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## Use of Diallel Analysis to Examine the Mode of Inheritance of Agronomic and Quality Parameters in F<sub>1</sub> Generation of Brown Mustard (*Brassica juncea* L. Czern and Coss)

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**Abstract:** A 6x6 diallel cross experiment on F<sub>1</sub> generation of Brown mustard (*Brassica juncea* L.) was conducted to estimate the genetic control of some important agronomic and quality parameters. The data obtained from the experiment were subjected to analysis of variance. The analysis of variance indicated highly significant differences among parents and their hybrids in F<sub>1</sub> generation for all the characters studied in this experiment except days taken to maturity, which was found non-significant. The genetic analysis revealed that the characters like days to flowering and erusic acid have shown the additive type of gene action. While the inheritance of characters such as glucosinolate content, oil percentage and days taken to maturity were found to be operated by an over dominant type of gene action. So far as the regression analysis is concerned the non-significant deviation of the regression line from unit slope indicated the absence of non-allelic interaction, which was presented in all the characters.

**Key words:** *Brassica juncea*, diallel analysis, agronomic and quality parameters

### INTRODUCTION

The *Brassica* oilseeds is one of the most important world sources of vegetable oil. *Brassica* oilseed crop 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 part of a balance human diet. Rapeseed, (*Brassica napus*, *Brassica campestris* and *Brassica juncea*) is grown world wide as a source of edible oil. (Downey and Rakow, 1987). These annual crops can be successfully grown in the different types of soils (French, 1977). Although widely and extensively grown as a vegetable, it is being grown more for its seeds, which yield an essential oil and condiment. Mustard oil is one of the major edible oils in India, the fixed oil content of rai varying between 28.6 to 45.7%. Oil is also used for hair oil, lubricants and, in Russia, as a substitute for olive oil. Seed residue is used as cattle feed and in fertilizers (Reed, 1976).

In Pakistan rapeseed and mustard are the second most important source of vegetable oil after cottonseed. They occupy an area of 301,000 ha with annual production of 229,000 Metric tones, contributing about 20% to the domestic production of edible oil (Anonymous, 1996). Mustard (*Brassica juncea*) is also one of the major oil seed crop in the Indian sub-continent.

It is mainly self-pollinating crop having 7.5 to 30% out crossing under natural field conditions. The presence of a wide range of *Brassica* species, types and cultivars i.e., *Brassica campestris*, *Brassica napus*, *Brassica nigra*, *Brassica carinata*, *Brassica oleraceae* and *Brassica hirta*, *Brassica juncea* that can be intercrossed, providing considerable germplasm to plant breeders for the development of new cultivars (Weiss, 1983).

Brown or Indian mustard (*Brassica juncea*) is one of the most important species in the genus *Brassica*. It is the predominant cruciferous species and has been widely grown throughout the rain-fed areas of Dera Ismail Khan. It has great yield potentials for semi arid conditions and known to be more droughts tolerant and shattering resistant than *Brassica napus* and *Brassica campestris*. It matures earlier than *Brassica napus* and consequently escapes the attack of aphids and hairy caterpillar. It is also more lodging resistant as compared to rapeseed (*Brassica napus* and *Brassica campestris*). There is much scope of developing new mustard varieties, containing low levels of erusic acid and glucosinolates. However one limitation of *Brassica juncea* is that the available genotypes contain higher glucosinolates and erusic acids content. Erusic acid is a fatty acid associated primarily with plants of genus *Brassica* and some other plants. Genotypes, especially in *Brassica juncea* are available where the erusic acid constitutes 60-65% of the total fatty acid. Feeding experiments with animals have demonstrated that rapeseed oil rich in erusic acid interferes in myocardial

conductance and the peripheral vascular system, decrease survival time, shorten coagulation time and increase blood cholesterol time (Renarid and McGregor, 1976). Thus restricting their use as edible oil crop. On the other hand defatted Brassica oilseed meal contains about 40% protein with a well-balanced amino acid composition (Miller *et al.*, 1962). Its use in human and animal nutrition is, however, limited by its glucosinolate content. The studies of glucosinolates have revealed that its all kinds are derived from amino acids and most of them are the product of a common biosynthetic pathway. Intact glucosinolate (without myrosinases: an enzyme which break down the glucosinolate) are capable of causing significant anti-nutritional and toxic effects (Bille *et al.*, 1983). In addition the oil content of these species is also lower than would be desired. Therefore there is great need to screen out breeding lines for lower levels of erusic acid and glucosinolates and higher yield potential. In the present studies an effort was made to ascertain the gene action of some important agronomic and quality traits in a six parent diallel cross experiment in F<sub>1</sub> generation of Brown mustard to evolve new canola quality (less than 2% erusic acid), low glucosinolate content and high oil content percentage genotypes through genetic recombination to face global challenges.

