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GENETIC STUDIES OF DROUGHT TOLERANCE TRAITS IN POST RAINY SEASON SORGHUM (*SORGHUM BICOLOR* (L.) MOENCH)

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ABSTRACT

The present investigation was undertaken to estimate the nature and magnitude of gene action involved in controlling the traits imparting drought tolerant in post rainy season sorghum The investigation comprised of six generations (P_1, P_2, F_1, F_2, B_1 and B_2) of the cross RSV1098 x RSV458 for the traits associated with drought tolerant. The joint scaling test for almost all the characters was found highly significant in all the crosses, indicating inadequacy of additive-dominance model and presence of higher order interactions. The dominance (h) gene effects were found predominant along with dominance x dominance (l) interaction effects in the inheritance of traits *viz.,* length of panical, harvest index, total above ground dry matter and grain yield. The parent RSV1098 was found superior in contributing traits *viz.,* , length of panicle, harvest index, total above ground dry matter and grain yield per plant. Duplicate type of epistasis observed for almost all the traits associated with drought tolerant.

Keywords: drought, generation mean analysis, *rabi* sorghum, epistasis, additive-dominance model

INTRODUCTION

In India, sorghum grown under stored soil moisture during *rabi* season experiences terminal drought. Thus, water stress is a major constraint limiting sorghum crop growth and reducing its productivity under dry land conditions. Sorghum has the reputation of 'crop camel' being one of the most drought tolerant crop and it has broad genetic diversity such that the genotype differ in their reaction to escape, avoidance, and tolerance mechanisms of drought. In sorghum, grain yields are generally affected mainly due to terminal drought situation occurring during post rainy season. In Maharashtra grain sorghum is grown in both *kharif* and *rabi* seasons. The low yield of *rabi* sorghum in Maharashtra as compared to national and world average is mainly because of its cultivation under stored residual soil moisture conditions in marginal soils. The *rabi* sorghum is normally grown under stored and receding soil moisture conditions with increasing temperature after flowering. Thus, it experiences both soil and atmospheric water deficit (drought). The limited availability of water causes moisture stress, which affects various metabolic processes of the plant.

Drought is one of the major abiotic factors which result in low productivity of sorghum. Production of sorghum in semi-arid region of the world is limited by drought. Developing plant type has an advantage under water limited conditions are major challenge of sorghum improvement programme. Results from breeding programme in USA and Austrailia (Henzell *et. al.*, 1992) suggested that advances in crop improvement under water stress condition are more likely, if drought resistance traits are selected. The physiological processes in the plant are affected due to the soil moisture stress and thereby resulting in plant growth mainly due to the development of high osmotic pressure in the root and shoot. Therefore, genetic improvement programme must be concentrated on combining high yield with resistance to stresses. Drought tolerance in *rabi* sorghum, is considered to be the product expression of many physiological and morphological traits. Hence, to know the genetics of traits related with drought tolerance is the necessity of plant breeders, which helps in the selection of parents in hybridization programme and apply the appropriate breeding procedure. Attempt was made during present investigation to assess the nature and magnitude of gene action with respect to the traits imparting drought tolerant.

MATERIALS AND METHODS

The investigation was conducted at All India Co-ordinated Sorghum Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, The parents RSV1098 (Phule Suchitra) and RSV458 (Phule Anuradha), obtained from Senior Sorghum Breeder, MPKV, Rahuri for generating six generations (P_1, P_2, F_1, F_2, B_1 and B_2) affected by hand emasculation and pollination to study the genetics of traits imparting drought tolerance. For raising parents during *rabi,* 2010-11 generating F_1 and selfing of F_1 generation and back crosses were affected to obtain enough self seed during *rabi,* 2011-12 and final evolutionary trial of six generations (P_1, P_2, F_1, F_2, B_1 & B_2) were conducted during *rabi,* 2012-13. The sowing of P_1, P_2 and F_1 generations were done in a single row of 4.5m length with a spacing of 45 x 15 cm, whereas the sowing of F_2, B_1 and B_2 were done in plot size of 4.5 x 3.6 m. accommodating 30 plants in each row. The recommended doses of fertilizers were applied @ 30 kg N ha-^{1} and 40 kg P_2O_5 ha^{-1} as a basal dose, at the time of sowing and remaining half 30 kg N ha^{-1} were applied after 30 days of sowing.

