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Research Article

Estimation of combining ability and heterosis for yield related characters with protein content in seed of mungbean

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Abstract
Twenty seven genotypes of mungbean were evaluated for combining ability for yield and its attributing traits. The field experiment were conducted during March to May both for 2012 and 2013 at the Instructional farm, Jaguli , Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal. The data were recorded on plant height, days to 50% flowering, days to maturity, number of branches plant $^{-1}$,number of pods plant $^{-1}$, number of seeds plant $^{-1}$, pod length, pod width, hundred seed weight, seed yield plant^{-1} and protein content. The study revealed that significant differences for all the characters. Samrat, Bireshwar and Tarm-2 were found to be superior for yield and its attributing traits along with protein content and TM-99-50 for earliness. High heritability accompanied by high genetic advance was observed for seed yield plant^{-1} followed by 100 seed weight, number of branches plant $^{-1}$ and number of pods plant $^{-1}$ which indicated the importance of additive gene effects in controlling the expression of these characters. Simple breeding strategies may be adopted to obtain desirable changes and further improvement in these characters.

Keywords
Greengram, sca, gca, combining ability

Introduction

The growing knowledge on the importance of pulses in our diet has driven us to make numerous efforts for increase in production of pulses in the country where much concentration and efforts was given on improvement of cereals which so long dominated the agricultural sector. Pulses, which are best known as "poor man's meat", constitute the major source of dietary protein of the large section of vegetarian population of the world. India is the largest producer and consumer of pulses in the world accounting for 33 per cent of world area and 25 per cent of world production (FAO 2007). Green gram also known as Mungbean is the third most important pulse crop in India covering an area of 34.4 lakh hectare with a total production of 14 lakh tonnes and the average productivity of 406.98 kg ha^{-1} (ZPDK 2011). Important green gram growing states in India are Orissa, Andhra Pradesh, Maharashtra, Karnataka and Bihar. Its seeds contain on dry weight basis approximately 25%-28% proteins, 1-1.5 per cent oil, 3.5-4.5 per cent ash and 52-65 per cent carbohydrates. Among all the pulses, green gram [*Vigna radiate* (L.), Wilczek] is found most suitable crop grown during summer months and with the development of early maturing varieties, it has proved to be an ideal crop for spring and summer seasons. Though greengram is an important pulse crop of India the average yield of greengram is low owing to low genetic yield potentiality, indeterminate growth habit, canopy architecture, low partitioning efficiency, cultivation in marginal land and due to many other biotic and abiotic stresses. In the present investigation attempts have been made to estimate the general combining ability (*gca*) effects of parents and specific combining ability (*sca*) of crosses for important morphological, seed yield and its component traits and also to study the extent of heterosis in respect to seed yield and its components.

Materials and Methods

A set of 27 mungbean genotypes (Sonali, Kopergaon, WBM-220, Hum-12, PS-16, K-851, Malda-95-13, WBM-4131, Pusa Visal, WBM-659, Sublobata-2, Basanti, Samrat, TM-99-50, Tarm-2, TM-99-37, Sublobata-14, TM-99-21, Pant Mung-2, TM-99-30, Midnapur Local, WBM-314, Bireswar, WBM04-05, WBM-611-3, TM-98-50, PDM-54) were considered for the experiment which was conducted at the Instructional Farm Jaguli, B.C.K.V., Mohanpur during *Kharif* 2012-2013. The genotypes were planted in a randomized block design with two replications. The row to row distance was 30 cm. Five plants were selected at random from each entry in each replication for recording observations on different characters, plant height (cm), days to 50% flowering, days to maturity, number of branches plant$^{-1,}$ number of pods per plant, number of seed pod^{-}

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[1], pod length (cm), pod width (mm), 100 seed weight (g), seed yield plant^{-1}, protein content. On the basis of evaluation, six genotypes were identified and selected (Hum-12, PS-16, Basanti, TM-99-50, WBM-314, Bireswar). These genotypes were crossed following 6 x 6 diallel mating systems in 2012 and the parents with hybrids were grown in 2013 to study the inheritance, combining abilities and heterosis for yield and its attributing traits. Combining ability was estimated following Model I method II (Griffing**,** 1956) and heterosis following Matzinger *et al*. 1962.

