

## “AN INTRODUCTION-DISEASES OF WHEAT”

### Abstract

On average, about 20% of the global wheat production is lost due to diseases and pests every year. In 2021, these losses amounted to about 165 million tons, equivalent to about \$35 billion. Fungal pathogens like rusts (*Puccinia* sp.), Septoria leaf blotch (*Septoria* sp.), powdery mildew (*Blumeria graminis*) and *Fusarium* species are ranked among the top ten of the most important fungal pathogens. Historical and current sources report epidemics leading to sometimes devastating yield losses in wheat caused by these pathogens. In regions with low productivity where no seed dressing is conducted, smuts and bunts are also important pathogens. Furthermore, in specific wheat-growing areas, fungal pathogens such as *Pyrenophora tritici-repentis* causing tan spot, *Oculimacula* spp. causing eye spot of wheat or *Cochliobolus sativus* are of importance. One option to avoid yield losses caused by these pathogens is the application of fungicides. However, the repeated use of fungicides induces a considerable selection pressure on respective pathogens resulting in fungicide resistance or tolerance, which has been detected already in *B. graminis*, *Septoria* spp. or *Fusarium* spp. The application of fungicides also depends to some extent on grain prices, fungicide costs and the possibility of applying these at the right time. Hence, cultivars carrying resistances are the most environment-friendly and cost-effective way of preventing yield losses in wheat. In particular, resistances against leaf rust, stripe rust, stem rust and powdery mildew infections result in complete resistance, but are at risk to be overcome by virulent isolates due to the extensive spore production of these pathogens.

**Keywords:** *Disease, Wheat, Rust, Smut, Bunt, Blight, Powdery Mildew.*

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## I. INTRODUCTION

Wheat is one of the world's most important staple grains and is the leading source of calories and plant-derived protein in human food. In 2017/2018, 735 million tonnes of wheat were produced globally, worth approximately US\$ 145 billion. A recent assessment of wheat production by the Food and Agricultural Organization of the United Nations indicates that current wheat supply is ample for global demand. Nevertheless, future production must increase as the global population is estimated to exceed nine billion people by 2050. As such, it is predicted that annual cereal production must grow by almost one billion tonnes. Furthermore, increased consumption of wheat products throughout many countries in Asia and changes to the grain quality requirements to meet the ‘hidden hunger’ objectives demand additional crop production. The continual drive to match yield and quality increases is not without its challenges. Decreasing availability of suitable farm land, climate change and a variety of unpredictable abiotic and biotic stresses continually pose threats to wheat production locally and globally. Wheat is one of the primary staple foods throughout the planet. Significant yield gains in wheat production over the past 40 years have resulted in a steady balance of supply versus demand. However, predicted global population growth rates and dietary changes mean that substantial yield gains over the next several decades will be needed to meet this escalating demand. A key component to meeting this challenge is better management of fungal incited diseases, which can be responsible for 15%–20% yield losses per annum. Prominent diseases of wheat that currently contribute to these losses include the rusts, blotches and head blight/scab. Other recently emerged or relatively unnoticed diseases, such as wheat blast and spot blotch, respectively, also threaten grain production. This chapter seeks to provide an overview of the impact, distribution and management strategies of these diseases. The decline in the genetic diversity of wheat, in the pursuit of elite high-performing cultivars, has contributed to a perfect storm in pathogen emergence to the point at which diseases threaten global wheat supplies. Pathogenic fungi represent a significant constraint to wheat production. This review considers the key diseases and causal pathogenic fungi affecting crop production, as well as those emerging as threats. In each case, we consider the geographical distribution, impact, disease management strategies.

## II. BLACK OR STEM RUST - *Puccinia graminis tritici*

- Symptoms



Symptoms are produced on almost all aerial parts of the wheat plant but are most common on stem, leaf sheaths and upper and lower leaf surfaces. Uredial pustules (or sori) are oval to spindle shaped and dark reddish brown (rust) in color. They erupt through the epidermis of the host and are surrounded by tattered host tissue. The pustules are dusty in appearance due to the vast number of spores produced. Spores are readily released when touched. As the infection advances teliospores are produced in the same pustule. The color of the pustule changes from rust color to black as teliospore production progresses. If a large number of pustules are produced, stems become weakened and lodge. The pathogen attacks other host (barberry) to complete its life cycle. Symptoms are very different on this woody host. Other spores are Pycnia (spermagonia) produced on the upper leaf surface of barberry which appears as raised orange spots. Small amounts of honeydew that attracts insects are produced in this structure. Aecia, produced on the lower leaf surface, are yellow. They are bell-shaped and extend as far as 5 mm from the leaf surface.

