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GENE ACTION FOR YIELD AND YIELD CONTRIBUTING CHARACTERS IN INDIAN MUSTARD (*Brassica juncea* L.)

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ABSTRACT

A study of the attributes for seed yield of 28 F_1s and their parents 8 x 8 diallel (excluding reciprocals) of *Brassica juncea* L., showed the contribution of both additive and non-additive components for all traits indicating the importance of both additive and dominance components. Dominant gene action was predominant in most of the traits except days to maturity, plant height and 1000-seed weight. Height heritability (76 per cent) was observed for days to maturity. The asymmetrical distribution of the positive and negative alleles at all loci was found for all the characters studied. The Vr-Wr graphs exhibited dominance effect of genes for all the characters. Over dominance was observed for the traits primary branches per plant, secondary branches per plant, length of siliqua, siliquae per plant, seeds per siliqua and seed yield per plant while partial dominance was observed for days to 50%flowering, days to maturity, plant height, 1000-seed weight, harvest index and oil content. The graphical analysis indicated wide genetic diversity among the parents.

Key words: *Brassica juncea*, additive and non-additive component, gene action and genetic diversity

INTRODUCTION

Indian mustard (*Brassica juncea* L.) is an important oilseed crop of Bangladesh, because the yield of the varieties of Indian mustard (*B. juncea* L.) is stable when it is planted late. It can tolerate both drought and salinity to some extent. Indian mustard (*B. juncea* L.) is non shattering type and can grow in boron deficient soil but the duration of this crop is long. It is important to know the nature and magnitude of gene action in developing an effective breeding programme. The diallel analysis provides information of the genetical control of a set of parents in the early generations (Jinks, 1954). A study was conducted to gather information on the gene action of various oil yielding attributes of *Brassica juncea* L., since information on this aspect is inadequate and inconclusive.

MATERIALS AND METHODS

The eight selected parents of Indian mustard were crossed in diallel mating design excluding reciprocal during winter 2004-05 at the experimental farm of Oilseed Research Center (ORC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, Bangladesh. Source of the materials along with some important characters of the parents are presented in Table 1. Twenty eight F_1s along with their eight parents were grown on 16 November 2005 at ORC farm in a randomized block design with three replications. Each F_1 line and their parents comprised of single rows of 2.5 m long with a spacing of 40 cm between rows and 10 cm between plants.

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Ten randomly selected competitive plants from each of the parents and F_1s will be used in each replication for recording data on plant height (cm), primary branches per plant, secondary branches per plant, length of siliqua (cm), number of siliquae per plant, seeds per siliqua, 1000-seed weight (g), seed yield per plant (g), harvest index and oil content (%). Days to 50% flowering and days to maturity were recorded on plot basis. The data were analyzed for variance according to Jones (1965). The partitioning of genetic components and Vr-Wr graph was done following the method of Hayman (1954).

Table 1. Sources or places of collection of eight Indian mustard genotypes with some important characters

Parent	Origin	Characteristics					
		Seed color	Seed size	Maturity (days)	Siliquae/ plant	1000-seed weight(g)	Oil content (%)
DH-18	Netherland	Brown	Bold	115-120	190-235	4.5-5.0	42-43
BARIsar-10	Bangladesh	Brown	Medium	85-95	140-195	3.0-3.2	40-41
DH-11	Netherland	Brown	Bold	115-120	200-240	4.5-5.0	42-43
Daulat	Bangladesh	Brown	Small	95-100	150-200	2.50-3.0	40-42
BJ-17	Bangladesh	Yellow	Small	95-100	140-190	2.50-3.0	41-42
BJ-11	Bangladesh	Yellow	Small	95-100	180-220	2.50-3.0	41-42
Jun-536	Bangladesh	Brown	Medium	95-105	140-190	3.50-4.0	41-42
BARIsar-11	Bangladesh	Brown	Bold	95-105	170-210	3.50-4.0	41-42

RESULTS AND DISCUSSION

The additive effect (a) and the dominance effect (b) were significant for all the characters studied (Table 2) indicating the importance of both additive and dominance components for controlling the characters. However, the higher b value for primary branches per plant, secondary branches per plant, siliquae per plant and seed yield per plant indicated the dominance deviation. An asymmetrical distribution of dominant gene was suggested by the higher significant b_2 value for all the characters. This indicated that some parents contain considerably more dominant alleles than others. The b_3 values were also significant for all the characters indicating important contribution to the over all mean values.

