Table 2. Effect of treatments on dry matter yield, total Zn-uptake, % Zndff and % Utilisation of applied Zn in rice (IR.50) (Mean of 4 replications)

	Dry matter yield (g/pot)		Total uptake (mg/pot)	% Zndff	% utilisation of applied Zn
	Grain	Straw			
Zinc sources					
Control	21.0	24.0	1.78	-	-
$ZnSO_4$	33.0	34.8	4.98	4.25	0.83
$ZnSO_4$ + APP	36.2	37.7	6.00	0.24	0.16
Zincated urea	29.6	31.5	4.25	8.30	1.45
Zincated DAP	32.9	34.4	4.51	0.36	0.10
CD (at 5% level)	2.5	2.7	0.66	0.88	0.20
Soil					
Madukkur series	37.6	43.1	4.99	3.77	0.70
Nedumbalam series	23.8	25.4	3.62	2.80	0.40
CD (at 5% level)	1.6	1.7	0.42	0.62	0.14

Deb (1990). The per cent Zn utilisation which is computed from Zndff, followed a similar trend as that of the % Zndff. The treatments zincated urea and $ZnSO_4$ registered significantly higher per cent utilisation values than zincated DAP and $ZnSO_4$ + APP which were on a par.

The utilisation of applied Zn was significantly higher in the Madukkur series soil than in the Nedumbalam series soil as this soil had initially a lesser content of DTPA-extractable Zn. The results of this investigation showed that with respect to the yield of rice, $ZnSO_4$ was the best among the carriers tried. Applying $ZnSO_4$ along with APP further enhanced the yield response. There were indications that the sequestering effect of APP induced more of Zn uptake from soil pool.

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Madras Agric. J., 82(2): 131-134 February, 1995
https://doi.org/10.29321/MAJ.10.A01147

HETEROSIS AND INBREEDING IN BLACK GRAM (*Vigna mungo*)

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ABSTRACT

Heterosis (over mid-parental value), inbreeding depression and inbreeding vigour were estimated among twenty hybrids generated from a 5x5 diallel analysis involving Co 4, Co 5, UG 135, UG 191 and T 9 as parents for total dry matter production (TDMP), grain yield, and harvest index. Wide range of heterosis, inbreeding depression and inbreeding vigour was observed among hybrids for all the characters studied. The implications of heterosis, inbreeding depression and breeding vigour on formulating the improvement programme was discussed and the best cross combinations which would throw superior segregants in the subsequent generations were identified.

KEY WORDS : Black gram, Heterosis, Inbreeding

Heterosis is the superiority of the hybrid over mid parent and better parent. This superiority may be in yield,quality, disease and insect resistance or susceptibility. In many cross pollinated crops, heterosis has been commercially exploited, for example in maize, bajra, jowar, cotton, sunflower,

Table 1. Analysis of variance for TDMP, grain yield and harvest index.

Source	df	Mean squares		
		TDMP	Grain yield	Harvest index ($x 10^{-3}$)
Parents	4	185.6*	16.5**	3.8**
F_1s	19	209.4**	20.0**	5.4**
F_2s	19	101.3**	10.9**	4.1**
Patents/F_1s/F_2s	2	775.4**	205.6**	3.5**
Error	88	5.6	1.3	0.4

** Significant at P = 0.01 % level

onion etc. Many crosses in self pollinated species also show heterosis, but the magnitude of heterosis is generally smaller than that in the case of cross pollinated drops.

Though the development of hybrid varieties does not seem to be economically feasible in pulse crops, the development of purelines from hybrid material is the common practice. Information on heterosis and maintenance of vigour in F_2 or reduction in the vigour in F_2 generation is essential to develope/isolate superior purelines in later generations. Such information are scanty in blackgram and hence, an attempt was made to estimate the heterosis and inbreeding depression/vigour in F_1 and F_2 generations obtained from a 5x5 diallel mating system.

