

Course- IMB(vocational)Hons. part3/ B.Sc.Bot.Part I Hons.

Plant Pathology: (Plant disease)

Black or Stem Rust Disease of Wheat

Causal organism- *Puccinia graminis tritici*

Host- *Triticum aestivum* (Wheat)

Introduction:

Black or stem rust is a very common disease of wheat plant. Wheat rusts are regarded as the most destructive pathogens on the crop in many countries. Wheat rust epidemics in India have been recorded as early as 1827 in the central provinces and in 1947 the black rust fungus almost caused a famine. The disease is marked with appearance of black/brown coloured elongated lesions with the powdery mass in the diseased part of the plant similar to rusting of iron. The disease is worldwide and most common in the wheat growing areas in our country also. This is caused by the fungus ***Puccinia graminis tritici*** belonging to class basidiomycetes. It is heteroecious (life cycle involves two different hosts), obligate parasite. It completes its life cycle on wheat plant (Primary host) and the Barberry plant (Secondary or alternate host).

Besides ***Puccinia graminis tritici***, there are another species of Puccinia infecting wheat, such as **Brown or orange rust**, caused by ***Puccinia recondita (P. triticina)*** and **Yellow or stripe rust, caused by *P. striiformis (P. glumarum)***. In black or stem rust the disease symptoms appear as brown coloured pustule mostly on stem or leaf sheath. This pustule later become more prominent and turn black coloured. It attacks all the above ground part of the plant. Infected plants usually produce fewer seeds and the kernels are smaller, generally shrivelled. Heavily infected plants may die or may weaken the plants making them susceptible to other pathogens. This disease has greatly affected the wheat production in USA and India.

Symptoms-

The pathogen causing stem rust of wheat attacks and produces symptoms on wheat and related cereals (barley, oats, rye) and grasses and on plants of barberry (*Barberris vulgaris*)
The symptoms of disease on wheat appear on stem, leaf sheath and leaf as elliptical blisters or pustules, called **Uredia**. These may appear on neck and glumes of the wheat spike (inflorescence).The epidermis lining the pustule are later ruptured. A powdery mass of brick red coloured uredospores get exposed beneath the ruptured epidermis. Later in the season, as the plant approaches maturity, the pustules turn black as the fungus produces teliospores or teleutospores instead of uredospores and uredia are transformed into black telia. Sometimes telia may develop independently. Uredia and telia may exist on the wheat plant in large numbers and the whole part of the infected plant appear to be covered with ruptured areas, which are filled with uredia and telia both.



Fig. Uredia of *Puccinia graminis tritici* covering wheat leaf (A), on stem and leaves (B)

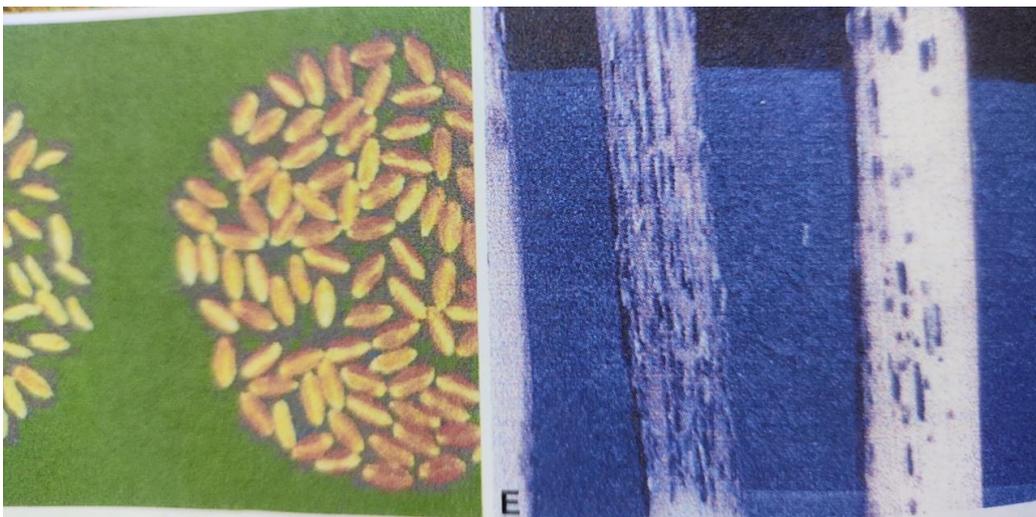


Fig. Smaller seeds due to rust infection. Fig. Telia on the wheat stem.



Fig. Wheat spike infected with *Puccinia graminis tritici*

(Figs. Courtesy. Plant pathology, Agrios G N.)

