DISEASES OF FIELD CROPS AND THEIR MANAGEMENT

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Diseases of Barley (*Hordeum vulgare*)

- Rusts
- Covered smut - *Ustilago hordei*
- Loose smut - *Ustilago nuda*
Rusts of Barley

• **Black or stem rust**- *Puccinia graminis* f. sp. *tritici*
• **Brown or leaf rust**- *P. hordei*
• **Yellow or stripe rust**- *P. striiformis*
**Stem or black rust of barley**

**DISEASE:** Stem rust (black rust or cereal rusts)

**PATHOGEN:** *Puccinia graminis f. sp. tritici*

**HOSTS:** Barley, wheat, and common barberry (*Berberis*, *Mahoberberis*, and *Mahonia* spp.)
Symptoms and Signs

On barley and other grass hosts:
Elongated to irregular shaped pustules (uredinia) are full of reddish-brown urediniospores break through the epidermis and develop on the upper leaf surfaces, leaf sheaths, glumes and awns.

On wheat

On barley
Later in the season, **brick red pustules** turn into black **telial stage** - full of **teliospores** to over summer. Microscopically, **teliospores** are two celled and thick walled.
Pre-disposing (environmental) factors

- **Warm-humid** weather conditions with intermittent rains.
- Hot days 25-30°C and mild nights (15-20°C)
- Leaf wetness from rain or dew
Brown or leaf rust of barley

DISEASE: *Brown or leaf rust*

PATHOGEN: *Puccinia hordei*

HOSTS: Barley, wheat, and common barberry (*Berberis*, *Mahoberberis*, and *Mahonia* spp.)
Symptoms and Signs

On barley and other grass hosts:

- Scattered **oval to circular** small brown **pustules**, producing a mass of **orange-brown uredospores** break through the **epidermis**, predominantly on the upper leaf surfaces.
Later in the season as the crop matures, the pustules turn **black** to form **telial stage** - full of **teliospores** to over summer. Microscopically, **teliospores** are two celled and thick walled.
Predisposing Factors

- Development of the disease is most rapid during warm (15-20°C) moist (rain or dew) weather.
- **Warm-humid** weather conditions with intermittent rains.
- Hot days 25-30°C and mild nights (15-20°C)
- Leaf wetness from rain or dew
Yellow or stripe rust of Barley

DISEASE:  Yellow or stripe rust
PATHOGEN:  *Puccinia striiformis* f. sp. *hordei*
HOSTS:  Barley, wheat and common grasses
Symptoms and Signs

On barley and other grass hosts:

Bright yellow-orange pustules occur in stripes along the leaves producing yellow-orange uredospores that break through the epidermis, predominantly on the upper leaf surfaces.
Pre disposing (environmental) factors

- **Cool -humid** weather conditions with intermittent rains.
- Cooler climates (10-16ºC)
- Leaf wetness from rain or dew
- Heavy dew or intermittent rains can accelerate the spread of the disease
Since the urediniospores are produced on the cereal host and can infect the cereal host from one year's crop to the next without infecting the alternative host (barberry). **Infected volunteer cereal plants can serve as a bridge from one growing season to another.** The fungus also passes between winter wheat/barley and spring wheat/barley, meaning that it has a cereal host all year round. Since the urediniospores are wind dispersed, this can occur over large distances. UREDINIOSPORES infect one cereal plant, leading to the production of more urediniospores which then infect other wheat/barley plants.
Rust resistance gene pool in India

**Stem rust** - Sr Sr2, Sr5, Sr7b, Sr8a, Sr8b, Sr9e, Sr11, Sr12, Sr24, Sr31

**Leaf rust** - Lr Lr1, Lr3, Lr9, Lr10, Lr13, Lr14a, Lr23, Lr24, Lr26, Lr34

**Yellow rust** - Yr Yr2, Yr2(KS), Yr3, Yr9, Yr18
Management Strategy

Prevention, early warning and rapid response

Resistant varieties
- The most effective way to control the rusts of wheat/barley is to grow varieties with resistance.

Cultural practices
- Barley rusts survive predominantly on self-sown barley over summer, so it essential to remove this source of inoculum. Use of heavy grazing or herbicides to remove green growth is important, especially following wet summers.

