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Combining Ability for Yield and Yield Attributes Characters in Greengram (*Vigna radiata* L. Wilczek)

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A B S T R A C T

Five lines were crossed with four testers in Line × Tester fashion to estimate the combining ability for yield and yield attributing traits in greengram. Analysis of variance revealed significant differences among genotypes, crosses, lines, testers and line × tester interactions for most of the traits. Preponderance of non-additive gene effects was realized from higher values of specific combining ability compared to general combining ability and ratio of variances of SCA to GCA except for day to maturity. Parents' viz., IPM 2-3, ML 1299, ML and 2037 were considered as superior parents as they recorded high per se performance with positive significant effects for seed yield per plant and other yield contributing traits. Cross combinations viz., BM 2003-2 x IPM 2-3, VAIBHAV x IPM 409-4, BM 4 x MH 2-15, BM 4 x PUSA 0612, VAIBHAV x ML 1299, AKM 4 x MH 2-15, BM 2002-1 x ML 818 and AKM 4 x IPM 409-4 were found to be good specific combinations for seed yield per plant and other desirable traits. These cross combinations could be utilized for further amelioration of seed yield in greengram.

Introduction

Greengram [*Vigna radiata* (L.) *Wilczek*], is an economically important short duration grain legume characterized by relatively more palatable, nutritive, cheap source of high quality and easily digestible protein, non-flatulent than other pulses and constitute an important source of cereal based diets in Asia (Kamleshwar *et al.,* 2014). In-spite of high demand, the yield of greengram worldwide is very low (384 kg/ha) and limited success has been achieved so far in augmenting its yield. To enhance the present yield levels, it is essential a systemic varietal improvement through hybridization and exploitation of generated variability through recombination breeding. To breed a genotype with high yielding potential, the information on the genetic mechanism controlling various traits in the material being handled, is a pre-requisite. The estimates of combining ability along with per se performance of genotypes in a crop improvement program have a direct bearing upon the choice of breeding methodology to be followed and to identify the parent and crosses (Khattak *et al.,* 2004), which could be exploited for future breeding programme. In literature, both additive and non-additive genetic systems, controlling seed yield and yield-relating traits in greengram, have been reported (Barad *et al.,* 2008, Marappa, 2008; Sathya and Jayamani, 2011; Sujatha and Kajjidoni, 2013 and Suresh, 2014). However, the major part of genetic variation for yield and its components was conditioned due to higher magnitude of non-additive genetic effects (Marappa, 2008; Sathya and Jayamani, 2011; Sujatha and Kajjidoni, 2013 and Suresh, 2014). Seed yield and several yield contributing characters lack stability due to strong environmental influence, suggesting the need for breeding for specific environment. Therefore, the present investigation was planned and executed to assess the nature of gene action involved and combining ability of parental genotypes for different characters utilizing Line × Tester mating design (Kempthorne, 1957) for evolving productive varieties in greengram.

Materials and Methods

Five lines BM 4, BM 2002-1, BM 2003-2, AKM 4, and VAIBHAV were crossed with seven tester IPM 409-4, ML 1299, MH 2-15, IPM 2-3, ML 2037, ML 818, and PUSA 0612 in Line X tester fashion at Agricultural Research station, Badnapur. College of Agriculture Badnapur, Maharastra. All the genotypes (twelve parent and 35 F_1' s) were evaluated in Randomized Block Design with two replication during summer, 2014. Each genotype was grown in one row of four meter length with a spacing of 30cm between row and 15cm between plants. Recommended agronomic and plant protection package of practice were followed to raise healthy crop. Data were recorded on five randomly selected competitive plants in each genotype and replication. Mean value on per plant basis were recorded for the characters, *viz.,* plant height, number of cluster per plant, number of pod per cluster, number of pod per plant, number of seed per pod, pod length, hundred seed weight, seed yield per plant, protein content and the micro-Kjeldahl 'N' procedure was used for the determination of nitrogen and crude protein was estimated by multiplying the nitrogen content by a factor of 6.25. However, data on day to 50% flowering and maturity were recorded on plot basis. The mean data was analysed to compute combining ability effect and their variances according to Kempthorne (1957).