Genetic components

The components of variation along with the derived genetic ratios for different traits (Table 3) showed that the D and H component which measure additive and dominance variation, respectively were significant for all the traits. This indicated the importance of both additive and dominance components for the inheritance of all the traits in Indian mustard. However, the magnitude of dominance was higher than the additive component for all the traits except days to maturity, plant height and 1000-seed weight which indicated that dominance component had a predominant role in the inheritance of these traits. These results agreed with that reported by

Trivedi and Mukharjee (1986). The H_2 representing dominance deviation due to relative frequency of positive and negative genes was significant for all the characters.

The net dominance effect, obtained by the estimate h^2 expressed as the algebraic sum over all loci in heterozygous condition in all crosses, was significant for all the characters studied (Table 3). This revealed that substantial contribution of dominance effects was due to heterogeneity of loci in all characters. The proportion of positive and negative effects as indicated by F value was significant and positive for days to maturity, primary branches per plant, length of siliqua, siliquae per plant, seeds per siliqua, seed yield and oil content, suggesting greater frequency of dominant alleles governing these characters. Negative F value for days to flower, plant height, secondary branches per plant, 1000-seed weight and harvest index exhibited a preponderance of recessive alleles. The environmental component E, exhibited significant values for all the traits, indicating influence of environmental factors in the expression of those traits. However, the magnitude of E for each character was much lower than the respective value of D and H_1 except siliquae per plant. This indicated that the characters were influenced less by the environment.

The average degree of dominance as indicated by the proportion $(H_1/D)^{1/2}$ was more than unity, suggesting that over dominance was operating in the expression of most of the components of oil yield. Trivedi (1980), Trivedi and Mukharjee (1986) also found over-dominance in graphic analysis of oil yield attributes in Indian mustard. The ratio of $H_2/4H_1$ provides an estimate of the average frequency of positive and negative alleles in all the parents. A value of this ratio smaller than 0.25 for all the characters studied suggested asymmetrical distribution of only the negative alleles. Most of the characters studied indicating unequal distribution of positive and negative alleles. However, the value of primary branches per plant (0.237), secondary branches per plant (0.235) and seed yield per plant (0.231) was closer to 0.25 suggesting equal distribution of positive and negative alleles (Table 3).

The ratio of $[(4DH_1)^{1/2} + F/(4DH_1)^{1/2} - F]$ estimates the relative proportion of dominant and recessive alleles in the parents. In the present study the ratio for all the characters except days to flower, plant height, secondary branches per plant, 1000-seed weight and harvest index were greater than unity, suggesting excess of dominant alleles and minority of recessive alleles i.e., asymmetrical distribution for dominant and recessive alleles in the parents for seven characters. The estimated number of effective factors (h^2/H_2) was less than unity for all yield attributes except for primary branches per plant and oil content. The proportion of genes or group of genes showing dominance was thus very less, which could be owing to the predominant concealing effects of positive and negative effects of genes or to non-isodirectional distribution of polygene (Cooke and Mather, 1962).

Heritability in narrow sense was higher for days to maturity, plant height and 1000-seed weight (Table 3), indicating that these characters were highly heritable. For the remaining traits it ranged from low to moderate and very low for seed yield. The results agree with that reported by Trivedi and Mukharjee (1986) in Indian mustard, Yadav and Yadava (1996) in toria and Chowdhury *et al.* (2004) in turnip rape.

Table 2. Jones analysis of variance for 12 characters in Indian mustard, *Brassica juncea* L.

