VARIABILITY, CORRELATION AND PATH ANALYSIS IN F_3 POPULATION OF *Brassica napus*

BY

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CERTIFICATE

This is to certify that thesis entitled, ***"VARIABILITY, CORRELATION AND PATH ANALYSIS IN F_3 SEGREGATING POPULATION OF Brassica napus OBTAINED THROUGH INTERGENOTYPIC "*** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE*** *in* ***GENETICS AND PLANT BREEDING,*** *embodies the result of a piece of bonafide research work carried out by* ***SHAHANA BEGUM,*** *Registration No.* ***05-01750*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

Dated: June 2013
Place: Dhaka, Bangladesh

(Prof. Dr. Firoz Mahmud)
Supervisor

DEDICATED
TO
MY BELOVED
DAUGHTER

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The Author

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LIST OF ABBREVIATED TERMS

FULL WORD	ABBREVIATION
Agro-Ecological Zone	AEZ
And others	*et al.*
Accessions	ACC
Bangladesh Agricultural Research Institute	BARI
Bangladesh Bureau of Statistics	BBS
Centimeter	cm
Co-efficient of Variation	CV
Etcetera	etc.
Figure	Fig.
Genotype	G
Genetic Advance	GA
Genotypic Co-efficient of Variation	GCV
Genotypic Variance	δ^2_g
Gram	g
Heritability in broad sense	h^2b
Journal	j.
Kilogram	Kg
Meter	M
Mean Sum of Square	MSS
Millimeter	Mm
Muriate of Potash	MP
Number	No.
Percent	%
Phenotypic Co-efficient of Variation	PCV
Phenotypic variance	δ^2_p
Randomized Complete Block Design	RCBD
Replication	R
Research	Res.
Sher-e-Bangla Agricultural University	SAU
Standard Error	SE
Square meter	m^2
Triple Super Phosphate	TSP

VARIABILITY, CORRELATION AND PATH ANALYSIS IN F_3 POPULATION OF *Brassica napus*

BY

SHAHANA BEGUM

ABSTRACT

The experiment was conducted with twenty six F_3 progenies of *Brassica napus* at the experimental farm of Sher-e-Bangla Agricultural University, Dhaka-1207, during November , 2011 to March, 2012 to study the variability, correlation and path analysis in F_3 population of *Brassica napus* . The phenotypic variances were higher than the genotypic variances. Least genotypic and phenotypic variances was observed among all the parental genotypes and their F_3 progenies for all the characters studied except for siliquae per plant. The high GCV value was observed for secondary branches per plant. The number of secondary branches per plant also showed high heritability with high genetic advance in percent of mean. Based on the variability and Yield per plant had significant positive association with number of primary branches per plant, number of siliquae per plant, Siliqua length, Seed per Siliqua and 1000 seed weight. Path co-efficient analysis revealed that days to 50% flowering, plant hieght, number of secondary branches per plant, Siliqua per plant , siliqua length, seeds per siliqua and thousand seed weight had the positive direct effect on yield per plant. Number of siliqua per plant had the hight positive direct effect on yield per plant. Genotype 9 and genotype 16 were found as short durated lines in the experiment.

Chapter I

Introduction

CHAPTER I

INTRODUCTION

Brassica, accounting for over 16% of the world's edible oil supply is an important genus of plant kingdom consisting of over 3200 species with high diverse morphology. *Brassica* belonging to the family Brassiceae is a wide gennus of cross pollinated oil crops. *Brassica* have taproot system, with succulent, straight and cylindrical stem. The leaves are pinnati-divided. The inflorescence is racemose and flowering is indeterminate beginning at the lowest bud on the main raceme and blooming continues for two-three weeks. Stigma is receptive for about six days. The primary centre of origin for *Brassica napus* is near the Himalayan region and the secondary centre of origin is located in the European -mediterranean area and Asia (Downey and Robelen, 1989). Major producing regions are China, the Indian subcontinent, Canada and Northern Europe (Ram and Hari, 1998).

In Bangladesh more than 153.588 thousand metric ton of local rape and mustard produced from total 174.45 thousand hectares of cultivable land and about 743.42 thousand metric ton of hybrid rape and mustard produced from total 59.16 thousand hectares of cultivable land in the year 2009-2010 (BBS, 2010). The genus *Brassica* has generally been divided in to three groups namely –rape seed, mustard and cole. The rape seed groups includes the diploid *Brassica rapa*, turnip rape (AA, 2n=20) and amphidiploid *Brassica napus* L, rape (AACC, 2n=38) while the mustard groups include species like *Brassica juncea* Czern and Coss; *Brassica nigra* Koch and *Brassica carinata* Braun (Yarnell, 1956). The genomic constitutions of the three elemental species of *Brassica* are as follows; "AA" for *Brassica campestris*, "BB" for *Brassica nigra* and "CC" for *Brassica oleracea* having diploid chromosome number 20, 16 and 18 respectively. The species *Brassica juncea* (AABB, 2n=36) *Brassica carinata* (BBCC, 2n=34) and *Brassica napus* (AACC, 2n=38) are the amphidiploid and originated by combination of the diploid elemental species. All these species have many cultivated varieties suited to different Agro-climatic conditions. In the oleiferous *Brassica* group, a considerable variation of genetic nature exists among different species and varieties within each species in respect of different morphological characters (Malik *et al.* 1995; Nanda *et al.* 1995; Kakroo and Kumar, 1991).

Brassica have great economic & commercial value and play a major role in our daily diet. Fat and oil are vital components of the human diet because they are important sources of energy and act as a carrier of fat soluble vitamins. Poor intake of fat and oil reduce the availability of fat soluble vitamins and caused dietary imbalance and food wastage. In a balanced diet 20-25% of calories should come from fats and oils and the average need of fats and oils is about 37 g/day (Rahman, 1981). The seeds of *Brassica rapa* contain 42% oil, 25% protein (Khaleque, 1985).

As an agricultural country Bangladesh is facing increasing deficiency in oil seed production and consequently import cost is also increasing. The causes are- low yield potential of the varieties, insufficient precipitation when the crops are cultivated under rain fed conditions, competion of other crops and the primitive crop husbandry method. Moreover, area of oil seed crops including mustard and rapeseed is also decreasing. On the other hand; high population growth rate is also putting increased pressure on the per capita consumption of oils.

Efforts are underway to develop better rapeseed genotypes. Genetic variability, broad sense heritability, genetic advance parameters were estimated in some studies (Naazar *et al.*, 2003; Akbar *et al.*, 2007) and phenotypic correlation coeffients between seed yield and yield determining characters have been analyzed in rapeseed (Kumar and Yadava, 1978; Özer and Oral, 1999; Khan et al., 2000; Marinkovic *et al.* 2003; Jeromela *et al.*, 2007, 2008). The influence of environmental effects can be excluded by calculating genetic correlations which are rarely investigated in winter rapeseed (Malik *et al.*, 2000; Akbar *et al.*, 2003) and just only few investigations include genetic correlations between seed yield, yield and quality characters (Engqvist and Becker, 1993; Khan *et al*., 2006).

The improvement through breeding could be made successfully by selecting the genetic material after determining the exact contribution of various components towards yield. Therefore, information on the association of plant characters with seed yield is of great importance to breeder in selecting a desirable genotype. In many cases the reported correlations are highly dependent on the environment and on the material. Basing decisions solely on correlation coefficients may not always be effective because they provide only limited information, disregarding interrelations among traits. Thus, information obtained from correlation coefficient can be enhanced by partitioning them into direct and indirect effects for a set of prior cause and interrelationship. Determination of correlation coefficients is an important statistical procedure to evaluate breeding programs for high yield, as well as to examine direct and indirect contributions to yield variables (Ali *et al*., 2003).

Path-coefficient technique splits the correlation coefficients into direct and indirect effects via alternative characters or pathways and thus permits a critical examination of components that influence a given correlation and can be helpful in formulating an efficient selection strategy (Sabaghnia *et al*.,2010).

Information on genetic variability is necessary for initiating a successful breeding program. Determination of correlation co-efficient between the characters has a considerable importance in selecting breeding materials. The path co-efficient analysis gives more specific information on the direct and indirect influence of each of the component characters upon seed yield (Behl *et al*. 1992).

Thus F_3 materials have been generated through different inter varietal crosses of *Brassica napus* and the present study was conducted to find out the variability, character association and the direct and indirect effect of different characters on yield per plant which will give an opportunity to select the desired plant types to meet the existing demand.

Conceiving the above idea the present study was undertaken-

- To study the variability and character association in F_3 generation.
- To select short durated higher yeilding line to meet the demand of the farmers.

Chapter II

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Brassica species has received much attention by a large number of researchers on various aspects of its production and utilization. *Brassica species* is the most important oil crop of Bangladesh and many countries of the world too. Many studies on the variability, interrelationship, path co-efficient analysis, heritability and genetic advance have been carried out in many countries of the world. The review of literature concerning the studies presented under the following heads:

2.1 Variability, heritability, genetic advance and selection in *Brassica species*

2.2 Correlation among different characters

2.3 Path co-efficient analysis

2.1 Variability, heritability, genetic advance and selection in *Brassica species*

Genetic variability is a prerequisite for initiating a successful breeding program aiming to develop high yielding varieties. A good number of literatures concerning the variability in the *Brassica species* are available. Some of those are presented here.

Abideen et al. (2013) carried out and experiment at the University of Agriculture, Peshawar during crop season year 2011-12. The objectives were to study the genetic variability and correlation among different traits in Brassica napus L. Data were recorded on agronomic and quality traits. The breeding material comprised 8 genotypes of Brassica napus L. These genotypes were evaluated in replicated trial in a randomized complete block design (RCBD) with three replications. Results revealed highly significant differences among the genotypes for most of the traits. Non-significant differences were, however, observed among the genotypes for primary branches plant-1 and pods plant-1. Genotype 1 was found superior for most of the traits i.e maximum oleic acid content etc. Correlation analysis presented highly significant positive phenotypic correlation of plant height with pods main raceme-1 and pod length seed yield exhibited significant positive phenotypic correlation with pods plant-1, protein content and moisture content. Similarly significant negative phenotypic correlation of oleic acid content with oil and erucic acid content was also observed. From the results it can be concluded that Genotype 2 can be used for developing superior genotypes for seed yield, seed pod-1 and protein content while Genotype 7 can be used for yielding high oil content. The significant and positive correlation of seed yield plant-1 with pods plant-1 and protein content was important in making indirect selection for seed yield.

The current study was aimed to develop direct or indirect relationship among the qualitative traits for ultimate improvement in yield and quality. Thirty five advance brassica mutant lines and one check were evaluated for genetic variability and phenotypic correlations for some qualitative traits during the growing year 2008-09. A randomized complete block design (RCBD) with four replications was used in this research experiment. The experimental populations showed highly significant differences for all the observed characters. The mutant line G2 gives the lowest value both for erucic acid (1.6%) and linolenic acid (12.38%) while the mutant line EA2 shows high value for oleic acid but lower for linolenic acid. Similarly mutant line EA3 recorded minimum value for glucosinolates (11.9 µMg). High genetic variability was recorded for erucic acid and 1glucosinolates while low genetic variability was recorded for protein and oil contents. Phenotypic variances were recorded higher than the genotypic variances for all the observed traits. Heritability and genetic advance were higher for glucosinolates and erucic acid while oil content showed the lowest values of heritability and genetic advance. Generally, low correlations were recorded among different characters. However, some of the connected traits like protein, glucosinolates and erucic acid showed significantly positive correlation with each other. Oil content was significantly but negatively correlated with protein contents. In short, the mutant lines O1, O2, EA2, EA3 and G2 showed brilliant performance for most of the quality traits (Ahmad *et al.*, 2013).

Zare and Sharafzadeh (2012) were studied for variability, heritability and correlation analysis of seed yield and yield components in Southern Iran for two years (2009 and 2010). These genotypes were planted in field arranged on randomized completely blocks design with three replications at the Research Centre of Islamic Azad

University of Firoozabad, 95 km of Shiraz. The studied traits were days from emergence to flowering, days from emergence to physiological maturity, plant height, pod length, pods number on main stem, pods per plant, seeds per pod, 1000-seed weight, harvest index and grain yield. Results showed that genetic variability of genotypes was significant for all traits except for pod length and seeds per pod. Interaction between year and genotype was highly significant for seeds per pod. Based on broad sense heritability of traits and correlation between grain yields and other traits, pods per plant, 1000-grain weight and pods on main stem had high direct effect on grain yield in both years. Therefore, selection for increasing grain yield through these traits might be more successful. Selection of desirable varieties to increase grain yield is based on yield component. Based on the results of cluster analysis, the genotypes were grouped into four clusters irrespective of the geographical divergence. Therefore, Modena and Sarigol cultivars were the best resources to increase grain yield during both years and Okapi cultivar was the worst.