### III. BROWN OR LEAF RUST - *Puccinia triticina* (*P. recondita*)

- **Symptom**



#### Symptoms

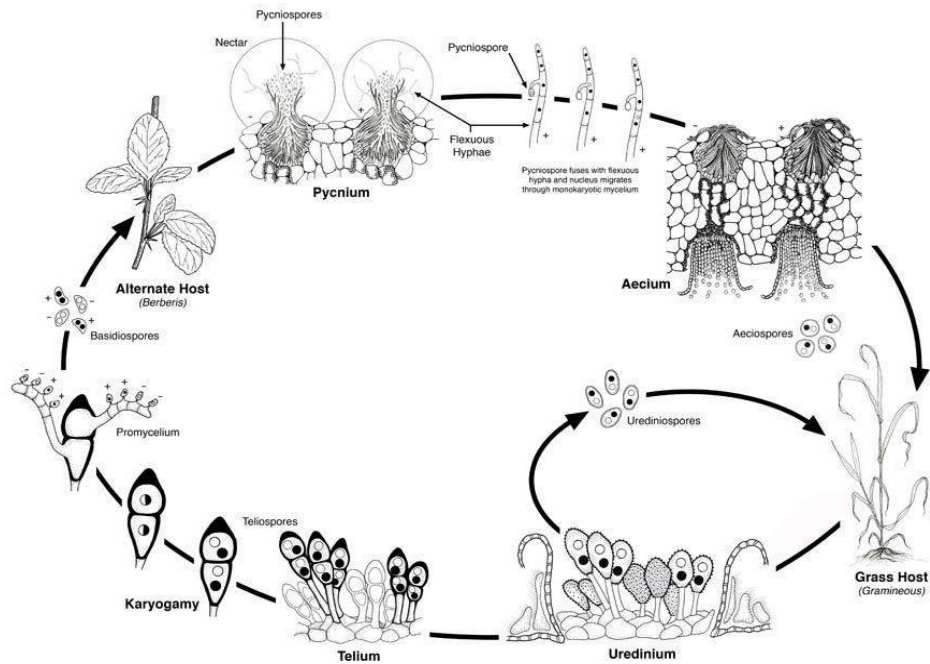
The most common site for symptoms is on leaf blades, however, sheaths, glumes and awns may occasionally become infected and exhibit symptoms. Uredia are seen as small, circular orange blisters or pustules on the upper surface of leaves. Orange spores are easily dislodged and may cover clothing, hands or implements. When the infection is severe leaves dry out and die. Since inoculum is blown into a given area, symptoms are often seen on upper leaves first. As plants mature, the orange urediospores are replaced by black teliospores. Pustules containing these spores are black and shiny since the epidermis does not rupture. Yield loss often occurs as a result of infection by *Puccinia recondite* f. sp. *tritici*. Heavy infection which extends to the flag leaf results in a shorter period of grain fill and small kernels.

#### IV. YELLOW OR STRIPE RUST - *Puccinia striiformis*

- **Symptom:** Mainly occur on leaves than the leaf sheaths and stem. Bright yellow pustules (Uredia) appear on leaves at early stage of crop and pustules are arranged in linear rows as stripes. The stripes are yellow to orange yellow. The teliospores are also arranged in long stripes and are dull black in colour.



- **Pathogen:** The uredospores of rust pathogen are almost round or oval in shape and bright orange in colour. The teliospores are bright orange to dark brown, two celled and flattened at the top. Sterile paraphyses are also present at the end of sorus.
- **Disease Cycle:** In India, all these rusts appear in wheat growing belt during Rabi crop season. Uredosori turn into teliosori as summer approaches. The inoculum survives in the form of uredospores/ teliospores in the hills during off season on self-sown crop or volunteer hosts, which provide an excellent source of inoculum. In India, role of alternate host (Barberis) is not there in completing the life cycle. The fungus is inhibited by temperatures over 20°C although strains tolerant of high temperatures do exist. The complete cycle from infection to the production of new spores can take as little as 7 days during ideal conditions. The disease cycle may therefore be repeated many times in one season. During late summer, the dark teliospores may be produced. These can germinate to produce yet another spore type, the basidiospore, but no alternate host has been found. Although the teliospores seem to have no function in the disease cycle they may contribute to the development of new races through sexual recombination.