Data collected for different characters were subjected to joint scaling test as outlined by Mather (1949) and Cavalli (1952).To provide information on the nature of gene action governing the traits under study, all the six parameters of generation means were calculated by the method outlined by Hayman (1958).

RESULTS AND DISCUSSION

On the basis of results obtained from the present investigations the parent RSV1098 and RSV458 are found to be most promising and may be considered in developing drought tolerant genotype in breeding programme. Analysis of variance indicated that all the characters associated with drought tolerance *viz.*, length of panical, harvest index, total above ground dry matter and grain yield exhibited highly significant difference, among the genotypes, indicated the considerable amount of variability in the experimental material. The scaling test all or either 'A', 'B', 'C' and 'D' were highly significant, indicated the presence of all three types of non-allelic gene interaction effects *viz.,* additive x additive (i), additive x dominance (j) and dominance x dominance (l) and provided information about all six genetic parameters *viz.,* m, d, h, i, j and l. Further joint scaling test also resulted into high chi-square values for most of the characters, indicating inadequacy of additive-dominance model. Gene action for the traits *viz.*, length of panical, harvest index, total above ground dry matter and grain yield associated with drought tolerance is given as below.

Length of panicle (cm) :

The mean values for length of panicle in parents were ranged from 27.17 cm (RSV458) to 29.97cm (RSV1098). Among the different generations of cross RSV1098 x RSV458, F_1 (30.45 cm) displayed maximum length of panicle followed by F_2 (29.34 cm) and B_2 (29.22cm), whereas the minimum length of panicle was recorded in B_1 (28.13 cm). (Tasble.1)

From the estimates of genetic parameter, dominance 'h' (-0.78) component and additive'd' (-1.09) component was negatively significant with higher magnitude in the cross RSV1098 x RSV458 for governing the trait length of panicle. Among the digenic interaction, additive x additive 'i' (-2.66) and additive x dominance 'j' (-2.49) component were negatively significant, while dominance x dominance 'l' (6.00) component was positively significant with higher magnitude in comparison with 'i' and 'j' component. The additive x dominance (j) component was negligible in cross RSV1098 x RSV458. The genetic parameter 'h' and 'l' recorded opposite sign with duplicate type epistasis (Table.3).

Significance of scaling tests 'A' and 'B' indicated inadequacy of additive-dominance model in the cross RSV1098 x RSV458, was observed by Premlatha *et al.* (2006) and Khot (2008). The relative magnitude of additive (d) gene action was found to be predominant than dominance (h) component in the inheritance of the character length of panicle. The parent RSV1098 (P_1) showed superior performance than parent RSV458 (P_2) in contribution of this trait. For this character also additive (d) and dominance x dominance (l) gene effects were predominant and important for the inheritance with duplicate gene action, suggested that simple selection method would be rewarded for the improvement of this trait. These findings are in accordance with the earlier findings of Dhole (2004) and Lad (2009).

Harvest index (%):

For the character harvest index (%) the estimate of genetic parameter, additive component 'd' (-0.10) and dominance 'h' (-10.79) components was negatively significant with higher magnitude than additive component (d) in the cross RSV1098 x RSV458. The interaction component additive x additive 'i' (-14.84) and additive x dominance 'j' (-1.31) were negatively significant, while dominance x dominance 'l' (29.10) component was positively significant with higher magnitude in comparison with additive x additive (i) and additive x dominance (j) components. The dominance (h) and dominance x dominance (l) component had negative and positive sign respectively, with duplicate epistasis (Table.3).

