



Fungal Biodiversity And Eco-Friendly Disease Management In Agricultural Forage Feeds

Vikas Verma Patel

Assistant Professor

P.G. Department of Botany, V.R.A.L. Government Girls Degree College, Bareilly, UP-243005

M.J.P. Rohilkhand University, Bareilly-243006

ABSTRACT

Fungal biodiversity plays a crucial role in the health and productivity of forage feed crops, influencing both disease outbreaks and plant resilience. While some fungal species cause significant yield losses and produce harmful mycotoxins, others contribute to plant growth, nutrient cycling, and disease suppression. Understanding the diversity of fungal communities associated with forage crops is essential for developing sustainable disease management strategies.

Eco-friendly approaches to disease management, such as biocontrol agents, organic amendments, crop rotation, and the use of resistant cultivars, offer effective alternatives to chemical fungicides. Beneficial fungi, including mycorrhizal and endophytic species, enhance plant resistance to pathogens and improve soil health. Moreover, advancements in microbial inoculants and natural fungicides derived from plant extracts and antagonistic microbes show promising potential for controlling fungal diseases in forage systems.

This research explores the complex interactions between fungal biodiversity and disease dynamics in forage crops, emphasizing sustainable management strategies. By integrating ecological principles and innovative biocontrol techniques, eco-friendly approaches can enhance forage productivity while minimizing environmental impacts. The findings contribute to the development of resilient agricultural systems that ensure livestock feed security and ecosystem sustainability.

KEYWORDS: Fungal biodiversity, forage crops, eco-friendly management, biocontrol agents, sustainable agriculture

INTRODUCTION

While the terms "fodder" and "forage" are conceptually similar, they are not exactly the same. A plant species that is typically used for feeding livestock, either directly or after minor processing such as hay and silage, is referred to as a fodder. Forage crops are those plants that are consumed by animals, either directly or indirectly. The area under forage production is about 5 percent of the total cultivated area of the country (Singh et al., 2011) while National Commission on Agriculture (1976) recommended that a minimum 10 percent of the arable area in the country (about 16.5 million ha) should be under improved forage crops to meet the green forage needs of the livestock population. If we examine the land resources available for growing fodder and forage crops, it is estimated that the average cultivated area devoted to fodder production is only 4.4 per cent (Asaadi and Yazdi 2011) of the total area. Similarly, the area under permanent pastures and cultivable wastelands is approximately 13 and 15 million hectares, respectively which is declining over the years and the trend could well continue in the future. These resources are able to meet the forage requirements of the animals only during the monsoon season. But for the remaining periods of the year, the animals have to be maintained on the crop residues or straws of jowar, bajra, ragi, wheat, barley, etc. either in the form of whole straw or a bhusa, supplemented with some green fodder, or as sole feed. The crop residues are available mainly from wheat, paddy, bajra, jowar, ragi, sugarcane trash, etc.

Among the various constraints, the diseases have always been the major limiting factor for fodder cultivation. Several diseases are causing serious damage to fodder crops. In India, diseases alone can cause losses up to 72 per cent in Lucerne; 74 per cent in cowpea; 50 per cent sorghum; 30 per cent in bajra; 75 per cent in cluster bean and 55 per cent in oats (Avice, et al., 2003). Besides, these diseases also affect the quality parameters of forages. Keeping this in mind the present article is written with the objective to focus the diseases problems of fodder crops along with their management.

DISEASES OF BERSEEM OR EGYPTIAN CLOVER

Root Rot complex

Disease is a common occurrence in the plains of the Gangetic and Central rivers. Numerous fungi, including *Fusarium semitectum*, *Rhizoctonia solani*, and *Tylenchrhynchus vulgaris*, have been linked to root rot complexes. Although fungi only can incite the disease but the presence of nematode accelerates the infection rate causing serious damage to the crop (Bhaskar, et al., 2003). Once the disease established in the field it becomes a permanent source of infection as the pathogen perpetuates in the soil through their resting structures. Heavy incidence of the disease reduces the plant density and the green fodder yield.

Management:

For the control of root disease seed treatment with Thiram (0.25 per cent) and Bavistin (0.1 per cent) followed by foliar spray of Bavistin (0.1 per cent) can be practiced (Jain, 2001).

