ISBN: 978-81-19149-19-3

11. Biotic Stresses in Millets and Their Management

Ippa Vinay

Department of Genetics and Plant Breeding,
Professor Jayashankar Telangana State Agricultural University,
Hyderabad, Telangana.

Singarapu Snigda Srilaasya

Department of Seed Science and Technology
Professor Jayashankar Telangana State Agricultural University,
Hyderabad, Telangana.

Patel Supriya

Department of Genetics and Plant Breeding,
Acharya N.G. Ranga Agricultural University,
Tirupati, Andrapradesh.

Thalari Vasanthrao

Department of Genetics and Plant Breeding
Professor Jayashankar Telangana State Agricultural University,
Hyderabad, Telangana.

Abstract:

Millets are the most climate-resilient crops when compared with cereals, pulses and other crops. While biotic and abiotic stresses can affect millet yields to some extent, they generally tolerate changes in the environment well.

Biotic stresses, such as pests, diseases, and birds can significantly reduce the yields and quality of millets. Given that millets are nutrient-rich superfoods; it is important to protect them from these biotic stresses. This chapter discusses the nutritional benefits of the millets, pests and diseases that affect the millet crops, as well as their management strategies.

The management of the pests and diseases in millets can be mostly done by sowing the resistant varieties of the millets, rather than using the chemicals. Scientists have developed many resistant varieties, and host plant resistance is an eco-friendly and less expensive option for poor farmers. Effective management of biotic stresses is critical for maximising millet yield and ensuring food security.

Keywords:

biotic stresses, millets, pest and disease management.

11.1 Introduction:

The major millets, which include sorghum (*Sorghum bicolor*), pearl millet (*Pennisetum glaucum*) and finger millet (*Eleusine coracana*), as well as minor millets such as foxtail millet, proso millet, barnyard millet, kodo millet, little millet and brown top millet, are small-seeded tropical grasses that are primarily cultivated for food, feed and forage. These crops provide a significant source of dietary energy and protein for the majority of individuals living in semi-arid tropics (Chandrashekar and Satyanarayana, 2006).

There are at least 10 genera and 14 species of identified millets belonging to the family Poaceae (Gramineae) (Kumar *et al*., 2005). Due to high importance of millets in human nutrition, the year 2023 has been declared as the "International year of millets". Small millets are packed with the goodness of B-vitamins, minerals like calcium, iron, zinc, and potassium. They can also provide essential nutrients. In agriculture, omics tools have been widely used to identify genomic sequences governing crucial agronomic characteristics such as grain yield, resistance to biotic and abiotic stresses, and more. Integration of functional analysis with genomic sequence data provides more accurate gene annotations, functional markers, quantitative trait loci (QTL) maps which helps to improve the development of crop varieties. Further improvement is needed to make millets more resilient to the biotic stresses, unprecedented impacts of climate change and associated environmental stresses although they are tolerant to most abiotic stresses, including drought and high temperatures" (Numan *et al*., 2021).

Table 11.1: Most Commonly Grown Millets in India and Their Nutritional Benefits

Sr. No.	Crop	Botanical Name	Family	Benefits
1.	Sorghum	*Sorghum bicolor*	Poaceae	Rich in vitamins and many minerals like magnesium, potassium, zinc and iron. It also contains anti-oxidant properties.
2.	Pearl millet	*Pennisetum glaucum*	Poaceae	Good source of carbohydrates, rich in dietary fibre and have cholesterol lowering properties.
3.	Finger millet	*Eleusine coracana*	Poaceae	Rich source of protein and also contains minerals like phosphorous, iron and magnesium.
4.	Barnyard millet	*Echinochloa frumentacea*	Poaceae	Rich source of highly digestible protein and contains low glycemic index.
5.	Proso millet	*Panicum miliaceum*	Poaceae	Rich source of essential phosphorous. Contains lecithin which supports the neural health system.

Sr. No.	Crop	Botanical Name	Family	Benefits
6.	Foxtail millet	*Setaria italica*	Poaceae	Rich source of Vitamin B_{12} helps in maintaining healthy heart and smooth functioning of nervous system.

11.2 Biotic Stresses:

Although abiotic stresses affect millet production, biotic stresses are major constraints that affect production. These biotic stresses are likely to increase due to the changing weather. Losses due to biotic stresses may vary depending on the stage of the crop, the plant part affected, the type of disease etc.,

Biotic stresses are mainly due to:

A. Diseases
B. Pests
C. Birds damage

11.2.1 Diseases of Millets:

Many diseases infect cultivated millets, some of which regularly appear in a severe form which ultimately cause huge economic losses to the crop. Fungal diseases are common on millets than bacterial and viral diseases.

