International Journal of Engineering Research and Modern Education (IJERME)
Impact Factor: 7.018, ISSN (Online): 2455 - 4200
(www.rdmodernresearch.com) Volume 8, Issue 1, 2023

HETEROSIS BREEDING IN GREENGRAM GENOTYPES

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Cite This Article: Pandiyan Muthaiyan, "Heterosis Breeding in Greengram Genotypes", International Journal of Engineering Research and Modern Education, Volume 8, Issue 1, Page Number 78-88, 2023.

Abstract:

In the present investigation data on F$_1$'s and parents were subjected to statistical analysis for thirteen important traits.The heterotic potential of hybrids over mid parent, better parent and standard check was also identified. Based on the superior performance of hybrids for seed yield, and *gca* and *sca* effects of the parents, four cross combinations namely VRM(Gg)1 x Vellore local, VRM(Gg)1 x ML 682, VBN1x Vellore local and K1 x Pusa bold were advanced to F$_2$ generation

Key Words: Greengram F1 hybrids, heterosis

Introduction:

Vigna radiata (L.) wilczek, commonly known as green gram or mungbean. It is one of the predominant sources of protein and certain essential amino acids like lysine and tryptophan in vegetarian diets. It possessed certain added features compared to other pulses. It is relatively drought tolerant and well adapted to a range of soil conditions including light soils and can thrive even under limited irrigation, more over, it is suited for crop rotation and crop mixtures (Baldev, 1988 and Sadaphal, 1988). However, this crop is suffering from the yield advantage as realized in case of C4 cereals.

Presently, the yield level of green gram as like other pulses is well below the optimum level. The average yield of mungbean is very low not only in India (425 kg/ha) but in entire tropical and subtropical Asia. In Tamil Nadu it is cultivated in an area of 1.63 lakhs hectare with a production of 0.78 lakhs tonnes. Besides management factors the prime cause for the low productivity can be ascribed to the inherently low yielding potential of the cultivars coupled with susceptibility to diseases.

The varietal breeding program taken up in this crop had resulted only with limited success as far as yield improvement is concerned. The basic reason for limited success had been due to the limited variability prevailed among the parents used for hybridization in most of the studies. There had been always possibility of improving the crop by incorporating wild genes to the cultivated species. For utilizing the variability available in the primary gene pools it is essential to attempt intraspecific crosses and to develop hybrids. These hybrids need to be critically evaluated as such and in the segregating generations for improvement in yield and yield components. With a view to evaluate the available germplasm using the descriptors and form the core collection and for attempting intraspecific hybridization to generate segregants for better yield, this study was taken up keeping the following objectives in mind**.**

- To generate variability through intra specific crosses
- To compare the variability created for yield and yield components among segregants generated through intra specific hybridization.

Materials and Methods:

This investigation was carried out during the period of 2021 to 2023 at Agriculture College and Research Institute, Tamil Nadu Agricultural University, Eachangkottai , Thanjavur, Tamil Nadu for African Moon University, Western Africa Material, the lines and testers were selected from the clusters of the core collection in such a way that no line and tester were from the same cluster. Adaptability and stability of parents were also given due weigtage in the selection procedure.

Female *viz.*, CO 4(L1) VRM(Gg)1 (L2), VBN1 (L3) and K1 (L4)
Male viz., Pusa bold (T1), ML 267 (T2), ML 682 (T3), VBN (Gg) 2 (T4) and
Vellore local (T5)

Twenty crosses were made using above parents in L x T fashion and their F$_1$s were planted in a randomized block design with two replications during Rabi 2022. Each entry was grown in a single row of 4-m length. The spacing was 30 cm between and 10 cm within the rows. Observation were recorded on five randomly selected plants from each plot for days to 50 per cent flowering, plant height, number of branches per plant, length of branch, number of clusters per branch, number of cluster per plant, number of pods per plant, length of pod, number of seeds per pod, hundred seed weight, single plant yield, dry matter production and days to full maturity.

Statistical analysis with AGRISTAT software used. The mean value for each entry (parents and crosses) was used for estimating the heterosis for each character. The relative heterosis, heterobeltiosis and standard heterosis were computed as follows

$$\text{a. Relative heterosis (heterosis over mid parent)} = \frac{F1-MP}{MP} \times 100$$

$$\text{b. Heterobeltiosis (heterosis over better parent)} = \frac{F1-BP}{BP} \times 100$$

$$\text{c. Standard heterosis (heterosis over standard parent)} = \frac{F1-SP}{SP} \times 100$$

Where
F1 = mean performance of the hybrid
MP = mean of the two parents involved in the cross
BP = mean of the better parent
SP = mean of standard variety (VRM(Gg)1)
Significance of the estimates of heterosis was tested by t test (Turner, 1953) at error degree of freedom as

$$\text{i. tmp} = \frac{F1-MP}{\sqrt{\frac{Me}{r} \times \frac{3}{2}}}$$

$$\text{ii. tbp} = \frac{F1-SP}{\sqrt{\frac{Me}{r} \times 2}}$$

$$\text{iii. tsp} = \frac{F1-SP}{\sqrt{\frac{Me}{r} \times 2}}$$

Where
Me = Error variance
r = Number of replications
t_{mp}, t_{bp} and t_{sp} = calculated ‘t’ value for mid parent, better parent and standard variety respectively..

