Electronic Journal of Plant Breeding, 2(2):248-252 (June 2011)
ISSN 0975-928X

Research Note

Variability for grain mold resistance in sorghum F_3 progenies of red × red and red × white grain crosses

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(Received:01Mar 2011; Accepted:09Apr2011)

Abstract:
The present investigation was carried out to estimate the nature and magnitude of genetic variability for yield and grain mold resistance in 99 sorghum F_3 progenies of red × red and red × white crosses including parents and checks. Variation for grain mold associated traits was analyzed with respect to grain hardness, panicle compactness, grain colour, glume length and glume colour. Among 99 F_3 progenies 30 progenies exhibited partly hard grains and 19 progenies had hard grains and which exhibited low incidence of grain mold. In case of panicle compactness, 6 progenies had very loose, 9 progenies had loose and 26 progenies had semi-loose panicles and exhibited low incidence of grain mold. Twenty one progenies and seven progenies had long glume coverage and very long glume coverage respectively and these were resistant to grain mold. All the red grain coloured progenies showed low incidence of grain mold and progenies which had red and black coloured glumes were moderately resistant. Genotypes with hard grains, loose panicles, medium to long glume coverage and red and black coloured glumes had low incidence of grain mold. First and eleventh F_3 progenies of IS 24995 × IS 23585, first and ninth progeny of IS 24996 × IS 23585 and 8^{th} progeny of IS 25022 × IS 23585 were high yielding and resistant to grain mold.

Keywords: Sorghum, variability, grain mold, resistance

In many regions of the world where sorghum is produced, grain mold is a serious disease that reduces grain quality and utilization. The term grain mold is used to describe the diseased appearance of sorghum grain resulting from infection by one or more parasitic fungal species. Grain mold is most commonly caused by *Fusarium moniliforme* and *Curvularia lunata* (Esele et al., 1993), although many other species also cause grain mold. This disease is especially severe when grain development coincides with wet and warm weather conditions.

Sorghum grain mold is one of the most important biotic constraints to sorghum improvement and production worldwide. It is estimated that annual economic losses in Asia and Africa as a result of grain mold are in the excess of US$ 130 million. Production losses due to sorghum grain mold range from 30 to 100 per cent depending on cultivar, time of flowering and prevailing weather conditions during flowering to harvesting. *Kharif* sorghum grains are usually caught in September – October rains, thus mold develops on grains and make the grain unfit for consumption. In addition, consumption of mold affected grains cause health hazards to human beings, dairy animals and poultry birds. Mold reduces the germination per cent of the affected seeds thus reduce the quality of seed and grain. Development of grain mold tolerant *kharif* sorghum varieties is the need of the day, which helps the farmers in reducing the loss of grain quality and fetches him high market price compared to deteriorated grains due to mold attack. This reduces the cost of production by avoiding spraying of chemicals and also checks the environmental hazards. The disease is hazardous on improved, short and medium-duration sorghum cultivars that mature during the rainy season in humid, tropical and subtropical climates. Photoperiod-sensitive cultivars that mature after the rains often escape mold infection. Sorghum cultivars with white grain pericarp are particularly more vulnerable to grain mold than those with brown and red grain pericarp. Though lot of information is available on the quantitative characters, less information is available about the inheritance of grain mold resistance as well as its association with other morphological traits. Keeping in this view, the present investigation was undertaken in segregating generation (F_3) progenies of red × red and red × white crosses in sorghum.

In the present study, F_3 generation material derived from red × red and red × white crosses were used. Along with F_3 progenies, respective parents and popular checks DSV 6 (resistant), 296 B (susceptible) were studied. The experiment was laid out in medium deep black soil under rainfed condition at Sorghum Improvement Project, University of Agricultural Sciences, Dharwad during *kharif* 2009. The randomized block design was followed with two replications and each treatments was in three rows of 6 m length with inter row spacing of 45 cm and intra row spacing of 15 cm. All the recommended practices were followed to raise good crop of *kharif* sorghum.

Screening for grain mold: The experiment was grown under mist formation unit to facilitate mist formation on panicles from flowering to the physiological maturity to provide high humidity (>90% RH). This high humidity keeps the panicles moist for longer period. Moisture on panicle along with surrounding temperature creates the favorable condition for mold development. The mist was created by installing perforated GI pipes horizontally at the height of 10 feet above the ground on iron poles. These perforated pipes with minute holes were connected to high pressure bore well pump so that fine mist is formed and spread over the panicle when the water is passed through the perforated pipes. The mist formation unit was run for one hour thrice a day morning, afternoon and at evening.