Results and Discussion

Analysis of variance along with the estimates of gca and sca variance their ratio for eleven character is shown in table 1. The annova showed highly significant differences for majority of character, indicating the presence of sufficient variability in experimental material. The variance due to crosses was highly significant for all the traits which indicated the diverse nature of selected parent for majority of the character. Partitioning of variance among the hybrid revealed that the mean square due to line showed highly significant differences for plant height, pod length and 100 seed weight, which indicated the presence of sufficient variability for these three characters. Significant variance is due to tester for plant height and protein content. The significant variance due to line x tester interaction for all the traits excepting that of plant height showed its existence among the tester and hybrid population respectively for these eleven traits. This indicated the presence of significant differences between males and females.

Based on the study per se performance of parents and estimates of gca effect Among female parents, BM 4 exhibited significant GCA effects for plant height, number of pods per cluster and number of pods per plant. The line BM 2002-1 exhibited significant GCA effects for days to maturity, number of seed per pod, pod length and hundred seed weight, while BM 2003-2 was good general combiner for day to 50% flowering, day to maturity, number of clusters per plant, pod length and hundred seed weight, while VAIBHAV was good general combiner for plant height, number of pod per plant and protein per cent.

Out of seven males, IPM 409-4 was a good general combiner for number of pod per cluster, number of pods per plant, where as ML 1299 was found good general combiner for Days to maturity, number of pod per plant and seed yield per plant. The tester MH 2-15 was found good general combiner for day to 50% flowering, days to maturity and number of pod per cluster.

Whereas IPM 2-3 was a good general combiner for day to 50% flowering, day to maturity, number of cluster per plant, number of pod per cluster, number of pod per plant, pod length, seed yield per plant and protein per cent, whereas ML 2037 was a good general combiner for day to 50% flowering, day to maturity, number of cluster per plant, pod length, hundred seed weight and protein per cent, whereas ML 818 also good general combiner for day to maturity and hundred seed weight, whereas PUSA 0612 was a good general combiner for plant height, and protein per cent (Table 2). Similar results were reported by Reddy and Sreeramulu (1982), Choudhary (1986), Halkunde *et al.*, (1996), Dasgupta *et al.*, (1998), Jahagirdar (2001), Aher *et al.,* (1999), Singh (2005), Barad *et al.*, (2008), Patil *et al.,* (2011).

The cross combination BM 2003-2 X IPM 2-3 (5.63) recorded highest significant desirable SCA effect for grain yield per plant. Similar result has also been reported by Barad *et al.*, (2008), Patil *et al.,* (2011).

The cross combination BM 4 x PUSA 0612 (7.42) recorded highest significant desirable SCA effect for number of pods per plant. This result is in agreement with the finding of Ahuja (1980), Shanthi priya *et al.*, (2012).

The highest significant negative desirable SCA effect was observed for days to 50% flowering in AKM 4 x ML 2037 (-3.30) these finding are in agreement with earlier report made by Deshmukh and Manjare (1980) and Jahagirdar (2001).

The highest significant negative desirable SCA effect was observed for days to maturity in BM 2003-2 x ML 2037 (-2.91) similar result were also reported by Jahagirdar (2001).

For plant height in BM 2003-2 x ML 2037 (5.84) was observed highest significant desirable SCA effect. This result was in agreement with the findings of Manjare (1976), Shanthi priya *et al.*, (2012)

The cross combination BM 2002-1 x IPM 409-4 (2.91) had recorded highest significant desirable SCA effect for number of clusters per plant. Similar results were also reported by Manjare (1976), Shanthi priya *et al.*, (2012).

For number of pods per cluster in BM 4 x MH 2-15 (1.94) was revealed highest significant desirable SCA effect. This result was in agreement with the finding of Shanthi priya *et al.*, (2012).

The cross combination AKM 4 x ML 1299 (1.53) observed highest significant desirable SCA effect for number of seed per pod (Table 3). These results are in confirmation with the previous work done by Jahagirdar (2001), and Singh and Dikshit (2003).

The hybrid combination BM 2003-2 x IPM 409-4 (1.83) recorded highest significant desirable SCA effect for pod length.

Similar result has also been reported by Yadav and Lavanya Roopa (2011).

