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COMBINING ABILITY FOR GRAIN MOLD RESISTANCE AND THE ASSOCIATED PARAMETERS IN F_1 AND F_2 GENERATIONS OF *KHARIF* SORGHUM

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Abstract

The estimates of *gca* effects revealed that among the ten parents, five parents *viz*., IS 14384, GMPR 65, IS 14332, GM 9219 and SVD 9601 appeared to be worthy of further exploitation in recombination breeding programme for grain mold resistance breeding because of the desirable and significant *gca* effects for germination percentage along with some other components in both F_1 and F_2 generations. Among the 45 cross combinations, the twelve crosses showed desirable and significant *sca* effects for germination percentage along with some of the component traits associated with grain mold resistance. Non additive type of gene action was noticed for almost all the characters in both F_1 and F_2 generations.

Key words : Combining ability, *gca*, germination, grain mold, *sca*.

Introduction

Knowledge of combining ability is necessary in selection of appropriate parents in for hybridization. Since it gives an idea whether a particular parent combines well in a cross and also denotes specific performance of a cross combination against the expectations from the general combining ability of parents. Study of grain mold is important in *kharif* sorghum because grain mold is one of the most important biotic stresses affecting the grain yield as well as the grain quality of *kharif* sorghum. The present investigation was undertaken to identify the potential parental lines as well as the superior cross combinations showing good combining ability for the parameters associated with grain mold resistance in kharif sorghum.

Materials and Methods

The experimental material consisted of ten parents (SVD 9601, GM 9219, IS 14332, AKMS 14 B, IMS 9 B, MS 296 B, ICS 70 B, MS 27 B, IS 14384 and GMPR 65) the forty five F_1 crosses developed by crossing these ten parents in half-diallel (excluding reciprocals) fashion and forty five F_2 progenies obtained by selfing of these forty five F_1 crosses. The experiment was conducted during *kharif* 2007-08 at the Sorghum Research Unit, Dr. P.D.K.V., Akola (M.S.), India. The experiment was laid out in randomized block design with spacing of 45x15 cm. in three replications. Five spore inoculated plants were randomly selected from each entry in each replication for recording the observations and the observations were days to 50% flowering, grain yield (g), glume coverage (%), 100 seed weight (g), seed hardness (kg/cm^2), grain density (g/ml), water absorption capacity (g), electrical conductivity of grain leachates (ms/ppt), germination (%), fungal load of *Fusarium moniliforme* (%), fungal load of *Curvularia lunata* (%) and fungal load of other species (%). In case of F_2 progenies, all the observations as in F_1 crosses except fungal load of *Fusarium moniliforme* (%), fungal load of *Curvularia lunata* (%) and fungal load of other species (%) were recorded on the fifteen spore inoculated plants. Combining ability analysis was done using method II, model I of Griffing (1956 b).

Results and Discussion

Combining ability analysis was carried out for 12 characters in F_1 crosses and 9 characters in F_2 progenies. The variance existing due to treatments was further

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Table 1: Analysis of variance for combining ability of F_1 and F_2 crosses.

Source of variation	DF	Generation	Mean squares											
			DTF	**GY**	**GC**	**HSW**	**SH**	**GD**	**WAC**	**EC**	**GP**	**FL-F**	**FL-C**	**FL-O**
GCA	**9**	F_1	45.54**	391.99**	198.54**	0.32**	5.81**	0.01**	0.03**	0.50**	201.53**	112.89**	96.001**	71.08**
	9	F_2	35.70**	36.27**	168.84**	0.48**	2.95**	0.006**	0.07**	0.26**	135.67**	-	-	
SCA	**45**	F_1	17.04**	125.28**	99.34**	0.16**	0.69**	0.01**	0.03**	0.09**	41.39**	36.36**	30.94**	39.56**
	45	F_2	25.03**	38.67**	108.30**	0.07**	0.29**	0.003**	0.03**	0.03**	22.63**	-	-	-
Error	**108**	F_1	2.96	2.61	1.02	0.02	0.03	0.0001	0.0001	0.0001	1.36	0.04	0.05	0.45
	108	F_2	5.18	11.67	1.37	0.01	0.05	0.0001	0.0001	0.0002	0.97	-	-	-
σ^2 ***gca***		F_1	3.30	32.45	16.46	0.03	0.48	0.0001	0.003	0.04	16.68	9.40	8.00	5.89
		F_2	2.54	2.05	13.96	0.04	0.24	0.0001	0.01	0.02	11.23	-	-	-
σ^2 ***sca***		F_1	14.08	122.67	98.32	0.14	0.66	0.01	0.03	0.09	40.03	36.32	30.89	39.11
		F_2	19.85	27.0	106.93	0.06	0.24	0.003	0.03	0.003	21.66	-	-	-
σ^2 ***gca/***		F_1	0.23	0.26	0.17	0.18	0.73	0.10	0.10	0.49	0.42	0.26	0.26	0.15
σ^2 ***sca***		F_2	0.13	0.08	0.13	0.69	1.004	0.19	0.21	0.64	0.52	-	-	-