Fungal structure- The fungal body consists of well branched mycelium. It is septate, endophytic, intercellular, branched and monokaryotic in primary mycelium. The secondary mycelium, which develops later in the life cycle, is dikaryotic due to dikaryotization. The mycelium produces haustoria with knob like apex, through which it absorbs nutrition from the host cell. The dikaryotic or secondary mycelium is confined to the primary host i.e., wheat and monokaryotic mycelium develops on the secondary host i.e., *Berberis*.

Disease Cycle –

The black or stem rust completes its cycle on two hosts i.e., wheat and Barberry. Wheat is initially infected by the aeciospores, coming from the secondary host barberry plants. However, the disease spreads on other hosts through the uredospores, which are produced on the infected wheat plant. The fungus, *Puccinia graminis tritici* produces five different types of spores in its life cycle involving two hosts. These spores are **Uredospores, Teleutospores, Basidiospores, Pycniospores and Aeciospores.**

1. Uredospores-

Uredospores are produced on the primary host (wheat). These are brown coloured, round or elliptical (shape varies in different species) one celled, dikaryotic and are borne on short, erect sporophores. Uredospores are having echinulate (spiny) exosporium and smooth, thin endosporium. The uredospores are produced in groups in a localized structure beneath the epidermis. These localized structures are called as Uredia. These uredia can be seen externally on the infected part as brown pustules. Uredospores are released from the pustules by rupture of epidermis of the infected part of wheat plant. These uredospores reach new wheat plants and infect them. Due to dissemination of uredospores, new hosts get infected at much faster speed.

2. Teleutospores-

These are also produced on wheat plant, which is the primary host. Teleutospores are thick walled dark coloured which develop either in the same uredium or in separate pustules after maturation of uredospores. These are black/ brown coloured, bicelled, dikaryotic spores. These possess thick exosporium, which help them to resist hot weather conditions present at the time of their maturity. The pustules containing Teleutospores are called as telia or teleutosori. The telia in black or stem rust are exposed, irregular, elongated, dark brown or black. On maturation, the telia rupture and Teleutospores are released. Teleutospores vary in shapes in different species of Puccinia. In *P. graminis tritici*, Teleutospores have pointed apex, but in **yellow or stripe rust** caused by *P. striiformis*, they are elongated with flat or oblique apices.

Teleutospores are bicelled, having upper and lower cell. The upper cell has single germ pore at the apex, but the lower cell has a lateral germ pore. The fully mature teleutospores are thick walled and dark brown in colour. The two nuclei of a dikaryon of each cell fuse, and in each cell a diploid nucleus develops. Therefore, each teleutospore contains two cells, each having a diploid nucleus. When teleutospores mature, the wheat crop is harvested and teleutospores are scattered on the crop residues. Teleutospores remain dormant until the favourable season comes.

On approach of favourable conditions, the dormant protoplasm of the resting Teleutospores become active and produces a single tubular outgrowth from the germ pore. This is called promycelium or basidium. The diploid nucleus is transferred to the basidium, where it divides meiotically. The first division is reductional and subsequent division gives four daughter nuclei. Four basidiospores develop in each basidium. Basidiospores are borne on pointed stalked structure called as sterigma. Each basidiospore is borne on a sterigma. Puccinia is heterothallic and two opposite mating mycelia (+ and -) are separate. Out of four basidiospores two of them belong to + strain while other two are of – strain.

After detaching from the sterigma, the basidiospores are blown by wind to the alternate host Barberry plants to complete its life cycle.

3. Basidiospores-

These are round, smooth walled, monokaryotic, haploid spores. These are produced on basidia. Basidiospores of black rust infect the alternate or secondary host Barberry. They germinate producing monokaryotic mycelia. The + strain gives (+) strain mycelia and the – strain germinates into (–) strain mycelia. The mycelia ramify in the Barberry leaf beneath the epidermis. The monokaryotic mycelium aggregate and form a flask shaped structure with its opening in upper epidermis. This structure is called **pycnidium** or **pycnium** or **spermogonium**, and the opening is called ostiole.

4. Pycnidiospores/Pycniospores

Pycniospores are produced on an erect hyphal structure, known as pycniophores. These pycniophores are present in a cup like structure formed of fungal mycelium on the upper surface of the barberry leaf. These cup like structures are called as pycnidium/pycnium.

Many vertical hyphae called pycniophores arise from the hymenium of the fungal tissue. From the terminal ends of pycniophores, round, oval, haploid and uninucleate spores develop in basigenous pattern. These spores are called Pycniospores or spermatia. The pycnium bears some sterile hyphae at its opening. These are called as paraphyses. Besides them, some flexuous hyphae also develop and come out of ostiole. These are receptors of spermatia/Pycniospores. On maturity, the pycnium secretes nectar like secretions. This stage is known as **honey-dew stage**. Pycniospores reach the flexuous hyphae. Pycniospores of one pycnium are compatible with flexuous hyphae of another pycnium only.