Stem Rot

This is the major disease of berseem caused by a fungus, *Sclerotinia trifoliorum* present in the soil. This is mainly a disease of temperate zone; however, it is also known to occur in the Gangetic plains of India during January and February when the temperature is around 100 C, which favours the multiplication and spread of the pathogen. The pathogen attacks the basal portion of the stem and causes it rot. Rotting of stem occurs generally 5 cm above the ground. It produces heavy white cottony mycelium in the field, which can be very easily spotted in the field around the wilted patches of the berseem crop. Later, black coloured sclerotial bodies can be seen that helps the pathogen to perpetuate in the field from one season to another making the disease soil-borne.

Management: Use of disease free seed, flooding of infested field during the summer are some the cultural practices which help to reduce the inoculum in the field. Drenching of soil with 0.4 per cent Brassicol, after cutting, can be practiced for its management (Singh, 2001).

Black leaf blight

Causal organism: *Leptotrochila trifolii* Narita, Ascomycotina;

Symptoms:

Fungal disease which causes leaf blight occurring in the cool region. The lesion is formed from the leaf rim and becomes black brown and V letterform with yellow surroundings. The small black grains (perithecia) are formed on the surface of the lesion, and ascospores are dispersed by wind and rain (Fig 1). The causal organism can infect other clovers, but their pathogenicities are differentiated.

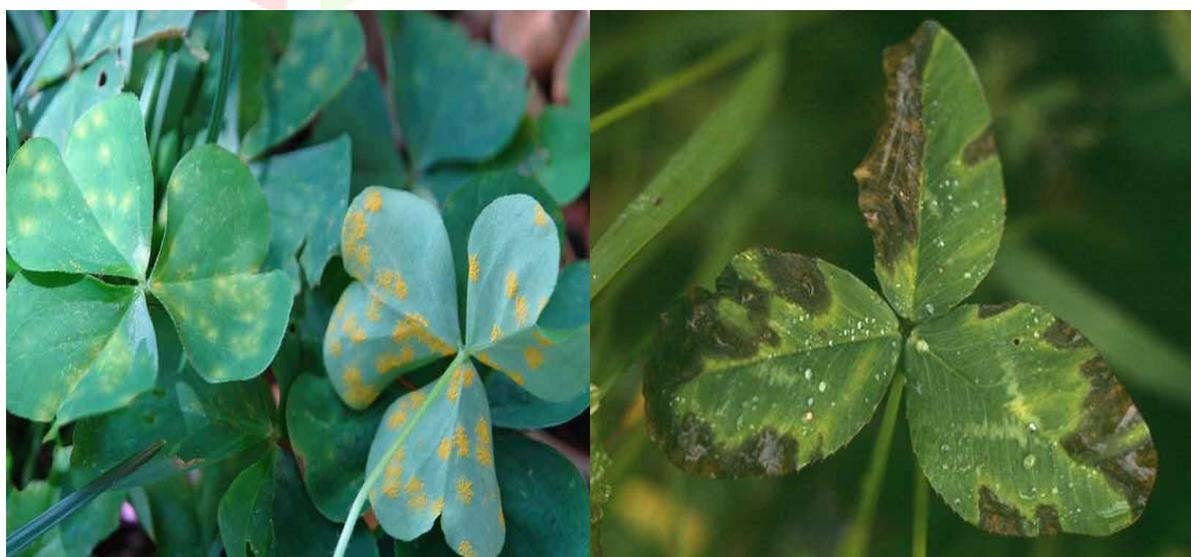


FIG-1: Symptoms of foliar fungal diseases on Egyptian clover (Barseem)

Management: Since, the disease is soil-borne, it is difficult to control. Nevertheless, deep summer ploughing, field sanitation including cutting and burning of diseased plant may help in reducing the disease to some extent. Seed treatment with Thiram (0.25 per cent) + Bavistin (0.1 per cent) followed by application of bioagent (*Trichoderma viride* or *T. harzianum*) has also been reported effective (Barrett, et al., 2009).

DISEASES OF SORGHUM

Smuts

Seven different types of smuts have been reported in sorghum however, four of which occur in India.

Grain Smut

This is the most destructive of all the smuts, causing extensive damage to grain yield all over the country. It is also known as covered smut, kernel smut or short smut. Grain smut of sorghum is caused by *Sphacelotheca sorghi*. It is reported to cause huge losses in USA, Italy, South America, Sri Lanka, Burma, Manchuria and several other countries. In India, it is known to occur in Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Gujrat and Uttar Pradesh. In certain areas, it is reported to cause up to 25 per cent of grain yield (Rangaswami and Mahadevan, 1999).

