

Albugo:

Contents:

1. Habit and Habitat of Albugo
 2. Symptoms of Albugo
 3. Vegetative Structure of Albugo
 4. Reproduction in Albugo
 5. Biological Specialization or Physiological Specialization in Albugo
 6. Control Measures of Albugo
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1. Habit and Habitat of Albugo:

Albugo (derived from a Latin word means white), the only genus of family Albuginaceae is represented by more than 25 species. It is an obligate parasite distributed all over the world.

In India about 18 species of Albugo have been reported which attacks mostly crucifers like turnip, mustard, radish, cabbage, cauliflower etc. However, it has also been reported on some members of family Asteraceae (Composite, Convolvulaceae and Chenopodiaceae).

2. Symptoms of Albugo:

The disease caused by Albugo is commonly known as white rust because it appears in the form of shiny, white, smooth irregular patches (pustules) or blisters on the leaves, stems and other aerial parts of the plant. The pustules are initially formed on the lower surface of the leaf but in several cases they may be present on both the surfaces (Fig. 1 A).

With this several other effects are also produced. Increase in the size of the cells (hypertrophy) and organs takes place. It results in the formation of large galls on the various parts of the host (Fig. 1 B-D). Severe infection causes proliferation of the lateral buds, discoloration of flowers, malformation of floral parts and sterile gynoeceium.

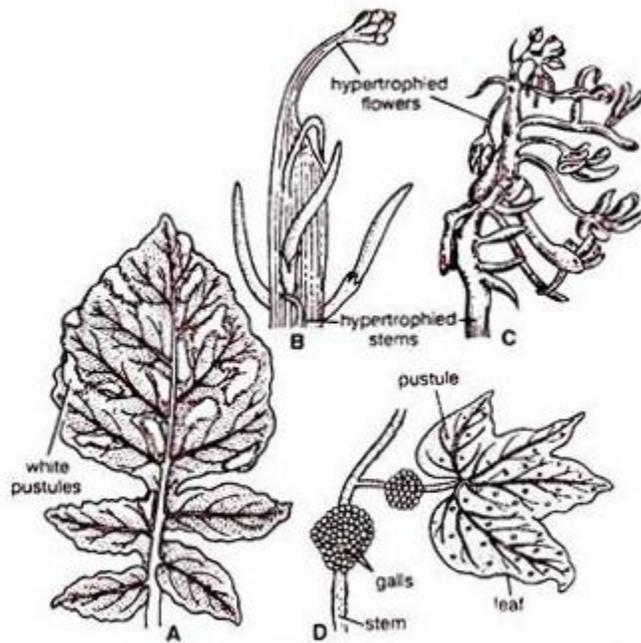


Fig. 1. (A–D). *Albugo*: Symptoms. (A) Infected radish leaf showing pustules; (B–C) Hypertrophied flowers and stem; (D) Galls on stem

3. Vegetative Structure of *Albugo*:

Thallus is eucarpic and mycelial. Hyphae are intercellular, coenocytic, aseptate and profusely branched (Fig. 2 B). Cell wall is composed of fungal cellulose. The protoplasm contains a large number of nuclei distributed in the cytoplasm.

Reserve food material is in the form of oil drops and glycogen bodies. Some mycelium is intracellular in the form of knob-like haustoria for the absorption of food material from the host cells. The ultrastructure of haustoria is studied by Berlin and Bowen (1964).

It can be differentiated into two parts:

- (a) Haustorial head, and
- (b) Narrow stalk.

The cytoplasm of the head of haustorium is densely packed with mitochondria, ribosomes, endoplasmic reticulum and lipid inclusions but nuclei are absent.

The base of the haustorium is surrounded by a collar like sheath which is an extension of the host cell wall. Between the haustorium and the host plasma membrane is an

encapsulation. Within the plasma membrane of the haustorium lomasomes are more numerous than in the intercellular hyphae.

4. Reproduction in Albugo:

The fungus reproduces both by asexual and sexual methods (Fig. 5, 6).

