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COMBINING ABILITY ANALYSIS FOR YIELD AND ITS COMPONENTS IN BROWN MUSTARD

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ABSTRACT

A 6x6 diallel experiment was conducted on brown mustard *Brassica juncea.L* to determine combining ability analysis for yield and its components during 2000-2002 at the Faculty of Agriculture, Gomal University Dera Ismail Khan. Estimates of variance due to general combining ability (GCA), specific combining ability (SCA) and reciprocal effects were highly significant for all characters except the variances due to reciprocal effect for the number of primary branches, length of main inflorescence and specific combining ability effect for seed yield plant^{-1} which were found to be non significant. Higher magnitude of mean squares for general combining ability effects as compared to specific combining ability were recorded for all the characters and thus all the parameters were governed by additive type of gene action. B.L 9141 and 9142 were found to be the best general combiners for all the characters studied. The good general combiners for all the traits formed superior specific and reciprocal combinations with R. L-18 and Early raya for all the characters and is therefore recommended for inclusion in the breeding programs for the evolution of high yielding Brown mustard varieties.

Key words: Combining ability, brown mustard, *B. juncea*, yield and its components.

INTRODUCTION

Mustard belongs to the family Cruciferae (Brassicaceae), and genus *Brassica*. Allied species of mustard include white mustard [*Sinapis alba* (L)] or *B. hirta* (L.) Moench, brown mustard (*B. juncea*), black mustard (*B. nigra*) and ethiopian mustard *(B. carinata)* [Knowles *et al.*, 1981].

Over the past couple of decades, *Brassica* oilseeds production has increased to become one of the most important world sources of vegetable oil. Oilseed *Brassica* crops annually occupy about 22 million hectares of the world's agricultural land and provide over 30 million tons of the world's oilseed production which is the third most commonly traded vegetable oilseed in the world after soybean and cotton (F.A.O, 1996). Edible oil is an important component of a balanced human diet. Rapeseed (primarily *B. napus, B. campestris,* and *B. juncea*) is grown worldwide as a source of edible oil. These annual crops can be successfully grown in different types of soils (French, 1977).

Mustard oil is one of the major edible oils in India. The fixed oil content of *rai* varies between 28.6 and 45.7%. It is also used as hair oil, lubricants and, in Russia, as a substitute for olive oil. Seed residue is used as cattle feed and in fertilizers as well (Reed, 1976).

Indian Mustard is a folk remedy for arthritis, foot ache, lumbago, and rheumatism (Duke and Wain, 1981). In Korea, the seeds are used for abscesses, colds, and lumbago, rheumatism, and stomach disorders. Chinese eat the leaves in soups for bladder inflammation or hemorrhage. Mustard oil is used for skin eruptions and ulcers (Perry, 1980).

In Pakistan, rapeseed and mustard are the second most important source of vegetable oil after cottonseed. They occupy an area of 0.3 m ha with annual production of 0.229 million tons, contributing about 20% to the domestic production of edible oil (Anonymous, 1996). Brown mustard (*B. juncea* L. Czern. and Coss.) is mainly a self-pollinated crop having 7.5 to 30% out crossing under natural field conditions.

There is considerable scope for developing new mustard varieties, with low levels of erucic acid and glucosinolates. However, one of the limitations of *B. juncea* is that the available genotypes contain higher glucosinolates and erucic acid content, restricting its use as edible oil crop (Pryde and Doty, 1981). In addition, the oil content of this species is also lower than what is desirable. Therefore, there is great need to screen out breeding lines for lower levels of erucic acid and glucosinolates, and higher yield potential. The success of breeding program for developing genetically superior brown mustard cultivars depends upon the selection of superior parents to be utilized in crossing program. The parents selected must be genetically pure, physiologically efficient and having better combining ability. In biometrical genetics two types of combining ability are considered i.e. general combining ability (GCA), referring to the average performance of a parental line as reflected in its hybrid combination and specific combining ability (SCA), which is average performance of a parental line in a particular cross combination. According to

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Sprague and Tatum (1942), general combining ability is due to genes which are largely additive in nature, while specific combining ability is due to non additive type of gene action as outlined by Griffing (1956). Sheikh and Singh (1998), Patel *et al.* (1996), Bhateria *et al.* (1995) and Khulbe *et al.* (1998) reported the merits of SCA effects than GCA, emphasizing the importance of non-additive (dominant or epistatic) type of gene action. On the other hand Yadave *et al.* (1993) estimated an appreciable degree of variance due to GCA in their studies.

The present breeding work on the combining ability analysis is therefore an attempt to evaluate different *B. juncea* genotypes for their potential in different cross combinations for various yield characters of Brown mustard.