Results and Discussion

Analysis of variance revealed highly significant varietal differences for all the characters studied hence there is enough scope for selection among the varieties (Khattak *et al.,* 1997, Khairnar *et al.,* 2003 and Rao *et al*., 2006). The mean performance of twenty seven genotypes for different yield and its attributing characters were presented in table 1. TM-99-21was found to be early maturing genotype for number of days to 50% flowering and K-851 as late maturing. The genotype TM-99-50 was identified as early maturing with 73.5 days and K-851 as late maturing with 53.5 days for maturity. The maximum plant height was recorded in Sublobata-14 (68.44 cm) followed by Sublobata-2 (64.09 cm) and minimum in Bireshwar (40.04 cm) followed by WBM-611-3 (41.94 cm). The highest number of branches plant $^{-1}$ was found in Sublobata-14 (5.550) and lowest in WBM-659 and Kopergaon (2.250). The number of pods plant $^{-1}$ ranged from (13.200- 28.000) with Samrat being the genotype with highest and WBM-04-05 with lowest number respectively. Tarm -2 contributed the highest number of seeds pod^{-1} followed by WBM-611-3 and lowest was recorded in WBM-04-05. The genotype WBM-611-3 scored the longest pod length (8.35 cm) while, WBM-659 scored the shortest (5.60 cm). Highest pod width was recorded in Bireshwar (0.467) and lowest in Sonali (0.307). The maximum 100 seed weight was observed in Bireshwar (5.611) and minimum in WBM-659 (2.174). The protein content among the genotype was ranged from 18.04 to 25.08 % and Bireshwar scored the highest and Sonali with the lowest score. Samrat yielded highest with 14.3 g plant^{-1} and TM-98-50 showed the lowest yield (3.29 g plant^{-1}).

The analysis of variance for combining ability and estimates of genetic components for different characters were shown in table 2 and indicated significant variance for most of the characters. Seed yield per plant exhibited highly significant variance for GCA and significant variance for SCA that indicated the influence of both additive and non-additive gene effects. Predominant role of additive component in expression of characters like number of branches per plant, pod width and seed yield per plant were also confirmed from predictability ratio of the concerned characters. The estimation of *gca* effects of six parents for six characters were presented in table 3 and by considering the trait, Bireshwar may be considered as the best general combiner for traits like plant height, pod length, pod width, 100 seed weight and seed yield per plant followed by PS-16 for traits like days to 50 % flowering, days to maturity, number of branches plant^{-1}, number of pods plant^{-1} and protein content in seed. Combination of these two parents may help to develop ideal plant type in mungbean with efficiency to give yield with high protein content in seed and earliness. Significant positive *sca* effect was observed for yield per plant in the cross [Hum-12 X Bireshwar] and it was also showed significant and desirable *sca* effect for 100 seed weight, number of pods plant^{-1} and protein content in seed (Table 4). The cross, Basanti X PS-16 with high positive *sca* effect for yield per plant was also accompanied by desirable *sca* effect for 100 seed weight, plant height and days to 50 % flowering.

Significant positive relative heterosis (Table 5) for number of days to 50 % flowering was observed in PS-16 x Bireshwar while Hum-12 x Bireshwar and WBM -314 X Basanti showed significant positive heterobeltiosis for this trait as also reported by (Patel *et al.,* 2009 and Dhuppe *et al.,* 2010). The cross, Hum-12 x TM-99-50 revealed significantly positive heterosis and heterobeltiosis for number of days to maturity. Six parents out of fifteen showed positive significant relative heterosis of which, WBM-314 x Basanti being the highest along with positive heterobeltiosis. Crosses, Hum-12 x PS-16 and WBM-314 X PS-16 showed highest significant relative heterosis as well as heterobeltiosis followed by WBM-314 x Basanti, Hum-12 x Bireshwar and PS-16 x Bireshwar, (Dethe *et al*., 2008 and Kumar *et al.,* 2011) reported the same. The cross, WBM-314 x Basanti exhibited superiority both for relative heterosis and heterobeltiosis for number of seed per pod. Relative heterosis as well as heterobeltiosis was found to be non-significant for pod width in all the hybrids except in PS-16 x Bireshwar where heterobeltiosis were found to be significantly negative. Significant positive relative heterosis for 100 seed weight was reported in WBM-314 x Bireshwar and WBM-314 x Hum-12 while WBM-314 x PS-16 showed significant relative heterosis as well as heterobeltiosis for protein content. Hum-12 x Bireshwar showed significant relative positive

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heterosis as well as heterobeltiosis for seed yield and components (Kumar**,** *et al.*, 2010).