Asexual Reproduction:

The asexual reproduction takes place by conidia, conidiosporangia or zoosporangia. They are produced on the sporangiophores. Under suitable conditions the mycelium grows and branches rapidly.

After attaining a certain age of maturity, it produces a dense mat like growth just beneath the epidermis of the host (Fig. 2 D). These hyphae produce, at right angles to the epidermis are short, thick walled, un-branched and club shaped. These are the sporangiophores or conidiophores.

They form a solid, palisade like layer beneath the epidermis (Fig. 2 A-D). They are thick walled on lateral sides and thin walled at tip. The sporangiophores contain dense cytoplasm and about a dozen nuclei. After reaching a certain stage of maturity, the apical portion of sporangiophore gets swollen and is ready is cut off a sporangium or conidium (Fig. 2E).

The sporangia are produced at the tip by abstraction method. A Deeping constriction appears below the swollen (fig 2. F) end and results in the formation of first sporangium. A second sporangium is similarly formed from the tip just beneath the previous one (Fig. 2 G).

This process is repeated several times. The new nuclei migrates from mycelium to cytoplasm and are used in the formation of another sporangium or conidium. Thus along chain of sporangia or conidia is formed above each sporangiophore in basipetal succession. (youngest at the base and oldest at the tip) (Fig. 2 H).

The sporangia or conidia are spherical, smooth, hyaline and multinucleate structures. The walls between them fuse to form a gelatinous disc-like structure called disjunctor or separation disc or intercalary disc. (Fig. 2 G).

It tends to hold the sporangia together. The continued growth and production of sporangia exerts a pressure upon the enveloping epidermis. Which is firstly raised up but finally ruptured exposing the underlying sours containing white powdery dust of multinucleate sporangia or conidia (Fig. 2 A, 3).

The separation discs are dissolved by water, and the sporangia are set free. They are blown away in the air by wind or washed away by rain water under suitable environmental conditions and falling on a suitable host, sporangia germinates within 2 or 3 hours. The sporangia germinate directly or indirectly depending on temperature conditions.

1. Direct Germination:

At high temperature and comparative dry conditions the sporangium germinates directly. It gives rise to a germ tube which in-fact the host tissue through stoma or through an injury in the epidermis (Fig. 2 I, P).

2. Indirect Germination:

In the presence of moisture and low temperature (10°C) the sporangium germinates indirectly i.e., it behaves like zoosporangium and produces zoospores. It absorbs water, swells up, and its contents divide by cleaving into 5-8 polyhedral parts (Fig. 2 J) depending upon the nuclei present in it. Each part later on rounds up and metamorphoses into zoospore (Fig. 2 K, L). A papilla is developed on one side which later burst and liberates the zoospores.

Zoospore:

The zoospores are uninucleate, slightly concavo-convex and biflagellate. The flagella are attached laterally near the vacuole. Of the two flagella one is of whiplash type and the other tinsel type (Fig. 2M). After swimming for some time in water, they settle down on the host.

They retract their flagella, secrete a wall and undergo a period of encystment (Fig. 2 N). On germination, they put out a short germ tube which enters the host through stomata (Fig. 2 O, P) or again infects the healthy plants.

