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ANALYSIS OF COMBININ GABILITY IN INDIAN MUSTARD (*Brassica juncea*)

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ABSTRACT

Ninety one crosses obtained by half diallel mating using fourteen parents (excluding reciprocal) to study the general and specific combining ability of parents and crosses, respectively and to isolate superior crosses for studying them in further generation. These parents and crosses were grown in complete randomized block design replicated thrice in the year *rabi* 2015 at Shankarnagar farm of Agril. Botany Section, College of Agriculture, Nagpur. Observations were taken on days to 50% flowering, days to maturity, plant height (cm), number of primary branches plant^{-1}, number of siliqua plant^{-1}, 1000 seed weight, seed yield plant^{-1}.The parents Bio 902, Pusa Mahak and JD 6 were identified as good general combiners for seed yield plant^{-1} and number of siliqua plant^{-1}. The crosses NRCHB 101 X Bio 902, Pusa Mustard 28 X JD 6, Pusa Tarak X Bio 902, Pusa Mustard 21 X GM 2, Pusa Agrani X GM 3, Pusa Mustard 25 X Pusa Mustard 28, Pusa Mahak X NRCHB 101 and Pusa Tarak X Pusa Mustard 24 were identified as the best F_1 crosses which can be forwarded to the next generation with aim to get useful transgrates in succeeding generation.

(Key words: Diallel, combining ability, Indian mustard)

INTRODUCTION

Indian mustard [*Brassica juncea* (L.) Czern and Coss.] is called as "rai", "raya" or "laha" is one of the important oilseed crops belonging to Brassicae group. Indian mustard belongs to the family Cruciferae, genus Brassica with chromosome number 2n=36. Over 159 species have been reported in genus *Brassica*. The important species of *Brassica* that are extensively cultivated commercially are *B. rapa, B. juncea* and *B. napus*. The oil content in Indian mustard seed varies from 30 to 48 per cent.

The important mustard growing countries of the world are India, China, Canada, France, Poland and Pakistan. India is the second largest rapeseed mustard growing country in the world and ranks third next to Canada and China in production. Major states producing mustard are Rajasthan, Punjab, Haryana, Uttar Pradesh, Madhya Pradesh, West Bengal and Gujarat. It is a minor crop of Vidarbha region of Maharashtra, often grown as mixed crop and hence, is one of the reason for lower productivity. The various mating designs have been used for assessing the breeding value of the parents through the estimation of variance and combining ability effects and analysis through diallel cross technique as suggested by Griffing (1956). Diallel analysis provides a mating design whereby the selected parents are crossed in all possible combinations.

MATERIALS AND METHODS

The experimental material comprising of fourteen genotypes of mustard (*Brassica juncea*) were crossed in half diallel mating design excluding reciprocals to obtain 91 crosses during *rabi* 2014-2015. There crosses along with 14 parents were raised in randomized complete block design in three replications with the spacing of 45 cm x 15 cm accommodating 10 plants in each row at the Shankar Nagar Farm of the Botany Section, College of Agriculture, Nagpur during *rabi* 2015-2016. Observations were recorded on five randomly selected plants in each replication for the characters including days to 50% flowering, days to maturity, plant height at maturity, number of primary branches^{-1}, number of siliqua plant^{-1}, 1000 seed weight, and yield plant^{-1}. The data were subjected to analysis of variance (Fisher, 1938), and analysis of combining ability (Griffings, 1956, Method 2 Model I).

