden in the soil; only the fruiting body is visible.While growing they exhibit a characteristic pattern called as fairy ring.

Thallus:

The mycelium, which remains underground and grows saprobically, is the dikaryotic, secondary mycelium,this dikaryotic mycelium is formed in the soil. It is formed by somatogamy between monokaryotic primary mycelia of different mating types formed by germination of the basidiospores. The primary mycelium is of short duration. The fruiting body, which forms the magnificent umbrella above the ground, is made up of dikaryotic hyphae called tertiary mycelium. The fruiting body is ephemeral and lives only for a few days.The secondary mycelium, however, is perennial and continues growing for several years and forms fruiting bodies year after year. The fruiting body, or the basidioma, has a stalk (stipe) and a circular cap (pileus). A skirt-like ring of tissue, called annulus, surrounds the stipe a little below the pileus.

The gills (= lamellae) can be distinctly seen if the stipe is removed and the pileus is inverted. The pileus on the under surface, bears numerous, vertically-hanging gills, which converge from

periphery towards the stipe. The gills are of different lengths and bear basidia all over the surface. The basidia produce basidiospores in astronomical numbers.

Reproduction:

Asexual Reproduction:

A. campestris produces only chlamydospores produced as a fusion of two monokaryotic mycelium of two strains.

Sexual Reproduction:

The sexual reproduction is represented by karyogomy and meiosis, which occur in basidia, borne on the gills.There has been complete degeneration of Sexuality means Sex organs in this group of Fungi. The nuclei of opposite mating types come together and form dikaryons after the fusion of the monokaryotic primary hyphae. The dikaryons multiply by conjugate divisions in the extensive, secondary mycelium.

Ultimately, club-shaped basidia develop from the terminal cells of these secondary hyphae. The binucleate cell enlarges and becomes broader and club-shaped. Karyogamy and meiosis occur resulting in the production of four haploid nuclei. Segregation of sex occurs during the meiosis and the nuclei formed are of two or more mating types, depending on the type of the heterothallism (bipolar or tetrapolar).

The nuclei later migrate into the sterigmata and from there into the basidiospores, perched asymmetrically on the tips of the sterigmata. The basidiospores, on germination, form primary mycelia, which by anastomosis and plasmogamy, establish the secondary mycelium. The basidiospores, which are borne asymmetrically on sterigmata are discharged forcibly by water drop method..

Family Lycoperdaceae:

Genus Lycoperdon (The Puff Ball):

The puff-balls are globose to pyriform in shape, depending upon the length of the stalk. These are found growing in pastures on ground in woods or on tree stumps. The basal part is sterile. When young, it is surrounded by fragile spines which soon fall off or get rubbed off.

The outer layer of the peridium withers and a pore is formed on the inner membrane at the top of the fruiting body. This membrane acts like a bellows, puffing out spores through the pore when

some object strikes the membrane. The fertile portion, gleba, is of lacunose type, i.e., consists of cavities, each lined with a hymenium. All the species are edible.

Order Phallales:

The order has 3 families. We shall study the family Geastraceae to which belongs the genus Geastrum, the 'earth star'. (The family, along with Lycoperdaceae was put under order Lycoperdales, which is now derecognized.)

Family Geastraceae:

Genus Geastrum:

The earth stars differ from the 'puff-balls in that the outer peridium splits radially and opens out like rays of a star. Such fruit bodies lying on the ground gave the name 'earth star'. A pore is formed on the inner peridium at the top .The spores are released through this pore.

Order Polyporales:

The order includes the polypores, the bracket and shelf fungi that cause severe damage, especially to forest trees. There are 6 families. We shall study genus Polyporus of the family Polyporaceae.

Family Polyporaceae:

Genus Polyporus:

This is the largest genus of Polyporaceae and its several species are important wood-rotting fungi. P. sulphurens causes wood rot of oaks and other trees; P. squamosus causes 'heart-rot' of a number of forest trees; P. betulinus causes 'heart-rot' of birch trees. Destruction of the heart wood makes the trees hollow which eventually die. Some, for example, Polyporus schweinitzii, attack the lower part of the trunk and the roots (butt-end rot), making the trees liable to snap off in gales.

