Original Research Article

Evaluation of sorghum breeding lines for identification of resistance sources for multiple diseases in Sorghum.

Abstract:

Sorghum is a dual purpose crop; both grain and fodder are highly valued for human and animal consumption respectively. However, the crop is vulnerable for many fungal diseases of which downy mildew, rust and grain molds have become major concern in Dharwad district of North Karnataka revealing impact on sorghum yield. New and alternate sources of host plant resistance are needed for successful management of these diseases. Host plant resistance is the best practice to enable the crop to tolerate diseases which aid in increasing yield. This study aimed to identify the resistant sources against these foliar diseases. About hundred sorghum entries were evaluated under natural unprotected conditions for three continuous years by providing feasible environmental conditions for respective pathogen growth in order to identify resistant sources for downy mildew, rust and grain mold diseases. The incidence of the downy mildew disease was recorded followed by grade for estimation of reaction to downy mildew. However, rust (top four leaves will be considered) and grain mold disease severity was scored using the disease severity rating scale *i.e.*, 1-9 scale at physiological maturity. Among the different entries evaluated, some of the entries *viz*., SVD-1621, SVD–1503K and SVD–1411K showed multiple disease resistance with reaction varied from resistant to moderately resistant to sorghum downy mildew, rust and grain mold.

Keywords: *Sorghum, downy mildew, rust, grain mold, host-plant resistance*

INTRODUCTION

Sorghum, *Sorghum bicolor* [L.] Moench subsp. bicolor is a primary staple food crop in the semi-arid tropics of Africa and Asia for more than 300 million people (Anonymous, 2008). It belongs to the family Poaceae. In India, the crop will continue to be an important and potential food grain since its relative importance for alternate uses such as poultry feed, livestock, forage, sugar, alcohol, fuel etc besides grain and fodder desirability. The crop gains an

agricultural area of around 41.97 million hectares globally and its production and productivity are assessed to be around 65.21 million tons and 1400 kg/ha respectively. India is the fifth largest sorghum producer, producing 4.60 million tons from an area of 4.82 million hectares (Reddy *et al*., 2022). India is the largest producer contributing 26 per cent of the total production of sorghum. In India, Maharashtra, Karnataka, Rajasthan and Andhra Pradesh are leading sorghum growing states. Karnataka state is one among the top sorghum growing states of India which stands second in sorghum production with 8.59 tonnes (18.51%) on an area of 7.07 lakh hectares and productivity of 1215 kgs/ha (Anon, 2023).

However, despite the importance of this crop, yield at farmers' level tends to decline due to limitations imposed by biotic and abiotic factors. The crop is the host of many diseases that are caused by fungi, bacteria, viruses, nematodes and parasitic plants. Sorghum is vulnerable to many fungal diseases. Most of the major foliar diseases caused by fungal pathogens in sorghum include rust, leaf blight, downy mildew, anthracnose, sooty stripe, zonate leaf spot, grey leaf spot and rough leaf spot sorghum. Panicle diseases include grain mold, ergot and smut. Of over 50 diseases reported and described on sorghum, at Dharwad district of north Karnataka, downy mildew, rust and grain molds are continued to be an economically important diseases during *kharif* season affecting the plant health by reducing the quality and quantity of the crop.

Sorghum downy mildew (*Peronosclerospora sorghi* [Weston and Uppal (Shaw)]) is highly destructive due to its systemic nature of infection resulting in death of plants or lack of panicle initiation. Initial infection is caused by the oospores in the soil that germinate and invade the roots of sorghum seedlings. The pathogen moves upward systemically within the seedling, colonizes the meristematic tissues and induces leaf chlorosis. Yield losses estimated to be 100 per cent in susceptible checks. Rust (*Puccinia purpurea* Cook) infection substantially reduces forage quality and grain yield. The typical symptoms of rust appear as scattered purple or red flecks on both surfaces of leaves (uredinia). Gradually, most uredinia are converted into telia and the color of pustules changes from reddish brown to dark or blackish brown. If infection occurs early, the premature drying of leaves results in reduction of yields. Severe rust infection also contributes to lodging by reducing leaf area and increasing plant stress. Yield losses ranging from 30-65 per cent due to rust infection have been reported in Philippines, India and Australia (Bandyopadhyay, 2000). Damage resulting from grain mold infection includes reduced kernel development, discoloration of grain, colonization and degradation of endosperm and germ, decreased grain density, decreased germination, decreased seedling vigor, and possible mycotoxin contamination. Such grains are not suitable for food and animal feed and thus fetch much reduced market price to the growers. A large number of pathogenic and saprophytic fungi are associated with grain mold complex. The major pathogenic fungi are

species of *Fusarium* (*F. thapsinum, F. proliferatum, F. andiyazi, F. nygamai* and *F. verticillioides*), *Curvularia lunata, Alternaria alternata* and *Phoma sorghina* (Thakur *et al*., 2007).

