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Genetics of traits imparting drought tolerant in post rainy season sorghum (*Sorghum bicolor* L. Moench)

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ABSTRACT

An investigation on generation mean analysis involving six generations (P_1, P_2, F_1, F_2, B_1 and B_2) of the cross RSV1098 x RSV458 in sorghum was carried out for the traits associated with drought resistance. The joint scaling test for almost all the characters was found highly significant in all the crosses, indicating inadequacy of additive-dominance model. The dominance (h) gene effects were found predominant along with dominance x dominance (l) interaction effects in the inheritance of traits viz., relative leaf water content (RWC), chlorophyll stability index (CSI), harvest index and grain yield. The preponderance of additive (d) gene effect along with dominance x dominance (l) gene effect was found importance in the inheritance of stomatal frequency on adaxial and abaxial surface and length of panicle. The parent RSV1098 was found superior in contributing traits viz., harvest index, length of panicle and total above ground dry matter and grain yield per plant, while parent RSV458 was found superior in contributing relative leaf water content (RWC), chlorophyll stability index (CSI) and stomatal frequency an adaxial and abaxial surface.

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

INTRODUCTION

Drought limits agricultural production by preventing the crop plants from expressing their full genetic potential. In sorghum grain yields are mainly affected 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. The limited availability of water causes moisture stress, which affects various metabolic processes of the plant.

Knowledge of gene action helps in the selection of parents for hybridization programe and also to choose the appropriate breeding procedure for the genetic improvement of various physiological characters. It is necessity of the plant breeder, to know the genetics of drought tolerance in sorghum to evolve promising genotype either through conventional breeding or biotechnological approach. Hence, to initiate a judicious breeding programme, plant breeder must know the nature of gene action involved in the expression of various quantitative characters.

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MATERIALS AND METHODS

Based on the genetic diversity and various traits associated with drought tolerant parents, RSV1098 (Phule Suchitra) and RSV458 (Phule Anuradha), procured from Senior Sorghum Breeder, All India Co-ordinated Sorghum Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri. Six generations (P_1, P_2, F_1, F_2, B_1 and B_2) were raised to study the genetics of traits imparting drought tolerant. The sowing of P_1, P_2 and F_1 generations were done in a single row of 4.5 m. 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. 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.

To test the adequacy of additive dominance model A, B, C, and D scaling test were applied. Data collected on the mean of the individual plant for different characters were subjected to the weighted least square analysis i.e. joint scaling test an outlined by Mather[11] and Cavali (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[6].

RESULTS AND DISCUSSION

From the estimates of mean performance, it was observed that parent RSV1098 and RSV458 exhibited better average performance, either individually or in combinations for all the characters *viz.,* relative leaf water content, chlorophyll stability index, stomatal frequency on adaxial and abaxial, harvest index, , and grain yield per plant. 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 programe. 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.

Relative leaf water content (%):

The mean values of relative leaf water content were ranged from 76.30 (P_1) to 81.50% (F_1) in cross RSV1098 x RSV458 (Table.1). Among the different generation of this cross F_1 (81.50%) recorded highest leaf water content followed by B_2 (77.25%), F_2 (76.50%) and B_1 (73.54%). The scaling test 'A', 'B' and 'C' were negatively significant in which scaling test 'C' were of greater magnitude, while scaling test 'D' was positively significant.

In the cross RSV1098 x RSV458 the relative magnitude of dominance (h) gene action was found to be predominant and desirable in the inheritance of relative leaf water content. Additive gene effects was negatively significant and not in favorable direction, indicated that heterosis breeding would be more appropriate method for the improvement of this traits and the parent RSV458 (P_2) was found superior in contribution of this trait. However, significantly predominance and positive dominance x dominance (l) interaction effect with higher magnitude than additive x additive (i) and additive x dominant (j) interaction effect, suggested that the importance of complementary epistasis for expression of this trait. The earlier findings of Bichkar[2], Thul[13], Jhansi Rani[7], and Kandekar[8] were in agreement with the present findings.

Chlorophyll stability index (%):

The chlorophyll stability index is an indicative of the maintenance of photosynthetic pigment under drought situation. This parameter can be used by breeder to pickup the most tolerant genotype. The mean values for this trait were ranged from 0.339 to 0.350 %. The parent RSV-1098 and RSV458 recorded 0.339 and 0.350% chlorophyll stability index, respectively in the cross RSV1098 x RSV458 . The scaling test 'A' and 'B' were negatively significant and scaling test 'C' and 'D' were positively significant for the character chlorophyll stability index (Table.2). In cross RSV1098 x RSV458, significantly negative additive (d) and dominance (h) gene action with higher magnitude revealed preponderance of dominance gene effects. Superior performance was observed for the parent RSV458 (P_2) in contribution of this trait. Dominance gene action appeared to be predominant in the inheritance of this trait. In digenic interaction, significantly negative additive x additive (i), while significantly positive additive x dominance (j) and dominance x dominance (l) interaction component with higher magnitude of dominance x dominance (l) component in desirable direction, indicated the presence of all three non-allelic gene interaction effects. However, genetic estimates indicated that dominance (h) and dominance x dominance (l) gene effects with duplicate gene action and suggested that heterosis breeding will be rewarded for the improvement of chlorophyll stability index for drought tolerance. These results are in conformity with the earlier findings of Thul[13], Kandekar[8] and Khot[9].

