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COMBINING ABILITY ANALYSIS FOR SEED YIELD, ITS COMPONENT AND PROTEIN CONTENT IN MUNGBEAN (*VIGNA RADIATA* L. WILCZEK)

Y. PUROHIT[1]*, Y. RAVINDRABABU[2], R. A. GAMI[3], M. P. PATEL[4], P. T. PATEL[5] AND A. M. PATEL[6]
[1]Cotton Research Station, Talod,
[2]Pulses Research Station,
[3]Maize Research Station, Bhiloda
[4]Department of Genetics and Plant Breeding, C. P. College of Agriculture,
[5]Seed spices Research Station,
[6]Pulses Research Station,
S. D. Agricultural University, Sardarkrushinagar - 385 506 (Gujarat)
e-mail: yogeshpurohit07@gmail.com

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***Corresponding author**

ABSTRACT

Ten widely varied genotypes of mungbean (*Vigna radiata* L. Wilczek) were crossed in a diallel fashion, excluding reciprocals to study general and specific combining ability (GCA and SCA) and gene action involved in the inheritance of characters. Analysis of variance for GCA and SCA were shown significant for all the traits. Predominance of non-additive gene action for all the characters apart from harvest index (%), where additive gene action was more evident. Parents, GM-4 (1.64) and Pusa-0871 (0.50) were found to be good general combiners for grain yield per plant and parent GM-4 was also good general combiner for most of traits, excluding numbers of branches per plant, pods per plants and protein content. Four promising crosses out of 45 crosses, *viz*., Sonamung-1 X Vamban-1 (2.52), Meha X IPM-02-19 (2.11) and Sonamung-1 X VGG-ru-1 (1.97) and Pusa-0871 X VGG-ru-1 (1.87) were revealed the best hybrids for grain yield per plant. Whereas the hybrids, Meha X IPM-02-19 (1.86), Meha X Vamban-1(1.49) and GM-4 X Pusa-0871 (1.29) were the best specific combiners for increasing protein content

INTRODUCTION

Pulses popularly known as "poor man's meat" since it provide the major source of dietary protein to the large section of vegetarian population of the world. Mungbean [*Vigna radiata* (L.) Wilczek] (2n = 2x = 22) is a third important pulse after Bengal gram and red gram .In India, there are about a dozen pulse crops, among them mungbean is highly priced and being of short duration and having wide adaptability, it is grown all the year round. Due to smaller grain size, low yield potential and susceptibility to various biotic stresses improved varieties is not sufficient to attract the farmers as well as consumers. (Yadav et *al*., 2015). In the present day of input responsive agriculture, there is a need to breed varieties which as a result of their ability to respond to better quantity of grain besides early and synchronous in maturity.

The combining ability studies in self-pollinated crop are regarded useful in assessing the nicking of parents, which on crossing would produce more desirable segregates. Such study also elucidate the nature and magnitude of gene action involved in the inheritance of grain yield and its components, which will decide the breeding programme to be followed in segregating generations. Among different mating designs, diallel analysis is a systematic approach for identification of superior parents and their cross combination(s). It provides an overall genetic nature of the experimental material in single generation. The earlier Aher *et al*. (2001) observed that GCA and SCA variances were significantly high for yield and it's components in an 8 X 8 diallel set of mungbean and also reported that the additive gene effects were predominant for all the characters. Swamy and Reddy (2004) and Gupta *et al*. (2006) were found non-additive gene effects for yield and its components traits. In other hand Patil *et al*. (2011) and Vaidya *et al*. (2015) reported importance of both additive and non additive type of gene action for inheritance of important yield and yield contributing traits. The nature of gene action, its magnitude and constitution of genetic architecture are of enormous value to plant breeder, keeping these in view the present investigation was undertaken to make an assessment of combining ability and gene action of parents and their hybrids in mungbean with the diallel analysis.