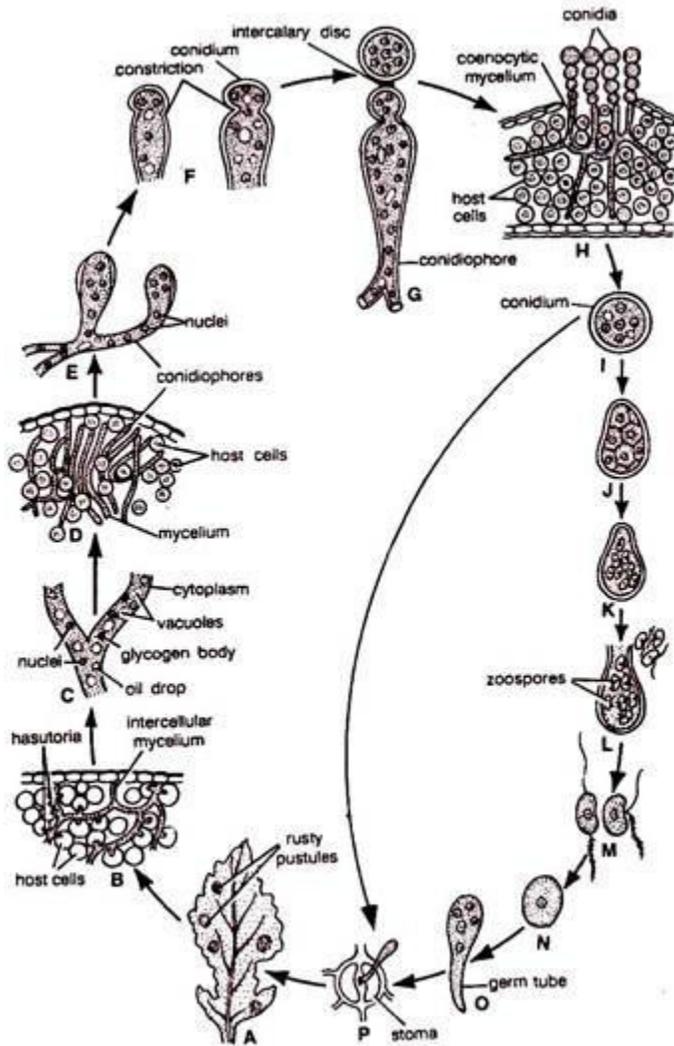


Fig. 2. (A-D). *Albugo* : A sexual reproduction

Sexual Reproduction:

It takes place when the growing season comes to an end. The mycelium penetrates into the deeper tissues of the host. The sexual reproduction is highly oogamous type. The antheridium and oogonium develops deeper in the host tissue in close association within the intercellular spaces.

Its formation is externally indicated by hypertrophy. The antheridium and oogonium are formed near each other on hyphal branches. They are terminal in position, however, intercalary oogonia also occur, though rarely.

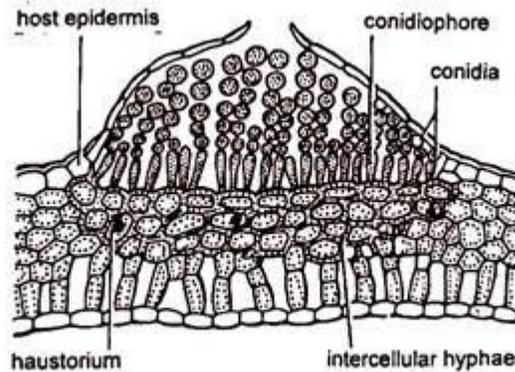


Fig. 3. *Albugo* : Asexual reproduction V.S. of *Brassica* leaf passing through infected portion

Antheridium:

It is elongated and club shaped structure. It is multinucleate (6-12 nuclei) but only one nucleus remains functional at the time of fertilization in *C. candidus*. However, in *C. bliti* and *C. portulacae* it is multinucleate at the time of fertilization and all the nuclei (nearly 100) remain functional. It is paragynous i.e., laterally attached to the oogonium (Fig. 4 A-C). It is separated by a cross wall from the rest of the male hyphae.

Oogonium:

It is spherical and multinucleate containing as many as 65 to 115 nuclei. All nuclei are evenly distributed throughout the cytoplasm (Fig. 4 A-C). As the oogonium reaches towards the maturity the contents of the oogonium get organised into an outer peripheral region of periplasm and the inner dense central region of ooplasm or oosphere or the egg (Fig. 4 D-G). The ooplasm and periplasm are separated by a plasma membrane.

The nuclei in the oogonium divides mitotically. The first mitotic division takes place before the organization of the periplasm and ooplasm (Fig. 4 E). After the organization, all the nuclei of the ooplasm, except one, migrate to the periplasm forming a ring and undergo second mitotic division. They divide in such a manner that one pole of each spindle is in ooplasm and the other in the periplasm (Fig. 4 E).