As sorghum is a low input crop our main strategy of disease management has been mainly through host-plant resistance *i.e*., through identification of resistant lines against the diseases which is economical, environment friendly and technically feasible at farmers' level. Stable and durable resistance could be achieved by properly evaluating sorghum genotypes to identify sources of resistance genes. The introduction of host plant resistance (HPR), defined as the purposeful use to reduce the impact of diseases on yield which has been a key target in sorghum breeding programme. Taking into account, this paper reports a field evaluation of SB lines for identification of resistance sources for multiple diseases in Sorghum.

MATERIAL AND METHOD:

1. Collection of sorghum germplasm

About hundred sorghum breeding lines obtained from AICRP Sorghum, MARS, UAS, Dharwad along with known resistant and susceptible checks were used for resistance evaluation to multiple sorghum diseases *viz*., downy mildew, rust and grain molds during *Kharif* 2021-22, 2022-23 and 2023-24 for three incessant years.

2. Experimental Layout Field screening of germplasms for their reaction to downy mildew, rust and grain mold was conducted at MARS, UAS, Dharwad under natural unprotected field conditions by maintaining sick plot for downy mildew and by planting susceptible line in every tenth row in field as infector rows. Grain mold inoculum build up achieved by providing sufficient moisture through over head sprinkler and naturally through rain coinciding with grain maturity. The seeds were sown in an augmented block design with recommended plot size, spaced at 45cm x 15cm. Recommended agronomic practices and insect pest control measures were followed to raise a good crop as per the package of practices of UAS, Dharwad excluding disease control measures.

3. Determination of disease parameters

3.1 Disease Incidence

The incidence of the downy mildew disease was recorded by establishing the proportion of plants showing the symptoms and expressing the result in percentage in each plot for systemically infected plants at 30 days after sowing.

3.2 Grades for estimation of downy mildew, rust and grain mold diseases

Grade for estimation of reaction to downy mildew was given as follows; Resistant =≤5%; Moderately Resistant =6-10% Susceptible =11-30%; Highly Susceptible =≥30%.

At physiological maturity, *i,e*., when the grains were fully matured, the rust and grain mold disease severity was scored using the severity rating scale (Das *etal* , 2023).

Table 1: Rust and other foliar diseases:

Grade (1-9)	Description (%leaf area is affected by spot)	Disease Reaction
1	No symptoms seen on the leaf and perfectly healthy	Highly Resistant (HR)
2	1-5% of the leaf area is affected by spot	Resistant (R)
3	6-10% of the leaf area is affected by spot	Resistant (R)
4	11-20% of the leaf area is affected by spot	Moderately resistant (MR)
5	21-30% of the leaf area is affected by spot	Moderately resistant (MR)
6	31-40% of the leaf area is affected by spot	Susceptible (S)
7	41-50% of the leaf area is affected by spot	Susceptible (S)
8	51-75% of the leaf area is affected by spot	Highly Susceptible (HS)
9	>75% of the leaf area is affected by spot	Highly Susceptible (HS)

Table 2: Grain mold: Field grade/Panicle grain mold rating (PGS)

Grade (1-9)	Description (% grains molded on panicle)	Disease Reaction
1	0 to <1 % grains molded on panicle	Highly Resistant (HR)
2	1-5% grains molded on panicle	Resistant (R)
3	6-10% grains molded on panicle	Resistant (R)
4	11-20% grains molded on panicle	Moderately resistant (MR)
5	21-30% grains molded on panicle	Moderately resistant (MR)
6	31-40% grains molded on panicle	Susceptible (S)
7	41-50% grains molded on panicle	Susceptible (S)
8	51-75% grains molded on panicle	Highly Susceptible (HS)
9	>75% grains molded on panicle	Highly Susceptible (HS)

RESULT AND DISCUSSION:

During the years 2021-22, 2022-23 and 2023-24, about hundred breeding lines were evaluated for identification of resistant sources for downy mildew, grain mold and rust diseases. Most of the entries evaluated showed susceptible reaction to foliar diseases.