MATERIALS AND METHODS

The experimental material comprised of ten parents (GM-4, Meha, Pusa-0871, IPM-02-19, Sonamung-1, SML-1082, Vamban-1, Pusa-9531, Pant-M-5, and VGG-ru-1) representing wide spectrum of variation were crossed in a diallel fashion, excluding reciprocals, The resultant 45 crosses along with their ten parents were evaluated in Randomized Block Design with three replications at Pulses Research Station, S. D. Agricultural University, Sardarkrushinagar during *kharif* 2014. Observations were recorded on five randomly competitive plants in parents and their hybrids for phonological traits (days to flowering, days to maturity and protein content (%)) and structural traits (plant height (cm), number of branches per plant, number of pods per plant, pod length (cm), number of seeds per pods, 100-seed weight (gm), grain yield per plant (gm) and harvest index (%)).Data on days to 50 % flowering was recorded on plot basis. same as the number of days from date of sowing to the date when 80 per cent plants in a plot reached on the stage of physiological maturity was recorded. The nitrogen content of each grinded sample was estimated on NIR-photo spectrometer apparatus. The nitrogen content was multiplied by 6.25 to obtained protein content. The combining ability analysis was performed for 55 genotypes (Parents and hybrids) according to the procedure given by Griffing (1956), as per Method-II and Model-I.

RESULTS AND DISCUSSION

The analysis of variance for combining ability were revealed that the mean square due to parents were significant for all the traits. While mean square due to parents *vs.* hybrids were significant for the all characters excluding pods per plants, 100 seed weight and protein content, enlightening good extent for expression of heterosis in all the characters studied (Table 1). The ratio $ó^2_{gca}/ó^2_{sca}$ however, indicated the predominance of non-additive gene action for all the characters except harvest index (%), one of the major yield component traits. It is ranges from 0.143 to 1.21 compliant the major role of non-additive gene action for all the traits under study except for harvest index (%) (Table 1). Consequently in present study grain yield and major yield contributing components expressed both non-additive and additive type of gene action. From the estimates of dominance and additive variance, it was observed that dominance variance was predominant for all the characters except for harvest index indicating the major role of non-additive gene action and was uppermost for number of seeds per pod followed by plant height and grain yield.The predominance of non-additive gene action, however, brought out that this component could be exploited in hybrid development in mungbean (Table 1). The similar result also reported by Patil *et al*. (2011):Vaidya *et al*. (2015), and so gene action might be expressed by both additive and non-additive type for grain yield and its contributing traits.

The earliness is one of the prime objectives of any breeding programme and it can be determined by early flowering and maturity. In the present study, parents SML-1082 (-2.23) and GM-4 (-1.34) and Pusa-9531 (-1.31), exhibited significant and negative gca effects and were considered to be a good general combiners for early flowering. While parents Pusa-9531(-2.79), GM-4 (-0.79) and IPM-02-19 (-0.71), indicated superiority of these parents in transmitting desirable gene for earliness in maturity to their descendants (Table 2). The estimates of specific combining ability effects ranged from -5.64 (GM-4 X Meha) to 3.92 (GM-4 X Sonamung-1). Three hybrids, (GM-4 X Meha) (-5.64), GM-4 X Pant-M-5 (-4.56), and GM-4 X SML-1082 (-3.16) were found the best hybrids for exploiting early flowering as they exhibited significant and negative sca effects. In case of days to maturity, the hybrids, Pusa-0871 X Pusa-9531

Table 1: Analysis of variance for combining ability for various characters in mungbean

