Agaricus:

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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).

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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 (Fig. 1 A).

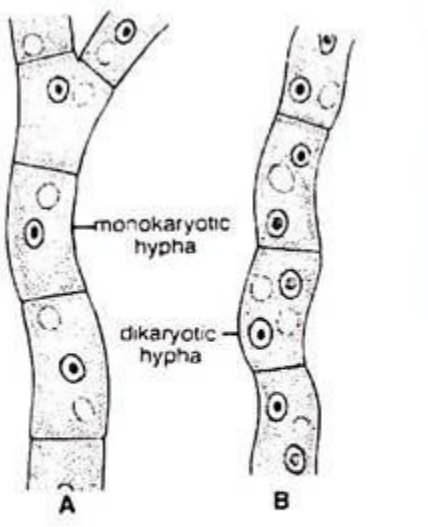

Fig. 1 (A, B). *Agaricus* mycelium. (A) Monokaryotic, (B) Dikaryotic

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 (Fig. 1 B).

Tertiary Mycelium:

The secondary mycelium grows extensively under the soil and becomes organized 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 (Fig. 2). 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.

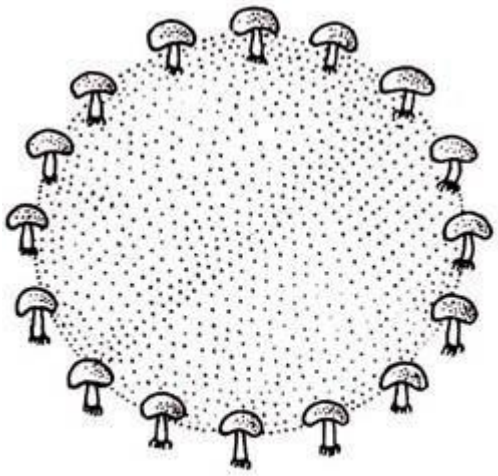

Fig. 2. *Agaricus* : Fairy rings

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 (Fig. 3 A).

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 (Fig. 3 B).

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 (Fig. 3 C-E). 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.

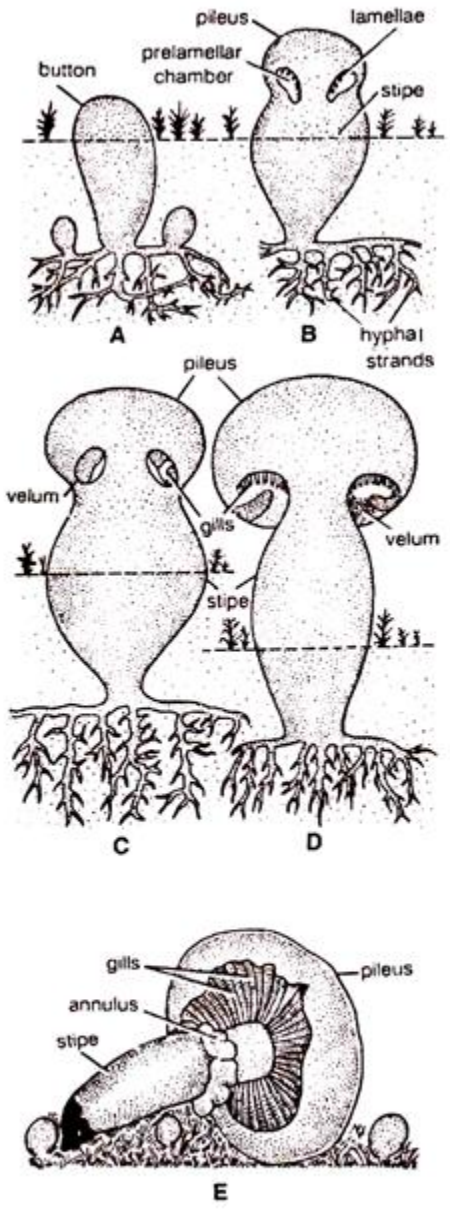

Fig. 3 (A–E). *Agaricus* : Development of basidiocarp; (A–D) Vertical sections of developing basidiocarp showing various stages of development; (E) A mature basidicarp

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 (Fig. 4 A-C).