*, ** = Significant at 5% and 1% levels, respectively.

DF-Degrees of freedom, DTF-Days to 50 % flowering, GY- Grain yield (g), GC-Glume colour, HSW- 100 Seed weight, SH- seed hardness(kg/cm^2), GD-Gain density(g/ml), WAC-Water absorption capacity (g), EC- Electrical conductivity of grain leachates (ms/ ppt), GP-Germination(%), FL-F-Fungal load of *Fusarium moniliforme* (%), FL-C-Fungal load of *Curvularia lunata* (%), FL-O-Fungal load of other species (%).

partitioned using appropriate expectations of the observed mean squares into components of variations attributable to general combining ability (*gca*) variance and specific combining ability (*sca*) variance (table 1).

Denis and Girad (1977) reported loss in viability to be very important part of the grain mold syndrome and recommended the germination test as part of the standard evaluation for identification of grain mold resistance. Accordingly, in this study also the superior parental lines (table 2) and the superior parental combinations (table 3) having significantly high general and specific combining ability effects respectively for germination percentage and its component traits have been identified.

It was observed form table 2 that none of the parents proved to be the best general combiner for all the traits under study. However, the parent IS 14384 was found to possess desirable *gca* for nine characters out of the twelve characters observed in F_1 and five out of nine characters studied in F_2 diallel progenies. Parent IS 14384 transmitted genes for minimum days to 50 per cent flowering, higher grain yield, higher 100 seed weight, higher grain density, lower water absorption capacity, lower electrical conductivity of grain leachates, higher germination percentage, minimum fungal load of *Fusarium moniliforme*, fungal load of *Curvularia lunata* and fungal load of other species in F_1 generation while in F_2 generation, it transmitted minimum days to 50 per cent flowering, higher 100 seed weight, lower water absorption capacity, lower electrical conductivity of grain leachates and higher germination percentage.

Besides IS 14384, other parents *viz.*, GMPR 65, IS 14332, GM 9219 and SVD 9601 also exhibited significant gca effects in desirable direction for germination percentage along with some of the component characters both in F_1 and F_2 generations.

Since high general combining ability effects corresponds with additive and additive × additive interaction (Griffing, 1956

Table 2 : Estimates of general combining ability effects of parents from F_1 crosses.