Symptoms:

The symptoms of the disease become visible only at the time of grain formation stage. The affected grains convert into smut sori. The size of the sori varies with the variety, but generally they are larger than the normal grain. The sori are oval or cylindrical, dirty grey sac, sometimes conical at the tip, and measuring 4-12 mm in length. The sac is surrounded by the unaltered glumes at the base. Sometimes the stamens develop normally, but more commonly they are absent or are involved in sorus, being replaced by 3 conical protrusions from sides of the sorus. These sacs rupture easily than in the unelongated sacs. The interior of the sac is completely filled with the spore powder.

Management: Since, the disease is externally seed-borne; seed treatment with suitable fungicides can easily control the disease. Immersion of seeds in 0.5 per cent formalin for 2 hours and dried quickly. Alternatively, they are treated in 0.5 – 3 per cent copper sulphate solution for 10 – 15 minutes, then dried and sowing had been old and very effective recommendation. The systemic fungicides like carboxin (Vitavax), Bavistin etc. have also been reported to control grain smut disease successfully (Singh, 2000).

Loose Smut

The loose smut of sorghum caused by *Sphacelotheca cruenta*, is reported from China, Iran, Italy, Africa and the USA. In India, it occurs in Tamil Nadu, Karnataka, Andhra Pradesh and Maharashtra.

The effects of the smut are not only on the grain but also on the plant growth. Thus, grains as well as fodder yield may be reduced.

Symptoms:

The affected plants remain stunted, produce thinner stalks, more tillers, and earlier flowering than the healthy plants. Generally, all the spikelets of the ear are affected and become malformed and hypertrophied. The floral bracts tend to elongate and proliferate. Frequently, the lemma and palea as well as the ovary contain smut sori. The size of the sori ranges from 3-18 mm in length and 2-4 mm in thickness. The affected ear appears like a leafy or leathery structure. The covering membrane of the sori ruptures early releasing the powdery mass of dark coloured spores.

Management: Seed treatment with formalin, Sulphur, copper sulphate, corboxin, Bavistin etc. as recommended for grain smut, is also effective in controlling the loose smut. Where soil survival of spores is possible, crop rotation and field sanitation are recommended.

Head Smut

Head smut caused by *Sphacelotheca reiliana* is reported from many countries in Asia, Southern Europe, Africa and America. In India, it is known to occur in Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Gujrat, Madhya Pradesh, Uttar Pradesh, Punjab and Bihar. This disease causes significant damage to sorghum as it affects the entire earhead, transforming it into a smutted head.

Symptoms:

The disease manifests itself only at the time of earhead formation or flowering. The inflorescence is invariably destroyed in the infected plants. In affected plants, the inflorescence is partially or entirely converted into a big sorus fully covered with a thin grayish-white membrane in its early stages but during emergence through the boot leaf the membrane is ruptured and spores are exposed. The sorus is usually 8- 10 cm long and 2.5-5.0 cm wide, and is cylindrical in shape. If the wind is blowing at the time of sorus emergence, the air-borne spores resemble a smoky cloud around the head. When the spores are blown off, a network of dark fibers traverses the spore mass and remains adhering even after the spores have been blown away.

Management: The disease can be controlled by a combination of practices such as sanitation, crop rotation and seed treatment (Singh, 2000).since, the smut is only sporadic i.e. only few plants are affected in a field it is possible to locate and destroy. Collecting smutted heads in cloth bags and dipping in boiling water to kill the pathogen will reduce the inoculum potential for the following crop (Ranagaswami and Mahadevan, 1999).

Rust

Rust caused by *Puccinia pupurea* is serious disease of sorghum wherever the crop is grown. It is found all over India, causing extensive damage to both irrigated and unirrigated crop. The damage depends on the variety and season. When it occurs late in the season, the loss in grain yield is relatively

insignificant, but when infestation starts in the early stages of the plant growth, there is heavy reduction in grain yield.