Some of the major diseases of millets are grain mold, ergot, smut, blast, rust, anthracnose, downy mildew, charcoal rot and sheath rot. Pest and/or pathogen attacks can cause a 10-40% reduction in crop yield depending on the geographical location (Repellin *et al.*, 2001).

Seedling diseases: Seedling blight, damping off, anthracnose, root rot of seedling appear mainly during the seedling stage of the crop and severe infection can damage the roots and tender leaves and often kill the seedling ultimately leading to the low plant stand in the crop. Seedlings may die prematurely depending on the intensity of the infection.

Grain diseases: The most important part of the millet crops-florets or developing grains, are infected by many pathogens. The most important grain disease is grain mold and then ergots and smuts. Grain mold infection on the grain surface becomes visible in pink, orange, gray, white, or black colored fungal bloom and these molded grains often contain mycotoxins which may be harmful even to humans and birds. Ergot is another important serious issue in hybrid seed production which is a sugary disease commonly affects grain, the symptoms of this disease include honey dew like droplets that are thick, viscous and sweet, which may vary in colour, such as pink or red. Infected florets usually fail to produce grains, and if they do, the grains exhibit reduced germination. Smut is another common grain disease that converts part of the head or whole head into fungal structure. The different types of smuts that occur in millets are head smut, loose smut, covered smut and long smut.

Leaf diseases: Leaf diseases, such as rusts and blights, destroy the leaf surfaces that perform photosynthesis and lower the crop yield. There are various types of leaf diseases that are occurring in millets. Some of them include downy mildew, anthracnose, blast, rust, leaf spots and leaf blight.

Downy mildew mostly occurs in sorghum, pearl millet and foxtail millet. The infection starts off in the seedling stage and eventually spreads to the entire leaf, ultimately killing the plant. Symptoms of downy mildew include white discoloration on the leaf blade, which is caused by the presence of conidia and conidiophores with downy growth. Apart from the downy mildew, rust also occurs in millets but it occurs during later stages of crop growth. Symptoms include reddish brown pustules on both surfaces of the leaves.

Root and stalk diseases: Most root and stalk diseases in millets are soil-borne, with charcoal rot being the most common. Symptoms first appear in the root and then destroy the cortical tissue, affecting water movement and ultimately resulting in rotting that can impact the quality of millet fodder (Das *et al*., 2023).

Table 11.2: Fungal diseases of millets

Sr. No.	Millet crop	Disease	Causal organism
1.	Finger millet	Grain smut	*Melanopsichium eleusinis*
2.	Foxtail millet	Grain smut	*Ustilago crameri*
3.	Barnyard millet	Grain smut	*Ustilago panici-frumentacei*
4.	Barnyard millet, Kodo millet and Proso millet	Head smut	*Sorosporium paspalithunbergii*
5.	Foxtail millet, Kodo millet and Little millet	Udabetta	*Ephelis oryzae*
6.	Foxtail millet	Downy mildew	*Sclerospora graminicola*
7.	Finger millet	Blast	*Pyricularia grisea*
8.	Foxtail millet	Blast	*Pyricularia setariae*
9.	Finger millet	Rust	*Uromyces eragrostidis*
10.	Foxtail millet	Rust	*Uromyces setariae italiae*
11.	Little millet	Rust	*Uromyces linearis*
12.	Finger millet and Little millet	Helminthosporium leaf spot	*Drechslera nodulosum*
13.	Foxtail millet	Helminthosporium leaf spot	*Cochliobolus setariae*
14.	Finger millet	Cercospora leaf spot	*Cercospora eleusinis*

Table 11.3: Bacterial diseases of millets

Sr. No.	Millet crop	Disease	Causal organism
1.	Finger millet	Bacterial leaf spot	*Xanthomonas eleusinae*
2.	Finger millet	Bacterial leaf stripe	*Pseudomonas eleusinae*

A. Management of Millet Diseases by Resistant Varieties:

Resistance or tolerance of millet crop varieties to diseases can vary depending on the specific pathogen strain and environmental conditions. Farmers should, therefore, choose the appropriate variety based on the specific disease pressures in their area and consult with their local agricultural extension services for advice on the best management practices for disease control.