Sr. No.	Source of variation	d.f.	Days to flowering	Days to maturity	Plant height (cm)	Number of branches per plant	Number of Pods Per plant	Pod length (cm)	Number of Seeds per pod	100-seed weight (g)	Grain yield per plant (g)	Harvest Index (%)	Protein content (%)
1.	GCA	9	24.13**	31.27**	328.34**	1.00**	173.99**	0.21**	5.43**	0.57**	6.33**	23.37**	0.50**
2.	SCA	45	4.61**	6.89**	52.35**	0.24**	101.92**	18.38**	0.84**	0.22**	1.32**	3.28**	0.67**
3.	Error	108	0.54	1.13	0.29	0.07	2.00	2.17	0.10	0.03	0.36	1.79	0.07
s^2gca			1.96	2.51	27.33	0.08	14.33	0.02	0.43	0.04	0.49	1.79	0.03
s^2sca			4.06	5.76	52.05	0.23	99.91	0.39	‘0.73	0.18	0.96	1.48	0.59
s^2gca/s^2sca			0.48	0.44	0.52	0.36	0.143	0.041	0.59	0.24	0.51	1.21	0.06

Table 2: Estimates of general combining ability (gca) effects of the parents for various characters in mungbean

Sr. No.	Source of variation	Days to flowering	Days to maturity	Plant height (cm)	Number of branches per plant	Number of Pods Perplant	Pod length (cm)	Number of Seeds per pod	100-seed weight (g)	Grain yield per plant (g)	Harvest Index (%)	Protein content (%)
1.	GM-4	-1.34**	-0.79**	-4.80**	-0.26**	-7.35**	0.24**	0.19*	0.48**	1.64**	1.87**	-1.34**
2.	Meha	0.42*	-0.01	1.59**	0.03	0.60	0.17**	0.20*	-0.17**	0.14	0.14	-0.42*
3.	Pusa-0871	-0.03	-0.65*	-0.62**	0.17**	0.10	-0.17**	0.18*	-0.22**	0.50**	0.80*	-0.03
4.	IPM-02-19	0.27	-0.71*	-3.71**	0.07**	5.86**	-0.003	-0.27**	-0.21**	-0.69**	-1.86**	0.27
5.	Sonamung-1	2.02**	3.04**	-10.65**	-0.65**	-3.62**	-0.19**	-1.78**	-0.18**	-0.88**	-2.94**	2.02**
6.	SML-1082	-2.23**	-0.54	-0.85**	-0.16**	-3.34**	-0.042	-0.041	0.051	0.16	0.73	-2.23**
7.	Vamban-1	1.38**	1.93**	4.68**	0.27**	0.86*	-0.006	0.46**	-0.07	-0.54**	0.24	1.38**
8.	Pusa-9531	-1.31**	-2.79**	4.71**	0.31**	3.05**	-0.02	0.542**	0.07	-0.40*	0.26	-1.31**
9.	Pant-M-5	-0.17	-0.34	5.72**	0.17**	1.99**	-0.04	0.37**	0.12*	0.18	-0.002	-0.17
10.	VGG-ru-1	1.83**	0.85**	3.93**	0.05*	1.85**	0.04	0.144	0.14**	-0.11	0.77*	1.83***
	$S.E.G_i$	0.20	0.29	0.15	0.02	0.39	0.04	0.08	0.05	0.16	0.36**	0.07

*p ≥ 0.05,** p ≥ 0.01

Table 3: Estimates of specific combining ability (SCA) effects for various characters in mungbean