Zebarjadi *et al.* (2011) carried out an experiment to study some traits and to estimate genetic parameters in sixteen rapeseed genotypes in two conditions (irrigation and non-irrigation). Statistical analysis showed significant differences among the genotypes based on the studied traits. At maturity stage, data for 13 different characters, including chlorophyll content (SPAD), sugar solution (SS), stem size (SS), plant height (PH), days to semi-flowering (DF), oil percent (OP), oil yield (OY), thousand kernel weight (TKW), pods/branch (PB), relative water content (RWC), mean length pod (MLP), seed per pod (SP), seed yield (SY), proline, grain filling period (GFP) and sub branch per plant (SBP) were recorded from 12 randomly selected plants. Correlation analysis in non-stress condition showed the yield oil was significantly correlated with the traits PH and PB. Maximum heritability (86.69%) was obtained for OY and heritability was high for OP, OY, and PB. Also for these traits we observed high genetic advance, thus these results indicated that these traits could be improved through mass selection (in non-stress condition), while in stress condition correlation analysis showed the OY was significantly correlated with MLP and SY. In stress condition heritability was maximum (74.85%) for oil percentage, whereas low genetic advance was observed for thousand kernel weight.

Nandjee Kumar *et al.* (2009) Studied karyotypic variation in some cultivated species of *Brassicaceae.* The result revealed that the Karyotypic studies were made in five cultivated species of *Brassicaceae* viz *Iberis amara* L., *Brassica campestris* L., *Brassica rapa* L., *Brassica oleracea* L. and *Raphanus sativus* L. The somatic chromosome number was determines as 2n=14 in *Iberis amara*, 2n=20 in *Brassica campestris* and *Brassica rapa* while 2n=18 in *Brassica oleracea* and *Raphanus sativus*. A significant interspecific variation of mean chromosome size and total chromatin was noted. Obviously *Iberis amara* and *Raphanus sativus* had symmetrical while *B. campestris, B. rapa* and *B. oleracea* had asymmetrical karyotype.

Information of the variability and the extent and type of relationship of some quantitative characters in rapeseed is important for an efficient breeding program. In addition, the association between seed yield and quality characters, oil and protein content, is of major interest. 10 winter rapeseed genotypes were evaluated for variation, genetic and phenotypic correlations and broad sense heritability for seed yield, yield and quality characters for 2 years. The results revealed significant differences for all yield and quality characters indicated the presence of sufficient genetic variability for effective selection. Variability, broad sense heritability, genetic advance were maximum for oil yield, seed yield followed by protein yield. In addition, very strong correlations were estimated among them. Simultaneous selection regarding seed yield would be an effective way to increase oil yield and protein yield. Plant height was associated with seed yield, oil yield, protein yield, number of pods on main stem and pod length. In conclusion, plant height, pod length, oil yield and protein yield were efficient characters as selection criteria (Aytac and Kınac, 2009).

Sheikh *et al.* (2009) studied the Induction of genetic variability in Ethiopian mustard (*Brassica carinata*) for quality traits through interspecific hybridization. The result revealed the Interspecific hybridization was used to enhance the spectrum of genetic variability in *Brassica carinata* (BBCC, 2n = 34*)* cv. PC5 for oil and meal quality traits from quality lines of *Brassica juncea* (AABB, 2n = 36).

Hosan *et al.* (2008) studied the association of gene-linked SSR markers to seed glucosinolate content in oilseed rape (*Brassica napus* ssp. *napus*) Breeding of oilseed rape (*Brassica napus* ssp. *napus*) has evoked a strong bottleneck selection towards double-low (00) seed quality with zero erucic acid and low seed glucosinolate content. The resulting reduction of genetic variability in elite 00-quality oilseed rape is particularly relevant with regard to the development of genetically diverse heterotic pools for hybrid breeding. In contrast, *B. napus* genotypes containing high levels of erucic acid and seed glucosinolates (++ quality) represent a comparatively genetically divergent source of germplasm. Seed glucosinolate content is a complex quantitative trait, however, meaning that the introgression of novel germplasm from this gene pool requires recurrent backcrossing to avoid linkagedrag for high glucosinolate content.

Abbas *et al.* (2008) studied the molecular and biochemical assessment of *brassica napus* and indigenous *campestris* species.The result revealed that the Parental lines along with five F2s were assessed for biochemical parameters using Near Infrared Reflectance Spectroscopy (NIRS). Parental lines contain more oil 45.85% as compared to F2s 42.26% while the F2s contain more protein 25.92% as compared to the parents 23.70%. Both parents and F2 contain high glucosinolate and fatty acids contents. Insulin Growth like Factor (IGF) primer sets were used to estimate genetic relationship among 5 F2 segregating population of *Brassica* along with 9 parental lines.

A study was conducted by Hosen (2008) using five parental genotypes of *Brassica rapa* and their ten F_3 progenies including reciprocals. The result revealed that there were large variations present among all the genotypes used in the experiment. Number of primary branches per plant, number of secondary branches per plant, days to 50% flowering, length of siliqua, number of seeds per siliqua, thousand seed weight and yield per plant showed least difference between phenotypic and genotypic variances. The values of GCV and PCV indicated that there was considerable variation among the all characters except days to maturity. The plant height, days to 50% flowering and number of siliquae per plant showed high heritability with high genetic advance and genetic advance in percentage of mean.

A field experiment was conducted by Jahan (2008) to study on inter-genotypic variability and genetic diversity in 10 F_4 lines obtained through intervarietal crosses along with 8 released varieties of *Brassica rapa* during November 2007 to March 2008. Significant variation was observed among all genotypes for all the characters studied. Considering genetic parameters high genotypic co-efficient of variation (GCV) was observed for number of secondary branches/plant, siliquae/plant, yield/plant whereas days to maturity showed very low GCV. High heritability with low genetic advance in percent of mean was observed for days to maturity which indicated that non-additive gene effects were involved for the expression of this character and selection for such trait might not be rewarding. High heritability with moderate genetic advance in percent of mean was observed for plant height and days to 50% flowering indicating that this trait was under additive gene control and selection for genetic improvement for this trait would be effective.

An experiment was carried out by Mahmud (2008) with 58 genotypes of *Brassica rapa* to study intergenotypic variability. Significant variation was observed among all the genotypes for all the characters studied except thousand seed weight. High GCV value was observed for number of secondary branches per plant. High heritability values along with high genetic advance in percentage of mean were obtained for days to 50% flowering, number of secondary branches per plant, seeds per siliqua, and siliqua length.

In an experiment Rashid (2007) studied variability of 40 oleiferous *Brassica species*. Result revealed that genotypes showed wider variation for morphological characteristics and thus were categorized under three cultivated species - *B. rapa*, *B. napus* and *B. juncea* considering genetic parameters. High GCV value was observed for days to 50% flowering, days to maturity, plant height and number of siliquae/plant.

Parveen (2007) studied variability in F_2 progenies of the inter-varietal crosses of 17 *Brassica rapa* genotypes. The result revealed that there were significant variations among the different genotypes used in the experiment. Number of primary branches/plant and secondary branches/plant showed high heritability coupled with high genetic advance and very high genetic advance in percentage.

Kelly (2006) characterized genotype specific differences in survival, growth, and reproduction for field grown, rapid cycling *Brassica rapa*. The result revealed that the rapid cycling *Brassica rapa* (RCBr) develops rapidly, and has both small adult size and a brief life cycle. This study is the first to describe the genotype specific variation in traits describing survival, growth, and reproduction for field grown; RCBr. Five genotypes of RCBr were used: standard, *anthocyaninless,* yellow-green, anthocyaninless and hairless, and *anthocyaninless* and yellow-green. Eight plant traits were measured: life span, height, growth rate, leaf size, number of flowers and fruits, fruit set, and fitness. All traits, except life span, differed significantly among the five genotypes.

Krumbein *et al.* (2005) studied Composition and contents of *phytochemicals (glucosinolates, carotenoids* and chlorophylls) and ascorbic acid in selected *Brassica species (B. juncea, B. rapa subsp. nipposinica var. chinoleifera, B. rapa subsp. chinensis and B. rapa subsp. rapa). Cultivars of selected Brassica species (B. juncea, B. rapa subsp. nipposinica var. chinoleifera, B. rapa subsp. chinensis [B. chinensis]* and B. rapa subsp. rapa) showed significant differences in their composition and contents of phytochemicals and ascorbic acid. B. *juncea* was characterized by a high proportion of alkenyl glucosinolates (85-96%) with a predominance of sinigrin; whereas in B. rapa subsp. nipposinica var. chinoleifera and B. rapa subsp. chinensis, the alkenyl glucosinolate proportion varied between 27 and 88% and consisted mainly of gluconapin, glucobrassicanapin and progoitrin. In B. *rapa* subsp. rapa, the main glucosinolate was the aryl glucosinolate gluconasturtiin (44-47%) with a relatively high level between 23.6 and 35.9 mg 100 g-1 FM. Distinct genotypic variations were also observed for lutein (3.4 to 8.9 mg 100 g-1 FM), beta -carotene (1.8 to 4.3 mg 100-1 FM) as well as chlorophyll a (35.7 to 96.8 mg 100 g-1 FM) and chlorophyll b (11.4 to 30.5 mg 100 g-1 FM).

Afroz *et al.* (2004) studied genetic variability of 14 genotypes of mustard and rape. The highest genetic advance was observed in percent of pollen sterility.

Mahak *et al.* (2004) conducted an experiment on genetic variability, heritability, genetic advance and correlation for 8 quantitative characters. The phenotypic coefficient of variation was higher than the genotypic coefficient of variation for all characters. High heritability coupled with high genetic advance in percentage of mean was observed for days to flowering, followed by thousand seed weight, days to maturity and plant height.

Niraj and Srivastava (2004) studied on variability and character association in Indian mustard of 21 genotypes of *Brassica juncea*. RH-9704 and IGM-21 recorded the highest seed yield. Phenotypic coefficient of variation was high for oil yield per plant, seed yield per plant and seed weight. Heritability was high for test weight, days to flowering, days to maturity and plant height.

Katiyar *et al*. (2004) studied on variability for the seed yield in ninety intervarietal crosses of *Brassica campestris*. Existence of significant variation among parents and crosses indicated the presence of adequate genetic variance between parents which reflected in differential performance of individual cross combinations.

Choudhary *et al.* (2003) studied variability in Indian mustard for 10 characters during rabi season in India. A wide range of variability was observed for all characters, except for primary branches per plant, siliqua length, number of seeds per siliqua and thousand seed weight. Genotypic and phenotypic coefficient of variability was recorded high for secondary branches per plant, seed yield per plant and number of siliqua per plant. High heritability coupled with high genetic advance as percentage of mean was observed for secondary branches per plant, seed yield per plant and number of siliquae per plant, indicating preponderance of additive gene action.

Genetic variability for 9 traits in 25 genotypes werw studied by Pant and Singh (2001). Analysis of variance revealed highly significant genotypic differences for all traits studied, except for days to flowering, number of primary branches and oil content. Seed yield per plant had the highest coefficient of genotypic and phenotypic variability. All traits showed high heritability, with the highest value estimated for seed yield per plant. The estimates of genetic advance were comparatively low for oil content and days to flowering. The genotypic coefficient of variation and heritability estimates for oil content and days to flowering suggest that these traits cannot be improved effectively merely by selection.

Ghosh and Gulati (2001) studied genetic variability and association of yield components in Indian mustard among 12 yield components for 36 genotypes selected from different geographical regions. The genotypic and phenotypic coefficients of variability (GCV and PCV, respectively) were high in magnitude for all the characters except plant height. The differences between the PCV and GCV were narrow for all the characters studied, coupled with high heritability except plant height, indicating the usefulness of phenotypic selection in improving these traits. High heritability, coupled with high genetic advance was observed for oil content, harvest index, number of primary branches, number of siliquae on main shoot, main shoot length and number of seeds per siliqua. This result suggests the importance of additive gene action for their inheritance and improvement could be brought about by phenotypic selection.

Tyagi *et al.* (2001) evaluated forty-five hybrids of Indian mustard obtained from crossing 10 cultivars for seed yield and yield components. Variation was highest for plant height of parents and their hybrids. The seed yield per plant exhibited the highest coefficient of variation (41.1%).

An experiment was conducted by Khulbe *et al.* (2000) to estimates of variability, heritability and genetic advance for yield and its components in Indian mustard revealed maximum variability for seed yield. All the characters except oil content exhibited high heritability with high or moderate genetic advance, suggesting the role of additive gene action in conditioning the traits. Non-additive gene action appeared to influence the expression of days to maturity, while environment had a major influence on oil content. The use of pedigree selection or biparental mating in advanced generations was advocated to achieve substantial gains.

An experiment was conducted by Shalini *et al.* (2000) to study variability in *Brassica juncea* L. Different genetic parameters was estimated to assess the magnitude of genetic variation in 81 diverse Indian mustard genotypes. The analysis of variance indicated the prevalence of sufficient genetic variation among the genotypes for all 10 characters studied. Genotypic coefficient of variation, estimates of variability, heritability values and genetic gain were moderate to high for 1000 seed weight, number of siliquae per plant and number of secondary branches per plant, indicating that the response to selection would be very high for these yield components. For the other characters, low coefficient of variation, medium to low heritability and low genetic gain were observed.