Source of variation	Mean square												
	df	Days to flower (50%)	Days to maturity	Plant height (cm)	Primary branches per plant	Secondary branches per plant	Length of siliqua (cm)	Siliquae per plant	Seeds per siliqua	1000-seeed weight (g)	Seed yield per plant	Harvest index	Oil content
a	7	113.47**	111.93**	2844.68**	0.753**	8.16**	0.194**	7639.95**	10.54**	2.59**	6.38**	31.94**	0.238**
b_1	1	45.01**	31.08**	1514.34**	5.72**	196.74**	0.021	131257.4**	1.41**	0.0003	232.92**	27.50**	0.172*
b_2	7	8.22**	7.38**	76.95**	0.089*	61. 2.03**	0.122**	3802.33**	2.65**	0.115**	3.08**	7.71**	0.217**
b_3	20	47.28**	48.57**	1289.14**	1.58**	62. 28.97**	0.691**	6169.22**	21.54**	1.02**	34.4**	31.46**	1.10**
Error	70	0.99	0.04	20.59	0.025	61. 0.169	0.016	253.56	0.229	0.01	0.263	0.70	0.054

* Significant at P = 0.05 ** Significant at P = 0.01

Table 3. Estimates of genetic components of variation and their ratios for 12 characters in Indian mustard, *Brassica juncea* L.

Source of variation	Characters											
	Days to flower (50%)	Days to maturity	Plant height (cm)	Primary branches per plant	Secondary branches per plant	Length of siliqua (cm)	Siliquae per plant	1000-seed weight	Seeds per siliqua	Seed yield per plant (g)	Harvest index	Oil content
D	11.81** ±0.009	24.01** ±0.009	423.42** ±0.171	0.290** ±0.0002	0.446** ±0.006	0.051** ±0.0002	142.52** ±7.16	0.354** ±0.0002	1.98** ±0.012	1.59** ±0.006	1.69** ±0.015	0.116** ±0.0003
H_1	15.15** ±0.022	15.66** ±0.023	280.98** ±0.393	0.894** ±0.0005	23.12** ±0.014	0.509** ±0.0004	17887.67** ±16.47	0.345** ±0.0005	17.59** ±0.027	27.93** ±0.013	22.44** ±0.036	0.470** ±0.0007
H_2	9.74** ±0.019	10.42** ±0.018	241.68** ±0.342	0.849** ±.0004	21.79** ±0.012	0.430** ±0.0003	15308.37** ±14.33	0.267** ±0.0004	15.77** ±0.024	25.87** ±0.011	17.18** ±0.032	0.347** ±0.0006
h^2	8.43** ±0.013	7.2** ±0.012	40.74** ±0.229	3.15** ±.0003	18.44** ±0.008	0.180** ±0.0002	334.48** ±9.61	-0.025** ±0.0003	-1.67** ±0.016	20.04** ±0.008	-7.24** ±0.021	-0.573** ±0.0004
F	-10.89** ±0.022	1.368** ±0.023	-242.31** ±0.404	0.154** ±0.0006	-0.199** ±0.014	0.085** ±0.0004	898.12** ±16.93	-0.213** ±0.0005	1.23** ±0.028	2.14** ±0.014	-0.859** ±0.037	0.192** ±0.0007
E	1.006** ±0.003	0.392** ±0.003	24.55** ±0.056	0.029** ±0.00008	0.261** ±0.002	0.016** ±0.00006	319.32** ±2.38	0.010** ±0.00007	0.224** ±0.004	0.331** ±0.002	0.701** ±0.005	0.053** ±0.00009
$(H_1/D)^2$	1.132	0.807	0.814	1.75	7.19	3.17	11.38	0.986	2.98	4.19	3.64	2.01
$H_2/4H_1$	0.161	0.166	0.215	0.237	0.235	0.211	0.214	0.193	0.224	0.231	0.191	0.185
$\frac{(4DH_1)^{1/2}}{(4DH_1)^{1/2}}$	0.421	1.073	0.480	1.36	0.939	1.72	1.78	0.533	1.23	1.38	0.869	2.39
Heritability(b)	0.90	0.96	0.90	0.89	0.96	0.87	0.93	0.96	0.95	0.95	0.89	0.65
H^2 (ns)	0.282	0.762	0.505	0.253	0.018	0.093	0.007	0.472	0.103	0.055	0.061	0.191