Table.1 Analysis of variance of line X tester with respect to eleven characters in Mungbean [*Vigna radiata* (L.) Wilczek]

Sorce of variability	d.f	Days to 50% flowering	Days to maturity	Plant height	No. of clusters per plant	No. of pods per cluster	No. of pods per plant	No. of seeds per pod	Pod length	100- seed weight	yield per plant	Protein
Replication	1	0.51	0.01	1.06	0.58	0.25	1.82	0.02	0.04	0.02	0.82	0.01
Crosses	34	8.15**	34.41**	56.78**	5.67**	2.54**	47.10**	1.46**	3.41**	0.79**	9.64**	2.86**
Lines	4	11.66	28.76	121.47*	6.47	5.09	95.94	1.91	13.18**	3.88**	12.54	4.36
Testers	6	15.49*	133.43**	120.41**	3.29	0.75	53.57	1.63	1.65	0.46	5.95	5.62*
Females x Males (L x T)	24	5.73**	10.60**	30.08	6.14**	2.48**	37.35**	1.34**	2.22**	0.35**	10.08**	1.92**
Error	34	0.86	0.44	2.60	0.16	0.07	0.49	0.22	0.02	0.02	0.96	0.09

* and ** indicates significance at 5 and 1 per cent level respectively

Table.2 Estimation of general combining ability with respect to eleven characters in Mungbean (*Vigna radiata* L. *Wilczek*)

Genotypes	Days to 50% flowering	Days to maturity	Plant height	No. of clusters per plant	No. of pods per cluster	No. of pods per plant	No. of seeds per pod	Pod length	100 seed weight	Seed yield per plant	Protein per cent
Testers											
IPM 409-4	2.44**	7.80**	0.86	-0.07	0.21*	1.56**	-0.89**	0.03	-0.14*	-0.16	-0.42**
ML 1299	0.44	-2.60**	-1.34*	-0.12	-0.01	3.15**	0.17	-0.27**	-0.12*	0.60*	-0.03
MH 2-15	-1.25**	-0.50*	-2.66**	-0.91**	0.29**	0.43	0.26	-0.16**	0.00	0.36	-1.17**
IPM 2-3	-0.65*	-2.80**	-2.02**	0.43**	0.25**	1.55**	-0.03	0.38**	0.04	0.90**	0.50**
ML 2037	-1.05**	-0.80**	-0.83	0.95**	-0.19*	-1.71**	0.20	0.64**	0.20**	-0.22	1.10**
ML 818	0.04	-1.80**	-1.43**	-0.16	0.07	-1.52**	0.13	-0.06	0.33**	-0.01	-0.40**
PUSA 0612	0.04	0.70**	7.46**	-0.12	-0.63**	-3.44**	0.14	-0.56**	-0.29**	-1.47**	0.43**
S.E ±	0.28	0.20	0.51	0.11	0.08	0.21	0.15	0.05	0.05	0.29	0.08
C.D. at 5%	0.57	0.41	1.04	0.23	0.17	0.43	0.31	0.11	0.12	0.59	0.17
C.D. at 1%	0.76	0.55	1.39	0.31	0.23	0.58	0.42	0.15	0.16	0.80	0.22
Lines											
BM 4	1.47**	2.08**	3.22**	-0.85**	0.83**	1.82**	-0.01	-0.59**	-0.43**	0.06	-0.30**
BM 2002-1	-0.10	-1.84**	-3.43**	-0.02	-0.52**	-3.19**	0.61**	1.13**	0.44**	-1.18**	-0.32**
BM 2003-2	-0.88**	-0.48**	-1.68**	1.03**	-0.563**	-2.14**	-0.13	0.82**	0.59**	0.26	-0.41**
AKM 4	-0.60*	0.44*	-1.03*	0.04	0.39**	3.00**	-0.39**	-1.18**	-0.61**	1.36**	0.11
VAIBHAV	0.11	-0.20	2.93**	-0.20*	-0.13	0.51**	-0.07	-0.17**	0.00	-0.51*	0.92**
S.E ±	0.23	0.17	0.43	0.09	0.07	0.18	0.13	0.04	0.05	0.24	0.07
C.D. at 5%	0.48	0.34	0.88	0.20	0.14	0.37	0.26	0.09	0.10	0.50	0.14
C.D. at 1%	0.64	0.46	1.18	0.26	0.1985	0.4981	0.35	0.13	0.13	0.67	0.19

* and ** indicates significance at 5 and 1 per cent level respectively.

