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HETEROSIS AND COMBINING ABILITY IN INTERSPECIFIC HYBRIDS BETWEEN *bajra (Pennisetum americanum)* AND NAPIER GRASS *(P.purpureum)*

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ABSTRACT

A set of 35 interspecific hybrids obtained by crossing seven genotypes of *bajra* *(Pennisetum americanum)* as line parents with five genotypes of Napier grass *P.purpureum)* as tester parents were studied for their combining ability and for identification of superior hybrids for further multiplication. A good degree of genetic diversity was noticed in both within and between the species for all forage yield characters excepting stem thickness. *Bajra* had comparatively larger extent of variability for plant height and leaf breadth and Napier grass for tillers per clump, leaves per tiller, leaf length, stem thickness and green forage yield. Both additive and non-additive gene action, the latter being preponderant, were found important in the inheritance of forage yield and its components. Line parents No.2 and No.3 were the outstanding general combiners for four characters, including forage yield in parent No.2 and plant height in parent No.3. Among the tester parents, FD 464 was a good combiner for plant height, leaves per tiller and leaf length. As many as 28 crosses could be identified to be superior in performance for any one or few characters. Nine crosses manifested high heterosis for green forage yield. The cross No.3/FD.437 could be singled out as the most promising one as it had shown high heterosis for all the seven characters simultaneously, mostly accounted by superior s.c.a. Another cross No.2/FD 437 showed remarkable heterosis for five characters *viz.*. plant height, leaves per tiller, leaf breadth, stem thickness and green forageyield. Heterosis observed for many characters in the interspecific the Bajra-Napier hybrids manifesting heterosis for forage yield components would help to maintain a high level of forage production.

KEY WORDS : Heterosis, Combining Ability, *Bajra*, Napier Grass

Bajra (Pannisetum americanum), an annual and diploid (2n = 14), and essentially á food crop comprises of certain genotypes valued as forage crops in as much as they yield highly nutritious, palatable and quality forage (Gupta, 1980). Such fodder *bajra* types are practically devoid of anti-nutritional factor like oxalic acid. As for their yielding ability, these are included in the category of poor forage yielders. Napier grass *(P.purpureum)*, an allied species of *bajra*, is a perennial and an allotetraploid (2n=28). It is a heavy yielder of low quality forage besides being less palatable. Napier grass is otherwise endowed with virtues like growing tall, profusely tillering, more leafiness with long and broad leaves and thick stems all of which go to contribute towards high biomass production. A consideration to the effect that it would be possible to produce a hybrid between *bajra* and Napier grass with the high yeilding ability as that of Napier grass combined with good forage quality attributes as that of *bajra* interspecific hybridisation between these two genetically divergent species was attempted and this turned out to be a tremendous success. The interspecific hybrids between *bajra* and Napier grass, popularly known as *Bajra*-Napier hybrid grass, was an allotriploid with an attendant hybrid sterility. These sterile hybrids were amenable for easy vegetative propagation through stem cuttings and root-stocks. The interspecific hybrids between *bajra* and Napier grass were highly vigorous, and produced an abundance of quality forage excelling both *bajra* and Napier grass in many respects (Patil and Gosh 1962; Powell and Burton, 1966; Gupta, 1969, 1971; Gupta and Bhardwaj, 1975; Jauhar, 1961). Though the hybrid sterility encountered in

Table 1. ANOVA for forage yield characters in interspecific crosses between *Pennisetum americanum* and *P. purpureum*

Source	df	X1 Pl. ht. (cm)	X2 Tillers/clump (No.)	X3 Leaves/tiller (No.)	X4 Leaf length (cm)	X5 Leaf breadth (cm)	X6 Stem thickness (cm)	X7 G.F.Y (kg.)
Parents	11	2630.17*	38.47*	25.23	100.40	1.061	0.034	0.020
Bajra	6	3411.41*	1.00	2.90*	51.24*	0.857*	0.015	0.013*
Napier	4	1812.25*	25.35*	19.75*	157.85*	0.166*	0.335*	0.031*
Bajra vs Napier	1	1214.40	123.43	181.07*	165.63	5.873*	0.152	0.017
Crosses	34	835.24*	30.10	5.17*	216.27	0.399*	0.300*	0.114*
Parents vs crosses	1	11347.51*	3756.42*	0.40	4.32	0.010	13.523	0.800*
Error	46	10.03	0.88	0.27	10.33	0.018	0.019	0.002