* Significant at P = 0.05 ** Significant at P = 0.01

Vr-Wr graph

Vr-Wr graphs, the two dimensional depiction made based on the parental variance (Vr) and parent offspring co-variance (Wr) are presented in the Fig. a to Fig. l. Regression line intersected the Wr-axis below the origin for all the characters except days to flowering, days to maturity, plant height, 1000-seed weight, harvest index and oil content indicating the presence of over dominance. Such serious inflation of dominance have been postulated by Hayman (1954) and Jinks (1955). A further support to the existence of pseudo-over dominance was visualized in the estimates of D and H components. This was supported by the earlier findings reported by Trivedi and Mukharjee (1986) in Indian mustard. The over dominance might not be an index of real

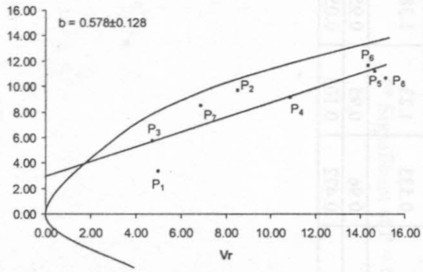

Fig a: Vr-Wr graph for days to flowering in *Brassica juncea*

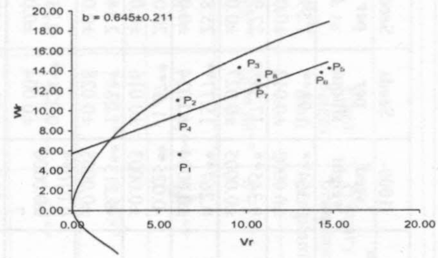

Fig b: Vr-Wr graph for days to maturity in *Brassica juncea*

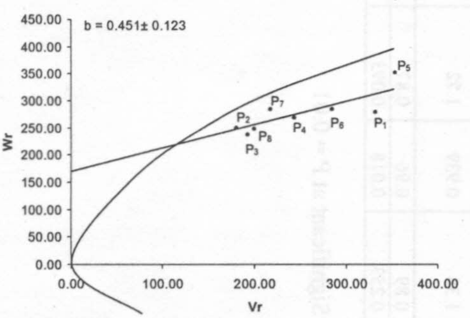

Fig c: Vr-Wr graph for plant height in *Brassica juncea*

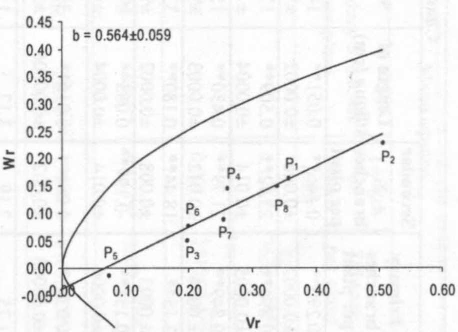

Fig d: Vr-Wr graph for primary branches per plant in *Brassica juncea*

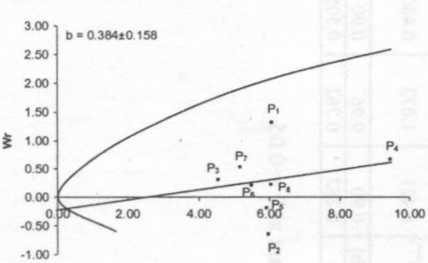

Fig e: Vr-Wr graph for secondary branches per plant in *Brassica juncea*

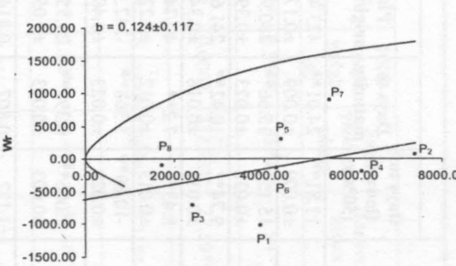