Table.3 Estimates of specific combining ability with respect to 11 characters in Mungbean (*Vigna radiata L. Wilczek*)

Sr. No.	Crosses	Days to 50% flowering	Days to maturity	Plant height	Cluster/ plant	No. of pods/ cluster	No. of pods/ plant	No. of seed/ pod	Pod length	100 seed weight	Yield/plant	Protein
1	BM 4 X IPM 409-4	1.12	-2.08**	0.78	-1.45 **	-2.03**	-7.08**	1.02**	-1.49**	-0.02	-2.77**	0.29
2	BM 4 X ML 1299	-0.37	0.31	-2.00	0.69*	-0.85**	-3.12**	-0.34	0.26*	0.02	-1.90**	-1.29 **
3	BM 4 X MH 2-15	0.82	-1.28**	2.91*	0.43	1.94**	6.69**	-0.43	0.00	-0.18	2.50**	-0.10
4	BM 4 X IPM 2-3	-0.77	2.01**	2.47*	-0.05	-0.02	2.02**	-0.03	1.65**	-0.02	0.69	-0.68**
5	BM 4 X ML 2037	0.12	4.51**	1.18	-0.72**	1.93**	-1.35**	-0.27	-0.59**	-0.05	-0.20	-0.58**
6	BM 4 X ML 818	-0.47	-0.98*	0.53	-1.26**	-0.64**	-4.59**	0.09	-0.24	0.16	-0.54	1.37**
7	BM 4 X PUSA 0612	-0.47	-2.48**	-5.91**	2.34**	-0.33	7.42**	-0.01	0.40**	0.10	2.23**	0.99**
8	BM 2002-1 X IPM 409-4	2.70**	2.84**	1.44	2.91**	-0.57**	-1.31*	1.35**	0.92**	-0.20	-1.43*	-0.98**
9	BM 2002-1 X ML 1299	0.20	0.74	-1.74	-2.03**	0.70**	0.79	-1.07**	-0.84**	0.32*	0.08	0.78**
10	BM 2002-1 X MH 2-15	-1.10	-0.85	-0.67	0.35	-1.10**	-6.23**	-0.56	0.72**	-0.01	-0.62	-1.12**
11	BM 2002-1 X IPM 2-3	-1.20	0.94*	0.63	-1.93**	-0.66*	-2.30**	0.29	-0.57**	0.06	-0.45	1.42**
12	BM 2002-1 XML 2037	0.70	-1.05*	-1.05	0.793**	-0.81**	0.71	0.55	0.65**	0.44**	0.77	-0.56**
13	BM 2002-1 X ML 818	0.10	-0.05	2.59*	-0.39	1.81	5.92**	-0.03	-1.12**	-0.26	1.91**	0.19
14	BM 2002xPUSA0612	-1.40*	-2.55**	-1.20	0.31	0.62**	2.39**	-0.54	0.24	-0.35*	-0.26	0.26
15	BM 2003-2 XIPM 409-4	-2.51**	0.48	-2.75*	-1.84**	1.46**	2.43**	-0.90*	1.83**	0.15	-0.30	0.89**
16	BM 2003-2 X ML 1299	-0.01	-1.11*	-5.79**	-0.69*	-0.15	0.94	-0.52	-0.51**	-0.01	-0.99	-0.21
17	BM 2003-2 X MH 2-15	-2.81**	5.28**	1.07	-2.70**	-1.31**	-3.03**	0.53	-1.37**	-0.15	-3.09**	0.65**
18	BM 2003-2 X IPM 2-3	2.08**	-1.91**	-0.91	1.95**	1.52**	6.24**	0.98**	-0.86**	0.45**	5.63**	-0.52**
19	BM 2003-2 X ML 2037	0.98	-2.91**	5.84**	2.83**	-1.02**	-2.33**	-0.18	1.11**	0.35*	-0.98	0.62**
20	BM 2003-2 X ML 818	1.38*	-0.91	0.44	1.29**	-0.29	-0.12	0.21	1.42**	0.33*	1.45*	-0.70**
21	BM 2003-2 X PUSA0612	0.88	1.08*	2.09	-0.84**	-0.18	-4.10**	-0.09	-1.62**	-1.13**	-1.70*	-0.72**
22	AKM 4 X IPM 409-4	0.70	-1.94**	-1.98	0.50	0.75**	2.33**	-1.85**	-1.35**	-0.07	1.82**	1.13**
23	AKM 4 X ML 1299	1.70*	0.45	5.05**	-0.05	0.53**	-1.05*	1.53**	1.00**	-0.15	0.74	0.50*
24	AKM 4 X MH 2-15	1.40*	-1.64**	-6.32**	1.98**	0.02	4.51**	0.34	0.06	-0.03	1.96**	-1.26**
25	AKM 4 XIPM 2-3	-0.20	0.65	0.33	1.29**	-0.93**	-2.70**	0.06	0.09	-0.10	-3.33**	-0.144
26	AKM 4 X ML 2037	-3.30**	-1.34**	1.74	-0.87**	0.11	1.36**	0.30	-0.35**	-0.08	0.76	0.387*
27	AKM 4 X ML 818	0.10	0.65	-3.45**	-0.31	-0.25	0.07	-0.43	0.16	-0.06	-1.58*	-0.09
28	AKM 4 X PUSA 0612	-0.40	3.15**	4.64**	-1.50**	-0.24	-4.55**	0.16	0.38**	0.44**	-0.37	-0.52**
29	VAIBHAV X IPM 409-4	-2.01**	0.70	2.520*	0.89**	0.38	3.62**	0.38	0.09	0.15	2.69**	-1.33**
30	VAIBHAV X ML 1299	-1.51*	-0.40	4.48**	2.09**	-0.23	2.43**	0.41	0.09	-0.18	2.06**	0.21
31	VAIBHAV X MH 2-15	1.68*	-1.50**	3.005*	-0.06	0.45*	-1.94**	0.12	0.57**	0.31*	-0.75	1.83**
32	VAIBHAV X IPM 2-3	0.08	-1.70**	-2.53*	-1.25**	0.09	-3.26**	-1.17**	-0.31*	-0.39**	-2.54**	-0.06
33	VAIBHAV XML 2037	1.48*	0.80	-7.72**	-2.02**	-0.20	1.60**	-0.40	-0.82**	-0.65**	-0.35	0.13
34	VAIBHAV X ML 818	-1.11	1.30**	-0.12	0.68*	-0.62**	-1.28*	0.15	-0.21	-0.17	-1.22	-0.77**
35	VAIBHAV X PUSA 0612	1.38*	0.80	0.37	-0.30	0.13	-1.16*	0.49	0.59**	0.93**	0.11	-0.01
	SE (+)	0.62	0.45	1.14	0.26	0.19	0.48	0.34	0.12	0.13	0.62	0.18
	CD 5 %	1.27	0.91	2.33	0.53	0.39	0.98	0.70	0.26	0.26	1.33	0.38