Chemical control
- Prophylactic sprays of Mancozeb (Dithane Z-78) @ 0.25%
- Fungicides that inhibit the synthesis of sterols [i.e., sterol biosynthesis inhibitors-SBIs] like Tilt (Propioconazole) 25 EC @ 0.1% at 15 days intervals
Smuts of Barley

- Covered Smut
  - *Ustilago hordei*

- Loose Smut
  - *Ustilago nuda*
Covered Smut of Barley

DISEASE: Covered Smut
PATHOGEN: Ustilago hordei
HOSTS: Barley
Symptom and Sign

There are no symptoms of the disease before ear emergence. At ear emergence, infested plant have compact smutted heads. Spike lets of infected plants are replaced by masses of dark brown smut spores (Teliospores).
Disease cycle of covered smut of barley

1. Mycelium follows growing point of oat plant
2. Mycelium invades young seedlings
3. Mycelium invades embryo in seed
4. Healthy grains contaminated with spores
5. Mycelium invades the grain sites
6. Grain sites replaced by masses of teliospores
7. Teliospores land on flowers of healthy plants and infect developing grain
Disease cycle of covered smut of barley is similar to bunt of wheat. The disease is externally seed borne and systemic. During the threshing process, teliospores are released to contaminate the healthy barley seeds. In either case, the spores remain dormant on the outside of the seed until it is sown when they germinate and infect the developing seedling. The fungus then develops systemically with the growing point of the plant until it once again colonises the developing ear.
Management strategy

• **Disease control:**
The disease is externally seed borne and systemic infection is there -as such spray of fungicides is not effective in controlling the disease.

• **Seed treatment** Systemic fungicides like carboxin, vitavax and benlate @ 2.0 g/Kg seed and Tilt (propioconazole) 25 EC @ 0.1% are used for seed treatment. A combination of vitavax with thiram is very effective for disease control.

• **Use of resistant varieties:**
The most successful method is the use of resistant varieties.

• **Crop rotation:**
Crop rotation at suitable intervals is also effective in disease control.
Loose Smut of Barley

DISEASE: Loose Smut

PATHOGEN: *Ustilago nuda*

HOSTS: Barley
Symptom and Sign

There are no symptoms of the disease before ear emergence. At ear emergence, smutted ear head containing dark olivaceous brown dusty (loose smut) sori, usually destroying all floral parts and leaving behind only the naked rachis as the spores are wind blown.
Spores globose to subglobose or ovoid, 6–9 × 5–7 µm, olivaceous brown, paler on one side, minutely echinulate.
Predisposing Factors

• Wind
• Moderate rains
• Cool temperatures (16-22 degrees Celsius)
Disease cycle of loose smut of barley is similar to as of loose smut of wheat. The fungus is internally seed borne (dormant mycelium within the embryo of the barley seed). The pathogen survives from one season to the next as dormant mycelium (fungal threads) within the embryo of the barley seed. The fungus breaks dormancy as the infected seed germinates and grows systemically within the developing barley plant. When the barley plant would normally produce a head the pathogen invades all the flower parts. When the head of the infected plant emerges it produces massive amounts of smut spores (teliospores) instead of a normal flowering barley head. Infection occurs when normal flowering heads of adjacent plants are dusted with the wind-blown teliospores form smutted heads. The teliospores germinate and invade the female parts of the barley flowers and eventually colonize the developing embryo. Once the infected seed matures, the pathogen goes dormant until the cycle is repeated with the germination of the barley seed.
USTILAGO NUDA (Flugbrand der Gerste)

USTILAGO TRITICI (Flugbrand an Weizen)

**interzelluläres**
Wachstum im Meristem

**intrazelluläres**
Wachstum im Keimling

Körner und Spelzen werden zersetzt

Brandsporen keimen auf Narbe und bilden eine Basidie
dikaryontisches Myzel infiziert via Griffel oder Ovarwand den Embryo

Überwinterung im Embryo
Management of Loose Smut of Wheat

- **Disease control:**
  The disease is internally seed borne and as such spray of fungicides is not effective in controlling the disease.

- **Seed treatment**

- **Use of resistant varieties:**
  The most successful method is the use of resistant varieties.