Symptoms:

The fungus affects the crop at all stages of growth, but more often the infection begins when the plants are about 2 month old. The first symptoms of the disease appear in the form of small flecks on the lower leaves (purple, tan or red depending upon the cultivar). Rust pustules (uredosori) appear on both surfaces of the leaf as purplish spots which rupture to release reddish powdery masses of uredospores (Fig 2). As the disease advances, infection spreads to the younger leaves, except for the youngest two or three leaves which are rarely infected. The pustules are elliptical, 1-2 mm in diameter and lie between and parallel with the leaf veins. In highly susceptible cultivars the pustules occurs so densely that almost the entire leaf is destroyed. Reddish brown to black teliospores develop later sometime in the old uredosori or in teliosori, which are darker and longer than the uredosori. The telia develop in linear patterns mostly on the lower surface of the leaves. The pustules may also occur on the leaf sheath and on the stalks of the inflorescence. The rust incidence causes older leaves to dry prematurely and the plants to appear smaller and generally unhealthy, even from distance.



FIG-2: Rust pustules on leaf and infected spike of Sorghum

Management: The fungus is known to survive on the alternate host *Oxalis comiculata*, hence, its removal can help in reducing the disease to some extent. Spraying the crop with Mancozeb at 1.25 kg/ha is also recommended.

Downy Mildew

This disease is reported to be prevalent in many parts of Asia and Africa, Italy and the USA, mostly in a mild form. It occurs in peninsular India, causing much damage to the crop in years when favourable climatic conditions prevail. The damage depends upon the environments and time of infection. The plants may be badly damaged before their full development or, if fully developed, may remain sterile. In a genotype with 100 per cent infection the loss in yield is 74 per cent (CIAT and CGIAR 2015).

Symptoms:

The fungus, *Peronosclerospora sorghi* is the cause of a systemic downy mildew of sorghum, earlier known as *Sclerospora sorghi* Weston and Uppal. It invades the growing points of young plants, either through oospore or conidial infection and as the leaves unfold they show various types of symptoms. The disease manifests itself as a downy, whitish growth on the lower surface of the leaves, consists of conidiophores and conidia. Later, this downy growth spreads over a major portion of the leaf blade, which appears yellowish through upper surface. The first few leaves that show symptoms are only partially infected with green or yellow colouration of the infected portion. As the disease advances, chlorotic streaks develop and turn brown as the leaf tissue die. As the infected bleached leaves mature they become necrotic and the interveinal tissues disintegrate, releasing the resting spores (oospores) and leaving the vascular bundles loosely connected to give the typical shredded leaf symptom. The younger ones remain normal, or, if infected, do not shred, and the plants produce healthy ears. However, the green-ear stage, though reported (Bandyopadhyay, et al., 2007), is not common. Management: Since, the pathogen is soil-borne in the form of thick walled persistent oospores, cultural control by deep ploughing (30-35 cm), systematic roguing of diseased plants and crop rotation have been suggested to reduce the oospore population in soil and the loss from downy mildews.

Leaf Spot or Leaf Blight

Symptoms: The leaf blight caused by *Exerohilum tericum* (syn: *Helminthosporium tericum*) also causes seed rot and seedling blight of sorghum. The disease appears in the form of small narrow elongated spots in the early stage but in later stages they extend along with the length of the leaf becoming bigger, spindle shaped, measuring several cm in length and up to one cm in width. The typical symptoms are long elliptical necrotic lesions with dark margins without distinct yellow haloes and bear a faint grey to brown bloom. The straw coloured center becomes darker during sporulation. Many lesions may develop and coalesce on the leaves, destroying large areas of the leaf tissues, giving the crop a distinctly burnt or blasted appearance.

Management: Seed treatment with Thiram @ 2.5 g/kg of seed and spraying crop with Mancozeb @ 2.5 kg/ha in 1000 liters of water are recommended for the management of this disease (Wrather & Sweets. 2022).

DISEASES OF PEARL MILLET OR BAJRA**Green Ear or Downy Mildew**

Green ear or downy mildew caused *Sclerospora graminicola* is a serious disease of pearl millet (*Pennisetum typhoides*). The disease is known to occur in India, Iran, Israel, China, Japan, Fiji, USA and many African countries. In India, the disease was first reported by Butler (1907) in sporadic form, not causing much damage, except in low lying fields where the loss could be significant. Since, then the disease has become widespread and virulent, causing considerable damage to the grain yield. Loss estimates vary from 6 to 60 per cent. Up to 27 – 30 per cent loss has been estimated in India (Mathur

and Dalela, 1971; Nene and Singh, 1976). Up to 60 per cent grain losses have been reported in many African countries.