the *Bajra*-Napier hybrid grass has precluded the possibility of embarking upon recombination breeding due to absence of seed set in the hybrids, the possible means of vegetative propagation is to be reckoned as a factor of high advantage in that any heterosis or desirable features manifest in the hybrid due to hybridity, can be made to persist for ever. It is such an easy means of propagation of any hybrid worth the forage value in its original form with no let up in its genetic make up that prompted to take up the present study in which a set of 36 interspecific *Bajra* - Napier hybrid grass obtained in a line x tester programme involving seven *bajra* genotypes as line and five Napir grass genotypes as tester were evaluated for their performance and promising ones identified, Alongside, an attempt has been made to obtain information on the nature and magnitude of genetic variances that govern the inheritance of the quantitative character - forage yield and its component characters.

MATERIALS AND METHODS

From among the germplasm maintained at the Department of Forage Crops, Tamil Nadu Agricultural University, Coimbatore, 7 *bajra* and 5 napier grass genotypes were selected and crosses effected during *rabi* 1989. *Bajra* was the line and Napier grass was the tester. The hybrids and their 12 parents along with the standard hybrid Co.1 were sown/planted in a randomised block design with two replications in the farm fields of the Department of Forage Crops, Tamil Nadu Agricultural University, Coimbatore, during *kharif* 1990. Hybrids and parents were sown/planted in separate blocks. Each entry was sown/planted in three row plots 4m long. Rows were spaced at 50 cm. Seeds of hybrids and that of *bajra* parents were hand-dibbled in rows following solid sowing method. Two or three budded stem cuttings in each of Napier grass parents and Co 1 were planted, adopting a spacing of 50 x 50 cm. In seed sown crops, thinning was done at appropriate time. Non-cross and selfed progenies were pulled out in the hybrid trial at the time of flowering. Hybrids were retained and care was taken to have a minimum of 50 hybrids scpaced at 50 cm in the row in each entry. Standard cultural, manurial, and manage ment practices were followed. As the hybrids were uneven in growth, all the hybrids and parents were uniformly cut at the base of the clump at 90 days after sowing. In the subsequent cut after 50 days, data were recorded on five competetive clumps in each plot for seven characters *viz*., plant height (on

Table 2. Analysis of combining ability in interspecific crosses between *Pennisetum americanum* and *P. purpureum*

Details	X1 Pl. ht.	X2 Tillers	X3 Leaves	X4 L.L.	X5 L.B.	X6 S.T.	X7 G.F.Y
Line m.s	1189.684	68.215	16.733	444.635	0.469	0.268	0.187
Tester m.s	917.812	3.551	4.270	62.412	0.123	0.311	0.155
Lx T.m.s.	732.876	25.000	2.430	184.823	0.427	0.306	0.089
6^2 g.c.a	26.739	0.906	0.673	5.725	N.E	N.E.	0.007
6^2 s.c.a	361.421	12.059	1.078	87.250	0.204	0.144	0.044
contribution of lines	25.14	39.99	87.11	36.28	20.74	15.75	10.49
" testers	12.93	1.39	9.71	3.39	3.61	12.20	7.58
" L x T	61.93	58.62	33.17	60.32	75.65	72.05	71.93

Table 3. Mean (m) and gca effects of parents involved in the interspecific crosses between *Pennisetum americanum* and *P. purpureum*

