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HETEROSIS STUDIES FOR YIELD AND ITS ATTRIBUTING TRAITS IN SORGHUM [*SORGHUM BICOLOR* (L.) MOENCH]

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SUMMARY

The present investigation in sorghum [*Sorghum bicolor* (L.) Moench] was carried out to study the magnitude of heterosis, heterobeltiosis and economic heterosis in 35 crosses (F_1s) by crossing the nine different parents in 9 x 9 diallel fashion (excluding reciprocals). Observations were recorded on nine characters viz., days to 50 per cent flowering, days to maturity, plant height, number of leaves/plant, leaf length, leaf breadth, grain yield/plant, stover yield/plant and 100-seed weight. The analysis of variance revealed significant differences among the genotypes viz., parents, crosses and parents vs crosses for all the characters. The crosses SPV 2110 x GFS 5, GFS 5 x GJ 39 and SPV 2113 x CSV 15 showed high heterosis over mid parent, better parent and economic heterosis for grain yield per plant, stover yield per plant and other component traits. In addition to this, crosses CSV 15 x SSV 84, SPV 2113 x SPV 1616, SPV 2110 x GJ 39 and GJ 39 x SSV 84 showed good heterosis for stover yield and their contributing traits. Thus, these crosses in future can be exploited easily for dual purpose attributes by conventional breeding procedure (Pedigree method).

Key words : *Sorghum bicolor*, heterosis, heterobeltiosis,economic heterosis, grain yield, stover yield

Sorghum is a food, feed, fodder and fuel crop in different parts of the world and has achieved a special significance after wheat, rice and maize among cereals. Sorghum covers 7.69 million hectare area in India producing 7.29 million tonnes of sorghum grain with a productivity of 0.95 t/ha. In India, it is an important **kharif** crop and its fodder is highly palatable and digestible as far as its nutritional quality is concerned. It has been in demand for industrial uses mainly as animal and poultry feed, ethanol industry (both grain and stalk) and as food items. For improving the genetic architecture of crop through breeding efforts, utilization of heterosis is very important for maximizing the yield. The magnitude of heterosis provides information on the extent of genetic diversity of parents in developing superior F_1s so as to exploit hybrid vigour. Although sustainable heterosis has been reported, commercial exploitation to its full potential has not been possible. Hence, study of heterosis helps to exploit the vigour with present genetic variability that helps to achieve a quantum jump in yield. Grain sorghum improvement programmes were concentrated primarily on traits that influence grain yield. Little attention was given to improvement of both grain and forage attributes by breeding. Studies by Ross *et al.* (1980) demonstrated that improvement of both grain and fodder traits by breeding were possible. Therefore, the present study was undertaken to assess the possibility of commercial exploitation of heterosis for grain and fodder yield along with a view of gene action in crosses involving high yielding well adopted homozygous lines of dual and forage sorghum through estimating of heterosis over mid parent, better parent and standard check for yield and their contributing traits.

MATERIALS AND METHODS

The nine genetically diverse lines of sorghum [*Sorghum bicolor* (L.) Moench] viz., SPV 2113 , SPV 2125 , SPV 1616, SPV 2118, SPV 2110, GFS 5, GJ 39, CSV 15 and SSV 84 were crossed in diallel mating design excluding reciprocals to produce 36 experimental hybrids for this study during **kharif** 2011. The 36 F_1s, nine parents including a popular local check GJ-39 were grown at the Sorghum Research Station, Sardarkrushinagar Dantiwada Agricultural University, Deesa (Gujarat) during **kharif** 2012. Deesa is situated at latitude of 24.5° N and longitude of 72° E and at an elevation of 136 M above the mean sea level. The soil of the field was sandy to deep sandy loam (49.8% coarse, 34.0% fine sand, 9.7% silt and 6.3% clay) in texture with pH value of 8.0 having 0.30 per cent organic matter and 0.25-36 EC at 25 C mm/holc. There was 362 mm rainfall during the growing season and average minimum and maximum temperature was 19.26 and 33.54°C, respectively, while average minimum and maximum humidity was 48.44 and 76.25 per cent, respectively. The experiment was laid out in randomized block design with three replications in a single-row plot of 6.75 m long, spaced at 0.45 m apart. NPK 120 : 40 : 00 fertilizers were applied as half basal dose of nitrogen and full dose of phosphorus at the time of sowing and half nitrogen applied after one month of sowing. Plots were thinned down after two weeks of crop emergence and plant-to-plant distance of 0.15 m was maintained. The all other recommended agronomical practices were followed to raise a good crop. The biometrical observations recorded on grain yield/plant (g), stover yield/plant (g), plant height (cm), number of leaves/plant, leaf length (cm), leaf breadth (cm) and 100- seed weight (g) on five randomly selected competitive plants of each genotype and each replication. The observations for days to 50 per cent flowering and days to maturity were recorded on the plot basis. Computation of heterosis was carried out as per procedure suggested by Briggle (1963) and Fonesca and Patterson (1968).