* and ** indicates significance at 5 and 1 per cent level respectively

The cross combination VAIBHAV x PUSA 0612 (0.93) recorded highest significant desirable SCA effect for hundred seed weight.

Similar result has also been reported by Katiyar (2015) and Tiwari and Ramanujan (1974).

In case of protein per cent the cross combination VAIBHAV X MH 2-15 (1.83) observed highest significant desirable SCA effect. These results are with confirmation with the result of Shanthi priya *et al.,* (2012).

The parents showed high GCA can be used for the future hybridization programmes. The gca estimates of lines and testers emphasized the importance of lines AKM 4 and tester IPM 2-3, ML 1299 for their use as a desirable parents for enhancing the yield potential through assembling the favourable genes for yield and yield components.

The crosses which showed high SCA effect could be used for the hybrid development. The high yielding crosses *viz*., BM 2003-2 X IPM 2-3, VAIBHAV X IPM 409-4, BM 4 X MH 2-15 were found to be the superior for seed yield and yield component and should be further tested across the different environment for their stability performance.

AKM 4 was best combiner for seed yield per plant and other some character like number of pod per cluster, number of pod per plant and negative significant for days to 50% flowering; ML 1299 for days to maturity, number of pod per plant, seed yield per plant and IPM 2-3 for days to 50% flowering, days to maturity, number of cluster per plant, number of pod per cluster, number of pod per plant, pod length, seed yield per plant and protein content. Since high gca effect are due to additive and additive x additive gene action they can be readily exploited in breeding program (Griffing, 1956).

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