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GENOTYPE x ENVIRONMENT INTERACTION IN RELATION TO COMBINING ABILITY IN INDIAN MUSTARD

RAVI KUMAR, S. P. SINHAMAHAPATRA AND SUBRATA MAITY

Department of Genetics and Plant Breeding, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, West Bengal 741235

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ABSTRACT

Combining ability effects and variances were estimated sperately and over four environments (two dates of sowing in two years) from a half-diallel cross involving nine parents. Although both gca and sca variances were important, nonadditive variance was of greater importance than additive variance controlling number of siliquae on the main branch, total number of siliquae/plant, and seed yield/plant. Difference among the environments was significant for all the characters. Both gca x environment and sca x environment interaction variances were significant for all the characters studied, while further partitioning revealed higher magnitude of nonadditive x environment interaction than additive x environment interaction for all the traits. The variety Sita exhibited good general combining ability for number of siliquae on the secondary branches and total number of siliquae/plant in at least two environments and over environments. Top ranking crosses selected on the basis of significant desirable sca effect involved high, medium and low general combiners.

Key words: Indian mustard, combining ability, gene effects, genotype x environment interaction.

Studies on combining ability help in selection of superior parents for hybridization and provide a knowledge of genetic behaviour of various economic traits which are important for a successful breeding programme [1, 2]. Paying due consideration to genotype x environment interaction during the studies on combining ability may be helpful in identifying desirable genotypes and in understanding the precise nature of inheritance of economic traits [3, 4]. In view of this, the present study on combining ability has been carried out over different environmental conditions.

MATERIALS AND METHODS

Nine diverse genotypes of Indian mustard (*Brassica juncea* (L.) Czern and Coss), i.e. RLM-619, Rohini, IC-73229, PR-16, NC-57354, NDR-8501, BHUR-5, RW 85-59, and Sita, were crossed in all possible combinations excluding reciprocals. Nine parents and their 36 F_1s were grown on two different dates in the two consecutive years of 1992–93 and 1993–94 in randomized block design with three replications. Each treatment was grown in a single row, 2 m long, spaced 30 cm apart, with the plant-to- plant distance 15 cm. Each experiment was guarded by one border row on either side to minimize the border effect. All the recommended agronomic practices were followed to raise the crop. Five competitive plants from each treatment were selected from each replication to record observations on number of siliquae on the main and secondary branches, total number of siliquae/plant, and seed yield/plant. The progeny means were used for statistical analysis. The combining ability analysis was carried out according to the procedure of Griffing's Method 2, Model 1 [5] and Singh [6, 7].

RESULTS AND DISCUSSION

The analysis of variance of combining ability (Table 1) showed that variances due to gca were significant for all the characters in three out of four environments as well as in the

Table 1. ANOVA (mean square) of combining ability in Indian mustard

Source	d.f.	Environment	No. of siliquae on main branch	No. of siliquae on secondary branches	Total No. of siliquae per plant	Seed yield per plant
Gca (G)	8	DS-1 1992-93	14.0	274.8	332.2	1.19**
		DS-2 1992-93	19.5*	1231.5**	1388.1**	1.11*
		DS-1 1993-94	18.9**	2306.4**	2526.6**	1.04**
		DS-2 1993-94	52.2**	787.2*	938.8**	0.49
		Pooled	45.6**	2287.3**	2680.1**	1.87**
Sca (S)	36	DS-1 1992-93	17.8**	765.4	841.5	1.10**
		DS-2 1992-93	9.8	719.6*	802.1**	1.28**
		DS-1 1993-94	9.8	1418.7**	1475.0**	0.84**
		DS-2 1993-94	10.9*	690.0**	746.9**	0.57**
		Pooled	11.9**	1514.0**	1602.7**	1.74**
Environments (L)	3		851.2**	7907.6**	13312.8**	12.51**
Interaction (G x L)	24		21.1**	2491.1**	834.3**	0.92**
Interaction (S x L)	108		12.0**	1418.1**	754.4**	0.65**
Error	88	DS-1 1992-93	8.1	552.5	606.8	0.50
		DS-2 1992-93	8.5	185.7	208.4	0.54
		DS-1 1993-94	6.4	313.6	351.5	0.38
		DS-2 1993-94	6.1	301.0	339.1	0.29
Pooled error	252	—	1.8	84.6	94.1	0.11

*,**Significant at 5% and 1% levels, respectively.

