

2.2 Black stem rust of Wheat :

A. OCCURRENCE AND IMPORTANCE—Black stem rust disease appears on the wheat crop in all wheat growing countries throughout the world ;

this disease also appears in an epiphytotic form in many countries. In northern India the disease does not appear before March. In southern India, the disease, however may appear as early as the last week of November.

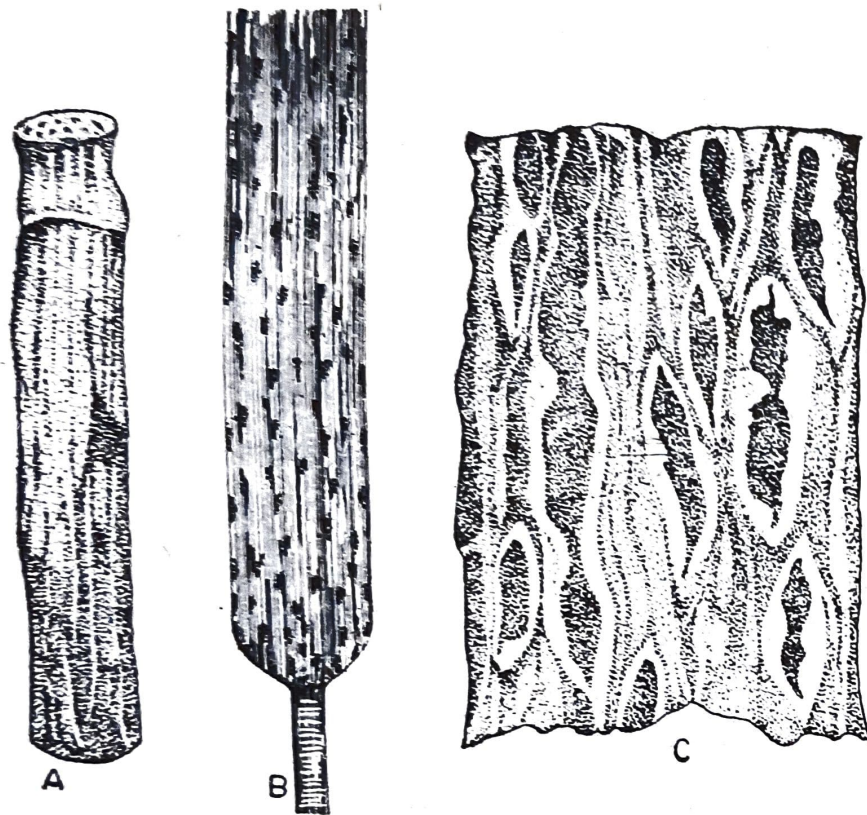


Fig. 2.2—Black stem rust disease of wheat. A—Presence of teleutosori on a portion of a diseased stem. B—Presence of uredosori on a portion of a diseased leaf. C—Portion of a stem with enlarged teleutosori.

of host plants (primary and secondary). The most serious and economically important symptoms are produced on wheat plant (primary host) while economically unimportant symptoms are produced on barberry plant (secondary host).

(1) *On wheat plant* (Fig. 2.2)—The symptoms on wheat appear at first as long, narrow, elliptical or oblong and brown pustules, parallel with long axis of the stem, leaf sheaths and leaves (lower surface mainly) of young seedlings or of plants at any stage of growth. In later stages of plant growth, pustules may appear on the glumes and even the beards. Those pustules called uredia grow and fuse to form larger lesions of dark brown colour, the pustules vary

Black stem rust causes losses by reducing yield and quality of seed. The amount of losses caused by stem rust may vary from slight to complete destruction of wheat fields over large areas. Heavily infected plants may die under extreme situation.

B. SYMPTOMS—The pathogen causing black stem rust of wheat produces symptoms on two distinctly different kinds

in size from small to about 3 mm wide by 10 mm long. Within a few days, the epidermis covering the pustules is ruptured irregularly exposing a powdery mass of reddish or rust-coloured spores, called uredospores.

