RESEARCH ARTICLE

SABRAO Journal
of Breeding and Genetics
45 (3) 510-522, 2013

PHENOTYPIC STABILITY FOR GRAIN MOLD RESISTANCE, GRAIN YIELD AND ITS COMPONENTS IN SORGHUM (*Sorghum bicolor* L.)

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SUMMARY

A total of 203 genotypes of grain sorghum including 8 lines and 21 testers and their 168 hybrids with 6 checks were evaluated for grain mold resistance, grain yield and its components in 2 locations in 2 years. Significant genotype and environmental interactions for Panicle Grain Mold Rate (PGMR), Threshed Grain Mold Rate (TGMR) and days to 50% flowering indicating differential behavior of genotypes under different environments for these characters. The hybrids are classified into 3 groups based on stability performance. Forty-six hybrids exhibited stable performance across environments in which top 5 hybrids (ICSA 384 × GD 65028, ICSA 370 × GD 65028, ICSA 384 × GD 65055, ICSA 369 × GD 65028 and ICSA 370 × GD 65055) with low PGMR scores. None of the resistant hybrids were adaptable to favorable environments. Two hybrids, ICSA 369 × GD 65055 and ICSA 369 × ICSR 89058, were suitable for unfavorable environments with low PGMR scores.

Keywords: G x E interaction, PGMR, sorghum, stability, TGMR

Manuscript received: October 16, 2012; Decision on manuscript: October 30, 2013; Manuscript accepted: November 22, 2013.

Communicating Editor: Bertrand Collard

INTRODUCTION

Sorghum is an important cereal crop after wheat, maize, rice and barley and widely cultivated in semi-arid tropical areas of world, particularly rain fed conditions. It is a staple food for millions of people in these areas. It is widely cultivated under different environmental conditions and it is known to exhibit a high degree of genotype x environment (G x E) interactions. It is important for plant breeders to identify specific genotypes adapted or stable to environment(s), thereby achieving quick genetic gain through screening of genotypes for adaptation and stability under varying environmental conditions prior to their release as cultivars (Flores, *et al*., 1998; Showemimo, *et al*., 2000; Yan and Kang, 2003). Hence there is a need to develop hybrids with stability. Stability of newly developed hybrids is quite important. Newly developed genotypes generally need to be tested at many locations and for several years before being recommended for a specific zone. To achieve this goal, multi environment trials are essential component of varietal testing programs. Several studies have investigated the effect of years and/or locations on agronomic traits on grain sorghum genotypes (El-Attar *et al*., 1986; Nayeem and Bapat, 1989; Bakheit, 1990; Ahmed, 1993; Narkhede *et al*., 1997; Ali, 2000; Hovny *et al*., 2005). The development of *kharif* sorghum hybrids has considerable potential due to the higher productivity. However, there are great fluctuations in their annual production in most of the improved sorghum varieties and hybrids that mature earlier than local varieties, often before the end of the rainy season. This results in increased exposure of the developing and maturing grain to conditions of high humidity and wetness. Grain mold develops under these conditions which results in decreased filling and size of the grain and chalky endosperm, which disintegrates during harvest and threshing. It is essential to develop a hybrid with a high degree of adaptability combined with superior productivity over a wide range of ecogeographical conditions. An interaction on Genotype x environment interaction poses challenge to plant breeders to develop high-yielding cultivars that manifest stable performance in a range of environments in targeted regions. Very little information is available on stability of grain mold resistant hybrids. Therefore, an attempt was made to assess the stability of the mold resistant hybrids using Eberhart and Russel (1966) model. The objective of this study was to find out the stability behavior of hybrids and their parents for grain mold resistance, grain yield and its components.

MATERIALS AND METHODS

In this study, 29 parents including 8 lines (5 lines were grain mold resistant) and 21 testers (9 testers were grain mold resistant) were crossed in line × tester mating design during *rabi* 2004 and 2005 seasons at ICRISAT, Patancheru, Hyderabad. The F_1s obtained were raised along with parents and checks (Bulk Y, IS 25017, IS 20, IS 14384, PVK 801 and CSH 16) in a Randomized Complete Block Design (RCBD) with 2 replications and screened for grain mold resistance at ICRISAT, Patancheru and College Farm, College of Agriculture, Rajendranagar during the rainy seasons (*kharif* 2004 and *kharif* 2005, June to September) following standard field screening technique (Bandyopadhyay and Mughogho, 1988). A separate trial was conducted using a RCBD with 3 replications to assess the yield potential of parents and hybrids at ICRISAT, Patancheru and College Farm, College of Agriculture, Rajendranagar during the rainy seasons (*kharif* 2004 and *kharif* 2005, June to September). Each genotype was raised in 2 rows of 2 m length with a spacing of 60 × 15 cm. Recommended agronomic practices were followed. The data were recorded on grain yield, other yield components and grain mold resistance characters for each genotype in each replication.

Statistical analysis

Data obtained from the 2 locations in 2 years were subjected to pooled analysis variance and the linear (b_i) and nonlinear (s^2d_i) components of genotype environment interaction was calculated as suggested by Eberhart and Russell (1966) using WINDOSTAT statistical software.