Characters →	Generation	DTF	GY	GC	HSW	SH	GD	WAC	EC	GP	FL-F	FL-C	FL-O
Parents ↓													
SVD 9601	F_1	0.38	-0.99*	-2.92**	0.10*	1.13**	-0.04**	-0.02**	-0.14**	2.72**	0.73**	1.85**	5.23**
	F_2	0.02	-0.56	0.31	0.11**	0.84**	-0.03**	0.17**	-0.08**	3.08**			
GM 9219	F_1	2.16**	1.70**	-0.79**	0.18**	0.73**	-0.002	0.03**	-0.24**	3.93**	-1.19**	0.47**	0.06
	F_2	3.86**	-0.56	5.20**	0.14**	0.68**	-0.03**	-0.03**	-0.16**	4.32**			
IS 14332	F_1	0.40	-8.07**	-4.72**	-0.26**	0.41**	-0.04**	-0.09**	-0.27**	5.83**	-5.79**	-4.64**	-0.78**
	F_2	-1.09	2.39*	6.21**	-0.33**	0.08	-0.03**	-0.06**	-0.15**	3.08**			
14 B	F_1	-3.80**	-7.99**	-4.73**	0.04	-0.54**	-0.01**	-0.01**	-0.05**	-2.93**	2.35**	2.12**	1.79**
	F_2	-1.98**	-3.93**	-4.12**	-0.23**	-0.53**	-0.001	-0.10**	0.07**	-2.43**			
9 B	F_1	1.90**	-2.79**	3.46**	-0.10*	-0.18**	0.02**	0.01**	0.15**	-2.46**	3.33**	0.90**	1.47**
	F_2	1.63*	0.82	-2.43**	-0.13**	-0.34**	0.02**	0.04**	0.10**	-4.78**			
296 B	F_1	1.65**	0.71	1.82**	-0.28**	-1.10**	0.01**	0.01**	0.42**	-6.24**	2.06**	0.22**	0.05
	F_2	0.72	0.72	-2.46**	-0.20**	-0.58**	0.004	0.02**	0.32**	-3.73**			
70 B	F_1	0.23	-2.83**	1.80**	-0.02	-0.83**	0.01*	-0.01**	0.11**	-3.77**	2.83**	2.39**	-1.30**
	F_2	-0.92	0.67	-3.70**	0.20**	-0.18**	0.01**	0.04**	0.04**	-1.66**			
27 B	F_1	-2.05**	4.42**	5.95**	0.10*	0.04	0.02**	-0.06**	-0.05**	2.55**	-3.25**	-4.23**	-2.78**
	F_2	0.05	-1.39	0.06	0.06	-0.32**	0.04**	-0.03**	0.04**	-2.61**			
IS 14384	F_1	0.45	7.87**	4.61**	0.16**	0.37**	0.04**	0.04**	-0.01**	3.34**	-2.67**	-2.50**	-3.21**
	F_2	-1.42*	1.21	3.46**	0.16**	-0.06	0.001	-0.02**	-0.13**	1.80**			
GMPR 65	F_1	0.47	0.44	0.28	0.04	0.04	0.003	0.001	0.003	0.32	0.05	0.06	0.18
	F_2	-0.87	0.64	-2.54**	0.21**	0.41**	0.02**	-0.03**	-0.05**	2.94**			
SE (m) (gi)	F_1	0.93	0.88	0.55	0.08	0.09	0.01	0.003	0.01	0.63	0.11	0.12	0.36
	F_2	0.62	0.94	0.32	0.03	0.06	0.003	0.003	0.003	0.27			
CD 5% (gi)	F_1	0.93	0.88	0.55	0.08	0.09	0.01	0.003	0.01	0.63	0.11	0.12	0.36
	F_2	1.24	1.86	0.64	0.06	0.12	0.01	0.01	0.01	0.53			

Table 2 continued....

Table 2 continued....

CD 1% (gi)	F_1	1.24	1.16	0.73	0.11	0.12	0.01	0.004	0.01	0.84	0.14	0.15	0.48
	F_2	1.64	2.46	0.84	0.08	0.16	0.007	0.007	0.01	0.71			
SE (m) (gi-gj)	F_1	0.70	0.66	0.41	0.06	0.07	0.004	0.002	0.004	0.48	0.08	0.09	0.27
	F_2	0.93	1.40	0.48	0.04	0.09	0.004	0.004	0.01	0.40			
CD 5 % (gi-gj)	F_1	1.39	1.31	0.82	0.12	0.13	0.07	0.004	0.01	0.94	0.16	0.17	0.54
	F_2	1.84	2.77	0.95	0.09	0.18	0.01	0.01	0.01	0.80			
CD 1 % (gi-gj)	F_1	1.84	1.73	1.08	0.16	0.17	0.01	0.01	0.01	1.25	0.21	0.23	0.72
	F_2	2.44	3.66	1.25	0.12	0.23	0.01	0.01	0.01	1.05			