Sr.No.	Source of variation	Days to flowering	Days to maturity	Plant height (cm)	Number of branches per plant	Number of Pods Perplant	Pod length (cm)	Number of Seeds per pod	100-seed weight (g)	Grain yield per plant (g)	Harvest Index (%)	Protein content (%)
1.	GM-4 X Meha	-5.64**	0.58	2.54**	-0.59**	-10.78**	-0.54**	-1.09**	-0.07	-1.41*	-1.91	0.33
2.	GM-4 X Pusa-0871	-1.69*	1.88	3.44**	-0.20*	-9.15**	0.61**	0.59	0.17	0.37	0.35	1.29**
3.	GM-4 X IPM-02-19	-0.67	-1.06	7.15**	0.59**	10.72**	-0.38**	-1.39**	1.13**	1.43*	2.75*	-0.21
4.	GM-4 X Sonamung-1	3.92**	-2.81**	-4.91**	-0.32**	-6.20**	-0.42**	0.34	-0.75**	-1.75**	-1.13	-0.55*
5.	GM-4 X SML-1082	-3.16**	-1.23	9.36**	0.29**	12.89**	-0.03	0.92**	-0.32	0.62	0.045	0.37
6.	GM-4 X Vamban-1	0.22	-3.03**	-8.88**	-0.23**	3.43*	0.55**	0.38	-1.09**	1.72**	0.59	-0.006
7.	GM-4 X Pusa-9531	-0.08	1.35	-0.40	0.65**	-6.30**	0.19	0.29	-0.32	-0.76	0.45	0.65*
8.	GM-4 X Pant-M-5	-4.56**	-0.76	1.10*	0.7**	6.93**	0.99**	0.85**	0.86**	0.78	1.16	0.85**
9.	GM-4 X VGG-ru-1	3.78**	-2.95**	-10.77**	0.58**	0.13	0.48**	-1.04**	-0.26	0.99	0.70	-0.021
10.	Meha X Pusa-0871	-1.28	0.44	-5.03**	0.10	12.22**	0.17	2.19**	-0.335	-0.76	2.03	0.47
11.	Meha X IPM-02-19	2.08**	-4.17**	-4.81**	0.60**	-1.60	-0.16	0.79*	-0.08	2.11**	2.53*	1.86**
12.	Meha X Sonamung-1	3.33**	-2.26*	1.44**	0.66**	16.28**	0.45**	-1.14**	0.28	0.31	-1.83	-1.12**
13.	Meha X SML-1082	-0.75	0.33	-1.43**	1.10**	-9.77**	0.18	0.33	0.037	0.71	-0.35	0.23
14.	Meha X Vamban-1	-2.03**	-2.15*	8.71**	0.78**	-0.66	0.55**	-1.07**	0.30	0.43	0.75	1.49**
15.	Meha X Pusa-9531	-1.00	1.24	-9.41**	-0.24**	1.38	0.08	0.22	0.09	0.57	0.35	0.41
16.	Meha X Pant-M-5	-0.47	-0.20	3.90**	-0.03	-12.93**	-0.22	-0.93**	-0.28	-0.59	-1.877	-1.15**
17.	Meha X VGG-ru-1	-0.47	-0.06	1.88**	0.05	2.68*	0.75**	0.18	-0.18	0.02	0.05	0.3
18.	Pusa-0871 X IPM-02-19	-0.31	-0.87	6.59**	-0.17*	-4.44**	0.04	0.73*	0.19	0.32	-0.8	-0.14
19.	Pusa-0871 X Sonamung-1	-0.06	0.05	2.66**	0.38**	-6.32**	0.39**	-1.18**	-0.09	-0.32	-1.91	1.1**
20.	Pusa-0871 X SML-1082	0.53	3.63**	7.9**	-0.07	-7.28**	0.13	-1.8*	-0.03	0.53	1.02	-0.99**
21.	Pusa-0871 X Vamban-1	0.25	-3.17**	-1.85**	-0.40**	-13.46**	0.28*	0.26	0.09	1.32*	-0.19	0.31
22.	Pusa-0871 X Pusa-9531	-0.06	-5.78**	-1.06*	-0.24**	-9.06**	-0.43**	0.56	-0.07	-1.29*	1.91	0.27