RESULTS AND DISCUSSION

The analysis of variance revealed significant differences among the genotypes and environments. The G × E interactions were significant for 3 characters *i.e.* panicle grain mold rate (PGMR), Threshed Grain Mold Rate (TGMR) and days to 50% flowering indicating differential performance of genotypes under different environments for these characters. The G × E interactions for the remaining 3 characters *i.e.* plant height, 100-grain weight and grain yield per plant were found to be non-significant. Therefore, stability parameters were not estimated for these 3 characters. Mean squares due to environments + (genotype × environment) were significant for all the 3 characters *i.e.* days to 50% flowering, PGMR and TGMR reemphasizing the existence of G × E interactions for these traits. These findings are consistent with Nayeem and Bapat (1989), Narkhede *et al*. (1997), Muppidathi *et al*. (1999), Indira *et al*. (1991) Rodriguez *et al*. (1997). Significant variation due to environment (linear) was observed for days to 50% flowering, PGMR and TGMR. Similar results were reported earlier by Nayeem and Bapat (1989) and Indira *et al*. (1991).The linear component of G × E was significant for all these 3 characters suggesting that genotypes response to variation in environments is predictable (Table 2).

For PGMR, the linear component of G × E interaction and deviation from linear components were found to be significant. Among the lines, 3 resistant lines *i.e*. ICSA 369 (2.49), ICSA 370 (2.84), ICSA 371 (2.93) registered unit b_i values and these are widely adaptable. Among the testers, 15 are having stable performance across the environments. Out of 15 testers, 3 were recorded with lower PGMR scores *i.e.*, GD 65028 (2.56), ICSV 96105 (2.33) and ICSV 96094 (3.04). Among the stable hybrids, 130 are considered to be widely adaptable to different environments with the average stability. The hybrid ICSA 384 × GD 65028 recorded the lowest score (1.93) with stable performance. Thirty-nine hybrids recorded low scores (1-3) with stable performance across the environments. None of the resistant hybrids were adaptable to favorable environments. Two resistant hybrids *i.e*. ICSA 369 × GD 65055 (2.04) and ICSA 369 × ICSR 89058 (2.68) with less than 1 b_i values, possess more than the average stability and are specifically adaptable to poor environments (Table 3).

For TGMR, the linear component of the G × E interaction was found to be significant. Among the lines 2 resistant lines *i.e.* ICSA 371 (2.63) and ICSA 370 (2.75) with unit regression coefficients (b_i values) and these were stable across the environments with average stability. ICSA 369 (2.25) had a greater than average stability and was adaptable to poor environments. Among the testers, 16 testers showed stable performance across environments. Out of 16, 2 testers recorded lower scores *i.e.*, ICSV 96105 (2.38) and GD 65028 (2.50) and none of the resistant tester recorded more than unit b_i values. One resistant tester *i.e.*, ICSV 96094 (3.00) recorded less than unit b_i values and adaptable to poor environments with more than average stability. Among the stable hybrids, 141 hybrids exhibited stable performance with wide adaptation. Genotypes had lower scores (1-3) and exhibited stable performance across environments. One resistant hybrid was adapted to favorable environments. Six resistant hybrids were adapted to poor environments with greater than average stability (Table 1).

Table 2. Classification of Hybrids based on stability and PGMR**.**

Group 1	Low PGMR and stable across environments	Forty-six hybrids exhibited stable performance across environments in which top 5 hybrids *i.e.*, ICSA 384 × GD 65028, ICSA 370 × GD 65028, ICSA 384 × GD 65055, ICSA 369 × GD 65028 and ICSA 370 × GD 65055
Group 2	Low PGMR and suitable to favorable environments	None of the resistant hybrid
Group 3	Low PGMR and suitable to unfavorable environments	ICSA 369 × GD 65055 and ICSA 369 × ICSR 89058

Table 1. Stability analysis of variance for GMR, yield and its components.

Source	Genotypes	Environments	Genotype × Environment	Environment + (Genotype × Environment)	Environment (linear)	Genotype × Environment (linear)	Pooled deviation	Pooled error
df	202	3	606	609	1	202	406	808
PGMR	9.77**	6.91**	0.57**	0.60**	20.57**	0.73**	0.48**	0.23
TGMR	14.46**	5.22**	0.58**	0.60**	15.66**	0.76**	0.48	0.47
df	202	2	404	406	1	202	203	1212
Days to 50% flowering	41.26**	350.57**	1.02*	2.737**	701.13**	1.85**	0.18	0.60
Plant height	4864.92**	9718.91**	40.38	-	-	-	-	64.70
100-grain weight	0.29**	0.04**	0.01	-	-	-	-	0.01
Grain yield	30.70**	182.78**	7.23	-	-	-	-	17.05

Significant at 5% level, ** significant at 1% level

Table 3. Mean performance and stability parameters for days to 50% flowering in sorghum, PGMR and TGMR.