Symptoms:

The symptoms of the disease appear on the leaves and inflorescence (Fig 3). The first symptoms can appear in the seedlings at 3 to 4 leaf stage. The affected leaves show chlorosis in streaks (light green to light yellow colour) on the upper surface. Just below these streaks on the lower surface a fine downy growth of the fungus may appear. As the disease advances, the streaks turn brown and the leaves become shredded along the veins. The downy growth seen on infected leaves consists of sporangiophores and sporangia. The characteristic symptom of the disease is the ear deformities characterized by the transformation of floral parts into twisted leafy structures. This gives the ear an appearance of green leafy mass hence the name "green ear". In most cases the entire ear is transformed into leafy structures, but sometimes only part of the ear is affected, the other part produce normal grains. All the floral parts including glumes, palea, stamens and pistil are converted into green, linear, leafy structures of variable length.

Management: Since, the pathogen is mostly soil-borne it is difficult to control the disease. As the fungus is persistent in soil up to about 5 or more years, crop rotation has little or no value in avoiding the disease. Rouging of diseased plants within a month of sowing followed by spraying of Dithane M-45 had also been an effective control method. The disease is partly disseminated through seeds, seed treatment Ridomil (8 g/kg seed) followed by one spray of 0.1 per cent Ridomil 20 days after planting is recommended for its management (Dang et al., 1983). Gupta and Verma (1991) also found that seed treatment with Apron SD-35 (2.5 g/kg seed) controlled the disease up to 30 days after sowing.

Rust

Rust disease caused by *Puccinia penniseti*, is serious disease of pearl millet, occurring wherever the crop is grown. In India, it is prevalent in all the bajra tracts, causing considerable damage from seedling stage to maturity.

Symptoms:

The first symptom of the disease appears mostly on the distal half of the lamina. Later, minute, round uredosori occur in groups on both surfaces of the leaves. The uredosori may also occur on leaf sheath, stem and even on peduncles. Later, telial formation takes place on leaf blade, leaf sheath and stem. The telia are black, elliptical and sub-epidermal. While, brownish uredia get exposed at maturity the black telia remain covered by the epidermis for longer duration. In severe infections; the plants appear unhealthy and slightly stunted as compared to healthy ones.



FIG-3: Symptoms of Green Ear or Downy Mildew of Bajra

Management: The only effective method of controlling bajra rust is to grow resistant varieties. So far most of the varieties tested are susceptible; therefore, work is needed to develop resistant varieties. Some control of the rust is reported through preventive sprays with 100 ppm of Cupramar and Dithane S 31 (Devaiah, et al., 2009).

Smut

Smut caused by *Tolyposporium penicillariae*, is a widespread disease of pearl millet. The disease has been reported from Pakistan, Africa, the USA and India. In India, it is prevalent in Tamil Nadu, Andhra Pradesh and Maharashtra. Ahmed and Reddy, 1993 estimated the loss from this smut by comparing the yield in untreated plots with yield in plots treated with 4 sprays of oxycarboxin (Plantvax). He reported that yield was 20.6 per cent more in the treated plots.

Symptoms:

The disease manifests itself at time of grain setting. A few grains scattered on the ear, may be replaced by oval to top-shaped sori, which are generally two to three times of the size of the normal grain. The top of the sorus is bluntly rounded to conical in shape. They are bright green to chocolate brown in the early stages and become dark black on maturity, often projected clearly beyond the glumes. The colour is due to the membrane covering the sorus and often rupture to expose a black spore mass.

Management: The pathogen survive in soil so removal of smutted ears, clean seed, hot weather ploughing, field sanitation etc. can reduce the incidence of disease to some extent (Tewari, 2000). Various non-systemic fungicides including zineb and mancozeb, the systemic fungicides Plantvax, Vitavax and Benlate and antibiotics heptanes and aureofungin have been tried either as seed treatment, foliage and panicle spray. Effective control by foliar and panicle sprays with Plantvax and Vitavax is reported (Chaube and Pundhir, 2005). Four sprays with captafol, zineb and heptanes have also been reported effective.

Ergot

Ergot caused by *Claviceps microcephala* is an important disease of pearl millet. It was first reported from South India but was not considered a major disease; however, in 1956 it occurred in epidemic

form in South Satara area of Maharashtra (Shinde and Bhide, 1958). By 1966 the disease had become a major limitation in the cultivation of improved hybrid varieties. Sever epidemics of the disease occurred in Delhi, Uttar Pradesh, Rajasthan, Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh and Haryana. Natarajan et al. (1974) estimated the average incidence to be about 62 per cent with grain loss of about 58 per cent.