One of the effective management for disease free millet crops is by growing of disease resistant varieties released and identified in India, some of them are:

a. Sorghum:

Sorghum (*Sorghum bicolor*) is susceptible to various diseases that can cause significant yield losses. However, several varieties of sorghum have been developed that are resistant or tolerant to different diseases.

Charcoal rot: CSV 17, CSV 22, CSV 26 and CSV 29R

Grain mold: CSH 25, CSV 27, CSV 28 and CSV 31

Anthracnose: CSV 17 and CSV 31

Leaf blight: CSV 31

Sugary disease: CSV 17

Rust, rough leaf spot, zonate leafspot, and gray leafspot: CSV 17 and CSV 18

b. Pearl Millet:

The pearl millet crop is susceptible to many diseases among them downy mildew is a significant disease of pearl millet that can cause yield losses of up to 50%. Several pearl millet varieties have been developed with resistance to downy mildew, including ICTP 8203, 86001B, and 843A.

Downy mildew: BHB-1202, GK 1116, JKBH 1008, MPMH 21, Proagro Tejas, HHB 234, Bio 70, HHB -226, RHB -177, HHB 216, RHB 154, JKBH 1326, DHBH 1397, PROAGRO 9450, Pusa 1201, XMT 1497, KBH 3940, Bio 8145, KBH 108, Phule Mahashakti,86M64,

AHB 1200 Fe, Nandi-75, MP 535 (Pusa Composite 701), Pearl Millet CO 10 and Dhan shakti (ICTP 8203 Fe 10-2)

Blast: BHB-1202, (MH 1831), Central Pearl Millet Hybrid RHB 223, JKBH 1008, MPMH 21, HHB 272, PB 1852, DHBH 1397, PROAGRO 9450, XMT 1497, Bio 8145, 86M84 (MH 1890), KBH 108, 86M88 (MH 1816) and ABV 04 (MP 552)

Rust: 86M88 (MH 1816), JKBH 1105, JKBH 1105, Bio 8145, JKBH 1100 and 86M82.

c. Finger Millet:

Blast: GPU 26, GPU 45, Chilika (OEB 10), VL 315, GPU 48, PRM 1, Bharathi (VR 762), Srichaitanya, KOPN 235, OEB 526, OEB 532, PPR 2700 (Vakula), VL 352, GNN - 6, GN - 5, VL Mandua - 348, KMR 340, Dapoli – 2 (SCN – 6) and CO 15

d. Foxtail Millet: *Downy mildew*: Meera (SR 16), SiA 3085 and RAU (Rajendra Kauni 1- 2)

Rust: TNAU 196 and RAU (Rajendra Kauni 1- 2) ″ Blast: RAU (Rajendra Kauni 1- 2) and SiA 3085

e. Barnyard Millet: *Grain smut*: VL Madira

f. Little Millet:

Grain smut: Tarini (OLM 203), OLM 217 and GNV - 3

Blast: Tarini (OLM 203) and GNV - 3

Rust: OLM 217 ″ Brown spot: Kolab (OLM 36)

Head smut: Jawahar Kutki 4 (JK 4)

g. Kodo Millet: *Head Smut*: Jawaharkodo 155(RBK 155), Jawaharkodo 48(JK 48), JK 13, JK 106, JK 65, JK 98 and Jawaharkodo 137. (Rawat *et al*.,2022)

B. Management of Millet Diseases by Cultural and Chemical Methods:

a. Cultural methods: Regularly following some agricultural practices can greatly reduce disease problems in the field. These practices include deep ploughing during the summer season, cleaning field bunds after every crop season, removing crop debris from the field, burning diseased plants, and restricting irrigation water entry from adjacent fields.

- Eradication of host plants from the field bund and surrounding, aids in the control of diseases like ergot, downy mildew, rust, blast, leaf spots and bacterial and viral diseases as these alternate and collateral host plants harbour pathogens.

- To reduce the soil-borne diseases that affect the crops, such as downy mildew, smut, charcoal rot and some leaf diseases caused by fungi and bacteria, it is helpful to do the following: till the soil deeply in summer, remove crop residues, and rotate the crops with non-host plants for these diseases.
- To reduce the incidence of diseases like blast, downy mildew and charcoal rot, it is essential to maintain the optimum plant spacing between plants and control the amount of nitrogenous fertilizer by following specific recommendations.
- To reduce the infection of ergot caused by seed contamination, it is helpful to remove the sclerotia from the seeds mechanically, by washing them in salt water with 30% concentration and then rinsing them in plain water.

b. Chemical methods: Chemicals are not typically used to manage millet diseases due to their expensive nature and labour-intensive requirements.

