RHIZOPUS

Distribution & Habitat

- Rhizopus has **35** species with cosmopolitan distribution
- Most of the species are strict **saprophytes** and grow on bread, jams, pickles, cheese, moist food stuffs, leather goods etc. Some of them are **weak facultative parasites** that grow on detached plant parts and fruits and cause diseases during transport and storage.
- It is called to "**Bread mould"** as it is the most common fungus growing on bread.
- It is referred as **Black mould** because it produces black coloured sporangia and spores in it. The complete mycelium appears black coloured.
- The sporangiophore with, sporangium appears as pin. Hence, it is known as **Pin mould**.
- It is common contaminant in microbial cultures. Hence it is also called as **Weed of the laboratory**.

Structure of Mycelium

- Fungal thallus is known as mycelium
- Rhizopus mycelium is malde up to long, filamentous, tubular and aseptate in vegetative stage.
- It has three types of hyphae known as i.) Stolons, ii) Rhizoids and iii) Sporangiophores.
- **Stolons** are horizontally spread, rapidly growing, stout and branched hyphae present on the surface of the substratum.
- **Rhizoids** are profusely branched hyphae developing from lower surface of the stolon. These enter into the substratum and act as holdfast to provide anchorage. These also secrete digestive enzymes such as amylases into the substratum, and absorb the food materials in the form of sugars.
- **Sporangiophores** are asexual unbranched hyphae present opposite to rhizoids on the upper surface of stolons. They arise in a group of **2 – 5**. Each sporangiophore bears a single sporangium at its apex.

Structure of Hypha

- Each filament of mycelium is known as Hypha. It usually lacks septa.
- It is transparent, tubular, branched, siphonous and **coenocytic** (multinucleate).
- Solid non perforated septa are seen in old or injured hyphae and in reproductive structures.
- Hypha shows apical growth and has cell wall made of **chitin**.
- Tip of the hypha has dense protoplasm
- Hypha has many small vacuoles, haploid nuclei, and other typical eukaryotic cell organelles except plastids.
- The food materials are present in the form of **glycogen** and **oil droplets.**

Reproduction

- It reproduces vegetatively, asexually and sexually.

1. Vegetative Reproduction

- It takes place by fragmentation. Each fragment of the mycelium can live and grow independently by forming rhizoids.

2. Asexual Reproduction

It reproduces asexually by **Sporangiospores** and **Chlamydospores** formation.

i. Sporangiospore formation

- It takes place during favourable conditions.
- Papilla like outgrowths known as Sporangiophores are developed on the upper surface of stolon opposite to Rhizoids.
- The tips of the sporangiophores swell due to migration of protoplasmic contents and form sporangia with peripheral nucleated region known as **Sporoplasm** and central vacuolated region known as **Columelloplasm**.
- **Sporoplasm** has few vacuoles and **columelloplasm** few nuclei.
- These two regions are separated by a layer of vacuoles arranged in the form of dome that flatten and fuse to form a cleft between the two zones.
- A wall is secreted in the cleft and the sporangium is separated into peripheral soporiferous zone and central dome shaped **columella**.
- Columella is continuous with the sporangiophore. The nuclei of columella gradually degenerate.
- The soporiferous zone undergoes cleavage due to invagination of its plasma membrane and forms many polyhedral **multinucleated** and sometimes **uninucleated pieces**.
- Each one secretes a wall and transforms into a **spherical**, **oval** or **elliptical** spore. These spores are called Sporangiospores.
- Spore wall is single layered and usually consists of **2-10** or rarely one haploid nuclei.
- With the maturation of spores, the size of **columella increases** and **exerts pressure** on the fragile sporangial wall cracks in dry air.

- The spores are dispersed by wind. The jerking and twisting of the sporangiophore also assists in the liberation of spores.
- The spores reach the suitable substratum, germinate and develop to give rise new mycelium.
- A part of the sporangial wall remains as a collar around the base of persistent columella.