At the end of the division one daughter nucleus of each spindle goes to the ooplasm and other in periplasm (Fig. 4 F). However, at the time of maturity, all nuclei disintegrate, except single functional nucleus (Fig. 4 G). On the basis of functional nuclei in ooplasm," *Albugo* is divided into following groups:

Group I:

The number of functional egg nucleus in ooplasm is one. It is represented by *C. tragopogonis*, *C. candidus*, *C. evolvuli* etc.

Group II:

The number of functional eggs in ooplasm is many. It is represented by *C. bliti*, *C. portulacae* etc.

It has been observed that in *C. portulacae* and *C. bliti* nearly 60 nuclei accumulate in the ooplasm and after fertilization they fuse with the male nuclei. However, in *C. tragopogonis* about a hundred female nuclei are present in the oosphere, but only one is functional. The rest of the nuclei disintegrate before fertilization.

Fertilization:

Before fertilization a deeply staining mass of cytoplasm, (Fig. 4 H) appears almost in the centre of the ooplasm. This is called coenocentrum. It persists only up to the time of fertilization. The functional female nucleus attracted towards it and becomes attached to a point near it.

The oogonium develops a papilla like out growth at the point of contact with the antheridium. This is called as receptive papilla (Fig. 4 G). Soon it disappears, and the antheridium develops a fertilization tube.

It penetrates through receptive papilla, oogonial wall and periplasm and finally reaches upto the ooplasm (Fig. 4 H, L). It carries a single male nucleus. Its tip ruptures to discharge the male nucleus near the female nucleus. Ultimately the male nucleus fuses with the female nucleus (karyogamy).

Oospore:

The oospore alongwith the fusion nucleus is called oospore (Fig. 4 J). In *C. tragopogonis* and *C. candidus*, one male functional nucleus fuses with one female functional nucleus. So, the oospore is uninucleate. However, in *C. portulacae* and *C. bliti*, oospore is multinucleate. consisting of nearly 60 functional nuclei.

The same number of functional male nuclei are discharged by the fertilization tube. Both male and female nuclei fuse, and the oospore produced in these species is multinucleate. Such oospore is called a compound oospore.

The oospore on maturity secretes a two to three layered wall (Fig. 4 J-L). The outer layer is thick, warty or tuberculated and represents the exospore. The inner layer is thin and called the endospore.