The mycelium ramifies within the substratum. It consists of septate dikaryotic hyphae which usually show clamp connections. The fruiting body (the basidioma or sporophore) develops as a laterally-stalked, fan- shaped, bracket which may be 20 to 40 cm in diameter and 2 to 3 cm thick. A vertical section of the basidioma shows the following zones – (a) pileus surface, (b) context, (c) tube layer, (d) pore surface and (e) hymenium.

The pileus surface may be smooth or encrusted. The context is white below, which lines the tube layer. The tube layer consists of vertically- placed tubes which open below at the under surface of the fruiting body called the pore surface; hence the name Polyporus.

The tubes are lined internally by hymenium, which consists of basidia and sterile structures, like paraphyses, cystidia and setae – all placed at right angles to the length of the tube. The basidiospores are shot into the cavity of the tubes, which then fall below through the pores and get disseminated by wind. Spore output is enormous. A single fruiting body may produce a billion spores.

FOR FIGURE STUDENTS CAN CONSULT LESSON PROVIDED TO THEM

Topic-8

Classification and characters of Deuteromycetes

The Deuteromycota is a heterogeneous group of unrelated species in which sexual reproduction has never been observed. Since mycologists refer to the "perfect phase" of a life cycle as the phase in which sexual reproduction occurs, these fungi are often referred to as imperfect fungi. These fungi may have lost their sexual phase through the course of evolution. Alternatively, biologists simply may not have found the appropriate environmental conditions to observe development of the sexual phase of their life cycle.

Deuteromycetes – The Fungi Imperfecti:

Some of the important points of Deuteromycetes are listed below:

1. Deuteromycetes is an artificial class of fungi which has been created to include all those fungi in which sexual stage is either absent or not known.

2. Some of the deuteromycetes are unicellular like yeasts. They are often studied along with the latter.

3. The mycelium is usually septate. Coenocytic forms are not known. Clamp connec-tions, typical of basidiomycetes, are absent.

4. Asexual reproduction often occurs by conidia along with some other types of spores. In some cases even asexual spores are absent.

5. It is believed that most members of deuteromycetes are actually ascomycetes in which sexual reproduction is either absent or yet to be discovered.

Salient Features of Deuteromycetes:

(i) Deuteromycetes occur mostly as saprophytes on a wide range of substrates, but a large number of them are parasites on plants and animals (including humans) and cause a variety of diseases.

Leaf- spots, blights, blotch, wilts, rots, anthracnose, etc. are the important diseases of plants, while diseases like meningitis, candidiasis, skin diseases, nail diseases, dermatomycosis as ringworms, athlete’s foot, etc. occur in animals (including humans).

(ii) The mycelium is made up of well-developed, profusely branched and septate hypha that possess multinucleate cells and simple pore septa.

(iii) The hyphae may be inter- or intracellular, and their cell wall chiefly contains chitin-glucan.

(iv) Deuteromycetes reproduce only asexually. The asexual reproduction may take place by hyphal fragments, budding (common in Blastomycetes), arthrospores (flat-ended asexual spores formed by the breaking up of cells from the hypha), chlamydospores (thick-walled modified cells functioning as resting spores), or most commonly by conidia or conidiospores (nonmotile spores formed externally on the surface of hyphae or on specialized hyphal branches called onidiophores).

(v) The cell of conidiophore that produces conidia is called conidiogenous cell and the conidia may be produced either at the tip or side of the conidiogenous cell either singly or in chains.

(vi) The conidiophores are either frees from one anther (mononematous) or they may be aggregated to form specialized structures such as synnemata and sporodochia.