- **Crop rotation:**
  Crop rotation at suitable intervals is also effective in disease control.
Seed treatment
(a) Hot water treatment:
The seeds are first soaked in water for five hours at 20°C, the water is drained off and then they are treated with hot water at 49°C for about a minute and finally with hot water at 52°C for 11 minutes. Immediately after the hot water treatment, the seeds are cooled off by dipping in cold water and dried. The dormant mycelium inside the seed dies off by this treatment.

(b) Use of systemic fungicides:
Several fungicides like carboxin, vitavax and benlate @ 2.0 g/Kg seed and Propioconazole @ 0.1% are used for seed treatment to reduce the pathogen infectivity. A combination of vitavax with thiram is very effective for disease control.
Diseases of Sorghum (*Sorghum bicolor*)

- Downy mildew - *Peronosclerospora sorghii / P. philippinensis*
  
  *Brown stripe DM – Sclerophthora rayssiae var zeae Sugarcane DM – Peronosclerospora sacchari*

- **Ergot** - *Claviceps sorghi* or *Sphacelia sorghi*

- Smuts - **Grain smut/Kernel smut / Covered smut / Short smut** - *Sphacelotheca sorghi* or *Sporisorium sorghi*
Downy mildew of Sorghum

DISEASE: **Downy mildew**
PATHOGEN: *Peronosclerospora sorghii*
HOSTS: **Sorghum/jawar or Bajra/Pearl Millet or maize**
Both **systemic** and **localized** infection occur. Soil-borne spores cause **systemic infection** of the **young seedlings**. These systemically infected plants will not produce heads. Infected leaves often will be more narrow than usual, **erect** and **shredded**. Plants may be **stunted** and **chlorotic**, and have an **no seed set**.
Young, systemically infected plants have light green to yellowish stripes lengthwise in the leaves often with a grayish-white downy fungal growth consisting of numerous tiny spores on the lower surface of the leaf opposite the pale striped areas. These sporangia can cause further localized infection.
Sporangiophores and sporangia of *Peronosclerospora sorghi*
Predisposing factors

- Cool - wet - humid weather
- Intermittent rains
- The rapid growth of fungal pathogen is favoured by rainy and humid environment.
Disease cycle of *Peronosclerospora sorghii*
Management Strategy

• Use resistant hybrids.
• Seed treatment with metalaxyl.
• Long-term rotation to soybeans – wheat.
• Avoid corn-sorghum rotation where the disease occurs.
Ergot of Sorghum

DISEASE: Ergot or Sugary disease
PATHOGEN: *Claviceps purpurea*
HOSTS: Sorghum or Bajra / Pearl Millet
Symptom and Sign

Cream to pink sticky "honeydew" droplets ooze out of infected florets on panicles bearing millions of conidia. These spores are carried by insects or splashed by rain to infect other kernels. The "honeydew" droplets dry and harden, and dark brown to black sclerotia ("ergots") develop in place of seeds on the panicle.
Sclerotia left behind in the field serve as sources of infection for the next season. The fungus produces mycotoxins as alkaloids which are highly poisonous to humans and animals, and are used for pharmaceutical applications.
Predisposing factors

• Relative humidity greater than 80%, and
• Temperatures between 20 to 30°C.
Life cycle
Management Strategy

- Use of resistant cultivars
- Use of certified seed,
- Cultural practices, phytosanitary measures (to reduce inoculum levels),
- Crop rotation and
- Fungicide treatments of seed and planted fields
Head smut of Sorghum

DISEASE: **Head smut**
PATHOGEN: *Sporisorium reilianum* (Syn. *Sphacelotheca reiliana*)
HOSTS: Sorghum/jawar or Bajra /Pearl Millet or maize
Symptom and Sign

The young head, enclosed in the boot, is usually completely replaced by a large smut gall covered by a thick whitish membrane. The membrane soon ruptures, often before the head emerges, exposing a mass of dark brown to black, powdery teliospores intermingled with a network of long, thin, dark, broomlike filaments of vascular tissue with characteristic "witches' brooms,".
Predisposing factors

- Relative humidity greater than 80%, and
- Temperatures between 20 to 30°C.
Disease cycle