Results:

In the present investigation, Analysis of variance

The analyses of variance for different characters are presented in Table 1. The Lines Vs testers variance was significant for all the characters studied (Table 2). Parents Vs crosses showed significant variance for all the traits (Table 2).

Table 1: Analysis of variance for all the 13 characters

S.No	**Characters**	**Mean sum of squares**			
		Hybrids (19)	**Parents (8)**	**Hy X Sp (1)**	**Error (28)**
1	PHT(cm)	364.85**	584.45**	29.25**	28.23
2	NOB	1.14	0.54	0.25	0.49
3	BRL(cm)	294.11**	325.50**	99.81**	43.04
4	DFF	9.67**	110.22**	0.00	2.15
5	NCB	14.34**	34.27**	16.29**	10.58
6	NOC	41.34**	69.21**	30.64**	18.85
7	NPP	143.17**	444.45**	282.05**	223.68
8	POL(cm)	0.48	0.32	0.13	0.31
9	NSP	1.60	2.25	0.59	0.79
10	HSW (g)	0.19	0.19	0.18	0.25
11	SPY(g)	19.98**	0.32	3.72	2.22
12	DMP(g)	43.92**	98.22**	25.15**	4.90
13	DFM	12.52**	188.09**	100.04**	2.88

* Significant at 5% level
** Significant at 1% level
Values in parenthesis indicate d.f.

The heterosis over mid parental value (Relative heterosis), better parental value (Heterobeltiosis) and commercial check (Standard heterosis) were computed for 20 hybrids. The extent of heterosis for individual traits is furnished in Table 2.

The extent of heterosis over mid parental value varied from -56.03 (L3 x T5) to 43.23 per cent (L4 x T1). The extent of heterobeltiosis ranged between -36.31 (L3 x T5) to 69.04 per cent (L2 x T5). The highest negative standard heterosis was noticed in L3 x T5 (-25.75 per cent). The highest significant and positive heterosis observed in L1 x T2 (114.85). Most of the hybrids showed positive and significant standard heterosis for this trait.

For number of branches per plant the lowest relative heterosis was observed in L4 x T4 (-32.28 per cent) and the maximum was recorded by L3 x T4 (93.02 per cent). The hybrids L2 x T5 (80.00) and L3 x T4 (151.52) had significant positive heterobeltiosis. The range of standard heterosis over the check VRM(Gg)1 was between -38.00 per cent (L3 x T3) and 80.00 per cent (L2 x T5). The hybrids L3 x T4 (66.00) and L2 x T5 (80.00) had significant positive standard heterosis.

Length of branch the extent of heterosis over mid parent varied from -48.73 per cent (L3 x T5) to 66.78 per cent (L4 x T1). Among the 20 hybrids L2 x T5 only exhibited significant and positive heterobeltiosis value of 133.77 per cent. The extent of standard heterosis ranged between -18.70 per cent (L3 x T3) and 163.38 per cent (L4 x T1).

Days to 50 per cent flowering the range of relative heterosis varied from - 17.27 (L1 x T5) to 17.95 (L2 x T2). Four hybrids recorded significant and negative relative heterosis for this trait. The magnitude of heterobeltiosis ranged between -14 .00 (L1 x T1) and 20.51 (L2 x T3). The highest standard heterosis in the negative direction over the check VRMG (g)1 was recorded by L2 x T1 (-2.56 per cent). Positive and significant standard heterosis was observed in sixteen hybrids

Number of clusters per branch lowest relative heterosis was observed in L3 x T5 (-62.79 per cent) and the maximum relative heterosis was observed in L3 x T1 (130.77 per cent). The hybrid L3 x T4 showed highest value of 73.33 per cent heterosis over better parent. It was followed by L4 x T5 (63.35 per cent). The range of standard heterosis over the check VRM(Gg) 1 was between -77.78 (L3 x T3) and 59.72 per cent (L4 x T5)

Number of clusters per plant lowest relative heterosis was observed in L3 x T5 (- 27.59 per cent) and maximum significant positive heterosis was registered by L3 x T1 (110.22). The hybrid L2 x T5 showed 112.50 per cent heterosis over better parent. It was followed by L4 x T5 (50.34 per cent). The range of standard heterosis over the check VRMG(g) 1 was between -46.04 per cent (L3 x T3) to 112.50 per cent (L2 x T5).Two hybrids L2 x T5 and L4 x T5 showed significant and positive heterosis over the check VRMG(g)1 .

Number of pods per plant the relative heterosis was highest in L2 x T1 (153.78) and lowest in L1 x T3 (-35.00). The maximum heterobeltiosis was observed in L2 x T4 with 75.46. The range of standard heterosis was between - 48.88 per cent (L2 x T5) and 75.46 per cent (L2 x T4). Fifteen hybrids exhibited positive heterosis over standard check VRM(Gg) 1.

Length of pod the maximum of relative heterosis expressed by the hybrids for this trait was 7.66 (L1 x T5) followed by 6.31 per cent (L1 x T3). Twelve hybrids showed negative heterobeltiosis for this trait. The highest standard heterosis was observed in L1 x T5 16.67 per cent) followed by L4 x T5 (16.59 per cent).