## MATERIALS AND METHODS

An experiment was conducted to study the gene action regarding agronomic and quality parameters in F<sub>1</sub> generation of Brown mustard. The experimental material comprised of F<sub>1</sub> hybrid seed resulted from 6x 6 diallel cross of four varieties R.L-18, B.M-1, Early raya, S-9 and two breeding lines, 91421 and 91416, including self and reciprocals.

The varieties and breeding lines were crossed in diallel fashion during October 2000-2001. The F<sub>1</sub> seeds of these crosses along with their parents were sown during October 2001-02 in the experimental field using randomized complete block design with three replications. Each replication comprised of 6 parents and 30 F<sub>1</sub>s. Sowing was done with hand drill. All agronomic activities and plant protection measures were kept normal and uniform for the entire experiment, weeds were controlled by hoeing.

At maturity 10 plants by leaving one plant on either side of each treatment were randomly selected in each replication. The data were recorded on the following plant parameters, number of days to flowering, number of days taken to maturity, oil percentage, erusic acid percentage and glucosinolate content. (Micro mole gram<sup>-1</sup> of oil free meal).

The data regarding different plant characters were averaged and subjected to statistical manipulation for the analysis of variance technique to establish the level of variability among F<sub>1</sub> hybrids and their parental lines (Steel and Torrie, 1980).

The diallel cross technique developed by jinks (1953, 1954 and 1956) was adopted for genetic analysis. All the crosses were arranged into arrays in the form of diallel tables and the two statistics, the variance (V<sub>r</sub>) of the family mean within an array and the covariance (W<sub>r</sub>) of these means with the non-recurrent parental values were calculated from each diallel table by the following methods.

$$V_r = \frac{\sum X_i^2 - (\sum X_i)^2/n}{n-1}$$
$$W_r = \frac{\sum x_i Y_i - (\sum X_i)(\sum Y_i) / n}{n-1}$$

The information on gene action was inferred by plotting the covariance (W<sub>r</sub>) of each array against its variance (V<sub>r</sub>). The slope and the position of the regression line fitted to the array points within the limiting parabola (W<sub>r</sub><sup>2</sup> = V<sub>p</sub>.V<sub>r</sub>) indicated the degree of dominance and the presence or absence of gene interaction.

The limiting parabola was constructed on the basis of formula, W<sub>r</sub><sup>2</sup> = V<sub>r</sub> x V<sub>p</sub> by plotting V<sub>r</sub>, (V<sub>r</sub> x V<sub>p</sub>)<sup>1/2</sup> points. The corresponding values of W<sub>r</sub> for all observed V<sub>r</sub> values were calculated as (V<sub>r</sub> x V<sub>p</sub>)<sup>1/2</sup>; where V<sub>p</sub> = Variance of the parents. The standard error for the regression line slope was estimated according to Snedecor (1962).

## RESULTS AND DISCUSSION

The results for the analysis of variance are presented in Table 1. The average performance of 30 hybrids along with their parents in 6x6 diallel cross for number of days to flowering, number of days taken to maturity, oil percentage, erusic acid percentage and glucosinolate content shown in the tables (2-6) and V<sub>r</sub>/W<sub>r</sub> graphic illustration for each trait are presented in Figs (1-5). All above characters are discussed as follows

**Number of days to flowering:** The analysis of variance for number of days to flowering given in Table 1 revealed highly significant variation due to various genotypes including parents and their F<sub>1</sub> hybrids.

A perusal Fig. 1 and Table 2 indicate that the regression line intercepts the W<sub>r</sub>-axis on the positive side above the origin therefore an additive type of gene action is responsible for controlling days to flowering trait.

Table 1: Mean squares and degree of freedom for various traits of Brown mustard (*Brassica juncea* L.)