The present investigation thus revealed that the genotypes Samrat, Bireshwar, Tarm-2 were superior with respect to yield along with a number of yield attributing traits and TM-99-50 with high protein content. From diallel analysis, it was found that number of seeds pods^{-1}, number of pods per plant, 100 seed weight, protein content, plant height, days to maturity and days to 50 % flowering were predominantly controlled by non-additive gene action while, number of branches per plant, pod width and seed yield per plant by additive gene action. The crosses, Basanti x Bireshwar followed by Hum-12 x TM-99-50, TM-99-50 x Bireshwar, WBM-314 x Basanti were found to be superior with respect to protein and the crosses, Hum-12 x PS-16 and Hum-12 x Basanti for earliness. These hybrids can be utilised in later generations for development of protein rich genotype accompanied by high yield and earliness.

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Table 1. Mean performance of eleven characters of twenty seven genotypes in mungbean (*Vigna radiata* L. Wilczek)

Sl. No	Genotypes	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of branches/plant	No. of pods/plant	No. of seeds/pod	Pod length (cm)	Pod width(cm)	100 seed weight (g)	Protein content (%)	Seed yield/plant (g)
1	Sonali	48.50	75.50	59.14	2.95	21.00	10.70	6.90	0.30	2.29	18.04	6.66
2	Kopergaon	48.00	76.50	53.37	2.25	21.35	10.15	6.57	0.42	3.26	23.44	7.42
3	WBM-220	47.50	75.50	45.88	2.75	16.00	8.35	6.20	0.40	2.61	22.01	4.45
4	Hum-12	49.50	77.50	42.00	2.30	17.10	9.15	6.40	0.42	4.05	20.05	7.38
5	PS-16	47.00	75.50	57.02	4.00	14.95	11.20	6.85	0.33	2.60	20.03	8.60
6	K-851	53.50	82.50	57.97	3.25	21.45	11.15	6.55	0.41	3.68	19.68	9.70
7	Malda-95-13	52.50	82.00	54.22	4.25	18.55	11.25	7.06	0.39	3.70	22.32	5.76
8	WBM-4151	51.00	74.50	46.99	4.25	16.95	9.75	6.26	0.32	2.71	19.01	4.79
9	Pusa Visal	50.50	74.50	55.15	3.35	16.95	9.95	6.15	0.32	2.33	20.06	4.96
10	WBM-659	49.50	79.50	44.12	2.25	16.50	9.85	5.60	0.42	2.17	19.92	5.68
11	Sublobata-2	49.00	79.00	64.09	5.35	17.05	8.85	6.25	0.35	2.37	19.02	5.00
12	Basanti	49.50	76.50	58.03	3.25	17.60	10.65	6.40	0.40	3.86	21.59	5.39
13	Samrat	48.50	75.50	34.00	2.55	28.00	12.35	7.05	0.42	4.95	23.50	14.32
14	TM-99-50	47.00	73.50	35.09	2.70	27.25	11.70	6.26	0.41	4.47	21.99	10.47
15	Tarm-2	47.50	74.50	55.44	3.60	25.45	12.45	7.21	0.38	4.66	24.88	9.96
16	TM-99-37	48.50	76.50	60.39	3.40	20.10	9.95	6.90	0.35	3.58	20.38	5.27
17	Sublobata-14	48.50	76.50	68.44	5.55	18.00	8.95	5.95	0.37	2.28	19.81	4.17
18	TM-99-21	46.50	76.00	56.07	3.25	17.05	10.65	6.16	0.35	2.18	20.40	4.30
19	Pant mung-2	48.50	76.50	45.07	3.20	15.30	9.95	7.50	0.39	3.66	19.89	6.29
20	TM-99-30	48.50	76.50	60.03	3.25	16.55	11.45	6.80	0.36	3.15	19.34	5.95
21	Midnapur local	49.00	78.50	47.80	3.45	20.00	10.60	5.69	0.39	2.60	20.27	7.12
22	WBM-314	47.50	74.50	47.47	2.40	17.65	10.25	6.83	0.42	3.68	21.48	9.22
23	Bireswar	47.00	74.50	40.04	2.60	24.20	8.00	6.40	0.46	5.61	25.02	10.10
24	WBM-04-05	49.00	79.50	43.98	2.30	13.20	7.85	6.64	0.43	3.87	19.05	7.60
25	WMB-611-3	50.00	81.50	41.94	3.00	15.90	12.00	8.35	0.37	2.99	23.16	6.58
26	TM-98-50	51.00	81.00	45.04	3.45	16.05	9.45	6.15	0.37	2.51	19.19	3.29
27	Pdm-54	48.50	78.50	52.57	3.55	15.00	11.15	6.78	0.32	2.66	18.67	4.16
Grand mean		48.50	77.13	50.79	3.27	18.70	10.28	6.59	0.38	3.28	20.82	6.84
CV		1.71	0.50	0.59	3.39	1.34	1.26	2.23	0.00	2.47	1.06	2.63
SE (m)		0.84	0.38	0.30	0.11	0.25	0.13	0.18	0.00	0.08	0.22	0.18
CD 5%		1.72	0.79	0.62	0.22	0.51	0.26	0.38	0.01	0.16	0.45	0.37

