LIFE CYCLE OF PHYTOPHTHORA

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For:
B.Sc. Botany(Part-I)
Fungi
Paper-I

Lecture-04

Scientific classification:

- Class: Phycomycetes
- Order: Peronosporales
- Family: Pythiaceae
- Genus: *Phytophthora*
- Species: *infestans*

Binomial name:

- *Phytophthora infestans*

Mycelium of Phytophthora:

It is profusely branched and consists of aseptate, hyaline, profusely branched, coenocytic, moderately thick hyphae about 4-8µ in diameter. The hyphal wall is approximately 0.1µ thick. Glucans is the predominant material in the hyphal wall. Cellulose is a minority component or even lacking altogether.

The cytoplasm contains scattered nuclei, mitochondria, endoplasmic reticulum, ribosomes and many large vacuoles with lipid inclusions. The fungal hyphae ramify in the intercellular spaces between the cells of the host tissue. These are called the intercellular hyphae. In addition there are hyphae that penetrate, traverse and eventually leave the cell. These are called the intracellular or transcellular hyphae. An infection peg arises from the hyphal bulge. It makes its way into the host cell pushing in front the host cell

plasma membrane and the host cytoplasm. Within the host cell the infection peg expands at its tip to form the haustorium.

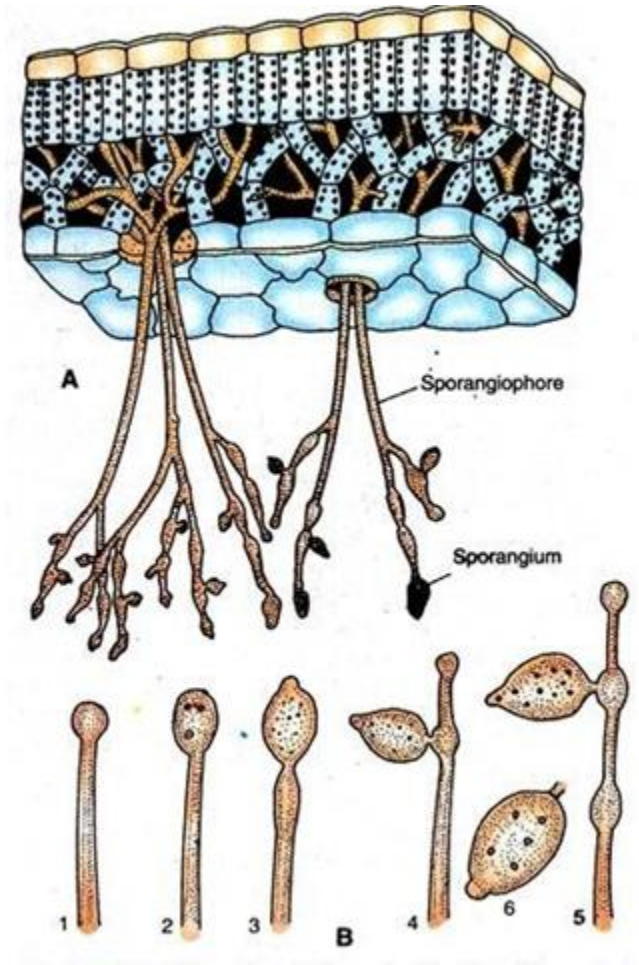

Fig: 01 Phytophthora infestans. A, V.S. infected potato leaf showing the intercellular mycelium and the emerging Sporangiophores; B, the stages in development of sporangia

Haustoria of Phytophthora:

The haustoria are variously shaped intracellular feeding structures. In P. infestans they are small globes, occasionally short, straight or curved pegs. There may be one or more haustoria in each host cell. The intracellular haustorium is connected with the intercellular hypha by a neck-like constriction at the penetration site. The haustoria are more commonly found in the tubers. In

severe cases of infection the entire plant above the ground is killed. The fungus passes winter in the form of mycelium in infected part

Asexual Reproduction :

With the onset of favourable conditions of warm, damp weather in spring a tuft of slender, branching hyphae arise from the internal mycelium. They push their way out either through a stoma (A) or by piercing through the epidermal cell on the lower surface of the leaf. In the case of the tubers they push their way through the lenticels or injured portions of the skin.