Among the different lines evaluated for downy mildew, Byahatti – LK and SVD-1101K and SPV–2569 were found to be resistant to downy mildew while entries *viz*., SVD- 1621, SVD–1503K and SVD –1411K and DNB-5K were evaluated as moderately resistant lines. The susceptible check SB 401B showed incidence of 55.95 per cent, 76.59 per cent and 92.83 per cent respectively during *kharif* 2021 and 2022 and 2023 (Table 1; fig 1).

Under reaction to rust , three entries *viz*., SVD -1417-1K, CSV – 42K and SVD – 1411K were showed resistant reaction while SVD- 1621, SVD -1416K , SVD – 1503K , SPV – 2569, Byahatti - LK , SVD – 1101K and DNB – 5K showed moderately resistant reaction (Table 1; fig.2). However, none of the entries were found highly resistant during the seasons.

Susceptible entry Kekri Local showed disease severity with grade 6 and 7 based on 1-9 disease severity rating during all three years.

For grain mold none of the entries showed highly resistant as well resistant reaction. While the entries *viz*., SVD- 1621, SVD -1416K, SVD – 1503K, SVD – 1417-1K, CSV – 42K and SVD – 1411K showed constant moderately resistant reaction. Byahatti - LK , SVD – 1101K and DNB – 5K entries showed susceptible reaction for two years whereas SPV – 2569 showed susceptible reaction for one year . One grain mold susceptible check Bulk Y showed susceptible and highly susceptible diseases reaction with grade 7, 9 and 7 based on 1-9 severity rating scale during the three seasons. Grain mold resistant entry B58586 also showed resistant and moderately resistant reaction with grade 2, 4 and 2 respectively during the three growing seasons (Table 1; Fig.3).

The variations obtained on disease incidence and severity in the different genotypes screened for diseases may be due to the differences in the individual inherent reaction to pathogens. In the same vein, climatic conditions during the study may also have influence on the levels of disease incidence and severity. These results agreed with an earlier report obtained by Sharma *et al*. (2012) who conducted experiment to screen against foliar diseases of sorghum during rainy and late rainy seasons. They evaluated 242 germplasm accessions for rust resistance. Six accessions exhibited resistance to rust in both the greenhouse and the field. Similar studies were conducted by Cuevas *etal.,* 2012 and Vishwas Gowda *etal.,* 2023 to identify new sources of rust resistance. Findings are also is in accordance with Ghada Radwan *et al*., 2018, who identified resistance sources for the new P6 sorghum downy mildew (SDM) pathotypes. The diversity among these materials is expected to provide different single-gene sources as well as quantitative sources of SDM resistance for use in breeding programs.

Table 3: Evaluation of SB lines for identification of resistance sources for downymildew, grain mold and rust diseases

Sl no	Entries	K-21-22	K-22-23	K-23-24	Reaction	K-21-22	K-22-23	K-23-24	Reaction	K-21-22	K-22-23	K-23-24	Reaction
		Downy mildew (DM)				**Rust**				**Grain Mold (GM)**			
1	SVD- 1621	11.11	5.80	14.18	MR	1	4	2	MR	2	4	4	MR
2	SVD -1416K	5.88	23.20	7.69	S	3	4	4	MR	2	4	5	MR
3	SVD – 1503K	0.00	10.50	11.11	MR	3	5	3	MR	2	4	2	MR
4	SVD – 1417-1K	18.75	9.00	14.29	S	3	3	2	R	3	5	5	MR
5	CSV – 42K	0.00	13.30	11.11	S	2	3	2	R	2	4	4	MR
6	SPV - 2569	0.00	6.20	7.69	R	3	5	4	MR	2	5	6	S
7	SVD – 1411K	0.00	8.30	10.00	MR	2	3	2	R	2	4	4	MR
8	Byahatti - LK	0.00	0.00	6.45	R	4	3	3	MR	4	7	6	S
9	SVD – 1101K	0.00	14.20	0.00	R	2	5	2	MR	4	7	6	S
10	DNB – 5K	0.00	0.00	20.00	MR	4	3	5	MR	2	7	6	S
Susceptible checks													
	SB 401B (DM-S)	55.95	76.59	92.83	HS	0	0	0	R	5	6	6	S
	K-Local (Rust-S)	3.50	5.00	25.25	S	6	6	7	S	2	9	8	HS
	Bulk Y(GM-S)	3.40	51.6	50.00	HS	4	7	5	S	7	9	7	HS
Resistant checks													
	CSV 17	2.50	6.20	5.45	R	3	4	4	MR	2	5	4	MR
	DSV 4 (Rust-R)	10.50	5.29	11.72	MR	2	3	3	R	3	4	3	MR
	B58586(GM-R)	2.80	2.00	3.55	R	3	4	3	MR	2	4	2	MR