RESULTS AND DISCUSSION

The analysis of variance for experimental design was performed for seven characters and data are presented in table 1. The mean squares due to genotypes was highly significant for all the characters studied i. e. days to 50% flowering, day to maturity, plant height at maturity, number of primary branches^{-1}, number of siliqua plant^{-1} and yield plant^{-1} except 1000 seed weight. The parents exhibited highly significant mean squares for days to % flowering, days to

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Table 1. Analysis of variance for experimental design

Source	d.f.	Mean squares: Days to 50 % flowering	Days to maturity	Plant height at maturity (cm)	No. of primary branches plant^{-1}	No. of Siliqua plant^{-1}	1000 seed weight (g)	Yield plant^{-1} (g)
Replication	2	11.47	1.95	1.47	0.76	1516.23	0.07	2.36
Genotypes	104	19.34**	56.74**	288.63**	1.91**	4585.75**	0.37	4.26**
Parents	13	46.23**	175.52**	192.80**	1.05	1089.38	0.77	1.03
Crosses	90	15.67**	37.76**	258.38**	1.88**	4902.11**	0.28	4.10**
Parents Vs. crosses	1	0.04	220.88**	4257.51**	14.83**	21565.82**	3.29**	61.00**
Error	208	4.57	7.06	62.38	0.66	689.69	0.39	1.26

Note: * Significant at 5% level, ** Significant at 1% level

Table 2 . Analysis of variance for combining ability

Source	d.f	Mean square: Days to 50 % flowering	Days to maturity	Plant height at maturity (cm)	No. of primary branches plant^{-1}	No. of Siliqua plant^{-1}	1000 seed weight (g)	Yield plant^{-1} (g)
GCA	13	22.58**	86.11**	195.09**	2.10**	4584.00*	0.26	2.01**
SCA	91	4.14**	9.31**	82.08**	0.43**	1092.00*	0.11	1.34**
Error	208	1.52	2.35	20.79	0.22	229.90	0.13	0.42

Note: * Significant at 5% level, ** Significant at 1% level

Table 3. General combining ability (gca) effects of parents

Parents	Days to50 % flowering		Days To maturity		Plant height (cm)		No. of primary branches plant^{-1}		No. of Siliqua plant^{-1}		Seed yield plant^{-1} (g)	
	gca	mean	gca	mean	gca	mean	gca	mean	gca	Mean	gca	mean
PM 25	-0.49	41.33	-2.87**	109	3.90**	131`	0.34*	5.83	35*	208	-0.28	5.8
PM 27	-0.40	45.67	-0.85*	118	4.03**	132	-0.04	6.50	32	211	-0.24	6.2
PM 28	1.32**	41.33	-1.99**	109	-2.93*	133	0.30*	6.23	5.04	261	0.16	7.8
P TARAK	-0.84*	44.33	-1.68**	115	-1.59	126.	0.54**	6.83	13	264	0.04	6.8
P MAHAK	1.01**	40.33	-1.85**	107	3.78**	126	0.53**	7.00	25	229	0.63**	6.5
P AGRANI	-0.88*	42.67	-2.12**	109	-2.09	128	0.20	6.17	8.4	238	-0.07	6.2
PM 21	2.20**	51.00	4.43**	129	3.30*	146	-0.26*	5.17	2.95	227	-0.36*	6.3
PM 22	2.49**	52.33	4.01**	129	1.85	145	-0.62**	5.17	16	223	-0.44*	6.8
PM 24	1.43**	52.00	3.15**	130	1.87	135	-0.42**	5.17	4.37	243	-0.29	6.2
NRCHB 101	-0.63*	45.67	-0.43	120	0.85	131	-0.11	6.00	3.31	252	-0.15	6.8
GM 2	0.12	43.33	0.70	118	-3.01*	138	-0.15	6.17	3.89	237	0.20	6.5
GM 3	-0.09	46.67	-0.16	116	2.12	148	-0.41**	6.50	0.15	245	-0.09	6.7
JD 6	-0.26	45.33	-0.14	116	6.28**	149	-0.08	6.50	8.6	269	0.15	6.8
BIO 902	-0.34	47.67	-0.22	116	5.07**	139	0.19	6.17	9.2*	225	0.75**	7.8
Gi-gj	0.90	42	1.11	109	3.31	132	0.34	7.14	11	291	0.47	7.9