RESULTS AND DISCUSSION

The analysis of variance revealed that mean squares due to genotypes, parents and crosses were significant for all the characters (Table 1). This reflected presence of adequate genetic variability in the experimental material. Similarly, significant mean squares due to parent's vs hybrids indicated presence of average heterosis for all the characters. The range of heterosis, heterobeltiosis and economic heterosis along with number of significant crosses for different characters are presented in Table 2. In the present study, heterosis for grain yield per plant was positively significant in 7, 5 and 3 crosses over mid parent, better parent and standard check, respectively. Cross SPV 2110 x GFS 5 followed by GFS 5 x GJ 39 exhibited highest magnitudes of heterosis, heterobeltiosis and economic heterosis for grain yield per plant. The range of heterosis for grain yield varied from 2.54 per cent (SPV 2118 x GFS 5) to 40.43 per cent (GFS 5 x GJ 39) over mid parent, 3.87 per cent (SPV 2113 x GJ 39) to 55.43 per cent (SPV 2110 x GJ 39) over better parent and 5.11 per cent (SPV 2113 x GJ 39) to 34.72 per cent (SPV 2110 x GJ 39) over standard check. The range of heterosis for 100-seed weight varied from 4.06 per cent (SPV 2118 x SSV 84) to 19.00 per cent (CSV 15 x SSV 84) over mid parent, 3.16 per cent (SPV 1616 x SSV 84) to 19.77 per cent (CSV 15 x SSV 84) over better parent and from 5.55 per cent (SPV 2113 x SPV 2115) 18.24 per cent (CSV 15 x SSV 84) over standard check (Table 2). Similar results for grain yield and 100-seed weight were reported by Sharma *et al.* (2003), Kulkarani and Patil (2004) and Sharma and Sharma (2006). Heterosis for days to 50 per cent flowering was significant in 6, 3 and 1 crosses over mid parent, better parent and standard check, respectively. Days to physiological maturity exhibited significance in 4 and 3 crosses over mid parent and better parent, respectively. The range of negative heterosis for days to 50 per cent flowering varied from -0.47 per cent (SPV 1616 x CSV 15) to -14.16 per cent (GJ 39 x CSV 15) over mid parent, -0.93 per cent (SPV 1616 x CSV 15) to -13.60 per cent (CSV 15 x SSV 84) over better parent and -0.48 per cent (SPV 2113 x CSV 15) to -7.82 per cent (GJ 39 x CSV 15) over standard check GJ 39, whereas for days to physiological maturity it ranged from -0.90 per cent (SPV 2118 x CSV 15) to -7.20 per cent (GJ 39 x CSV 15) over mid parent and from -0.11 per cent (SPV 1616 x CSV 15) to -2.00 per cent (GJ 39 x CSV 15) over better parent, respectively. High negative heterosis for days to 50 per cent flowering and physiological maturity was also reported by Sharma *et al.* (2003) and Sharma and Sharma (2006). This indicated that there was a possibility for breeding of sorghum for earliness. For plant height, heterosis ranged from 3.04 per cent (SPV 2118 x CSV 15) to 44.39 per cent (SPV 2118 x GJ 39) over mid parent, from 5.52 per cent (SPV 1616 x GJ 39) to 52.49 per cent (SPV 2110 x GFS 5) over better parent and from 6.52 per cent (SPV 1616 x SSV 84) to 33.27 per cent (CSV 15 x SSV 84) over local check in desired direction. A positive heterosis for plant height was also reported by Parmar and Tikka (2005) and Singh and Shrotria (2008). Significant positive heterosis, heterobeltiosis and economic heterosis were observed in six crosses for number of leaves per plant. The magnitude of heterosis among above crosses ranged from 5.79 per cent (SPV 2110 x CSV 15) to 45.95 per cent (CSV 15 x SSV 84) over mid parent, from 7.72 per cent (SPV 2118 x GFS

TABLE 1
Mean squares for different characters in sorghum

Character	Source of variation					
	Replication	Genotype	(a) Parents	(b) Crosses	(c) Parents vs crosses	Error
d. f.	3	44	8	35	1	88
Days to 50% flowering	0.422	43.31**	22.39**	18.91**	76.31**	0.437
Days to maturity	79.07**	325.32**	277.99**	213.70**	1227.04**	13.43
Plant height	125.95**	2324.23**	1418.08**	2048.23**	11261.4**	3.06
No. of leaves/plant	0.456	49.23**	26.50**	56.59**	19.37**	0.47
Leaf length	35.23*	245.23**	567.43**	134.76**	213.55**	7.45
Leaf width	0.453	6.543**	7.435*	6.765**	3.234**	0.143
Grain yield/plant	3.15	1356.67**	486.56**	777.13**	3015.5**	0.692
100-seed weight	0.024	4.37**	2.75*	0.156*	0.317*	0.0036
Stover yield/plant	71.14*	23786.2**	6328.5**	16807.9**	8709.6**	11.83