From each entry 10 plants of uniform height and flowering were tagged. The visual panicle grain mold rating was scored at physiological maturity and these tagged plants were harvested threshed separately and scored for threshed grain mold rating. Visual scores were recorded using 1-9 scale, where 1= no mold, 2=1- 5%, 3=6-10%, 4=11-20%, 5=21-30%, 6=31-40%, 7=41- 50%, 8=51-75% and 9>75% mold. Data were recorded for panicle type, glumes coverage, glumes colour and grain colour, grain hardness, grain yield, fodder yield, 1000 grain mass and grain hardness at the appropriate time of crop growth and development.

Grain molds of sorghum have destructive status in recent years, particularly after the release of short duration varieties or hybrids for commercial cultivation in the states like Tamil Nadu, Karnataka and parts of Maharashtra. As such in recent sorghum breeding programme in our country and elsewhere emphasis is being given to developing varieties resistant to grain mold. For any breeding programme on disease resistance, the basic needs are availability of source of resistance and genetics of resistance. Although source of grain mold resistance are available, not much information is documented on its inheritance. Reaction of F_3 progenies derived from red × red and red × white crosses of sorghum to grain mold is discussed bellow.

Among 99 red × red and red × white F_3 progenies, 55 progenies (Table 1) showed resistant reaction to grain mold. Those progenies were seven of IS 25025 × IS 23585 (first, second, third, fourth, seventh, eighth and ninth progenies), six of IS 21509 × IS 24996 (first, second, third, fourth, fifth and sixth progenies), three of IS 24995 × IS 23585 (fourth, fifth and sixth progenies) nine of IS 20721 × IS 25084 (first, second, third, fourth, fifth, sixth seventh, eighth and ninth progenies), five progenies of CS 3541 × IS 1130 (second, third, fourth, fifth and seventh progenies); nine of IS 24996 × IS 23585 (first, second, fourth, fifth, sixth seventh, ninth, tenth and elventh progenies) and six of IS 24995 × IS 1130 (one to sixth), Parents IS 25025, IS 1130, IS 23585, IS 20721, IS 24996, IS 24995, IS 20757, IS 25084, IS 25022 and DSV-6 (check) showed resistance to grain mold. Hence, further selection may be carried out in these resistant progenies to develop resistant varieties.

Grain hardness is an important component for grain mold tolerance. Out of 99 F_3 progenies 19 progenies (Table 2) and 30 (30%) progenies had partly hard and hard seeds, respectively. Progenies with hard seeds shown resistance to grain mold at both field and threshed grain which results are in accordance with Audilkshmi *et al.* (1999) and Bheemashankar (2007). Hence, this trait can be taken as component of resistance in breeding. Hard seeds are less amenable for imbibition by continuous rains and there shall be less scope for saprophytes to grow on seeds. Among 99 F_3 progenies, 6 per cent of them had very loose, 9 per cent had loose and 26 per cent had semi loose panicles. Low incidence of grain mold was observed in these progenies. These progenies recorded resistance at both panicle and threshed grain mold score. The results are in conformity with the findings of Glueck *et al.* (1977), Rao *et al.* (1995). Hence, loose panicle is one of the important component traits for grain mold tolerance. The reason for low incidence of mold in loose panicles is due to non retention of moisture and better air circulation.

Glume length and area of coverage over the grain is related to grain mold escape as the grains are protected from exposure to rain. In the present study, twenty one progenies (21%) and seven progenies (7%) had long glume coverage and very long glume coverage respectively and were not infected by grain mold at both field and threshed grain score. The results confirmed the findings of Mansuetus *et al.* (1990). Among 99 F_3 progenies 63 progenies (63%) and 17 progenies (17%) had black and red glume colour respectively. Low incidence of grain mold was observed in these progenies. Progenies which had red and black coloured glumes were moderately resistant to grain mold, where as progenies which had brown and straw coloured glumes were susceptible to grain mold. Black and red coloured glumes contain the tannins, which inhibits the growth of saprophytic fungi and thus reduce the mold incidence. These results confirm the findings of Thakur *et al.* (2008).