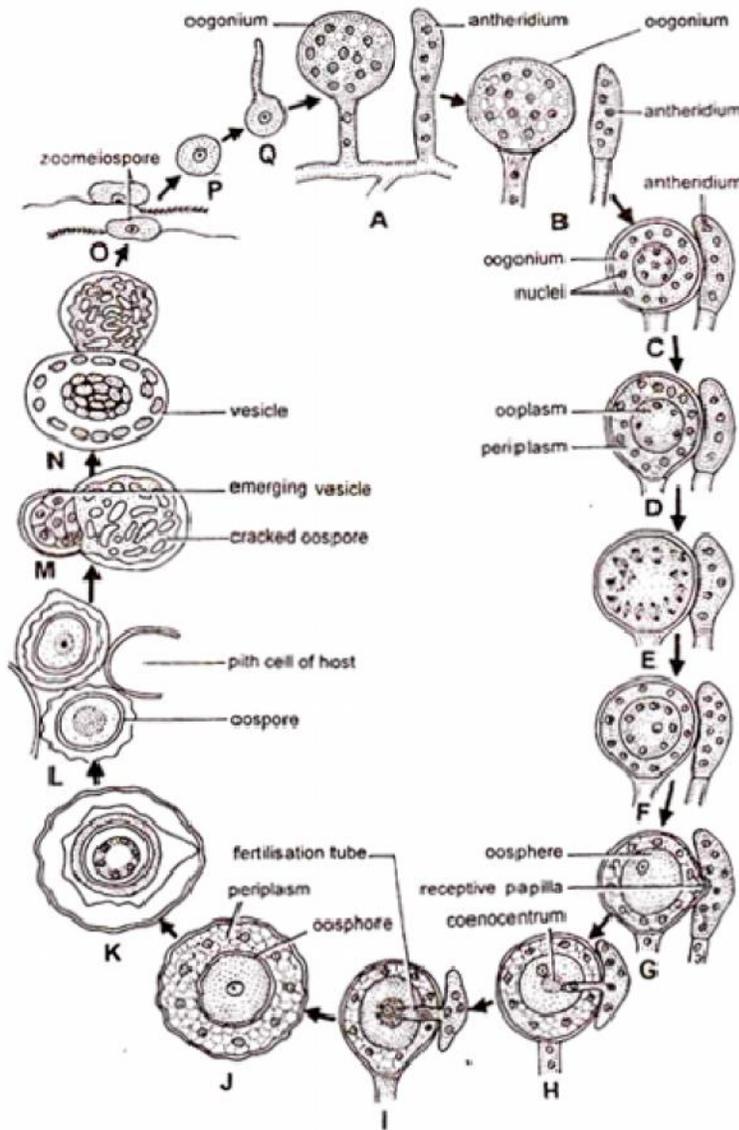


Fig. 4. (A-Q). *Albugo* : Sexual reproduction

Germination of oospore:

With the secretion of the wall, the zygotic nucleus divides repeatedly to form about 32 nuclei. The first division is meiotic. At this stage the oospore undergoes a long period of rest until unfavorable conditions are over. Meanwhile its host tissues disintegrate leaving the oospore free. After a long period of rest the oospore germinates. Its nuclei divide mitotically and large number of nuclei are produced.

A small amount of cytoplasm gathers around each nucleus. Protoplasm undergoes segmentation and each segment later on rounds up and metamorphoses into a zoomeiospre or zoospore (Fig. 4 O). The exospore is ruptured and the endospore comes out as a thin vesicle (Fig. 4 M). The zoospores move out into the thin vesicle which soon perishes to liberate the zoospores.

However, Vanterpool (1959) reported that oospore forms a short exit or germ tube which ends in a thin vesicle. According to Stevens (1899), Sansome and Sansome (1974), the thallus of *Albugo* is diploid and the meiosis occurs in gametangia i.e., Antheridia and oogonia. Zygotic nucleus divides only mitotically and not meiotically.

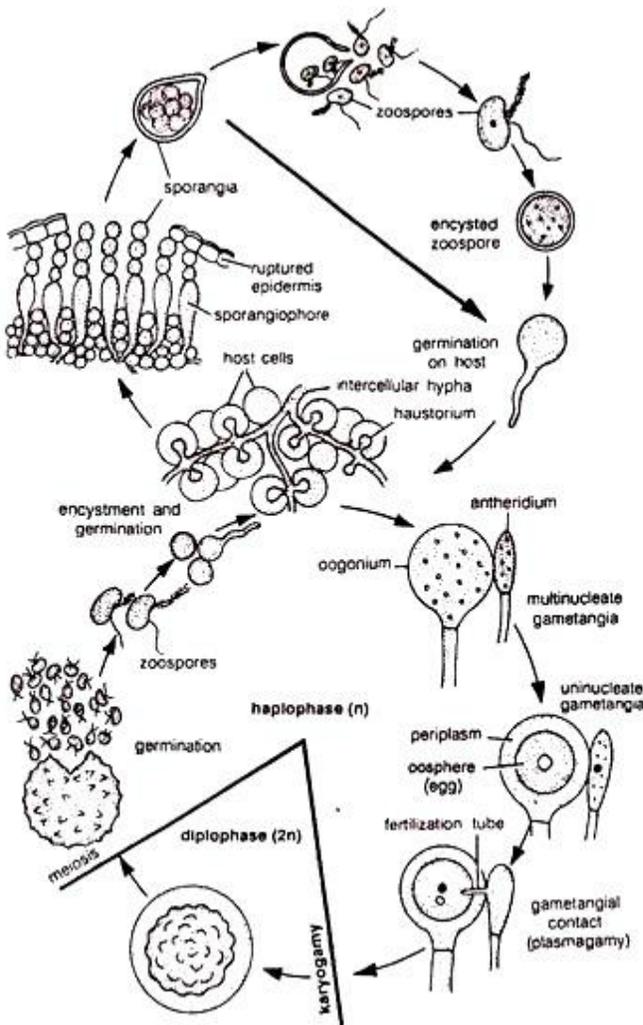


Fig. 5. *Albugo* : Diagrammatic life cycle

Germination of Zoospore:

