GENETICS OF PHENOTYPIC STABILITY IN A DIALLEL CROSS OF INDIAN MUSTARD /*Brassica juncea* L. Coss/

S.S.Badwal, K.S.Labana, R.S.Rana, M.L.Gupta

Department of Plant Breeding
Punjab Agricultural University
Ludhiana-141 004, India

Abstract

Stability parameters, viz. mean, regression coefficients and deviations from regression estimated for 55 genotypes resulting from a 10 parent half diallel studied over four unpredictable environments were subjected to combining ability analysis. The variance due to non - additive effects for the linear response was higher than the additive variance for seed yield and other component traits. The additive variance for non-linear response was higher than the non-additive variance for seed yield,plant height, secondary branches, main shoot length, and pods on main shoot, whereas, for primary branches, pod length, seeds per pod and stem thickness, non-additive variance was high. Four parental lines, RS 3, RL 18, P Rai 219 and P 16-13 showed high gca effects on the stability parameters "b" for seed yield and its 4-5 component characters excluding at least 3 characters varying for each stable parent. The component characters which exhibited plasticity were secondary branches, main shoot length, pods on the main shoot, pod length and seeds per pod. Instability of some yield components in a particular genotype seemed to contribute towards stability of seed yield. Five crosses, RS 3 x P Rai 219, RS 3 x P 16-13, M 590 x P 16-13 and M 160 x P 16-13, BR 13 x Varuna exhibited high sca effects on stability of yield and 2-3 yield components. These crosses were combinations of high x high or high x average stable parents, suggesting thereby the genetic control of stability. The four parental lines and their crosses which exhibited high stability also possessed high mean perfor-

mance for yield and its component traits giving an evidence that phenotypic stability and high performance *per se* are under the same genetic control.

Introduction

In recent years, the understanding of genetic control of phenotypic stability of performance in various crop species has caught the attention of geneticists and plant breeders. In Indian mustard, genetic information on stability of performance for seed yield and its related component traits is very scanty. The findings of such an investigation would prove highly fruitful in the development of fairly stable mustard cultivars with high performance *per se*. Large scale cultivation of such varieties over a wide range of environmental conditions in the Indian continent is expected to meet the challenge of boosting productivity. This type of breakthrough in varietal front coupled with improved agronomic and plant protection technology in rapeseed and mustard would in turn lead to self-reliance in oilseeds and an answer to check the drain on foreign exchange of about rupees one thousand crores used every year for importing edible oils.

Materials and methods

Ten parental lines namely, RL 18, BR 13, Varuna, M 160, RS 3, T 6342, KR 5610, M 590, P 16-13 and Pant Rai 219 were crossed in all possible combinations, excluding reciprocals. The resultant 55 progenies /10 parents + 45 F_1's/ were studied at two locations /Ludhiana and Gurdaspur/ for two years i.e. 1977-78 and 1978-79.
These experiments represented four environments and were sown by 20th October each year in each of the environment. The material was sown in randomised block design with four replications in one row plots of 2.25 m in length with a row to row and hill to hill spacings of 30 cm and 15 cm respectively. The recommended package of practices were followed to raise the experimental material in each environment. Ten plants were randomly chosen from each row for recording observations. The data on individual plant

basis were recorded for plant height /m/, number of primary branches, number of secondary branches, main shoot length, number of pods on main shoot, pod length /cm/, stem thickness, number of seeds per pod and seed yield. The data were averaged to single plant basis. The statistical analyses for genotype x environment interaction and stability were carried out according to the models of Eberhart and Russell /1966/. Combining ability analyses of regression coefficients and deviation mean squares of 55 values each were carried out using Method-1 and Model-1 of Griffing /1956/.

Results and discussion

The results of combining ability analyses of regression coefficients /b/ and the deviations from regression /S^2d_i/ obtained from 10 selected parental lines and their 45 F_1 progenies have been utilized to understand the genetics of stability of seed yield and its components traits in Indian mustard. The mean squares due to general combining ability /GCA/ in respect of "b" estimates were highly significant for the traits studied i.e. seed yield, plant height, primary branches, secondary branches, main shoot length, pods on main shoot, pod length, seeds per pod and stem thickness. The SCA mean squares were not significant for seed yield and plant height, whereas, these were highly significant for the rest of the yield components indicating thereby the importance of additive and non - additive gene effects in the expression of linear response of the genotypes for various traits except seed yield and plant height for which only additive gene effects seem to be controlling the inheritance of linear response.
A comparison of the estimated variances, however, gave a clear picture regarding the role of additive and non - additive gene effects governing the linear response of the genotypes. The ratio of $\sigma^2 s_{ij}/\sigma^2 g_i$ revealed that the non additive portion showed little edge over the additive gene effects governing the linear response of the genotypes for all the traits.