Superior 10 genotypes for grain yield and grain mold resistance are listed in Table 3. All the ten genotypes showed resistance to moderate resistance to grain mold. With respect to grain hardness only two progenies had partly hard grains and rest all had soft grains,. For glume coverage five progenies had medium glume coverage and five progenies had short glume coverage and with respect to glume colour eight progenies had black coloured glume, one had red and the other one had light red glume colour. Thus all the ten progenies had one or the other grain mold resistance trait which contributes to the resistance to grain mold. Hence, selection can be made in these progenies in further generations to have high yielding and grain mold tolerant genotypes.

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Table 1: Frequency distribution of field and threshed grain score for grain mold tolerance in F_3 families of sorghum derived from red × red and red ×white grain crosses

Scale	Infection (%)	Resistance level	Frequency	
			Panicle grain mold score	Threshed grain mold score
1.	No mold infection	Highly Resistant	0	0
2.	1-5	Resistant	20	16
3.	6-10	Resistant	35	12
4.	11-20	Moderately Resistant	16	22
5.	21-30	Moderately Resistant	14	22
6.	31-40	Susceptible	5	13
7.	41-50	Susceptible	4	8
8.	51-75	Highly Susceptible	4	5
9.	76 and above	Highly Susceptible	1	1
		Total	**99**	**99**

Table 2: Variation between F_3 families of sorghum derived from red × red and red × white grain crosses for grain mold associated characters

Sl. No.	Character	F_3 progenies	
		No. of families	Per cent families
1	**Grain hardness**		
a.	Very soft	15	15.15
b.	Soft	35	35.35
c.	Partly hard	30	30.30
d.	Hard	19	19.19
e.	Very hard	00	00.00
	Total	**99**	**100.00**
2	**Panicle compactness**		
a.	Very loose	06	6.06
b.	Loose	09	9.09
c.	Semi loose	26	26.26
d.	Semi compact	41	41.41
e.	Compact	17	17.17
	Total	**99**	**100.00**
3.	**Glume coverage**		
a.	Very short	00	0.00
b.	Short	19	19.19
c.	Medium	52	52.52
d.	Long	21	21.21
e.	Very long	07	7.07
	Total	**99**	**100.00**
4.	**Glume colour**		
a.	Black	63	63.63
b.	Brown	2	2.02
c.	Red	17	17.17
d.	Light red	8	8.08
e.	Straw	9	9.09
	Total	**99**	**100.00**

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Table 3: Superior genotypes for grain yield and grain mold resistance

Progenies	Grain yield / plant (g)	Fodder yield/ plant (g)	PGMS	Grain hardness	Panicle compactness	Glume coverage	Glume colour	Grain colour
1st progeny of IS 24995 × IS 23585	52.7	156	Moderately resistant	Soft	Semi loose	Medium	Black	Red
12th progeny of IS 24995 ×IS 23585	51.3	139	Resistant	Soft	Semi loose	Medium	Black	Red
1st progeny of IS 24996 × IS 23585	46.9	172	Resistant	Soft	Semi compact	Short	Black	Red
9th progeny of IS 24996 × IS 23585	45.9	110	Resistant	Soft	Loose	Short	Black	Red
8th progeny of IS 25022 × IS 23585	44.3	168	Resistant	Soft	Semi compact	Short	Black	Red
9th progeny of IS 24996 × IS 25022	44.3	147	Moderately resistant	Partly hard	Semi compact	Medium	Red	Pearly white
9th progeny of IS 25025 × IS 23585	43.7	144	Resistant	Soft	Loose	Short	Black	Red
1st progeny of IS 20757 × RSSV 09	43.3	172	Moderately resistant	Soft	Semi loose	Medium	Black	Chalky white
4th progeny of IS 25025 × IS 23585	43.2	171	Resistant	Soft	Semi loose	Short	Black	Red
3rd progeny of IS 24996 × IS 25022	43.1	140	Moderately resistant	Partly hard	Semi loose	Medium	Light red	Pearly white
Check(DSV-6)	**41.3**	**135**	**Resistant**	**Soft**	**Compact**	**Short**	**Light red**	**Pearly white**

PGMS - Panicle Grain Mold Score