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Inheritance of drought tolerance in post rainy season sorghum (*Sorghum bicolor* L. Moench)

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Abstract
The significance of scaling tests A, B, C and D in the cross *viz.,* CSV-29R x CRS-19 for the traits related to drought tolerance indicated the presence of all three non-allelic interaction effects under non stress and moisture stress conditions. The joint scaling test was also found significant for all the characters under both condition indicating inadequacy of Additive-dominance model and presence of higher order interactions. Under non stress condition, the dominant component (h) and additive x additive (i) gene interaction for the cross CSV-29R x CRS-19 was found significant for the characters *viz*., dry fodder yield and grain yield per plant. While under moisture stress condition, dominant component (h) and additive x additive (i) gene interaction for the cross CSV-29R x CRS-19 was found significant for the characters *viz*., dry fodder yield, grain yield and harvest index.

Keywords: scaling test, additive-dominance model, generation mean analysis, drought resistance, sorghum

Introduction

In Sorghum, the grain yield is affected by various abiotic factors, among them; drought is one of the primary reason of low yield. Even though past achievements in the field of *rabi* sorghum improvement are remarkable, much needs to be done as average yields of *rabi* sorghum in Maharashtra is low.

Drought limits the agricultural production by preventing the crop plants from expressing their full genetic potential. Production of sorghum in semi-arid regions of the world is limited by drought. Developing plant type has an advantage under water limited condition and is the major challenge for sorghum improvement programme. Sorghum is efficient in converting solar energy to chemical energy and also uses less water compared to other grain crops.

Drought tolerance in *rabi* sorghum, is considered to be the product expression of many morphological, physiological and biochemical traits, therefore it is necessary to know the genetics of traits related with drought tolerance. The knowledge of gene actions helps in the selection of parents for hybridization programme and to apply appropriate breeding procedure.

Material and Methods

The experimental material for generation mean analysis study comprised P_1, P_2, F_1, F_2, B_1 and B_2 generations of cross CSV-29R x CRS-19 The parents involved in this cross have considerable variation for quantitative characters, physiological characters and drought tolerance with good grain quality. Two field trials comprising of six different generations of cross, replicated thrice were conducted under non stress (Normal) and moisture stress (rainout shelter) conditions during *rabi* 2016-17 at Sorghum Improvement Project, M.P.K.V., Rahuri.

The generations *viz*., P_1, P_2, F_1, B_1, B_2 were represented by two rows and F_2's by six rows each having 3.0 meter length in each replication. Randomly selected competent five plants in P_1, P_2 and F_1 generations, 10 plants in B_1 and B_2 generations and 20 plants in F_2 generation in each treatments were selected for recording observations in each replication. Data on following characters were recorded on single plant basis for different quantitative characters *viz*., Days to 50 per cent flowering, Dry fodder yield/plant, Grain yield/plant, Harvest index. To test the adequacy of additive-dominance model A, B, C, and D scaling tests 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. Scaling tests were carried out to detect presence or absence of gene interaction by Mather (1949) [8]. To determine information on the nature of gene action governing the traits under study, all the six parameters of generation means were calculated as per Hayman (1958).

Results and Discussion

The mean performance of the basic generations P_1, P_2, F_1, F_2, B_1 and B_2 of the cross viz. CSV-29R x CRS-19 showed existence of substantial variability in the material for days to 50 per cent flowering, dry fodder yield per plant, grain yield per plant and harvest index. Parents showed wide divergence for plant days to 50 per cent flowering, dry fodder yield per plant and grain yield per plant under both non stress and stress condition. In general, for cross CSV-29R x CRS-19 F_1 performance was better than either of the parents for days to 50% flowering, dry fodder yield, grain yield and harvest index.

Table 1: Mean performance of different generations for yield and yield contributing characters under non stress and moisture stress condition in *rabi* sorghum

SN	Generations	Days to 50% flowering		Dry fodder yield (g/plant)		Grain yield (g/plant)		Harvest index (%)	
		Non stress	Moisture Stress	Non-stress	Moisture Stress	Non stress	Moisture Stress	Non stress	Moisture Stress
1	P_1	78.86	76.13	179.86	129.85	72.32	45.35	31.00	25.98
2	P_2	67.06	65.20	127.20	99.34	59.91	48.96	33.38	30.32
3	F_1	71.20	69.13	185.86	131.97	88.08	58.09	35.15	31.05
4	F_2	70.06	68.05	118.03	109.77	63.88	46.73	28.30	26.62
5	B_1	71.90	70.50	150.33	115.38	68.65	43.68	29.92	26.97
6	B_2	69.83	67.80	170.73	120.73	72.23	55.25	31.45	28.48
Mean		71.48	69.46	155.33	117.85	70.84	49.67	31.54	28.24
SE$\pm$		0.69	0.72	0.63	0.75	0.49	0.67	0.22	0.23
CD at 5%		2.17	2.27	2.85	2.39	2.22	2.13	0.69	0.74

Table 2: Estimates of individual scaling tests and Cavelli's (1952) χ2 values for different characters under non stress and moisture stress conditions in *rabi* sorghum