In the later stages, as the plant approaches maturity, the reddish or rusty colour of the pustules turns black because the fungus produces teliospores instead of uredospores and uredia are transformed into black and smooth-walled telia. Telia form oblong to linear lesions and are more frequent on leaf sheaths than on stem. Sometimes uredia and telia may exist on wheat plants in such a great numbers that greater part of the plant appears to be covered with the ruptured areas which are filled with either reddish uredospores or the black teliospores or both. In severe attacks, plants in general look sickly and fail to form normal ears; the grains become shrivelled and lighter in weight.

(2) *On barberry plant*—The symptoms appear on the leaves and sometimes on young twigs and fruits as yellowish to orange-coloured spots. On the upper side of the leaf and within the spots, a few minute dark-coloured bodies bearing a small droplet of liquid appear. On the lower side of the leaf, beneath the pycnia, groups of orange-yellow cup-like projections called aecia appear. The host tissue bearing the aecia becomes often hypertrophied. The aecial wall, called a peridium usually protrudes at the margin of the cups.

C. THE CAUSAL ORGANISM (The pathogen)—*Puceinia graminis tritici* Erikss & Henn. This fungal pathogen is a basidiomycete. It is heteroecious, its principal host is wheat plant (*Triticum aestivum*) and the alternating host is barberry plant (*Berberis vulgaris*).

D. ETIOLOGY OF THE PATHOGEN—The mycelium of this fungus is colourless and produces several different types of spores. Prominent uredia (uredosori) are the first to appear on the culms, leaf-sheaths and also the leaves of wheat plant; they are oblong to circular, reddish-brown, powdery and frequently merge into one another. The dikaryotic mycelium is intercellular, the hyphae produce small round or branched haustoria which draw nutrition from the host cells. A mass of hyphae collects beneath the host epidermis and forms an uredosorus (uredium). From the base of this sorus, numerous stalked, one-celled, oval, brown, binucleate (dikaryotic), thick-walled with minute spines on the outer wall and 4-germpored (equatorially arranged) uredospores arise. Uredospores germinate in presence of water or moist air forming germ tubes which are capable of re-infecting (secondary infection) wheat plants; hence uredospores are called repeating spores.

Telia (teleutosori) arise late in the season, either in uredia or independently from the same or similar dikaryotic mycelium. They are oblong to linear, dark-brown to black and not powdery although spores (teliospores) are exposed through rifted epidermis. A teliospore (also called teleutospore) is stalked, two-celled, spindle-shaped, slightly constricted at the septum, dark brown (but black in mass) and has a thick smooth wall with 2 germpores—one at the apex and the other below the septum; the apex is rounded or pointed. Each cell of a teliospore possesses 2-nuclei (derived from the dikaryotic mycelium); at maturity, the two nuclei in each cell fuse forming a diploid nucleus. Hence mature teliospores represent the diploid phase in the life cycle of *P. graminis tritici*. Unlike uredospores, teliospores do not germinate immediately but undergo a period of rest for several months. Teliospores as usually germinate in presence of moisture; on germination each cell of a teliospore produces a long and four-celled promycelium (basidium); during the formation of promycelium, the diploid nucleus undergoes meiosis and 4 hyaline, roundish sporidia *i.e.* basidiospores (2 of '+' strain and 2 of '-' strain) are formed on sterigmata (formed from the cells of promycelium). Sporidia fall off easily and are blown about by wind. Being a heteroecious fungus, the sporidia of *P. graminis tritici* are unable to infect wheat plants.

Therefore sporidia germinate on barberry plant (alternating host) in presence of moisture to form monokaryotic mycelium.

This mycelium forms two types of flask-shaped and ostiolate pycnia (spermogonia) i.e. '+' and '-' on the upper epidermis of leaves of barberry plant, they remain embedded in the host tissue in orange-yellow spots. Pycnia contain paraphyses and hyaline pycniospores (spermatia) which emerge in a viscous exudate through an ostiole along with slender flexuous hyphae. The pycniospores are carried to respective '+' to '-' and '-' to '+' flexuous hyphae through insects establishing dikaryotic condition.

