Sorghum Anthracnose: The Global Notorious Intervention in Production and Productivity

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Sorghum (*Sorghum bicolor* (L.) Moench) is historically farmed in regions with high ambient temperatures and little soil moisture. It is a tropical crop that may have originated in northeast Africa and was domesticated between three thousand and five thousand years ago (Pedersen *et al*., 2003). Sorghum comes in after wheat, rice, maize, and barley as the world's fifth-largest cereal crop. Sorghum is a dual-purpose crop, producing stover and grain, both of which are very valued. Stover contributes around 50% of the overall crop value in the majority of the developing countries. Sorghum is regarded as a "poor man's crop". Since it provides the majority of the calories for rural residents who rely solely on grains and millets. Pests and plant diseases reduce the production of the sorghum crop. It is afflicted by root, stalk, foliar, panicle, and caryopsis diseases brought on by a variety of plant pathogens, including fungus, bacteria, and viruses (Prom *et al*., 2005). According to Sharma *et al*. (1978), downy mildew, rust, anthracnose, zonate leaf spot, leaf blight, grey leaf spot, sooty stripe tar spot, and rust are the most common sorghum foliar diseases of fungal origin in India.

Anthracnose, a disease caused on by *Colletotrichum graminicola*, is among the most significant and economically significant (Nicholson and Epstein, 1991). On the affected portion of the crop, anthracnose disease is indicated by the development of dark, sunken lenticular symptoms. Sorghum anthracnose was initially discovered in Togo, West Africa, in 1902 (Sutton, 1980), and it has subsequently been discovered in many other sorghum-growing areas throughout the world. Higher loss is caused by this disease in tropical and semi-arid regions where weather conditions favor *C. graminicola* growth, propagule dispersal, and sporulation. These conditions include high temperatures, relative humidity, and total rainfall.

Economic importance of disease

According to Hiremath and Lakshman (1990), the anthracnose disease is particularly worse in the Indian states of Andhra Pradesh, Maharashtra, Delhi, Madhya Pradesh, Uttar Pradesh, Tamil Nadu, and Karnataka. Serious yield losses might not happen if leaf symptoms don't show up until after the plant has reached maturity. *Colletotrichum* species affect infected plants and cause blight, spot disease, and damping-off in addition to anthracnose. It has been discovered that *C. graminicola* is a very variable pathogen.

Extent of damage

The anthracnose disease causes losses that differ according on the location. It is 50% in Georgia. It is 30% in Pakistan and 1.2 to 16.4% in India. Anthracnose-related losses often fell between 41% and 60%. Infected grains lose 51% of their weight when compared to healthy grains from plants the same age. In the highly sensitive cultivar. Grain losses from anthracnose to be as high as 88.7%.

Symptoms of the disease

Colletotrichum graminicola produces a wide range of symptoms on sorghum plants depends on the cultivar, inoculum load present in the location and weather parameters.

Symptoms on leaves: The host genotype affects the size and color of the symptoms, which move from lower to higher leaves. On a susceptible hybrid, typical symptoms emerged as tiny, semitransparent, water-soaked spots that ranged in shape from oval to elongate. Spots that ranged in color from red to orange to purple to tan grew into larger and turned tan, with a wider border. If lesions coalesce, the entire leaf could become blighted, giving it a "fired" appearance. Acervuli may cluster in concentric rings when they develop in huge numbers. Conidiospores and structures that resemble black hair (setae) develop in the acervulus. As seen in Figures 2A and B, a midrib infection may also manifest as a leaf infection.

Infection on stems: symptoms often appear on mature plants. When conidia from the leaf blight stage are splashed or wind-blown onto the stalks, infection ensues. A water-soaked browning of rind tissue in the lower internodes is the first sign of stalk infection. Infected tissue is intermingled with healthy tissue, and lesions take on a reddish colour (Fig. 2 C). Lesions on panicle and grains are initially water-soaked and, as they age, become tan or purple. They appear immediately below the epidermis and might be elliptical or bar-shaped. Areas of reddish, diseased tissue can be observed intermingled with healthy, white tissue if the panicle is dissected longitudinally. Infected tissue may develop black acervuli that spread to the seed (Fig. 2 D).

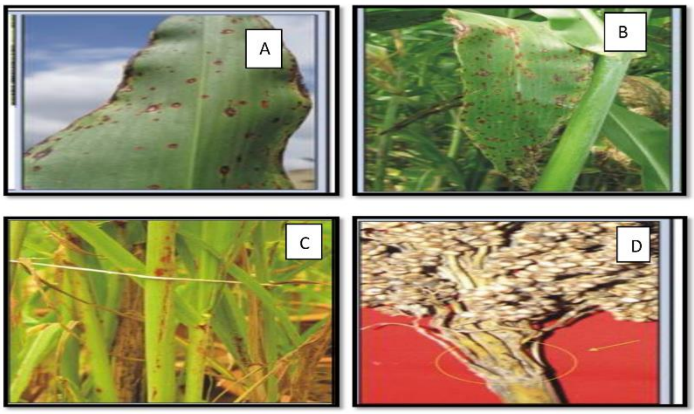


Fig. 2. Symptoms of anthracnose of sorghum A and B. Symptoms on leaves, C. Symptoms on stem and D. Symptoms on panicle

Pathogen

The pathogen was initially termed *Dicladium graminicola* by Cesati and then given the name *Colletotrichum graminicola* cereale. Wilson is currently known as the pathogen *Colletotrichum graminicola* (Ces.) Wilson (1914) renamed by waving on all the pathogenic species on cereals. *Glomerella tucumanensis* (Speg.) was named by Arx and Mullar (1954) as the fungus's ideal stage.