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Table 2. Analysis of variance for combining ability and estimates for genetic components for different characters

Source	d.f	Mean sum of squares										
		Days to 50% flowering	No. of days to maturity	Plant height (cm)	No. of branches/ plant	No. of pods / plant	No. of seeds / pod	Pod length (cm)	Pod width (cm)	100 seed weight(g)	Protein content (%)	Seed yield/plant (g)
Gca	**5**	14.00***	15.28***	8.99	1.10***	4.13**	0.96*	0.78***	0.00**	0.92***	3.76***	6.15***
Sca	**15**	5.76***	10.25***	25.74**	0.03**	6.38***	0.75*	0.25**	0.00	0.29***	1.17***	0.52
Error	**20**	0.71	0.71	2.14	5.80	0.00	0.83	0.33	0.06	0.00	0.04	0.05
Genetic component												
$\sigma^2 g$		1.66	1.64	0.39	0.13	0.41	0.07	0.08	0.00	0.11	0.46	0.74
$\sigma^2 s = \sigma^2 D$		5.04	8.11	19.94	0.02	5.54	0.41	0.18	-0.00	0.24	1.12	0.31
$\sigma^2 A$		3.32	3.28	0.79	0.27	0.82	0.15	0.17	0.00	0.22	0.92	1.48
H^2 (broad sense)		0.92	0.84	0.78	0.97	0.88	0.63	0.84	0.39	0.91	0.97	0.89
H^2 (narrow sense)		0.36	0.24	0.03	0.90	0.07	0.17	0.41	0.56	0.43	0.44	0.74
Predictability ratio		0.39	0.28	0.03	0.92	0.12	0.27	0.49	1.42	0.47	0.45	0.82

***** Significant at 0.01% ** significant at 1% * significant at 5%**

Table 3. Estimates of general combining ability effects of the parents for different characters

Parents	No. of days to 50% flowering	No. of days to maturity	Plant height (cm)	No. of branches / plant	No. of pods / plant	No. of seeds / pod	Pod length (cm)	Pod width (cm)	100 seed weight(g)	Protein content (%)	Seed yield/plant (g)
WBM-314	-0.396	-0.021	-0.015	-0.192***	-0.785*	0.200	0.300**	0.013	0.184*	0.190*	0.135
HUM-12	-1.208***	-1.646**	0.142	-0.260***	0.665*	-0.612**	-0.215*	-0.013	0.033	-0.360***	0.059
BASANTI	-0.458	-0.833	0.754	0.108**	-0.154	0.200	-0.169	-0.026**	-0.297***	-0.642	-0.675***
PS-16	2.604***	2.104**	1.048	0.708***	0.883***	0.250	-0.220*	-0.013	-0.454	1.283***	-1.215***
TM-99-50	-0.271	1.104*	0.054	-0.117***	0.215	-0.225	-0.187*	0.006	0035	-0.335***	0.371*
BIRESWAR	-0.271	-0.708	-1.983	-0.248***	-0.823	0.187	0.492***	0.032**	0.499***	-0.135	1.325***
SE(gi)	0.27300	0.47219	0.77739	0.02887	0.29417	0.18698	0.08462	0.00891	0.068855	0.07405	0.14714
SE(gi-gj)	0.42293	0.73152	1.20433	0.04472	0.45572	0.28966	0.13110	0.01380	0.10666	0.11472	0.22795
CD at 5%	0.70177	1.21382	1.99836	0.07421	0.48064	0.48064	0.21753	0.02290	0.17698	0.19035	0.37824

*** Significant at 0.01% ** significant at 1% * significant at 5%

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Table 4. Estimates of specific combining ability effects of the crosses for different characters