The dikaryotic mycelium then produces saucer-shaped aecia on the lower epidermis of barberry leaves; aecia have well-developed peridium which breaks with the maturity and protrudes out of the leaf. The aecium produces aeciospores in chains. Aeciospores are one-celled, binucleate and hexagonal in shape; they are disseminated by wind and infect wheat; being dikaryotic, the aeciospore produces dikaryotic mycelium which ultimately gives rise to uredosori on wheat plant.

E. DISEASE CYCLE—The pathogen survives on stubble and straw of primary host (wheat plant) for several months as teleutospores. Practically this spore convey the disease to the alternate host i.e. barberry. Being heterothallic, the teleutospore of *P. graminis tritici* on germination produces basidiospores of two opposite strains i.e. 2 of '+' and 2 of '-' strains. Basidiospores are dispersed by wind and fall on barberry plant infecting leaves mainly. Two types of pycnia (+ and -) are produced towards the upper epidermis of barberry leaf by the respective (+ and -) basidiospores. Following spermatization by insects or raindrops, dikaryotic condition is established which results in the formation of aecia and aeciospores. The aeciospores are cut off in chain from the aecia and are carried to the wheat plant by wind. The aeciospores germinate in presence of moisture and ultimately form dikaryotic hyphae which ramify intercellularly into the parenchymatous tissue, from this hyphae uredospores are produced in uredosori. The uredospores are carried by wind and germinate on healthy wheat plants to spread infection. With the dissemination of uredospores, fresh uredospores continue to be formed, i.e. the uredospore-cycle may be repeated several times during the season, comprising the red-rust stage or repeating stage, which causes the chief damage. In uredosori and in other spots, the hyphae give rise to teleutosori and teleutospores as the primary host plant approaches maturity (refer Fig. 4.6, Fungi portion).

On the plains of India, the source of primary infection is the uredospores formed in wheat plants on hills, where the crop is grown throughout the year. When winds blow from hills downwards, the uredospores reach the plains infecting wheat crops late in the season. Uredospores initiate the infection and produce uredosori, these uredosori produce several successive generations of uredospores. This condition results in spread of infection to healthy plants. In the last few generations of uredospore-formation and with the gradual maturity of wheat plants, teleutospores in teleutosori appear which perish in the high temperature of the intervening summer months. Next year, the wind again bring the primary inoculum i.e., uredospores from the hills. The dikaryotic aeciospores do not initiate the disease cycle in India as they do in U.S.A. Since barberry plants (alternating host) do not carry natural infections of this pathogen, the barberry eradication programme, which was successful in U.S.A., is ineffective in India.

F. CONTROL—(1) The most effective and the only control measure of the stem rust of wheat is through the use of wheat varieties resistant to infection by the pathogen. In India 14 physiologic races and 6 biotypes of the fungus are reported. It is difficult to obtain resistance against all races in

one wheat variety—hence varieties that are resistant to most virulent locally existing races should be used in a particular area.

(2) Excessive use of nitrogenous manures which influence the growth of rust fungi should be avoided. Dense seeding also to be avoided.

(3) Proper drainage in the wheat field should be maintained, as the dampness of the soil and atmosphere promotes the growth of rust fungi.

(4) Chemical control of black stem rust of wheat too is available. It can be controlled by dusting with sulphur @ 6.7 to 9.0 kg. per acre or spraying with zinc sulphate or parate @ 2.25 litres + 336 grams per 450 litres water per acre. As soon as the symptoms of the disease appear, the crop may be sprayed 3-4 times with dithiocarbamate fungicides such as Dithane Z-78, Dithane M-22, Dithane S-31 etc. @ 1 kg. per acre. Several other fungicides such as sulphur, dichlone, zineb, maneb etc. can effectively control the stem rust of wheat—in most cases 5-10 applications per season are required for complete control of the rust.