Dikaryotization- Dikaryotization takes place by the transfer of one nucleus from spermatium to the flexuous hyphal cell, which is monokaryotic. This happens as the insects visit the pycnium for the nectar and transfer the Pycniospores to flexuous hyphae of another pycnium. When the opposite strain pycniospores and the flexuous hyphae come in contact, the wall of contact dissolves and the nucleus of pycniospore passes into the flexuous hypha. This makes the beginning of dikaryotic mycelium or **dikaryophase**. The dikaryotization of mycelium is the result of **spermatization**. The mechanism of spermatization involves plasmogamy between spermatia and flexuous hyphae. The mature spermatia exude from spermogonium in a drop of sticky nectar secretion. This nectar attracts insects to visit spermogonium and the spermatia or Pycniospores are passively transferred to another pycnium/spermogonium. This stage is called as **Honey-dew stage**. The dikaryotic mycelium grows and moves towards lower epidermal region of the leaf. These mycelia form another flask shaped structure, called as **aecidium** or **aecium**. These aecia have opening with ostiole in the lower epidermis of the Barberry leaf.

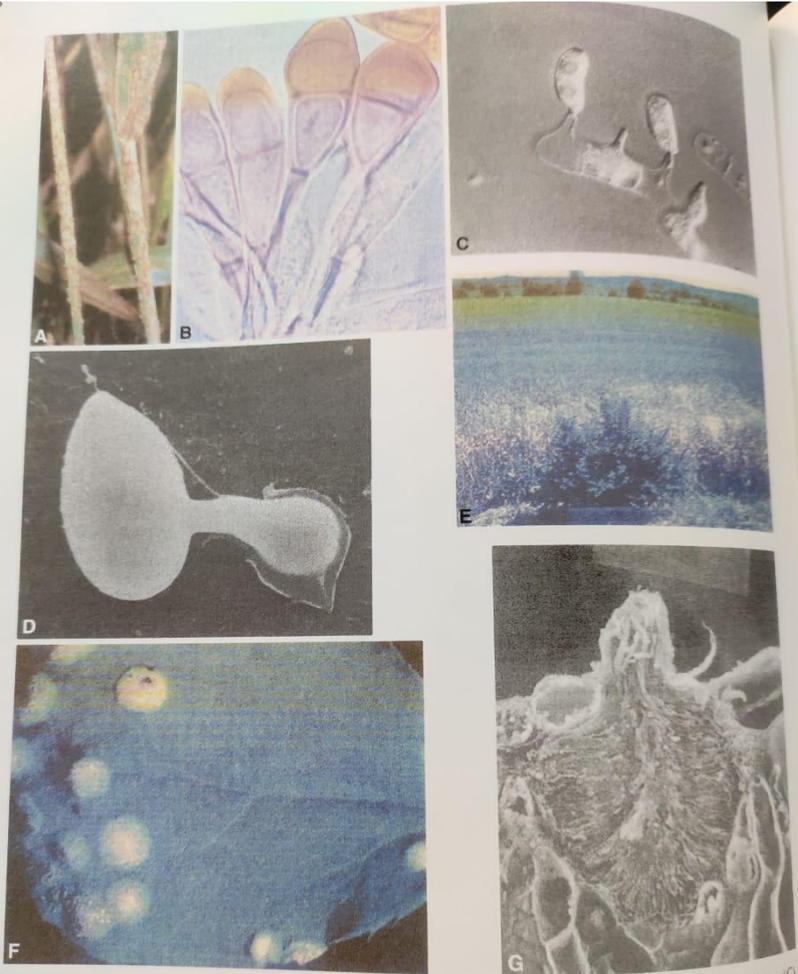


FIGURE 11-132 (A) Uredia and telia on stem rust-infected wheat plant. (B) Teliospores of stem rust of wheat. (C) Basidium with two of the four basidiospores produced by a teliospore. (D) A germinating basidiospore with a swollen appressorium covered with extracellular material. (E) Early infection of wheat plants growing next to a bush of barberry, the alternate host of the wheat stem rust fungus. (F) Spermatogonia of the stem rust fungus produced on the upper surface of a barberry leaf. (G) Cross section of spermatogonium of a rust fungus. [Photographs courtesy of (A) WCPD, (B) J.F. Hennen, (C, D, and G) C.W. Mims, University of Georgia, (E) Cereal Dis. Lab. Archives, and (F) D. L. Long, USDA.]