These aerial hyphae are hyaline, and sympodially branched and are of indeterminate growth. These special branched aerial hyphae are called sporangiophores (conidiophores).

The sporangium is formed by the inflation of the tip of the side branch of the sporangiophore (B_1). The multinucleate inflation is then cut off by a transverse septum basal plug as a sporangium. The hyphal branch bearing the young terminal sporangium continues to grow (B2-3). As the sporangium reaches maturity, the branch tip swells slightly just below the sporangium and proliferates pushing the sporangium to the side as the elongation proceeds (B4).

The process may be repeated. The sporangia are, thus, borne terminally but are subsequently shifted to a lateral position. The mature sporangia are lightly attached, the sporangiophore of Phytophthora is, therefore, sympodially branched.

It bears nodular swellings (B5) which denote the points of detachment of sporangia. These swellings give the branched sporangiophore a jointed appearance characteristic of the genus. **Sporangium Structure:** The mature sporangium is a hyaline, oval to elliptical, thin-walled spore sac with a basal plug. It has a small stalk and an apical papilla. The sporangial wall is nearly 0.3µ thick and appears to be faintly layered. Within the wall is the plasma membrane.

It is closely appressed to the sporangial well and encloses the multinucleate cytoplasm which contains the usual cell organelles such as mitochondria, dictyosomes, endoplasmic reticulum and ribosomes.

Dispersal of sporangia:

Wind, rain splashes or contact with other leaves detach and spread or scatter the ripe sporangia on to the leaves of other potato plants. They may also be washed into the soil The sporangia lose their viability if they fail to germinate within a few hours.

Sporangium germination:

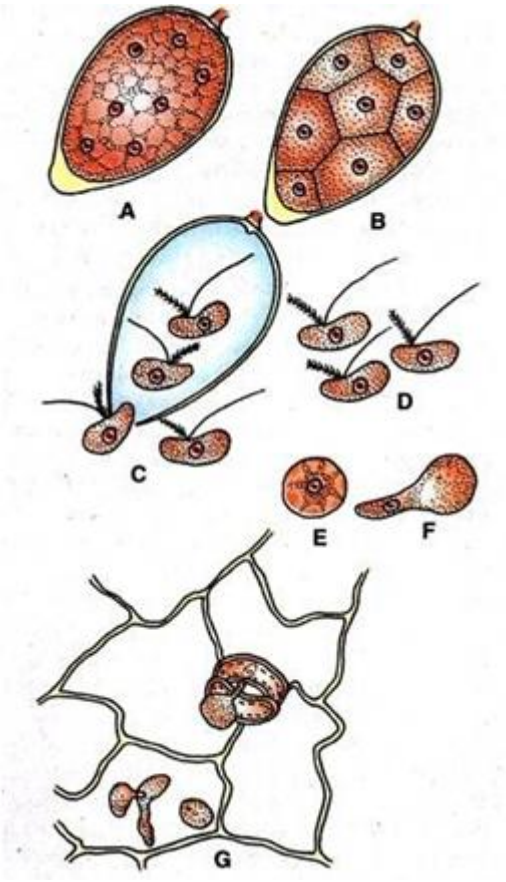

Fig:02 Phytophthora infestans. Stages in indirect germination of sporangium and germination of a zoospore

Landing on the healthy leaf of a host plant, the sporangia germinate. The main factors governing germination are moisture and temperature. The sporangia are adversely affected by desiccation

In the presence of moisture provided by rain or dew, the sporaniga of phytophora infestants germinate either indirectly by producing zoospores and thus functioning as zoosporangia or directly by a germ tube and functioning as conidia**a)**

Indirect germination (Fig: 02)

Wet, cool soil favours indirect germination of sporangia. Thus in the presence of moisture at 16°C or below 12-14°C the sporangium behaves as a zoosporangium

plasma membrane delimiting the multinucleate sporangial protoplast into 5-8 uninucleate daughter protoplasts (B) . Each subsequently metamorphoses into a biflagellate zoospore which is reniform.