Number of seeds per pod the negative relative heterosis and heterobeltiosis were the highest in the hybrid L3 x T5 with -20.40 and - 14.47 per cent respectively. The standard heterosis ranged between -7.11 (L2 x

T5) and 22.27 per cent (L4 x T1). Two hybrids L4 x T1 and L1 x T2 exhibited significant heterosis in the positive direction over the check (Table 27).

Hundred seed weight the hybrids, L4 x T5 and L3 x T3 showed the maximum (17.24 per cent) and minimum (-27.79 per cent) relative heterosis respectively. For heterobeltiosis, the hybrid L4 x T2 recorded highest the positive value 19.06 per cent followed by L4 x T1 (18.67). Eight hybrids exhibited positive standard heterosis over the check VRM(Gg) 1

Single plant yield the maximum of significant and positive of 67.40 (L4 x T1), 67.92 (L4 x T1) 97.78 (L1 x T4) for relative heterosis, heterobeltiosis and standard heterosis respectively were observed. Eight hybrids showed significant and positive relative heterosis while five hybrids showed significant negative heterosis. For heterobeltios, seven hybrids showed significant positive values for this trait while three hybrids exhibited significant and negative values. Eight hybrids showed significant and positive standard heterosis than check VRM(Gg)1 while hybrid L1 x T1 exhibited significant and negative heterosis.

Dry matter production the maximum relative heterosis was observed in L3 x T1 (174.33) and maximum heterobeltiosis was observed in the hybrid L2 x T5 (120.83). The range of standard heterosis was between - 46.04 (L3 x T3) to 120.83 per cent (L2 x T5) .

Days to maturity the highest positive and significant relative heterosis was exhibited by the hybrid L3 x T1 (6.06). The heterobeltiosis for this trait was significant and positive in the hybrids L2 xT3, L2 x T4 and L2 xT5. The eleven hybrid combination exhibited the significant and positive values of standard heterosis over the check VRM(Gg) 1.

Table 2: Magnitude of heterosis for 13 quantitative characters

Crosses	**PHT**			**NOB**			**BRL**			**DFF**			**NCB**		
	di	**dii**	**diii**	**di**	**dii**	**diii**	**di**	**dii**	**diii**	**di**	**dii**	**diii**	**di**	**dii**	**diii**
L1 x T1	-4.32	-34.27 **	55.77 **	0.00	-18.18	-10.00	-23.53	-49.12 **	42.21	1.18	-14.00 **	10.26 *	-15.35	-51.60	-49.44
L1 x T 2	14.19	-9.33	114.85 **	-10.20	-20.00	-12.00	13.43	-18.77	127.01 **	0.00	-11.00 **	14.10 **	-42.49	-58.24	-56.39
L1 x T3	-0.99	-23.60 **	81.04 **	15.79	0.00	10.00	27.11	-6.32	161.82 **	-4.26	-10.00 **	15.38 **	-26.83	-52.13	-50.00
L1 x T4	-3.77	-18.40 *	93.36 **	-3.70	-5.45	4.00	5.74	-16.17	134.29 **	-4.30	-11.00 **	14.10 **	-22.66	-31.91	-28.89
L1 x T5	-18.07 **	-20.80 **	87.68 **	4.35	9.09	20.00	-3.78	-14.78	138.18 **	-17.27 **	-9.00 **	16.67 **	-31.13	-11.17	-7.22
L2 x T1	14.24	7.74	7.74	20.00	2.00	2.00	37.65	32.47	32.47	2.70	-2.56	-2.56	-13.04	-50.00	-50.00
L2 x T 2	-11.16	6.32	6.32	-15.48	-21.40	-21.40	7.29	18.44	18.44	17.95 **	17.95 **	17.95 **	-46.42	-60.56	-60.56
L2 x T3	6.23	21.50	21.50	-6.67	-16.00	-16.00	11.06	29.09	29.09	13.25 **	20.51 **	20.51 **	2.52	-32.22	-32.22
L2 x T4	-10.79	18.17	18.17	-4.85	-2.00	-2.00	28.08	68.83	68.83	4.88	10.26 *	10.26 *	-46.13	-51.67	-51.67
L2 x T5	5.26	69.04 **	69.04 **	63.64 **	80.00 **	80.00 **	48.15 *	133.77 **	133.77 **	-6.06 *	19.23 **	19.23 **	-35.01	-13.89	-13.89
L3 x T1	24.10	9.21	27.33	2.94	6.06	-30.00	4.53	-0.63	1.95	10.67 **	3.75	6.41	130.77	50.00	-25.00
L3 x T2	-5.19	4.07	21.33	31.58	51.52	0.00	3.26	12.41	15.32	6.33	5.00	7.69	-4.00	-6.67	-53.33
L3 x T3	-24.02	-20.05	-6.79	-15.07	-6.06	-38.00	-30.83	-20.76	-18.70	-1.19	3.75	6.41	-45.95	-55.56	-77.78 *
L3 x T4	-15.79	1.67	18.53	93.02 **	151.52 **	66.00 *	-7.71	19.75	22.86	4.82	8.75 *	11.54 **	33.91	73.33	-13.33
L3 x T5	-56.03 **	-36.31 *	-25.75	-1.08	39.39	-8.00	-48.73 *	-20.51	-18.44	-13.00 **	8.75 *	11.54 **	-62.79 *	-20.00	-60.00

