Quadrant II – Transcript and Related Materials

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Module Name: *Agaricus*- Reproduction

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Notes

Agaricus reproduces by vegetative, asexual and sexual means.

1. Vegetative Reproduction:
The edible mushrooms are propagated by vegetative means. It reproduces vegetatively by its perennating mycelium. Small pieces of dikaryotic mycelium are used as **inoculum**. The pieces are grown in soil rich in organic manure to obtain basidiocarps.

2. Asexual Reproduction: Asexual reproduction is very rare, but a few species produce **chlamydospores**, **oidia**,or **sclerotia**. It is not a common method of propagation in *Agaricus*.
(a) Chlamydospores are produced which are lateral, terminal or intercalary in position on the secondary mycelium. On germination, it gives rise to hyphae to produce dikaryotic mycelium.
(b) Oidia may also be formed under certain conditions but these are involved mainly in **dikaryotization** rather than developing directly into new mycelia.

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. Most species of *Agaricus* are **heterothallic** however, a few species of *Agaricus*, like *A. campestris* and *A. bisporus*, are homothallic, but they do not have sex organs; in traditional sense. Primary mycelia formed by the germination of basidiospores of two different strains act as male and female sex organs. There is somatogamy between the somatic hyphae of opposite strains and this results in diplotization and formation of the secondary mycelium. The secondary mycelium later develops fruiting bodies, known as

basidiocarps. Somatogamy between two primary hypha of opposite strains takes place through **plasmogamy**, **karyogamy** and **meiosis**. The members produce well-developed and distinct fruiting bodies called **basidiocarps**. The basidiocarps are fleshy with 'monomitic type' of construction. The non-septate basidia develop in the form of **hymenium** on gills or lamellae. The gills develop on the under surface of the fruiting body like spokes of a cycle wheel. Hence, these are also known as **gill fungi**.

(a) Plasmogamy:

It is the first step in the sexual reproduction of *Agaricus*. The two primary monokaryotic hyphae with uninucleate haploid cells from mycelia of opposite strains (heterothallic) or from the same mycelium (homothallic) come into contact and fuse. At the point or their contact, the cell walls are dissolved, each of such fusion results into a bi-nucleate and a **dikaryon** on is formed (dikaryotic) cell. The dikaryotic cell, by successive divisions, gives rise to the bi-nucleate or dikaryotic mycelium. At the time of the division of dikaryotic cell, both nuclei of the dikaryon divide synchronously and form four haploid daughter nuclei, two of (-) and two of (+) strain. Out of these, two nuclei (one of(+) and one of (-) strain) are transferred to the daughter cell by the formation of **clamp connection**. The dikaryotic mycelium is perennial and subterranean. It produces basidiocarps under favourable conditions.

(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 both the two nuclei of dikaryon takes place to form a diploid nucleus. Karyogamy takes place in young basidium..

(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. The subterranean secondary mycelium takes nutrients from the soil and then forms the fruiting body or the basidiocarp. After absorbing sufficient food material mycelium produces fruiting bodies, which are very small in size and remain underground. Basidiocarps develop as small 'white-knot' like structures at the tips of the underground hyphae. 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. 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. A ring like cavity (gill chamber) develops at the junction of stalk and pileus region. Some hyphae at the junction of the stipe and pileus are drawn apart and form a ring-like chamber, called **pre-lamellar chamber**. The inner surface of the roof of the pre-lamellar chamber becomes deeply concave and it is lined with alternating radial bands of slow and rapidly dividing cells. The latter form **gill primordia**, which develop into gill lamellae that hang downward into the prelamellar chamber. As pileus expands, there is an increase in radial interspaces between the gills. A membrane, called **velum** or **inner veil**, connects the margin of the pileus with the stipe. Due to the elongation of stalk, the buttons are raised on the soil surface.

The upper hemispherical region of the button grows more rapidly than the stalk. This causes rupture of the velum and the upper hemispherical region finally expands out as an open umbrella-like structure with numerous gills attached to its lower surface. The gills are exposed by the rupture of the velum. At this stage, remnants of the velum are still attached to the stipe in the form of ring, called **annulus**. ln dry season, when soil is hard, buttons do not grow and remain underground. In rainy season, when soil is moist, they grow rapidly and come out of the soil surface. Hence, many basidiocarps can be seen in rainy season on the soil surface.

Mature Basidiocarp

The mature basidiocarp is an umbrella-shaped structure with a long massive stipe and a broad pileus. The stipe is a thick, fleshy and cylindrical structure, light pink or white in colour.

An umbrella-like pileus, 5-12 cm in diameter, is present at the distal end of the stipe. The upper convex surface of the pileus is white, light brown or yellow in colour. About 300-600 radially arranged gills hang down from the inner surface of the pileus. All gills are not of the same length; they may be of full, half or quaner length. The surface of the gill is enveloped by a fertile layer, the hymenium. The gills are of light pink colour when young, but they tum brown or purplish black at maturity.

Development of Basidium:

The basidia are spore producing bodies. The young basidia arise from the terminal, bi-nucleate cells of the sub-hymenium layer. The young basidium is a dikaryon and as the basidium matures the two nuclei of the dikaryon fuse to form a diploid nucleus synkaryon (karyogamy). This diplophase is ephemeral and after karyogamy the diploid nucleus divides meiotically to form four haploid nuclei. The diploid nucleus soon undergoes meiosis to form four haploid nuclei. Simultaneously, four narrow peg/ tube-like outgrowth structures develop at the distal end 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.

The young basidiospore is unpigmented but it develops brown or black pigments at maturity. At the junction of the mycelium basidiospore and the sterigma, there is a small projection, known as **hilar appendics**. Due to the presence of hilar appendics, the basidiospore is slightly oblique placed on the sterigma.

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 CO_2 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.

Dispersal and Germination of Basidiospores

As the basidiospore matures, a drop of liquid appears at the hilar appendics which remains surrounded by a limiting membrane. The basidiospore thus lies just above this drop. The drop increases in size gradually and attains a size of about one-fifth of the spore. Then the basidiospore is suddenly shot away from the sterigma. The four basidiospores of a basidium are dispersed in rapid succession. When the basidiospore falls on a suitable substratum, it germinates by producing a **germ tube** that grows into a primary monokaryotic mycelium. Depending on the strain of the basidiospore, the mycelium may be of (+) or (-) strain. The mycelia of two different strains fuse to form a secondary or dikaryotic mycelium (somatogamous copulation, heterothallic). The primary monokaryotic mycelia form dikaryotic mycelium by somatogamy. However, in homothallic species, a single basidiospore is capable to give rise to secondary mycelium. The secondary mycelium develops the basidiocarps