Symptoms:

The disease becomes evident by exudation of small droplets of pinkish or light honey-coloured sticky fluid (the honey dew stage) from the infected spikelets. Under severe infection many such spikelets exude plenty of honey dew which trickles along the earhead. Later, these droplets become darker, coalesce, and cover large areas of the cob. With the advancement of disease, small dark brown sclerotia can be seen projecting from between the glumes. These sclerotia (ergot) contain alkaloids responsible for ergot poisoning in animals.

Management: The sclerotia remain viable for longer time in soil therefore; repeated deep ploughing especially during dry summer, long crop rotation, planting sclerotia free seeds, adjustment of sowing dates, and intercropping may help in avoiding soil-borne inoculum. Many workers have recommended 2-3 sprays of ziram, copper oxychloride + zineb, and wettable Sulpher at 5-7 days intervals starting just before earhead emergence (Singh, 2000). Besides, chemical control Mower et al. (1975) has reported that *Fusarium roseum* “*Sambucinum*” is a highly potential biocontrol agent against *Claviceps purpurea*. Similar parasitism of *C. purpurea* by *Fusarium heterosporum* has also been reported by several workers.

Other diseases of bajra of minor importance are:

- i. Twisted top (*Fusarium moniliforme*)
- ii. Leaf blast (*Pyricularia setariae*)
- iii. Leaf spot (*Curvularia penniseti*)
- iv. Leaf spot (*Xanthomonas campestris* pv. *Penniseti*)
- v. Leaf blotch (*Xanthomonas campestris* pv. *Annamalaiensis*)
- vi. Leaf spot (*Drechslera australiense*)

DISEASES OF LUCERNE

Downy Mildew

In India the disease confined to North India and central India during winter (December to February). The disease causes considerable damage to the young plants and reduces the stand of the crop and is most conspicuous in the subsequent years. The characteristic symptoms of the disease are light green

leaves especially at the apex of the stem and presence of brownish mycelium on the lower surface of the leaves. The mycelium consists of enormous number of conidiophores with hyaline conidia. Heavy infection results in the stunting and defoliation of the plants. The pathogen *Peronospora trifolii* persists in the soil through oospores lying in the plant debris.

Management: Foliar spray of Dithane M-45 (0.25 per cent) and Chlorothalonil (0.1 per cent) were found effective against this disease (Jain, 2001).

Rust

Rust caused by *Uromyces striatus*, is a common disease of lucerne in Northwest, Western Himalayas, Gangetic and Western plains of India. The disease is characterized by the presence of reddish brown uredia and telia on the leaves and stems develop late in the season. The pustules usually are single but sometimes arranged in circles around the single pustule. The telia that are black in colour are formed independently or in the same lesions. The rust is heteroecious in nature and forms its sexual stage on *Euphorbia* sp.

Management: Foliar spray of Dithane M-45 (0.25 per cent) has been found effective against this disease.

Common Leaf Spot

The disease caused by *Pseudopeziza medicagensis* is common to all lucerne growing areas, but more serious in the north-west, Gangetic and central plains of the India. The disease appears in the form of small dark brown to black, circular spots measuring 3-4 mm in diameter. The edge of the spot is toothed with dark brown to black apothecia in the center, a feature that distinguishes it from all other leaf spots. Heavy infection results in the yellowing and subsequently defoliation of leaves.

Management: Early cutting of lucerne can help in reduction of disease to some extent. Foliar spray of Dithane M-45 (0.25 per cent) has been found effective against this disease (Singh, 2001).