Masood *et al.* (1999) studied seven genotypes of *Brassica campestris* and standard cultivar of *Brassica napus* to calculate genetic variability. The co-efficient of variation was high for thousand seed weight, pod length and number of seeds per pod for both genotypic and phenotypic variability. The genotypic and phenotypic correlation coefficients showed that seed yield per plant were significantly positively correlated with plant height, number of siliquae per plant and number of seeds per siliqua.

In a study, Zhou *et al.* (1998) found significant variation in plant height in M_2 generation. Plant height was reported to be responsive to gamma rays, which decreased plant height substantially. Sengupta *et al.* (1998) also obtained similar results. Significant genetic variability was observed for plant height by many workers like Kumar *et al.* (1996), Malik *et al.* (1995), Kumar and Singh (1994), Yadava *et al.* (1993), Andrahennadi *et al.* (1991), Gupta and Labana (1989), Lebowitz (1989), Chaturvedi *et al.* (1988), Chauhan and Singh (1985), Sharma (1984) and many others among different genotypes of *B. napus*, *B. rapa* and *B. juncea*.

Lekh *et al.* (1998) reported that secondary branches per plant showed highest genotypic co-efficient of variation. High genotypic and phenotypic co-efficient of variation was recorded for days to 50% flowering in the same study. He found early flowering genotype will mature early and vice versa.

In general, high number of seeds per siliqua is desirable. Kumar *et al.* (1996) reported the presence of significant variability for number of seeds per siliqua in the genotypes of *Brassica napus*, *Brassica rapa* and *Brassica juncea*. Similar significant variability for number of seeds per siliqua in oleiferous *Brassica* materials of diverse genetic base have also been observed by Kudla (1993) and Kumar and Singh (1994).

For days to maturity Biswas (1989) found high GCV and PCV among 18 genotypes of *B. napus*, while Sharma (1984) found low GCV and PCV values among 46 genotypes of *B. juncea.* Tak and Patnaik (1977) found these values as 4.5 % and 1.8 % respectively in yellow sarson and toria, while Yadava (1973) found GCV 7.6 % among 29 strains of *B. juncea.*

High heritability coupled with high genetic advance for seed yield per plant, number of secondary branches per plant, siliqua per plant, 1000 seed weight (g) and number of primary branches per plant was observed by Sheikh *et al.* (1999) while working with 24 genotypes of toria.

Lekh *et al.* (1998) carried out an experiment with 24 genotypes of *B. juncea* and 10 genotypes each of *B. campestris*, *B. carinata* and *B. napus* and observed highest genetic advance and high genotypic and phenotypic co-efficient of variation for days to 50% flowering and high heritability for others yield contributing characters.

Working with different strains of *B. napus* Malik *et al.* (1995) observed very high broad sense heritability (h^2_b >90%) for number of primary branches per plant, days to 50% flowering and oil content and low heritability (h^2_b=<50%) for number of siliqua/plant, number of seeds/siliqua, plant height and seed yield. But Singh *et al.* (1991) found high heritability for all these character studied with *B. napus*. Li *et al.* (1989) also observed similar results while studied with *B. napus*.

In a study of 46 genotypes of *B. juncea*, Sharma *et al.* (1995) observed high heritability for plant height, days to flowering and low heritability for days to maturity. He also found low genetic advance for days to maturity and high genetic advance for yield/plant. In another study of 179 genotypes of Indian mustard Singh *et al.* (1987) observed high heritability for yield/plant and low heritability for number of primary branches/plant.

Diwakar and Singh (1993) studied heritability and genetic advance in segregating populations of yellow seeded Indian mustard (*Brassica juncea* L. Czern and Coss.). They used data on yield and 5 component traits in 8 cultivars and their 28 F_3 hybrids. They observed a wide range of phenotypic variation for most of the measured traits. They also reported that narrow sense heritability and genetic advance were high for days to flowering and plant height.

Singh *et al.* (1991) studied different morpho-physiological characters of 29 genotypes of *B. napus* and *B. campestris*. They found significant genetic variability in days to 50% flowering.

According to Labowitz (1989), Chowdhury *et al.* (1987), Biswas (1989) in *B. rapa*, Andrahennadi *et al.* (1991) in brown mustard, Kudla (1993) in seweden rape and Kumar and Singh (1994) in *Brassica juncea* reported different degrees of significant variations of 1000 seed weight due to variable genotypes.

Significant genetic variation for number of primary branches/plant was recorded by several researchers. Singh *et al.* (1989) studied this character under normal and stress conditions in 29 genotypes of *B. napus* and *B. rapa* and found significant variation among the genotypes. Similar result was reported earlier by Kumar and Singh (1994), Kakroo and Kumar (1991), Biswas (1989), Jain *et al.* (1988), Labana *et al.* (1987) and Gupta *et al.* (1987).

Working with 8 cultivars of *B. napus* Yin (1989) found the highest genotypic co-efficient of variation for secondary branches. High heritability estimates were observed for all the characters under all environments except harvest index and biological yield. Highest genetic advance and high genotypic and phenotypic co-efficient of variation was recorded for days to 50% flowering.

Thurling (1988) reported that selection for increased siliqua length is an effective strategy for yield improvement through raising seed weight/siliqua.

The most important feature in winter rape plant selection for seed yield was number of branches was reported by Teresa (1987).

Chatterjee and Bhattacharyya (1986) found higher efficiency with index selection than selection based on yield alone. The efficiency increased with an increase in the number of characters in the index. The index comprising plant height, thousand seed weight and yield per plant was considered effective from the practical point of view.

Singh (1986) studied 22 genotypes of *B. napus*, *B. rapa* and *B. juncea*. He observed high heritability and genetic advance in seed yield, 1000 seed weight and number of seeds/siliqua.

Vershney *et al.* (1986) found high heritability and high genetic advance for plant height in all three species; but high heritability and genetic advance were found for number of siliquae/plant only in *B. rapa* and in *B. juncea*. He reported high heritability and genetic advance in seed yield, 1000 seed weight and number of seeds/siliqua in *B. napus*.

Selection for bold seed size from F_2 to F_5 generations was highly effective was observed by Gupta and Labana (1985) in Indian mustard.

Working with 46 genotypes of *B. juncea* Sharma (1984) found low GCV and PCV values, while Biswas (1989) found high GCV and PCV among 18 genotypes of *B. napus*.

High heritability and genetic advance for flowering time, number of primary branches/plant and plant height was observed by Wan and Hu (1983). Low heritability of yield was reported by many researches like Malik *et al.* (1995), Kumar *et al.* (1988), Yadava *et al.* (1985), Li *et al.* (1989), Chen *et al.* (1983) etc. But Singh (1986) found high heritability for this trait. Low to medium heritability of siliqua length was observed by Kakroo and Kumar (1991), Sharma (1984) and Yadava *et al.* (1996).

Working with 30 varieties of *B. rapa* Chandola *et al.* (1977) found high genetic advance for plant height. Paul *et al.* (1976) observed in his study that a good genetic advance was expected from a selection index comprising seed yield, number of seeds/siliqua, number of siliquae/plant and number of primary branches/plant.

Working on genetic variability, heritability and genetic advance of seed yield and its components in Indian mustard Katiyar *et al.*(1974) reported that high genetic coefficients of variation were observed for seed yield/plant, days to first flowering and plant height, whereas low values were observed for other characters like days to maturity and number of primary branches.

According to Yadava (1973) high heritability in the broad sense and genetic advance for days to maturity, plant height and number of node on the main shoot among the nine traits studied in 29 varieties.

Most breeders tend to suggest delaying selection until at least the F_4 generation, when yield comparisons might be based on reasonably large replicated plots. According to Shebeski (1967) selection for yield related traits in F_2 (or F_3) generation has been recommended to minimize the expected losses of transgressive or productive segregants from the breeding populations.

2.3 Correlation among different characters

Analysis of correlation among different traits is important in breeding program. A good number of literatures are available on correlation among characters of Brassica sp. Some of these literatures are reviewed here:

Twenty Brassica napus L. genotypes including a check cultivar Abasin-95 was evaluated to study correlation and path co-efficient analysis to partition the cause and effect relationship into direct and indirect components. The experiment was laid out in randomized complete block design with three replications at Khyber Pakhtunkhwa Agricultural University, Peshawar, Pakistan during 2010-11. Correlation analysis revealed that seed yield plant had significant positive genetic (r) and phenotypic (r) correlation with flowering (0.44, 0.34), maturity GP (0.68, 0.51), plant height (0.55, 0.46), primary branches plant (0.83, 0.68), main raceme length (0.71, 0.49), pods main 1 raceme (0.74, 0.60) and pods plant (0.87, 0.79), whereas significant positive phenotypic association with seeds 11 pod (0.39). Path coefficient analysis indicated that primary branches plant had maximum positive direct effect 11 on seed yield plant followed by pods main raceme , seeds pod and 1000-seed weight, whereas, pods plant , 1 11 1 main raceme length, maturity, flowering and plant height had positive indirect effect on seed yield. The most prominent characters which influence seed yield in rapeseed were primary branches plant , pods main raceme ,11 seeds pod , pods plant , main raceme length and 1000-seed weight. Strong association of these yield components 11 with seed yield suggested good selection criteria for improving seed yield in rapeseed (Khan et al. 2013)

Rameeh (2012) was aimed at finding out the planting dates effects on yield associated traits and also determining the variations of correlations among the traits in different planting dates of rapeseed genotypes. Significant planting dates and genotypes effects for phenological traits, yield components, seed yield and oil percentage revealed significant differences of planting dates and genotypes for these traits. Plant height had positive effect on pods per plant by increasing number of branches in each plant and length of main raceme. 1000-seed weight had significant positive correlation with seed yield, so any changes for this trait had considerable effect on seed yield. The variation of correlation between duration of flowering and pods per plant was less than the correlation of duration of flowering to other traits in different planting dates, so it can be used as selection breeding criterion.

Improvement of new rapeseed (Brassica napus L.) cultivars requires efficient tools to monitor trait relationship in a breeding program. Twenty rapeseed genotypes including 4 cultivars and 16 advanced lines were evaluated based on randomized complete block design with three replications. Significant genotypes effect were exhibited for phenological traits, plant height, seed yield and yield components except seeds per pod. High broad sense heritability estimates for phenological traits, plant height, pods per plant, 1000-seed weight and seed indicating selection gain for improving these traits will be high. Days to maturity had low value of genetic coefficient of variation and therefore for improving this trait, the correlated traits viz. days to flowering and days to end of flowering can be used. The results of factor analysis revealed three factors including fixed capital factor (phenological traits), sink factor (pod per plant, seeds per pod and seed yield) and secondary yield components (pods per main axis and 1000-seed weight) for 10 studied traits. On the basis of scattering of the genotypes based on their scores for three factors, the genotypes G19, G18, G15, G10, G8 and G4 were classified as the same group and all of these had high seed yield. Scattering of genotypes based on their scores for related factors can be used as suitable method for grouping and classifying the genotypes for more important yield associated traits (Rameeh, 2012).

Thirty-six rapeseed genotypes including four cultivars and 32 advanced lines were evaluated in randomized complete block design with three replications. Analysis of variance indicated significant genetic variation for different seed yield contributing characters. Most variations among the genotypes were in seeds per siliqua and siliquae on main raceme with 18.0 and 25.3 per cent coefficient of variation, respectively. Heritability (bs) estimates were high for siliquae on main raceme, seeds per siliqua and siliquae per plant (0.70, 0.77 and 0.81, respectively). Siliquae per plant had significant positive correlation (0.80**) with seed yield and also it had significant positive direct effect (0.85**) on seed yield. So any change for this trait will have considerable effect on seed yield (Rameeh, 2011).

A study was conducted by Hosen (2008) using five parental genotypes of *Brassica rapa* and their ten F_3 progenies including reciprocals. He found yield per plant showed highest significant and positive correlation with days to maturity followed by number of seeds per siliqua, number of secondary branches per plant, length of siliqua and number of siliquae per plant.

In an experiment Mahmud (2008) found highly significant positive association of seed yield per plant with number of primary branches per plant, number of secondary branches per plant, number of siliquae per plant.

Rashid (2007) carried out an experiment with 40 oleiferous *Brassica species* to estimate correlation and observed that, highly significant positive association of yield per plant with number of primary branches per plant , number of secondary branches per plant, number of seeds per siliqua and number of siliquae per plant.

Mondragon-Portocarrero *et al.* (2006) studied effects of different pre-freezing blanching procedures on the physicochemical properties of Brassica rapa leaves (Turnip Greens, Grelos). The result revealed that the blanching, the grelos were stored for up to 120 days at -18 degrees C, with sampling at two-weekly intervals for analysis of physicochemical properties (ash weight, vitamin C content, pH, acid value, moisture content and CIEL*a*b* colour variables). In almost all respects steam blanching gave the best results: notably, vitamin C losses were markedly lower, while moisture content and colour remained closer to those of the fresh product.

