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Combining Ability for Different Aphid Resistance Parameters and Seed Yield in Indian Mustard (*Brassica juncea* L. Czern and Coss)

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Abstract

A half diallel set of crosses involving eight aphid resistant lines of Indian mustard and their 28 F_1 hybrids were raised to study the combining ability and the nature of gene action of aphid resistant parameters and seed yield. Only the sca variances were significant for all the aphid resistant parameters. In contrast, both gca and sca variances were significant for seed yield per plant. Partitioning of variances into additive and dominance components further confirmed the predominant role of dominance variance controlling all the traits studied. The gca effects of parents revealed that out of eight genotypes P_5 was the best combiner followed by P_2 and P_7 considering the resistance parameters and seed yield. Out of 28 crosses, three crosses $P_1 \times P_7$, $P_2 \times P_8$ and $P_3 \times P_6$ showed significantly positive sca effects for seed yield along with significantly negative sca effects for at least one of the resistant parameters. As the dominant gene action is the predominant factor, exploitation of heterosis would be the best choice.
Key words : Indian mustard, Aphid resistance, Seed yield, Combining ability.

Among the various types of pests, mustard aphid (*Lipaphis erysimi* Kalt.) continues to be the major pest limiting successful mustard cultivation. The yield losses due to this pest have been reported to vary from 45 to 96% in different agro-climatic zones in India (1, 2). Chemical control is effective but it causes imbalance in the ecosystem and invites health hazards. Therefore the host plant resistance seems to be the best alternative to keep the pest population at a manageable level. Although several studies revealed the presence of some resistance mechanisms in some genotypes of mustard, but none was immune to aphid infestation. Use of different identified sources of resistance and understanding the nature and magnitude of gene actions for resistance are prerequisite for a breeding program on aphid resistance. Few studies so far made, revealed significance of both additive and non-additive gene actions controlling the aphid resistance parameters (3—6). The ultimate goal of a breeder is to evolve an aphid resistant and moderate to high yielding variety as the seed yield of the resistant lines is of paramount importance. In the present study, some aphid resistant and high yielding lines were used to study the nature of gene action of resistance parameters as well as seed yield.

Methods

The eight lines used in this experiment comprised seven true breeding advance elite lines, developed through hybridization among some selected aphid resistant lines and resistant check varieties T 6342 and RC 1425, followed by selection for aphid resistance and higher yield in the segregating generations for six generations and a national resistant check variety, T 6342. Eight parents, their 28 hybrids and one aphid susceptible check variety (Varuna) were sown in randomized block design with two replications at the Instructional Farm, Jaguli, Bidhan Chandra Krishi Viswavidyalaya, Nadia, WB on 24 November 2005. Data were recorded for percentage of highly affected plants, first infestation score on 65 DAS (days after sowing), second infestation score on 73 DAS, third infestation score on 82 DAS, damage score and seed yied per plant. Highly affected plants were classified on the basis of symptoms as very poor growth, heavy curling and yellowing of leaves, stunting of plants, little or no flowering and only a few pods formation. Infestation score was done (7). To work out the damage score, a visual rating from 1—5 was done on 87 DAS on the basis of damage on the plants, inflicted

Table 1. Mean performance of parents, hybrids and the check for different aphid resistance parameters and seed yield.

Parents and check	Percentage of highly affected plants	First infestation score on 65 DAS	Third infestation score on 82 DAS	Damage score on 85 DAS	Seed yield per plant
P_1	23.76	2.38	2.88	3.45	0.41
P_2	14.79	2.25	3.12	2.90	0.80
P_3	24.16	2.62	3.12	3.25	0.45
P_4	24.70	3.00	2.50	3.25	0.48
P_5	20.83	3.00	2.50	2.7	0.70
P_6	14.83	2.88	2.88	2.85	1.01
P_7	17.34	2.75	2.88	3.25	0.46
P_8	17.32	3.12	3.00	2.95	0.65
Mean	19.72	2.75	2.86	3.08	0.59
Mean of hybrids	16.94	2.30	1.90	2.69	1.06
Varuna (check)	41.67	3.50	4.05	3.55	0.47
CD at 5%	9.70	1.06	0.82	0.61	0.56

after the dispersal of aphids. Seed yield per plant was recorded after harvesting, by averaging the yield of 10 plants at random from each line. The data were analyzed for combining ability (8).