		Days to 50% flowering			PGMR			TGMR		
	Parents/Hybrids	Mean	b_i	s^2d_i	Mean	b_i	s^2d_i	Mean	b_i	s^2d_i
	Lines									
1	ICSA 369	59.56	0.37	-0.57	2.49	1.82	-0.22	2.25	-1.66*	-0.45
2	ICSA 370	60.22	0.15	-0.40	2.84	0.50	-0.19	2.75	-0.70	-0.11
3	ICSA 371	60.11	0.96	-0.58	2.93	1.15	-0.15	2.63	1.31	-0.44
4	ICSA 400	66.56	0.36	-0.55	8.16	0.73	-0.23	8.50	-2.03	-0.38
5	ICSA 384	61.78	0.08	-0.56	4.01	-0.34	0.04	3.63	-2.01	-0.28
6	ICSA 382	66.56	0.37	-0.57	7.98	-3.89*	-0.13	8.38	4.04	-0.25
7	ICSA 52	63.56	0.59*	-0.61	8.93	-0.39*	-0.23	9.00	0.00*	-0.47
8	ICSA 101	65.33	1.09	-0.53	4.98	4.94	0.15	4.88	-5.48	0.47
	Testers									
1	IS 41720	61.33	-0.22	-0.55	5.40	2.96	1.49**	5.50	-1.92	1.14*
2	IS 41397	63.00	0.22	-0.55	3.94	-0.39	-0.16	4.00	0.00*	-0.47
3	IS 41675	68.11	0.29	-0.38	5.89	-0.24	-0.09	5.75	1.44	-0.17
4	IS 18758C-618-2	56.89	0.36	-0.55	6.31	-4.87	0.51*	7.50	6.08	0.36
5	IS 18758C-618-3	55.78	0.51	-0.54	6.98	-2.62	-0.02	8.50	2.25	-0.41
6	IS 30469C-140-2	64.56	0.59*	-0.61	6.83	2.93	0.46	6.63	-4.26	-0.32
7	IS 30469C-1508-2	69.44	0.52	-0.57	5.54	2.10	-0.11	5.63	0.35	-0.38
8	ICSV 96105	65.67	0.01	-0.39	2.33	1.75	-0.12	2.38	-2.38	-0.34
9	ICSV 96094	60.44	0.29*	-0.61	3.04	2.37	0.27	3.00	-3.32*	-0.39
10	IS 84	59.56	-0.08	-0.56	8.15	0.24	0.42	8.88	0.94	-0.41
11	SPV 462	69.44	0.52	-0.57	4.59	0.85	-0.13	4.63	4.63*	-0.45
12	ICSR 89013	62.22	0.58	-0.36	5.43	2.77	0.24	5.50	0.22	-0.22
13	ICSR 91011	69.22	0.37	-0.57	7.00	-5.66	1.88**	7.00	9.74	0.62
14	ICSR 89018	61.33	0.22	-0.55	4.93	4.87	1.03*	5.25	-4.42	0.40
15	ICSR 89058	66.22	0.35	-0.09	6.40	0.89	-0.17	6.13	-0.72	-0.39
16	PVK 801	68.11	0.07	-0.56	4.94	-0.59	0.07	5.38	5.11	0.37
17	GD 65028	75.67	0.66	-0.58	2.56	-2.21	0.04	2.50	3.32	-0.39
18	GD 65055	73.00	-0.22	-0.56	3.08	-3.83	0.61*	3.63	11.05	0.67
19	ICSR 92001	74.56	0.80	-0.54	4.43	-1.24	-0.09	4.63	4.41	-0.12
20	ICSR 91019	72.89	-0.07	-0.56	6.14	1.97	2.60**	6.88	3.82	1.31*

	Parents/Hybrids	Days to 50% flowering Mean	b_i	s^2d_i	PGMR Mean	b_i	s^2d_i	TGMR Mean	b_i	s^2d_i
21	ICSR 91029	65.00	-0.22	-0.55	5.83	4.45	0.19	6.00	-1.80	0.16
	Hybrids									
1	ICSA 369 × IS 41720	60.78	1.18	-0.45	3.00	0.53	-0.15	2.75	1.66	-0.45
2	ICSA 369 × IS 41397	58.44	0.73	-0.61	3.35	-2.06	0.03	3.13	0.13	-0.12
3	ICSA 369 × IS 41675	62.00	1.32	-0.61	3.46	-0.50	0.60*	3.38	1.05	0.33
4	ICSA 369 × IS 18758C-618-2	53.33	1.09	-0.53	4.39	-1.14	0.23	4.13	3.67	-0.14
5	ICSA 369 × IS 18758C-618-3	55.22	0.79	-0.05	4.69	0.81	-0.04	5.38	2.24	-0.07
6	ICSA 369 × IS 30469C-140-2	59.56	0.15*	-0.61	2.30	0.41	-0.17	2.38	0.72	-0.39
7	ICSA 369 × IS 30469C-1508-2	62.33	1.10	-0.58	2.51	1.33	-0.01	2.38	-1.31	-0.44
8	ICSA 369 × ICSV 96105	61.56	1.02	-0.61	2.69	-3.61	0.13	2.50	0.73	0.01
9	ICSA 369 × ICSV 96094	58.89	1.24	-0.52	4.88	-4.73	0.46	4.38	-2.83	0.07
10	ICSA 369 × IS 84	59.56	0.81	-0.58	6.58	2.53	0.09	7.13	3.67	-0.14
11	ICSA 369 × SPV 462	62.00	0.66	-0.58	3.88	0.38	0.02	3.88	4.04	-0.25
12	ICSA 369 × ICSR 89013	60.33	1.76*	-0.61	3.89	-3.93	0.04	3.50	0.73	0.01
13	ICSA 369 × ICSR 91011	61.33	1.32	-0.61	2.56	1.70	-0.23	2.38	0.72	-0.39
14	ICSA 369 × ICSR 89018	58.33	1.09	-0.53	3.13	-2.47	0.81*	3.00	0.51	0.77
15	ICSA 369 × ICSR 89058	62.00	1.32	-0.61	2.68	-1.20*	-0.23	2.38	2.97*	-0.46
16	ICSA 369 × PVK 801	61.00	1.53	-0.51	2.43	0.90	0.65*	2.00	0.00*	-0.47
17	ICSA 369 × GD 65028	64.11	1.39	-0.52	2.10	0.01	-0.21	2.13	-0.72	-0.39
18	ICSA 369 × GD 65055	63.78	1.18	-0.45	2.04	-0.59*	-0.23	2.00	0.00	-0.47
19	ICSA 369 × ICSR 92001	61.89	1.02	-0.61	2.65	-0.93	0.07	2.13	0.35	-0.38
20	ICSA 369 × ICSR 91019	61.22	1.24	-0.52	3.38	0.37	-0.14	3.13	-0.94	-0.41
21	ICSA 369 × ICSR 91029	61.11	1.17	-0.61	3.74	1.17	0.63*	3.50	1.41	0.96*
22	ICSA 370 × IS 41720	60.67	1.33	-0.46	3.20	0.78	-0.20	3.00	0.00*	-0.47
23	ICSA 370 × IS 41397	59.78	0.51	-0.54	2.81	-1.13	-0.08	2.88	0.72	-0.39
24	ICSA 370 × IS 41675	61.67	0.66	-0.58	3.00	-1.61	-0.16	2.88	0.72	-0.39
25	ICSA 370 × IS 18758C-618-2	53.89	1.46	-0.61	4.30	-1.13	-0.17	4.38	3.93	-0.22
26	ICSA 370 × IS 18758C-618-3	57.44	0.96	-0.19	3.61	-2.95	0.02	3.25	2.39	-0.06
27	ICSA 370 × IS 30469C-140-2	60.78	1.18	-0.45	2.21	-0.31	-0.18	2.38	-0.35	-0.38
28	ICSA 370 × IS 30469C-1508-2	62.22	1.02	-0.61	2.28	0.42	-0.15	2.13	1.31	-0.44
29	ICSA 370 × ICSV 96105	60.44	0.73	-0.61	3.39	-3.65	0.06	3.13	1.09	-0.17