MATERIALS AND METHODS

Five parents of diverse origin namely CO 4, CO 5, UG 135, UG 191 and T 9 were crossed in a diallel system including the reciprocals to obtain 20 hybrid combinations. Five parents and their 20 F_1 and 20 F_2 families were raised in completely randomised block design with three replications, at the School of Genetics, Tamil Nadu Agricultural University, Coimbatore during 1987 summer. For parents and F_1s, each plot consisted of single row and F_2 it consisted of ten rows for each family with a spacing of 30 cm between rows and 10 cm between plants. Data were recorded on total drymatter production (TDMP), grain yield, and harvest index. Five random plants in parents and F_1s and 50 random plants in F_2 families were selected in each replication for recording the observations. The heterosis was estimated as percentage deviation of F_1 from the mid parent value. Inbreeding value was estimated as

Table 2. Mean values of F_1 and F_2 generation; heterosis over mid-parental value (d_i) and inbreading depression/vigour (ID) for TDMP, grain yield and harvest index.

Cross	TDMP				Grain yield				Harvest index			
	F_1	F_2	d_i	ID	F_1	F_2	d_i	ID	F_1	F_2	d_i	ID
CO 4/CO 5	40.8	21.7	44.6**	46.7**	14.4	7.5	50.0**	47.5**	0.3	0.36	14.49**	-2.86
CO 4/UG 135	31.6	25.7	62.0**	18.3**	13.7	8.3	101.4**	38.8**	0.4	0.33	20.55**	25.00**
CO 4/UG 191	32.1	33.3	52.8**	-3.8	12.2	12.2	62.6**	0.0	0.3	0.37	2.70	2.63
CO 4/T 9	36.0	31.1	48.1**	13.5*	14.3	9.8	64.3**	31.1**	0.4	0.32	9.59**	20.00**
CO 5/CO 4	31.5	26.2	11.7	16.6**	12.9	8.2	34.3**	35.9**	0.4	0.31	18.84**	24.39**
CO 5/UG 135	41.9	26.7	110.5**	36.1**	12.2	10.0	67.1**	18.0*	0.2	0.38	-23.68**	-31.03**
CO 5/UG 191	34.3	24.1	60.2	29.5**	12.6	6.9	52.5**	45.2**	0.3	0.29	-3.90	21.62**
CO 5/T 9	37.5	32.9	51.8**	12.0**	15.6	9.3	69.5**	40.6**	0.4	0.28	10.53*	33.33**
UG 135/CO 4	30.6	25.6	56.9**	16.0*	11.8	9.4	73.5**	19.9*	0.3	0.37	6.85*	5.13
UG 135/CO 5	36.3	29.0	82.4**	19.8**	14.9	11.3	104.1	23.8**	0.4	0.39	7.89	4.88
UG 135/UG 191	26.6	17.0	109.4**	35.9**	12.0	6.6	130.7**	44.7**	0.4	0.39	11.11**	13.33**
UG 135/T 9	26.0	14.8	62.5**	43.0**	10.7	5.6	87.5**	47.4**	0.3	0.38	-2.50	2.56
UG 191/CO 4	29.5	27.7	40.4**	5.8	12.2	10.1	62.6**	16.8*	0.4	0.37	13.51**	11.90**
UG 191/CO 5	26.2	19.4	22.4*	25.6**	11.3	7.7	4.1	31.8**	0.4	0.40	11.69**	6.98*
UG 191/UG 135	19.3	16.4	51.9**	14.9	7.7	6.3	48.0**	17.9	0.4	0.38	-1.23	5.00
UG 191/T 9	20.4	17.9	16.5	12.2	10.3	6.8	45.0**	33.9**	0.5	0.38	23.46**	24.00**
T 9/CO 4	48.6	28.9	100.0**	40.4	18.2	9.9	109.2**	45.1**	0.3	0.35	4.11	7.89*
T 9/CO 5	38.0	19.0	53.8**	49.8	14.2	7.0	54.3**	50.7**	0.3	0.37	-2.63	0.00
T 9/UG 135	13.5	24.2	-15.6	-79.9**	7.1	10.5	10.9	-48.0**	0.4	0.43	7.50	0.00
T 9/UG 191	26.4	16.0	50.8**	39.3**	10.3	5.7	45.0**	43.8**	0.3	0.36	-3.70	7.69*

* Significant at 5% level ** Significant at 1% level

percentage deviation of F_2 mean from its F_1 mean for each cross. The significant negative inbreeding value indicated the presence of inbreeding vigour whereas positive significant value indicated inbreeding depression.