### Life cycle of *Puccinia graminis*

- **Favourable Conditions**
  - Low temperature (15-20°C) and high humidity during November – December favour black and brown rusts.
  - Temperature less < 10°C favours yellow rusts.
- **Disease Cycle**
  - Uredospores and dormant mycelium survive on stubbles and straws and also on weed hosts and self sown wheat crops. Wind borne uredospores from hills are lifted due to cyclonic winds and infect the crop in the plains during crop season.
- **Management**
  - Mixed cropping with suitable crops.
  - Avoid excess dose of nitrogenous fertilizers.
  - Spray Zineb at 2.5 kg/ha or Propioconazole @ 0.1 %.
  - Grow resistant varieties like PBW 343, PBW 550, PBW 17

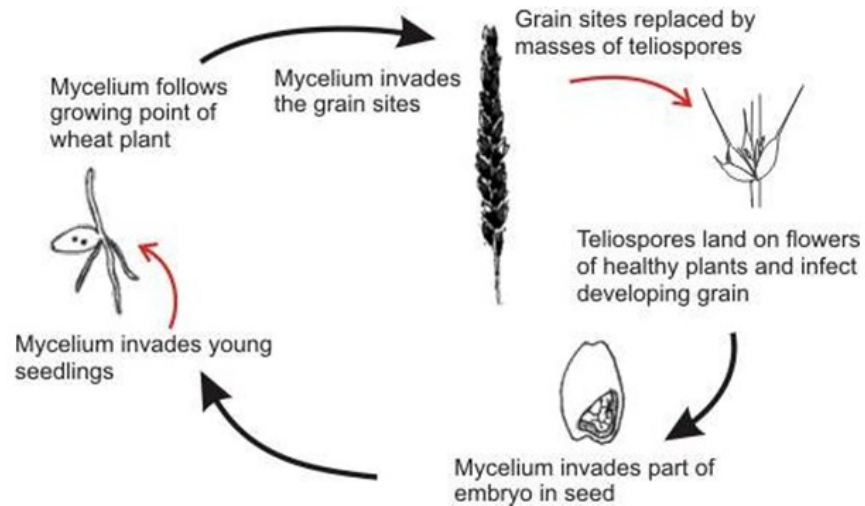
### V. LOOSE SMUT - *Ustilago nuda tritici* (*Ustilago tritici*)

- **Symptoms**



It is very difficult to detect infected plants in the field until heading. At this time, infected heads emerge earlier than normal heads. The entire inflorescence is commonly affected and appears as a mass of olive-black spores, initially covered by a thin gray membrane. Once the membrane ruptures, the head appears powdery. Spores are dislodged, leaving only the rachis intact. In some cases remnants of glumes and awns may be present on the exposed rachis. Smutted heads are shorter than healthy heads due to a reduction in the length of the rachis and peduncle. All or a portion of the heads on an infected plant may exhibit these symptoms. While infected heads are shorter, the rest of the plant is slightly taller than healthy plants. Prior to heading affected plants have dark green erect leaves. Chlorotic streaks may also be visible on the leaves.

- **Disease Cycle**



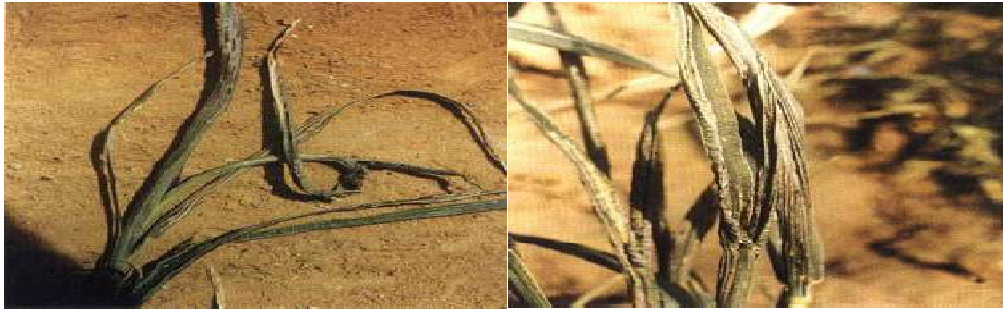
Ears of infected plants emerge early. The spores released from the infected heads land on the later emerging florets and infect the developing seed. Infection during flowering is favoured by frequent rain showers, high humidity and temperature. The disease is internally seed borne, where pathogen infects the embryo in the seed.