Results and Discussion

The analysis of variance for 8 × 8 half diallel revealed significant variation among the progenies for all the traits studied except second infestation score which might be attributed to insecticide spray after first infestation was scored (65 DAS) and was omitted for further studies. Parents did not differ significantly for any of the traits but the hybrids performed better than the parents in third infestation score, damage score and seed yield per plant (Table 1). The mean sum of squares due to gca for all the resistant parameters were insignificant while those due to sca were significant. The mean sum of squares both due to gca and sca were significant for seed yield per plant (Table 2). Earlier reports (3, 4, 6) revealed the importance of both gca and sca or additive and non-additive gene action controlling the aphid resistant traits although the parameters were different and included both resistant and susceptible parents in their study. In the present study all the parents were resistant to aphids, the initial variability among the parents was unidirectional and narrow in nature.

Table 3. Estimates of variance components for aphid resistance parameters and seed yield.

Variance components	Mean sum of square: Percentage of highly affected plants	First infestation score on 65 DAS	Third infestation score on 82 DAS	Damage score on 84 DAS	Seed yield/ plant
σ^2 gca	1.285	0.002	0.003	0.002	0.007
σ^2 sca	39.156	0.197	0.224	0.065	0.148
σ^2 e	11.298	0.136	0.081	0.0446	0.038
σ^2 A	2.569	0.003	0.005	0.0041	0.015
σ^2 D	39.156	0.197	0.224	0.065	0.148
σ^2 P	53.023	0.336	0.309	0.114	0.200
$\sigma^2 D/\sigma^2 A$	15.242	65.533	44.78	15.854	10.061
h^2	4.85	0.89	1.61	3.61	7.34

Further partitioning of variances also revealed the predominant effect of dominance variance (σ^2_D) in controlling the traits (Table 3). Additive variances (σ^2_A) were of very lower magnitude as compared to dominance variance as evident from the dominance ratios of the traits. The heritability estimates in the narrow sense were also very low. These results inferred the unfixable nature of gene action to aphid resistance. However, before making any conclusion regarding the nature of gene action, the reason that the population builds up was too high as evident

Table 2. Analysis of variance for gca and sca for mustard aphid resistance parameters and seed yield. * and ** = Significant at 5% and 1% level, respectively.

Source of variation	df	Mean sum of squares: Percentage of highly affected plants	First infestation score on 65 DAS	Third infestation score on 82 DAS	Damage score on 84 DAS	Seed yield/plant
gca	7	24.144	0.151	0.106	0.065	0.1138*
sca	35	50.454**	0.333**	0.305**	0.109**	0.186**
Error	27	11.298	0.136	0.081	0.045	0.038

Table 4. Estimates of gca effects for aphid resistance parameters and seed yield. * and ** = Significant at 5% and 1% level, respectively.

Parents	Percentage of highly affected plants	First infestation score on 65 DAS	Third infestation score on 82 DAS	Damage score on 85 DAS	Seed yield/ plant
P_1 (AR-A28)	-0.84	-0.12	-0.03	-0.08	-0.08
P_2 (AR-A29)	-0.45	0.04	00.04	-0.06	0.06
P_3 (AR-A210)	1.11	-0.01	-0.09	-0.03	-0.03
P_4 (AR-A211)	3.09	-0.18	-0.01	0.07	-0.21**
P_5 (AR-A212)	-1.62	-0.08	-0.15	-0.09	0.04
P_6 (AR-A213)	-0.64	0.03	0.09	0.00	0.06
P_7 (AR-A214)	-0.13	0.13	-0.01	0.10	0.05
P_8 (AR-T6342)	0.48	0.18	0.18	0.10	0.12*
SE (gi) ±	0.994	0.109	0.084	0.062	0.057

from the performance of the susceptible check Varuna (Table 1) should be taken into account.

As it is known that aphid resistance is governed by polygenes and the expression of resistance is dependent on the population pressure of the insect, it might be more important to test the parents and their hybrids in low to moderate population pressure in the field or under controlled population level. Smaller level of resistance governed by a number of genes might be masked by high population pressure of the insect and even a resistant variety or line might turn out to be susceptible under such circumstances. As it is evident that parents have sown resistance to aphids compared to the check and further the hybrids have sown higher resistance to aphid compared to the parents, the polygenic nature of gene action and predominant role of dominant gene action in controlling the resistance parameters are unmistakable.

