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Path Coefficient Analysis and Correlation Coefficients Effects of Different Characters on Yield of *Brassica rapa* L.

Shahidul Islam[1], Md. Maksudul Haque[2, *], Shahidur Rashid Bhuiyan[1], Sarowar Hossain[1]

[1]Department of Genetics and Plant Breeding, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh

[2]Plant Breeding Division, Bangladesh Rice Research Institute, Gazipur, Bangladesh

Email address:

maksudulhq@gmail.com (Md. M. Haque)

*Corresponding author

Abstract: A study was conducted by using twenty one (21) F_9 populations derived from inter-varietal crosses of *Brassica rapa* L. Path co-efficient analysis revealed that plant height, number of primary branches per plant, number of siliqua per plant, seeds per siliqua, and siliqua length had the positive direct effect on yield per plant and days to 50% flowering, number of secondary branches per plant, and thousand seed weight had the negative direct effect on yield per plant. Correlation study revealed that yield per plant had significant positive association with plant height, number of primary branches per plant, number of siliqua per plant, seeds per siliqua, and siliqua length (genotypic or phenotypic level). Based on the variability study, some F_9 plants showed high heritability for short duration and yield contributing characters were selected from some of the crosses combinations of the intervarital crosses of *Brassica rapa* for further selection.

Keywords: Path Coefficient, Correlation Coefficients, Siliqua, *Brassica rapa* L.

1. Introduction

Brassica oil is the world's third most important sources of edible vegetable oils [1]. Oleiferous *Brassica species* can be classified into three groups *viz*; the cole, the rapeseed and the mustard. The mustard groups include species like *Brassica juncea* Czern and Coss, *Brassica nigra* Koch and *Brassica carinata* Braun; while the rapeseed groups includes *Brassica rapa* L. and *Brassica napus* L. [2]. The genomic constitutions of the three diploid elemental species of *Brassica* are AA for *Brassica rapa,* BB for *Brassica nigra* and CC for *Brassica oleracea* having diploid chromosome number of 20, 16 and, 18 respectively. On the Other hand, the species *Brassica juncea (*AABB), *Brassica carinata* (BBCC) and *Brassica napus* (AACC) are the amphidiploids.

The coles are consumed as vegetables and the other two are the valuable sources of edible oils and proteins. The mustard oil is not used only for edible cooking purpose but also is used in hair dressing, body massing and in different types of pickles preparation. It has also several medicinal values. Oil cake is the most important feed for livestock and is also used as organic manure. The important regions growing these crops include Canada, China, Northern Europe and the Indian subcontinent. In Bangladesh, local cultivars/varieties like *B. juncea* and *B. napus* are highyielding but not short durated. That's why *B.rapa* are widely grown and it gives moderate yield but early cultivars produce high yield and it is drought and stress resistant. In Bangladesh, *Brassica* is the most important oilseed crop. The country is facing huge shortage in edible oils. Almost one fourth of the total edible oil consumed annually is imported. The import cost was about 690 million US dollar in 2003 [3]. On Recommended Dietary Allowance (RAD) basis, Bangladesh requires 0.29 million tons of oils which is equivalent to 0.8 million tons of oilseeds; but it produces only about 0.254 million tons, which covers only 45% of the domestic need [4]. This crop covers the highest acreage which is 78% of the total oilseed acreage of Bangladesh [3]. The average yield of *Brassica* oilseed in Bangladesh is around 963 kg/hectare [4].

In Bangladesh there is limited scope to increase acreage due to pressure of other crops and to increase yield due to

cultivation of the existing low yielding varieties with low inputs, *B. rapa* is the most popular cultivated species. Short duration variety Tori-7 of *B. rapa* is still popular in Bangladesh because it can fit well into the T. Aman-Mustard-Boro cropping pattern. Early maturity line (SAU sarisha 2 X SAU sarisha 1), combination SAU sarisha 2 X BARI sarisha 6gave higher number of primary branches and number of siliquae / plant. No improved short duration variety of *B. napus*is available to replace this short duration variety. So *B. rapa* is the most popular variety to the farmers. There should be an attempt to develop short duration and high yielding varieties of rapeseed to meet the challenge of edible oils of the country by increasing the production. Segregating materials obtained through different inter-varietal crosses of the species *B. rapa* will give an opportunity to select the desired plant types to meet the existing demand. Therefore, this study was carried out with following objectives: to study the variability among F_9 generation materials for selection of desired lines, to study the inter-relationship and effect of characters on yield and to select early maturing, high yielding lines for release.