Crosses	No. of days to 50% flowering	No. of days to maturity	Plant height (cm)	No. of branches plant^{-1}	No. of pods plant^{-}	No. of seeds / pod	Pod length (cm	Pod width (cm)	100 seed weight(g)	Protein content (%)	Seed yield / plant (g)
WBM-314 X HUM-12	-0.777	0.857	-6.579**	0.126	-1.848*	-0.359	-0.359	-0.017	0.204	-0.584*	0.385
WBM -314 X BASANTI	2.973**	2.045	0.908	0.357***	2.921**	1.029	0.261	0.009	0.021	-0.153	-0.048
WBM -314 X PS-16	-0.089	-0.893	2.664	0.157	3.883***	0.379	-0.073	-0.008	-0.161	1.522***	-0.252
WBM -314 X TM-99-50	0.286	-0.393	-2.692	-0.168	-3.248**	1.054	0.588*	0.019	0.192	0.391	0.311
WBM -314 X BIRESWAR	-2.214**	-3.080*	2.546	-0.187*	-2.711**	0.641	0.983***	0.028	0.710**	-0.109	0.298
HUM-12 X BASANTI	1.286	-3.330*	4.052	-0.174*	-0.029	0.641	0.538	0.029	-0.203	-0.303	-0.233
HUM-12 X PS-16	-2.277**	-6.768***	1.858	0.076	2.433**	0.791	0.121	-0.001	0.076	-0.128	0.080
HUM-12 XTM-99-50	0.098	5.232**	2.052	0.101	2.452**	-0.334	0.046	-0.040	-0.122	-2.209***	-0.522
HUM-12 X BIRESWAR	2.598**	2.045	4.089	0.082	2.289*	-0.846	0.060	0.011	0.582**	1.291***	1.772
BASANTI X PS-16	-3.027**	-0.080	-9.454***	-0.093	-2.598**	-0.021	0.321	0.008	0.442*	-0.796**	0.526
BASANTI X TM-99-50	-0.652	-0.580	-1.861	-0.018	1.671	-0.046	-0.195	0.025	0.435	-1.078***	0.323
BASANTI XBIRESWAR	0.348	-0.768	2.177	0.013	0.158	0.941	-0.492	-0.007	-0.985***	0.372	0.081
PS-16 X TM-99-50	4.286***	2.482	-5.254	0.132	-0.917	-0.496	0.083	-0.002	-0.169	0.847***	-0.156
PS-16 X BIRESWAR	4.286***	5.295***	-6.917	0.213*	2.171*	-1.309*	-0.922**	-0.039	-1.115	-0.003	-1.004*
TM-99-50 X BIRESWAR	-0.339	-0.705	-0.923	-0.062	-1.761*	0.266	-0.121	0.007	-0.032	-0.784**	0.747
SE (Sij)	0.74977	1.29684	2.13505	0.07928	0.80791	0.51352	0.23241	0.02447	0.18909	0.20338	0.40412
SE (Sij-Sik)	1.11897	1.93542	3.18636	0.11832	1.20572	0.76638	0.34686	0.03652	0.28220	0.30352	0.60310
SE (Sij-Skl)	1.03596	1.79185	2.95000	0.10954	1.11628	0.70953	0.32113	0.03381	0.26127	0.28100	0.55837

*** Significant at 0.01% ** significant at 1% * significant at5%

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Table 5. Per cent heterosis over mid-parent (relative heterosis) and better parent (heterobeltiosis) for different characters

Crosses	Days to 50% flowering		Days to maturity		Plant height (cm)		No. of branches / plant		No. of pods / plant	
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
WBM-314 X HUM-12	-1.14	-3.33	0.00	-1.97	-16.17	-20.5 *	10.42*	8.16	-2.93	-3.38
WBM -314 X BASANTI	7.26 **	6.67 *	1.32	0.66	-2.31	-4.74	16.07**	3.17	12.10 **	11.47 *
WBM -314 X PS-16	1.59	-3.03	-1.61	-3.77	-5.50	-14.42	10.61**	-12.05**	18.21 **	17.44 **
WBM -314 X TM-99-50	2.82	1.11	1.00	0.00	-13.93	-16.90	-3.85	-9.09	-14.21 **	-17.76 **
WBM -314 X BIRESWAR	-2.27	-4.44	-3.70	-5.92	5.54	-2.56	-4.08	-4.08	-11.13	-12.22 *
HUM-12 X BASANTI	4.00	2.25	-6.08*	-7.33	11.48	3.28	-3.64	-15.87**	6.93	6.83
HUM-12 X PS-16	-2.70	-9.09 **	-9.51**	-13.21 **	-2.52	-15.77 *	7.69*	-15.66**	18.76 **	17.44 **
HUM-12 XTM-99-50	2.89	2.30	8.47**	7.38	3.24	-5.24	5.88	-1.82	12.01 **	6.90
HUM-12 X BIRESWAR	9.30 **	9.30 **	3.09	2.74	16.72	13.39	6.25	4.08	13.96 **	13.09 *
BASANTI X PS-16	-4.26	-9.09 **	-0.97	-3.77	-33.07 **	-37.97 **	1.37	-10.84**	-3.10	-4.27
BASANTI X TM-99-50	1.14	0.00	0.33	0.00	-12.21	-13.10	0.00	-6.35	6.33	1.38
BASANTI X BIRESWAR	4.00	2.25	-1.02	-2.67	3.70	-6.44	1.79	-9.52	2.78	2.09
PS-16 X TM-99-50	12.90 **	6.06 *	5.19 *	1.89	-25.94 **	-30.71**	7.25*	-10.84 **	-0.45	-3.97
PS-16 X BIRESWAR	13.51 **	6.06 *	7.89 **	3.14	-26.94 **	-38.38**	10.61**	-12.05	13.04**	10.95*
TM-99-50 X BIRESWAR	4.05	3.45	2.04	0.67	-7.59	-17.38	-1.92	-7.27	-7.92	-12.76
SE	1.04	1.196	1.79	2.069	2.950	3.406	0.109	0.126	1.116	1.288