	Parents/Hybrids	Days to 50% flowering Mean	b_i	s^2d_i	PGMR Mean	b_i	s^2d_i	TGMR Mean	b_i	s^2d_i
30	ICSA 370 × ICSV 96094	58.89	1.46	-0.61	4.63	-3.74	1.01**	4.25	2.84	1.60*
31	ICSA 370 × IS 84	61.56	0.37	-0.57	6.63	-0.22	0.19	6.63	3.56	-0.36
32	ICSA 370 × SPV 462	61.56	0.82	-0.18	3.40	-1.91	-0.08	2.88	-0.24	-0.13
33	ICSA 370 × ICSR 89013	57.89	1.25	-0.59	4.23	-2.74	0.02	4.13	0.35	-0.38
34	ICSA 370 × ICSR 91011	62.44	0.96	-0.58	2.30	-1.34	-0.14	2.25	0.37	-0.35
35	ICSA 370 × ICSR 89018	59.00	0.00*	-0.61	3.26	-1.51	0.19	3.50	0.73	0.01
36	ICSA 370 × ICSR 89058	60.89	1.26	-0.21	2.81	-1.35	-0.08	3.00	2.14	0.36
37	ICSA 370 × PVK 801	60.89	1.03	-0.44	2.38	0.66	0.59*	2.38	1.05	0.33
38	ICSA 370 × GD 65028	63.67	1.33	-0.46	2.09	-0.88	-0.19	2.13	0.35	-0.38
39	ICSA 370 × GD 65055	65.11	1.17	-0.61	2.14	0.14	-0.14	2.13	0.35	-0.38
40	ICSA 370 × ICSR 92001	62.56	1.25	-0.59	2.78	2.46	0.09	2.38	-2.38	-0.34
41	ICSA 370 × ICSR 91019	62.56	1.89	0.49	3.41	2.45	-0.04	3.63	-4.26	-0.32
42	ICSA 370 × ICSR 91029	62.22	1.69	-0.60	3.49	1.11	0.15	3.63	1.53	2.04*
43	ICSA 371 × IS 41720	59.33	0.66	-0.58	3.06	0.62	-0.01	2.63	-0.72	-0.39
44	ICSA 371 × IS 41397	62.00	1.54	-0.59	3.33	-2.01	0.47	3.13	1.42	0.05
45	ICSA 371 × IS 41675	61.44	0.75	0.20	3.19	-0.26	0.08	2.75	-1.66*	-0.45
46	ICSA 371 × IS 18758C-618-2	51.22	0.14	-0.38	3.89	-2.93	0.22	3.38	1.68	-0.23
47	ICSA 371 × IS 18758C-618-3	57.89	1.03	-0.44	4.24	-3.55*	-0.23	4.13	2.38	-0.34
48	ICSA 371 × IS 30469C-140-2	61.78	0.95	-0.53	2.46	0.43	0.02	2.63	-2.97*	-0.46
49	ICSA 371 × IS 30469C-1508-2	61.89	1.25	-0.59	2.90	1.51	0.51*	2.88	-3.67	-0.14
50	ICSA 371 × ICSV 96105	61.33	0.44*	-0.61	3.03	-2.87	-0.11	2.75	0.37	-0.35
51	ICSA 371 × ICSV 96094	59.22	1.24	-0.52	4.31	-5.37	0.61*	3.50	-1.07	-0.26
52	ICSA 371 × IS 84	60.67	1.33	-0.46	7.09	0.80	-0.07	6.88	-3.11	0.25
53	ICSA 371 × SPV 462	61.56	0.37	-0.57	3.20	-2.31	0.80*	2.75	3.07	1.30*
54	ICSA 371 × ICSR 89013	60.78	2.05*	-0.60	4.31	-1.99	-0.05	3.38	2.01	-0.28
55	ICSA 371 × ICSR 91011	59.44	-0.36	-0.55	2.54	0.21	-0.22	2.38	0.94	-0.41
56	ICSA 371 × ICSR 89018	58.67	0.01	-0.39	3.79	-2.98	0.06	3.88	-1.76	0.51
57	ICSA 371 × ICSR 89058	61.78	0.29	-0.38	2.83	-0.34	0.12	2.25	1.66	-0.45
58	ICSA 371 × PVK 801	61.00	1.53	-0.51	2.53	-1.96	-0.16	2.38	0.72	-0.39
59	ICSA 371 × GD 65028	62.89	1.46	-0.61	2.53	-0.01	0.72*	2.25	0.70	-0.11
60	ICSA 371 × GD 65055	63.78	0.30	-0.41	2.15	-0.13	-0.08	2.13	0.35	-0.38