Fig f: Vr-Wr graph for siliquae per plant in *Brassica juncea*

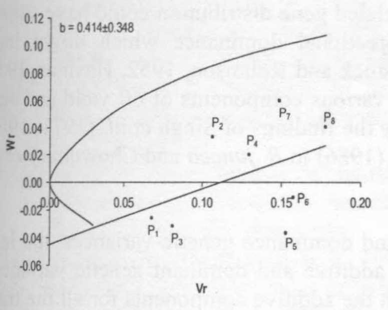

Fig g: Vr-Wr graph for length of siliqua in *Brassica juncea*

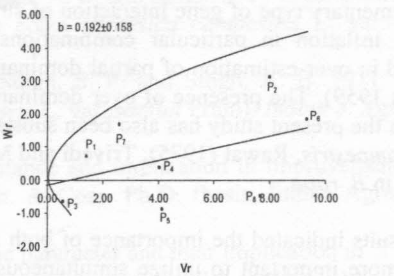

Fig h: Vr-Wr graph for seeds per siliqua in *Brassica juncea*

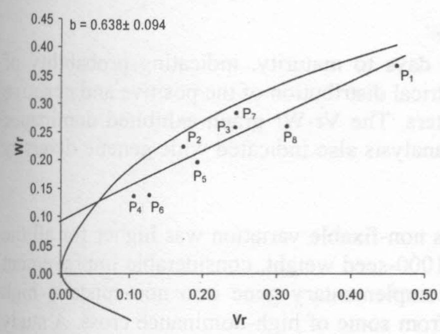

Fig i: Vr-Wr graph for 1000-seed weight in *Brassica juncea*

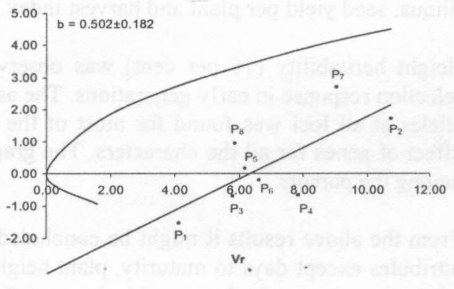

Fig j: Vr-Wr graph for seed yield per plant in *Brassica juncea*

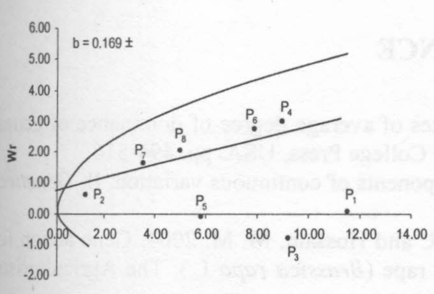

Fig k: Vr-Wr graph for harvest index in *Brassica juncea*

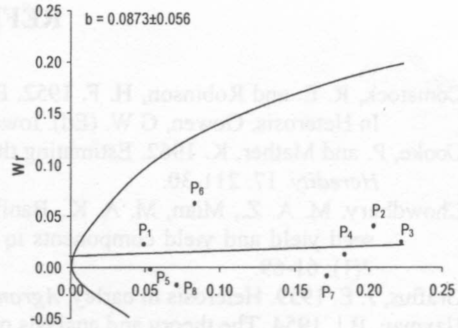

Fig l: Vr-Wr graph for oil percent in *Brassica juncea* over-dominance at gene level, since particular combination of positive and negative genes or a complementary type of gene interaction of simply correlated gene distribution could have caused serious inflation in particular combinations of unidirectional dominance which might have resulted in over-estimation of partial dominance (Comstock and Robinson, 1952, Hayman 1954, Grafius 1959). The presence of over dominance in the various components of oil yield and seed yield in the present study has also been substantiated by the findings of Singh *et al.* (1971, 1971) in *B. campestris*, Rawat (1975), Trivedi and Mukharjee (1986) in *B. juncea* and Chowdhury *et al.* (2004) in *B. rapa*.