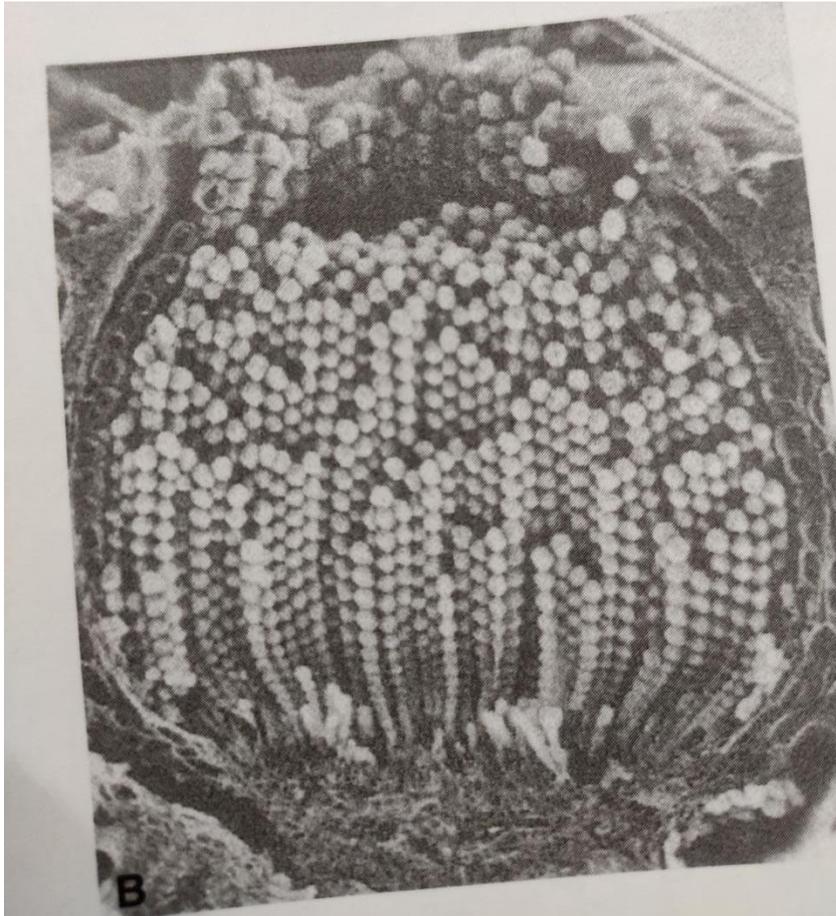


Fig. Aecidium of *P.graminis tritici* on Barberry leaf.

Figs. Courtesy: Plant pathology, Agrios G N.

5. Aeciospores-

Aeciospores are produced in aecium or aecidium. The aecium develops from the dikaryotic mycelium produced by the dikaryotization in pycnium. Aeciospores are produced from the aeciospores mother cell and are separated from each other by a disjuncter cell. These aeciospores are produced in basigenous manner in the number of millions per aecium. On maturation, the intercalary or disjuncter cell degenerate and aeciospores are released free in the air. Aeciospores are orange coloured, round, but become polygonal due to mutual pressure, unicellular, dikaryotic (xx) and double walled. Aeciospores are disseminated by wind to plains, where wheat is grown. It was observed that there is least or no role of alternate host in our country. However, some other hilly plants acting as collateral hosts may play role in recurrence of rust in India.

Annual recurrence

Recurrence of rust of wheat in India has been explored in the past by Mehta (1940, 52). He had earlier presumed that the primary inoculum of this rust comes from Nepal. However, his further researches could reveal that the inoculum sources are the Nilgiri and Palney hills in the south. If, the inoculum would have come from Himalayan range, the early infection would have occurred as early as in February, but in Indian plains, the infection begins in late March or in April.

The disease appears during the months of December–January in the southern plains due to favourable environmental conditions including winds and availability of abundant inoculum, coming from Nilgiri and Palney hills, where there are source of inoculum (Barberry).

Disease control/Management-

The most effective, and the practical means of control of this disease is through the use of varieties resistant to the disease. Many works have been done in this field to develop resistant varieties with desired parameters. Rust resistant varieties could be developed in U.P., M.P., Maharashtra and elsewhere. Varieties like S 27, S 307, S 308, S 331, Lerma Rojo and Sonora 63 and 64 showed resistant to most races of the rusts. Some other resistant varieties for stem rust are HD-2278, HW 741, and WT.

Eradication of alternate hosts is partly useful in control of the disease. However, in our country none of the wheat rusts depends on for survival. The pathogen spores may overwinter on stray or self sown wheat plants and many collateral hosts in hills. It is not an easy task to remove all the alternate hosts.

Chemical control- use of sulphur fungicides has been in practice to control the disease, but it is expensive. Many fungicides, which act both as eradicants as well as protectants are recommended. These include various Dithanes, Dithiocarbamates like Dithane D-14, Dithane M-45, Zineb, Mancozeb, and Maneb etc. Systemic fungicides are also effective as seed treatment and foliar spray chemicals. These include Vitavax, Plantvax. Very effective control is found with the use of newly introduced triazole fungicides, like triadimefon, triarimol and fenapanil.