L4 x T1	43.23 **	2.88	108.85 **	4.17	-18.03	0.00	66.78 **	17.91	163.38 **	6.25	-5.56	8.97 *	59.6	-7.95	-10.00
L4 x T2	2.26	-13.77	75.04 **	-23.08	-34.43	-20.00	15.32	-11.16	98.44 **	7.14 *	0.00	15.38 **	-41.76	-56.82	-57.78
L4X T3	28.19 **	4.75	112.64 **	-16.83	-31.15	-16.00	38.18 *	10.06	145.84 **	-3.37	-4.44	10.26 *	-8.12	-38.92	-40.28
L4 x T4	-20.65 *	-28.09 **	45.97 *	-32.28	-36.72	-22.80	-23.22	-33.49 *	48.57	2.27	0.00	15.38 **	-33.17	-39.43	-40.78
L4 x T5	-15.08 *	-11.28	80.09 **	15.70	14.75	40.00	3.85	2.03	127.92 **	-10.48 **	4.44	20.51 **	21.56	63.35	59.72

Cont.,

Crosses	NOC			NPP			POL			NSP		
	di	dii	diii	di	dii	diii	di	dii	diii	di	dii	diii
L1 x T1	-7.96	-44.68	-13.33	-22.71	-55.71*	7.16	-2.47	1.63	11.11	3.25	-5.18	12.80
L1 x T 2	-22.37	-44.15	-12.50	-21.60	-48.61	24.34	3.57	2.30	11.85	3.55	-1.20	17.54 *
L1 x T3	-1.27	-35.11	1.67	-35.00	-55.96*	6.54	6.31	3.93	13.63	4.31	-3.59	14.69
L1 x T4	-2.13	-20.74	24.17	-14.38	-37.11	52.15	3.46	3.25	12.89	-5.93	-5.18	12.80
L1 x T5	-9.80	-2.13	53.33	1.21	-39.98	45.19	7.66	6.71	16.67	-6.72	-3.19	15.17
L2 x T1	46.20	-3.75	-3.75	153.78	71.78	71.78	3.73	13.33	13.33	14.01	13.74	13.74
L2 x T 2	-20.99	-33.33	-33.33	-4.90	-16.67	-16.67	-10.39	-7.41	-7.41	-6.61	-2.84	-2.84
L2 x T3	21.13	-9.58	-9.58	65.02	53.37	53.37	-5.80	-3.70	-3.70	-1.42	-0.95	-0.95
L2 x T4	35.73	33.75	33.75	64.37	75.46	75.46	-4.04	0.22	0.22	-5.15	4.74	4.74
L2 x T5	50.00*	112.50**	112.50 **	-29.48	-48.88	-48.88	5.71	9.63	9.63	-18.50**	-7.11	-7.11
L3 x T1	110.22	45.45	20.00	116.29	40.63	65.64	-8.03	-2.92	3.56	9.21	3.40	15.17
L3 x T2	33.33	22.22	0.83	49.15	22.22	43.97	-4.86	-4.86	1.48	-6.70	-8.09	2.37
L3 x T3	-18.12	-34.60	-46.04	-29.92	-39.41	-28.63	-2.39	-3.40	3.04	-6.92	-11.28	-1.18
L3 x T4	13.69	23.74	2.08	-18.66	-20.14	-5.93	-3.78	-2.78	3.70	-4.08	0.00	11.37
L3 x T5	-27.59	16.67	-3.75	40.45	-2.95	14.31	-10.73	-10.42	-4.44	-20.40**	-14.47	-4.74
L4 x T1	77.42	11.49	37.50	28.44	-19.23	10.84	-2.82	-2.52	14.81	15.70 *	9.32	22.27*
L4 x T2	-2.82	-24.32	-6.67	35.90	5.22	44.38	-3.37	-7.92	8.44	3.45	1.69	13.74
L4X T3	29.86	-9.12	12.08	37.49	11.77	53.37	-2.47	-7.99	8.37	9.58	4.24	16.59
L4 x T4	-17.35	-26.15	-8.92	10.38	0.83	38.36	-0.72	-4.47	12.52	-5.78	-1.99	9.62
L4 x T5	20.92	50.34	85.42*	8.19	-28.17	-1.43	3.55	-1.01	16.59	-5.14	1.69	13.74

Cont.,

Crosses	HSW			SPY			DMP			DFM		
	di	dii	diii	di	dii	diii	di	dii	diii	di	dii	diii
L1 x T1	0.00	12.90	6.06	-59.10**	-57.38**	-53.41*	-24.59	-55.76**	-19.17	1.38	-13.53**	8.09 **
L1 x T 2	-6.03	-4.52	-10.30	-14.27	-15.31	-7.41	-30.41*	-52.11**	-12.50	-1.96	-11.76**	10.29 **
L1 x T3	-16.92	-12.90	-18.18	-22.11	-23.85	-16.74	-13.03	-44.81**	0.83	-5.36 **	-11.76**	10.29 **
L1 x T4	2.77	7.74	1.21	56.48 **	56.17 **	70.74 **	-10.85	-32.04**	24.17	-11.75**	-18.24**	2.21
L1 x T5	1.69	-3.23	-9.09s	-0.89	-1.76	7.41	-24.11**	-18.36	49.17 *	-21.13 **	-17.65 **	2.94