- **Management**

- Treat the seed with Vitavax @ 2g/kg seed before sowing.
- Burry the infected ear heads in the soil, so that secondary spread is avoided.

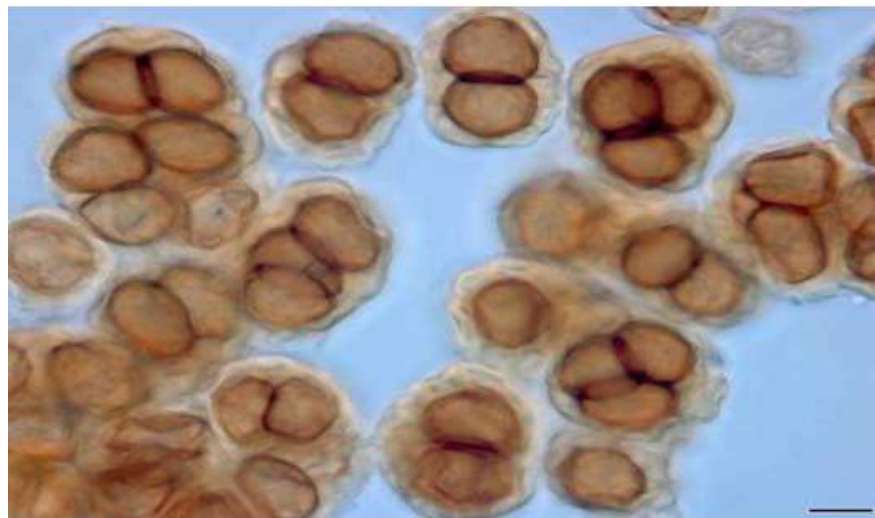
## VI. FLAG SMUT - *Urocystis tritici*

- **Symptoms**



The symptoms can be seen on stem, clum and leaves from late seedling stage to maturity. The seedling infection leads to twisting and drooping of leaves followed by withering. Grey to grayish black sori occurs on leaf blade and sheath. The sorus contains black powdery mass of spores.

- **Pathogen**



- **Spore Balls**

- Aggregated spore balls, consisting 1-6 bright globose, brown smooth walled spores surrounded by a layer of flat sterile cells.

- **Favourable Conditions**

- Temperature of 18-24°C.
- Relative humidity 65% and above.

- **Disease cycle**
  - Seed and soil borne.
  - Smut spores are viable for more than 10 years.
- **Management**
  - Treat the seeds with carboxin at 2g /kg.
  - Grow resistant varieties like Pusa 44 and WG 377.

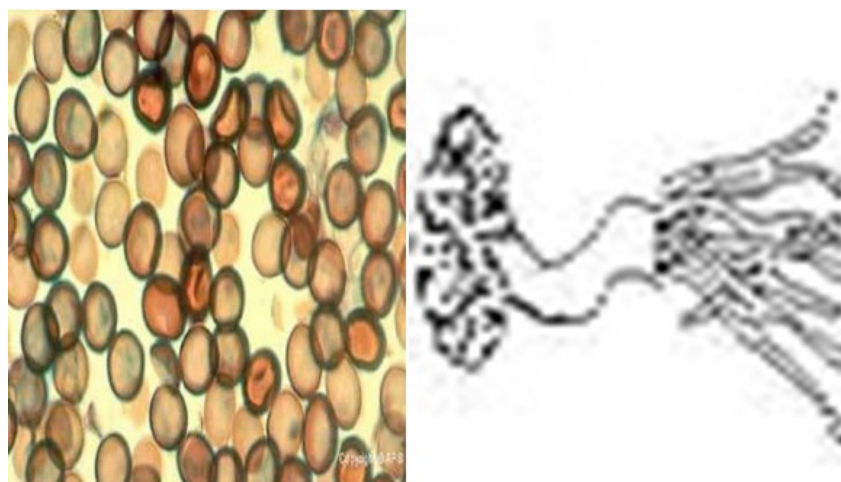
## VII. HILL BUNT OR STINKING SMUT - *Tilletia caries* / *T. foetida*