Parveen (2007) conducted an experiment with F_2 population of *Brassica rapa* to study the correlation and observed that yield per plant had non-significant positive association with plant height, number of secondary branches per plant, number of seeds per siliqua and number of siliquae per plant, days to 50% flowering and length of siliqua.

An experiment on oleiferous *Brassica campestris* L. was conducted by Siddikee (2006) to study the correlation analysis. The results revealed that yield per plant highest significant positive correlation with number of siliquae per plant.

Tusar *et al.* (2006) studied phenotypic correlation and observed that seed yield per plant was positively and significantly associated with plant height, total dry matter production and husk weight. The number of siliquae per plant, 1000-seed weight, crop growth rate during 60-75 days after sowing and number of branches per plant were also positively associated with seed yield.

Zahan (2006) studied correlation and reported that yield/plant had highly significant positive association with plant height, length of siliquae, siliquae/plant and seed/siliquae but insignificant negative association with days to 50% flowering, days to maturity.

Afroz *et al.* (2004) studied correlation and found seed yield per plant had significant and positive correlation with number of primary branches per plant and number of siliqua per plant. Path coefficient revealed maximum direct positive effects on plant height followed by number of siliqua per plant, seed yield per plant, number of primary branches per plant, 1000-seed weight and number of siliqua shattering per plant.

Mahak *et al.* (2004) conducted an experiment and studied correlation for 8 quantitative characters. Seed yield per plant showed positive correlation with number of primary branches, length of main raceme, 1000-seed weight and oil content. Selection should be applied on these traits to improve seed yield in Indian mustard.

An experiment conducted by Niraj and Srivastava (2004) on character association studies in Indian mustard of 21 genotypes of *Brassica juncea*. Seed and oil yields were positively and significantly correlated with plant height and primary branches but negatively correlated with test weight.

Pankaj *et al.* (2002) studied four parental cultivars and the 174 progenies of resultant crosses for correlation between yield and yield component traits. The genetic correlation was higher than the phenotypic correlation for the majority of the characters. The number of siliquae per plant, which had the strongest positive and significant correlation with yield per plant at both levels, was positively associated with the number of seeds per siliqua and test weight at both levels. The number seeds per siliqua were positively associated with siliqua length and yield per plant at both levels.

Srivastava and Singh (2002) studied correlation in Indian mustard (*Brassica junea L.* Czern and Coss) for 10 characters in 24 strains of Indian mustard along with 2 varieties. Results revealed that number of primary branches per plant, number of secondary branches per plant, 1000 seed weight (g) and oil percent were positively associated with seed yield.

Badsra and Chaudhary (2001) studied correlation on 14 traits of 16 Indian mustard genotypes. Seed yield was positively correlated with stem diameter, number of siliquae per plant and oil content, while oil content was positively correlated with harvest index only. Among the characters only 3 characters positively correlated with seed yield.

Association of yield components in Indian mustard among 12 yield components were studied in 36 genotypes selected from different geographical regions by Ghosh and Gulati (2001). Seed yield exhibited significant positive association with yield contributing traits like days to 50% flowering, days to maturity, plant height, number of secondary branches, number of siliquae on main shoot and oil content.

Days to maturity showed insignificant correlation with seed yield at both genotypic and phenotypic levels. The number of branches per plant and number of siliquae per plant showed significant negative correlation with number of seeds per siliqua and 1000 seed weight was reported by Malek *et al.* (2000), while studied correlation analysis.

Shalini *et al.* (2000) evaluated 81 genotypes of Indian mustard for the magnitude of association between their quantitative characters of secondary branches, plant height, number of siliquae and seeds per siliquae were highly associated with seed yield.

In a study of correlations in 8 Indian mustard *(Brassica juncea)* parents and their 28 F_1 hybrids Khulbe and Pant (1999) revealed that the number of siliquae per plant, length of siliqua, number of seeds per siliqua, thousand seed weight and harvest index were positively associated with seed yield.

The number of siliquae per plant, number of seeds per siliqua and plant height was significantly positively correlated with seed yield was observed by Masood *et al.* (1999) while studied 7 genotypes of *B. campestris* and standard cultivar of *B.napus* to calculate correlation co-efficient.

Kumar *et al.* (1999) reported that genotypic correlation co-efficient were higher in magnitude than corresponding phenotypic correlation co-efficient for most characters. The plant height, siliquae on main shoot, siliquae per plant and thousand seed weight were positively correlated with seed yield.

Das *et al.* (1998) carried out an experiment with 8 genotypes of Indian mustard *(B. juncea)* and reported that the length of siliqua, seeds per siliqua had high positive genotypic correlated with seed yield per plant.

Zajac *et al.* (1998) studied phenotypic correlation between yield and its component and reported that strong positive correlation occurred between seeds per siliqua and actual yield. The number of seeds per siliqua had the greatest influence and siliquae number per plant had the smallest effect on yield.

Kumar *et al.* (1996) studied 12 genotypes of *B. juncea* for correlation analysis and found flowering time and plant height negatively correlated with number of primary branches per plant.

Plant height, siliquae per plant, siliqua length, seed weight, and seeds per siliqua had positive and significant effects on seed yield per plant was observed by Tyagi *et al.* (1996) while carried out an experiment with 6 yield components in 3 cultivars of mustard.

Gill and Narang (1995) studied correlation in gobhi sarson *(B. campestris* var. sarson) and observed that seed yield was positively correlated with number of primary branches and secondary branches per plant, number of siliquae per plant and thousand seed weight.

Seed yield per plant had high positive and significant correlations with plant height and thousand seed weight, but high negative and significant correlations with seeds per siliqua at both genotypes and phenotypic levels was reported by Uddin *et al.* (1995) while studied correlation analysis in 13 Indian mustard *(B. juncea).*

Positive association between yield and siliqua filling period was observed by Nanda *et al.* (1995) while studied correlation analysis with 65 strains of *B. juncea, B. rapa* and *B. napes.* Similar results also found by Olsson (1990) in *B. napes.* He also observed positive correlation between siliqua density and yield.

Nasim *et al.* (1994) studied correlation analysis in B. *rapa* and found 1000 seed weight was significantly and positively correlated with seed yield per plant and number of siliqua per plant but significantly and negatively correlated with siliqua length and number of seeds per siliqua.

Siliqua length, number of siliquae per plant, number of seeds per siliqua and seed weight per siliqua was positively and linearly associated with seed yield per plant was observed by Ahmed (1993) while working with 8 cultivars of *B. campestris and B.juncea* for study of nature and degree of interrelationship among yield components.

Chaudhury *et al.* (1993) observed seed yield was positively correlated with siliqua length when evaluated 7 of *B. juncea, 2* of *B. carinata* cultivars and 1 cultivar each of *B, campestris* and B. *tournefortii.*

The number of seeds per siliqua negatively correlated with siliquae per plant was reported by Zaman *et al.* (1992) when they studied several yield contributing traits of

Swedish advanced rape lines.

Reddy (1991) studied correlation analysis in Indian mustard (*B. juncea*) and reported that positive and significant correlation between seed yield and number of primary branches per plant, number of secondary branches per plant, siliquae per plant and seeds per siliqua.

Singh *et al.* (1987) observed number of primary branches per plant negatively correlated with siliqua length and 1000 seed weight, but positively correlated with number of siliquae per plant.

In F_3 population of brown sarson Das *et al.* (1984) observed 1000 seed weight had highly significant genotypic and phenotypic correlation with seed yield per plant.

In *B. juncea* Srivastava *et al.* (1983) observed that the number of primary branches per plant and secondary branches per plant, plant height and days to maturity showed significant positive association with the seed yield per plant. The number of primary branches showed positive and significant association with the number of secondary branches per plant, plant height and days to maturity. Plant height showed positive and significant correlation with the number of secondary branches and days to maturity.

Increasing the number of branches is a means of increasing yield, since the number of primary and secondary branches have a significant positive correlation with seed yield (Singh *et al.* 1969; Katiyar and Singh, 1974).

Banerjee, (1968) found significant correlation between number of siliqua/plant and numbers of seeds/siliqua in yellow sarson. But Tak and Patnaik (1977) found negative genotypic correlation between number of siliqua/plant and numbers of seeds/in brown sarson and toria varieties of *B. rapa*. On the contrary, Das *et al.* (1984) reported number of siliquae/plant showed significant and positive correlation with number of seeds/siliqua and 1000 seed weight. Chay and Thurling (1989) studied the inheritance of siliqua length among several lines of *B. napus* and reported that the siliqua length when increased there was an increase in the number of seeds per siliqua and thousand seed weight. The siliqua length was positively correlated with both number of seeds per siliqua and thousand seed weight was observed by Singh *et al.* (1987) in *B. rapa,* Chowdhury *et al.* (1987), Lebowitz (1989) and Lodhi *et al.* (1979) in *B. juncea.*

2.4 Path co-efficient analysis

When more characters are involved in correlation study it becomes difficult to ascertain the traits which really contribute towards the yield. The path analysis under such situation helps to determine the direct and indirect contribution of these traits towards the yield.

hotshot, Amica, SW5001, Eagle and RGS003). The experiment was split plot design under hydroponic culture in Greenhouse of university of Tabriz, Iran. Morphological parameters of root and shoot dry weight, 1000-seed weight, length of pod, number

The path co-efficient analysis by Hosen (2008) exhibited that thousand seed weight had the highest positive direct effect followed by days to 50% flowering, length of siliqua, number of primary branches per plant, number of secondary branches per plant, days to maturity and number of seeds per siliqua while working with five parental genotypes of *Brassica rapa* and their ten F_3 progenies including reciprocals.

An experiment was carried out by Mahmud (2008) with 58 genotypes of *Brassica rapa.* Path analysis showed that yield per plant had the highest direct effect on number of primary branches per plant, number of siliquae per plant, number of secondary branches per plant and number of seeds per siliqua.

Tel-Zur and Goldman (2007) studied analysis of sub-populations of rapid-cycling Brassica rapa following recurrent bi-directional selection for cotyledon size. This study was conducted total cell number exhibited statistically significant differences in broad and bottleneck-1 sub-populations, while cell number per unit area exhibited statistically significant differences in broad, bottleneck-2 and bottleneck-3 sub-populations. Decreases in pollen viability in comparison with the base population were observed in three sub-populations. Among the eight sub-populations studied, the most significant phenotypic differences were observed within broad sub-populations.

Rashid (2007) carried out an experiment with 40 oleiferous Brassica species to estimate path analysis and observed that yield per plant had the highest direct effect on days to maturity, number of seeds per siliqua, number of siliquae per plant and number of primary and secondary branches per plant.

Parveen (2007) conducted an experiment with F_2 population of *Brassica rapa* to study the path analysis and observed that number of seeds per siliqua showed highest direct effect on yield per plant.

By path analysis, Zahan (2006) reported that siliquae/plant had positive direct effect on yield/plant. And days to 50% flowering had negative direct effect on yield/plant.

Kelly (2006) Studied characterizing genotype specific differences in survival, growth, and reproduction for field grown, rapid cycling Brassica rapa. The result revealed that the Correlation analysis revealed that fitness increased as each of these of seven plant traits increased. This study demonstrates that RCBr can serve as a model organism in ecological field studies

Afroz *et al.* (2004) studied path analysis of 14 genotypes of mustard and observed that maximum direct positive effects on plant height followed by number of siliqua per plant, seed yield per plant, number of primary branches per plant, 1000-seed weight and number of siliqua shattering per plant.

Srivastava and Singh (2002) reported that number of primary branches per plant, number of secondary branches per plant and 1000 seed weight had strong direct effect on seed yield while working with Indian mustard (*B. juncea* L. Czern and Coss). Results suggested that number of primary branches and 1000 seed weight were vital selection criteria for improvement-in productivity of Indian mustard.

The number of siliquae per plant had the highest direct effect on seed yield followed by 1000 seed weight, number of primary branches per plant and plant height. Most of the characters had an indirect effect on seed yield was observed by Shalini *et al.* (2000) while studied path analysis of Indian mustard germplasm.

Khulbe and Pant (1999) studied path co-efficient analysis in 8 Indian mustard (*B.juncea*) parents and their 28 F_1 hybrids. The results revealed that harvest index, siliqua length, seeds per siliqua, siliquae per plant, thousand seed and days to initial flowering were the major traits influencing seed yield.

The number of seeds per siliqua exerted the highest effect on seed yield was observed by Masood *et al.* (1999) when they studied seven genotypes of *B. campestris* and standard cultivar of *B. napus.*

Sheikh *et al.* (1999) worked with 24 diverse genotypes of toria for assess the direct and indirect effects of seven quantitative and developmental traits on seed yield. Results revealed that thousand seed weight and siliquae per plant had highly positive direct effect on seed yield.

The number of siliquae per plant had the highest positive direct effect on seed yield was observed by Yadava *et al.* (1996) when studied path co-efficient analysis of 6 yield components of 25 diverse varieties of Indian mustard.