- Treating the seed with Ridomyl-MZ at 6g per kg of seed and then spraying it once with Ridomyl-MZ at 3g per liter of water helps to lower the occurrence of downy mildew.
- Treating the seed with propiconazole at 1 ml per kg of seed was effective in lowering the occurrence of banded sheath blight in finger millet.
- Loose and covered smuts are seed-borne on the outside and can be easily controlled by dressing the seed with sulphur at 4g per kg of seed.
- Spraying the leaves with Mancozeb at 0.2% concentration helps to prevent the rust effectively. (Das *et al.,* 2016)

11.2.2 Pests of Millets:

- **Soil pests:** The majority of soil pests include white grubs. Species of Holotrichia and Anomala are known to occur. C shaped grubs affect the roots and causes them to die and there will be loss of plant stand.
- **Seedling pests:** These shoot pests include shoot flies which belong to the genus Atherigona. The female deposits eggs in the young leaves and hatches in 2-3 days by cutting growing point and producing dead heart. Seedlings are also infested by leaf beetles, menolepta species etc.,
- **Foliage pests:** Foliage pests commonly include leaf caterpillars, army worms, grasshoppers and sap sucking pests. Leaf caterpillars include *Amsacta albistriga Moore, Estigmene lactinea Cram., A. moorei Butler* etc., Because they live in groups and eat a lot, these animals can quickly strip the millet plants of their leaves or ruin the seedling of young plants. On the lower side of leaves, yellowish eggs are deposited in clusters. A reddish body with many blackish hairs is what the large larvae have.
- **Armyworms:** *Mythimna loreyi Dup., Spodoptera exempta Wlk.,* are widely distributed in African tropics. These cause ragging and crop failure.
- **Grasshoppers:** The crop can be destroyed by young and adult grasshoppers, who eat the leaves like locusts do. *Hieroglyphus nigrorepletus Bol., H. banian Fb., Chrotogonus spp.,* are known to cause to destruction to millet crops.
- **Sap sucking insects:** Both nymphs and adult aphids, *Peregrinus maidis.,* shoot bugs, plant bugs are some of the majorly occurring sap sucking pests. They make the plants wilt, turn yellow and twist by feeding on the juice from young leaves and the part where the leaves join. This results in dry and empty grains.

- **Stem borers:** Attacking millets, stem borers are a destructive group of insects. *Acigona ignefusalis Hmps., Sesamia calamistis Hmps., Chilo partellus Swinhoe* and *Sesamia inferens* are some of the stem borers commonly occurring in the millets. *Sesamia inferens* occurs most frequently in finger millet. The stem gets pierced and the central part dies, causing many branches to grow with spikes that don't produce anything. When they attack later, they damage the stalk that holds the flower and make the plant break. This also causes less grains and animal feed to be produced. *Sesamia inferens*, they lay their round yellow-white eggs in groups of 30 to 100 eggs. The eggs are arranged in two or three lines on the part of the leaf that wraps around the stem or on the top of the leaf. The larva is pinkish and the young insect pierces the stem right away without eating the leaf when it is in its early stages of growth.
- **Earhead pests:** Earhead pests commonly include spike worms, head beetles, head bugs, grain midges, thrips and earwigs. The number of grains produced is lower because the young insects eat the grains that are growing.
- **Storage pests:** Stored millets suffer significant losses due to insects, fungal and rodent attack. Angoumois grain moth, *Sitotroga cerealella Oliv.* are commonly occurred as stored grain pests (Gahukar.,1989).

A. Management of millet pests:

- Treating the seed with imidacloprid 600FS at 10-12 ml per kg of seed is an effective way to control white grubs.
- To protect pearl millet from shoot fly and stem borer, spray profenophos 50EC at 0.05% or fenobucarb 50EC at 0.1% twice, once at 20 days after germination and again at 40 days. (Gahukar and Reddy., 2019)
- Thrips are regarded as minor pests, can be effectively controlled by malathion 0-05% or carbaryl 0-7% sprays.
- Dusts of a mixture of methyl parathion + DDT or sprays of fenitrothion or phosalone reduces the grain midges.
- Use of resistant cultivars are also known to reduce the pest incidence.