II. Chlamydospore formation

- Chlamydospores are formed during unfavourable conditions in **older stolons**.
- Protoplasm contents of hyphae accumulate at certain regions and intervening parts become empty.
- Each protoplasmic accumulation secretes a thick wall around it to transform into a **multinucleated Chlamydospore**.
- These spores **perannate in** unfavourable conditions and germinate in favourable conditions.

3. Sexual Reproduction

- It takes place during the end of growing season by **gametangial copulation**. Entire cell contents of the two gametangia are involved in the fusion.
- Rhizopus has both homothallic (Gametangia of the same mycelium are involved in fusion e.g. *R. sexualis*) and heterothallic (Gametangia of different strains mycelia are involved in fusion *R. stolonifer*) species.
- Sexual reproduction of heterothallic species is regulated by a sex hormone known as **Trisporic acid**.
- The vegetative terminal hyphae of stolons transform into sexual hyphae known as **zygophores**.
- The zygophores of compatible + and – strains are attracted towards each other and come in contact.
- At the point of contact, the zygophores give out swollen structure known as **progametangium** or **copulating branch**.
- The tips of progametangia swell due to flow of cytoplasm and nuclei from zygophores.

A cross wall is formed separating the swollen terminal multinucleate region with the basal short slender region. The terminal region is known as **Gametangium** and the basal one as **Suspensor**.

- Suspensor consists of **few nuclei** and **many vacuoles**.
- The gametangium is described as **Coeno-gametangium** as it contains many nuclei.
- The separating wall between the two gametangia is dissolved by the action of enzymes.
- The cytoplasms of the two gametangia fuse and the nuclei of opposite strains pair and later fuse to form diploid nuclei. The unpaired nuclei gradually degenerate.
- The diploid structure formed due to the fusion of gametangia is known as **Zygospore**. It has **two** layered wall with outer **thick** and **warty** exospore and inner thin endospore.
- The gametangia that fail to fuse secrete a thick wall around it and transforms into a **Parthenospore** or **Azygospore**.

Germination of Zygospore

- Zygosprore undergoes a period of dormancy for **5 – 9** months during unfavourable conditions.
- At the onset of favourable conditions the diploid nuclei of the zygospore undergo **meiosis** and form haploid nuclei.
- The protoplast absorbs water and swells. The exine is ruptured and the intine with protoplasm comes out as tube like structure known as **Promycelium** or **Germ tube**. It grows to a limited extent and bears a terminal sporangium without columella called '**Germ sporangium**'.
- The protoplast of germ sporangium undergoes cleavage to produce non-motile meiospores known as '**germ spores**'.
- The germ spores are initially uninucleate and later become multinucleate due to free nuclear divisions.
- The germ spores are liberated due to rupturing of wall and carried to suitable substratum by different agents. They germinate and form a new *Rhizopus* mycelium.

Life cycle

- Rhizopus reproduces vegetatively by fragmentation and asexually by sporangiospore and chlamydospore formation.
- During sexual reproduction the + and – strain gametangia formed on respective mycelia fuse and form diploid structure known as **Zygospore**.
- Zygospore nuclei undergo meiosis and the **+ and – strain** nuclei are segregated.
- Promycelium, germ sporangium, germ spores and vegetative mycelium formed subsequently are haploid.
- Since most of the stages in the life cycle of Rhizopus are haploid and diploid stage is limited to only **zygospore**, the life cycle is described as **Haplontic life cycle**.

Sexuality in Rhizopus

- In homothallic species of Rhizopus, the gametangia or hyphae of the same mycelium are involved in sexual fusion. They are self compatible and do not show any morphological and physiological differentiation.

- A.F. Blakeslee observed physiological differentiation in Rhizopus and called it as **Heterothallism**.
- In heterothallic species, the mycelia of two different physiological strains (+ and –) are involved in sexual fusion. It is a kind of physiological anisogamy as seen in *Rhizopus stolonifer*.