The GCA and SCA mean squares for S^2d_i were highly significant for all the traits. The ratio of $\sigma^2 s_{ij}/\sigma^2 g_i$ showed that for primary branches, pod length, seeds per pod and stem thickness, the non-additive portion of genetic variance for S^2d_i was high, whereas, for seed yield, plant height, secondary branches, main shoot length and pods on main shoot, the additive variance was higher.

From the perusal of Table 3, it was revealed that the parental lines, RS 3, RL 18, P Rai 219 and P 16-13 had high GCA effects on the linear response and also recorded high performance per se for seed yield and important yield components. The performance per se of the 55 genotypes /10 parents + 45 F_1's/ exhibited a highly significant positive correlation with the linear response "b" of the genotypes for seed yield, primary branches, pod length, seeds per pod and stem thickness. The linear response of seed yield was observed to have highly significant correlation with the linear response of plant height, primary branches, secondary branches and pod length /Badwal et al. 1983/. They further reported the predominance of linearity in the parental lines for seed yield and plant height. Similar observations were made for primary branches, secondary branches and pod length in the F_1 progenies of 45 diallel crosses. These results suggested that performance per se for these characters could be precisely predicted. The variation in gca effects of the component characters, of the stable parental lines, RS 3, RL 18, P Rai 219 and P 16-13, further suggested that the component characters like secondary branches, main shoot length, pods on main shoot, pod length and seeds per pod seemed to possess plasticity leading to instability of combining ability in at least 2-3 component characters which contributed to the stability of performance in seed yield. It may be inferred that plant height, primary branches, secondary branches and pod length served as homeostatic devices for imparting stability to yielding ability of the parental lines and their F_1 progenies. Badwal et al.

/1986/ reported that these 4 parental lines possessed high GCA in respect of their performance for seed yield and other important yield components. A significantly positive relationship between gca effects and performance *per se* for yield and other important component traits was also observed in this material.

In Table 2, 10 crosses showing high sca effects on the linear response in order of merit have been presented. It was observed that these crosses involved parental lines which had high or average general combining ability for seed yield and some important yield components. Five crosses, RS 3 x P Rai 219, M 590 x P 16-13, M 160 x P16-13, RS 3 x P 16-13 and BR 13 x Varuna, were the high specific crosses for the linear response and were the combinations of high x high or average x high general combiners. These crosses also possessed high sca effects on at least three important yield components. Variation in the sca effects of the component traits in different crosses /Table 2/ also substantiate the compensating mechanism for imparting stability to yielding ability. These findings suggest the genetic control of stability in Indian mustard. Similar observations on genetic control of stability in wheat were made by Bains and Gupta /1972/ and Talukdar and Bains /1982/. The foregoing discussion of the results clearly indicate that the phenotypic stability and the performance *per se* in Indian mustard are under the same genetic control. The results of the present investigation led to the understanding of genetics of phenotypic stability of seed yield and its component traits in Indian mustard, which would be of vital utility in manipulation of the breeding materials for the development of stable cultivars with high yield potential.

References

Badwal S.S., P.K.Gupta, K.S.Labana, 1983. Proc. 6th Intl. Rapeseed Conference, Paris, pp. 540-545.

Badwal S.S., P.K.Gupta, K.S.Labana, 1986. Crop Improv. 13, p.p. 86-91.

Bains K.S., V.P.Gupta, 1972. Indian J. Genet. 32,306-312.
Griffing B., 1956. J. Biol. Sci. 9, 463-493.
Eberhart S.A., W.A.Russell, 1966. Crop Sci. 6, 36-40.
Talukdar P., K.S.Bains, 1982. Z.Pflanz. 89, 197-205.