*** Significant at 0.01% ** significant at 1% * significant at5%

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Table 5. Contd.,

Crosses	No. of seeds pod^{-1}		Pod length (cm)		Pod width (cm)		100 seed weight(g)		Protein content (%)		Seed yield/ plant (g)	
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
WBM-314 X HUM-12	3.26	2.15	1.38	-2.52	-3.82	-7.37	18.34 *	16.71	-3.95 **	-4.89 **	11.27	7.71
WBM -314 X BASANTI	25.13 **	24.47 *	10.72 *	7.09	10.49	-3.68	6.23	0.70	-1.88	-2.24	3.74	-6.00
WBM -314 X PS-16	8.82	0.00	2.32	1.54	-2.85	-4.77	-4.95	-9.84	10.21 **	5.22 **	-3.72	-14.75
WBM -314 X TM-99-50	19.52 *	17.71	15.49 **	11.54 *	7.93	7.64	15.82	15.25	-0.24	-2.39	7.55	4.74
WBM -314 X BIRESWAR	12.44	4.63	15.92 **	6.60	9.21	2.14	18.66 *	-0.53	1.77	0.50	10.06	0.53
HUM-12 X BASANTI	13.51	11.70	11.60 *	10.92	13.24	2.06	-4.71	-8.46	-6.32 **	-7.58 **	4.01	-2.86
HUM-12 X PS-16	5.94	-3.60	1.59	-1.60	-4.56	-6.25	-0.71	-4.55	-1.18	-4.76 **	3.42	-5.70
HUM-12 XTM-99-50	-2.67	-5.21	3.85	3.38	-11.93	-14.95	2.79	0.88	-16.43 **	-17.42 **	0.27	-5.39
HUM-12 X BIRESWAR	-9.55	-16.67 *	0.53	-10.79 *	1.64	-8.19	12.89	-6.42	5.00 **	2.69	28.66 **	14.11 *
BASANTI X PS-16	4.39	-3.60	4.69	2.01	4.56	-7.24	4.78	4.71	-4.41 **	-9.07 **	7.22	4.49
BASANTI X TM-99-50	7.37	6.25	0.20	0.05	13.66	-0.69	14.33	7.87	-11.14 **	-13.37	8.32	-4.15
BASANTI X BIRESWAR	14.85	7.41	-6.86	-16.91 **	2.81	-15.32	-33.31 **	-46.45 **	0.38	-0.50	8.33	-9.46
PS-16 X TM-99-50	-5.31	-11.71	0.99	-1.75	-2.86	-4.53	-10.63	-15.62	2.33	-0.23	-2.35	-15.50 *
PS-16 X BIRESWAR	-14.16 *	-15.32	-15.39 **	-22.73	-12.81	-19.95 *	-40.85 **	-52.48 **	2.64	-3.17	-8.69	-25.24 **
TM-99-50 X BIRESWAR	2.94	-2.78	-1.94	-12.64	2.48	-4.39	-4.17	-`9.34 **	-6.42	-9.55 **	14.49 *	7.19
SE	0.709	0.819	0.321	0.370	0.033	0.039	0.261	0.301	0.281	0.324	0.558	0.644

*** Significant at 0.01% ** significant at 1% * significant at5%