REFERENCES

1. Ahmed, K.M., Reddy, Ch. R. (1993). A Pictorial guide to the identification of seed borne fungi of sorghum, pearl millet, finger millet, chickpea, pigeon pea and groundnut. Information Bulletin No. 34. Patancheru, A.P. 502 324 India: International Crops Research Institute for the semi-Arid Tropics. 200 pp.
2. Asaadi, A. M., and Yazdi, A. K. (2011). Phenological stage effects on forage quality of four forbs species. *J. Food Agric. Environ.* **9**: 380–384.
3. Avice, J. C., Dily, F. L., Goulas, E., Noquet, C., Meuriot, F., Volenec, J. J., et al. (2003). Vegetative storage proteins in overwintering storage organs of forage legumes: roles and regulation. *Can. J. Bot.* **81**: 1198–1212. doi: 10.1139/b03-122

4. Bandyopadhyay, R., Frederickson, D., McLaren, N. W., Odvody, G. N., & Ryley, M. J. (2007). Ergot: A new disease threat to sorghum in the Americas and Australia. The American Phytopathological Society. <https://doi.org/10.1094/PDIS.1998.82.4.356>
5. Barrett, B., Baird, I., and Woodfield, D. (2009). "White clover seed yield: a case study in marker-assisted selection," in *Molecular Breeding of Forage and Turf*, eds T. Yamada, and G. Spangenberg (New York, NY: Springer), 241–250.
6. Bhaskar, R. B., Hasan, N., Pandey, K. C., & Melkania, N. P. (2003). Management of root-rot disease complex of berseem (*Trifolium alexandrinum* L.). *Forage Research*, **29**: 84–87.
7. Chaube, H.S. and Pundhir, V.S. (2005). *Crop diseases and their management*. Prentice Hall of India Pvt. Ltd. New Delhi. 703p.
8. CIAT and CGIAR (2015). *Improved Forages to Enhancing Farm Productivity, Climate Change Resilience, and Environmental Sustainability in Eastern and Southern Africa* [Online]. Nairobi: International Centre for Tropical Agriculture (CIAT).
9. Dang, J.P.; Thakur, D.P. and Grover, R.K. (1983). Control of pearl millet downy mildew caused by *Sclerospora graminicola* with systemic fungicides in an artificially contaminated soil. *Ann. Appl. Biol.*, **102**: 99- 106.
10. Devaiah, S. P., Mahadevappa, G. H., & Shetty, H. S. (2009). Induction of systemic resistance in pearl millet (*Pennisetum glaucum*) against downy mildew (*Sclerospora graminicola*) by *Datura metel* extract. *Crop Protect*, **28**: 783–791.
11. Gupta, G.K and Verma, S.K. (1991). Control of downy mildew of pearl millet with Ridomil. *Indian Phytopath.*, **44**: 448-461.
12. Jain, R.K. (2001). *Pests and diseases of fodder crops and their management*. In: *Plant Pathology* (ed. Trivedi, P.C.). Pointer Publishers, Jaipur. 422p.
13. Mathur, R.L. and Dalela, G.S. (1971). Estimation of losses from green ear disease (*Sclerosporagraminicola*) of bajra and grain smut of jowar in Rajasthan. *Indian Phytopath.*, **24**: 101-104.
14. Mower, R.L.; Snyder, W.C. and Hancock, J.G. (1975). Biological control of ergot by *Fusarium*. *Phytopathology*. **65**: 5-10.
15. Natarajan, U.S.; Guruswamy Raja, V.D.; Selvaraj, S. and Parambaramani, C. (1974). Grain loss due to ergot disease of bajra hybrids. *Indian Phytopath.*, **27**: 179-182.
16. Nene, Y.L. and Saxena, S.C. (1970). Studies on the fungicidal control of downy mildew of maize caused by *Sclerophthora rayssiae* var. *zeae*. *Indian Phytopath.*, **23**: 216-219.
17. Rangaswami, G. and Mahadevan, A. (1999). *Diseases of cereals*. In: *Diseases of crop Plants in India* (4th ed.) Prentic Hall of India, Pvt. Ltd. New Delhi, pp.160-264.
18. Singh, A.K., Khan, M.A., Subhash, N. and Singh, K.M. (2011). *Forages and fodder – Indian perspective*. Daya publishing house Delhi. 472p.
19. Singh, C. (2001). *Modern techniques of raising field crops*. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi. 523p.

20. Singh, R.S. (2000). Diseases caused by basidiomycotina - ustilaginales. In: Plant Diseases (7th Edition). Oxford & IBH Publishing co. pvt. Ltd. New Delhi. pp. 315-370.
21. Tewari, A.N. (2000). Identification of plant diseases and their control: Field diagnosis manual. G.B. Pant University of Agriculture and Technology, Pantnagar. 88p.
22. Wrather, A., & Sweets, L. (2022). Management of grain sorghum diseases in Missouri. University of Missouri Extension. <https://extension.missouri.edu/publications/g4356>

