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Genetic Studies of Drought Tolerant Traits in Post Rainy Season Sorghum (*Sorghum bicolor* L. Moench)

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ABSTRACT

The significance of scaling test 'A', 'B', 'C' and 'D' indicated the presence of all three types of non-allelic gene interaction effects for physiological traits governed by additive (d) gene effects Additive (d) gene effects along with predominant of dominance x dominance (l) non-allelic gene interaction effect was important in the inheritance of traits associated with drought tolerance viz; harvest index, length of panicle, total above ground dry matter and grain yield per plant, in which duplicate epistasis was involved in the expression of all these traits and parent SPV1587 was found superior in contributing traits harvest index, length of panicle and total above ground dry matter while parent Phule Maulee was found superior in contributing grain yield per plant in cross SPV-1587 x Phule Maulee.

Key words: *Epistasis, additive-dominance model, generation mean analysis, drought resistance, Sorghum bicolor (L.)*

INTRODUCTION

Drought is one of the major abiotic factors which result in low productivity of sorghum. Sorghum (*Sorghum bicolor* (L.) Moench) is one of the most important food crop in the semi-arid tropics. Besides food it is also used for animal food, fuel, syrup, alcoholic beverages and ethanol. 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. Attempts were made to study the gene action which helps in the selection of parents for hybridization programme and also to choose the appropriate breeding procedure for the genetic improvement of various physiological characters.

MATERIAL AND METHODS

The experimental material comprised of parents, F_1, F_2, B_1F_1, B_2F_1, F_3, B_1F_2 and B_2F_2 of cross SPV-1587 x Phule Maulee. The investigation was conducted at Sorghum Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri. Based on the genetic diversity and various traits associated with drought tolerance two parents SPV-1587 and Phule Maulee of sorghum were selected for generating nine generations.

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Ten competitive plants was randomly selected from each replication in both the experiment in P_1, P_2 and F_1 and twenty five plants in F_2, B_1, B_2, F_3, B_1F_2, and B_2F_2 generations. The mean values were computed for eight physiological characteristics associated with drought tolerance. The mean values recorded for various characters from observational plants, were used for statistical analysis and computed for four physiological characteristics associated with cross SPV1587 x Phule Maulee, imparting to drought tolerance for harvest index, length of panicle, total above ground dry and grain yield per plant. To provide information on the nature of gene action governing the traits under study, all the six parameters of generation means were calculated following the method outlined by Hayman[4]. To test the adequacy of additive dominance model A, B, C, and D scaling test were applied. The individual scaling test indicated that all or either A. B, C, and D significantly deviated from zero for all the characters, which indicated the presence of non-allelic interaction. Three tests of scale were carried out to detect presence or absence of gene interaction by Mather[11].

RESULTS AND DISCUSSION

Drought tolerance mechanism can be studied based on the interpretation of relationship between leaf structure function and stress tolerance[5]. Despite the progress in sorghum breeding, lack of knowledge about genetic basis of drought tolerant, unavailability of appropriate gene to develop transgenic plant, limited information on inheritance and behavior of major characters, lack of precise screening techniques are the main constraints for genetic improvement of drought tolerant. Drought tolerant is a complex trait, expression of which depends on action and interaction of different morphological, physiological and biochemical characters. The management practices and breeding efforts is important aspect for better understanding of effects of drought on sorghum crop.

The cross combination SPV 1587 x Phule Maulee, had better performance for all the characters associated with drought tolerance *viz;*, harvest index, length of panicle, total above ground dry and grain yield per plant. The parents SPV1587 and Phule Maulee and its combination exhibited somewhat higher magnitude tolerance to drought (Table 2), which could be considered in developing drought tolerance genotypes.