Uddin *et al.* (1995) studied path analysis in 13 Indian mustard *(B. juncea)* and observed that seeds per siliqua and thousand seed weight had high positive direct effect on seed yield per plant.

Saini and Kumar (1995) studied 28 lines of yellow and brown sarson *(B. campestris)* for path coefficient analysis. Results revealed that seeds per siliqua and 1000 seed weight had direct positive effect on yield.

Plant height, siliquae per plant and seeds per siliqua had high positive direct effect on seed yield was observed by Chauhan and Singh (1995).

Kudla (1993) reported that 1000 seed weight had positive direct effect on seed yield.

Kachroo and Kumar (1991) studied path co-efficient analysis in *B. juncea* and found that thousand seed weight had positive direct effect but days to flowering and number of primary branches had negative indirect effect via seeds per siliqua on seed yield.

Thousand seed weight had positive direct effect, but days to 50% flowering and primary branches had negative indirect effect via seeds per siliqua on seed yield was found by Kakroo and Kumar (1991) while working with several strains of *B. juncea.*

Han (1990) studied *B. napus* and observed negative direct effect of number of siliquae per plant, siliqua length and positive direct effect of seeds per siliqua and plant height on seed yield.

Dhillon *et al.* (1990) reported that the plant height had the highest positive direct effect on seed yield per plant in *B. juncea,* but Singh *et al. (1978)* also found negative direct effect of the trait on seed yield.

Siliqua length had highest positive direct effect and number of primary branches per plant had the highest negative direct effect on seed yield was observed by Chowdhury *et al.* (1987) while working with 42 strains of mustard.

Primary branches per plant and thousand seed weight had the direct effect on seed yield was observed by Gupta *et al*. (1987).

Chauhan and Singh (1985) found high positive direct effect of days to flowering, plant height, primary branches per plant, siliquae per plant and seeds per siliqua on seed yield while working with several strains *of B. juncea.*

Hari *et al.* (1985) studied 38 cultivars of *Brassica juncea* and observed that siliquae number per plant and thousand seed weight had considerable direct effect on yield.

In *B. juncea* Kumar *et al.* (1984) found the negative indirect effect of days to flowering via plant height and pod length, but negative direct effect of these traits was observed by Singh *et al.* (1987).

Negative indirect effect on seed yield of days to flowering via plant height and siliqua length on seed yield was observed by Kumar *et al.* (1984) while working with *B. juncea.*

Chapter III

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

3.1 Experimental site

The present experiment was conducted at the experimental farm of Sher-e-Bangla Agricultural University, Dhaka-1207, during November, 2011 to March, 2012. The location of the experimental site was situated at **23^0 74'** N latitude and **90^0 35'** E longitude with an elevation of 8.6 meter from the sea level.

3.2 Soil and Climate

The experimental site was situated in the subtropical zone. The soil of the experimental site belongs to Agroecological region of "Madhupur Tract" (AEZ No. 28). The soil was clay loam in texture and olive gray with common fine to medium distinct dark yellowish brown mottles. The pH was 5.47 to 5.63 and organic carbon content is 0.82% (Appendix I). The records of air temperature, humidity, and rainfall during the period of experiment were noted from the Bangladesh Meteorological Department, Agargaon, Dhaka (Appendix II).

3.3 Plant materials

A total number of 26 (Twenty-six) materials were used in this experiment where twenty-six were F_3 segregating generations . All the Materials were collected from Department of Genetics and Pant Breeding, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. The materials used in that experiment is shown in Table -1.

Table 1: Materials used for the experiment

Genotypes	F_3 populations	Sources
G_1	9905×9908	**SAU**
G_2	9906×9908	**SAU**
G_3	2066×0130	**SAU**
G_4	9901×2066	**SAU**
G_5	9908×9901	**SAU**
G_6	108×2066	**SAU**
G_7	9906×2066	**SAU**
G_8	108×2066	**SAU**
G_9	108×9905	**SAU**
G_{10}	205×0130	**SAU**
G_{11}	9906×0130	**SAU**
G_{12}	9906×9901	**SAU**
G_{13}	108×205	**SAU**
G_{14}	9908×0130	**SAU**
G_{15}	108×9901	**SAU**
G_{16}	9901×0130	**SAU**
G_{17}	9901×205	**SAU**
G_{18}	9905×0130	**SAU**
G_{19}	9905×9906	**SAU**
G_{20}	9908×2066	**SAU**
G_{21}	9905×9901	**SAU**
G_{22}	2066× 205	**SAU**
G_{23}	9906×205	**SAU**
G_{24}	9905×2066	**SAU**
G_{25}	9905×108	**SAU**
G_{26}	9905× 205	**SAU**

Plate:1:Flowering stage of the research field

3.4 Methods

The following precise methods have been followed to carry out the experiment:

3.4.1 Land preparation

The experimental plot was prepared by several ploughing and cross ploughing followed by laddering and harrowing with tractor and power tiller to bring about good tilth. Weeds and other stubbles were removed carefully from the experimental plot and leveled properly.

3.4.2 Application of manure and fertilizer

The crop was fertilized at the rate of 10 tons of Cowdung, 250 kg Urea, 175 kg Triple Super Phosphate (TSP), 85 kg Muriate of Potash (MoP), 250 kg Gypsum, 3 kg Zinc oxide and Boron 1 kg per hectare. The half amount of urea, total amount of Cowdung, TSP, MoP, Gypsum, Zinc Oxide and Boron was applied during final land preparation. The rest amount of urea was applied as top dressing after 25 days of sowing.

3.4.3 Experimental design and layout

Field lay out was done after final land preparation. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The total area of the experiment was 56m × 14m = 784 m^2. Each replication size was 56 m × 3.5 m, and the distance between replication to replication was 1 m. The spacing between lines to line was 30 cm. Seeds were sown in lines in the experimental plots on 20 November 2011. The seeds were placed at about 1.5 cm depth in the soil. After sowing, the seeds were covered with soil carefully so that no clods were on the seeds.

3.4.4 Intercultural operations

Intercultural operations, such as weeding, thinning, irrigation, pest management, etc. were done uniformly in all the plots. One post sowing irrigation was given with cane after sowing of seeds to bring proper moisture condition of the soil to ensure uniform germination of the seeds. A good drainage system was maintained for immediate release of rainwater from the experimental plot during the growing period. The first weeding was done after 15 days of sowing. At the same time, thinning was done for maintaining a distance of 10 cm from plant to plant in rows of 30 cm. apart. Second weeding was done after 35 days of sowing. Aphid infection was found in the crop during the siliqua development stage. To control aphids Malathion-57 EC @ 2ml/liter of water was applied. The insecticide was applied in the afternoon.

3.4.5 Crop harvesting

Harvesting was done from 3th to 22th February, 2012 depending upon the maturity. When 80% of the plants showed symptoms of maturity i.e. straw color of siliqua, leaves, stems desirable seed color in the mature siliqua, the crop was assessed to attain maturity. Ten plants were selected at random from the parental line and 40 plants from F_4 progenies in each replication. The plants were harvested by uprooting and then they were tagged properly. Data were recorded on different parameters from these plants.

3.4.6 Data collection

For studying different genetic parameters and inter-relationships ten characters were taken into consideration. The data were recorded on fourty selected plants for each cross and ten selected plants for each parent on the following traits-

I. **Days to 50% flowering:** Days to 50% flowering were recorded from sowing date to the date of 50% flowering of every entry.

II. **Days to 50% maturity:** The data were recorded from the date of sowing to siliquae maturity of 50% plants of each entry.

Plate:2:Field view at maturity stage

III. **Plant height (cm):** It was measured in centimeter (cm) from the base of the plant to the tip of the longest inflorescence. Data were taken after harvesting.

IV. **Number of primary branches/plant:** The total number of branches arisen from the main stem of a plant was counted as the number of primary branches per plant.

V. **Number of secondary branches/plant:** The total number of branches arisen from the primary branch of a plant was counted as the number of secondary branches per plant.

VI. **Number of siliquae/plant:** Total number of siliquae of each plant was counted and considered as the number of siliquae/plant.

VII. **Siliqua length (cm):** This measurement was taken in centimeter (cm) from the base to the tip of a siliqua without beak of the ten representative siliquae.

VIII. **Number of seeds/siliqua:** Well filled seeds were counted from ten representative siliquae, which was considered as the number of seeds/siliqua.

IX. **1000 seed weight (g):** Weight in grams of randomly counted thousand seeds of each entry was recorded.

X. **Seed yield/plant (g):** All the seeds produced by a representative plant was weighed in g and considered as the seed yield/plant.

3.4.7 Statistical analysis

The data were analyzed for different components. Phenotypic and genotypic variance was estimated by the formula used by Johnson *et al.* (1955). Heritability and genetic advance were measured using the formula given by Singh and Chaudhary (1985) and Allard (1960). Genotypic and phenotypic co-efficient of variation were calculated by the formula of Burton (1952). Simple correlation coefficient was obtained using the formula suggested by Clarke (1973); Singh and Chaudhary (1985) and path co-efficient analysis was done following the method outlined by Dewey and Lu (1959).

i) Estimation of genotypic and phenotypic variances:

Genotypic and phenotypic variances were estimated according to the formula of Johnson *et al.* (1955).

a. Genotypic variance, $\delta^2 g = \frac{MSG-MSE}{r}$

Where, MSG = Mean sum of square for genotypes

MSE = Mean sum of square for error, and

r = Number of replication

b. Phenotypic variance, $\delta^2 p = \delta^2 g + \delta^2 e$

Where, $\delta^2 g$ = Genotypic variance,

$\delta^2 e$ = Environmental variance = Mean square of error

ii) Estimation of genotypic and phenotypic co-efficient of variation:

Genotypic and phenotypic co-efficient of variation were calculated by the following formula (Burton, 1952).

$$GCV = \frac{\delta_g \times 100}{\overline{x}}$$

$$PCV = \frac{\delta_p \times 100}{\overline{x}}$$

Where, GCV = Genotypic co-efficient of variation

PCV = Phenotypic co-efficient of variation

δ_g = Genotypic standard deviation

δ_p = Phenotypic standard deviation

$\overline{x}$ = Population mean

iii) Estimation of heritability:

Broad sense heritability was estimated by the formula suggested by Singh and Chaudhary (1985).

$$h^2_b (\%) = \frac{\delta^2_g}{\delta^2_p} \times 100$$

Where, h^2_b = Heritability in broad sense.

δ^2_g = Genotypic variance

δ^2_p = Phenotypic variance

iv Estimation of genetic advance: The following formula was used to estimate the expected genetic advance for different characters under selection as suggested by Allard (1960).

$$GA = \frac{\delta^2_g}{\delta^2_p} . K. \delta_p$$

Where, GA = Genetic advance

δ^2_g = Genotypic variance

δ^2_p = Phenotypic variance

δ_p = Phenotypic standard deviation

K = Selection differential which is equal to 2.06 at 5% selection intensity

v) Estimation of genetic advance in percentage of mean: Genetic advance in percentage of mean was calculated by the following formula given by Comstock and Robinson (1952).

$$\text{Genetic Advance in percentage of mean} = \frac{\text{Genetic advance}}{\bar{x}} \times 100$$

vi) Estimation of simple correlation co-efficient: Simple correlation co-efficients (r) was estimated with the following formula (Clarke, 1973; Singh and Chaudhary, 1985).

$$r = \frac{\sum xy - \frac{\sum x . \sum y}{N}}{[\{\sum x2 - \frac{(\sum x)2}{N}\}\{\sum y2 - \frac{(\sum y)2}{N}\}]}$$

Where, $\sum$ = Summation

x and y are the two variables correlated

N = Number of observations

vii) Path co-efficient analysis:

Path co-efficient analysis was done according to the procedure employed by Dewey and Lu (1959) also quoted in Singh and Chaudhary (1985) and Dabholkar (1992), using simple correlation values. In path analysis, correlation co-efficient is partitioned into direct and indirect independent variables on the dependent variable.

In order to estimate direct & indirect 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 below:

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

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

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

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 (Singh and Chaudhary, 1985):

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

Where, $P^2RY = (R^2)$; and hence residual effect, $R = (P^2_{RY})$ ½

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

riy = Correlation of the character with yield.

Chapter IV

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

Results on variability and character association based on ten different characters in twenty six F_3 segregating population of *Brassica napus* obtained from intergenotypic crosses presented and discussed under the following heads.