MATERIALS AND METHODS

A field experiment was conducted at Faculty of Agriculture, Gomal University, Dera Ismail Khan to study the gene action regarding yield parameters in F_1 generation of Brown mustard. The experimental material comprised F_1 hybrid seed, obtained from a 6 x 6 diallel cross of four varieties R.L-18, B.M-1, Early raya and S-9 and two breeding lines (B.L.) 91421and 91416, including self's and reciprocals. The varieties and breeding lines were crossed in a diallel fashion during October 2001. The F_1 seeds of these crosses along with their parents were space planted during October 2002, in the experimental field using randomized complete block design with three replications. Each replication comprised 6 parents and 30 F_1's, having single row of 5 m length per treatment, and one m apart. Between replications a space of 2 m was left unplanted to facilitate walking in between the three replications for recording observations. Sowing was done with single row hand drill. All agronomic practices and plant protection measures were kept normal and uniform for the entire experiment. Weeds were controlled manually. At maturity, 10 guarded plants (leaving one plant on either side of each treatment) were randomly selected in each replication. The data were recorded on the number of primary branches, length of main inflorescence (cm), siliquae main inflorescence^{-1} and seed yield plant^{-1}(g). The data were subjected to statistical manipulation to determine the significance among the genotypes.

Only the significant genotypic differences allowed the data for further analysis of combining ability. Variances due to crosses were partitioned into that due to general combining ability (GCA), specific combining ability (SCA) and reciprocal effects, using Griffing's Method-1 Model-1 (1956).

RESULTS AND DISCUSSION

Number of Primary Branches

The results of variance due to general combining ability and specific combining ability were found highly significant, while the reciprocal effects were non significant (Table I). Components of variance for GCA, SCA and reciprocal effects in Table II indicated that variance due to GCA was much higher in magnitude and more important for number of primary branches, 50.87 % whereas the variance due to SCA and reciprocals were 24.326 and 4.23%, respectively for this character. A reference to Table III revealed that the B.L. 9142 showed the highest and positive general combining effect (0.773) which was closely followed by B.L. 9141 (0.415), while rest of the genotypes showed negative general combining ability effect for number of primary branches (Table II). Hybrid Early raya x S-9 exhibited the maximum value of SCA effects (0.885) while the minimum values of SCA were observed in crosses R.L-18 x B.L9142 (-0.173), R.L-18 x Early Raya (-0.245), B.M-1 x S-9 (-0.154), B.L9141 x Early Raya (-0.420), B.L9141 x S-9 (-0.501), B.L9142 x Early Raya (-0.312), and B.L9142 x S-9 (-0.176) exhibited negative SCA effects (Table IV). For the reciprocal effects, it is obvious from Table V that the hybrid between Early Raya x B. L.9141 manifested the maximum reciprocal effect (0.500) and cross Early Raya x B.M-1 produced the lowest reciprocal effect (-0.300) for this character. These results are in conformity with the findings of Yadave *et al* (1993). However, these are contradictory to the findings of Sheikh and Singh (1998), Patel *et al.* (1996), Bhateria *et al.* (1995) and Khulbe *et al.* (1998), who found non-significant GCA effects for the trait under reference. The deviation might be the difference in the macro- and micro-environment of the experiments and the variable genetic material used in the studies.

Length of Main Inflorescence (cm)

The ANOVA depicted the variance due to general combining ability as highly significant ($P<0.01$), while that due to specific combining ability was found significant at $P<0.05$. The reciprocal effects were found to be non significant statistically ($P>0.05$) [Table I]. Table II indicated that variance due to specific combining ability was the highest in magnitude (26.28%) and more important for length of main inflorescence, whereas the variance due to GCA and reciprocal effects were 21.03 and 2.05%, respectively for this character. Hence the over dominance type of gene action was operative in determining the length of main inflorescence. Table III revealed that the B.L.9142 showed the highest and positive general combining effect (0.624), which was closely followed by B.L.9141 (0.513), while rest of the entries showed negative general combining ability effect for length of main inflorescence. Hybrid R.L-18 x B.L9141 exhibited the maximum value of SCA effect (1.068), while the crosses R.L-18 x B.M-1 (-0.849), R.L-18 x B.L9142 (-0.071), R.L-18 x Early Raya (-0.049), B.M-1 x S-9 (-0.049), B.L9141 x Early Raya (-0.974), B.L9141 x S-9 (-0.582) and B.L9142 x S-9 (-0.855) expressed the lowest values of SCA effects for this character (Table IV). For the reciprocal effects, it is obvious from Table V, that the hybrid between S-9 x B.L9142 reflected maximum reciprocal effects (0.967) and cross B.M-1x R.L-18 produced the lowest reciprocal effect (-0.750). These results are in conformity with the findings of Yadave *et al* (1993). However, these results are not in line with the findings of Sheikh and Singh (1998), Patel *et al.* (1996), Bhateria *et al.* (1995) and Khulbe *et al.* (1998), who reported non-significant GCA effects for the trait under reference. The difference could be due to the varying genetic material employed and the varying agro-ecological conditions of the experiments.