Table 1: Mean performance and standard error of different generations for four characters of sorghum

Crosses	Generations	Characters			
		Harvest index (%)	Length of panicle (cm)	Total above ground dry matter	Grain yield (g/plant)
SPV-1587 x Phule Maulee	P_1	33.43 ± 0.30	30.24 ± 0.24	194.93 ± 1.48	66.51 ± 0.97
	P_2	32.07 ± 0.32	29.54 ± 0.21	189.03 ± 1.28	70.42 ± 0.96
	F_1	35.27 ± 0.16	31.40 ± 0.26	203.13 ± 1.21	75.39 ± 1.07
	F_2	32.49 ± 0.18	30.52 ± 0.14	192.28 ± 0.80	70.94 ± 0.63
	B_1	30.40 ± 0.17	29.27 ± 0.15	180.81 ± 0.82	65.51 ± 0.78
	B_2	29.85 ± 0.16	29.26 ± 0.16	181.04 ± 0.84	66.15 ± 0.60
	F_3	28.74 ± 0.20	29.07 ± 0.13	176.97 ± 0.89	60.94 ± 0.84
	B_1F_2	27.82 ± 0.21	27.61 ± 0.16	171.25 ± 0.82	58.96 ± 0.78
	B_2F_2	26.95 ± 0.16	27.14 ± 0.15	170.99 ± 0.84	56.33 ± 0.64

Table 2: Estimation of scaling test for detecting non-allelic interactions for four characters of sorghum

Characters	Scaling test	SPV1587 x Phule Maulee	Characters	Scaling test	SPV1587 x Phule Maulee
Harvest Index (%)	A	-7.90**	Total above ground dry matter (g/plant)	A	-36.44**
	B	-7.64**		B	-30.08**
	C	-6.09**		C	-21.11**
	D	4.72**		D	22.70**
Length of panicle (cm)	A	-3.10**	Grain yield (g/plant)	A	-11.41**
	B	-2.42**		B	-14.04**
	C	-2.49**		C	-7.22*
	D	2.51**		D	9.12**

Table 3: Estimation of gene effects for the traits associated with drought tolerant

S. No.	Character	Genetic parameter					
		m	d	h	i	j	l
1.	Harvest index %	32.48** (0.18)	0.55* (0.23)	-6.92** (0.91)	-9.44** (0.87)	-2.74** (0.31)	24.99** (1.30)
2.	Length of panicle (cm)	30.52** (0.13)	1.92** (0.22)	-3.52** (0.77)	-5.03** (0.70)	-0.33 (0.27)	10.55** (1.20)
3.	Total above ground dry matter (g./plant)	192.28** (0.80)	-4.22** (1.19)	-34.26 (4.25)	-45.41** (3.96)	-3.17* (1.52)	111.94** (6.46)
4.	Grain yield per plant (g./plant)	70.38** (0.63)	-3.64** (0.98)	-10.77** (3.45)	-18.23** (3.21)	4.31** (1.99)	43.69** (5.33)

Harvest index (%)

The harvest index of parent SPV1587 and Phule Maulee was 33.43 and 32.07%, respectively**.** Among all the different generations F_1 (35.27%) recorded highest harvest index followed by F_2 (32.49%), B_1 (30.40%), B_2 (29.85%), whereas the lowest harvest index was recorded in B_1F_2 (27.82%) generation (Table 1).The estimates of scaling test ‘A’ (-7.90), ‘B’ (-7.64) and ‘C’ (-6.09) were negatively significant and all the scaling test were equal in magnitude, while scaling test ‘D’(4.72) was positively significant and lower in magnitude (Table 2.).

In cross SPV 1587 x Phule Maulee, the relative magnitude of dominance (h) component was observed higher in magnitude, but negative and undesirable in direction (Table 3). However, additive (d) component was significantly positive in desirable direction, indicated preponderance of additive (d) gene action and played an important role in the inheritance of harvest index for drought tolerance. Among the digenic interaction, significantly positive dominance x dominance (l) magnitudinally higher interaction effect and significantly negative additive x additive (i) and additive x dominance (j) interaction effects revealed the presence of all three non-allelic interaction effects along with predominance of dominance x dominance (l) interaction effect (Table 3.). From the estimates of genetic parameter, it was evident that additive (d) and dominance x dominance (l) gene effect were predominant and important in the inheritance of this trait, with duplicate type of epistasis and suggested that selection would be more effective in the improvement of harvest index. These results are in conformity with the earlier findings of Palanisamy and Subramanian[12], Salunke *et al*[13]., Dhole[3], Thul[14] and Khot[9].