The results indicated the importance of both additive and dominance genetic variances, the later being more important to utilize simultaneous by both additive and dominant genetic variances. The magnitude of dominant component was higher than the additive components for all the traits except days to maturity, plant height and 1000-seed weight which indicated that dominance component had a predominant role in the inheritance of these traits. Non-additive type of gene action was found to be predominant for secondary branches per plant, siliquae per plant, seeds per siliqua, seed yield per plant and harvest index.

Height heritability (76 per cent) was observed for days to maturity, indicating probability of selection response in early generations. The asymmetrical distribution of the positive and negative alleles at all loci was found for most of the characters. The Vr-Wr graph exhibited dominance effect of genes for all the characters. The graphical analysis also indicated wide genetic diversity among the parents.

From the above results it might be concluded that as non-fixable variation was higher for all the attributes except days to maturity, plant height and 1000-seed weight, considerable improvement of these traits might be possible by transferring complementary gene into non-epistatic high dominance cross or by eliminating duplicate genes from some of high-dominance cross. A study of epistatic components would thus be helpful in formulating an efficient and effective breeding programme.

REFERENCE

Comstock, R. E. and Robinson, H. F. 1952. Estimates of average degree of dominance of genes. In Heterosis. Gowen, G.W. (Ed). Iowa State College Press, USA. pp. 494-516.

Cooke, P. and Mather, K. 1962. Estimating the components of continuous variation. II. *Genetical Heredity*. 17: 211-30.

Chowdhury, M. A. Z., Mian, M. A. K., Banik, B. R. and Hossain, M. M. 2004. Gene action for seed yield and yield components in turnip rape (*Brassica rapa* L.). The Agriculturists. 2(1): 61-69.

Grafius, J. E. 1959. Heterosis in barley. *Agronomy J.* 51: 551-554.

Hayman, B.I. 1954. The theory and analysis of diallel crosses. *Genetics*. 39:789-809.

Jinks, J. L. 1954. The analysis of continuous variation in a diallel cross of *Nicotiana rustica* varieties. *Genetics*. 39: 767-788.

Jinks, J. L. 1955. A survey of genetical basis of heterosis in variety of diallel cross. *Heredity*. 8: 223-38.

Jones, R. M. 1965. Analysis of variance of the half diallel table. *Heridity*. 20:117-121.

Rawat, D. S. 1975. Genetic studies on yield, oil content and characters related to yield in *Brassica juncea* Coss,. Ph.D. thesis, Indian Agricultural Research Institute, New Delhi.

Singh, D. P., Singh, D., Singh, N., Pandey, K. N. Singh, A. B. and Singh. S. P. 1970. Diallel cross of some quantitative characters in Indian colza (*Brassica campestris* L. var. *sarson* Prain). *Indian J. Agric. Sci.* 40: 663-676.

Singh, D. P., Singh, D., Singh, I. S., Singh, H., Singh, S. P. and Singh, A. B. 1971. Diallel analysis in yellow sarson (*Brassica campestris* L. var. *sarson* Prain). *Indian J. Agric. Sci.* 41: 315-323.

Trivedi, H. B. P. 1980. Studies on nature of inheritance and implication in improvement of oil characteristic of *Brassica juncea* L. Czern. & Coss. Ph.D. thesis, Indian Agricultural Research Institute, New Delhi.

Trivedi, H. B. P. and Mukharjee, B. K. 1986. Genetic parameter and their implication in breeding high-oil varieties of Indian mustard. *Indian J. Agric. Sci.* 56(1): 10-14.

Yadav, I. S. and Yadava, T. P. 1996. Genetic analysis and combining ability for seed yield Components in Toria (*Brassica campestris* L. var. Toria). *J. Oilseeds Res.* 13(1): 84-87.