The zoospores are reniform (kidney shaped) and biflagellate. Of the two flagella, long one is of whiplash type and short one is of tinsel type (Fig. 4 O). The zoospores after swimming for sometime encyst and germinate by a germ tube which re-infects the host plant (Fig. 4 O, P, Q).

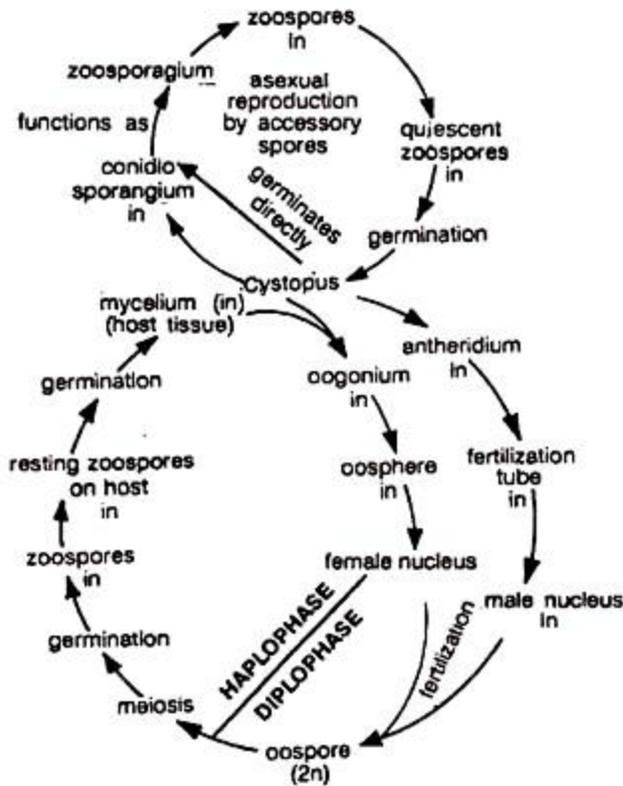


Fig. 6. *Albugo* : Graphic life cycle

5. Biological Specialization or Physiological Specialization in *Albugo*:

In *Albugo*, it has been observed that a species for e.g., *A. Candida* attacks only the members of family Brassicaceae (Cruciferae) but not others. It has also been observed that *A. Candida* infects only one host e.g., Brassica but it does not infect the other host i.e., radish. This means that the *A. Candida* obtained from different host are not the same and therefore, have to be named differently.

Thus the species should be divided into groups below species level. These are called biological forms or physiological forms. These biological forms are specialised in

parasitism, therefore, the phenomenon is called as biological specialization or physiological -specialization.

Some common species of Albugo with their hosts are:

- (i) *A. candida* (= *C. candidus*) – Brassica, turnip, cabbage, Raphanus, Capsella, Eruca saliva.
 - (ii) *A. ipomoeae-panduranae* – Sweet potato, *Ipomoea pestigrades*.
 - (iii) *A. bliti* – Common on Amaranthaceae.
 - (iv) *A. tragopogonis* – On member of Asteraceae.
 - (v) *A. occidentalis* – infects spinach.
 - (vi) *A. portulacae* – on *Portulaca*.
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6. Control Measures of Albugo:

- (i) Growing resistant varieties.
- (ii) Eradication of infected plant and their complete destruction.
- (iii) Rotation of crucifers plants with non cruciferous plants.
- (iv) Spraying the fungicides like lime, sulphur etc