2. Materials and Methods

The present study was carried out in the Experimental Farm, Sher-e-Bangla Agricultural University (SAU), Dhaka during Rabi season. A total number of 19 (nineteen) materials were used in this experiment. Where were F_9 segregating generation materials and six check varieties (tester). The seeds of testers and F_9 materials were laid out in a randomized complete block design (RCBD) with three replications.

Statistical analysis

The data were analyzed for different components. Phenotypic and genotypic variance was estimated by the formula used Johnson [5]. Heritability and genetic advance were measured using the formula given by [6-7]. Genotypic and phenotypic co-efficient of variation was calculated by the formula of Burton [8]. Simple correlation coefficient was obtained using the formula suggested by [9, 6] and path co-efficient analysis was done following the method outlined by [10].

i) Path co-efficient analysis: Path co-efficient analysis was done according to the procedure employed by [10] also quoted in [6 and 11] using simple correlation values. In path analysis, correlation co-efficient is partitioned into direct and indirect of independent variables on the dependent variable.

In order to estimate direct andindirect effect of the correlated characters, say x1, x2 and x3 yield y, a set of simultaneous equations (three equations in this example) is required to be formulated as shown blow;

$$r_{yx1} = P_{yx1} + P_{yx2}r_{x1x2} + P_{yx3}r_{x1x3}$$

$$r_{yx2} = P_{yx1}r_{x1x2} + P_{yx2} + P_{yx3}r_{x2x3}$$

$$r_{yx3} = P_{yx1}r_{x1x3} + P_{yx2}r_{x2x3} + P_{yx3}$$

Where, r's denotes simple correlation co-efficient and P's denote path co-efficient (Unknown). P's in the above equations may be conveniently solved by arranging them in matrix from.

Total correlation, say between x_1 and y is thus partitioned as follows:

P_{yx1} = The direct effect of x_1 on Y.

$P_{yx2}r_{x1x2}$ = The indirect effect of x_1 via x_2 on y

$P_{yx3}r_{x1x3}$ = The indirect effect of x_1 via x_3 on y

After calculating the direct and indirect effect of the characters, residual effect (R) was calculated by using the formula given below [6]:

$P^2_{RY} = 1 - \sum P_{iy}.r_{iy}$

Where, $P^2_{RY} = (R^2)$; and hence residual effect, $R = (P^2_{RY})^{1/2}$

P_{iy} = Direct effect of the character on yield

r_{iy} = Correlation of the character with yield.

ii) Estimation of Genotypic and Phenotypic Co-efficient of variation: Genotypic and phenotypic co-efficient of variation were calculated by the following formula [8].

$$GCV = \frac{\delta g \times 100}{\bar{x}}$$

$$PCV = \frac{\delta p \times 100}{\bar{x}}$$

Where, GCV= Genotypic co-efficient of variation

PCV = Phenotypic co-efficient of variation

Δg = Genotypic standard deviation

Δp = Phenotypic standard deviation

$\bar{x}$ = Population mean

3. Results and Discussion

3.1. Path Co-efficient Analysis

Association of character determined by correlation co-efficient may not provide an exact picture of the relative importance of direct and indirect influence of each of yield components on seed yield per plant. In order to find out a clear picture of the inter-relationship between seed yield per plant and other yield attributes, direct and indirect effects were worked out using path analysis at genotypic level which also measured the relative importance of each component. Seed yield per plant was considered as a resultant (dependent) variable and days to 50% flowering, days to maturity, plant height, number of primary branches/plant, number of secondary branches/plant, length of siliqua, number of seeds/siliqua and 1000 seeds weight were casual (independent) variables. The results of path co-efficient analysis using F_9 materials of *Brassica rapa* were presented in Table 1.

Path analysis revealed that plant height had positive direct effect (0.347) on yield per plant followed by negative indirect effect on number of primary branches per plant (-0.146) and siliqua per plant (-0.110). Positive indirect effect through number of secondary branches per plant (0.038).

Length of siliqua (0.059), seeds per siliqua (0.026), days to

80% maturity (0.021) and 1000 seed weight (0.065) (Table 1). Singh [6] reported plant height, siliquae per plant and seeds per siliqua had high positive direct effect on seed yield.Number of primary branches per plant had negative direct effect on yield per plant (-0.502). This trait had positive indirect effect on seeds per siliqua (0.015). On the other hand negative indirect effect was found on number of number of siliqua per plant (-0.006) (Table 1). Number of primary braches per plant had the highest negative direct effect on seed yield was observed Chaudhary [12] while working with 42 strains of mustard.