Number of Siliquae Main Inflorescence^{-1}

The ANOVA showed that the variances due to general combining ability, specific combining ability and reciprocal effects were found to be highly significant (Table I). The components of variance for GCA, SCA and reciprocal effects in Table II indicated that variance due to general combining ability effect was much higher in magnitude and more important (44.521 %) for siliquae main inflorescence^{-1} whereas the variance due to SCA and reciprocal effects were 17.71 and 28.27%, respectively for this character. A perusal of Table III revealed that the B.L. 9141 showed the highest and positive general combining effects (2.842), which was closely followed by B.L. 9142 (2.397) while rest of the genotypes showed negative general combining ability effects for Siliquae main^{-1} inflorescence. Hybrid B.L9142 x Early Raya exhibited the maximum value of SCA effects (2.281) while the crosses R.L-18 x B.M-1 (-0.383), R.L-18 x Early Raya (-0.772), R. L-18 x S-9 (-0.561), B. M-1 x Early Raya (-0.567), B.L9141 x B. L 9142 (-0.872), B.L9141 x Early Raya (-1.375) and B.L9142 x S-9 (-1.758) gave the lowest value of SCA effects for this character (Table IV). In case of reciprocal effects, it is obvious from Table V that the hybrid between Early Raya x B. L9141 expressed the maximum reciprocal effects (4.317) and the cross S-9 x B.M-1 produced the lowest reciprocal effect (-1.383) for the character under consideration. These results are in conformity with the findings of Yadave *et al* (1993), Sheikh and Singh (1998), Patel *et al.* (1996), Bhateria *et al.* (1995) and Khulbe *et al.* (1998) who communicated non-significant GCA effects for this trait.

Seed Yield plant^{-1} (g)

The ANOVA revealed that variances due to general combining ability to be highly significant, while those due to specific combining ability and reciprocal effects were non significant (Table I). Table II indicated that variance due to general combining ability effects was enormously higher in magnitude (79.26) and more important for seed yield plant^{-1}, whereas the variance due to SCA and reciprocal effects were -28.671 and -48.67%, respectively and were very low. A reference to Table III revealed that the B.L. 9141 showed the highest and positive general combining effect (1.789), which was closely followed by B.L. 9142 (1.726), while rest of the varieties showed negative general combining ability effects for seed yield plant^{-1}. Hybrid R.L-18 x B.L9142 exhibited the maximum value of SCA effect (0.993) while the crosses R.L-18 x B.M-1 (-0.060), R. L-18 x S-9 (-0.688), B. M-1 x Early Raya (-0.763), and B.L9141 x B. L 9142 (-1.487) gave the lowest value of SCA effects for this character (Table IV). In case of reciprocal effects, it is obvious from Table V that the hybrid between B.L9141x R.L-18 reflected maximum reciprocal effects (0.277) and cross Early Raya x B. L9141 showed the lowest reciprocal effect (-0.103) for this character. These results are in conformity with the findings of Yadave *et al* (1993) who concluded highest significant and positive GCA effects for this trait. Sheikh and Singh (1998), Patel *et al* (1996), Bhateria *et al* (1995) and Khulbe *et al* (1998), however, deciphered non-significant GCA effects for this trait. This difference could be due to the differences in genotypes and the agro-ecological conditions of the studies.

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Table I. *Mean squares due to general, specific and reciprocal effects for various characters of Brown mustard (B. juncea L.) in a six parent diallel cross experiment.*

Variance components	D.F	No of Primary Branches	Length of Main Inflorescence	Siliquae main Inflorescence^{-1}	Seed yield plant^{-1}
General combining ability (GCA)	5	3.150**	2.703**	54.644**	22.978**
Specific combining ability (SCA)	15	0.300*	0.748*	3.813**	1.117N.S
Reciprocal Effects	15	0.128NS	0.428N.S	6.295**	1.733N.S
Error	70	0.104	0.394	0.905	2.251

**=Significant at P≤0.01, *= Significant at P≤0.05, N.S = Non-significant

Table 1I. *Estimates of components of variance due to general, specific and reciprocal effects for various characters of Brown mustard (B. juncea L.) in a six parent diallel cross experiment.*