4.1 Variability study in *Brassica napus* of F_3

The analysis of variance indicated the existence of highly significant variability arrange the population for all the characters studied (table 2). The mean values over three replications for the characters of all genotypes are presented in table 3. The maximum, minimum mean values over ten characters of all genotypes are presented in Apendix II. The mean sum of square, mean, range, variance components, coefficients of genotypic and phenotypic variations, heritability estimates, genetic advance and genetic advance in percent of mean (GAPM) are presented in (Table 4). The results are discussed character wise as follows:

Table 2. Analysis of variance of the data of 10 important characters of 26 *Brassica napus* genotypes

		Mean Sum of squares of characters									
Sources of Variation	**D.F**	**Days to 50% flowering**	**Days to 50% Maturity**	**Plant Height (cm)**	**No. of Primary Branches /Plant**	**No. of Secondary Branch/ Plant**	**No. of Siliqua/ Plant**	**Siliqua length (cm)**	**No. of Seed per Siliqua**	**1000 seed weight**	**Seed yield per plant (g)**
Replication	2	1.321	4.654	65.628	3.628	2.936	5461.167	0.247	26.115	704.556	79843.26
Genotype	25	2.189*	7.007*	64.495*	0.729*	1.399*	949.434*	1.016*	8.442*	275.028*	8546.191*
Error	50	0.987	2.027	34.535	0.375	1.163	804.62	0.288	5.675	199.351	6717.028

* Significant at 5% level of probability

4.1.1 Days to 50% flowering

Mean sum of square for days to 50% flowering showed highly significant difference among the genotypes (Table 2) indicating existence of considerable difference for this trait. The maximum days to 50% flowering (38.67) was found in G_9 and the minium days to % flowering (35.33) was recorded from G_6(table 3).

The genotypic variance (0.40), phenotypic variance (1.39), genotypic co-efficient of variation (1.72) and phenotypic co-efficient of variation (3.19) were close to each other indicating less environmental influence in case of days to first flowering (Table 4). Heritability estimates for this trait was (28.87) but genetic advance (0.70) and genetic advance in percent of mean (1.90) was found low, indicated that selection for this character would be less effective. Lekh *et al.* (1998) recorded highest GCV and PCV for days to 50% flowering.

Plate:3:50%flowering stage of research field

4.1.2 Days to 50% Maturity

Mean sum of square for days to 50% maturity was highly significant (Table 2) indicating existence of considerable difference for this trait. The maximum days to 50% maturity (90.33) was found in G_9 and the minimum days to 50% maturity (85.33) was recorded from G_{16} and G_{24} (table 3).

The genotypic variance (1.66), phenotypic variance (3.69), genotypic co-efficient of variation (1.48) and phenotypic co-efficient of variation (2.20) were close to each other indicating less environmental influence in case of days to 50% maturity (Table 3). Heritability estimates for this trait was high (45.02) but genetic advance (1.78) and genetic advance in percent of mean (2.04) was found low, indicated that selection for this character would be less effective. Higher genotypic variances indicate the better transmissibility of a character from parent to the offspring (Ushakumari *et al.* 1991). Working with 46 genotypes of *Brassica juncea* Sharma (1984) found low GCV% and PCV% values. Tak and Patnik (1977) found this value as GCV% (1.8%) and PCV% (4.5%) respectively.

Table 3. Mean performance of ten different characters of 26 *Brassica napus* genotypes

Genotypes	Days to 50% flowering	Days to 50% Maturity	Plant Height 9(cm)	No. of Primary Branches/ Plant	No. of Secondary Branches/ Plant	No. of Siliqua per plant	Siliqua length (cm)	No. of Seed per Siliqua	1000 seed weight (g)	Seed yield per plant (g)
G_1	38.00 ab	88.00 a-f	112.00 a-d	3.33 bc	3.00 ab	138.30 abc	9.67 a	26.33 a-d	73.67 abc	271.10 a-d
G_2	36.33 b-e	88.67 a-d	104.70 b-e	3.33 bc	2.67 ab	138.30 abc	8.70 bc	26.33 a-d	67.33 abc	219.10 a-d
G_3	36.67 b-e	85.67 ef	106.00 b-e	4.33 ab	3.67 ab	135.30 abc	7.70 c-f	25.33 a-d	77.67 abc	267.20 a-d
G_4	35.67 de	86.00 def	106.00 b-e	3.67 abc	4.00 ab	153.30 abc	7.13 f	24.00 d	71.00 abc	254.80 a-d
G_5	38.00 ab	86.33 c-f	114.00 ab	4.00 abc	3.00 ab	147.70 abc	7.87 c-f	25.00 bcd	84.67 ab	302.00 a-d
G_6	35.33 e	89.00 abc	100.30 de	3.00 C	2.33 ab	113.30 c	8.03 c-f	25.00 bcd	57.67 bc	146.50 D
G_7	37.67 abc	86.00 def	104.30 b-e	3.33 bc	2.33 ab	150.70 abc	8.10 c-f	26.00 a-d	76.00 abc	295.80 a-d
G_8	36.67 b-e	88.67 a-d	107.30 b-e	3.00 C	3.67 ab	179.70 a	7.97 c-f	24.33 d	89.67 a	382.30 A
G_9	38.67 a	90.33 a	102.00 cde	3.00 C	2.00 b	129.00 abc	8.33 cde	24.33 d	54.33 c	171.40 Cd
G_{10}	35.67 de	86.00 def	99.00 e	3.67 abc	2.67 ab	128.70 abc	8.70 abc	27.67 a-d	61.00 bc	222.60 a-d
G_{11}	37.67 abc	87.33 b-f	105.00 b-e	3.00 C	2.00 b	134.70 abc	8.10 c-f	26.00 a-d	66.33 abc	235.50 a-d
G_{12}	36.00 cde	85.67 ef	109.00 a-e	4.67 A	3.33 ab	178.30 ab	8.60 bc	24.33 d	77.33 abc	337.50 Ab
G_{13}	36.67 b-e	89.67 ab	107.00 b-e	3.67 abc	3.00 ab	141.00 abc	7.37 ef	30.00 a	72.67 abc	310.50 a-d
G_{14}	38.00 ab	89.00 abc	100.70 de	3.67 abc	2.67 ab	130.00 abc	8.37 cde	27.67 a-d	66.00 abc	239.30 a-d
G_{15}	37.00 a-e	87.00 b-f	107.00 b-e	4.33 ab	3.33 ab	125.00 abc	8.47 bcd	26.33 a-d	71.47 abc	256.10 a-d

Table 3. Contiued

G_{16}	37.00 a-e	85.33 f	105.30 b-e	4.00 abc	2.00 b	165.00 abc	9.40 ab	24.67 cd	86.00 ab	336.10 Abc
G_{17}	37.33 a-d	86.00 def	107.70 b-e	4.00 abc	2.33 ab	125.30 abc	7.87 c-f	26.00 a-d	63.00 abc	213.40 Bcd
G_{18}	37.00 a-e	87.33 b-f	102.70 b-e	3.00 C	4.00 ab	124.00 abc	8.17 c-f	27.33 a-d	75.33 abc	270.70 a-d
G_{19}	36.33 b-e	87.67 a-f	119.30 a	3.67 abc	3.00 ab	132.30 abc	8.57 bc	26.00 a-d	83.00 ab	290.40 a-d
G_{20}	36.67 b-e	85.67 ef	106.70 b-e	4.00 abc	2.67 ab	154.00 abc	7.97 c-f	26.00 a-d	85.67 ab	329.00 Abc
G_{21}	36.00 cde	85.67 ef	112.70 abc	3.67 abc	3.67 ab	128.00 abc	7.47 def	27.67 a-d	67.33 abc	254.80 a-d
G_{22}	37.00 a-e	86.00 def	110.30 a-e	4.00 abc	3.33 ab	110.30 c	8.23 cde	28.00 a-d	60.33 bc	221.00 a-d
G_{23}	36.67 b-e	89.33 ab	112.70 abc	4.33 ab	4.33 a	132.30 abc	7.93 c-f	26.67 a-d	72.00 abc	267.30 a-d
G_{24}	36.00 cde	85.33 f	109.00 a-e	4.00 abc	2.00 b	128.30 abc	7.47 def	27.33 a-d	73.67 abc	260.50 a-d
G_{25}	38.00 ab	88.33 a-e	103.70 b-e	3.33 bc	3.00 ab	158.00 abc	8.47 bcd	29.33 abc	64.33 abc	307.40 a-d
G_{26}	36.67 b-e	88.00 a-f	105.30 b-e	4.33 ab	3.67 ab	121.70 bc	8.73 bc	29.67 ab	57.67 bc	210.20 Bcd
LSD $_{(0.05)}$	1.63	2.34	9.64	1.00	1.77	46.52	0.88	3.91	23.16	134.40
CV (%)	2.69	1.63	5.5	16.52	6.10	10.47	6.54	9.02	9.79	11.01

Means separated by uncommon letters in order of alphabetic preferences are significantly different from each other at p=0.05

Table 4. Genetic parameters of 10 vegetative and yield contributing characters of twenty six *Brassica napus* genotypes

Parameters	Gen. var.	Env. var	Phn. var.	herit.	G.Ad (5%)	G.Ad (5%) in %mean	GCV	PCV	ECV
50% flowering	0.40	0.99	1.39	28.87	0.70	1.90	1.72	3.19	2.69
50% maturity	1.66	2.03	3.69	45.02	1.78	2.04	1.48	2.20	1.63
Plant height	9.99	34.54	44.52	22.43	3.08	2.88	2.96	6.24	5.50
Primary branches/ plant	0.12	0.38	0.49	23.94	0.35	9.34	9.27	18.95	16.53
Secondary branches/ plant	0.36	0.32	0.68	53.02	0.90	30.13	20.09	27.59	18.91
Siliqua pe plant	169.97	439.51	609.49	27.89	14.18	10.24	9.41	17.82	15.13
Siliqua length	0.24	0.29	0.53	45.73	0.69	8.36	6.00	8.88	6.54
Seed per siliqua	0.32	13.43	13.75	2.30	0.18	0.67	2.16	14.22	14.05
1000 seed weight	91.41	25.65	117.05	78.09	17.40	24.30	13.35	15.11	7.07
Seed yield per plant	2175.97	2018.29	4194.26	51.88	69.21	26.18	17.65	24.50	17.00

Gen. var = Genetic Vairance , Env. var = Environmental Vairance, Phn var= Phenotypic Variance herit= Heritability, G.Ad =Genetic Advance, PCV= Phenotypic co efficient of variance , GCV= Genetic co efficient of variance ECV= Environmental co efficient of variance

4.1.3 Plant height (cm)

Mean sum of square for plant height was highly significant (Table 2) indicating existence of considerable difference for this trait. The maximum plant height (119.30 cm) was found in G_{19} and the minimum plant height (99.00 cm) was recorded from G_{10} (Table 3).

The genotypic variance (9.99), phenotypic variance (44.52), genotypic co-efficient of variation (2.96) and phenotypic co-efficient of variation (6.24) were close to each other indicating less environmental influence in case of plant height. Heritability (22.43) estimates for this trait were moderate together with considerable moderately high genetic advance in percent of mean (2.88) indicated that selection for this character would be more effective (Table 4). Tyagi *et al.* (2001) observed highest variation in plant height among parents and their hybrid.

4.1.4 Number of primary branches per plant

Mean sum of square for number of primary branches per plant was highly significant (Table 2) indicating existence of considerable variability for this trait. The maximum number of primary branches per plant (4.67) was found in G_{12} and the minimum number of primary branches per plant (3.00) was recorded from G_6, G_8, G_9 and G_{11} (Table 3).

The genotypic variance (0.12), phenotypic variance (0.49), genotypic co-efficient of variation (9.27) and phenotypic co-efficient of variation (18.95) were close to each other indicating less environmental influence in case of number of primary branches per plant. Heritability (23.94) estimates for this trait was genetic advance in percent mean (9.34) were also found high, indicated that selection for this character would be more effective (Table 4). Chowdhary *et al.* (1987) found significant differences for number of primary branches per plant.

4.1.5 Number of secondary branches per plant

Mean sum of square for number of secondary branches per plant was highly significant (Table 2) indicating existence of considerable variability for this trait. The maximum number of secondary branches per plant (4.33) was found in G_{23} genotype and the minimum number of secondary branches per plant (2.00) was recorded from G_9, G_{11} and G_{16} (Table 3).

The genotypic variance (0.36), phenotypic variance (0.68), genotypic co-efficient of variation (20.09) and phenotypic co-efficient of variation (27.59) were close to each other indicating less environmental influence in case of number of secondary branches per plant. Heritability (53.02) estimates for this trait was very high genetic advance in percent mean (30.13) were also found high, indicated that selection for this character would be more effective (table 4). Lekh *et al.* (1998) reported similar results in their study.

4.1.6 Number of siliqua per plant

Mean sum of square for number of siliqua per plant was highly significant in *Brassica napus* (Table 2) indicating existence of considerable variability for this trait. The maximum number of siliqua per plant (179.70) was found in G_8 and the minimum number of siliqua per plant (110.3) was recorded from G_{22}, which was statistically similar with G_6 genotype (Table 3).

The genotypic variance (169.97), phenotypic variance (609.49), genotypic co-efficient of variation (9.41) and phenotypic co-efficient of variation (17.82) were close to each other indicating less environmental influence in case of no. of siliqua per plant. Heritability (27.89) estimates for this trait was found moderate and genetic advance in percent of mean (10.24) was found moderate, indicated that selection for this character would be effective (table 4). Higher genotypic variances indicate the better transmissibility of a character from parent to the offspring (Ushakumari *et al.* 1991).