DS_1, DS_2 – 1st and 2nd dates of sowing, respectively.

pooled analysis, whereas the variances due to sca were significant for number of siliquae on main branch in two environments, for number of siliquae on secondary branches and total number of siliquae/plant in three environments, and for seed yield/plant in all the four environments. The pooled analysis of sca variances showed significant mean squares for all the four characters. This shows the importance of additive and nonadditive gene effects in the inheritance of these characters. The estimates of gca variances were generally higher than sca variances for all the characters in three out of four environments as well as in pooled analysis. The difference among the environments was highly significant for all the traits. Both gca x environment (G x L) and sca x environment (S x L) interactions were also highly significant for all the traits. The G x L interactions were of higher magnitude than the S x L interactions for all the characters except for number of siliquae on secondary branches. Significance of interaction variances warrants collection of data over different environments for obtaining unbiased estimates of genetic variances. The result also clearly reveals that genetic estimates computed from a single environment are highly unreliable.

Partitioning of genetic variances (Table 2) into additive and nonadditive and estimates of predictability ratios further revealed higher estimates of nonadditive variances and lower estimates of additive variances, resulting into the predictability ratios far from unity for number of siliquae on secondary branches, total number of siliquae/plant and seed yield/plant. This indicated the importance of nonadditive gene effects controlling these traits. Similar results were also reported earlier [8–10]. In such a situation, improvement through simple selection would not be possible for these traits. Number of siliquae on main branch revealed higher values for both additive and nonadditive gene effects in three environments as well as in pooled analysis, and

Table 2. Estimates of genetic components in Indian mustard

Source	Environment	No. of siliquae on main branch	No. of siliquae on secondary branches	Total No. of siliquae per plant	Seed yield per plant
σ^2A	DS-1 1992-93	1.10	-50.5	-49.9	0.13
	DS-2 1992-93	2.0	190.2	214.5	0.10
	DS-1 1993-94	2.3	362.3	395.5	0.12
	DS-2 1993-94	8.4	88.4	109.0	0.04
	Pooled	1.9	100.0	117.6	0.08
σ^2D	DS-1 1992-93	9.7	212.9	234.8	0.60
	DS-2 1992-93	1.4	533.9	593.7	0.74
	DS-1 1993-94	3.2	1105.1	1123.5	0.46
	DS-2 1993-94	4.8	389.0	407.8	0.28
	Pooled	2.5	357.4	377.1	0.41
$\frac{\sigma^2A}{\sigma^2A + \sigma^2D}$	DS-1 1992-93	0.1	—	—	0.18
	DS-2 1992-93	0.6	0.26	0.27	0.12
	DS-1 1993-94	0.4	0.25	0.26	0.21
	DS-2 1993-94	0.6	0.19	0.21	0.13
	Pooled	0.4	0.22	0.24	0.16
σ^2gl		1.8	-234.2	67.3	0.07
σ^2sl		10.2	1333.6	660.3	0.55

DS_1, DS_2 — 1st and 2nd dates of sowing, respectively.

very high value of nonadditive gene effect in only one environment. The predictability ratios around 0.5 also confirm the importance of both additive and nonadditive gene effects controlling this trait. The additive x environment interaction components (σ^2gl) were lower than the nonadditive x environment interaction components (σ^2sl) for all the traits, which indicates that nonadditive variance was more prone to environmental variation than additive variance.

The predominance of nonadditive gene action for seed yield and its components could be exploited through heterosis breeding [10] or through population improvement by intermating the improved genotypes in successive generations [11].

Studies on gca effects (Table 3) of the nine parental strains revealed that BHUR-5 and RW 85-59 were good general combiners for number of siliquae on main branch showing significant gca effects at least in two environments as well as over the environments. Sita