Note: * Significant at 5% level, ** Significant at 1% level

Table 4 . Specific combining ability (sca) of crosses

Name of crosses	Days to 50 % Flowering		Days to maturity		Plant height (cm)		No. of primary branches		No. of siliqua plant^{-1}		Seed yield plant^{-1}(g)	
	sca	Mean	sca	Mean	sca	mean	sca	mean	Sca	Mean	sca	Mean
PM25 X PM27	1.50	46	1.30	113	14.01*	152	0.39	7.3	16.77	208	1.06	8.3
PM25 X PM 28	0.09	48	-6.56**	113	15.58**	142	-0.13	6.7	-9.65	222	-1.59*	6.6
PM25 X P TARAK	3.27*	44	2.80	104	14.91**	155	-0.03	7.2	32.62*	219	1.10	6.1
PM25 X P MAHAK	4.11**	48	3.97*	114	10.43*	155	-0.87	7.5	-5.71	270	-0.97	8.7
PM25 X P AGRANI	2.32*	48	0.90	115	-4.26	149	0.65	6.7	22.85	243	0.00	7.2
PM25 X PM21	-0.10	47	-0.64	111	-17.32**	136	-0.74	7.8	12.44	255	0.69	7.4
PM25 X PM22	3.00*	47	3.42*	116	-3.63	128	0.59	6.0	-62.08**	239	-0.11	7.8
PM27 X PM28	1.86	45	-0.22	115	5.37	130	0.35	7.0	5.85	200	-0.09	6.8
PM27 X P TARAK	1.02	45	2.94*	108	6.22	114	0.86	7.0	7.85	148	0.87	7.0
PM27 X P MAHAK	1.23	45	2.22	110	0.87	125	0.29	6.3	-70.92**	149	-0.43	6.8
PM27 X P AGRANI	-3.18*	44	-6.33**	110	-22.19**	146	-0.51	8.3	-54.00**	235	-1.86*	8.5
PM27 X PM 21	-1.23	47	-1.74	116	-4.40	132	0.50	7.2	33.10*	226	0.84	8.6
PM28 X P TARAK	3.27*	45	3.42*	114	-2.88	140	0.01	7.2	31.44*	202	1.59*	7.7
PM28 X P MAHAK	-0.52	46	2.69	114	0.10	154	0.68	7.0	15.33	180	-0.21	7.7
PM28 X PM21	1.73	44	2.49	115	9.37*	163	-0.03	8.0	-6.42	273	-0.26	9.2
P TARAK X P MAHAK	1.79	47	1.78	116	-3.22	135	0.61	7.5	57.71**	170	2.04*	7.6
P TARAK X P AGRANI	1.67	46	2.72	113	7.10	146	0.11	7.5	43.27*	247	2.08**	7.5
P TARAK X PM21	-1.41	45	-3.49*	116	0.70	144	1.00*	8.0	20.19	260	1.20	9.1
P MAHAK X P AGRANI	1.50	46	2.88*	115	-14.05*	141	0.78	7.1	45.27*	165	1.16	7.1
P MAHAK X PM 21	-5.25**	44	-6.33**	113	8.89*	123	0.24	5.8	35.19*	176	0.78	5.3
P AGRANI X PM21	-0.71	45	-4.72*	116	9.53*	135	-0.09	5.8	-13.25	153	0.31	6.2
PM25 X PM22	-2.39*	46	-1.56	119	-13.86*	146	0.63	5.8	-6.12	283	-0.32	8.8