23.	Pusa-0871 X Pant-M-5	-0.86	-0.56	-3.28**	-0.14	-5.6**	-0.42**	0.71*	0.42*	0.19	0.02	-1.10**
24.	Pusa-0871 X VGG-ru-1	-0.53	-1.76	-0.9	-0.39**	-12.02**	-1.02**	0.11	-0.25	1.87**	-1.28	-0.02
25.	IPM-02-19 X Sonamung-1	-1.03	1.44	5.59**	0.31**	9.68**	-0.05	1.44**	0.23	-0.005	1.23	0.83**
26.	IPM-02-19 X SML-1082	-0.78	-1.65	2.1**	-0.27**	-4.56**	-0.10	-0.95**	-0.34*	-1.00	-1.28	0.18
27.	IPM-02-19 X Vamban-1	0.61	0.21	-0.31	0.4**	10.01*	0.2	-0.45	-0.32	-0.35	-2.69*	-0.09
28.	IPM-02-19 X Pusa-9531	2.64**	0.60	-5.65**	-0.45**	6.68**	-0.04	0.45	0.001	0.26	1.66	-0.05
29.	IPM-02-19 X Pant-M-5	-1.83*	4.16**	-5.73**	-0.37**	13.81**	-0.21	-0.20	-0.29	-1.09	-1.69	-0.41
30.	IPM-02-19 X VGG-ru-1	-0.83	2.96**	-2.92**	-0.02	15.41**	1.12**	-0.27	-0.31	-0.8	0.61	-1.04**
31.	Sonamung-1 X SML-1082	-1.53*	2.27*	-7.1**	-0.19*	2.02	0.31*	1.92**	-0.36*	-1.49**	-1.12	1.16**
32.	Sonamung-1 X Vamban-1	-0.47	1.8	-2.29**	-0.014	1.73	0.49**	-0.27	-0.12	2.52**	3.29*	-0.87**
33.	Sonamung-1 X Pusa-9531	-0.44	-3.15**	1.35*	-0.42**	-2.47	0.37**	0.37	-0.50**	0.04	0.65	0.18
34.	Sonamung-1 X Pant-M-5	-0.58	-0.26	0.45	-0.32**	-9.17**	1.77**	-0.39	0.79**	1.17*	2.5*	-0.40
35.	Sonamung-1 X VGG-ru-1	0.42	0.88	-2.89**	-0.30**	-1.30	-0.45**	-0.01	0.74**	1.97**	3.44**	-0.41
36.	SML-1082 X Vamban-1	1.78*	-2.62*	-9.47**	-0.54**	-3.19*	0.07	0.43	0.61**	-0.11	1.07	-0.98**
37.	SML-1082 X Pusa-9531	-0.19	0.10	7.02**	-0.38**	-3.49*	-0.2	0.16	-0.33	0.47	-1.34	-0.73**
38.	SML-1082 X Pant-M-5	0.67	-3.008**	-0.32	-0.37**	1.11	0.24	-0.17	-0.48**	0.60	1.39	-0.15
39.	SML-1082 X VGG-ru-1	1.33	4.46**	1.15*	-0.02	2.01	-0.64**	-1.57**	0.30	-0.61	0.96	-0.77**
40.	Vamban-1 X Pusa-9531	1.53*	-1.37	15.06**	0.12	-0.65	-1.55**	0.58	0.34*	-0.09	-0.18	-0.40
41.	Vamban-1 X Pant-M-5	0.06	1.19	20.97**	0.30**	12.01**	-0.59**	0.11	0.60**	-1.11*	-0.58	-0.19
42.	Vamban-1 X VGG-ru-1	-0.94	-0.67	-6.27**	-0.62**	-5.98**	-0.22	0.35	0.08	-1.47*	0.38	0.26
43.	Pusa-9531 X Pant-M-5	2.42**	0.58	-10.9**	0.25**	-4.21**	0.44**	-0.29	0.41*	0.68	0.39	-0.48
44.	Pusa-9531 X VGG-ru-1	1.42*	-1.62	-4.25**	0.20*	2.13	0.05	0.60*	-0.34	0.26	1.39	0.52*
45.	Pant-M-5 X VGG-ru-1	-0.06	2.60*	-7.02**	0.51**	6.02**	-0.6**	1.02**	-0.39*	1.12*	-5.08**	0.51
	S.E.ij.±	0.68	0.98	0.50	0.08	1.30	0.13	0.30	0.17	0.55	1.24	0.25