The disease is externally seed borne and systemic. The spores germinate with the seed and infect the seed by penetrating through the radicle or mesocotyl to establish systemic infection that develops along the meristematic tissues. At the time of flowering, the fungal hyphae get converted into spores, replacing the ovary with the sori. At threshing, the healthy grains become contaminated with the smut spores released from the bursting of the sori. The spores remain dormant on the seed until next season.
Management Strategy

- Use disease free seeds.
- Grow resistant varieties like T 29/1, PJ 7K, PJ 23K, Nandyal and Bilichigan.
- Treat the seed with fine sulphur powder @0.5% or Captan or Thiram @0.3
- Follow crop rotation.
- Collect the smutted ear heads in cloth bags and dip in boiling water.
Diseases of Bajara or Pearl Millet

(*Pennisetum typhoides*)

- Downy mildew or Green ear - *Sclerospora graminicola*
- Ergot or Sugary disease - *Claviceps fusiformis* or *C. microcephala*
Downy mildew or Green ear of Bajra

**DISEASE:** Downy mildew or Green ear disease

**PATHOGEN:** *Sclerospora graminicola*

**HOSTS:** Bajra / Pearl Millet or Sorghum
Both systemic and localized infection occur. Soil-borne spores cause systemic infection of the young seedlings. The characteristic symptoms of the disease are pale, chlorotic, broad streaks extending from base to tip of leaves. Infected chlorotic leaf areas can support abundant asexual sporulation with a grayish-white downy fungal growth on the lower leaf surface. These sporangia can cause further localized infection.
Downy mildew or Green ear of Bajra
The diseased plants are **dwarf** due to shortening of internodes and **tiller** excessively. **Severely infected plants** are generally **stunted** and do not produce **panicles**. **Green ear** symptoms result from transformation of **floral parts** into **leafy structures**.
Predisposing factors

- Warm-wet-humid weather
- Intermittent rains
- The atmospheric temperatures between 25-30 °C and above 85 per cent relative humidity favours high level of secondary infection.
Disease Cycle

The oospores in the soil serve primary source of infection in host plants. The germ tubes directly penetrate in root hairs and coleoptile to cause systemic infection. The secondary spread of disease starts from sporangia, which are most active in moist environment. The germ tubes of zoospores get entry in leaf tissues through stomata.
Disease Cycle
Management Strategy

• Sow disease resistant varieties like NHB-5, PHB-10, PHB-14.
• Eradicate the infested plants and burn them.
• Practise crop rotation.
• Sow certified and healthy seeds.
• Treat the seeds with Agrosan GN (2.5 g/kg seed) and spray the crop with 0.2 % Dithane Z- 78 at boot leaf stage.
Ergot of Bajra / Pearl Millet

DISEASE: Ergot
PATHOGEN: *Claviceps purpurea*
HOSTS: Bajra / Pearl Millet or Sorghum
Symptom and Sign

The ergot causing fungus infects the florets and develops in the ovaries, producing initially copious creamy, pink, or red colored sweet sticky liquid called honey dew. Often pollen and anther sacs adhere to the honeydew. Subsequently long dark colored hard structures, sclerotia, develop from infected florets, first dark at the tip and then completely black.
Predisposing factors

• Relative humidity greater than 80%, and
• Temperatures between 20 to 30°C.
The sclerotia falling on the soil or planted with the seed germinate when the plants are flowering. They produce ascospores that are wind-borne to the flowers, where they invade the young kernels and replace the kernels with fungal growth. The fungal growth bears millions of tiny spores (macro- and micro-conidia) in a sticky, sweet, honeydew mass. These spores are carried by insects or splashed by rain to infect other kernels.
Life cycle of *Claviceps purpurea*

- Perithecia release ascospores which infect flowering plant. Mycelium penetrates ovary tissue.
- Ascospores infect grasses - especially black-grass.
- Germinating sclerotia produce stroma containing perithecia.
- Secondary spread from grasses in honeydew.
- Grains replaced by sclerotia.
- Sclerotia overwinter in soil.
Management Strategy

- Plant resistant varieties, where available.
- Remove affected panicles.
- Avoid planting seeds from infected panicles.
- Plough deep.
- Rotate with non-cereals preferably with pulses.
- Practise good field sanitation.