TABLE 2
The range and number of crosses showing significant heterosis, heterobeltiosis and economic heterosis in sorghum

Character	Range			Number of significant crosses		
	Heterosis	Heterobeltiosis	Economic heterosis	Heterosis	Heterobeltiosis	Economic heterosis
Days to 50% flowering	-0.47 to -14.16	-0.93 to -13.60	-0.48 to -7.82	6	3	1
Days to maturity	-0.90 to -7.20	-0.11 to -2.00	-	4	3	-
Plant height	3.04 to 44.39	5.52 to 52.49	6.52 to 33.27	23	20	14
No. of leaves/plant	5.79 to 45.95	7.72 to 52.49	6.29 to 43.63	6	6	6
Leaf length	0.49 to 39.39	0.21 to 39.17	0.52 to 24.97	7	6	5
Leaf width	2.11 to 60.38	1.56 to 49.67	3.01 to 44.32	7	6	5
Grain yield/plant	2.54 to 40.43	3.87 to 55.43	5.11 to 34.72	7	5	3
100-seed weight	4.06 to 19.00	3.16 to 19.77	5.55 to 18.24	7	4	3
Stover yield/plant	3.42 to 45.32	2.44 to 65.21	2.13 to 43.92	8	4	3

5) to 52.49 per cent (CSV 15 x SSV 84) over better parent and from 6.29 per cent (SPV 2125 x CSV 15) to 43.63 per cent (CSV 15 x SSV 84) over standard check. For leaf length and leaf width maximum heterosis was expressed by cross GJ-39 x SSV-84 (39.39 and 60.38%), SPV 2113 x GJ 39 (39.17 and 49.67per cent) and cross SPV 2113 x GFS 5 (24.97 and 44.32%) over mid parent, better parent and standard check, respectively.

Heterosis for stover yield per plant was positively significant in 8, 4 and 3 crosses over mid parent, better parent and standard check, respectively. The range of heterosis for stover yield per plant varied from 3.42 per cent (SPV 2110 x SSV 84) to 45.32 per cent (GFS 5 x GJ 39) over mid parent, 2.44 per cent (SPV 2110 x SSV 84) to 65.21 per cent (SPV 2110 x GFS 5) over better parent and from 2.13 per cent (SPV 2110 x SSV 84) to 43.92 per cent (SPV 2110 x GFS 5) over standard check in desirable direction. A positive heterosis for stover yield and its contributing traits was also reported by Lakshyadeep and Choudhary (2006), Sukhain and Singh (2008) and Singh and Shrotria (2008).

In the present study, the crosses SPV 2110 x GFS 5, GFS 5 x GJ 39 and SPV 2113 x CSV 15 showed high heterosis over mid parent, better parent and economic heterosis for grain yield per plant, stover yield per plant and other component traits. In addition to this, crosses CSV 15 x SSV 84, SPV 2113 x SPV 1616, SPV 2110 x GJ 39 and GJ 39 x SSV 84 also showed good positive heterosis for stover yield and their contributing traits viz., leaf length, leaf width and number of leaves per plant (Table 3).

Heterosis for end product i. e. yield is being

TABLE 3

Crosses having highest heterosis, heterobeltiosis and economic heterosis for nine characters in sorghum

Character	Best crosses
Days to 50% flowering	GFS 5 x CSV 15, GJ-39 x SSV 84
Days to maturity	SPV 2113 x CSV 15, SPV 2125 x GFS 5
Plant height	SPV 1616 x GFS 5, GFS 5 x GJ 39
No. of leaves/plant	SPV 1616 x SSV 84, CSV 15 x SSV 84
Leaf length	GJ-39 X SSV-84, SPV 2113 x GFS 5
Leaf width	SPV 2110 x GFS 5, GFS 5 x GJ 39
Grain yield/plant	SPV 2110 x GFS 5, GFS 5 x GJ 39, SPV 2113 x CSV 15
100-seed weight	SPV 2110 x GFS 5, GFS 5 x GJ 39
Stover yield/plant	SPV 2110 x GFS 5, GFS 5 x GJ 39, CSV 15 x SSV 84, SPV 2113 x SPV 1616, SPV 2110 x GJ 39, GJ 39 x SSV 84

manifested as the cumulative effect of heterosis for component traits. The elaborative study of above crosses revealed this fact as most of the crosses that exhibited positive and significant heterosis for yield also showed it for most of the component characters. The findings of the present investigation are consistent with the earlier reports of Agrawal and Shrotria (2005), Sharma and Sharma (2006), Bhatt (2008) and Pandey and Shrotria (2012).

The present study on heterosis has clearly indicated that heterotic response for yield and its components resulted only in selected cross combinations indicating the predominant role of non-fixable interallelic interactions. These crosses hold promise for further evaluation and commercial exploitation of heterosis and in future can be exploited easily for dual purpose attributes by conventional breeding procedure (Pedigree method).

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