Sr. No.	Characters	Scaling Test	Non Stress condition	Moisture Stress condition
1	Days to 50% flowering	A	-6.26**	-4.27**
		B	1.40	1.26
		C	-8.06**	-7.40**
		D	-1.60	-2.20*
		Chi Square (χ2)	36.71**	25.31**
2	Dry fodder yield/plant(g)	A	-65.06**	-31.05**
		B	28.40**	10.14**
		C	-206.66**	-54.02**
		D	-84.99**	-16.56**
		Chi Square (χ2)	742.24**	86.00**
3	Grain yield per plant (g)	A	-23.10**	-16.08**
		B	-3.52	3.41
		C	-52.84**	-23.56**
		D	-13.10**	-5.44
		Chi Square (χ2)	142.14**	43.42**
4	Harvest index (%)	A	-6.30**	-3.10*
		B	-5.63**	-4.41**
		C	-21.48**	-11.93**
		D	-4.77**	-2.20
		Chi Square (χ2)	68.00**	24.24**

Table 3: Estimates of genetic effects for yield and yield contributing characters in Cross CSV-29R x CRS-19 under non stress condition in *rabi* sorghum

Sr. No.	Name of Character	m	d	h	i	j	l
1	Days to 50% flowering	70.06** (0.41)	2.06** (0.73)	1.43 (2.33)	3.20 (2.21)	-3.83** (0.83)	1.66 (3.68)
2	Dry fodder yield/plant (g)	118.03** (2.51)	-20.40** (2.50)	202.32** (11.26)	169.99** (11.22)	-46.73** (2.58)	-133.32** (14.31)
3	Grain yield/plant (g)	63.88** (1.08)	-3.58 (2.30)	48.18** (6.42)	26.21** (6.32)	-9.78** (2.38)	0.41 (10.43)
4	Harvest index (%)	28.30** (0.45)	-1.52* (0.76)	12.49** (2.54)	9.53** (2.36)	-0.33 (0.89)	2.40 (4.02)

Table 4: Estimates of genetic effects for yield and yield contributing characters in Cross CSV29R x CRS 19 moisture stress condition in *rabi* sorghum

Sr. No.	Name of Character	m	d	h	i	j	l
1	Days to 50% Flowering	68.05** (0.39)	2.70** (0.69)	2.86 (2.19)	4.40* (2.09)	-2.76** (0.79)	-1.40 (3.45)
2	Dry Fodder yield (g)	109.78** (2.78)	-5.34* (2.51)	50.49** (12.25)	30.12** (12.22)	-20.60** (2.59)	-12.22 (15.13)
3	Grain yield (g)	46.73** (1.04)	-11.55** (2.30)	21.83** (6.32)	10.89 (6.22)	-9.75** (2.38)	1.77 (10.37)
4	Harvest index (%)	26.62** (0.45)	-1.51* (0.75)	7.31** (2.53)	4.41* (2.35)	0.65 (0.88)	3.09 (3.98)

Under non stress condition, all the four scales A, B, C and D were highly significant dry fodder yield per plant and harvest index, while A, C and D were significant for grain yield per plant. The scale A and C were significant for days to 50% flowering while scale A, C, D was significant for grain yield per plant. In moisture stress condition, all the four scaling test A, B, C and D were highly significant for dry fodder yield per plant. While A, B and C scale was significant for harvest index. Scale A and C were significant for grain yield per plant. Simultaneously, the χ^2 value (Cavelli, 1952) [1] was highly significant for all characters studied confirming the presence of non-allelic interactions.

Gene action for days to 50% flowering

Under both the condition, the additive (d) was positively significant and dominance (h) components was positively non-significant, the magnitude of additive (d) component was observed higher than dominant (h) component in the cross CSV-29R x CRS-19 under non stress condition. The importance of additive gene action for days to 50 per cent flowering was noticed by Patil (2000) [9]; Siddiqui and Baig (2001) [11] and Kulkarni *et al.* (2006) [6].

Gene action for dry fodder yield / Plant

The dominance (h) gene action appeared to be predominant and positively significant than additive (d) component for inheritance of dry fodder yield per plant under both non stress condition and stress condition, Where as significantly negative magnitude of additive x dominance (j) and dominance x dominance (l) interaction effects were observed in cross which indicate the presence of all the three type of non-allelic interaction effect. The important of non additive gene action for this trait was noticed by Khandelwal *et al.* (2006); Wadikar *et al.* (2006) [13] and Kshirsagar (2007) [5].

Gene action for grain yield/ plant

Dominance gene effects was more pronounced and desirable direction in the inheritance of grain yield per plant under non stress condition, suggested that the breeding progress should be through exploitation of heterosis or hybrid development. The similar results were reported earlier by Prabhakar *et al.* (2013) [10] and Karande (2015) [4].

Gene action for harvest index

For harvest index, the relative magnitude of dominant (h) component was observed higher in magnitude and desirable direction in cross indicated preponderance of dominance gene action in the inheritance of harvest index under both the condition. These results are in conformity with the earlier finding of Kumar *et al.* (2003) [4]; Dhole (2004) [2]; Khandelwal *et al.* (2006); Kshirsagar (2007) [5] and Udutha (2008) [12] and Karande (2015) [4].

Conclusion

Under non stress condition

In cross CSV-29R x CRS-19 the dominant component (h) and additive x additive (i) gene interaction was found significant for the character *viz.*, dry fodder yield, grain yield per plant and harvest index. These characters could be improved by the method of Reciprocal Recurrent Selection method.

Under moisture stress condition

In cross CSV-29R x CRS-19 dominant component (h) and additive x additive (i) gene interaction was found significant for the characters *viz.*, dry fodder yield and harvest index. These characters can be improved by following Reciprocal Recurrent Selection. While the character grain yield per plant is under the control of dominant gene action therefore this can be improved by heterosis breeding or by hybrid development or by Recurrent Selection for sca.

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