Variance components	No of Primary Branches	Length of Main Inflorescence	Siliquae main Inflorescence^{-1}	Seed yield plant^{-1}
General combining ability (GCA)	0.238 **(50.87)**	0.164 (21.03)	4.244 **(44.52)**	1.819 **(79.259)**
Specific combining ability (SCA)	0.114 (24.33)	0.205 **(26.28)**	1.688 (17.71)	-0.658 (-28.67)
Reciprocal Effects	0.0198 (4.23)	0.016 (2.05)	2.695 (28.27)	-1.116 (-48.67)
Error	0.104 (20.57)	0.395 (50.64)	0.905 (9.53)	2.251 (98.12)

Upper values denote variance estimates, while the **Lower values** denote variance estimates in percentage.

Table III. *Estimates of general combining ability (GCA) effects for various characters of Brown mustard (B. juncea L.) in a six parent diallel cross experiment.*

Varieties	No of Primary Branches	Length of Main Inflorescence	Siliquae main Inflorescence^{-1}	Seed yield plant^{-1}
R.l-18	-0.069	-0.084	-0.289	-0.460
B.M-1	-0.091	-0.609	-0.994	-1.136
B.L.9142	**0.773**	**0.624**	**2.397**	**1.726**
B.L.9141	**0.415**	**0.513**	**2.842**	**1.789**
Early raya	-0.530	-0.259	-1.822	-1.122
S-9	-0.499	-0.184	-2.133	-0.797
CD$_{0.05}$ (g_i - g_j)	0.258	0.5028	0.7612	1.2005

Table IV. ***Estimates of specific combining ability (SCA) effects for various characters of Brown mustard (B. juncea L.) in a six parent diallel cross experiment.***

Cross Combinations	No of Primary Branches	Length of Main Inflorescence	Siliquae main Inflorescence^{-1}	Seed yield plant^{-1}
R.L-18 x B.M-1	0.149	-0.849	-0.383	-0.060
R.L-18 x B.L9141	0.585	1.068	1.775	0.631
R.L-18 x B.L9142	-0.173	-0.071	0.881	0.993
R.L-18 x Early Raya	-0.245	-0.049	-0.772	0.001
R.L-18 x S-9	0.091	0.426	-0.561	-0.688
B.M-1 x B.L9141	0.141	0.309	1.481	0.830
B.M-1 x B.L9142	0.316	0.254	1.303	0.320
B.M-1 x Early Raya	0.110	0.043	-0.567	-0.763
B.M-1 x S-9	-0.154	-0.049	0.361	0.321
B.L9141 x B.L9142	0.119	0.054	-0.872	-1.487
B.L9141 x Early	-0.420	-0.974	-1.375	0.986
Raya B.L9141 x S-9	-0.501	-0.582	0.703	0.101
B.L9142 x Early	-0.312	0.337	2.281	0.258
Raya	-0.176	-0.855	-1.758	0.491
B.L9142 x S-9	0.885	0.984	1.239	0.081
Early Raya x S-9				
CD$_{0.05}$(Sij-Sik)	0.577	1.124	1.702	2.684
CD$_{0.05}$(Sij-Ski)	0.516	1.01	1.522	2.401

Table V. ***Estimates of Reciprocal effects for Various Characters of B. juncea in a six parent diallel cross experiment.***

Cross Combinations	No of Primary Branches	Length of Main Inflorescence	Siliquae main Inflorescence^{-1}	Seed yield plant^{-1}
B.M-1x R.L-18	0.133	-0.750	-0.017	0.110
B.L9141x R.L-18	0.100	0.100	0.400	*0.277*
B.L9142x R.L-18	0.050	0.450	0.383	0.012
Early Raya x R.L-18	0.033	0.567	0.933	-0.018
S-9x R.L-18	-0.267	0.583	0.833	-0.015
B.L9141x B.M-1	0.100	0.083	0.067	-0.007
B.L9142xB.M-1	0.317	0.017	0.400	-0.027
Early Raya xB.M-1	-0.300	-0.533	1.333	0.008
S-9xB.M-1	0.067	-0.450	-1.383	-0.142
B.L9142xB.L9141	0.383	0.417	-0.050	0.008
Early Raya xB.L9141	*0.500*	-0.150	*4.317*	-0.103
S-9xB.L9141	0.283	0.350	2.383	-0.037
Early Raya xB.L9142	0.350	0.150	-0.250	-0.078
S-9xB.L9142	0.117	*0.967*	4.133	-0.007
S-9xEarly Raya	-0.200	-0.033	-0.133	0.038
CD$_{0.05}$ ($r_{ij} – r_{ki}$)	0.632	1.232	1.865	2.941

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