*p ≥ 0.05,** p ≥ 0.01

(-5.78) and Meha X IPM-02-19 (-4.17) were the best specific combiners (Table 3). The results were in accordance with Barad *et al*. (2008) and Sujatha and Kajjidoni (2013).

Among the parents, Sonamung-1 (-10.65), GM-4 (-4.80) and IPM-02-19 (-3.71) showed significant and negative gca effect for dwarfness. In contrast to this, the parents, Pant-M-5 (5.72), Pusa-9531 (4.71), Vamban-1 (4.68) and VGG-ru-1 (3.93) were good general combiner for tallness, as they exhibited significant and positive GCA effects (Table 2). Out of 45 crosses, three crosses *viz,* Pusa-9531 X Pant-M-5 (-10.9), SML-1082 X Vamban-1 (-9.47) exhibited significant and negative SCA effects and emerged out as the best specific combiner for dwarfness. In contrast to this, the cross combinations Vamban-1 X Pant-M-5 (20.97), Vamban-1 X Pusa-9531 (15.06) and GM-4 X SML-1080 (9.36) were considered to be the best cross combinations for tallness (Table 3). The results show resemblance to the finding of Zubair *et al*. (2007), Barad *et al*. (2008), Kumar *et al*. (2010), Yadav and Lavanya (2011) and Patil *et al*. (2011).

The top three parents which exhibited highest gca effect for the number of branches per plant were Pusa-9531 (0.31), Vamban-1 (0.27), Pusa-0871 (0.17) and Pant-M-5 (0.17). Likewise, hybrids, Meha X SML-1082 (1.10), Meha X Vamban-1 (0.78) and GM-4 X Pant-M-5 (0.7) exhibited significant positive SCA effects for the number of branches per plant. Whereas parent IPM-02-19 (5.86), Pusa-9531 (3.05), Pant-M-5 (1.99), VGG-ru-1 (1.85), and Vamban-1 (0.86) possessed positive and significant gca effect for higher number of pods per plant and were emerged good general combiner (Table 2). Despite the fact that in case of pods per plant crosses Meha X Sonamung-1 (16.28), IPM-02-19 X VGG-ru-1 (15.41), IPM-02-19 X Pant-M-5 (13.81) and GM-4 X SML-1082 (12.89) were found the best three specific combiners (Table 3). The similar type of results also reported by Patel *et al*. (2010), Yadav and Lavanya (2011), Sujata and Kajjidoni (2013), Bainade *et al*. (2014) and Vaidya *et al*. (2015)

Table 4: Top ranking parents with respect to *per se* performance and gca effects and the three top ranking hybrids with respect to *per se* performance and their sca effects