Table 1. ANALYSES OF VARIANCE FOR COMBINING ABILITY OF STABILITY PARAMETERS

Stability parameters	Source of variation	d.f.	Mean squares: Seed yield	Plant height	Primary branches	Secondary branches	Main shoot length	Pods on main shoot	Pod length	Seeds per pod	Stem thickness
Regression coefficients /b/	gca	9	0,87^{xx}	1,91^{xx}	1,11^{xx}	0,46^{xx}	0,14^{xx}	0,31^{xx}	2,02^{xx}	0,40^{xx}	0,04^{xx}
	sca	45	0,08	0,20	0,18^{xx}	0,21^{xx}	0,08^{xx}	0,13^{xx}	1,43^{xx}	0,23^{xx}	0,02^{xx}
	Error	395	0,07	0,16	0,09	0,04	0,01	0,03	0,17	0,03	0,01
	Variances										
	$\sigma^2 gi$	-	0,96	0,95	0,93	0,97	0,78	0,83	0,69	0,79	0,80
	$\sigma^2 sij$	-	0,99	0,99	0,99	0,99	0,99	0,99	0,94	0,99	0,99
	$\sigma^2 sij / \sigma^2 gi$	-	1,03	1,04	1,06	1,02	1,27	1,19	1,36	1,26	1,24
Deviations from regression /$S^2 di$/	gca	9	255,9^{xx}	407,5^{xx}	0,80^{xx}	5276,9^{xx}	831,6^{xx}	136,5^{xx}	0,50^{xx}	2,26^{xx}	0,13
	sca	45	128,9^{xx}	423,4^{xx}	0,21^{xx}	7066,7^{xx}	366,1^{xx}	99,0^{xx}	0,49^{xx}	1,72^{xx}	0,02^{x}
	Error	395	21,2	33,9	0,01	439,7	69,2	11,4	0,04	0,18	0,01
	Variances										
	$\sigma^2 gi$	-	0,80	0,18	0,44	0,60	0,82	0,73	0,67	0,72	0,92
	$\sigma^2 sij$	-	0,16	0,02	0,99	0,01	0,06	0,02	0,98	0,94	0,99
	$\sigma^2 sij / \sigma^2 gi$	-	0,20	0,11	2,25	0,01	0,07	0,03	1,46	1,31	1,08

$^{x}P \leq 0,05$; $^{xx}P \leq 0,01$

Table 2. CROSSES WITH HIGH SPECIFIC COMBINING ABILITY EFFECTS FOR REGRESSION COEFFICIENTS

Sr. No.	Seed yield	Plant height	Primary branches	Secondary branches	Main shoot length	Pods on main shoot	Pod length	Seeds per pod	Stem thickness
1.	RS 3 x P Rai 219	M 590x P Rai 219	RS 3 x P Rai 219	RL 18 x M 160	RL 18 x P 16-13	M 160 x KR 5610	RL 18 x RS 3	RS 3 x P Rai 219	P 16-13 x P Rai 219
2.	M 590 x P 16-13	M 160 x I 6342	P 16-13 x P Rai 219	RL 18x P Rai 219	M 590 x P 16-13	M 590 x P 16-13	I 6342 M 590	I 6342 x P Rai 219	M 590 x P 16-13
3.	M 160 x P 16 13	M 160 x RS 3	M 160 x P 16-13	RS 3 x I 6342	M 160 x KR 5610	M 160 x P Rai 219	M 160 x P 16-13	Varuna x RS 3	RL 18 x P 16-13
4.	BR 13 x Varuna	RL 18 x RS 3	BR 13 x Varuna	Varuna x RS 3	BR 13 x Varuna	BR 13 x Varuna	BR 13 x Varuna	BR 13 x Varuna	BR 13 x Varuna
5.	RS 3 x P 16-13	RS 3 x P 16-13	RL 18 x M 160	RS 3 x P 16-13	BR 13 x M 160	RS 3 x I 6342	RS 3 x M 590	I 6342 x KR 5610	RS 3 x P 16-13
6.	BR 13 x M 160	BR 13 x KR 5610	M 590 x P Rai 219	Varuna x I 6342	KR 5610 x P Rai 219	RL 18 x BR 13	BR 13 x M 160	BR 13 x M 160	BR 13 x M 160
7.	KR 5610 x M 590	M 160 x M 590	Varuna x M 160	I 6342 KR 5610	M 590 x P Rai 219	KR 5610 x M 590	KR 5610 x P Rai 219	P 16-13 P Rai 219	RL 18 x RS 3
8.	RL 18 x M 590	RL 18 x M 590	KR 5610 x P Rai 219	RL 18 x M 590	Varuna x RS 3	BR 13 x RS 3	M 590 x P Rai 219	RL 18 x M 590	RL 18 x M 590
9.	Varuna x KR 5610	Varuna x RS 3	Varuna x M 590	Varuna x M 590	RL 18 x P Rai 219	Varuna x RS 3	RL 18 x Varuna	Varuna x I 6342	M 160 x KR 5610
10.	KR 5610 P 16-13	BR 13 x P 16-13	KR 5610 x P 16-13	KR 5610 x P 16-13	RS 3x KR 5610	Varuna x P 16-13	RL 18 x P 16-13	KR 5610 x P 16-13	BR 13 x P 16-13
r pb	xx	-	xx	-	-	-	xx	xx	xx
r $S^2 d_i$	-	-	-	xx	-	-	-	-	xx