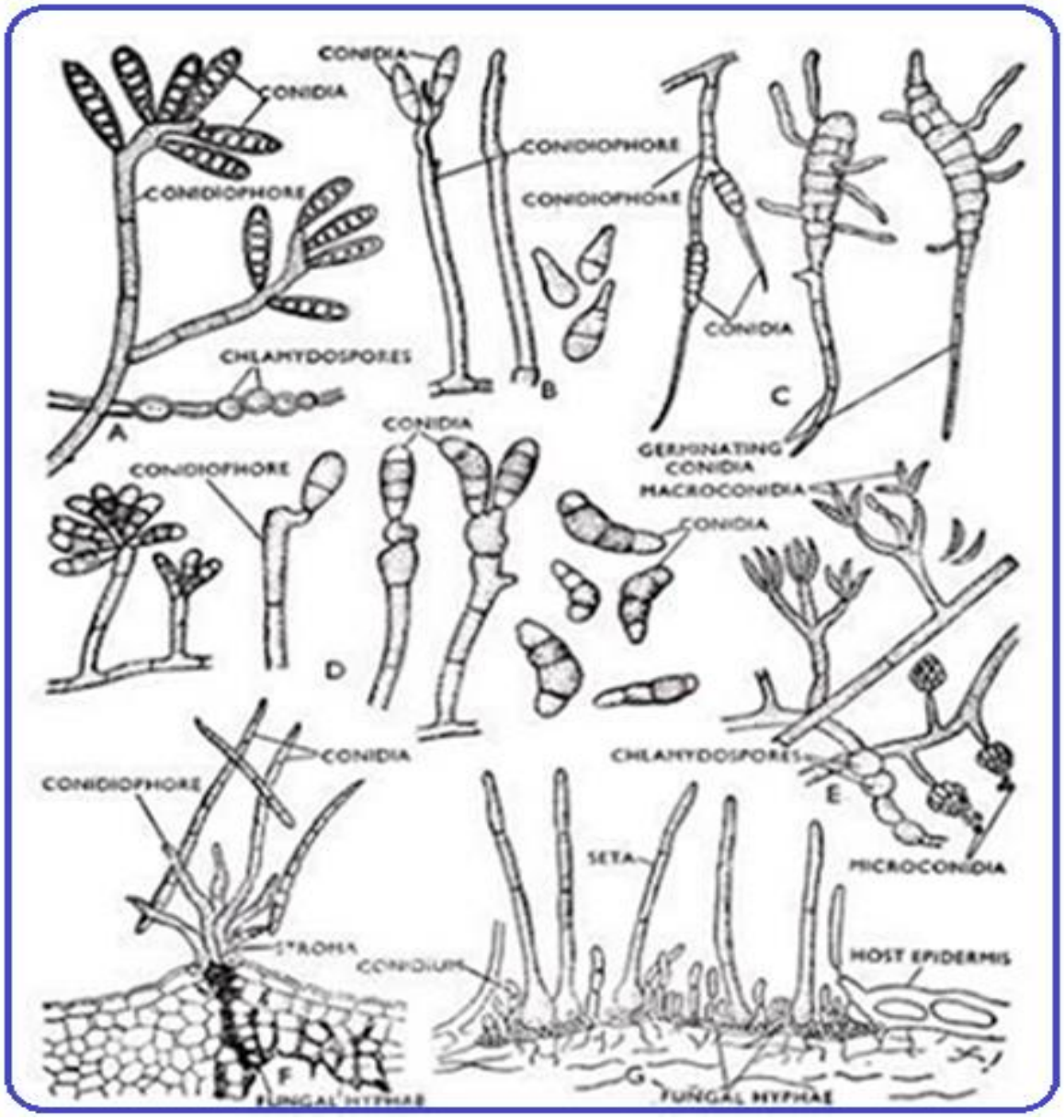
In large number of Deuteromycetes, the conidiophores are formed in more specialized and organized fruiting layers present within the specialized fruiting bodies called conidiomata (sing. Conidioma; formerly called conidiocarps). The conidiomata may be acervulus or pycnidium.

(vii) Sexual reproduction lacks, but a parasexual cycle or parasexuality generally operates in their life to fulfil the requirements of sexuality.

Form–class-DEUTEROMYCETES
(The Imperfect Fungi)

Orders

1. Sphaeropsidales (Reproduction by means of conidia borne in pycnidia).	2. Melanconiales (Reproduction by) means of conidia borne in acervuli).	2. Moniliales (Reproduction by means of conidia borne otherwise, by oidia or by budding).	4. Mycelia Sterilia (No reproductive) structures known).
Form-Families 1. Sphaeropsi-daceae 2. Zythiaceae 3. Leptostromata-ceae 4. Excipulaceae	**1. Melanconiaceae** Genus-*Colle-torichum*	1. Moniliaceae **2. Dematiaceae** *Helminthosporium*, *Alternoria*, *Cerospora*, 3. Stilbellaceae 4. Tuberculariaceae Genus—*Fusarium*	Important form genera *Rhizoctonia*; and *Sclerotium*



Conidia and conidiophores of different form-genera of the Deuteromycetes. A. *Helminthosporium*. B. *Pyricularia*. C. *Alternaria*. D. *Curvularia*. E. *Fusarium*. F. *Cercospora*. G. *Colletotrichum*.