Character	Best performing parent (*per se* per formance)	Best general combiners	Best performing hybrids (*per se* performance)	Status of the parents	Hybrid with SCA effects	Status of the parents	sca effects
Days to flowering	Pusa-9531	SML-1082	GM-4 X Meha	G X A	GM-4 X Meha	G X A	-5.64**
	SML-1082	GM-4	GM-4 X SML-1082	G X A	GM-4 X Pant-M-5	G X A	-4.56**
	IPM-02-19	Pusa-0871	GM-4 X Pant-M-5	G X G	GM-4 X SML-1082	G X G	-3.16**
Days to maturity	IPM-02-19	Pusa-9531	Pusa-0871 X Pusa-9531	G X G	Pusa-0871 X Pusa-9531	G X A	-5.78**
	SML-1082	GM-4	Meha X IPM-02-19	A X G	Meha X IPM-02-19	A X G	-4.17**
	Pant-M-5	IPM-02-19	SML-1082 X Pant-M-5	G X A	Pusa-0871 X Vamban-1	G X P	-3.17**
Plant height (cm)	Sonamung-1	Sonamung-1	GM-4 X Sonamung-1	G X G	Pusa-9531 X Pant-M-5	P X P	-10.9**
	IPM-02-19	GM-4	Sonamung-1 X SML-1082	G X G	GM-4 X VGG-ru-1	G X A	-10.8**
	GM-4	IPM-02-19	GM-4 X VGG-ru-1	G X P	SML-1082 X Vamban-1	G X P	-9.5**
	SML-1082	-	-	-	-	-	-
Number of branches per plant	Pusa-0871	Pusa-9531	Meha X Vamban-1	A X G	Meha X SML-1082	A X P	1.10**
	Pusa-9531	Vamban-1	Meha X SML-1082	A X P	Meha X Vamban-1	A X G	0.78**
	Vamban-1	Pusa-0871	GM-4 X Pusa-9531	P X G	GM-4 X Pant-M-5	P X G	0.7**
Number of pods per plant	Pusa-0871	IPM-02-19	IPM-02-19 X VGG-ru-1	G X G	Meha X Sonamung-1	A X P	16.28**
	Pusa-9531	Pusa-9531	IPM-02-19 X Pant-M-5	G X G	IPM-02-19 X VGG-ru-1	G X G	15.41**
	Meha	Pant-M-5	IPM-02-19 X Vamban-1	G X G	IPM-02-19 X Pant-M-5	G X G	13.81*
Pod length (cm)	Pusa-9531	GM-4	Sonamung-1 X Pant-M-5	P X A	Sonamung-1 X Pant-M-5	P X A	1.77**
	VGG-ru-1	Meha	GM-4 X Pant-M-5	G X A	IPM-02-19 X VGG-ru-1	A X A	1.12**
	Vamban-1	-	IPM-02-19 X VGG-ru-1	A X A	GM-4 X Pant-M-5	G X A	0.99**
Number of Seeds per pod	Vamban-1	Pusa-9531	Meha X Pusa-0871	G X G	Meha X Pusa-0871	G X G	2.19**
	Meha	Vamban-1	Vamban-1 X Pusa-9531	G X G	Sonamung-1 X SML-1082	P X A	1.92**
	VGG-ru-1	Pant-M-5	Pant-M-5 X VGG-ru-1	G X A	IPM-02-19 X Sonamung-1	P X A	1.44**
100-seed weight (g)	GM-4	GM-4	GM-4 X Pant-M-5	G X G	GM-4 X IPM-02-19	G X P	1.13**
	VGG-ru-1	VGG-ru-1	GM-4 X IPM-02-19	G X A	GM-4 X Pant-M-5	G X G	0.86**
	SML-1082	Pant-M-5	Sonamung-1 X Pant-M-5	P X G	Sonamung-1 X Pant-M-5	P X G	0.79**
Grain yield per plant (g)	GM-4	GM-4	GM-4 X Vamban-1	G X P	Sonamung-1 X Vamban-1	PX P	2.52**
	SML-1082	Pusa-0871	GM-4 X Pant-M-5	G X A	Meha X IPM-02-19	A X P	2.11**
	Pusa-0871	-	GM-4 X Pusa-0871	G X G	Sonamung-1 X VGG-ru-1	P X A	1.97**
	-	-	GM-4 X VGG-ru-1	G X P	-	-	-
Harvest Index (%)	GM-4	GM-4	GM-4 X VGG-ru-1	G X G	Sonamung-1 X VGG-ru-1	P X G	3.44**
	Pant-M-5	Pusa-0871	GM-4 X Pant-M-5	G X A	Sonamung-1 X Vamban-1	P X A	3.29**
	SML-1082	VGG-ru-1	Pusa-0871 X Pusa-9531	A X P	GM-4 X IPM-02-19	G X P	2.75**
Protein content (%)	Pant-M-5	Sonamung-1	Meha X IPM-02-19	P X A	Meha X IPM-02-19	P X A	1.86**
	Vgg-ru-1	VGG-ru-1	Sonamung-1 X SML-1082	G X P	Meha X Vamban-1	P X G	1.49**
	SML-1082	Vamban-1	Meha X Vamban-1	P X G	GM-4 X Pusa-0871	G X P	1.29**