S.O.V.	D. F	Days to flowering	Days taken to maturity	Oil percentage	Erusic acid percentage	Glucosinolate content
Genotypes	35	9.019	137.49	60.56	446.60	1562.4
Errors	70	2.13	97.16	27.86	15.47	200.99
F. ratio		4.22**	1.42 <sup>NS</sup>	2.17**	28.87**	7.59**

\*\* = Highly significant, NS = Non significant

Table 2: 6x6 Diallel average for days to flowering

Parents	R.L-18	B.M-1	B.L9141	B.L9142	Early Raya	S-9	(Vr)	(Wr)
R.L-18	68.6667	71.1667	73.0000	72.8333	70.0000	69.8333	3.0305	4.31667
B.M-1		70.3333	73.3333	72.3333	70.0000	72.0000	1.6046	2.9870
B.L9141			74.3333	73.5000	71.5000	73.3333	0.8667	2.2000
B.L9142				73.6667	71.5000	73.0000	0.6379	1.8907
Early Raya					67.3333	70.6667	2.3778	3.6678
S-9						70.0000	2.3157	3.6351

Regression coefficient = 1.00, ± = 0.023. t value at b0 = 42.277, t value at b1 = -0.0018

Table 3: 6x6 Diallel average for days taken to maturity

Parents	R.L-18	B.M-1	B.L9141	B.L9142	Early raya	S-9	Mean	(Vr)	(Wr)
R.L-18	155.750	161.375	160.750	159.500	157.250	156.500	158.521	5.4901	11.580
B.M-1		146.500	158.375	158.125	156.125	155.625	156.021	25.8901	36.886
B.L9141			173.500	159.875	158.500	157.250	161.375	36.7875	49.581
B.L9142				181.000	158.875	157.750	162.521	82.5964	102.411
Early raya					148.750	156.750	156.042	13.8417	32.310
S-9						150.250	155.688	7.6109	20.572

Regression coefficient = 1.1079, ± = 0.00682, t value at b0 = 16.240, t value at b1 = -1.5815

Table 4: 6x6 Diallel average for oil content percentage

Parents	R.L-18	B.M-1	B.L9141	B.L9142	Early raya	S-9	Mean	(Vr)	(Wr)
R.L-18	41.990	40.215	31.742	36.126	31.1788	39.385	36.772	20.581	7.0466
B.M-1		41.010	36.925	30.217	33.5075	34.723	36.099	16.988	9.1434
B.L9141			38.835	34.797	34.2025	32.203	34.784	7.4482	-1.1342
B.L9142				35.555	33.7550	33.815	34.044	4.3929	-1.2890
Early Raya					37.4650	30.187	33.382	6.5116	-3.0666
S-9						39.410	34.954	14.224	5.2614

Regression coefficient = 0.730, ± = 0.1458, t value at b0 = 5.00, t value at b1 = 1.849

Table 5: 6x6 Diallel average for erusic acid percentage

Parents	R.L-18	B.M-1	B.L9141	B.L9142	Early Raya	S-9	Mean	(Vr)	(Wr)
R.L-18	32.167	34.355	33.320	32.210	36.0750	32.270	33.429	2.531	10.896
B.M-1		33.972	34.345	34.317	36.0362	33.957	34.527	0.597	3.511
B.L9141			1.5075	1.5125	35.3675	32.950	23.167	282.13	277.3
B.L9142				1.4050	33.8475	33.587	22.813	274.10	272.56
Early Raya					36.0500	37.563	35.838	1.524	14.953
S-9						31.015	33.572	5.086	7.620

Regression coefficient = 0.0963, ± = 0.0143, t value at b0 = 67.156, t value at b1 = 2.5411

Table 6: 6x6 Diallel average for glucosinolate content

Parents	R.L-18	B.M-1	B.L9141	B.L9142	Early raya	S-9	Mean	(Vr)	(Wr)
R.L-18	92.245	100.95	131.95	111.34	137.561	84.296	109.72	460.13	472.61
B.M-1		95.450	115.51	125.74	134.043	121.49	115.53	219.65	250.43
B.L9141			145.80	146.55	128.546	106.96	129.22	253.33	341.31
B.L9142				145.47	137.376	116.35	130.47	223.77	381.89
Early Raya					133.605	138.23	134.89	13.425	-51.82
S-9						93.685	110.17	381.15	266.13

Regression coefficient = 0.976, ± = 0.322, t value at b0 = 3.029, t value at b1 = 0.0719

From the position of array points along the regression line it is quite obvious from the Vr/Wr graph that the breeding line 9141 contains the maximum number of dominant genes because of its nearest position to the lower interception of regression line and the parabola. While the variety R.L18 have shown the most recessive genes, as it is distantly located from the origin. The additive and partial type of gene action requires careful selection of desired lines while using them in breeding

programs. The regression line does not deviate significantly from the unit slope thus indicating the absence of non-allelic interaction. These results are in conformity with those of Kant *et al.* (2001), who reported the additive type of gene action responsible for this trait.