- **Symptom**



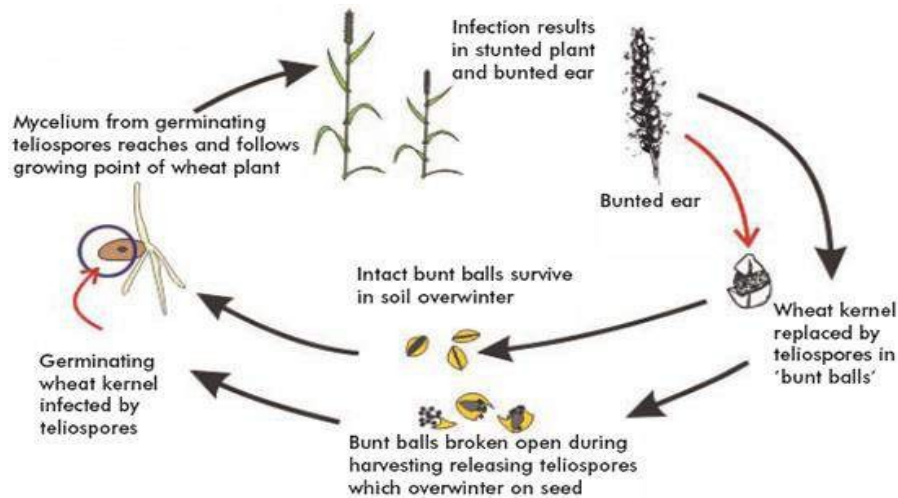
The fungus attacks seedling of 8-10 days old and become systemic and grows along the tip of shoot. At the time of flowering hyphae concentrate in the inflorescence and spikelets and transforming the ovary into smut sorus of dark green color with masses of chlamydo spores. The diseased plants mature earlier and all the spikelets are affected.

- **Pathogen**





- **Spores & Germination**
  - Reticulate, globose and rough walled.
  - No resting period.
  - Germinate to produce primary sporidia which unite to form ‘H’ shaped structure.
- **Life Cycle**

