In the present case it might be due to the presence of smectite clay mineral.

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HETEROSIS STUDIES FOR GRAIN YIELD CHARACTERS IN SWEET SORGHUM

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ABSTRACT

Superior cross combinations for seven grain yield related characters were selected by heterosis study from 42 cross combination of sweet sorghum (7 x 7 diallel cross of six sweet sorghum variety and one grain sorghum variety). The cross combination AKSS 5 x SSV 84 for more plant height, HES 4 x SSV 108 for earliness and CO 26 x AKSS 5 for better grain yield is recommended from the study.

KEY WORDS : Sorghum, Heterosis, Grain, Yield

Plant breeding research in sweet sorghum is a recent development. Identification of superior genotypes is of immediate necessity for further improvement through breeding programmes. Heterosis was recognised in sorghum only in 1927 by Conner and Karper (1927). Heterosis study is the one method widely utilised for the selection of superior cross combination. Hence, the present study was taken up to select superior hybrids for grain yield characters based on heterosis in sweet sorghum.

MATERIALS AND METHODS

Experimental materials consist of six sweet sorghum varieties *viz.,* SSV 84, SSV 74, SSV 108, [illegible] variety (CO 26). The seven parents have been crossed in a 7 x 7 diallel mating design. The resulting 42 hybrids along with seven parents were raised in randomised bloch design with three replications. Observations were recorded for seven grain yield related characters. Heterosis over mid parent (relative heterosis), over better parent (heterobeltiosis) and over standard parent (standard heterosis) were calculated. Significance for heterosis was tested by 't' test as per the formula given by Wynne *et al.* (1970). The study was conducted during 1990-92.

RESULTS AND DISCUSSION

Heterosis value of different hybrid combinations is given in the Table 1. In respect of

Table 1. Extimation of heterosis over mid, better and standard parents for different characters in important hybrid combinations

Entries	Plant height			Leaf area/Plant			Days to 50% flowering		
	D I	D II	D III	D I	D II	D III	D I	D II	D III
CO26 x SSV74	-12.28**	-28.10**	-12.02**	14.67	-17.61*	-4.23	-7.09**	-0.98	-8.97**
CO26 x SSV108	-4.52	-16.26**	-13.15**	-47.31**	-55.07**	-67.66**	-6.98**	-2.44	-10.31**
CO26 x AKSS5	-9.85**	-24.80**	-11.99**	-21.57*	-35.32**	-49.42**	-0.24	0.98	-7.17**
CO26 x HES4	0.23	-14.09**	-6.96	-4.79	-5.35	-51.36**	-17.00**	-16.52**	-23.32**
CO26 x SSV84	8.38*	-3.43	-3.43	34.08**	1.09	-1.09	2.34	6.83**	-1.79
CO26 x RSSV3	0.90	-16.64**	-0.05	33.13**	16.43	-21.07*	8.25**	8.78**	0.00
AKSS5 x CO26	30.43**	8.80*	27.33**	68.11**	38.65**	8.41	2.18	2.93	-5.38**
AKSS5 x SSV74	3.68	1.42	24.12**	10.29	-7.76	7.22	4.09**	1.44	-5.38**
AKSS5 x SSV108	8.93**	2.22	19.63**	34.17**	28.85*	0.74	3.00*	0.97	-5.83**
AKSS5 x HES4	9.43*	5.35	23.29**	45.83**	20.83	-5.52	8.43**	8.70**	0.90
AKSS5 x SSV84	35.32**	25.47**	46.85**	34.93**	20.21*	20.21*	2.09	5.77*	-1.35
AKSS5 x RSSV3	6.32*	5.04	25.96*	-3.75	-10.14	-29.75**	7.95**	8.20**	0.45
HES4 x CO26	4.97	9.60*	-2.11	-12.24	-12.77	-55.17**	16.50**	-16.10**	-22.87**
HES4 x SSV74	1.59	7.26*	13.50**	-12.75	-37.09**	-26.87**	4.78**	11.10**	3.13**
HES4 x SSV108	5.96*	-7.94*	-0.31	-45.41**	-53.22**	-66.33**	-25.46**	-22.23**	-27.80**
HES4 x AKSS5	19.58**	15.11**	34.72**	75.29**	45.25**	13.57	-11.12**	-11.12**	-17.49**
HES4 x SSV84	26.21**	21.38**	31.44**	39.54**	5.63	5.63	-1.40*	2.41	-4.93
HES4 x RSSV3	15.24**	9.66**	31.49**	55.26**	36.47**	-7.48	8.70	8.70**	0.90
SSV84 x CO26	6.93*	4.71	-4.75	82.37**	37.49**	37.49**	2.34	15.26**	-1.79
SSV84 x SSV74	16.63**	5.96	29.68**	6.56	-8.85	15.21	-0.66	1.35	1.35
SSV84 x SSV108	5.49	3.60	7.45	26.06**	8.41	8.41	4.46**	5.75*	4.93**
SSV84 x AKSS5	14.72**	6.37	24.49**	10.93	-1.17	1.17	6.73**	10.57**	3.14
SSV84 x HES4	22.13**	17.46**	27.20**	28.91	-2.42	-2.42	-3.26*	1.00	-6.73**
SSV84 x RSSV3	15.40**	5.82	26.89**	12.15**	-5.91	-5.91	0.46	4.35*	-3.13
RSSV3 x CO26	29.08**	6.64	27.87**	26.89*	10.97	-24.77*	12.62*	13.17**	4.03*
RSSV3 x SSV74	-9.42**	-10.33**	9.73*	7.40	-14.98	-1.18	-6.15**	0.96	-7.62**
RSSV3 x SSV108	2.53	-4.42	14.61**	15.67	12.30	-19.16	4.17**	8.78**	-0.89
RSSV3 x AKSS5	-0.33	-1.53	18.08**	24.21*	15.96	-9.34	9.87**	10.15**	2.24
RSSV3 x HES4	24.44**	18.39**	41.96**	57.46**	38.40**	-6.17	2.90*	2.85	-4.48*
RSSV3 x SSV84	15.64**	6.04	27.15**	49.86**	25.72**	25.72**	-5.12**	-1.45	-8.52**
SE	6.21	8.28	8.28	0.05	0.07	0.07	1.01	1.34	1.34