Estimates of General Combining Ability

Estimates of gca effects of parents for percentage of highly affected plants, aphid infestation scores and damage score reflects that P_1 and P_5 are the best general combiners for these traits followed by P_2, P_3 and P_4 (Table 4). All the seven resistant lines (P_1, P_2, P_3, P_4, P_5, P_6 and P_7) were superior to the national resistant check T 6342 as none of its resistance parameters showed desirable (negative) gca effects. T 6342 is known to be a potential source of resistance to aphid (7, 9) and it has been extensively utilized in hybridization program as donor parent with a view to incorporate aphid resistance. In the present study it is found to be otherwise. It might be due to high aphid population pressure generally witnessed in West Bengal (hot spot), which is not usual in northen India where the said studies were conducted.

Table 5. Top ranking crosses selected on the basis of significant sca effects with their mean performance and gca status. * and ** = Significant at 5% and 1% levels, respectively; L, M and H : Low, medium and high combiners respectively.

Characters	Crosses	Mean performance: First infestation score on 65 DAS	Seed yield per plant (g)	SCA effects	GCA status
Seed yield per plant	$P_1 \times P_7$	2.83	1.86	0.93**	L × M
	$P_2 \times P_5$	1.75	1.86	0.81**	M × M
	$P_3 \times P_8$	3.50	1.62	0.58**	L × H
	$P_2 \times P_8$	2.88	1.55	0.42*	M × H
	$P_3 \times P_6$	1.88	1.40	0.42*	L × M
		Infestation score	Seed yield per plant (g)		
First infestation score on 65 DAS	$P_7 \times P_8$	1.75	1.46	-0.96**	L × L
	$P_1 \times P_8$	1.50	1.25	-0.96**	H × L
	$P_3 \times P_5$	1.52	1.22	-0.79*	M × M
	$P_4 \times P_8$	1.62	0.76	-0.77*	H × L
	$P_5 \times P_6$	1.62	1.30	-0.72*	M × L
Third infestation score on 82 DAS	$P_2 \times P_8$	1.62	1.55	-0.70**	L × L
	$P_3 \times P_5$	1.25	1.22	-0.62*	M × H
	$P_3 \times P_6$	1.50	1.40	-0.60*	M × L
	$P_1 \times P_8$	1.75	1.25	-0.52*	M × L
		Damage score	Seed yield per plant (g)		
Damage score on 85 DAS	$P_1 \times P_4$	2.25	0.59	-0.52**	H × L
	$P_1 \times P_7$	2.35	1.86	-0.45*	H × L
	$P_1 \times P_3$	2.25	1.17	-0.42*	H × L
	$P_3 \times P_5$	2.25	1.22	-0.41*	M × H
	$P_1 \times P_2$	2.25	0.69	-0.39*	H × M

Estimates of Specific Combining Ability

Among all the crosses, five best crosses were selected on the basis of significant positive sca effects for seed yield (Table 5). The crosses were $P_1 \times P_7$, $P_2 \times P_5$, $P_3 \times P_8$, $P_2 \times P_8$ and $P_3 \times P_6$ and *per se* performance of seed yield of all the crosses was good. These crosses except $P_3 \times P_8$ also showed desirable *per se* performance for first aphid infestation score. These five crosses involved low × medium, medium × high, low × medium, medium × medium and low × high general combiners as parents respectively. Specially, the crosses $P_2 \times P_5$ and $P_2 \times P_8$ were promising as they involved medium and high general combiners for seed yield. When five best crosses were selected on the basis of significant sca effects for first infestation score (Table 5), none of the best crosses selected on the basis of significant sca effects for seed yield was included, although their *per se* performance for first aphid infestation score were better and *per se* yield performance was not much lower. Best five crosses involved low × low, high × low, medium × medium and medium × low general combiners. The gca status of the parents involved in the crosses could be explained if the predominant dominance gene action controlling these traits and absence of any sowing significantly negative gca effects were considered. Among the best four crosses, selected on the basis of significant sca effects for the third infestation score (Table 5) two crosses $P_3 \times P_5$ and $P_1 \times P_8$were common with the five crosses selected on the basis of significant sca effects for first infestation score. The best four crosses showed almost similar *per se* performance regarding aphid infestation score compared to first infestation sore. The *per se* performance of seed yield of these crosses selected on the basis of third infestation score was similar or better than the crosses selected for the first infestation score. Best five crosses selected on the basis of significant sca effects for damage score (Table 5) involved P_1 as one parent of the four crosses which was judged as good general combiner for damage score. *Per se* performance for seed yield per plat was poor for the crosses $P_1 \times P_4$ and $P_1 \times P_2$. The cross $P_1 \times P_2$ involved both good general combiner parents for damage score.