+ = Significant and desirable general combining ability estimates, - = Nonsignificant or undesirable general combining ability estimates.
DF-Degrees of freedom, DTF-Days to 50 % flowering, GY- Grain yield (g), GC-Glume colour, HSW- 100 Seed weight, SH- seed hardness (kg/cm^2), GD-Gain density (g/ml), WAC-Water absorption capacity (g), EC- Electrical conductivity of grain leachates (ms/ ppt), GP-Germination(%), FL-F-Fungal load of *Fusarium moniliforme* (%), FL-C-Fungal load of *Curvularia lunata* (%), FL-O-Fungal load of other species (%).

b) and represents the fixable genetic component of variation, the above mentioned five parents *viz.*, IS 14384 ,GMPR 65, IS 14332, GM 9219 and SVD 9601 appeared to be worthy of further exploitation in recombination breeding programme for grain mold resistance breeding.

Among the 45 cross combinations studied, twelve crosses exhibited significant desirable *sca* effects in both F_1 and F_2 diallel set for germination percentage. Highest significant desirable *sca* effects for germination percentage in both F_1 and F_2 generations *i.e.* 10.24** and 7.76** respectively was observed in the cross SVD 9601 × 296 B. This cross also exhibited significant desirable *sca* effects for three component characters in F1 diallel crosses *i.e.* seed hardness, water absorption capacity and fungal load of other mold fungi. The same cross also recorded significant desirable *sca* effects for seed hardness, grain density and electrical conductivity in F_2 diallel progenies. The second cross 9 B × GMPR 65 recorded significant desirable *sca* effects for germination percentage in both F_1 (8.60**) and F_2 (1.07*) generations. This cross also exhibited significant desirable *sca* effects for grain yield, 100 seed weight, seed hardness, grain density, fungal load of *Fusarium moniliforme* and *Curvularia lunata* in F_1 diallel crosses and for glume coverage percentage and grain density in F_2 diallel progenies. The third cross SVD 9601 × IS 14384 exhibited significant desirable *sca* effects for germination percentage in both F_1 (6.98**) and F_2 (1.75*) diallel sets. It also recorded significant desirable *sca* effects for glume coverage, seed hardness, water absorption capacity, electrical conductivity, fungal load of *Fusarium moniliforme* and fungal load of other species in F_1 diallel crosses whereas in F_2 generation it recorded significant and desirable *sca* effects for two component characters *i.e.* glume coverage and electrical conductivity. The remaining nine crosses in table 3 also exhibited significant *sca* effects for germination percentage in both F_1 and F_2 diallel sets. These crosses also showed significant *sca* effects for some of the important component characters associated with grain mold resistance in both F_1 and F_2 diallel sets. These crosses were 9 B × GMPR 65, SVD 9601 × IS 14384, 14 B × 9 B, GM 9219 × 70B, 70 B × GMPR 65, IS 14332 × 296 B, IS 14332 × 27 B, IS 14384 × GMPR 65, 14 B × 70 B, SVD 9601 × GMPR 65 and SVD 9601 × 70 B.

Thus, it could be concluded that the above mentioned twelve crosses were found to be most desirable since these crosses had significant positive *sca* effects for germination percentage in both F_1 and F_2 diallel sets. Similarly these crosses also exhibited desirable and significant *sca* effects for some of the characters

Table 3 : Superior combinations showing significant *sca* effects for germination percentage along with desirable *sca* effects for various components.