	Parents/Hybrids	Days to 50% flowering Mean	b_i	s^2d_i	PGMR Mean	b_i	s^2d_i	TGMR Mean	b_i	s^2d_i
61	ICSA 371 × ICSR 92001	62.56	1.68	-0.51	2.76	-0.11	-0.15	3.50	7.49	0.12
62	ICSA 371 × ICSR 91019	63.11	-0.15	-0.40	3.19	2.21	0.22	3.63	1.53	2.04**
63	ICSA 371 × ICSR 91029	62.11	2.04	-0.27	3.54	1.95*	-0.23	3.00	-1.18	-0.02
64	ICSA 400 × IS 41720	61.89	1.03	-0.44	3.94	0.70	0.16	3.63	-0.72	-0.39
65	ICSA 400 × IS 41397	63.11	1.61	-0.61	4.86	2.66	0.01	5.50	1.52	0.19
66	ICSA 400 × IS 41675	63.00	0.44*	-0.61	2.89	-0.39	-0.13	2.63	-0.72	-0.39
67	ICSA 400 × IS 18758C-618-2	57.44	0.07	-0.56	5.35	3.68	0.03	7.00	-1.29	-0.28
68	ICSA 400 × IS 18758C-618-3	59.22	0.80	-0.54	5.98	6.29	1.36**	8.00	3.32	-0.39
69	ICSA 400 × IS 30469C-140-2	62.00	1.09	-0.53	3.50	4.28	0.44	4.13	-1.05	0.33
70	ICSA 400 × IS 30469C-1508-2	64.22	1.69	-0.60	3.50	0.15	-0.06	4.25	-3.69	-0.37
71	ICSA 400 × ICSV 96105	63.00	0.89	0.18	2.73	-1.46	0.08	3.13	-1.05	0.33
72	ICSA 400 × ICSV 96094	62.11	0.73	-0.61	4.38	-0.93	0.81*	4.25	-4.25	0.46
73	ICSA 400 × IS 84	60.78	1.17	-0.61	8.34	2.34	-0.22	8.63	-1.68	-0.23
74	ICSA 400 × SPV 462	63.56	1.24	-0.52	3.70	1.34	0.08	4.75	5.60	0.45
75	ICSA 400 × ICSR 89013	62.11	1.39	-0.52	6.13	4.35	0.08	6.63	0.57	-0.14
76	ICSA 400 × ICSR 91011	66.11	1.83	-0.50	2.91	2.40	-0.16	3.25	-0.70	-0.11
77	ICSA 400 × ICSR 89018	61.11	1.39	-0.52	4.68	1.28	0.00	4.88	0.72	-0.39
78	ICSA 400 × ICSR 89058	63.67	1.75	-0.29	3.30	1.17	-0.14	4.00	-3.10	-0.09
79	ICSA 400 × PVK 801	64.11	1.19	1.20	3.65	2.08	0.11	5.00	6.64	-0.17
80	ICSA 400 × GD 65028	67.44	0.73	-0.61	2.20	0.32	-0.07	2.13	0.35	-0.38
81	ICSA 400 × GD 65055	65.78	0.30	-0.41	2.30	1.51	-0.15	2.88	0.72	-0.39
82	ICSA 400 × ICSR 92001	69.00	1.53	-0.51	3.51	2.27	0.03	4.75	8.53	0.10
83	ICSA 400 × ICSR 91019	66.33	1.96	0.06	3.91	2.44	-0.08	5.38	4.26	-0.32
84	ICSA 400 × ICSR 91029	62.89	1.69	-0.60	5.54	4.83	0.47	6.50	-0.73	0.01
85	ICSA 384 × IS 41720	62.56	0.81	-0.58	4.41	1.67	0.35	4.00	0.45	0.52
86	ICSA 384 × IS 41397	61.33	0.01	-0.39	4.16	-1.23	0.11	4.50	1.69	0.67
87	ICSA 384 × IS 41675	61.56	0.37	-0.57	3.20	-0.51	0.50*	3.38	-1.42	0.05
88	ICSA 384 × IS 18758C-618-2	59.11	0.96	-0.58	5.70	1.02	1.22**	6.63	-2.35	1.16*
89	ICSA 384 × IS 18758C-618-3	58.89	-0.06	-0.11	6.41	3.97	3.38**	8.63	2.38	-0.34
90	ICSA 384 × IS 30469C-140-2	63.22	1.46	-0.61	4.41	5.31*	-0.15	6.00	-2.03	-0.38
91	ICSA 384 × IS 30469C-1508-2	64.11	0.95	-0.53	4.24	-0.20	0.88**	4.63	2.71	0.59