Stomatal frequency (No./mm^2):

Stomata on adaxial and abaxial leaf surface played an important role in regulation of transpiration rate. Lower number of stomata and minimum stomatal length were correlated with drought tolerant by reducing water and increasing assimilation rate of sorghum genotype. The drought tolerant parent RSV458 exhibited lowest stomatal frequency on upper and lower surface, 119.33 and 132.31no/mm^2 respectively. Among the different generations of adaxial stomatal frequency F_1 (118.55) exhibited lowest stomatal frequency (Table.1). The entire scaling test were equal and lower in magnitude for this trait, however, scaling test 'A' and 'B' were negatively significant and scaling test 'C' and 'D' were positively significant. For the inheritance of stomatal frequency on both adaxial and abaxial surface, significantly positive with lower magnitude of additive (d) component over the dominance (h) in the cross RSV1098 x RSV458. While, considering the interaction component, significantly negative dominance x dominance (l) and significantly positive additive x additive (i), additive x dominance (j) component with higher magnitude, indicated the importance of dominance x dominance (l) component. The higher estimates of dominance x dominance (l) than rest of component and preponderance of additive (d) gene action revealed that duplicate gene action played an important role in the inheritance of this trait and suggested that the exploitation of heterosis would be effective in the improvement of stomatal density on adaxial and abaxial surface. Similar, findings were reported earlier by Thul[13], Kandekar[8] and Lad[10].

Harvest index (%):

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%). 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 this trait for drought tolerance. Among the epistatis gene interaction significantly positive dominance x dominance (l) magnitudinally higher and desirable interaction effects 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.*[12], Dhole[4], Khot[9] and Lad[10].

Grain yield per plant:

The F_1(68.53g.) generation derived from cross RSV1098 x RSV458 recorded highest grain yield followed by F_2 (65.93g.) and B_2 (62.11g.). 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.*[1] and Goyal *et al.*[5].

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

Cross	Generations	Characters					
		Relative leaf water content (%)	Chlorophyll stability index (%)	Stomatal frequency		Harvest index (%)	Grain yield (g/plant
				Adaxial	Abaxial		
RSV1098 x RSV458	P_1	76.30 (0.41)	0.339 (0.41)	121.93 (0.55)	135.55 (1.40)	70.64 (0.92)	70.64 (0.92)
	P_2	78.90 (0.42)	0.350 (0.40)	119.33 (0.41)	132.31 (1.75)	50.61 (0.90)	50.61 (0.90)
	F_1	81.50 (0.41)	0.349 (0.42)	118.55 (0.45)	134.56 (1.40)	68.53 (0.99)	68.53 (0.99)
	F_2	76.50 (0.28)	0.320 (0.28)	124.57 (0.35)	140.13 (1.20)	65.93 (0.44)	65.93 (0.44)
	B_1	73.54 (0.28)	0.310 (0.26)	128.77 (0.39)	144.67 (0.80)	53.77 (0.46)	53.77 (0.46)
	B_2	77.25 (0.28)	0.329 (0.28)	120.53 (0.38)	137.66 (0.90)	62.11 (0.52	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

N o.	Characters	Scaling test	RSV1098 x SV458	No.	Characters	Scaling test	RSV1098 x RSV458
1.	Relative leaf water content (RLWC)	A	-10.72**	4.	Harvest index (%)	A	-5.44**
		B	-5.90**			B	-5.82**
		C	-12.20**			C	-3.58**
		D	2.21**			D	7.42**
2.	Chlorophyll Stability index (CSI)	A	-0.034**	5.	Grain yield (g)	A	-11.63**
		B	-0.041**			B	-15.10**
		C	0.011**			C	-5.41*
		D	0.027**			D	15.98**
3.	Stomatal frequency (mm^2) (Adaxial)	A	17.10**				
		B	3.18**				
		C	19.92**				
		D	-0.16				
	Stomatal frequency (mm^2) (Abaxial)	A	19.23**				
		B	8.45**				
		C	23.54**				
		D	-2.10*				

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

No.	Characters	Cross RSV1098 x RSV458						
		Genetic parameter						
		m	d	h	i	j	l	Gene action
1.	Relative leaf water content (%)	76.50** (0.28)	-3.71** (0.40)	1.52 (1.46)	-4.42* (1.38)	-2.41 (0.49)	21.04** (2.19)	Complem-entary
2.	Chlorophyll stability index (CSI)	0.32** (0.028)	-0.02 (0.040)	-0.05** (0.146)	-0.01** (0.137)	0.02** (0.049)	0.10** (0.219)	Duplicate
3.	Stomatal frequency Adaxial) No./mm^2	124.57** (0.89)	1.76** (1.94)	8.24** (3.53)	0.32* (5.27)	5.39* (3.21)	-20.56** (9.19)	Duplicate
	Stomatal frequency(Abaxial)No./mm^2	140.13** (0.28)	4.77** (0.40)	10.87** (1.46)	4.14* (1.37)	6.94* (0.49)	-31.82** (2.19)	Duplicate
4.	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
5.	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.**
(Figures in parenthesis indicates S.E.)

CONCLUSION

The cross combination RSV1098 x RSV458, had better performance in different generations for all the characters associated with drought tolerance *viz.,* relative leaf water content (RWC), chlorophyll stability index (CSI), stomatal frequency adaxial and abaxial, harvest index and grain yield per plant. The parents RSV1098 and RSV458 and its combination exhibited higher magnitude of tolerant to drought, which could be considered in developing drought tolerance genotypes. 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 were found to be quite appreciable. Further, it would be possible to select transgressive segregants possessing higher intensity of expression for drought tolerance in combination with desirable attributes from segregating generations of the crosses involving one or both these parents. Such type of cross deserves good combination for further breeding. The significance and higher magnitude of tolerant parents suggested the major role in inheritance of drought tolerant. The traits in which dominance effects with duplicate type of epistasis in which heterosis breeding have been suggested to break the undesirable linkage to accumulate favorable genes and to generate desirable recombinants.

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