D I - Heterosis over mid parent ** - Significant at 0.01 level
D II - Heterosis over better parrent * - Significant at 0.05 level
D III - Heterosis over standarad parent

plant height, considerable extent of heterosis was noted 12 out of the 42 crosses studied significantly exceeded their better parental values. The heterobeltiosis ranged upto 25.47 per cent. The hybrid AKSS 5 x SSV 84 is considered to be the best for plant height because it recorded the highest value for three types of heterosis. The hybrid SSV 84 x CO 26 recorded the highest relative heterosis and standard heterosis value for leaf area per plant (Table 2). This cross combination can further be utilised for increasing forage value of grain sorghum. Senthil and Palanisamy (1994) have also reported high heterosis for leaf area in sorghum.

Days to 50 per cent flowering is one of the characters utilised for selecting early cross combinations. The hybrid HES 4 x SSV 108 is considered to be the earliest because it recorded a high negative heterosis for days to 50 per cent flowering. Heterosis for earliness in interspecific hybrids of sorghum was reported earlier by Surendran *et al.* (1988). The hybrid HES 4 x SSV 108 had the longest panicle and also recorded the highest heterobeltiosis and standard heterosis. Earlier high heterosis for panicle length was reported by Nandanwankar (1990). In respect of panicle weight a fair degree of heterosis was observed in, fifteen hybrids exceeding their better parental values. The hybrid CO 26 x AKSS 5 recorded the highest relative heterosis and standard heterosis value for panicle weight. RSSV 3 x HES 4 recorded the highest heterosis (di, dii, diii) value for 100 grain weight.

Table 1. (Continued)