11.2.3 Birds Damage in Millet Crops and Their Management:

Grain eating birds pose a serious threat to millet production both in India and Africa. The most notorious avian pest in the world, the Red-billed Quelea, is a major threat to pearl millet production. Other important bird pests of millets include various species of weavers, sparrows, parakeets, pigeons, crows, mynas and doves (Sharma & Davies, 1988). Some common bird pests of millets include:

- Sparrows (*Passer spp*): These birds feed on millet seeds and can cause significant damage to the crop.
- Baya weavers *(Ploceus philippinus)*: are small bird species which are widely distributed in India and are known to feed on the seeds of millet crops. They can cause damage by feeding on the grain heads, which can result in reduced yields.
- Rose-ringed parakeets (*Psittacula krameri*) are grass-green coloured birds that can cause damage to millet crops in several ways. They primarily feed on the grain heads

of the plants, which can cause yield losses and reduced crop quality. They may also cause damage by pecking at the tender shoots and leaves during the early growth stages.

- Crows (*Corvus spp*): Crows are opportunistic feeders and can attack millet crops, especially during the maturation stage. They can cause damage by pecking at the mature seed heads.
- Pigeons (*Columba spp*): Pigeons are known to attack millet crops, especially during the seedling stage. They can cause damage by pecking at the tender shoots and leaves.

A. Control Measures:

a. **Traditional Methods:** Bird scaring through shouting, beating empty tin cans, pelting stones or mud pellets at the flocks of birds, bursting firecrackers, covering crop heads with bags, hanging dead birds, cutting or burning nest bearing trees, and using bird scaring devices etc., have proven to be useful on small areas, but they are impractical on large farms.

b. **Physical Barriers:** Fish nets or nylon nets can be used to cover the millet crop to prevent birds from accessing it.

c. **Plant Phenology:** To protect millet crops from bird damage, farmers can plant long or short duration varieties such that they mature during low bird activity. Compact earheads with small grains and earheads with awns are less damaged. Plant characteristics such as bristles and anther covering of the grain may also be associated with resistance to birds.

d. **Bioacoustics**: Using distress alarms or warning calls to scare some bird species such as parakeets. The bird damage to millet crops may vary according to the location and stage of the crop. Among the different types of millet crops, pearl millet is more susceptible to bird damage.

11.3 Conclusion:

To protect millet crops, it is important to identify and manage the range of biotic stresses that affect crop production, using a variety of approaches such as cultural, biological, chemical control methods, and resistant varieties. Integrated plant disease management approaches that combine multiple control methods are particularly effective in minimizing the impact of biotic stresses on millet production. Recent advances in biotechnology and genomics are helping to identify novel sources of resistance to biotic stresses in millets. The sequencing cost has come down due to identification of the new sequencing technologies and quicker identification of the genes for the resistance has led to the early development of the varieties. Understanding host plant resistance has been instrumental in developing of these varieties. However, further research is necessary to develop effective and sustainable management strategies for biotic stresses in millets.

11.4 References:

1. Chandrashekar, A. and Satyanarayana, K. V. (2006). Disease and pest resistance in grains of sorghum and millets. *Journal of Cereal Science*. *44*(3): 287-304.
2. Das, I. K., Palanna, K.B., & Rajesh, G. (2023). Disease management for improved millet production.

3. Das, I.K., Rao, T. N. and Nagaraja, A. (2016). Diseases of millets and their management. *Indian Council of Agricultural Research*.
4. Gahukar, R. T. and Reddy, G. V. (2019). Management of economically important insect pests of millet. *Journal of Integrated Pest Management*, *10*(1):28.
5. Gahukar, R.T. (1989). Insect pests of millets and their management: a review. *International Journal of Pest Management*, *35*(4):382-391.
6. Kumar, S., Kothari, A., & Watanabe, K. N. (2005). Applications of biotechnology for improvement of millet crops: review of progress and future prospects. *Plant Biotechnology*. *22*(2): 81-88.
7. Numan, M., Serba, D. D., and Ligaba-Osena, A. (2021). Alternative strategies for multi-stress tolerance and yield improvement in millets. *Genes*.*12*(5): 739.
8. Rawat, L., Bisht, T. S., and Kukreti, A. (2022). Potential of seed biopriming with Trichoderma in ameliorating salinity stress and providing resistance against leaf blast disease in finger millet (*Eleusine coracana* L.). *Indian Phytopathology*, *75*(1): 147-164.
9. Repellin, A.M., Baga, P.P., Jauhar, P.P. and Chibbar, R.N., (2001). Genetic enrichment of cereal crops via alien gene transfer, new challenges. Plant Cell Tissue Organ Culture 64:159-183.
10. Sharma, H. C., & Davies, J. C. (1988). Insect and other animal pests of millets.