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Name of crosses	Days to 50% flowering		Days to maturity		Plant height (cm)		No. of primary branches plant^{-1}		No. of siliqua plant^{-1}		Seed yield plant^{-1}(g)	
	sca	Mean		Mean	sca	mean		mean	Sca	mean	Sca	Mean
P TARAK X JD6	1.71	46	-0.26	114	-3.28	155	-0.12	5.8	-12.81	238	-0.48	11
P TARAK X BIO 902	-2.87*	46	-1.51	114	3.26	156	-0.05	6.3	-19.79	271	-1.92*	10
P MAHAK X PM22	-1.21	46	-2.24	115	0.01	152	-0.90*	7.3	-23.04	280	0.19	9
P MAHAK X PM24	-1.81	45	-2.06	114	6.66	131	0.40	8.0	21.77	244	-1.13	7
P MAHAK X NRCHB101	-1.41	42	-1.81	113	8.01	144	-0.91*	6.2	-34.17*	210	-2.26**	6
P MAHAK X GM2	1.84	46	-0.60	115	-2.13	147	0.46	7.0	15.25	269	1.55*	8
P MAHAK X GM3	0.04	45	1.92	115	-3.59	153	0.40	7.3	-4.04	262	-0.32	9
P MAHAK X JD6	-0.12	45	0.24	112	2.91	126	-0.61	8.2	5.52	338	-0.06	7
P MAHAK X BIO902	2.96*	46	3.99*	113	6.12	154	0.95*	7.2	6.87	322	1.66*	8
P AGRANI X PM22	-3.00*	42	-2.64	112	-0.34	144	0.10	5.7	33.19*	244	0.22	7
P AGRANI X PM 24	-0.60	45	-2.45	114	9.97*	151	0.44	7.2	22.33	310	0.74	10
P AGRANI X NRCHB101	-1.54	42	1.13	112	5.99	151	-0.07	6.2	5.73	253	0.77	9
P AGRANI X GM2	2.71*	46	1.67	115	-7.49	137	-0.04	7.5	-16.52	303	0.58	8
P AGRANI X GM3	-3.41*	44	-3.47*	115	7.06	141	-1.44*	7.2	-40.81*	280	-1.45*	7
P AGRONI X JD6	1.75	43	2.51	111	2.22	151	0.73	6.5	9.08	298	0.14	6
P AGRONI X BIO902	1.17	47	0.26	114	10.76*	153	-0.38	8.3	20.77	300	-0.97	10
PM21 X PM22	-0.75	45	2.15	115	10.60*	157	0.40	6.5	9.77	257	-0.65	8
PM21 X PM24	1.98	44	3.34*	114	10.91*	145	0.20	6.3	-8.08	284	-0.80	9
PM21 X JD6	-1.00	46	-3.37*	114	-6.51	153	1.02*	5.0	46.33*	227	0.76	8
PM21 X BIO902	2.09	43	2.38	114	4.03	152	0.92*	7.5	36.02*	285	1.15	8
PM22 X PM24	3.36*	48	1.09	116	8.03	160	-0.44	6.7	-11.31	298	-0.56	9
PM22 X GM2	1.00	46	-2.45	116	-0.09	162	-0.72	6.2	38.83*	258	0.28	8
PM22 X GM3	1.21	46	0.74	113	-10.88*	151	0.22	5.7	7.54	252	1.41*	8
PM22 X JD6	-0.62	50	-1.62	126	-0.05	148	0.21	6.3	-7.23	278	-0.66	6
PM22 X BIO902	1.46	51	-0.87	126	8.16*	153	0.61	6.0	37.12*	262	2.06*	6
PM24 X NRCHB101	1.15	49	-0.81	121	2.03	149	1.05*	7.3	26.56	317	2.82**	8
PM24 X GM2	-0.93	50	-2.26	122	8.56	158	0.28	7.5	-25.69	307	0.47	6
PM24 X GM3	-0.06	49	-1.41	121	-5.24	158	0.52	5.2	9.35	235	0.10	8
PM24 X JD6	-1.23	47	-3.10*	116	3.93	156	0.51	6.7	47.58*	242	0.69	8
PM24 X BIO902	-1.81	50	-3.35*	122	-1.53	145	-0.59	5.2	-17.06	285	-0.08	9
NRCHB101 X GM3	0.34	49	1.51	119	-1.22	154	-0.96*	6.2	17.42	244	-0.54	7
NRCHB101 X JD6	0.50	49	0.15	118	-3.38	161	-0.80	6.8	-22.35	289	1.05	8
NRCHB X BIO902	-2.08	49	-3.43*	120	1.49	151	0.27	7.2	-17.33	293	-1.39*	9
GM2 X GM3	-3.08*	47	-1.95	118	15.46**	153	0.41	6.4	63.17**	242	1.60*	7
GM2 X JD6	0.42	45	0.36	112	10.47*	145	-0.26	6.8	-15.60	268	0.20	7
GM2 X BIO902	-1.16	47	-1.56	113	-1.32	137	-0.53	7.0	0.42	238	-0.58	9
GM3 X JD6	-0.37	45	-0.78	112	-3.32	145	-0.83	6.2	-10.56	356	-1.01	8
GM3 X BIO902	1.04	43	1.30	117	-8.11	143	0.07	8.3	-28.54*	325	-0.61	7
JD6 X BIO902	-1.46	47	-1.06	110	6.72	157	0.63	7.5	38.02*	296	1.65*	7