	Parents/Hybrids	Days to 50% flowering Mean	b_i	s^2d_i	PGMR Mean	b_i	s^2d_i	TGMR Mean	b_i	s^2d_i
92	ICSA 384 × ICSV 96105	62.44	1.17	-0.61	3.36	1.52	-0.08	3.38	-1.31	-0.44
93	ICSA 384 × ICSV 96094	59.11	0.96	-0.58	3.91	-2.28	-0.16	4.13	1.82	1.00*
94	ICSA 384 × IS 84	61.00	1.09	-0.53	7.64	0.87	-0.11	8.13	-0.72	-0.39
95	ICSA 384 × SPV 462	64.11	1.65	4.51**	3.93	4.93*	-0.23	5.00	3.32	-0.39
96	ICSA 384 × ICSR 89013	62.00	1.10	-0.58	5.43	6.23	0.14	6.38	-3.90	0.04
97	ICSA 384 × ICSR 91011	61.56	0.80	-0.54	2.83	1.71	-0.06	3.50	-1.07	-0.26
98	ICSA 384 × ICSR 89018	63.00	1.10	-0.58	4.03	4.25	-0.01	5.38	0.72	-0.39
99	ICSA 384 × ICSR 89058	63.00	1.54	-0.59	4.43	2.63	-0.02	6.63	-0.72	-0.39
100	ICSA 384 × PVK 801	65.22	1.91	-0.48	3.80	3.34	0.73*	5.75	7.01	-0.24
101	ICSA 384 × GD 65028	69.44	1.39	-0.59	1.93	1.13	-0.07	2.00	0.00*	-0.47
102	ICSA 384 × GD 65055	63.78	0.96	-0.58	2.09	0.92	-0.21	2.13	-0.72	-0.39
103	ICSA 384 × ICSR 92001	65.00	1.97	-0.49	4.70	3.42	8.06**	5.63	5.81	1.57*
104	ICSA 384 × ICSR 91019	66.00	1.32	-0.61	5.98	8.47	0.71*	7.38	6.18	-0.10
105	ICSA 384 × ICSR 91029	62.56	0.82	-0.18	5.55	5.93	0.15	6.75	-1.21	0.60
106	ICSA 382 × IS 41720	62.78	0.74	-0.43	4.16	3.15	0.30	4.25	1.55	0.07
107	ICSA 382 × IS 41397	61.44	0.29*	-0.61	4.99	1.69	0.80*	5.25	0.59	-0.36
108	ICSA 382 × IS 41675	65.89	2.56	-0.47	3.45	1.03	-0.05	4.38	1.45	0.29
109	ICSA 382 × IS 18758C-618-2	54.67	-0.21	-0.10	5.41	2.89	0.38	7.63	7.22	0.37
110	ICSA 382 × IS 18758C-618-3	60.22	-0.96*	-0.58	5.83	5.06	1.17**	7.75	1.66	-0.45
111	ICSA 382 × IS 30469C-140-2	62.67	1.75	-0.29	3.36	0.61	-0.05	3.50	1.29	-0.28
112	ICSA 382 × IS 30469C-1508-2	65.11	2.72	-0.31	4.11	0.99	-0.12	3.88	-3.78	0.07
113	ICSA 382 × ICSV 96105	62.67	1.33	0.14	3.15	-1.25	0.23	3.13	-3.08	0.26
114	ICSA 382 × ICSV 96094	60.56	0.80	-0.54	4.43	2.42	0.37	4.25	-1.66*	-0.45
115	ICSA 382 × IS 84	60.89	1.24	-0.52	7.83	1.47	0.14	7.75	0.93	0.12
116	ICSA 382 × SPV 462	64.44	2.24	2.55*	4.48	1.30	0.77*	4.63	5.70	-0.13
117	ICSA 382 × ICSR 89013	62.67	1.76*	-0.61	4.58	4.38	-0.10	5.50	0.96	-0.25
118	ICSA 382 × ICSR 91011	64.44	1.61	-0.61	3.16	-0.13	-0.09	3.00	-2.36	0.07
119	ICSA 382 × ICSR 89018	62.33	1.54	-0.59	4.74	0.54	0.34	4.88	-1.76	0.51
120	ICSA 382 × ICSR 89058	63.33	1.53	-0.51	3.78	0.99	0.00	5.13	7.95*	-0.31
121	ICSA 382 × PVK 801	64.11	1.63	0.11	3.63	3.06	0.17	4.75	4.98	-0.30
122	ICSA 382 × GD 65028	66.78	1.39	-0.52	2.21	0.40	-0.15	2.13	0.35	-0.38