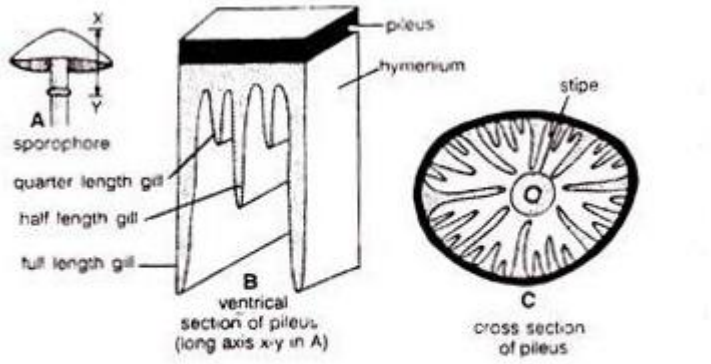

Fig. 4 (A–C). *Agaricus* : Pileus. (A, B). Vertical section of pileus: (C) Cross section of pileus

Structure and Anatomy of Basidiocarp:

The mature fruiting body can be differentiated into three parts i.e., stipe, pileus and annulus (Fig. 5).

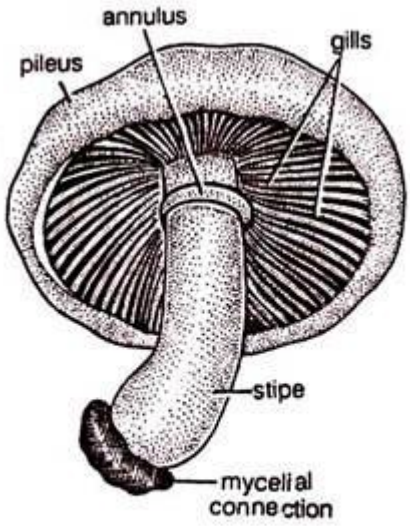

Fig. 5. *Agaricus* : A mature basidiocarp

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 (Fig. 6).

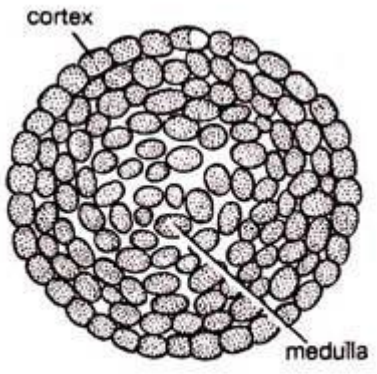

Fig. 6. *Agaricus* : Transverse section of stipe

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 (Fig. 7 A):

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) (Fig. 7A). 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 (Fig. 7 B 1). As the basidium grows, the two nuclei of the dikaryon fuse to form the synkaryon (karyogamy, Fig. 7 B 2). 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 (Fig. 7 B 4-5). 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 (Fig. 7B 6).