Of the two flagella one is of whiplash type and the other tinsel

The flagella arise from the depression on the concave side. The zoospores are set free in a group by the bursting of the apical papilla into a vesicle in P. cactorum No vesicle is formed in P. infestans (C).

Germination of zoospore and infection of the host (Fig. 02 D-G):

The sporangia which land on the leaves of potato plants germinate in cool wet environment liberating zoospores. The liberated zoospores (D) swim about actively in a surface film of water for some time and then come to rest. Each quiescent zoospore retracts its flagella and may encyst (E). The encysted zoospore then germinates by putting out a special, short hypha called the germ tube (F).

The germ tube, as it grows over the epidermis of the leaf and closely adheres to it produces a flattened pressing organ, the appressorium at its tip (G_2).

From the undersurface of the latter arises a fine tubular, peg-like outgrowth, the infection hypha, which pierces the cuticle and forces its way through the epidermis into the host tissue to bring about infection

Within the host the invading hypha grows vigorously and branches to form the mycelium which is coenocytic and consists of intracellular and intercellula hyphae

b) Direct Germination of Sporangium (Fig. :

In wet warm environment (at higher temperature from 20 to 23°C), the sporangium behaves like a conidium and germinates directly by a germ tube

Chlamydospore formation:

Various species of Phytophthora produce chlamydospores. These develop as oblong intercalary or terminal spores. Most have relatively thick walls but this varies with the species. In a mature chlamydospore the cytoplasm is dominated by lipid and reserve vacuoles

Sexual Reproduction:

In Phytophthora sexual reproduction is oogamous.

Some species were considered homothallic while others heterothallic .Phytophthora are monoecious. It means their mycelium is potentially capable of producing both antheridia and oogonia. These monoecious species, however, differ in their mating capabilitie so be heterothallic.included in this category.

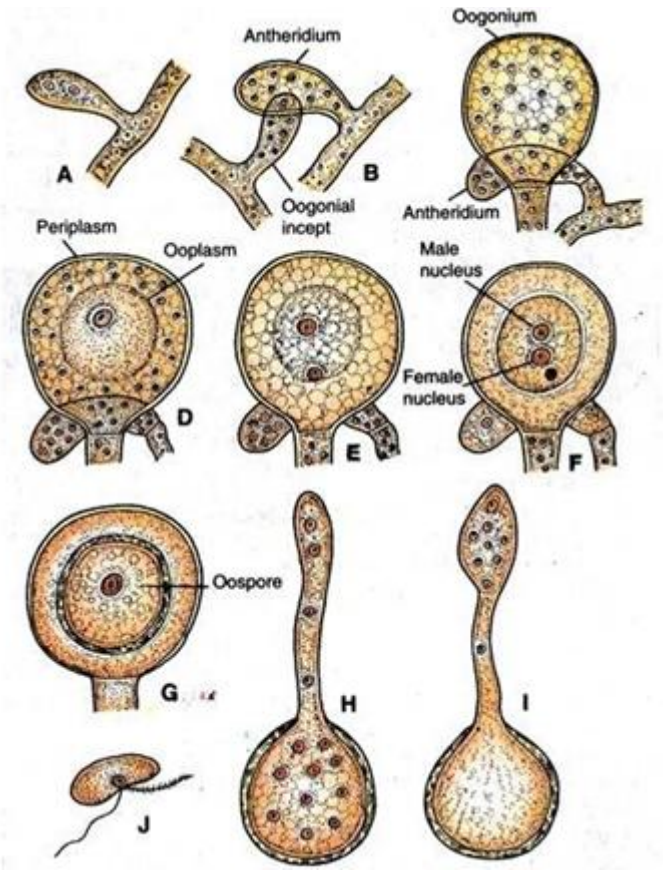

Fig:03 Phytophthora infestans.showing stages in development of sex organs and fertilisation (A-G) germination of oospore (H-I);liberated zoospore(J)

the mycelium of each strain in P. infestans produces both antheridia and oogonia which are self-sterile.