L2 x T1	-5.56	3.03	3.03	47.12 *	60.74 *	60.74 *	88.73 **	24.25	24.25	1.56	-4.41	-4.41s
L2 x T 2	-7.69	-9.09	-9.09	-18.14	-15.41	-15.41	10.22	-7.00	-7.00	0.00	0.00	0.00
L2 x T3	2.09	3.64	3.64	53.84 **	57.26 *	57.26 *	91.06 **	42.50 *	42.50 *	6.01 **	10.29 **	10.29 **
L2 x T4	-10.45	-9.09	-9.09	47.23 *	53.78 *	53.78 *	36.60 *	33.75	33.75	1.78	5.15 *	5.15 *
L2 x T5	1.64	-6.06	-6.06	25.50	30.15	30.15	42.28 **	120.83**	120.83 **	-8.41 **	8.09 **	8.09 **
L3 x T1	-13.14	-5.71	-4.85	-26.45	-22.36	-17.19	174.33 **	82.45 **	75.00 **	6.06 *	-2.78	2.94
L3 x T2	6.58	4.50	5.45	-41.25 *	-41.25	-37.33	22.47	5.13	0.83	0.00	-2.78	2.94
L3 x T3	-27.79 *	-27.03	-26.36	-37.47 *	-38.12	-34.00	-25.62	-43.74 *	-46.04 *	-3.78	-2.78	2.94
L3 x T4	-4.31	-3.30	-2.42	-49.14**	-48.61 *	-45.19	-27.29	-27.32	-30.29	-1.73	-1.39	4.41
L3 x T5	-7.34	-14.71	-13.94	45.54 *	46.04 *	55.78 *	-47.99**	-16.94	-20.33	-11.85 **	0.69	6.62 *
L4 x T1	3.19	18.67	7.88	67.40 **	67.92 **	97.78 **	103.37 **	29.29	50.83 *	5.07 *	-7.05 **	6.62 *
L4 x T2	15.16	19.00	8.18	18.09	12.52	32.52	13.39	-9.89	5.12	0.00	-6.41 **	7.35 **
L4X T3	-5.00	1.33	-7.88	-37.47*	-41.01*	-30.52	36.43	-3.04	13.12	-6.27**	-8.97 **	4.41
L4 x T4	-11.25	-5.33	-13.94	39.08*	33.84	57.63*	0.51	-8.46	6.79	-3.65	-7.05**	6.62 *
L4 x T5	17.24	13.33	3.03	53.55 **	46.79 *	72.89**	-15.01	19.14	39.00*	-14.96 **	-7.05**	6.62 *

di - Relative heterosis dii - Heterobeltiosis diii - Standard heterosis

Discussion:

The present investigation for selection of parental accessions from the core and performing intraspecifc crosses in L x T fashion and evaluation of the intraspecific F_1 and F_2 generations for computing combining ability heterosis, gene action and variability parameters for yield and yield components Intraspecific hybridization there are many approaches for selection of parents for hybridization programme viz., selection of parents based on *per se* performance, ecogeographical diversity, regression analysis, genotypic value, multivariate approaches and combining ability analysis. Hierarchical cluster and Principal component analyses are multivariate analyses of quantitative and qualitative traits for measuring divergence among a set of population using the concept of statistical distance computed using multivariate measurements. If parents are identified on the basis of divergence analysis, the resulting recombinants through hybridization would be more heterotic with the possibility of obtaining larger frequency of better segregants in subsequent generations (Reddy. 1998) and Aher *et al* .(2001). For intrtraspecific hybridization the parents selected for represent maximum genetic diversity. The hierarchical cluster analysis and Principal component analysis approaches were utilized to select parents for interspecific hybridization. The parents were selected from distant clusters to represent maximum diversity. The lines and testers were selected from the clusters of the core collection in such a way that no line and tester were from the same cluster. However wider adaptability and stability were also given due weigtage for selection. By considering all the genetical factors, parental lines *viz.,* CO4, VRM(Gg)1, VBN1, K1, Pusa bold, ML 267, ML 682, VBN(Gg)2 and Vellore local were selected for performing intraspecific crosses. Heterosis the combining ability analysis gives useful information regarding selection of parents based on the performance of their hybrids and further it helps for the exploitation of heterosis. Among the parents, Vellore local was found to be the best general combiner as it exhibited significant and positive general combining ability effects for six traits. This was followed by K1 which exhibited high significant and positive general combining ability effects for four characters. The accessions VRM(Gg)1 and CO4 exhibited high significant and positive general combining ability for two traits each. The combining ability analysis also provides an understanding of genetic architecture of traits and would be useful in handling the segregating material. The ability of parents to combine well depends upon various complex genic interactions, which cannot fully be judged by phenotypic performance. Thus the combining ability gives indication of genetic behaviour of parent material enabling the breeder to select upon and utilize it for further exploitation.