Table 3. Estimates of gca effects of parental strains in Indian mustard

Character	Environment	RLM-619	Rohini	IC-73229	PR-16	NC-57354	NDR-8501	BHUR-5	RW85-59	Sita	S.E gi
No. of siliquae on main branch	DS1-1992-93	–0.34	–0.70	–0.77	–0.96	0.31	–0.77	–0.51	1.61*	2.13*	0.81
	DS2-1992-93	0.34	–0.13	–0.35	–0.24	0.71	–1.93*	–1.64	2.54**	0.70	0.83
	DS1 1993-94	–1.98**	1.22	–0.12	0.02	–0.04	–1.57*	2.23**	0.78	–0.54	0.72
	DS2 1993-94	–0.65	0.95	–0.50	–1.04	2.43**	–4.01**	3.12**	–1.48*	1.18	0.70
	Pooled	0.60**	0.31	–0.46*	–0.58**	0.82**	–1.98**	0.77**	0.84**	0.96**	0.19
No. of siliquae on secondary branches	DS1-1992-93	–3.43	–8.45	1.09	–1.44	0.86	4.63	–0.24	–2.29	9.28	6.68
	DS2 1992-93	–12.02**	0.98	3.67	–9.28*	–1.32	–3.00	–8.71*	6.98	22.70**	3.87
	DS1 1993-94	–18.76**	–10.80*	–0.46	–5.06	–9.93	3.50	2.30	23.06**	23.13**	5.03
	DS2 1993-94	2.29	–7.58	1.69	–5.18	18.89**	–4.58	–9.29	–0.22	3.97	4.93
	Pooled	–7.98**	–6.46**	1.50	–5.24**	2.11	–1.61	–3.99**	6.87**	14.77**	1.31
Total siliquae per plant	DS1 1992-93	–3.62	8.92	0.56	–2.18	0.44	3.15	–0.53	–0.44	11.54	7.00
	DS2 1992-93	–11.69**	0.85	3.46	–9.52*	–0.74	–4.94	–10.33*	9.51*	23.39**	4.10
	DS1 1993-94	–21.06**	–9.97	–0.96	–5.54	–10.29	–3.67	4.14	25.21**	22.15**	5.33
	DS2 1993-94	1.64	–6.62	1.19	–6.22	21.33**	–8.59	–6.18	–1.70	5.15	5.23
	Pooled	–8.68**	–6.17**	1.06	–5.87**	2.69	–3.51*	–3.22*	8.15*	15.56**	1.38
Seed yield per plant	DS1 1992-93	–0.22	–0.41*	0.01	0.29	–0.71**	0.77**	0.05	0.13	0.09	0.20
	DS2 1992-93	–0.22	–0.16	0.30	–0.49*	–0.26	0.30	0.32	–0.14	0.36	0.21
	DS1 1993-94	–0.32	–0.30	–0.10	–0.04	–0.29	0.00	0.18	0.61**	0.24	0.17
	DS2 1993-94	0.20**	–0.19**	0.04	–0.13**	–0.27**	0.32**	0.21**	0.11*	0.11*	0.06

*,**Significant at 5% and 1% levels, respectively.

DS1, DS2 — 1st and 2nd dates of sowing, respectively.

Table 4. Five top ranking crosses selected on the basis of pooled sca effect along with their mean performance and gca status

Cross	Mean performance	Sca effect	Gca status	Cross	Mean performance	Sca effect	Gca status
No. of siliquae on main branch				**Total No. of siliquae/plant**			
Rohini x Sita	46.2	2.87	L x H	NDR 8501 x Sita	249.8	44.58	L x H
NC 57354 x Sita	46.1	2.32	H x H	RLM-619 x IC 73229	220.4	34.87	L x L
RLM 619 x IC73229	43.2	2.30	L x L	Rohini x NC57354	214.9	25.25	L x L
Rohini x IC73229	44.2	2.29	L x L	PR16 x Sita	226.9	23.98	L x H
NDR 8501 x RW85-59	43.2	2.28	L x H	RW-85-59 x Sita	237.6	20.75	M x H
No. of siliquae on secondary branches				**Seed yield/plant (g)**			
NDR 8501 x Sita	210.2	45.86	L x H	RLM619 x PR16	5.8	1.13	L x L
RLM 619 x IC73229	177.3	32.60	L x L	NDR-8501 x Sita	6.5	1.01	H x M
Rohini x NC57354	172.6	25.76	L x L	Rohini x NDR-8501	6.1	0.94	L x H
PR16 x Sita	183.8	23.09	L x H	NC57354 x RW-85-59	5.7	0.84	L x M
RW 85-59 x Sita	194.5	27.71	M x H	NDR-8501 x RW-85-59	6.2	0.76	H x M

H — high, M — medium, L — low general combiner.

exhibited good general combining ability in at least two environments and over the environments for number of siliquae on secondary branches and total number of siliquae/plant. The parental strains RLM 619, NDR 8501 and BHUR 5 showed highly significant gca effect for seed yield/plant over environments and therefore, would be useful materials for improving seed yield/plant.

The five top ranking hybrids (Table 4) selected on the basis of highly significant desirable sca effect revealed that in most cases, their high sca was not associated with per se performance, thus, high mean performance of a cross does not reflect high sca effect. Hence, selection of specific crosses for further breeding programmes may be based on higher values of both of these parameters. The top ranking crosses involved high, medium and low general combiners. The cross NDR-8501 x Sita showed significant desirable sca effects for number of siliquae on secondary branches, total number of siliquae/plant, seed yield/plant, and involved at least one high gca parent for all these traits.

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