Number of secondary branches per plant had positive direct effect (0.232) on yield per plant and negative indirect effect on primary branches per plant (-0.209), siliqua per plant (-0.057), seeds per siliqua (-0.004) and days to 80% maturity (-0.003). On the other hand, this trait showed positive indirect effect on Plant height (0.057), length of siliqua (0.001) and 1000 seed weight (0.089) (Table 1). Chaudhary [13] found the number of secondary branches per plant had positive direct effect (0.295) on yield per plant.

Path co-efficient analysis revealed thatnumber of siliqua per plant had negative direct effect (-0.208) on seed yield followed by positive indirect effect on plant height (0.184), secondary branches per plant (0.064) and thousand seed weight (0.120). And this trait had negative indirect effect on number of primary branches per plant (-0.016), length of siliqua (-0.020), seeds per siliqua (-0.007) and number days to 80% maturity (-0.007) (Table 1).Yadava*et al*. [14] found the number of siliquae per plant had the highest positive direct effect on seed yield.

Path analysis revealed that length of siliqua had direct positive effect (0.273) on yield per plant. This trait had also indirect positive effect on seeds per siliqua (0.018). On the other hand length of siliqua showed indirect negative effect on number of primary branches per plant (-0.203), number of secondary branches per plant (-0.273), 1000 seed (-0.012) (Table 1).

Seeds per siliqua had positive direct effect (0.066) on yield per plant and positive indirect effect on plant height (0.137), number of siliqua per plant (0.021), siliqua length (0.073) and thousand seed weight (0.040). On the other hand, this trait showed negative indirect effect on number of primary branches per plant (-0.293), secondary branches per plant (-0.013), days to 80% maturity (-0.011) and Pearson correlation with yield (-0.003) (Table 1).

Thousand seed weight had positive direct effect on yield per plant (0.428) and negative indirect effect on number of primary branches per plant (-0.022), siliqua per plant (-0.058), length of siliqua (-0.007) and days to 80% maturity (-0.030). On the other hand, this trait showed positive indirect effect on number of plant height (0.053), secondary branches per plant (0.048) and seeds per siliqua (0.006) (Table 1).

Through path analysis the residual effect was observed. The residual effect (R) was 0.430, which indicating the character under study contributed 44.1% of the seed yield per plant (Table 1).It is suggested that there were some others factors those contributed 55.1% to the seed yield per plant not included in the present study may exert significant effect on seed yield.

Table 1. Path coefficient analysis showing direct and indirect effects of different characters on yield of Brassica rapaL..

Characters	Direct effect	Plant height (cm)	Primary branches per plant	Secondary branches per plant	Siliqua per plant	Length of siliqua	Seeds per siliqua	Days to 80% maturity	1000 seed weight	Pearson correlation with yield
Plant height (cm)	0.347		-0.146	0.038	-0.110	0.059	0.026	0.021	0.065	0.300**
Primary branches per plant	-0.502	0.101		0.097	-0.006	0.110	0.039	0.017	0.018	-0.126
Secondary branches per plant	0.232	0.057	-0.209		-0.057	0.001	-0.004	-0.003	0.089	0.106
Siliqua per plant	-0.208	0.184	-0.016	0.064		-0.020	-0.007	-0.007	0.120	0.112
Length of siliqua	0.273	0.075	-0.203	0.001	0.015		0.018	0.042	-0.012	0.204
Seeds per siliqua	0.066	0.137	-0.293	-0.013	0.021	0.073		-0.011	0.040	-0.003
Days to 80% maturity	0.190	0.038	-0.044	-0.004	0.007	0.060	-0.004		-0.069	0.175
1000 SEED WEIGHT	0.428	0.053	-0.022	0.048	-0.058	-0.007	0.006	-0.030		0.418**

Residual effect: 0.430

** = Significant at 1%.

* = Significant at 5%.

3.2. Correlation Co-efficient

Seed yield is a complex product being influenced by several quantitative traits. Some of these traits are highly associated with seed yield. The analysis of the relationship among those traits and their association with seed yield is very much essential to establish selection criteria. Breeders always look for genetic variation among traits to select desirable type. Correlation co-efficient between pairs of trait for F$_9$ materials of B. *rapa* are shown in Table 2. Breeders always look for genetic variation among traits to select desirable type. Correlation co-efficient between pairs of trait for F$_9$ materials of B. *rapa* are shown in Table 2.

3.3. Plant Height (Cm)

Plant height showed positive significant interaction between number of siliqua per plant (G=0.516) and seeds per siliqua (G=0.329) followed by positive interaction with secondary branches per plant (G=0.085), length of siliqua (G= 0.032), days to 80% maturity (G= 0.247), 1000 seed weight (G=0.159) and seed yield per plant (G=0.263). Whereas positive significant interaction was found in number of primary branches per plant (P = 0.280), siliqua per plant (P=0.529)and seed yield per plant (P=0.292) followed by positive interaction was found in secondary branches per plant (P=0.156), length of siliqua (P=0.208), seeds per siliqua

(P=0.042), days to 80% maturity (P=0.118) and 1000 seed weight (P=0.160) (Table 2).These findings are close resemblance to the reports of [13-14].