S.no.	Desirable crosses for germination % on the basis of *sca* effects of F_1 crosses	*Sca* estimates for germination % in F_1 crosses	*Sca* estimates for germination % in F_2 progenies	Significant *sca* effects for component characters in F_1 crosses	Significant *sca* effects for component characters in F_2 progenies
1	SVD 9601 × 296 B	10.24**	7.76**	Seed hardness, water absorption capacity, fungal load of other species	Seed hardness, grain density, electrical conductivity
2	9 B × GMPR 65	8.60**	1.07*	Grain yield , 100 seed weight, seed hardness, grain density, fungal load of *Fusarium moniliforme* ,fungal load of *Curvularia lunata*	Glume coverage, grain density
3	SVD 9601 × IS 14384	6.98**	1.75*	Glume coverage , seed hardness, water absorption capacity, electrical conductivity, fungal load of *Fusarium moniliforme* , fungal load of other species	Glume coverage, electrical conductivity
4	14 B × 9 B	6.94**	5.15**	Grain yield , seed hardness, water absorption capacity, electrical conductivity, fungal load of *Fusarium moniliforme* , fungal load	Days to 50 % flowering, glume coverage, of other species 100 seed weight, water absorption capacity, electrical conductivity
5	GM 9219 × 70 B	6.49**	1.43*	Grain yield , seed hardness, electrical conductivity, fungal load of *Fusarium moniliforme*	Glume coverage, seed hardness, grain density, water absorption capacity, electrical conductivity
6	70 B × GMPR 65	5.66**	0.93*	Grain yield , glume coverage , seed hardness, grain density, electrical conductivity, fungal load of *Fusarium moniliforme* , fungal load of other species	Glume coverage, 100 seed weight, water absorption capacity, electrical conductivity
7	IS 14332 × 296 B	5.65**	3.00**	100 seed weight, electrical conductivity, fungal load of *Fusarium moniliforme*	Grain density, electrical conductivity
8	IS 14332 × 27 B	5.46**	7.06**	Glume coverage , 100 seed weight, water absorption capacity, electrical conductivity, fungal load of *Fusarium moniliforme*, fungal load of *Curvularia lunata*, fungal load of other species	Grain density, electrical conductivity
9	IS 14384 × GMPR 65	4.72**	5.69**	Grain yield , glume coverage , 100 seed weight, seed hardness, grain density, electrical conductivity, fungal load of *Fusarium moniliforme*	Seed hardness, electrical conductivity
10	14 B × 70 B	4.51**	1.52*	Days to 50% flowering, grain yield , 100 seed weight, grain density, water absorption capacity, electrical conductivity, fungal load of *Fusarium moniliforme* ,fungal load of *Curvularia lunata*, fungal load of other species	Water absorption capacity
11	SVD 9601 × GMPR 65	4.24**	2.93**	Glume coverage , 100 seed weight, grain density, water absorption capacity, electrical conductivity, germination, fungal load of *Fusarium moniliforme*	Glume coverage, water absorption capacity, electrical conductivity
12	SVD 9601 × 70 B	2.76*	4.59**	Glume coverage , seed hardness, water absorption capacity, fungal load of *Fusarium moniliforme* ,fungal load of *Curvularia lunata*	Glume coverage, electrical conductivity

*, ** = Significant at 5% and 1% levels, respectively

associated with grain mold resistance both in F_1 and F_2 generations.

The general and specific combining ability variances for the traits studied indicated the gene action associated with them. From the plant breeding point of view, knowledge of type of gene action involved is useful in the choice of the most appropriate breeding procedure. Broadly general combining ability variances indicate additive gene action and additive x additive interaction effects, while specific combining ability effects corresponds with non-additive gene action like dominance and other epistatic interaction *viz.,* additive × dominance and dominance × dominance (Griffing, 1956a). It was found in the present study that in F_1 generation non-additive type of gene action was observed for all the twelve characters while in F_2 generation non additive type of gene action was noticed for all the characters except for seed hardness for which additive as well as non additive type of gene action was found. Thus improvement for grain mold and its associated traits would be possible by the heterosis breeding.

When the performance of all the desirable cross combinations was reviewed, it was fond that these crosses involved parents having all three possible combinations of *gca* effects *i.e.* high × high, high × low and low × low. It was also observed that two parents with high *gca* effects may not necessarily give superior cross combination. But, highly superior cross combinations had involved at least one parent of high *gca* effects. Thus in the development of superior cross combination for grain mold resistance, at least one parent should be having high gca effects for germination percentage. Similar suggestion was also given by Ravindrababu *et al.* (2001) for the character grain yield in sorghum. However, Hariprasanna *et al.* (2012) reported that for grain yield some of the crosses with positive significant *sca* for grain yield involved even low × low combinations of parents. Wadikar and Jagtap (2010) reported highest *sca* for germination percentage among all the characters studied.

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