		Days to 50% flowering			PGMR			TGMR		
	Parents/Hybrids	Mean	b_i	s^2d_i	Mean	b_i	s^2d_i	Mean	b_i	s^2d_i
123	ICSA 382 × GD 65055	66.22	1.24	-0.52	2.65	-0.44	0.30	2.38	1.05	0.33
124	ICSA 382 × ICSR 92001	66.78	1.39	-0.59	3.55	0.96	0.52*	4.63	5.70	-0.13
125	ICSA 382 × ICSR 91019	64.11	1.61	-0.61	4.30	3.88	0.55*	6.13	10.83	0.61
126	ICSA 382 × ICSR 91029	63.67	1.75	-0.29	4.70	2.83	0.26	5.25	3.58	0.16
127	ICSA 52 × IS 41720	64.11	2.49*	-0.60	4.69	4.77	1.46**	4.50	-5.13	0.27
128	ICSA 52 × IS 41397	64.78	2.93*	-0.59	6.14	2.27	1.14**	6.75	0.03	0.91
129	ICSA 52 × IS 41675	64.44	2.27*	-0.60	3.84	0.76	0.43	4.50	-0.73	0.01
130	ICSA 52 × IS 18758C-618-2	55.00	-0.22	-0.55	6.19	-0.78	0.06	7.63	2.38	-0.34
131	ICSA 52 × IS 18758C-618-3	60.22	1.46	-0.31	7.16	3.37	0.25	7.88	0.72	-0.39
132	ICSA 52 × IS 30469C-140-2	65.00	3.07*	-0.58	5.49	0.76	-0.13	6.00	2.25	-0.41
133	ICSA 52 × IS 30469C-1508-2	65.22	3.44*	-0.61	4.79	3.54	-0.15	5.00	-4.28*	-0.42
134	ICSA 52 × ICSV 96105	62.44	0.74	-0.43	2.93	-2.00	-0.01	3.00	0.96	-0.25
135	ICSA 52 × ICSV 96094	61.00	1.53	-0.51	5.06	-3.53	-0.02	4.50	-0.11	0.78
136	ICSA 52 × IS 84	60.00	1.54	-0.59	8.30	0.30	-0.16	9.00	0.00*	-0.47
137	ICSA 52 × SPV 462	64.22	1.69	-0.60	3.78	1.41	0.38	4.00	-1.07	-0.26
138	ICSA 52 × ICSR 89013	61.67	0.45	-0.42	5.76	3.43	0.09	5.88	-0.02	-0.12
139	ICSA 52 × ICSR 91011	63.22	1.46	-0.31	5.26	5.30	0.02	7.38	4.04	-0.25
140	ICSA 52 × ICSR 89018	63.00	1.32	-0.61	5.24	1.21	0.73*	6.38	6.80	0.84
141	ICSA 52 × ICSR 89058	63.67	2.42*	-0.61	4.60	4.74	0.22	6.00	0.22	-0.22
142	ICSA 52 × PVK 801	64.33	2.19	-0.26	4.34	3.78	-0.10	5.13	7.95*	-0.31
143	ICSA 52 × GD 65028	64.89	1.46	-0.61	2.36	-1.40	-0.17	2.63	2.60	-0.38
144	ICSA 52 × GD 65055	65.56	1.24	-0.52	2.83	0.12	1.28**	2.50	1.41	0.96*
145	ICSA 52 × ICSR 92001	66.56	0.80	-0.54	4.85	6.75	0.05	7.75	8.53	0.10
146	ICSA 52 × ICSR 91019	61.78	0.52	-0.57	5.33	1.52	0.02	6.38	3.70	0.10
147	ICSA 52 × ICSR 91029	63.33	1.54	-0.59	5.53	1.81	0.10	6.88	6.07	1.71**
148	ICSA 101 × IS 41720	62.56	1.69	-0.60	3.98	2.79	-0.02	4.00	-1.47	1.45*
149	ICSA 101 × IS 41397	64.00	1.09	-0.53	4.60	3.23	1.18**	5.50	-3.43	0.83
150	ICSA 101 × IS 41675	63.00	0.00*	-0.61	3.38	4.31	0.39	4.13	0.35	-0.38
151	ICSA 101 × IS 18758C-618-2	58.33	0.65	-0.06	6.26	6.31	0.16	8.38	1.79	0.00
152	ICSA 101 × IS 18758C-618-3	59.44	1.39	-0.59	6.05	3.06	-0.07	6.25	4.87	-0.26
153	ICSA 101 × IS 30469C-140-2	63.33	1.10	-0.58	4.44	3.88	-0.07	5.75	4.14	0.00