Entries	Panicle length			Panicle weight			100 Grain weight			Grain yield/Plant		
	D I	D II	D III	D I	D II	D III	D I	D II	D III	D I	D II	D III
CO26 x SSV74	5.12	-0.44	31.51**	1.98	-0.04	36.89**	2.62	-4.13	-1.15	-10.37	-13.76	-48.22**
CO26 x SSV108	16.39**	13.99**	34.63**	-5.50	-21.03**	61.07**	-7.17	-16.52**	-6.40	-13.52**	-43.68**	50.05**
CO26 x AKSS5	21.65**	4.74	23.71**	96.34**	65.57**	126.74**	-2.30	-4.26	-14.27**	106.19**	52.66**	162.36**
CO26 x HES4	-1.56	-0.34	18.55**	14.04**	13.21	55.03**	10.04*	9.47	-19.71	10.23	-3.27	66.25**
CO26 x SSV84	10.61**	2.13	20.62**	91.36**	65.54**	126.71**	-3.03	-8.09	-8.09	89.47**	49.86**	157.56**
CO26 x RSSV3	-5.63*	-18.00**	31.24**	32.54**	17.33**	108.54**	-1.11	-6.30	-6.26	24.68**	11.31	143.52**
AKSS5 x CO26	14.71**	-1.24	16.66**	52.56**	28.65**	76.18**	6.60	4.47	-6.44	55.66**	15.24*	98.06**
AKSS5 x SSV74	4.93**	-13.66**	14.04**	33.42**	14.40*	50.46**	10.86**	1.65	4.80	48.26**	12.68	79.02**
AKSS5 x SSV108	11.52**	-2.25	10.69*	10.07*	-19.60**	63.98**	4.51	-7.69	3.50	11.26*	-27.11**	94.17**
AKSS5 x HES4	42.74**	20.94**	48.47**	95.56**	65.90**	123.87**	4.60	3.02	8.69	139.69**	96.15**	154.52**
AKSS5 x SSV84	15.38**	6.89	6.89	61.83**	56.99**	56.99**	16.78**	8.58	8.58	116.21**	97.42**	97.43
AKSS5 x RSSV3	-16.98**	-36.37**	1.83	11.44*	- 14.81**	51.42**	8.35*	0.72	0.76	17.29**	-19.21**	76.75**
HES4 x CO26	20.21**	17.93**	44.78**	43.97**	42.91**	95.72**	11.79**	11.21*	-0.41	42.72**	25.24**	115.24**
HES4 x SSV74	4.83	1.13	33.58**	1.26	-2.10	34.91**	3.60	-3.68	-0.69	-4.43	-13.19**	37.93**
HES4 x SSV108	39.51	34.09**	64.62**	7.71	-10.51*	82.52**	7.07	-4.15	7.47	8.34	-19.44**	114.61**
HES4 x AKSS5	23.14**	4.33	28.09**	76.47**	49.71**	102.01**	0.19	-1.32	-12.55*	138.51**	95.19**	153.27**
HES4 x SSV84	31.78**	19.56**	46.78**	20.21**	4.64	41.20**	9.05	3.65	3.65	52.18**	34.73**	74.82**
HES4 x RSSV3	8.07**	4.52	52.82**	7.65	-5.31	68.31**	7.50	1.37	1.41	18.48**	-5.27	106.46**
SSV84 x CO26	19.28**	10.13	30.08**	31.46**	13.73*	55.75**	-4.22	-9.22	-9.22	25.44**	-0.79	70.51**
SSV84 x SSV74	-0.40	-17.78**	8.62	32.89**	16.96*	53.83**	-5.31	-6.74	-3.84	36.39**	11.12	76.54**
SSV84 x SSV108	0.19	-5.66	6.88	-26.31**	- 45.09**	11.98	4.48	-1.17	10.81*	-21.56*	-46.06**	43.71**
SSV84 x AKSS5	5.75	-2.03	2.04	28.29**	24.46*	24.46*	-2.37	9.22	-9.22	66.81**	52.32**	52.32**
SSV84 x HES4	15.43**	4.73	28.56**	18.54**	3.19	39.25**	16.20**	9.59	9.59	32.53**	17.33*	52.25**
SSV84 x RSSV3	-3.70	-21.77**	25.20**	22.97**	-3.92	70.77**	8.01	8.03	8.03	37.62**	0.62	119.35**
RSSV3 x CO26	-8.36**	-20.37**	27.44**	6.31	-5.89	67.28**	6.00	-0.46	-0.46	-0.48	-11.15*	94.38**
RSSV3 x SSV74	-34.29**	-40.03**	-4.02	1.56	- 11.64*	57.05**	10.26*	12.00*	12.00*	-4.10	-17.15**	81.25**
RSSV3 x SSV108	-14.10**	-26.66**	17.37**	4.53	-2.19	99.50**	-3.36	2.52	2.52	-0.86*	-16.76**	121.77**
RSSV3 x AKSS5	-16.15**	-35.74**	2.85	-2.69	- 25.61**	32.21**	-11.08**	-17.31**	-17.31**	-4.21	-34.01**	44.36**
RSSV3 x HES4	13.58**	0.35	60.60	20.73**	6.19	88.75**	23.10**	16.21*	16.21**	33.51**	6.35	132.67**
RSSV3 x SSV84	-0.65	-19.29**	29.17**	5.76	-17.36**	46.88**	2.10	2.18	2.18	1.42	-26.11**	61.65**
SE	0.77	1.03	1.03	3.36	4.48	4.48	0.10	0.13	0.13	2.82	3.77	3.77

D I - Heterosis over mid parent
D II - Heterosis over better parrent
D III - Heterosis over standarad parent