3.4. Number of Primary Branches Per Plant

Number of primary branches per plant showed positive significant interaction with number of secondary branches per plant (G = 0.399) followed by positive interaction with seeds per siliqua (G= 0.548). Whereas the negative significant interaction was seed yield per plant (G=-0.343) but negative interaction was found in siliqua per plant (G = -0.078) (Table 2). Singh *et al.* (1987) reported number of primary branches per plant negatively correlated with siliqua length and 1000 seed weight positively correlated with number of siliqua per plant.

3.5. Number of Secondary Branches Per Plant

Number of secondary branches per plant showednegative significant interaction with length of siliqua (G= -0.122, P=-0.008) seeds per siliqua (G= -0.159, P= -0.066) and days to 80% maturity (P= -0.010) followed by positive interaction with siliqua per plant (G= 0.254), thousand seed weight (G = 0.194, P= 0.215) and yield per plant (G = 0.051, P=0.094) (Table 2).

3.6. Number of SiliquaPer Plant

Siliqua per plant showed positive significant interaction with thousand seed weight (G = 0.318, P=0.285) followed by positive interaction with seed yield per plant (G = 0.061, P = 0.105). Whereas rest parameter the negative significant interaction (Table 2). Das *et al* [15] reported number of siliquae/plant showed significant and positive correlation with r of seeds/siliqua and 1000 seed weight.

3.7. Length of Siliqua (Cm)

Length of siliqua showed positive significant interaction days to 80% maturity (G = 0.480) (Table 2). Das *et al.* [16] reported that seed yield per plant positively correlated with length of siliqua and seeds per siliqua.

3.8. Seeds PerSiliqua

Seeds per siliqua showed significant positive interaction with 1000 seed weight(G = 0.108, P=0.100) (Table 2). Dhillon*et al* [17] reported that number of siliqua per plant, thousand seed weight were positively correlated with seed yield. Tyagi*at.* [18] reported that no. of seeds per siliqua had positive and significant effects on seed yield per plant.

3.9. Thousand Seed Weight

Thousand seed weight showed significant positive interaction with yield per plant (Table 2).

Table 2. Genotypic correlation coefficients among different pairs of yield and yield contributing characters for different genotype of Brassica rapaL..

Characters		Primary branches per plant	Secondary branchess per plant	Siliqua per plant	Length of siliqua (cm)	Seeds per siliqua	Days to 80% maturity	1000 seed weight (gm)	Seed yield per plant (gm)
Plant height (cm)	G	0.142	0.085	0.516**	0.032	0.329**	0.247	0.159	0.263
	P	0.280*	0.156	0.529**	0.208	0.042	0.118	0.16	0.292*
Primary branches per plant	G		0.399**	-0.078	0.245	0.548**	0.21	0.005	-0.343**
	P		0.409**	0.021	0.397**	0.579**	0.104	0.055	0
Secondary branches per plant	G			0.254	-0.122	-0.159	0.009	0.194	0.051
	P			0.273	-0.008	-0.066	-0.01	0.215	0.094
Siliqua per plant	G				-0.237	-0.197	-0.069	0.318**	0.061
	P				-0.08	-0.11	-0.03	0.285*	0.105
Length of siliqua (cm)	G					0.045	0.480**	-0.131	0.124
	P					0.178	0.227	-0.018	0.195
Seeds per siliqua	G						-0.114	0.108	-0.119
	P						-0.049	0.1	-0.018
Days to 80% maturity	G							-0.07	0.363**
	P							-0.166	0.191
1000 seeds weight (g)	G								0.410**
	P								0.433**

** = Significant at 1%.

* = Significant at 5%.

4. Conclusion

Path co-efficient analysis revealed that days to plant height, number of secondary branches per plant, length of siliqua, seeds per siliqua, days to 80% maturity and thousand seed weight had the positive direct effect on yield per plant and primary branches per plant and siliqua per plant had the negative direct effect on yield per plant.Correlation revealed that yield per plant had significant positive association with plant height, number of primary branches per plant, secondary branches per plant, number of siliqua per plant, seeds per siliqua, and siliqua length (genotypic or phenotypic level). Based on the variability study, some F_9 plants showed high heritability for short duration and yield contributing characters were selected from some of the cross combinations of the intervarital crosses of *Brassica*

*rapa*for further selection.

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