Morphological characters of pathogen

Colletotrichurn graminicola mycelium is submerged, branching, septate, hyaline, and either light brown or dark brown in color. It is distinguished by conidiomata known as acervulus that are present in the necrotic area of the lesion. On leaf and stem lesions, acervuli are black, rounded or elongated, and range in size from 70 to 300. Acervulus cells sporadically grow into setae, which are dark, somewhat inflated at the base, and tapered to the rounded, occasionally whiter tip. On this point, conidia can occasionally form. Conidiophores are many, brief, tightly packed, hyaline structures that are each 1-2 x 6-12 m in size and possess a single terminal conidium.

Morphological characters:

1. **Conidia**

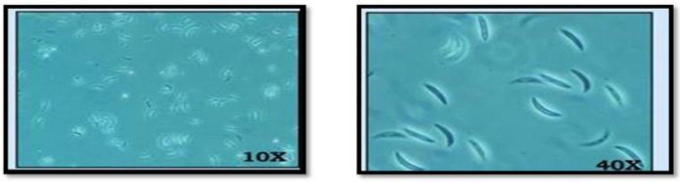
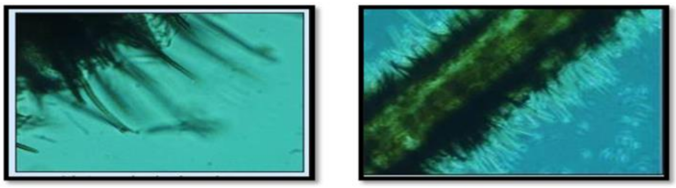


Fig.3 Conidia of *Colletotrichum graminicola*.

2. **Acervulus**



Acervulus in the culture **Acervulus on the leaf**

Fig. 3 Acervulus of *Colletotrichum graminicola*

Survival of pathogen

The pathogen may live on maize kernels for more than three years at 4°C during his three-year investigation on the survival of *C graminicola* in corn kernels. Disease may live for up to 2.5 years on sorghum seed but only for a maximum of 9 weeks in soil. Conidiospores are the source of inoculum for secondary infection and have a creamy to pinkish appearance when they are abundant.

Variability

This pathogen fungus had a wide range of variation. The pathogen's physical and cultural diversity make it difficult to identify it on a particular host. Furthermore, there is no set cultural condition that taxonomists adhere to and the phenotypic plasticity of the features in artificial culture varies widely. The presence, absence, and form of setae, the presence of sclerotia and appressoria, and the presentation of symptoms on the hosts have all been used to identify the pathogen in general terms (Sutton, 1992).

Management

For management of this disease is quite difficult due to its airborne nature and survives in various alternate and collateral hosts. Hence the most practical, cost-effective, and viable technique for managing plant diseases has been discovered to be breeding for resistance, but it cannot keep up with the emergence of increasingly aggressive pathogens. It is common knowledge that pathogenic diversity makes it difficult to find and use an efficient host resistance, which is a dependable and cost-effective method of managing plant diseases. when disease onset occurs at or prior to boot, a single application of pyraclostrobin-containing fungicide at or just prior to flowering reduces anthracnose, protects yield, and increases income. Rekha *et al.*, 2015 studied effect of sowing dates on the sorghum disease severity on cultivars PC-6 and MP-Cheri. Although the first sowing date (1st July) had higher disease severity, yield were higher than of medium and late sown sorghum cultivars and thus did not cause significant yield loss.

Rewale *et al.*, 2016 evaluated the bioefficacy of five fungal antagonists against the anthracnose of sorghum in-vitro *viz.*, *Trichoderma viride*, *T. harzianum*, *T. longibrachiatum* and *T. koningii, Aspergillus niger* and two bacterial antagonists *viz.*, *Pseudomonas fluorescens* and *Bacillus subtilis.* Results were exhibited significant mycelia growth inhibition of *C. graminicola* However, *T. viride* recorded significantly highest mycelial growth inhibition (79.62%), followed by *T. harzianum* (71.85%) and *T. longibrachiatum* (67.77%).

Rewale *et al.*, 2018 evaluated all nine botanicals *In vitro* and all were found fungistatic against *C. graminicola*. However, significantly highest average growth inhibition was recorded with *A. indica* (70.73%), followed by *Z. officinale* (62.58%), *A. cepa* (54.43%), *P. hystrophorus* (49.81%) and *P. pinnata* (42.95%).

Conclusion

Sorghum anthracnose is foliar disease affect the photosynthesis responsible for the reduction yield and affect the quality parameters. A further option for treating sorghum anthracnose is the prudent use of pesticides. While currently required, chemicals are not a sustainable solution for crop health. For the management of disease, number of bacterial and fungal biocontrol agents have been employed. The development of a comprehensive system, including DNA-marker technology, for characterizing races, virulence pattern, organ specificity, and symptom types, identification of R genes, and tactical utilization and deployment of R genes in combination with other management options for economical and efficient management of the pathogen are some of the future research directions. Further, more diverse types of botanicals and foliar biocontrol agents need to be evaluated for developing eco-friendly and sustainable approach for management of this disease.

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