RESULTS AND DISCUSSION

The Analysis of variance indicated significant differences within the parents, F_1's and F_2 generation and between the parents, F_1 and F_2 generation for all the three characters indicating the presence of appreciable amount of heterosis and inbreeding depression/vigour (Table 1). Out of 20 hybrids, 17 hybrids showed significant heterosis ranging from 22.5 (UG 191/CO 5) per cent to 110.5 (CO 5/UG 135) per cent for TDMP, 18 hybrids showed heterosis ranging from 34.3 (CO 5/CO 4) per cent to 130.7 (UG 135/UG 191) per cent for grain yield and only 9 hybrids showed heterosis ranging from - 23.6 (CO 5/UG 135) per cent to 23.4 (UG 191/T 9) per cent for harvest index (Table 2). Singh and Srivastava (1981) also reported heterosis for grain yield and harvest index, while Prem Sagar and Chandra (1977), Sagar and Lal (1979), Singh and Singh (1971) and Waldia and Malik (1981) reported heterosis for grain yield in this crop.

Appreciable amount of inbreeding depression was exhibited by almost all the hybrids in F_2 generation which showed heterosis in F_1 for all the three characters. It ranged form 12.0 per cent (CO5/T 9) to 49.8 per cent (T 9/CO 5), for TDMP production. 16.8 per cent (UG 191/CO 4) to 47.5 (CO 4/CO 5) for grain yield and from 6.9 per cent (UG 191/CO 5) to 33.3 per cent (UG 135/UG 191) for harvest index. Such expression of high heterotic vigour in F_1 followed by high inbreeding depression in subsequent F_2 generation suggested the importance of non-additive genes in these characters (Tiwari and Pandey, 1987). However, the hybrid T 9/UG 135 exhibited significant amount of inbreeding vigour for total drymatter production and grain yield (-79.9 per cent and 48.0 per cent respectively). Hybrid CO 5/UG 135 showed significant heterosis as well as significant inbreeding vigour for harvest index. Presence of such enhanced vigour for these characters can be attributed to epistatic gene action . (singh *et al.*, 1976; Deshmukh and Bhapker, 1982).

Hybrid vigour is based primarily on allelic non-additive action of codominant genes and inbreeding vigour an allelic additive action of semi codominant genes, dominant genes equally effective to both categories of vigour by acting either non-additively or additively (Fasoulas, 1980). Based on this theory, it is essential to have to study the F_1 and F_2 generations to distinguish whether the observed heterosis is due to fixable or non-fixable codominant genes, and to see the consistancy of vigour over generations or to see whether the vigour is maintained or breaks down. If the vigour is maintained dominant genes are involved otherwise codominant. (Kalia *et al.*, 1988) Such crosses with increased vigour in F_1 generation are likely to throw desirable segregants in subsequent generations and those crosses showed stable performance over generations can be used as initial breeding material for further studies (Choudhary and Anand, 1984). In the present study such stable performance in F_1 and F_2 generations was noticed in the cross combinations viz. CO 4/UG 191 for all the three characters, and in CO 4/CO 5, CO 4/UG 191, UG 135/T 9, T 9/CO 5 and T 9/UG 135 for harvest index alone.

Based on the above discussion, in the present investigation, the crosses, T 9/UG 135, CO 4/UG 191/CO 4, UG 191/UG 135, CO 5/UG 135 and UG 135/CO 5 were identified as the best hybrids for further study to improve yield, in black gram.

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Madras Agric. J., 82(2): 134-138 February, 1995

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 a 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