**Number of days taken to maturity:** The analysis of variance for days taken to maturity given in Table 1 revealed non-significant variation due to various

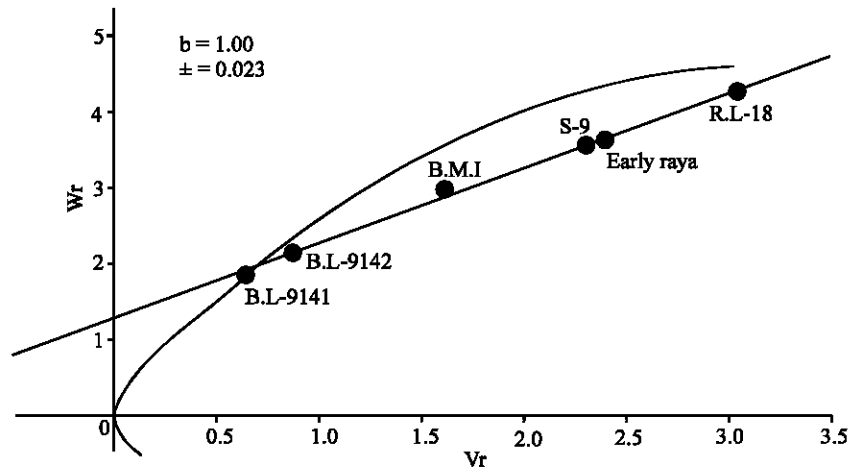


Fig. 1: Vr/Wr graph for number of days to flowering (F1)

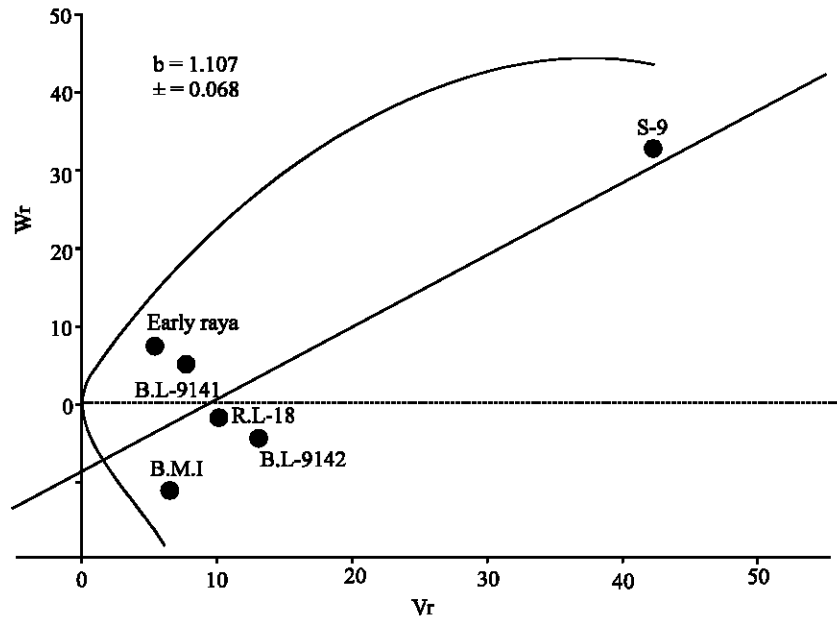


Fig. 2: Vr/Wr graph for number of days taken to maturity (F1)

genotypes including parents and their F<sub>1</sub> hybrids.

The Vr/Wr graph Fig. 2 and Table 3 shows that the regression line cuts the Wr-axis below the origin, indicating an over dominance type of gene action.

From the position of array points along the regression line it is obvious that the Attention:varieties Early raya contains the maximum dominant genes while the variety S-9 seems to have recessive alleles due to its farthest location from the origin.