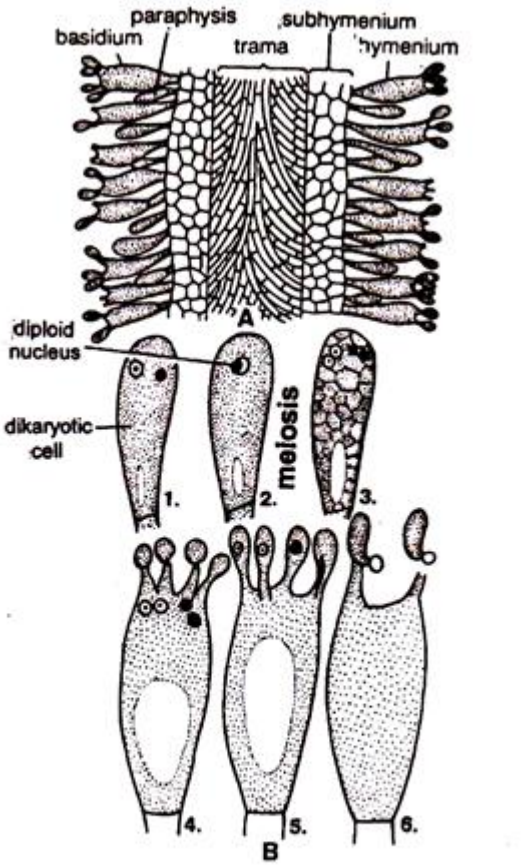

Fig. 7 (A–B). *Agaricus* : Structure of gill, (A) Vertical section of gill, (B_{1-6}). Various stages in the development of basidium

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.

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 (Figs. 8 A-M, 9).

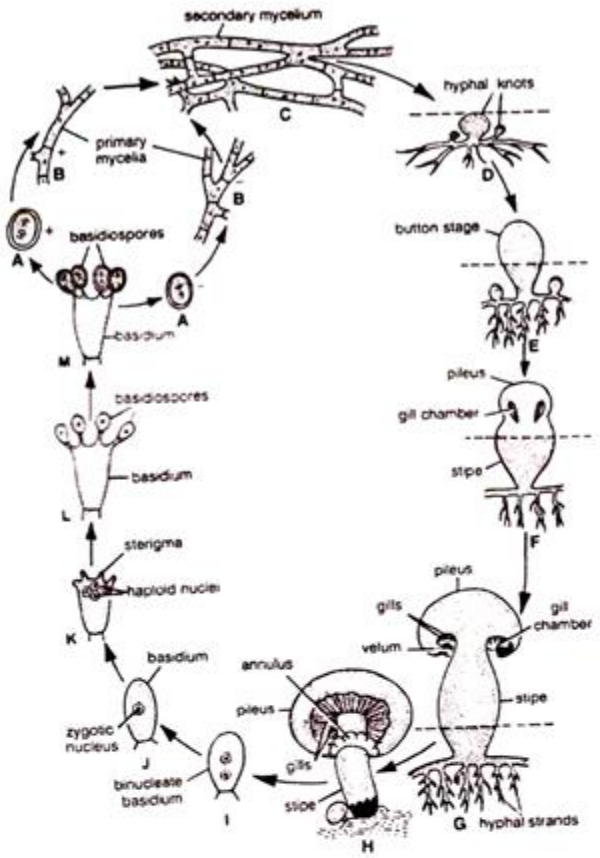

Fig. 8 (A–M). *Agaricus* : Diagrammatic life cycle

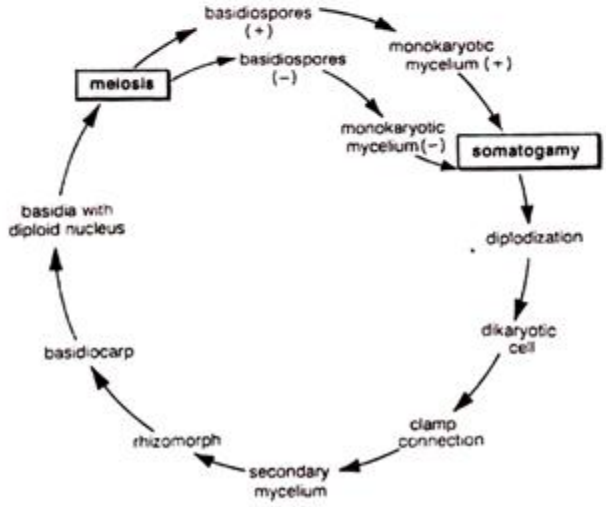

Fig. 9. *Agaricus* : Graphic life cycle