Length of panicle (cm)

The mean value for length of panicle in parents were ranged from 29.54 (Phule Maulee) to 30.24 cm (SPV1587). Among the different generations F_1(31.40cm) exhibited maximum length of panicle followed by F_2(30.52cm), B_1 (29.27cm) and B_2 (29.26cm). (Table 1). All the scaling test for length of panicle were significant in which scaling test A, B and C were negatively significant, while scaling test D was positively significant and all the four scaling test were equal in magnitude. (Table 2.).

The overall adequacy of additive-dominance model for length of panicle was observed in the present investigation, was also by Khot[9]. Relative magnitude of additive (d) gene action was found to be predominant than dominant (h) component in the inheritance of drought tolerance character length of panicle, in which significantly positive additive (d) and significantly negative dominance (h) gene effects indicated the presence of both additive (d) as well as dominant (h) gene effects, along with preponderance of additive (d) gene action in cross SPV 1587 x Phule Maulee and parent SPV 1587 (P_1) showed superior performance than parent Phule Maulee (P_2) in contribution of this trait.

The significantly negative and magnitudinally lower, additive x additive (i) and significantly positive and magnitudinally greater, dominance x dominance (l) interaction component indicated the presence of both non-allelic gene interaction effects *viz;* additive x additive (i) and dominance x dominance (l) interaction component, while additive x dominance (j) components was negligible in contributing 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. These findings are in accordance with the earlier findings of Chhina and Phul[2], Refiq *et al*., Kaul *et al*[8]., and Manonmani *et al*[10].

Total above ground dry matter (g/plant)

The parent SPV1587 (194.93g.) exhibited highest total above ground dry matter followed by Phule Maulee (189.03g.) and among the different generations F_1 (203.13g.) recorded the highest total above ground dry matter followed by F_2(192.28g.) and B_2 (181.04g.) (Table 1).

Additive (d) gene action appeared to be predominant and negatively significant in the inheritance of total above ground dry matter in cross SPV 1587 x Phule Maulee, in which both additive (d) as well as dominance (h) gene effects were negatively significant along with preponderance of dominance (h) gene effects. (Table 3.)

However, among the digenic interaction, dominant x dominant (l) interaction component was magnitudinally much higher and significantly positive, indicating its predominance and importance 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. The earlier findings of Bichkar[1], Jhansi rani[6], Thul[14] and Khot[9] were in agreement with the present findings.

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 effect in governing this trait, suggested that simple selection could be exploited in the improvement of trait total above ground dry matter.

Grain yield per plant (g.)

The mean values for grain yield per plant were ranged from 56.33 to 75.39 g/plant. The highest grain yield per plant was exhibited by F_1 (75.39 g/plant) followed by F_2 (70.94 g) and P_2 (70.42g), whereas the lowest grain yield per plant was recorded in B_2F_2 (56.33) generation. The parent P_2 (70.42g) exhibited highest grain yield per plant (Table 1). The scaling test A, B, and C were negatively significant in which scaling test A and B were of equal magnitude.

However, the scaling test D was positively significant in desirable direction (Table 2.)

In cross SPV 1587 x Phule Maulee significantly negative additive (d) and dominance (h) components with higher magnitude indicated the presence of additive (d) as well as dominance (h) component along with preponderance of dominance (h) component in the expression of this trait and the parent Phule Maulee (P_2) showed superior performance in contribution of this trait. The estimate of digenic interaction revealed significantly negative additive x additive (i) interaction components with higher magnitude than additive x dominance (j) component and significantly positive additive x dominance (j) and dominance x dominance (l) with 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). These findings are in accordance with the earlier report of Bichkar[1] and Kandekar[7].

CONCLUSION

In cross SPV1587 x Phule Maulee both the parents and its combination exhibited higher magnitude of tolerance. Parent SPV1587 was found promising in contributing traits harvest index, length of panicle and total above ground matter, whereas parent Phule Maulee was found promising for contributing grain yield per plant. From the estimates of genetic components both the additive and non-additive gene effects were found to be important for the traits associated with drought tolerant *viz*, harvest index, length of panicle, total above ground dry matter and grain yield per plant in which additive gene effects with dominance x dominance gene effects were found to be quite appreciable, suggested that selection would be effective for the improvement of these traits.

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