The harvest index of the parent RSV458 and RSV1098 was 30.21 and 32.63 % respectively. Among all the different generation F_1 (35.47%) recorded highest harvest index followed by F_2 (33.59%) (Table.1). In the cross RSV1098 x RSV458, the relative magnitude of dominance (h)component was observed greater and desirable in magnitude than additive (d) component, indicated preponderance of dominant (h) gene action and played an important role in the inheritance of harvest index for drought tolerance. Among the epistatis gene interaction significantly positive and magnitudinally higher interaction effects dominance x dominance (l) was observed for this traits. From the estimates of genetic parameter, it was evident that dominance (h) and dominance x dominance (l) gene effects, were predominant and important in the inheritance of this trait, with duplicate type of epistasis and suggested that heterosis breeding would be more effective in the improvement of harvest index. These results are in conformity with the earlier findings of Salunke *et al.* (2003), Dhole (2004), Khot (2008) and Lad (2009) .

Total above ground dry matter (g/plant):

In cross RSV1098 x RSV458 the estimates of genetic component, additive'd' (-1.43) and dominance 'h' (-20.45) were negatively significant. The dominance (h) component had higher magnitude in negative direction in comparison with additive (d) component, for total above ground dry matter, while considering the interaction component in this cross, additive x additive 'i' (-26.98) and additive x dominance 'j' (-7.73) components were negatively significant, whereas additive x additive (i) component exhibited higher magnitude than the additive x dominance (j) components. The interaction component dominance x dominance 'l' (71.35) was positively significant with higher magnitude in comparison with additive x additive (i) and additive x additive (j) components. The genetic component dominance (h) and dominance x dominance (l) recorded opposite sign with duplicate epistasis (Table.3).

The parent RSV1098 (192.96g.) exhibited highest total above ground dry matter and among the different generation F_1 (193.18g.) recorded highest total above ground dry matter. Dominance (h) gene action appeared to be predominant and negatively significant in desirable direction than additive (d) component for inheritance of total above ground dry matter in cross RSV1098 x RSV458. However, among the digenic interaction, dominant x dominant (i) interaction component was magnitudinally much higher and significantly positive, indicating its predominance role in the expression of this trait, whereas significantly negative, higher magnitude additive x additive (i) and significantly negative lower magnitude additive x dominance (j) interaction effects, indicated the presence of all three non-allelic interaction effects. It was evident from the digenic interaction that, dominance (h) and dominance x dominance (l) gene effects had opposite sign, indicated the role of epistasis and predominant gene action in governing this trait, and suggested that heterosis breeding could be exploited in the improvement of trait total above ground dry matter. The earlier findings of Rajguru *et al.* (2004), Bichkar (2005) and Lad (2009) were in agreement with the present findings.

Grain yield per plant:

The mean values for grain yield per plant were ranged from 50.61 (RSV458) to 70.64 g (RSV1098) in cross combination RSV1098 x RSV458. The F_1 (68.53g) generation derived from cross RSV1098 x RSV458 recorded highest grain yield per plant, followed by F_2 (65.93g) and B_2 (62.11g) whereas the lowest grain yield per plant was recorded in B_1 (53.77g) (Table.1). From the estimates of genetic parameter additive'd' (-8.34) and dominance 'h' (-24.05) component were negatively significant in which dominance (h) component was higher in magnitude in the cross RSV1098 x RSV458 for the inheritance of grain yield per plant. The estimates of digenic interaction revealed that additive x additive 'i' (-24.05) component and additive x dominance 'j (-31.96)' was negatively significant, while dominance x dominance (l) (58.51) component were positively significant. Among the digenic interaction the dominance x dominance (l) component had higher magnitude in positive direction in comparison with additive x additive (i) and additive x dominance (j) components.