It will be more appropriate and reliable to consider together the combining abilities evaluated and the *per se* performance of parents and hybrids and the extent of heterotic vigour for suggesting viable future breeding programmes. Singh and Jain (1971) and Singh (1974) suggested that, selection of pure lines, through hybridization would be the best alternative to the exploitation of hybrid vigour. In grain legumes like greengram, the inter-varietal crosses often exhibit higher expression of heterosis which is generally due to dominant gene effects (Singh and Singh, 1972) and sometimes due to epistatic interaction and gene dispersion (Jinks, 1983).

Many workers have reported a relationship between combining ability and *per se* performance, in order to understand these relationships, the results on combining ability, *per se* performance and heterosis observed for various traits

Plant Height (cm):

Among the parents studied the genotypes CO4 and K1 had exhibited significant and positive gca effects among lines and ML. 267, ML 682 and Vellore local registered highest gca effects for plant height among testers. These genotypes may be inferred as good general combiners and donors for this trait.

The sca effects of hybrids CO4 x ML 267, VRM(Gg) 1 x Vellore local and K1 x Pusa bold were high. There was a fair agreement between sca effect, *per se* performance and heterosis with regard to CO4 x ML 267 the similar results were reported by Malar. (1994).

Positive relative heterosis for plant height was recorded by eight hybrids. The average magnitude of positive heterosis was higher than that of the negative direction. Positive heterobeltiosis was registered by 10 hybrids and positive and significant standard heterosis was exhibited by 11 hybrids. The magnitude was still wider when compared to relative heterosis. The hybrid CO4 x ML 267 expressed the highest heterosis of 114.85 per cent over the standard parent. Heterosis for plant height was recorded by Raghuram Reddy and Sree Ramulu (1982). Breeding tall varieties appears to be a preferable line of approach in greengram since tallness is always positively associated with high productivity. This could be explained on the basis that tall plants produced more vegetative and reproductive nodes on the main stem (Malar 1994 and Bhatnagar and Balram Singh,1964).

Number of branches per plant:

The *gca* effects as well as *per se* performance recorded by VRMG(g)1 and Vellore local was high and these parents were found to be good general combiners for number of branches per plant. The *sca* effects of the hybrids VBN 1 x VBNG(g)2 was high and the *per se* performance of this hybrid was moderate. Among the parents showing good *gca* effects the only parent VBN1 seemed to be a good specific combiner with VBN(Gg) 2. Thus VBN1 was identified as best donor for number of branches per plant.

The relative heterosis and heterobeltiosis on positive direction were recorded by nine and eight hybrids respectively. The magnitude of relative heterosis and heterobeltiosis on positive direction was higher when compared to negative direction. Heterotic vigour in greengram for number of branches per plant was reported by Khattak *et al.* (2002), Singh and Jain (1971), Raghuram Reddy and Sree Ramulu (1982), Manjare and Deshmuk (1981).

Length of branch (cm)

The parents CO4, K1 and Vellore local showed high *gca* effects for length of branch coupled with high *per se* performance and so the genotypes CO4, K1 and Vellore local were considered as the best donors for this trait.

The hybrids K1 x Pusa bold, VRM(Gg)1 x Vellore local and CO4 x ML 682 registered high *sca* effects. The *per se* performance was also high in all these three hybrids. It was observed that there existed a fair agreement between *sca* effect, *per se* performance and heterosis.

For this trait the relative heterosis and heterobeltiosis on positive direction was expressed by 14 and 10 cross combinations respectively. The magnitude of positive relative heterosis and heterobeltiosis was higher when compared with those on negative directions.

Days to 50 per cent flowering:

The genotypes Pusa bold, ML.267, VBN1 and VRM(Gg)1 showed low *gca* effects for 50 per cent flowering with low *per se* performance and so the genotypes Pusa bold, VBN1 and VRM(Gg)1 were considered as the best donors for this trait.

The hybrids K1 x ML 682, VBN1 x ML 267 and VRM(Gg)1 x Pusa bold encountered low *sca* effects and the *per se* performance was found as moderate in all these three hybrids. It was observed that there existed a fair agreement between *sca* effect, *per se* performance and heterosis.

For this trait the relative heterosis and heterobeltiosis on positive direction was expressed by 11 and 10 cross combinations respectively. The magnitude of positive relative heterosis and heterobeltiosis was higher when compared with those on negative directions.

Number of clusters per branch:

The genotypes Vellore local, K1, Pusa bold and VBN (Gg) 2 showed higher *gca* effects. The *per se* performance was high for Vellore local and it was moderate in K1 and low in Pusa bold. Thus among the nine parents, Vellore local was considered as best donor for this trait.

The hybrids K1 x Vellore local, VRM(Gg) 1 x ML 682, VBN1 x Pusa bold and VBN1 x ML 267 registered high *sca* effects. The *per se* performance was high in K1 x Vellore local and VBN 1 x Pusa bold and it was moderate in other hybrids. The magnitude of relative heterosis and heterobeltiosis was higher in positive direction when compared to negative direction. Heterotic vigour in greengram for number of clusters per plant was also observed by Raghuram Reddy and Sree Ramulu (1982) in greengram and Premsagar and Lal (1979) in black gram.