Plate:4: Length of siliqua

Plate:5: The highest length of siliqua

4.1.7 Siliqua length (cm)

A significant variation was recorded among the genotypes in consideration of length of siliquae (table 2). The maximum siliqua length (9.67 cm) was found in G_1 genotype and the minimum siliqua length (7.13 cm) was recorded from G_4 genotype (Table 3).

The genotypic variance (0.24), phenotypic variance (0.53), genotypic co-efficient of variation (6.00) and phenotypic co-efficient of variation (8.88) were close to each other indicating less environmental influence in case of siliqua length. Heritability (45.73) estimates for this trait was genotypic advance in percent of mean (8.36), indicated that selection for this character would be effective (Table 4). Labowitz (1989) studied *Brassica campestris* population for pod length and observed high genetic variation on this trait. Olson (1990) found high genetic variability for this trait.Pictorial view of siliqua length of F_3 generation is presented Plate 3

4.1.8 Number of seed per siliqua (g)

Mean sum of square for number of seed per siliqua was significant in *Brassica napus* (Table 2) indicating existence of considerable difference for this trait. The maximum number of seed per siliqua (30.00) was found in G_{13} genotype and the minimum number of seed per siliqua (24.00) was recorded G_4 genotype (Table 3).

The genotypic variance (0.32), phenotypic variance (13.75), genotypic co-efficient of variation (2.16) and phenotypic co-efficient of variation (14.22) were close to each other indicating less environmental influence in case of number of seed per siliqua. Heritability (2.30) estimates for this trait was low together with considerable genetic advance in percent of mean (0.67) indicated that selection for this character would be effective (Table 4). Bhardwaj and Singh (1969) observed 35.85 % GCV% in *Brassica campestris.*

4.1.9 Thousand seed weight (g)

Mean sum of square for thousand seed weight was highly significant in *Brassica napus* (Table 2) indicating existence of considerable difference for this trait. The maximum thousand seed weight (89.67g) was found in G_8 genotype and the minimum thousand seed weight (54.33g) was recorded from G_9 genotype (Table 3).

The genotypic variance (91.41), phenotypic variance (117.05), genotypic co-efficient of variation (13.35) and phenotypic co-efficient of variation (15.11) were close to each other indicating less environmental influence in case of thousand seed weight. Heritability (78.09) estimates for this trait was high together with considerable genetic advance in percent of mean (24.30) indicated that selection for this character would be more effective. Bhardwaj and Singh (1969) reported values 11.8% and 18.9% of GCV% and PCV% for thousand seed weight in *Brassica campestris*. Similarly Tak and Patnaik (1977) reported values 13.1% and 16.5% of GCV% and PCV% for *Brassica campestris*.

4.1.10 Yield per plant (g)

Mean sum of square for yield per plant (g) was highly significant in *Brassica napus* (Table 2) indicating existence of considerable difference for this trait. The maximum yield per plant (382.3 g) was found in G_8 genotype and the minimum yield per plant (146.50 g) was recorded from G_6 genotype (Table 3). Katiyar *et al.* (2004) found significant variation among parents and crosses indicated the presence of adequate genetic variance which reflected in differential performance of intervarietal cross combinations of *Brassica campestris.*

The genotypic variance (2175.97), phenotypic variance (4194.26), genotypic co-efficient of variation (17.65) and phenotypic co-efficient of variation (24.50) were close to each other indicating less environmental influence in case of yield per plant. The heritability value (51.88) as well as genetic advance in percent of mean (26.18) was observed moderatley high (Table 4). The very high heritability with moderate genetic advance in percentage of mean was provided opportunity for selecting high valued genotypes for breeding programme. Bhardwaj and Singh (1969) reported values 11.8% and 18.9% of GCV% and PCV% for thousand seed weight in *Brassica campestris*. Similarly Tak and Patnaik (1977) reported values 13.1% and 16.5% of GCV% and PCV% for *Brassica campestris*.

4.2 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_3 materials of *Brassica. napus* are shown in Table 5.

4.2.1 Days to 50% flowering

Days to 50% flowering showed highly significant positive association with days to 50% maturity (G = 0.470), siliqua length (G = 0.337) and seed per siliqua (0.642) genotypic level (Table 5) and days to 50% flowering showed highly significant positive association with days to 80% maturity (P = 0.293), siliqua length (P = 0.241) and seed per siliqua (0.402) phenotypic level. The result revealed that if days to 50% flowering are increased, then days to 80% maturity, siliqua length and seed per siliqua also increased. Days to 50% flowering showed highly significant negative association with number of primary branches per plant (-0.498), number of secondary branches per plant (-0.520) at genotypic level. Rao et al. (2006), Yaqoob et al. (1997) reported that days to 50% flowering were positive and significantly associated with seed yield. Rahman (1982) obtained positive correlation of days to 50% flowering with days to maturity.

Plate:6: Field view at 90% maturity

4.2.2 Days to 50% maturity

Days to 50% maturity showed positive interaction only with number secondary branch es(G = 0.046, P = 0.035), number of siliqua per plant (G=0.021,P=0.055), siliqua length (G=0.102,P=0.046), on the other hand significant negative interaction were found in number of primary branch (G = -0.956, P = -0.414), thousand seed weight(G=-0.371, P=-0.304) and yield per plant (G = --0.206, P = -0.265). (Table 5).

4.2.3 Plant height (cm)

Plant height showed positive significant interaction with Number of primary branches (G = 0.347, P = 0.243), whereas negative interaction were found in Siliqua pe plant (G = -0.164, P = -0.042), Seed per Siliqua (G = -0.090, P = -0.053) and Siliqua length (G = -0.042, P = -0.137) (Table 5). These findings are close resemblance to the reports of Chowdhury *et al.* (1987) and Yadava *et al.* (1978).

4.2.4. Number of primary branches per plant

Number of primary branches per plant showed positive significant interaction with number of secondary branch (G = 0.686, P = 0.269) and yield per plant (G = 0.430, P = 0.247). Whereas the negative significant interaction was found in number of seeds per Siliqua (G = -0.325, P = -0.241). Similar results were obtained by Afroz *et al.* (2004), Rashid (2007), Siddikee (2006), Kumar et al. (1996), and Shabana et al. (1990). Negative associations were found by Vershney *et al.* (1986).

4.2.5 Number of secondary branches per plant

Number of secondary branches perplant showed positive significant interaction with found number of seed per siliqua (G = 0.687, P= 0.410), whereas negative no significant interaction were found siliqua lenght (G =--0.034, P =-0.072) (Table 5). These findings are closing similar to the reports of Chowdhary *et al.* (1987) and Mahmud (2008).

Table : 5 Genotypic and phenotypic Correlations co-efficient among different characters of 26 F_3 of *Brassica napus*:

		D50M	PH	PB	SB	SP	SL	SS	SW	SY
D50f	r_g	0.470**	0.012	-0.498**	-0.520**	-0.123	0.337**	0.642**	-0.015	0.035
	r_p	0.293*	0.017	-0.252*	-0.276*	0.024	0.241*	0.402**	-0.028	0.052
D50M	r_g		-0.129	-0.956**	0.046	0.021	0.102	-0.043	-0.371**	-0.206*
	r_p		-0.034	-0.414**	0.035	0.055	0.046	-0.074	-0.304**	-0.265**
PH	r_g			0.347**	0.163	-0.164	-0.042	-0.090	0.165	0.171
	r_p			0.243*	0.152	-0.012	-0.137	-0.053	0.208*	0.03
PB	r_g				0.686**	0.156	0.165	-0.325**	0.255*	0.430**
	r_p				0.269*	0.083	0.09	-0.241*	0.176	0.247*
SB	r_g					0.138	-0.034	0.687**	0.144	0.195
	r_p					0.107	-0.072	0.410**	0.130	0.208*
SP	r_g						0.392**	0.188	0.430**	0.907**
	r_p						0.268*	0.264*	0.338**	0.440**
SL	r_g							-0.382**	0.374**	0.455**
	r_p							-0.247*	0.271*	0.362**
SS	r_g								-0.144	0.442**
	r_p								-0.03	0.272*
SW	r_g									0.863**
	r_p									0.671**

D50F=50% flowering, D50M=50% Maturity, PH=Plant Height, PB=Primary Branch, SB=Secondary Branch, SP=Siliqua pe plant, SL=Siliqua length, SS=Seed per Siliqua, SW=1000 seed weight, SY=Seed yield per plant

** Significant at the 1% level of probability

* Significant at the 5% level of probability

4.2.6 Number of siliqua per plant

Siliqua per plant showed positive significant interaction with siliqua length (G = 0.392, P = .268), thousand seed weight (G=0.430,P=0.338)and yield per plant(G = 0.907, P = 0.440) (Table 5). Dileep et al. (1997) reported that number of siliquae per plant, were positively correlated with seed yield. Tyagi *et al.* (1996) reported that no. of seeds per siliqua had positive and significant effects on seed yield per plant.

4.2.7 Length of siliqua (cm)

Length of Siliqua showed positive significant interaction with thousand seed weight (G = 0.374, P = 0.271), yield per plant (G=0.455, P=0.362) and showed negative interaction with Seed per Siliqua (G -0.382, P -0.247) (Table 5). Das et al. (1998) reported that seed yield per plant positively correlated with length of siliqua and seeds per siliqua.

4.2.8 Seeds per siliqua

Seeds per Siliqua showed positive interaction with yield per plant (G=0.442, P=0.272) and negative no significant interaction with number of thousand seed weight (G = -0.144, P =-0.03) (Table 5). Dileep et al. (1997) reported that number of siliquae per plant, thousand seed weight were positively correlated with seed yield. Tyagi *et al.* (1996) reported that no. of seeds per siliqua had positive and significant effects on seed yield per plant.

4.2.9 Thousand seed weight

Thousand seed weight showed significant positive interaction with yield per plant (G = 0.863, P =0.671) (Table 5). Saini and Sharma (1995), Kakroo and Kumar (1991) and Olsson (1990) found positive association which support the results.

4.3 Path co-efficient analysis of F_3

Path coefficient analysis was done with, days to 50% flowering, days to 50% maturity, plant height (cm), no. of primary branches per plant, no. of secondary branches per plant, Siliqua per plant, Siliqua length (cm), number of Seed per Siliqua, number of seeds per plant, 1000 seed weight (g) and yield per plant (g). The direct and indirect effects of different characters on yield are present in table 6 and fig. 1. Path co-efficient analysis revealed that, Siliqua per plant had the highest direct positive effect (0.735) on seed yield per plant followed by housand seed weight (0.353), plant height (0.298), Siliqua length (0.211) and Seed per Siliqua (0.187) which indicating true relationship between them and direct selection for this trait will be rewarding for yield improvement.

4. 3.1 Days to 50% flowering

Days to 50% flowering had positive direct effect (0.047) on yield per plant. Days to 50% flowering had positive indirect effect on plant height (0.004), no. of primary branches per plant (0.177), siliqua length (0.071) and Seed per siliqua (0.120). Negative indirect effect were found via number of secondary branch (-0.084), siliqua per plant (-0.090) and thousand seed weight (-0.005) (Table 6). By path analysis, Zahan (2006) reported that, days to 50% flowering had negative direct effect on yield/plant.

4. 3.2 Days to 50% maturity

Path co-efficient analysis revealed that days to 50% maturity had negetive direct effect (-0.434) on yield per plant and negative indirect effect through plant height (-0.038), Seed per siliqua (-0.008) and thousand seed weight (-0.131). On the other hand days to maturity had positive indirect effect via days to 50% flowering (0.022), no. of primary branches per plant (0.339), number of secondary branch (0.007), Siliqua per plant (0.015), siliqua length (0.022) (Table 6). Yadava (1982) revealed that days to maturity had positive direct effect on yield.

4. 3.3 Plant height

Path analysis revealed that plant height had positive direct effect (-0.298) on yield per plant and positive indirect effect through days to 50% flowering (0.001), days to 50% maturity (0.056), number of secondary branches per plant (0.026), thousand seed weight (0.058) (Table 6). On the other hand, plant height showed negative indirect effect on yield per plant via number of primary branches per plant (-0.123), Siliqua per plant (-0.120), Siliqua length (-0.009) and Seed per Siliqua (-0.017). Maximum direct effect on seed yield was observed in plant height reported by Makeen *et al.* (2007), Sirohi *et al.* (2006), Sharma *et al.* (1999). Rao *et al.* (2006), Yaqoob *et al.* (1997) found plant height showed negative direct effect on seed yield.

4.3.4 Number of primary branches per plant

Number of primary branches per plant had the negetive direct effect on yield per plant (-0.355). This trait had positive indirect effect on days to 50% maturity (0.415), plant height (0.103), and number of secondary branch (0.111), number of siliqua per plant (0.114), siliqua length (0.035) and thousand seed weight (0.090). On the other hand negative indirect effect was found on days to 50% flowering (-0.024) and number of seed per siliqua (-0.061) (Table 6). Gupta *et al.* (1987) observed that primary branching and thousand seed weight had the direct effect on seed yeild.