Fig 1. Downy mildew susceptible and Rust resistant check- SB 401B

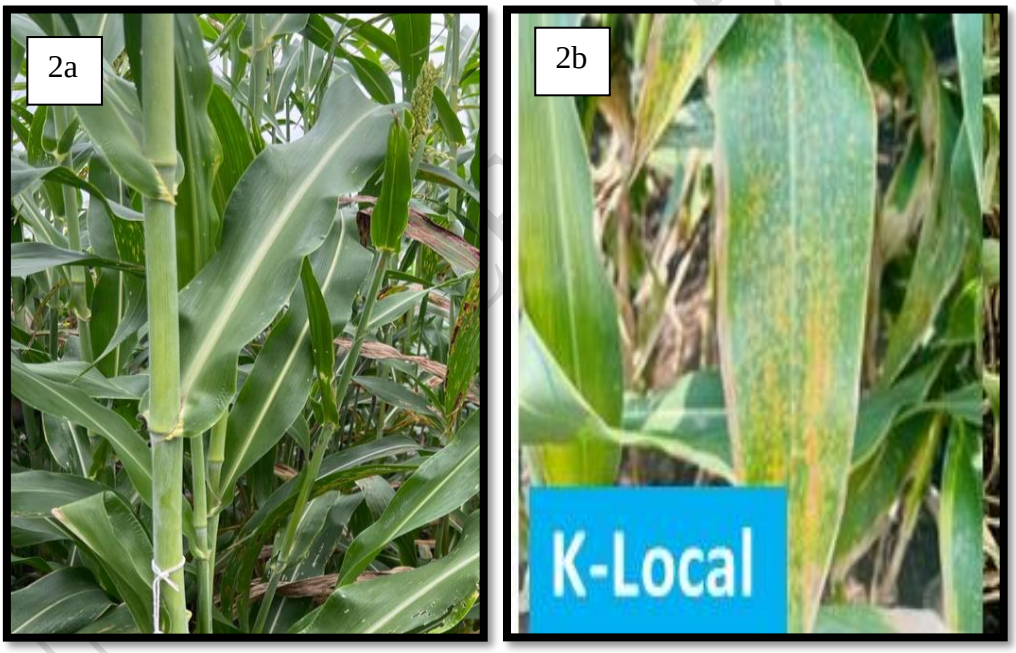

Fig 2a and b: CSV – 42K (rust R) and K local (rust S)

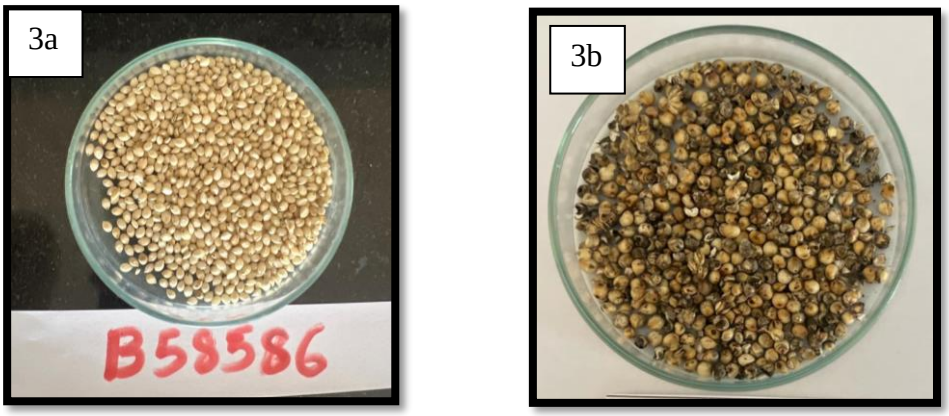

Fig 3a.Grain mold resistant (B58586)

Fig 3b.Grain mold susceptible (bulkY)

CONCLUSION:

Among the hundred entries lines evaluated for multiple disease resistance to sorghum diseases *viz*., downy mildew, rust and grain molds, none of the entries showed multiple disease resistant reaction to all the three diseases evaluated. However, entries *viz*., SVD-1621, SVD–1503K and SVD–1411K showed multiple disease resistance with reaction varied from resistant to moderately resistant to sorghum downy mildew, rust and grain mold.

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