Parent	X1		X2		X3		X4		X5		X6		X7	
	m(cm)	gca	m(cm)	gca	m(cm)	gca	m(cm)	gca	m(cm)	gca	m(cm)	gca	m(cm)	gca
Lines														
No. 3	133.0	17.61*	5.5	-0.91*	5.5	2.7*	55.0	13.20	1.55	0.38*	0.75	-0.086	0.195	-0.047*
No. 2	142.5	-5.69*	4.0	-3.31*	6.0	0.3*	48.0	4.70	1.50	0.17*	0.65	0.094	0.155	-0.068*
SAR.763	154.0	6.51*	5.0	4.69*	6.0	-0.4*	58.5	-2.20	3.10	0.01	0.75	-0.176*	0.175	-0.053*
732A	50.5	-11.89	4.0	-1.01*	3.5	-0.6*	45.5	-4.06	3.15	0.02	0.85	-0.314*	0.105	-0.252*
81A	85.5	-12.89*	4.5	-0.71*	7.0	-1.4*	53.0	-5.20	2.25	0.15*	0.80	-0.116*	0.145	-0.184*
TNSC.1	162.5	4.01*	5.0	-0.91*	6.5	-0.3*	59.0	-4.10	2.25	-0.23	0.70	-0.086	0.345	-0.064*
P.131	147.5	2.31*	3.5	2.19	7.0	-0.3*	51.5	-2.40	2.25	-0.18	0.60	0.004	0.255	-0.014
S.E. gi.		0.85		0.25		0.14		0.86		0.04		0.04		0.004
Testers														
FD 464	119.0	4.54*	9.5	0.66	11.5	0.97*	54.5	3.23*	1.25	-0.07	0.75	-0.202*	0.245	-0.066*
FD 477	97.5	-3.60*	11.0	-0.20	13.0	-0.10	59.5	-0.41*	1.55	-0.08	1.05	-0.030	0.155	0.131
FD 437	168.0	1.97	8.5	0.23	10.5	-0.24	43.0	0.30	1.55	0.02	1.00	0.198*	0.440	0.067
FD 461	161.5	9.11*	13.0	0.01	15.5	-0.39	39.0*	-2.63*	1.25	-0.01	0.80	-0.045	0.255	0.003
FD 446	151.5	-11.96*	3.5	-0.70	7.0	-0.25	42.0	-0.49	0.85	0.15	0.85	-0.077	0.125	-0.135*
SE. gi.		1.00		0.55		9.17		1.02		0.04		0.04		0.004

the tallest tiller), number of tiller pr clump, number of leaves in the tallest tiller, leaf length, leaf breadth, stem thickness and green yield on clump basis. Combining ability analysis was done and heterosis was estimated as per cent improvement over better parent, mid-parent and the standard Co.1.

RESULTS AND DISCUSSION

For the first time, a serious attempt has been made in this study to analyse the components of combining ability in the interspecific hybrids between*Bajra (P.americanum)* and Napier grass *(P.purpureum)*. Significant differences were observed among parents for all characters except stem thickness and this showed that the parents chosen for the study had a good degree of genetic diversity for green forage yield and its component characters (Table 1). In between the two species, *bajra* was highly variable for plant height and leaf breath and Napier grass for other characters. The comparison of *bajra* vs Napier grass was significant for all characters and this pointed out the vast extent of genetic divergence between the two species. The variation due to hybrids and the comparison of parents vs hybrids were significant for all characters and this indicated that there was a high heterotic response in each character. Studies in genetic evaluation of germplasm in *bajra* and Napier grass have been made to choose genetically diverse parents for use in the interspecific hybridisation between *bajra* and Napier cross (Gupta, 1980).

The ANOVA for combining ability showed that the differences due to lines, testers and line x tester interaction were all significant. The mean squares due to lines were of higher magnitude compared to those of testers in respect of each character other than stem thickness and thus showed that the line *bajra* was responsible for majority of additive gene effects for all the characters, as also evidenced through a higher extent of contribution by lines to the observed variance. Both additive gene action exerted considerable influence in the inheritance of fodder yield and related characters in general (Table 2). The estimates of gca and sca variances, the later being far in excess of the former in magnitude, revealed the importance of additive and non-additive gene action in the control of the quantitative character-green forage yield and its components in the interspecific *Bajra*- Napier hybrids grass. There was a preponderance of non-additive gene action for every character and this would be reflected in the expression of high heterosis for majority of the characters. It is usually observed that additive and non-additive gene action are present for almost all yield components in crop