Mating, however, takes place between the sex organs of opposite mating types.

Oospores in this species are thus formed only if antheridium of A_1 strain copulates with oogonium of A_2 mating type and vice versa

Antheridial incept (Fig. 03:)

It arises as a short lateral hypha from the mycelium with its tip inflated to form a more or less clavate structure known as the young antheridium (A). It is thin-walled and contains non-vacuolated cytoplasm with a single nuclei before the entry of oogonial incept (A). Usually the young antheridium is not separated by a septum from the supporting hypha or stalk.

Oogonial incept (Fig. 03)

It also arises as a short, lateral hypha without any inflation (B). It contains dense, multinucleate cytoplasm.

The antheridial and oogonial incepts of the opposite mating types (A_1 and A_2) grow and curve towards each other. Eventually the tip of the oogonial incept of one strain comes in contact with the young antheridium of the opposite mating strain, punctures and grows through it (B) to emerge on the other side (C) where it swells into a globose structure, the oogonium (C).
The antheridium, now forms a collar-like structure surrounding the base of the oogonium (C). This type of antheridium is termed amphigynous.

Mature Oogonium (Fig. 03):
It lies above the antheridium and is spherical or pear-shaped in form (B). It has a dense, multinucleate cytoplasm when young (C). Towards maturity it increases in size. The protoplast becomes vacuolated. The nuclei which are spherical and about 40 in number undergo division

At this stage the oogonial protoplast becomes differentiated into an outer or peripheral, hyaline zone with vacuolate multinucleate cytoplasm surrounding a central, uninucleate region with denser cytoplasm. The former is called periplasm and the latter ooplasm (D).

All the nuclei in the periplasm later disintegrate (E). Prior to fertilization the single nucleus in the ooplasm divides into two daughter nuclei (E). One of these denegerates. The surviving one functions as the egg or oosphere nucleus.
Mature Antheridium:
It is funnel-shaped, sits on the oogonial stalk forming a collar-like structure around the base of the oogonium. This type of antheridium surrounding the base of the oogonium is termed amphigynous. It is delimited from its urpporting hypha by a septum. The antheridium contains about 12 nuclei.

These are formed from the original two nuclei of the young antheridium, after penetration by the oogonial branch by division. The division according to some investigators is haploid mitotic and according to others meiotic. Prior to fertilization all the nuclei except one degenerate. The surviving one functions as the male nucleus.

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Fertilization in Phytophthora:
The oogonial wall bulges at one point into the antheridium. This point is called the receptive spot. It then dissolves at the receptive spot. Through the opening the antheridium pushes the fertilization tube.

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Oospore:

The fertilized egg secretes a heavy wall around it and becomes an empty space between the oogonial wall and the thick oospore wall. The oospore thus partially fills the oogonial cavity and is described as aplerotic.

It is a resting spore

Germination of oospore:

Germination takes place after the decay of the host tissues and on the onset of conditions suitable for germination. The outer wall layer cracks and the inner one comes out as a germ tube which develops a sporangium at its tip. The sporangium may germinate indirectly by producing meiozoospores or directly by putting forth a germ tube. In all the instances, the first division of zygote nucleus is always reductional. Germ tube initiates formation fresh mycelium.