Note: * Significant at 5% level, ** Significant at 1% level

Note: gca and sca effect for 1000 seed weight was not calculated because mean square due to crosses were non significant.

maturity and plant height at maturity. While the crosses exhibited significant mean squares for days to 50% flowering, days to maturity, number of primary branches^{-1}, number of siliqua plant^{-1}, and yield plant^{-1}. However, parents vs. crosses exhibited significant differences for all the characters except days to 50% flowering. Analysis of varience for the experimental design revealed the presence of substantial genetic variability among the genotypes which allows further estimation in the experimental material. The wide variability for plant^{-1} yield and yield contributing characters including, plant height (cm), number of primary branches, number of siliqua, and 1000 seed weight (g) in mustard were also observed by Aghao *et al.* (2010), Singh *et al.*(2010), Ramesh (2010). Nasrin *et al.* (2011), Turi *et al.* (2011), Vaghela *et al.* (2011), Tele (2014) and Puttawar *et al.* (2014).

Data regarding analysis of variance for combining ability are presented in table 2. The variation between crosses was partitioned into different components representing mean squares due to general combining ability (GCA) and specific combining ability (SCA). The mean squares due to gca was of higher magnitude than those due to sca indicating the relative importance of parents in the crosses. The mean squares due to gca were highly significant for all the characters under study except 1000 seed weight. The mean squares due to sca were significant for all the character except 1000 seed weight.

Data regarding the gca effects of fourteen parents for days to 50% flowering, days to maturity, plant height at maturity, number of primary branches^{-1}, number of siliqua plant^{-1}, and yield plant^{-1} are presented in table 3. Data regarding the sca effects of 91 crosses for days to 50% flowering, day to maturity, plant height, number of primary branches^{-1}, number of siliqua plant^{-1} and yield plant^{-1} are presented in table 4. Results showed that the parent Bio 902 recorded significant positive gca effect for yield plant^{-1}, plant height, number of siliqua plant^{-1}, number of primary branches^{-1}, days to maturity and days to 50% flowering. Similarly another parents Pusa Mahak exhibited higher significant gca effect for yield plant^{-1}, 1000 seed weight, plant height, number of siliqua plant^{-1} and number of primary branches^{-1}. These three parents Pusa Mahak, JD 6 and Bio-902 were identified as good general combiners and can be used in crossing programme. Out of 91 crosses, twenty two exhibited significant sca effects of which fourteen showed positive and eight had negative significant sca effects.

The potentiality of the cross to be forwarded to next generation was decided on the basis of high mean performance, high gca of one or both the parents involved in the cross, and with the negative sca effects. The selection of crosses in this manner was also done by Aghao *et al.* (2010) in mustard. Based on this criteria promising crosses and their selected *per se* performances the specific combining ability analysis of economically important characters under study showed that the crosses NRCHB 101 X Bio 902, Pusa Mustard 28 X JD 6, Pusa Tarak X Bio 902, Pusa Mustard 21 X GM 2, Pusa Agrani X GM 3, Pusa Mustard 25 X Pusa Mustard 28, Pusa Mahak X NRCHB 101 and Pusa Tarak X Pusa Mustard 24 were superior. These crosses were also found to have high mean performance for seed yield plant^{-1} and number of siliqua plant^{-1} and also possessed and negative sca effects and hence these crosses can be forwarded to next generation for producing genotype of inherent superiority by blending and mixing maximum favorable genes following by simple selection methods.

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