4.3.2.5 Number of secondary branch per plant

Path co-efficient analysis revealed that number of secondary branch has positive direct effect (1.699) on yeild per hector. Positive indirect effect through 50% maturity (0.537), number of primary branch (0.006) and yeild per plant (0.585). On the other hand negative indirect effect via plant height(-0.135),number of siliqua per plant(-1.637),number of seed per siliqua(-1.071), and siliqua length(-.712),thousand seed weight(-0.206) (table 6). Yadava *et al.* (1996) found the number of secondary branch had the highest positive direct effect on seed yield.

4. 3.5 Siliqua pe plant

Siliqua per plant showed positive direct 0.735) effect on yield per plant and positive indirect effects through number of secondary branch (0.022), siliqua length (0.083), seed per Siliqua (0.035) and thousand seed weight (0.152). Siliqua per plant had negative indirect effect on all other parameter. (Table 6). Makeen *et al.* (2007), Rao *et al.* (2006), Rajan *et al.* (2000), Sharma *et al.* (1999) found maximum positive direct effect on seed yield was observed in Siliquas per plant. Yadava *et al.* (1996) found the number of siliquae per plant had the highest negative direct effect on seed yield.

4. 3.6Siliqua length

Path analysis revealed that Siliqua length had direct positive effect (0.211) on yield per plant. This trait had also indirect positive effect on Siliqua per plant (0.288) and thousand seed weight (0.132). Siliqua length had negative indirect effect on all other parameter (Table 6). Chaudhury *et al.* (1978) reported that siliqua length had highest positive direct effect on seed yield.

4. 3.7 Number of seed per Siliqua

Seeds per siliqua had positive direct effect (0.187) on yield per plant and positive indirect effect on days to 50% flowering (0.030), days to 50% maturity (0.019), number of primary branch (0.115),), number of primary branch (0.111), siliqua per plant (0.138). On the other hand this trait showed negative indirect effect on all other parameters (Table 6). Uddin *et al.* (1995) reported that seeds per siliqua and thousand seed weight had high positive direct effect on seed yield per plant.

Table 6. Direct (Diagonal) and indirect effect of some yield contributing characters on *Brassica napus*

	D50F	D50M	PH	PB	SB	SP	SL	SS	SW	Yield (g/pl)
D50f	0.047	-0.204	0.004	0.177	-0.084	-0.090	0.071	0.120	-0.005	0.035
D50M	0.022	-0.434	-0.038	0.339	0.007	0.015	0.022	-0.008	-0.131	-0.206*
PH	0.001	0.056	0.298	-0.123	0.026	-0.120	-0.009	-0.017	0.058	0.171
PB	-0.024	0.415	0.103	-0.355	0.111	0.114	0.035	-0.061	0.090	0.430**
SB	-0.025	-0.020	0.049	-0.243	0.162	0.101	-0.007	0.128	0.051	0.195
SP	-0.006	-0.009	-0.049	-0.055	0.022	0.735	0.083	0.035	0.152	0.907**
SL	0.016	-0.044	-0.012	-0.058	-0.005	0.288	0.211	-0.071	0.132	0.455**
SS	0.030	0.019	-0.027	0.115	0.111	0.138	-0.081	0.187	-0.051	0.442**
SW	-0.001	0.161	0.049	-0.090	0.023	0.316	0.079	-0.027	0.353	0.863**

D50F=50% flowering, D50M=50% Maturity, PH=Plant Height, PB=Primary Branch, SB=Secondary Branch, SP=Siliqua pe plant, SL=Siliqua length, SS=Seed per Siliqua, SW=1000 seed weight,

** indicate significant at P=0.01 level of significance

* indicate significant at P=0.05 level of significance

4. 3.8 Thousand seed weight

Thousand seed weight had high positive direct effect on yield per plant (0.353) and positive indirect effect on days to 50% maturity (0.161), plant height (0.049), number of secondary branch (0.023), Siliqua per plant (0.316) and siliqua length (0.316). Thousand seed weight had negative indirect effect on number of primary branches per plant (-0.090) and seed per siliqua (-0.027) (Table 6). Kudla (1993) reported that 1000 seed weight had positive direct effect on seed yield.

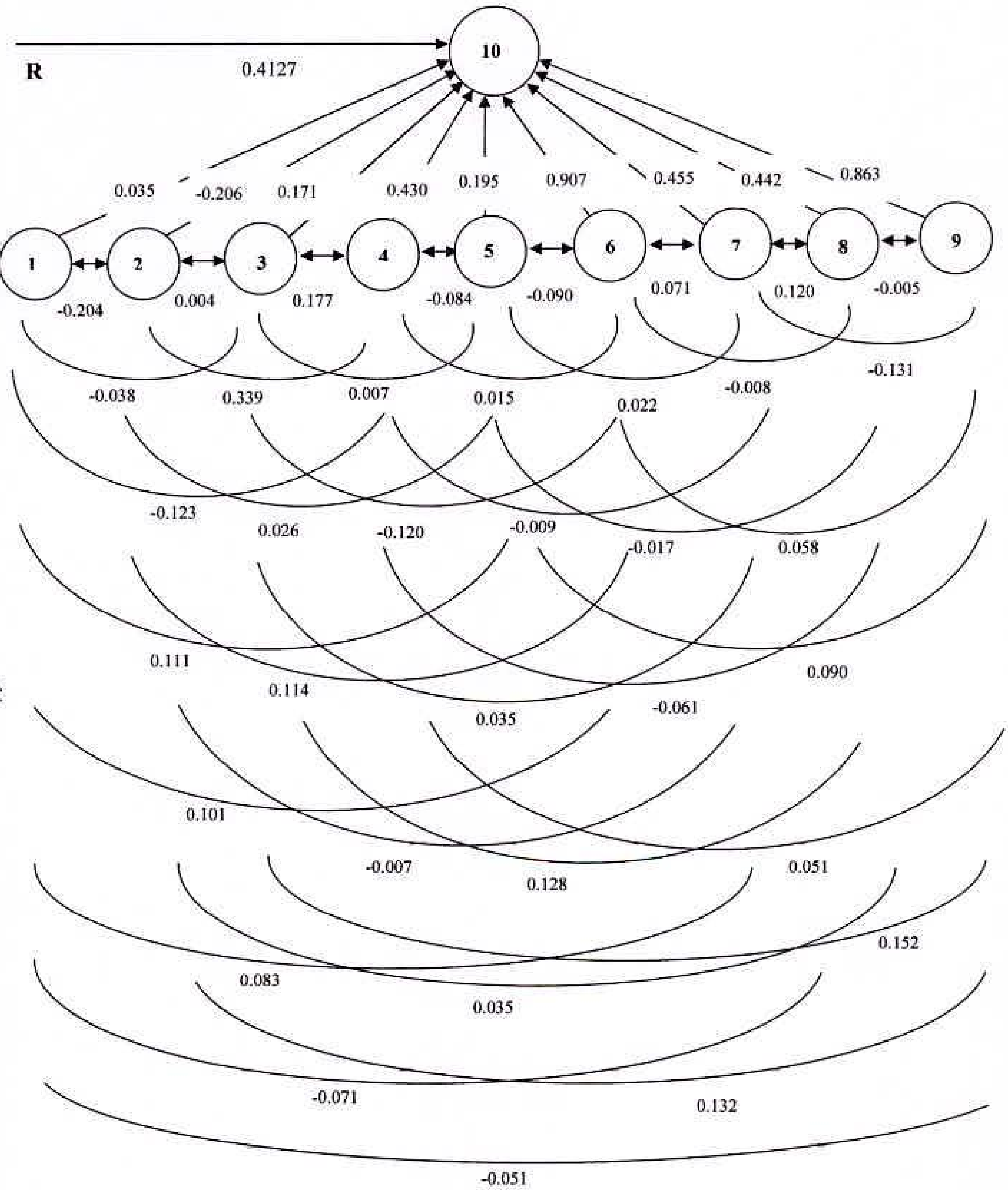

Fig. 7 Path diagram of yield contributing traits in F_3- *Brassica napus*----------
1=50% flowering, 2=50% Maturity, 3=Plant Height, 4=Primary Branch, 5=Secondary Branc, 7=Siliqua length, 8=Seed per Siliqua, 9=1000 seed weight, 10=Seed yield per planth, 6=Siliqua pe plant
R= Residual effect.

Chapter V

Summary and Conclusion

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SUMMARY AND CONCLUSION

An experiment was conducted during the period ofNovember, 2011 to March, 2012, at the experimental farm of the Department of Genetics and Plant Breeding, Sher-e-Bangla Agricultural University using twenty six F_3 progenies of *Brassica napus* .The experiment was carried out to study variability, correlation and path analysis in F_3 segregating population of *Brassica napus* obtained through intergenotypic cross. All twenty six F_3 progenies varied significantly with each other for all the characters studied. The results of the present study are summarized as follows:

From variability analysis of F_3 progenies, it was observed that significant variation exist among all the genotypes used for most of the characters studied. The maximum days to 50% flowering was found in G_9 and the lowest in G_6. The highest days to 50% maturity was observed in G_9 and lowest days were observed in G_{16}. Plant height exhibited highest in G_{19} and the lowest in G_{10}. The highest number of primary branches per plant was recorded in G_{12} and the lowest number was recorded in G_{11}.The highest number of secondary branches per plant was observed in G_{23} and the lowest number of secondary branch was observed in G_{16}.The number of siliqua per plant showed highest in G_8 and lowest in G_{22} .The lowest length of siliqua was recorded in G_4 and the highest length of pod was observed in G_1. The number of seeds per siliqua was found highest in G_{13} and the lowest in G_2. The thousand seed weight exhibited the highest in G_8 and the lowest in G_{26}. The seed yield per plant was highest in G_6 and lowest observed in G_8.

The phenotypic variance was higher than genotypic variance in all the characters studied. The phenotypic coefficients of variation were also higher than genotypic coefficients of variation in all the characters studied. Phenotypic coefficients of variation were also close to genotypic coefficients of variation for most of the characters except number of primary branches per plant, number of secondary branches per plant, siliqua per plant and seeds per siliqua. High heritability (>50%) was observed for the characters like number of secondary branches per plant, thousand seed weight and seed yield per plant. The high heritability coupled with high genetic advance in percent of mean observed in number of secondary branches per plant, thousand seed weight and seed yield per plant suggested that effective selection may be done for these characters. Low heritability coupled with low genetic advance in percent of mean was observed number of seeds per siliqua.

Number of primary branches per plant, siliqua per plant, siliqua length, seed per siliqua and thousand seed weight showed significant and positive correlation with seed yield per plant at both genotypic and phenotypic levels. Significant and positive genotypic and phenotypic correlation was observed between days to 50% flowering. Plant height was positively and significantly correlated with number primary branches per plant, at both levels. Significant and positive correlation was observed between primary and secondary branches per plant and Siliqua per plant and seeds per plant. Siliqua length was significantly and positively correlated with thousand seed weight. Seed per siliqua was positively and significantly correlated with seeds yield per plant.

Siliqua per plant showed the highest positive direct effect (0.735) with seed yield per plant. On the other hand negative direct effect on seed yield per plant showed by days 50% maturity, number of primary branches per plant, maturity. Plant height, secondary brances per plant, siliqua length, seed per siliqua, 1000 seed weight also showed positive direct effect on seed yield. The highest indirect effect of siliqua per plant observed with thousand seed weight. Siliqua per plant showed high direct effect on seed yield indicated that direct selection for this trait might be effective and there is a possibility of improving seed yield per plant through selection based on those characters.

As the traits like, number of secondary branches per plant, plant height, seeds per pod and days to flowering showed high heritability coupled with high genetic advance in percent of mean and selection would be effective for those traits.

The selected lines can be further used for advance research or varietal improvement program. High yielding variety can be found from the selected line.

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Appendices

APPENDICES

Appendix I: Experimental site at Sher-e-Bangla Agricultural University, Dhaka-1207

Figure: The map of Bangladesh showing experimental site

APPENDICES

Appendix II. Physical characteristics and chemical composition of soil of the experimental plot

Soil characteristics	Analytical results
Agrological Zone	Madhupur Tract
P^H	6.00 – 6.63
Organic matter	0.84
Total N (%)	0.46
Available phosphorous	21 ppm
Exchangeable K	0.41 meq / 100 g soil

Source: Soil Resource and Development Institute (SRDI), Dhaka

Appendix III: Mean performance of different parameters of twenty six *Brassica napus* genotypes

Parameters	Minimum	Maximum	Mean
50% flowering	35.33	38.67	36.87
50% fMaturity	85.33	90.33	87.23
Plant Height	99.0	119.3	106.9
Primary Branch	3.000	4.670	3.705
Secondary Branch	2.000	4.330	2.99
Siliqua pe plant	110.3	179.7	138.6
Siliqua length	7.130	9.670	8.207
Seed per Siliqua	24.00	30.00	26.42
1000 seed weight	54.33	89.67	71.61
Seed yield per plant	146.5	382.3	264.3