Number of clusters per plant:

The genotypes K1, VRM(Gg)1 and Vellore local showed high *gca* effects for this trait with high *per se* performance and hence the genotypes K1, Vellore local and VRM(Gg)1 were considered as best donors for number of clusters per plant..

The hybrids VRM(Gg)1 x Vellore local and VBN1 x ML 267 recorded high *sca* effects. While *per se* performance of the former was high that of the later was moderate. It was observed that there existed a fair agreement between *sca* effect, *per se* performance and heterosis.

For this trait the relative heterosis and heterobeltiosis were on positive direction and was expressed by 10 and eight cross combinations respectively. The magnitude of positive relative heterosis and heterobeltiosis was higher when compared with those on negative directions, similar results were also reported by Reddy (1998) and Loganathan *et al.* (2001).

Number of pods per plant:

The genotypes VBN(Gg)2, Pusa bold, K1, CO4 and VRM(G g)1 possessed high *gca* effects, whereas the mean performance was high in CO4 and K1 and it was moderate in VBN1 and low in Pusa bold. As combining ability of these three genotypes namely VBN(Gg)2, Pusa bold and K1 were high they could be considered as the best donors for this trait.

Higher *sca* effects were noticed in the crosses CO4 x Vellore local, VBN 1 x Pusa bold, VRM (Gg)1 x Pusa bold and VRM(Gg) 1 x VBN(Gg) 2. The crosses VRM(Gg) 1 x Pusa bold, VBN1 x Pusa bold, VRM(Gg)1 x VBN(Gg)2 registered high *per se* performance coupled with high heterotic vigour. Thus a fair agreement was observed between *sca* effects, *per se* performance and heterosis for this trait in these hybrids.

The relative heterosis was in positive direction for 12 hybrids and heterobeltiosis was in positive direction for eight hybrids. The magnitude of positive heterosis was higher both in relative heterosis and heterobeltiosis, similar results were reported by Reddy (1998) and Loganathan *et al.* (2001).

Length of pod (cm):

The parental accessions K1, CO4, Pusa bold and Vellore local exhibited good general combining ability effects and high *per se* performance. So these four genotypes were considered as best donor for pod length.

The hybrids VRM(Gg)1 x Pusa bold, VRM(Gg)1 x Vellore local, VBN1 x ML 267, VBN1 x ML 682, CO4 x ML 267 and CO4 x ML 682 exhibited higher *sca* effects coupled with higher *per se* performance. The good general combiner CO4 was also found to be good specific combiner in three out of five cross combinations.

The relative heterosis was positive for seven hybrids and heterobeltiosis was positive in eight cross combinations. The difference in magnitude between positive and negative direction heterosis was higher in relative heterosis and it was not so wider in heterobeltiosis. Similar results were reported by Malhotra (1983) and Singh and Jain (1971).

Number of seeds per pod:

CO4, K1 and Pusa bold were the parents possessing good *gca* effects hence these parents were considered as good general combiners for number of seeds per pod.

Cross combinations CO4 x Vellore local, CO4 x ML 267, VBN1 x VBN(Gg)2 VRM(Gg)1 x Pusa bold, VRM(Gg)1 x VBN2 , K1 x ML 682 and K1 x Vellore local registered high *sca* effect and the *per se* performance was higher in K1 x Pusa bold, CO4 x ML 267, K1 x ML 682, CO4 x Vellore local, VBN1 x Pusa bold and VRM(Gg)1 x Pusa bold. The genotype K1 though was good general combiner, exhibited poor specific combining ability in many hybrids. The relative heterosis and heterobeltiosis were positive in eight and seven hybrids respectively and the magnitude was higher in positive direction when compared with negative direction both in relative heterosis and heterobeltiosis. Hybrid vigour for seeds per pod was reported by Raghuram Reddy and Sree Ramulu (1982) in greengram, similar result was reported by Reddy (1998) and Loganathan *et al.,* (2001)

Hundred seed weight (g):

The parents recorded high *per se* values were Pusa bold, ML 682 and VBN(Gg)2 and they could be used as donor for this trait. The *gca* value was also high for Pusa bold and hence could serves as best combiner. The hybrid VRM(Gg)1 x ML 682 recorded high sca value with moderate *per se* performance. The relative heterosis was positive for eight hybrids and the heterobeltiosis was positive for nine hybrids. The magnitude of positive heterosis was lower than the negative heterosis Loganathan *et al.* (2001).

Single plant yield (g):

The parents that possessed high mean performance were Pusa bold and K1 hence they could serve as best donor for this trait. As the *gca* value was higher in parent K1 followed by Vellore local and VRM(Gg)1, they could serve as best general combiners. The hybrids possessed high *sca* values and high mean performance for this trait were K1 x Pusa bold, CO4 x VBN(Gg)2, VBN1 x Vellore local , VRM(Gg)1 x Pusa bold and

VRM(Gg)1 x ML 682. The relative heterosis was positive for 10 hybrids and heterobeltiosis was positive for 10 hybrids. The magnitude of positive heterosis was equal to negative heterosis, similar result was reported by Reddy (1998), Naidu and Satyanarayana (1993) and Loganathan *et al.* (2001)

Dry matter production:

The parents, Vellore local and CO4 recorded high mean values for total dry matter production while the *gca* effects were high in VRM(Gg)1, Vellore local and Pusa bold indicating the disagreement between combining ability and *per se* performance. Thus the parental genotypes Vellore local could serve as good donors for this trait. The hybrids VBN1 x Pusa bold, VRM(Gg)1 x Vellore local registered high *sca* effects and the *per se* performance was also high in these hybrids. For this trait about 11 and 8 hybrids possessed positive relative and heterobeltiosis respectively. The magnitude of positive heterosis was high for this trait. The heterosis over mid parent and better parent for this trait was registered by Natarajan (1989) and Natarajan and Palaniswamy (1988 and 1990) in their studies on green gram.