Considering aphid infestation scores, damage score and seed yield per plant the cross $P_3 \times P_5$ might be considered as the promising cross to proceed further followed by $P_1 \times P_7$ and $P_1 \times P_8$. So, P_3 (AR-A210) and P_5 (AR-A213) lines are the best combiners for resistance to mustard aphid, hence these should be utilized in a resistance breeding program and the crosses showing high sca effects for seed yield should be exploited for developing high seed yielding cultivars with resistance to aphids. Kumar et al. (4) suggested that resistant × resistant crosses would make better choice for assembling favorable genes in advanced generations from their studies on combining ability for resistance parameters to aphid. It has been suggested to increase the available level of resistance by increasing the frequency of resistant alleles (6). In the present study, as the dominant gene action is the predominant factor, exploitation of heterosis would be the best choice. However, diallel selective mating (10) or biparental mating (11) might be useful if the appropriate crosses are chosen.

References

1. Phadke K. G. 1980. Strategy for increasing rapeseed and mustard production through insect pest control. Proc. FAI Gr. Disc. on increasing pulse and oilseed production in India, Sep 4—5 1980, New Delhi, pp. 151—158.
2. Singh B., R. Singh, M. S. Mahal and H. S. Brar. 1983. Assessment of loses in yield of *Brassica juncea* by *L. erysimi* (Kalt.). Influence of varying level of aphid population. Ind. J. Ecol. 10 : 97—105.
3. Kumar V., D. Singh and H. Singh. 1990. Combining ability analysis for resistance to mustard aphid (*L. erysimi* Kalt.) in Indian mustard (*B. juncea* L.). Crop Res. Hisar 3 : 204—210.
4. Kumar V., D. Singh, M. C. Kambaj, S. R. Pundir and N. Chandra. 1994. Genetics of resistance to mustard aphid (*L. erysimi* Kalt.) in Indian mustard (*B. juncea* L.) at different stages of crop. Crop Res. Hisar 7 : 256—262.
5. Yadav A. K., Hari Singh and Harvir Singh. 1991. Combining ability analysis of resistance to mustard aphid (*Lipaphis erysimi* Kalt.) in Indian mustard *Brassica juncea* (L. Czern and Coss). J. Oils. Res. 8 : 31—34.
6. Singh D., V. Kumar and D. Kumar. 2000. Genetics of percent plant infestation due to mustard aphid (*L. erysimi* Kalt.) at different growth stages, siliqua characters and seed yield in Indian mustard. Ann. Biol. 16 : 185—190.
7. Bakhetia D. R. C. and R. S. Sandhu. 1973. Differential response of *Brassica* species/varieties to the mustard aphid *L. erysimi* (Kalt.) infestation. J. Res. Punjab Agric. Univ. 10 : 272—273.
8. Griffing B. 1956. Concepts of general and specific combining ability in relation to diallel crossing system. Aust. J. Biol. Sci. 2 : 463—493.
9. Brar K. S. and G. S. Sandhu. 1978. Comparative resistance of different *Brassica* species/varieties to the mustard aphid under natural and artificial conditions. Ind. J. Agric. Res. 12 : 298—300.
10. Jensen N. F. 1970. A diallel selective mating system for cereal breeding. Crop Sci. 10 : 629—635.
11. Comstock R. E. and H. F. Robinson. 1948. The components of genetic variance in population of biparental progenies and there use in estimating the average degree of dominance. Biometrics 4 : 254—266.