Table 4. Means, heterosis and sca effects of heterotic crosses

X1				X2				X3			
Cross	m	sca	h	Cross	m	sca	h	Cross	m	sca	h
No.3/FD 464	144.5	16.5*	50.5	No.3/FD 437	28.0	7.8*	55.6	No.3/FD 464	14.5	2.7*	75.8
No.3/FD 477	129.0	9.1*	34.4	No.3/FD 446	22.0	2.7*	22.2	No.3/FD 477	14.0	3.3*	69.7
No.3/FD 437	117.0	-4.5	21.9	SAR 763/FD 464	28.5	2.2*	58.3	No.3/FD 437	10.5	-0.1	27.3
No.3/FD 461	133.0	0.4	38.5	SAR 763/FD 477	27.5	2.1	52.8	No.3/FD 446	10.5	-0.1	27.3
No.2/FD 477	137.5	35.3*	43.2	SAR 763/FD 437	25.0	-0.8	38.9				
SAR 763/FD 464	132.5	15.6*	38.2	SAR 763/FD 461	27.5	1.9*	52.9				
SAR 763/FD 461	158.0	36.5*	64.6	732/FD 437	22.5	2.4*	25.0				
TNSC 1/FD 437	120.0	8.1*	25.0	81A/FD 464	24.0	3.1*	33.3				
TNSC 1/FD 461	116.0	-3.0	20.8	81A/FD 477	22.5	2.5*	25.0				
P 131/FD 464	122.5	9.8*	27.6	P 131/FD 477	25.5	7.0*	41.7				
				P 131/FD 461	27.0	8.3*	50.0				
				P 131/FD 446	24.0	6.0*	33.3				

X4				X5				X6				X7			
Cross	m	sca	h	Cross	m	sca	h	Cross	m	sca	h	Cross	m	sca	h
No.3/FD464	84.5	16.9*	54.2	No.3/FD 437	2.6	0.2	23.8	No.3/FD 437	2.2	0.5*	72.0	No.3/FD 437	0.710	0.26*	61.4
No.3/FD437	73.0	8.3*	44.0	No.3/FD 461	2.6	0.2	23.3	No.2/FD 477	2.1	0.4*	31.3	No.2/FD 477	0.825	0.20*	87.5
No.3/FD446	61.5	-2.4	21.3	No.2/FD 437	2.6	0.4*	23.8	No.2/FD 437	2.1	0.2*	31.3	No.2/FD 437	0.875	0.31*	98.9
No.2/FD477	71.5	15.3*	41.0	No.2/FD 446	2.7	0.4*	28.6	732A/FD 437	2.4	0.2*	50.0	SAR763/FD477	0.855	0.35*	94.3
SAR763/FD446	61.0	12.5*	20.3	SAR763/FD446	3.1	0.9*	47.6	732A/FD 461	2.1	0.1*	31.3	732A/FD464	0.920	0.31*	109.1
								81A/FD 437	2.1	0.3*	31.3	732A/FD477	0.570	-0.22*	29.5
								TNSC1/FD446	2.4	0.6*	50.0	732A/FD461	0.695	0.01*	89.7
								P 131/FD 464	2.0	0.6*	25.0	732A/FD437	0.206	0.06*	82.9
								P 131/FD 446	2.0	-0.1	25.0	P131/FD461	0.840	0.42*	90.9

plants. Under these circumstances, a detailed understanding of the combining ability effects of *Bajra* and Napier grass parents would help in the indentification of high yielding hybrids.

All the parents of tester and line excepting 81 A were good general combiners for any one or more characters (Table 3) Parents, No.2 and No.3 in the line were the out-standing general combiners for a maximum of four characters. Both had positive and significant g.c.a effect for each of leaves per tiller, leaf length and beadth. In addition, parent No.2 had positive gca effect for green forage yield and parent No:3 for plant height. SAR 763 was another good general combiner for plant height and tillers per clump. Other line parents-732 A, TNSC.1 and P.131 were observed to be good general combiners for green forage yield, plant height and tillers per clump respectively.

Among the tester parents, FD 464 was a good general combiner for plant height, leaves per tiller and leaf length. Both FD.437 and FD.477 were outstanding general combiners for green forage yield. FD.446 was a good general combiner for leaf breadth and FD.461. for plant height.