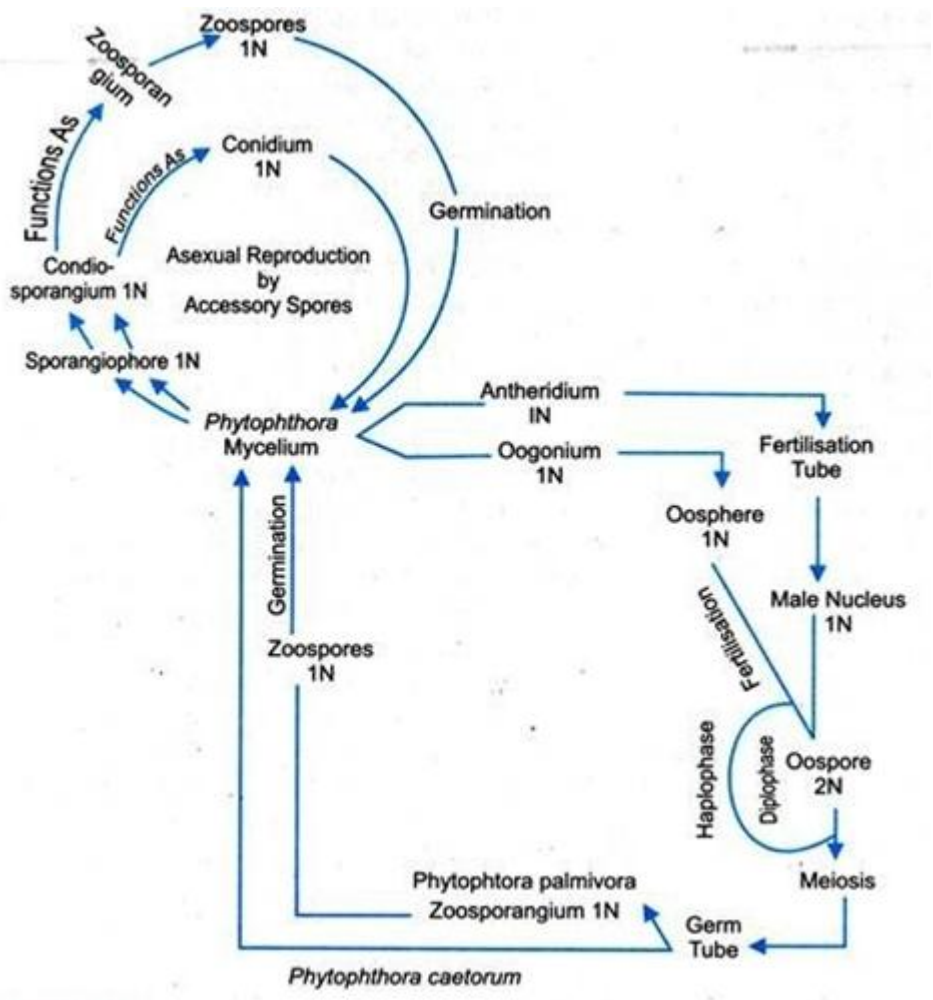

Fig:04 Graphic representation of life cycle of Phytophthora with zygotic meiosis

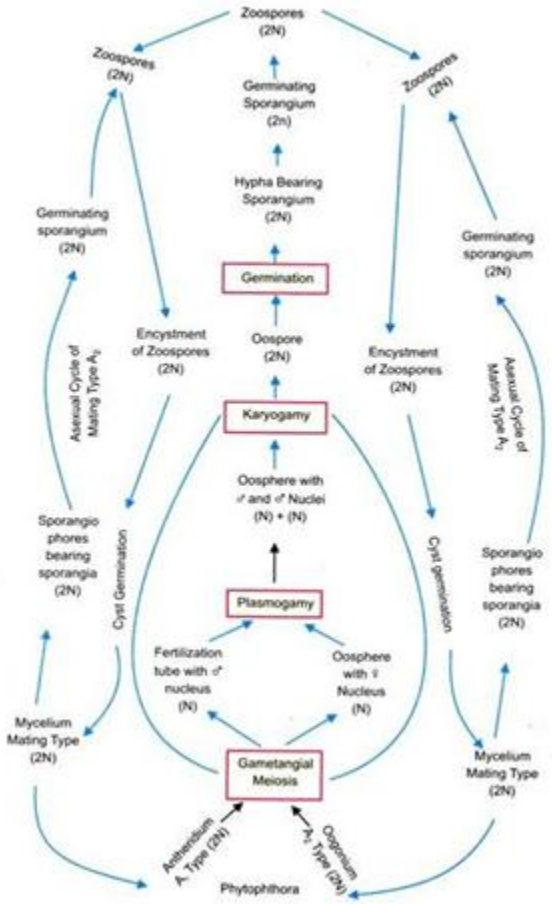

Fig: 05 Graphic representation of life cycle of Phytophthora with gametangial meiosis