Days to full maturity:

The parents recorded low mean values for the earliness related trait were Pusa bold, ML 267 and VRM(Gg)1 and they serves as best donor for earliness. The gca value was also low for Pusa bold which inturn serves as best combiner. The hybrid VRM(Gg) 1 x Pusa bold recorded low values of *sca* and *per se* performance. The relative heterosis was negative for 11 hybrids and the heterobeltiosis was negative for 15 hybrids. The magnitude of negative relative heterosis was lower than the heterobeltiosis. (Swindell and Poehlman 1976).

Donors for different traits:

The donors for different yield attributes based on mean performance were CO4, Vellore local and K1 for plant height, number of branches per plant, length of branch and number of clusters per plant, Vellore local, CO4 and VRM(Gg)1 for number of clusters per branch and dry matter production, CO4, VBN1 and VBN(Gg)2 for number of pods per plant, Pusa bold, K1 and CO4 for length of pod and single plant yield, Pusa bold, ML 682 and VBN(Gg)2 for hundred seed weight and Pusa bold , VRM(Gg)1 and ML 267 for lesser number of days to 50 per cent flowering and days to full maturity.The hybrids combinations of VRM(Gg)1 x ML 682, K1 x Pusa bold, VRM(Gg)1x Vellore local, VBN1 x Vellore local and CO4 x VBN(Gg)2 are worth pursuing for their best *per se* performance, heterosis and high sca effects with respect to seed yield and other yield components.

Gamble (1962) reported that reduction in magnitude of additive effect was met within crosses involving parents that had undergone selection for the characters in question. Narayanan (1978) and Kadambavanasundaram (1980) in cotton and Iyemperumal (1983) in greengram reported the influence of dominance and epistasis when widely divergent parents were used. It may also be due to the fact that the characters concerned possessed complexity of inheritance with low magnitude of additive effect. The non-fixable dominance deviation and epistatic effects are likely to hinder the improvement through simple pedigree selection, which is being commonly followed at present in grain legumes, particularly in greengram. Under such situation breeding procedure has to be amended to suit the needs by postponing the selection to later segregating generations. Alternatively, among the available breeding methods, intermating of the F_2 segregants followed by reciprocal recurrent selection could alter the different kinds of gene effects. Repeated selection and intermating of the segregating materials for two or three cycles, makes it possible to achieve simultaneous improvement in seed yield and related economic characters. The other viable breeding technique to handle the present set of breeding materials seems to be effecting multiple crosses which are expected to be superior to those of single crosses as suggested by Natarajan (1987). Appreciable heterosis is present in the hybrids investigated. However, the development of commercial hybrids does not seem to be a possibility at present due to lack of male sterile mechanisms and low amount of natural crossing in greengram. Alternatively the possibility of development of high yielding homozygotes equal to or better than the heterotic F_1 hybrids in greengram can be developed through proper and efficient handling of the cross combinations with high *per se* and heterotic performance as opined by Rathnaswamy and Jagathesan, (1984) and Aher *et al.* (2001).

Conclusion:

For selection of parental lines with maximum genetic diversity, Intra- specific hybridization was carried out by adopting L x T model for which the parents were selected from the core collection by giving due weightage for genetic diversity and wide adaptability.

Computation of GCA and SCA variances for most of the traits indicated predominance of dominant gene action as sca variances were higher than gca variance. The values of standard heterosis were high for most of the traits and majority of the crosses indicating existence of practically usable heterosis and the possibility of generating promising segregants in the later generations.

The mean performance of parents and hybrids were higher for various characters *viz.*,K1(3.05) and Vellore local (3.00), VRM(Gg)1 x Vellore local (4.50) for number of branches per plant, CO4 (53.80) and K1 x Pusa bold (50.70) for length of branch. For number of clusters per branch, Vellore local (14.85) and K1 x Vellore local (14.38) recorded highest mean performance. Vellore local (22) and VRM(Gg)1 x Vellore local

(25.50) for number of cluster per plant, CO4 (59.15) and VRM(Gg)1 x VBN(Gg)2 (49.90) for number of pods per plant and for hundred seed weight highest mean performance among the parents and crosses were registered by Pusa bold (3.90) and K1 x ML 267 (3.57) and K1 x Pusa bold (3.56). The cross VRM(Gg)1 x Vellore local exhibited significant and positive relative, heterobeltiosis and standard heterosis for characters, plant height, number of branches per plant, length of branch, number of clusters per plants and dry matter production. The crosses VRM(Gg)1 x VBN(Gg)2 and CO4 x Vellore local recorded higher magnitude of relative, heterobeltiosis and standard heterosis, for number of pods per plant , single plant yield and pod length.

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