It was not the objective of the study to make inferences concerning gene action. The primary interest was, however, to identify crosses superior in performance, compared with standard Co.1. It was based on this consideration that the standard heterosis in per cent was worked out. A study of the standard heterosis in per cent for different characters showed that a number of them were heterotic for any one or more characters. Characterwise, 24 crosses for X_1, 29 for X_2, 15 for X_3, 13 for X_4, 11 for X_5, 19 for X_6, and 12 for X_7 were heterotic, the degree of heterosis in percent ranging from 2.6 to 64.6 for X1, 2.8 to 58.3 for X2, 3.0 to 75.8 for X3, 1.6 to 54.2 for X4, 4.8 to 47.6 for X5, 6.3 to 72.0 for X6 and 4.5 to 109.1 for X7. Considering the observed standard heterosis at a level of 20 per cent and above as more than worth exploiting for increased forage yield, a total of 28 crosses could be identified to be promising. There were 10 such crosses for X1, 13 for X2, four for X3, five each for X4 and X5 and nine each for X6 and X7 (Table 4). Of these 28 crosses, No.3 FD 437 was an outstanding one manifesting high heterosis for all the seven characters. This cross showed superior sca for four characters *viz.* tillers per clump, leaf length, stem thickness and green forage yield combined with high gca of the line parent for leaf length and stem thickness, and of the tester parent for stem thickness and gree forage yield. The cross No. 2/FD 437 showed remarkable heterosis for five characters *viz.*, plant height, leaves per tiller, leaf breadth, stem thickness and green forage yield mostly due to superior sca for all excepting stem thickness. Both parents were already indentified as good general combiners for few of the above characters. It was observed that a majority of crosses ie. 7 out of 10 for X_1, 10 cut 12 for X_2, 2 out of 4 for X_3, 4 out of 5 for X_4, 3 out of 5 for X5 out of 9 for X6 and 7 out 5 out of 9 for X7 showed superior sca and as such there was a close correspondence between high heterosis and sca. (Table 4), though high heterosis could also be observed in the absence of non- additive components in the cross No.3 /FD 437 / for plant height, leaves per tiller and leaf breadth.

The fact that the interspecific *Bajra*-Napier hybrids are vegetatively propagated, any extent of heterosis noticed in certain specific cross combinations like No.3 /FD 437 and No.2 FD 437. could be made to persist for any period of time ensuring a high level of production.

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RESEARCH NOTES

MOTH EMERGENCE AND PRODUCTION OF QUALITY EGGS OF PURE AND HYBRID RACES OF SILKWORM (*Bombyx mori*).

The success of sericultural industry depends upon the production of quality eggs. The crop loss in sericulture is mainly due to defective eggs (layings), owing to their lower hatching per cent, which may be attributed either to the defects in selection of eggs cocoons or mother moth examination. The unhygienic and defective grainage practices also add significant damages to the industry by way of low quality egg production. A temperature of 25-26 °C and 75- 80 per cent relative humidity was found ideal during incubation period. The hatching could be delayed up to 60 days by storing the eggs at 5 °C. However hatching of the acid treated eggs could be delayed up to 20 days by storing at 5 °C and the cold stored eggs could be released for incubation on any day within 20 days (Kovalev, 1970; Ullal and Narasimhanna, 1978; Jolly, 1983). Generally the storage of moths could be done at temperature of 7-8 °C while the range of storage temperature and period of preservation of male and female moths were 5-10 °C for 5-7 days and 7-10 °C for 3 days respectively (Kovalev, 1970, Krishnaswamy *et al.*, 1973 Ullal and Narasimhanna, 1978, Anonymous, 1980). Krishnaswamy *et al.*, (1973) and Ullal and Narasimhanna (1978) reported the optimum range of temperature and relative humidity for preservation of eggs cocoons as 23-25 °C and 70-80 per cent for 7 days respectively, while cocoons of 5th day after spinning were to be stored at 5 °C for a maximum period of 3 days. The mating habit and oviposition characters were studied by Krishnaswamy *et al*,, (1973) and reported that the coupling pairs were to be kept in semidark condition at a temperature of 24-25°C. The moths usually laid eggs in the afternoon hours and reached the peak of oviposition by 18-20 h. However, scientific literature on the emergence of