From location of genes on regression line, it is estimated that selection in early generation will not give positive results for this character. The regression line

does not deviate significantly from the unit slope thus indicating the absence of non-allelic interaction.

Similar results were reported by Khulbe *et al.* (2000), also observed a non-additive type of gene action responsible for the character of days taken to maturity.

**Oil content percentage:** The results of analysis of variance given in Table 1 showed that the genotypes were highly significant different for production of oil content percentage.

The Vr/Wr graph shows that regression line intercepts the Wr-axis below the origin revealing over

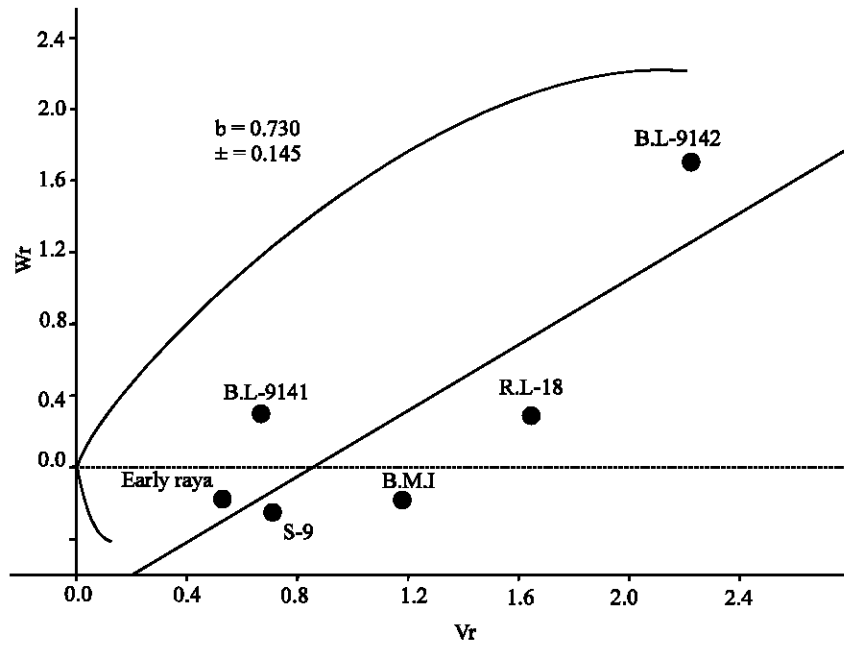


Fig. 3: Vr/Wr graph for oil percentage (F1)

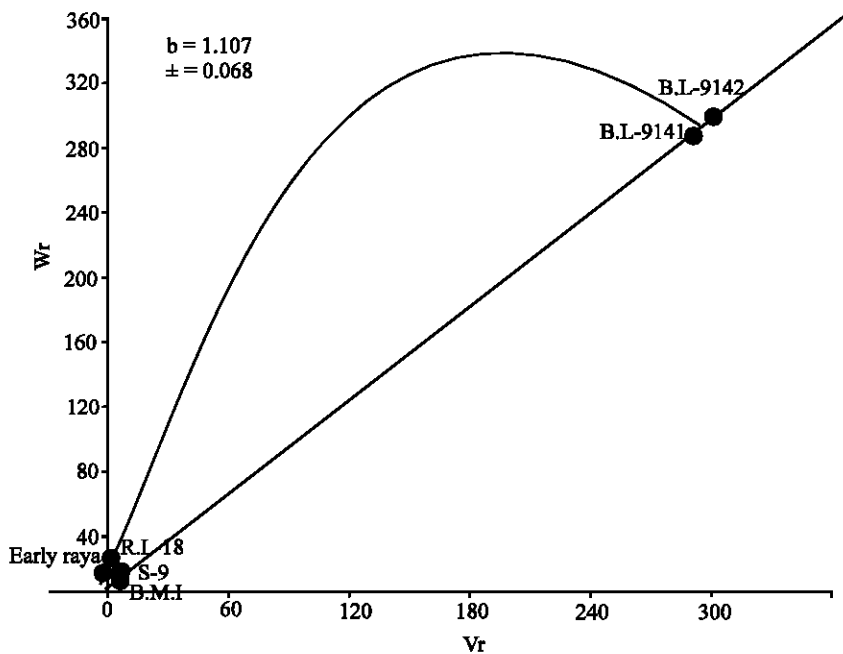


Fig. 4: Vr/Wr graph for erusic acid percentage (F1)

dominant type of gene action to be responsible for oil content in *Brassica juncea* Fig. 3 and Table 4.