Out of ten parents were found to be good general combiners for pod length, GM-4 (0.24) and Meha (0.17), while the parent Pusa-9531 (0.54), Vamban-1 (0.46), Pant-M-5 (0.37) were the top three parent having positive gca effect for the number of seeds per pod (Table 2). Twelve hybrids out of 45 exhibited significant and positive SCA effects, for pod length. The cross combinations Sonamung-1 X Pant-M-5 (1.77), IPM-02-19 X Vgg-ru-1 (1.12) and GM-4 X Pant-M-5 (0.99) were found to be the best three specific combiners for this trait. In case of number of seeds per pod, crosses Meha X Pusa-0871 (2.19), Sonamung-1 X SML-1082 (1.92), IPM-02-19 X Sonamung-1 (1.44) and Pant-M-5 X VGG-ru-1 (1.02) were found the best three specific combiners (Table 3). The results were akin to the findings of Barad *et al.* (2008), Kumar *et al.* (2010), Yadav and Lavanya (2011), Sujata and Kajjidoni (2013) and Vaidya *et al.* (2015). Parent GM-4 (0.48), VGG-ru-1(0.14) and Pant-M-5 (0.12) possessed positive and significant gca effects for test weight, hence they were considered to be good general combiner for test weight. For grain yield per plant, Parents GM-4 (1.64), and Pusa-0871 (0.50) were considered good general combiner as they displayed positive significant GCA effects (Table 2). Out of 45 hybrids, four hybrids, GM-4 X IPM-02-19 (1.13), GM-4 X Pant-M-5 (0.86), Sonamung-1 X Pant-M-5 (0.79) and Sonamung-1 X VGG-ru-1 (0.74) exhibited significant and positive SCA effects indicating the best specific combiner for test weight. The estimates of specific combining ability effects for seed yield varied from -1.75 (GM-4 X Sonamung-1) to 2.52 (Sonamung-1 X Vamban-1). Out of 45 hybrids, four hybrids, Sonamung-1 X Vamban-1 (2.52), Meha X IPM-02-19 (2.11) and Sonamung-1 X VGG-ru-1 (1.97) and Pusa-0871 X VGG-ru-1 (1.87) were revealed the best hybrids, as they exhibited positive and significant SCA effects (Table 3). The results were in accordance with Barad *et al.* (2008),Patel *et al.* (2009), Rout *et al.* (2009), Kumar *et al.* (2010), Patil *et al.* (2011), Yadav and Lavanya (2011), Sujata and Kajjidoni (2013), Narsimhulu *et al.* (2014) and Patil *et al.* (2014).

The parents, GM-4 (1.87), Pusa-0871 (0.80), and VGG-ru-1 (0.77) possessed positive and significant gca effects and were found good general combiner for the harvest index (Table 2). On the basis of SCA effects, Sonamung-1 X VGG-ru-1 (3.44), Sonamung-1 X Vamban-1 (3.29) and GM-4 X IPM-02-19 (2.75) and Meha X Vamban-1 (2.53) were the best specific combinations for this trait (Table 3). The results were in accordance with Sujata and Kajjidoni (2013), Patil *et al.* (2014) and Vaidya *et al.* (2015).

In case of protein content results revealed that three parents, *viz*., Sonamung-1 (2.02), VGG-ru-1(1.83) and Vamban-1(1.38) exhibited positive and significant gca effect (Table 2). The results revealed that the estimates of sca effects for protein content ranged from -1.15 (Meha X Pant-M-5) to 1.86 (Meha X IPM-02-19). Out of forty five cross combinations, nine crosses exhibited significant and positive SCA effects. Among them Meha X IPM-02-19 (1.86), Meha X Vamban-1(1.49) and GM-4 X Pusa-0871 (1.29) were the best specific combiners for increasing protein content as they had positive and significant SCA effects (Table 4). The results show resemblance to the finding of Barad *et al*. (2008) and Patil *et al*. (2011).

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