** - Significant at 0.01 level
* - Significant at 0.05 level

Table 2. Best hybrid combinations based on heterosis values

Character	Relative heterosis (di)	Hetero-beltiosis (dii)	Standard heterosis (diii)
Plant height	AKSS 5 x SSV 84	AKSS 5 x SSV 84	AKSS 5 x SSV 84
Leaf area/plant	SSV 84 x CO 26	HES 4 x AKSS 5	SSV 84 x CO 26
Days of 50% flowering	HES 4 x SSV 108	HES 4 x SSV 108	HES 4 x SSV 108
Panicle length	AKSS 5 x HES 4	HES 4 x SSV 108	HES 4 x SSV 108
Panicle weight	CO 26 x AKSS 5	AKSS 5 x HES 4	CO 26 x AKSS 5
100 grain weight	RSSV 3 x HES 4	RSSV 3 x HES4	RSSV 3 x HES 4
Grain yield/plant	AKSS 5 x	AKSS 5 x	CO 26 x

Heterobeltiosis ranged upto 97.42 per cent for grain yield, and the hybrid AKSS 5 x SSV 84 recorded the highest value for this character. Twenty one hybrids showed positive relative heterosis for grain yield. The hybrid AKSS 5 x HES 4 recorded the highest relative heterosis value, the highest standard heterosis value was recorded in CO 26 x AKSS 5 cross combinations. The above mentioned three hybrids can further be exploited for improving grain yield in high energy sorghum types.

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RESEARCH NOTES

HETEROSIS FOR FODDER YIELD IN COWPEA

Cowpea (*Vigna unguiculata* (L.) Walp.) is an important leguminous forage crop. Being highly self-pollinated, the exploitation of hybrid vigour will depend upon the direction and magnitude of heterosis and the nature of gene effects involved in this crop. Use of heterosis *per se* may not be of much use due to absence of male sterility and efficient pollinating system. However, crosses having high heterosis can be utilized for evolving high fodder yielding quality lines. Therefore, the present study was conducted to find out the extent of heterosis for fodder yield and yield related attributes.

The experimental material consisted of six cowpea genotypes which are geographically divergent in nature (CS 98, IFC 901, UPC 9202, C 152, UPC 9103 and CO 5). Diallel crossing programme (6x6) was taken up with 15 direct crosses and 15 reciprocals. F_1 seeds with parents were grown in a randomised block design with three replications. The spacing between rows was 45 cm and between plants within a row was 20 cm. Five plants in a treatment in each replication were taken at random for recording observations for plant height, number of leaves, days to flowering, leaf area index, specific leaf weight, number of branches, green fodder yield, dry matter yield, leaf:stem ratio and crude protein content. The relative heterosis (di), heterobeltiosis (dii) and standard heterosis (diii) were calculated as outlined by Fonseca and Patterson (1968).

In the present study, the hybrids which recorded high heterotic expression over the mid parental value, better parental value and standard parent for the various traits studied are presented in Table 1. It was found that for all the characters, majority of the hybrids were significantly superior over their parents except for days to flowering. Earlier similar results were observed by Mylsami (1988). The crosses C 152 x CS 98 (plant height), UPC 9103 x IFC 901 (specific leaf weight), UPC 9103 x CS 98 (number of branches) and UPC 9103 x CO 5 (leaf:stem ratio) recorded superior heterotic expression for all the three bases of heterosis. The hybrid CO 5 x UPC 9103 showed the highest significant standard heterosis for the traits like number of leaves, green fodder yield and crude protein content and the hybrid CO 5 x UPC 9202 for days to flowering and dry matter yield.

The following hybrids namely CO 5 x C 152 for days to flowering, UPC 9202 x CS 98 for number of leaves, C152 x CO5 for leaf area index, CO5 x UPC 9103 for green fodder yield, CO 5 x UPC 9202 for dry matter yield and IFC 901 x C 152 for crude protein content exhibited highest relative heterosis. The following hybrids namely CO 5 x UPC 9202 for days to flowering, UPC 9202 x CS 98 for number of leaves, C 152 x CO 5 for leaf area index, CS 98 x C 152 for green fodder yield, CS 98 x UPC 9103 for dry matter yield and IFC 901 x C 152 for crude protein content exhibited highest heterobeltiosis.

Positive heterotic values for plant height was observed earlier by Savithramma (1991). Lodhi *et al.* (1990) reported both positive and negative heterosis for number of leaves and also for days to flowering. Positive heterotic values for leaf area index and specific leaf weight was reported by Sanghi and Kandalkar (1991). Selvaraj (1984) observed positive heterosis for number of branches. Positive heterotic effect for greeen fodder yield were reported by Jatasra *et al.* (1989).