From the position of array points along the regression line it is clear that the varieties Early raya possesses most dominant genes because of its nearest position to the point of the origin. It was very closely followed by S-9. Similarly the Breeding line 9142 due to its

farthest position from the point of origin got the recessive genes for oil percentage.

From the observed gene action it can be concluded that selection in early generation will be ineffective. The regression line does not deviate significantly from the unit slope thus indicating the absence of non-allelic interaction.

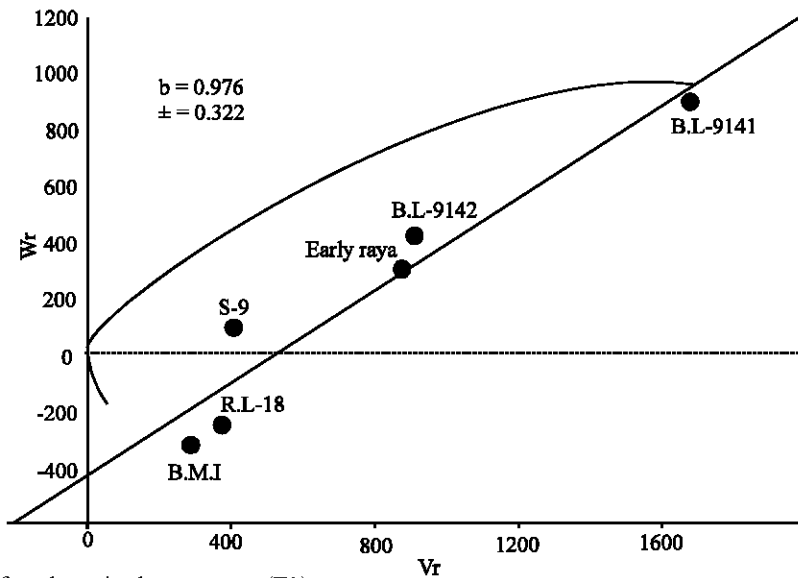


Fig. 5: Vr/Wr graph for glucosinolate content (F1)

These results are in conformity with the findings of Badwal and Labana (1987), Sheikh *et al.* (1998) and Pahuja *et al.* (1996), who also reported the presence of non-additive type of gene action for this trait.

**Erusic acid percentage:** The analysis of variance for erusic acid percentage given in Table 1 revealed highly significant variation due to various genotypes including parents and F<sub>1</sub> hybrids.

A perusal Fig. 4 and Table 5 indicated that the regression line passes through the Wr-axis just above the origin therefore an additive type of gene action seems to be responsible for controlling this character.

From the position of array points along the regression line it is quite obvious from the Vr/Wr graph that the varieties BMI, S-9, Early raya, R-L18 and Early raya contains the maximum number of dominant genes while the Breeding line 9142 and Breeding line 9141 have shown the most recessive genes as they are distantly located from the origin. Additive type of gene action suggests that selection will be beneficial in early segregating generation and there are every possibilities of having transgressive segregation. The regression line does not deviate significantly from the unit slope thus indicating the absence of non-allelic interaction.

These results confirm the findings of Bhat *et al.* (2002), who also reported that an additive type of gene action was responsible for controlling this trait.

**Glucosinolate content:** The analysis of variance for glucosinolate content indicates highly significant differences among various genotypes Table 1. Study of

Fig. 5 and Table 6 depicted that the regression line cuts the Wr-axis on the negative side indicating the presence of over dominant type of gene action. So far as the position of array points on regression line is concerned, it is clear from the Fig. 5 that the variety B.M-1 followed by R.L-18 and S-9 contains the maximum dominant genes while the Breeding line 9141 has shown the most recessive genes as it is distantly located from the origin.

From the observed gene action, it can be concluded that selection in early generation will be ineffective for this character while using them in any breeding program. The regression line does not deviate significantly from the unit slope thus indicating the absence of non-allelic interaction.

These results confirm the findings of Sodhi *et al.* (2002) also reported that an additive type of gene action was controlling the glucosinolate content in *Brassica juncea*.

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