$^{xx}P \leq 0,01$

TABLE 5. GENERAL COMBINING ABILITY EFFECTS OF REGRESSION COEFFICIENTS AND DEVIATIONS FROM REGRESSION

Parents	Seed Yield			Plant height			Primary branches			Secondary branches		
	Mean§	b	S^2d_i	Mean	b	S^2d_i	Mean	b	S^2d_i	Mean	b	S^2d_i
RL 18	16.9	0.19	-0.65**	170	0.29*	85.1**	7.2	0.19	0.09	23.9	0.17	-12.6**
BR 13	8.0	-0.26*	-3.12**	119	-0.44**	71.0**	4.5	-0.24*	0.01	17.6	0.06	-13.2**
Varuna	10.8	0.13	-4.20**	145	-0.03	-31.2**	4.4	-0.09	0.03	16.6	0.11	-13.9**
M 160	13.2	-0.05	-3.52**	158	0.17	-25.5**	6.7	0.13	-0.04	23.2	-0.19	37.8**
RS 3	14.5	0.25*	0.09	160	0.28*	-87.3**	6.5	0.19	0.06	21.6	0.04	-5.7**
T 6342	9.9	-0.61**	12.05**	170	-0.93**	68.2**	6.3	-0.71**	0.03	23.0	-0.45**	40.8**
KR 5610	9.8	-0.13	-2.16**	138	0.06	-15.9**	5.3	-0.01	0.11	19.1	-0.11	-8.7**
M 590	10.3	0.14	0.06	125	0.04	-24.8**	5.6	-0.04	-0.17	19.3	0.05	-11.1**
P 16-13	11.4	0.16	0.09	151	0.18	-56.9**	5.5	0.28*	-0.02	22.3	0.17	-7.2**
P Rai 219	13.2	0.17	1.36**	159	0.38**	17.5**	6.4	0.30*	-0.09	23.2	0.16	-6.3**
Overall mean	11.8			149			5.8			21.0		

Parents	Main shoot length			Pods on main shoot			Pod length			Seeds per pod		
	Mean	b	S^2d_i	Mean	b	S^2d_i	Mean	b	S^2d_i	Mean	b	S^2d_i
RL 18	50.9	-0.14	-7.8**	41.4	-0.24*	-4.48**	4.00	0.69**	-0.04	10.6	0.03	-0.33**
BR 13	44.6	0.18	19.9**	31.1	0.11	6.86**	3.74	-0.50**	-0.07	10.1	0.03	0.49**
Varuna	57.9	0.06	-4.8**	35.8	0.17	-0.02	4.00	0.05	-0.11	10.5	0.19	-0.13
M 160	55.7	-0.10	-1.6**	39.4	0.04	-0.98**	3.74	0.11	-0.12	10.3	-0.31*	-0.34**
RS 3	52.8	-0.06	4.0**	37.7	-0.06	-0.94**	4.10	0.28*	-0.11	9.5	0.12	-0.08
T 6342	53.8	-0.07	-1.9**	37.4	-0.30*	3.65**	4.00	-0.34**	0.10	10.3	-0.22*	-0.49**
KR 5610	53.6	-0.06	0.2	38.9	0.01	-1.77**	3.63	-0.52**	-0.97**	9.9	0.05	-0.10
M 590	46.6	0.09	-4.9**	33.1	0.15	0.29*	3.98	-0.25*	-0.11	11.2	0.13	0.78**
P 16-13	54.4	0.14	-8.2**	37.5	0.13	-0.39**	3.53	0.49**	0.32**	10.1	-0.21	-0.29*
P Rai 219	48.5	-0.04	5.3**	35.5	-0.01	-4.10**	3.69	-0.01	0.44**	11.0	0.19	0.51**
Overall mean	51.9			36.8			3.84			10.3		

§ Mean = Performance averaged over 4 environments.