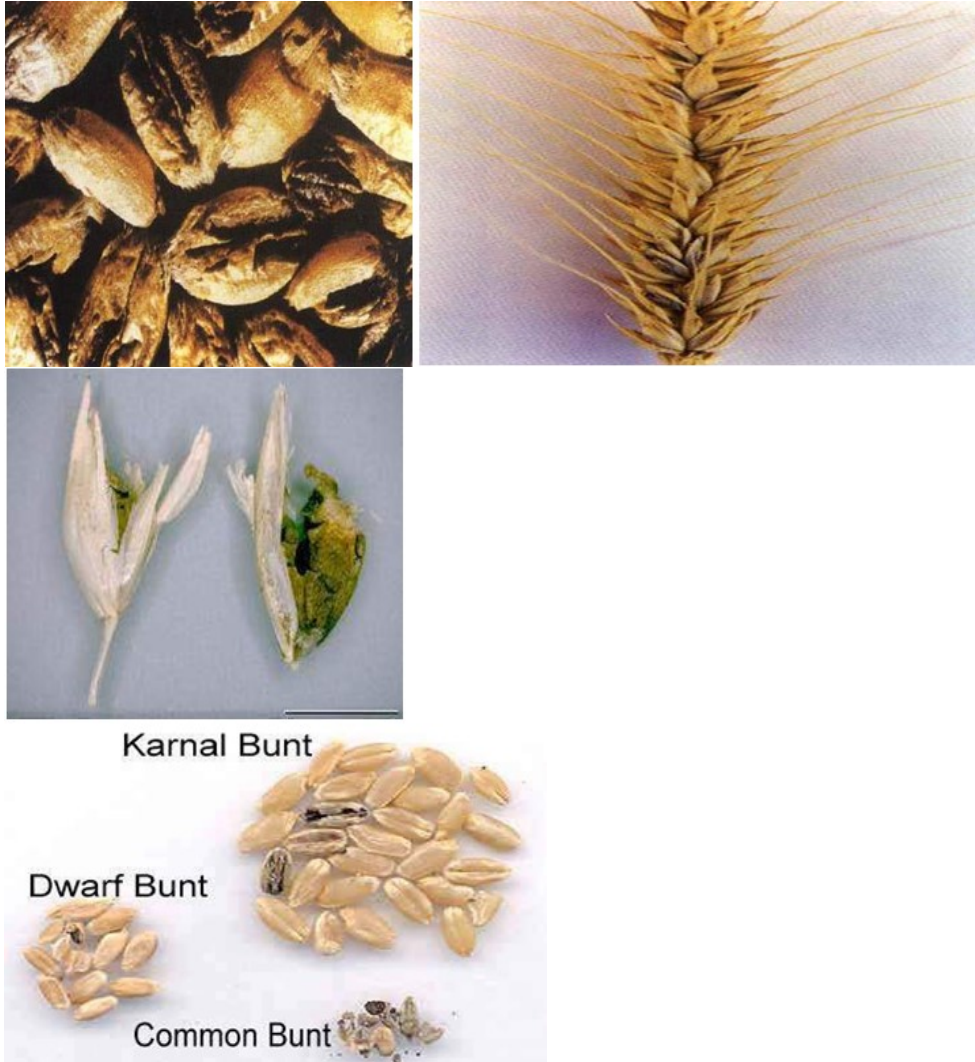


The spores on the seed surface germinate along with the seed. Each produces a short fungal thread terminating in a cluster of elongated cells. These then produce secondary spores which infect the coleoptiles of the young seedlings before the emergence of the first true leaves. The mycelium grows internally within the shoot infecting the developing ear. Affected plants develop apparently normally until the ear emerges when it can be seen that grain sites have been replaced by bunt balls. In India disease occurs only in Northern hills, where wheat is grown.

- **Favourable Conditions**
  - Temperature of 18-20°C.
  - High soil moisture.
- **Disease Cycle**
  - Externally seed borne
- **Management**
  - Treat the seeds with carboxin or carbendazim at 2g/kg.
  - Grow the crop during high temperature period.
  - Adopt shallow sowing.
  - Grow resistant varieties like Kalyan sona, S227, PV18, HD2021, HD4513 and HD4519.

## VIII. KARNAL BUNT - *Neovassia indica*

- Symptoms



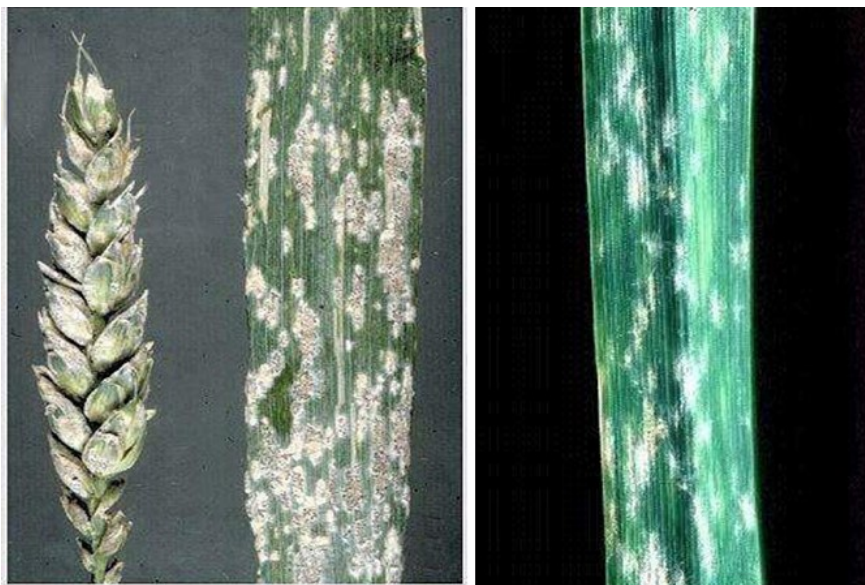
Symptoms of Karnal bunt are often difficult to distinguish in the field due to the fact that incidence of infected kernels on a given head is low. There may be some spreading of the glumes due to sorus production but it is not as extensive as that observed with common bunt. Symptoms are most readily detected on seed after harvest. The black sorus, containing dusty spores is evident on part of the seed, commonly occurring along the groove. Heavily infected seed is fragile and the pericarp ruptures easily. The foul, fishy odor associated with common bunt is also found with karnal bunt. The odor is caused by the production of trimethylamine by the fungus. Seed that is not extensively infected may germinate and produce healthy plants.