	Parents/Hybrids	Days to 50% flowering Mean	b_i	s^2d_i	PGMR Mean	b_i	s^2d_i	TGMR Mean	b_i	s^2d_i
154	ICSA 101 × IS 30469C-1508-2	66.78	2.27	-0.48	4.44	4.33	0.26	5.25	0.37	-0.35
155	ICSA 101 × ICSV 96105	59.67	-1.09*	-0.53	2.56	0.02	0.17	2.75	-0.37	-0.35
156	ICSA 101 × ICSV 96094	62.00	0.00*	-0.61	3.44	-0.85	-0.13	3.38	-0.35	-0.38
157	ICSA 101 × IS 84	61.00	0.01	-0.39	7.40	0.41	-0.03	7.38	2.24	-0.07
158	ICSA 101 × SPV 462	64.44	1.17	-0.61	3.44	1.43	0.07	5.00	8.33	3.85**
159	ICSA 101 × ICSR 89013	61.78	0.51	-0.54	5.51	5.57*	-0.21	7.00	0.00*	-0.47
160	ICSA 101 × ICSR 91011	64.22	1.24	-0.52	4.38	4.70	1.06**	5.38	-1.31	-0.44
161	ICSA 101 × ICSR 89018	62.89	1.03	-0.44	4.65	2.51	-0.02	5.75	3.69	-0.37
162	ICSA 101 × ICSR 89058	65.33	2.85	-0.46	3.00	1.19	-0.20	3.63	-1.79	0.00
163	ICSA 101 × PVK 801	65.00	1.75	-0.29	2.68	1.44	0.09	2.63	0.46	0.37
164	ICSA 101 × GD 65028	66.00	1.53	-0.51	2.53	0.17	-0.03	2.25	1.66	-0.45
165	ICSA 101 × GD 65055	65.11	0.52	-0.57	2.29	2.96	-0.11	2.63	-1.45	0.29
166	ICSA 101 × ICSR 92001	67.00	0.66	-0.58	4.81	6.72*	-0.12	5.88	0.94	-0.41
167	ICSA 101 × ICSR 91019	63.33	1.32	-0.61	6.13	5.90	0.10	6.75	-1.66*	-0.45
168	ICSA 101 × ICSR 91029	62.00	0.65	-0.06	4.21	5.72	0.29	5.50	-1.41	0.96*
	Checks									
1	Bulk Y	66.67	-0.21	-0.10	8.58	1.69	-0.22	9.00	0.00*	-0.47
2	IS 25017	78.00	0.21	-0.10	1.95	-0.38*	-0.23	2.00	0.00*	-0.47
3	IS 20	75.78	-0.14	-0.38	5.03	9.91	5.09**	5.63	-7.42	5.25*
4	IS 14384	72.44	-0.14	-0.38	1.10	0.18	-0.18	1.00	0.00*	-0.47
5	PVK 801	67.89	-0.07	-0.56	4.64	-4.21	0.45	5.00	7.49	0.12
6	CSH 16	63.33	0.43	-0.37	6.88	-2.86	0.27	7.13	6.77	0.36
	S.E of b_i		0.23			2.18			2.51	

For days to 50% flowering, the linear component of G × E interaction was found to be significant. Among the lines, 7 lines *i.e*. ICSA 369 (59.56 days), ICSA 370 (60.22 days), ICSA 371 (60.11 days), ICSA 400 (66.56 days), ICSA 384 (61.78 days), ICSA 382 (66.56 days) and ICSA 101 (65.33 days) possessed average stability and performance of these parents does not change with the change in environments. One line ICSA 52 (63.56 days) was adapted to poor environments. Among testers, 19 were stable across environments. The remaining 2 testers IS 30469C-140-2 (64.56 days) and ICSV 96094 (60.44 days) were adaptable to poor environments. Among the stable hybrids, 6 hybrids *i.e*. ICSA 371 × IS 18758C-618-2 (51.22 days), ICSA 369 × IS 18758C-618-2 (53.33 days), ICSA 370 × IS 18758-618-2 (53.89 days), ICSA 382 × IS 18758C-618-2 (54.67 days), ICSA 52 × IS 18758C-618-2 (55.00 days) and ICSA 369 × IS 18758C-618-3 (55.22 days) recorded early flowering duration compared to check CSH 16 (63.33 days) whose performance does not change with the change in environments and concluded that there was a predictable response for flowering and early vigor. Three hybrids *i.e*. ICSA 369 × ICSR 89103 (60.33 days), ICSA 371 × ICSR 89013 (60.78 days) and ICSA 382 × ICSR 89013 (62.67 days) recorded lower flowering duration than the check (CSH-16), had lower than average stability and are adaptable to favorable environments. Eight hybrids *i.e*. ICSA 370 × ICSR 89018 (59.00 days), ICSA 369 × IS 30469C-140-2 (59.56 days), ICSA 101 × ICSV 96105 (59.67 days), ICSA 371 × ICSV 96105 (61.33 days), ICSA 382 × IS 41397 (61.44 days), ICSA 101 × ICSV 96094 (62.00 days), ICSA 400 × IS 41675 (63.00 days) and ICSA 101 × IS 41675 (63.00 days) recorded lower flowering duration than check CSH-16 (63.33), possessed more than average stability and are adaptable to poor environments.

CONCLUSION

Identification of stable grain mold resistant hybrids in sorghum is very essential for *kharif* sorghum grown areas. Among the lines, 3 resistant lines *i.e*. ICSA 369 (2.49), ICSA 370 (2.84), ICSA 371 (2.93) registered unit b_i values and these are widely adaptable. Among the testers, 15 were having stable performance across the environments. Out of 15 testers, 3 testers recorded lower PGMR scores *i.e*. GD 65028 (2.56), ICSV 96105 (2.33) and ICSV 96094 (3.04). These parents may be helpful in making grain mold resistant hybrids. Among 168 hybrids, 46 hybrids exhibited stable performance across environments in which top 5 hybrids *i.e*., ICSA 384 × GD 65028, ICSA 370 × GD 65028, ICSA 384 × GD 65055, ICSA 369 × GD 65028 and ICSA 370 × GD 65055 with low PGMR scores. Two hybrids *i.e*., ICSA 369 × GD 65055 and ICSA 369 × ICSR 89058 with low PGMR and suitable to unfavorable environments. These hybrids are highly useful to obtain good yields under disease prone areas.

ACKNOWLEDGEMENTS

We gratefully acknowledge the assistance of the sorghum unit at ICRISAT.

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