Significance of scaling tests 'A' and 'B', indicated inadequacy of additive-dominance model in the cross. Significantly negative additive (d) and dominance (h) components with higher magnitude of dominance (h) component than additive (d) component indicated the preponderance of dominance (h) component in desirable direction for the expression of this trait. The parent RSV458 (P_2) showed superior performance in contribution of this trait. The estimates, of digenic interaction revealed significantly negative additive x additive (i) interaction components with higher magnitude than additive x dominance (j) component and significantly positive dominance x dominance (l) component exhibited predominance of dominance x dominance (l) interaction effects, indicated the presence of all three non-allelic gene interaction effects *viz*., additive x additive (i) additive x dominance (j) and dominance x dominance (l). From the estimates of genetic components the predominance of dominance (h) and dominance x dominance (l) with opposite sign, indicated that the duplicate gene action played an important role in expression of this trait and suggested that heterosis breeding would be more effective for the improvement of this trait. These findings are in accordance with the earlier reports of Ameer *et al.* (2012) and Goyal *et al.* (2013).

Table 1: Mean performance of six generations for four characters in sorghum

Cross	Generations	Characters			
		Length of panicle (cm)	Harvest index (%)	Total above ground dry matter(g/plant)	Grain yield (g/plant)
RSV1098 x RSV458	P_1	29.97 (0.55)	32.63 (0.45)	192.96 (1.22)	70.64 (0.92)
	P_2	27.17 (0.52)	30.21 (0.33)	180.35 (1.25)	50.61 (0.90)
	F_1	30.45 (0.47)	35.47 (0.36)	193.18 (1.30)	68.53 (0.99)
	F_2	29.34 (0.33)	33.59 (0.27)	185.57 (0.72)	65.93 (0.44)
	B_1	28.13 (0.30)	29.83 (0.29)	178.11 (0.82)	53.77 (0.46)
	B_2	29.22 (0.31)	29.93 (0.28)	179.54 (0.80)	62.11 (0.52

(Figures in parenthesis indicates S.E.)

Table 2: Scaling test for detecting non-allelic interactions for the cross RSV1098 x RSV458 in four traits.

No.	Characters	Scaling test	RSV1098 x RSV458
1.	Length of Panicle (cm)	A	-2.16**
		B	-2.82**
		C	-2.68**
		D	2.33**
2.	Harvest index (%)	A	-5.44**
		B	-5.82**
		C	-3.58**
		D	7.42**
3.	Total above ground dry matter (g/plant)	A	-29.92**
		B	-14.45**
		C	-17.39**
		D	24.49**
4.	Grain yield (g/plant)	A	-11.63**
		B	-15.10**
		C	-5.41*
		D	15.98**

Table 3: Gene effects for the four different traits associated with drought resistance in *rabi* sorghum.

Sr	Characters	Cross RSV1098 x RSV458						
		Genetic parameter						
		m	d	h	i	j	l	Gene action
1.	Length of panicle (cm)	29.37** (0.19)	-1.09** (0.28)	-0.78** (0.82)	-2.66** (0.72)	-2.49* (0.32)	6.00** (1.36)	Duplicate
2.	Harvest index (%)	35.49** (0.16)	-0.10* (0.27)	-10.79** (0.95)	-14.84** (0.80)	-1.31** (0.35)	29.10** (1.55)	Duplicate
3.	Total above ground dry matter (g/plant)	185.57** (0.78)	-1.43** (1.32)	-20.45 (3.90)	-26.98** (3.32)	-7.73* (1.92)	71.35** (4.45)	Duplicate
4.	Grain yield per plant (g/plant)	65.93** (0.55)	-8.34** (0.72)	-24.05** (2.90)	-31.96** (3.72)	-18.36** (0.99)	58.51** (4.32)	Duplicate

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

CONCLUSION

Both additive and non-additive gene effects were found to be important and playing an important role, while considering the gene effects simultaneously in the inheritance of all the traits associated with drought resistance in which either additive (d) or additive x additive (i) or dominance (h) or dominance x dominance (l) gene effects, in all the crosses were found to be quite appreciable. The cross combination RSV1098 x RSV458, had better performance in different generations for all the characters associated with drought tolerance *viz.,* , length of panicle, harvest index, total above ground dry and grain yield per plant. The parents RSV1098 and RSV458 and its combination exhibited higher magnitude of tolerance to drought, which could be considered in developing drought tolerance genotypes.

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