### IX. FOOT ROT - *Pythium graminicolum* and *P. arrhenomanes*

- **Symptoms:** The disease mainly occurs in seedlings and roots and rootlets become brown in colour. Seedlings become pale green and have stunted growth. Fungus produces sporangia and zoospores and oospores.
- **Favourable Conditions**
  - Wet weather and high rainfall.
- **Disease cycle**
  - Through soil and irrigation water.
- **Management**
  - Follow crop rotation.
  - Treat the seeds with Carboxin or Carbendazim at 2g/kg.

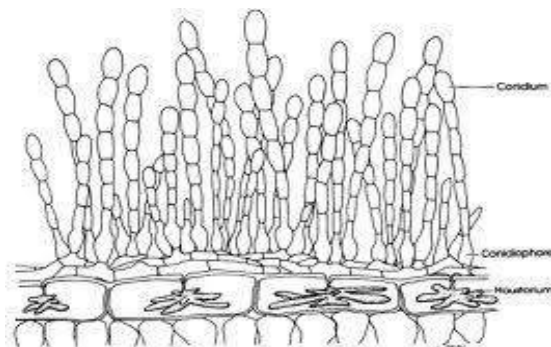
### X. POWDERY MILDEW - *Erysiphe graminis* var. *tritici*

- **Symptoms:** Greyish white powdery growth appears on the leaf, sheath, stem and floral parts. Powdery growth later become black lesion and cause drying of leaves and other parts.



- **Pathogen:** Fungus produces septate, superficial, hyaline mycelium on leaf surface with short conidiophores. The conidia are elliptical, hyaline, and single celled, thin walled and produced in chains. Dark globose cleistothecia containing 9-30 asci develop with oblong, hyaline and thin walled ascospores.

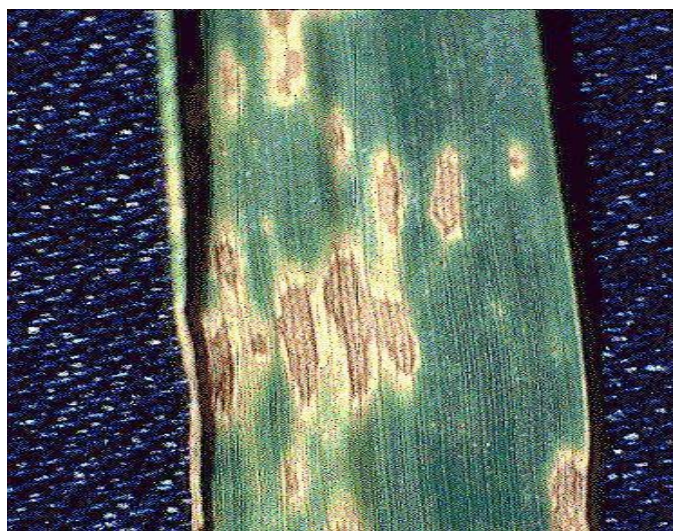
- **Disease cycle**



- **Conidia and Conidiophores:** Fungus remains in infected plant debris as dormant mycelium and asci. Primary spread is by the ascospores and secondary spread through airborne conidia.
- **Favourable Conditions**
  - Temperature of 20-21°C.
- **Management**
  - Spray Wettable Sulphur 0.2% or Carbendazim @ 500 g/ha.

#### XI. LEAF BLIGHT - *Alternaria triticina* / *Bipolaris sorokiniana*

- **Symptoms:** Reddish brown oval spots appear on young seedlings with bright yellow margin. In severe cases, several spots coalesce to cause drying of leaves. It is a complex disease, having association of *A.triticina*, *B.sorokiniana* and *A. alternate*.



- **Disease cycle**
  - Primary spread is by externally seed-borne and soil borne conidia. Secondary spread by air-borne conidia.
  
- **Favourable Conditions**
  - Temperature of 25°C and high relative humidity.
  
- **Management**
  - Spray the crop with Mancozeb or Zineb at 2 kg/ha.
  
- **Other Minor Diseases**
  - Helminthosporium leaf spot: *Helminthosporium* spp.
  - Tundu or yellow ear rot: *Corynebacterium tritici* + *Anguina tritici*
  - Seedling blight: *Rhizoctonia solani* and *Fusarium* spp.
  - Sclerotinia rot: *Sclerotinia sclerotiorum*
  - Molya disease: *Heterodera avenae* (Nematode)

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