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Correlation and path analysis of *Brassica napus genotypes* for yield related traits

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Abstract: The present study was conducted in the research area of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad. Fifteen accessions of *Brassica napus* DGL, Cyclone, Punjab Sarsoon, Zn-R-1, Shiralee, Zn-M-5, Zn-M-6, Zn-M-9, Chakwal Sarsoon, Napus-2, Zn-21, AH-Rooh, Zn-R-8, Dunkled and Rainbow were collected from the Oilseed Research Programmed of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad. The experiment was laid out in a randomized complete block design with three replications. The seeds of the germplasm were sown in field by maintaining row to row and plant to plant distance 75 and 25 cm, respectively. Data of randomly selected 10 plants of each replication was recorded. The analysis of variance was performed that showed that all accessions were significantly differ from each other for all the yield parameters (both quantitative and qualitative parameters). The traits included plant height, primary branches, secondary branches, number of seeds in a silique, seed yield of a plant, 1000 seed weight, oil contents, protein contents, oleic acid contents, linolenic acid and erucic acid contents. Correlation and Path analysis were performed. Some characters showed positive correlation and some characters showed negative correlation. The results reflected that correlation coefficient yield was positively and significantly correlated with seeds in a silique and protein contents. Whereas yield was negatively correlated with weight of 1000 seeds, oleic acid contents, linolenic acid and erucic acid contents. On the other hand, path analysis revealed the direct and indirect effects between yield and yield parameters. Plant height, primary and secondary branches, silique of a plant, seeds of a silique, oil contents and protein contents had direct and positive effects on yield while weight of 1000 seeds, oleic acid, linolenic acid and erucic acid proportion exhibited direct and negative effects on yield of seeds.
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1. Introduction

Edible oil is essential need and important source of energy for our body. Because it has an important role for the growth and development of our body. Oilseed crops contributes major part for supplying edible oil. The following crops have main contribution in Pakistan, such as cotton, sunflower, canola, and rapeseed/mustard. In 2015-2016, edible oil was available about 3.726 million tons and only 0.462 million tons was local oil production. Edible oil import was spent Rs.284.546 billion. So, the requirement of edible oil in the country was fulfilled by the import of about 3.264 million tons. In 2016-17, the import was reduced by 4 percent (1.98 million tons) by spending Rs.152.514 billion. It was provisionally estimated that edible oil was available about 2.426 million tons from all sources. (Anonymous, 2016-2017). Rapeseed (Brassica napus L.), is cultivated for seeds. It has 35-45 % oil which is basically used for edible purpose. Its seeds are used for the extraction of oil by different methods. Plant oils attain the higher value in agricultural commodities. (Naheed *et al*., 2017). It is listed as second number in oil extraction after cotton in Pakistan. The production of 0.466 million tons of oil was taken by growing rapeseed on an area of 0.193 million acres. (Anonymous, 2016-2017). While the requirement of oil is not compensated by the production. There are multiple causes of lower edible oil production i.e. cultivation on marginal lands, deficiency of agricultural inputs and their improper utilization, reduction of short duration varieties and major crops competition. The main reason for less production is that the scientist is paying less attention toward the improvement of genetics of oilseed crops. The enhancing growth of papulation and per capita consumption are related with increasing demand of edible oil. It is creating worse situation by establishing more difference between production and utilization. Therefore, it compels to make the oil production more in magnitude by different measurements (Shah *et al*., 2007). Lower availability of high oil yielding varieties is a cause of low production of edible oil. So, it has become important to increase the local production of edible oil by developing diverse varieties of oilseed crops. (Aftab *et al.*, 2020). Rapeseed has tendency to give high production of oil. At the same time, it has better quality characters such as shattering resistance and low erucic acid as compared to its other species. The production gap can be potentially fulfilled by rapeseed. So, 1% of oil content can be enhanced by rising up the 2.3-2.5% of seed yield (Ali *et al*., 2014). Rapeseed oil consists of 61% of oleic acid and 8.8% of linoleic acid. So, its quality is better than other oilseed crops. (Afridi et al., 2002). By considering the above facts, government of Pakistan shall try to decrease the imports and make more efforts to enlarge the area and production of *Brassica napus*. It is also important to increase the yield potential and oil content of rapeseed by adopting multiple breeding strategies. Effective breeding programs lead to the genetic variability. There is different analysis used to evaluate the genetic diversity among various genotypes by observing the association between yield and yield parameters. Different types of analysis include correlation analysis and path analysis. Many researchers use genotypic and phenotypic correlation to obtain information of yield related characteristics that can be used for improving crop yield. Path analysis is more reliable in comparison to correlation analysis. Therefore, the results reported by the path analysis, are more effective in determining the direct and indirect effects among yield and yield parameters. So, path analysis provides detailed information of yield traits (Singh & Narayanam, 2007). The analysis of correlation analysis proves efficient in determining the interrelationship between yield and the parameters of yield. (Aftab *et al.*, 2020). The yield components of oilseed crops that contribute in increasing yield must be analyzed i.e. Height of plant, primary and secondary branches, siliques in a plant, seeds in a silique, seeds in a plant,1000 seed weight, protein and oil percentage. Understanding the association among yield and its components helps to provide better criteria for selection of superior genotypes. Breeding was proved successful in developing improved varieties by determining the exact proportion of yield components of *Brassica napus* (Sadat *et al*., 2010). In the perspective of previously explained situation, the first and foremost objective of all this study was to indicate the impacts of quantitative and qualitative characters on the yield. The analysis of correlation and path was mainly done for evaluating the quantitative and qualitative parameters of yield. In this way the different genotypes of *Brassica napus* was evaluated that enormously contributed in improving growth and development of rapeseed.

2. Materials and methods

Present research was conducted at experimental area of Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad. Plant material was collected from Oilseed Research program section, Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad. Fifteen accessions of *Brassica napus* namely (DGL, Cyclone, Punjab Sarsoon, Zn-R-1, Shiralee, Zn-M-5, Zn-M-6, Zn-M-9, Chakwal Sarsoon, Napus-2, Zm-21, Ah-Rooh, Zn-R-8, Dunkled and Rainbow) were planted and evaluated on morphological basis under field conditions. Randomized complete block design along with three replications was used for uniform placement of experimental units under field conditions. Seeds of *Brassica napus* were sown in field after maintaining 75 cm and 25 cm row to row and plant to plant distance respectively. All the agronomic properties were followed for the trial. Data was recorded of the planted material against following parameters, plant height (cm), primary branches, secondary branches, silique per plant, seed per silique, seed yield (g), 1000 seed weight, oil proportion (%), protein proportion (%), fatty acid content (%)

Statistical Analysis:

The recorded data against various morphological and chemical characters was analyzed by using standard analysis of variance method given by Steel et al. (1997). Correlation coefficient were determined using the methodology described by Kwon and Torrie (1964) and Path analysis were analyzed using Dewey and Lu (1959) methodology.

Estimation of path coefficient:

Correlation coefficients were further partitioned into path coefficient analysis that revealed direct and in direct effects among various parameters, basically developed by Wright (1921 and 1923) and later described by Dewey and Lu (1956). Path coefficient was estimated for 11 characters related to yield.

3. Results and discussion

Genetic Variability Analysis

Plant height

Analysis of variance showed highly significant results for plant height among different genotypes. The range of plant height means lied between 240.67 cm and 77.23 cm. Plant height mean value of Napus-2 was maximum while Rainbow accession had minimum value of mean of plant height. There was significant relation of Napus-2 with all other accessions. The accession Chakwal Sarsoon and Punjab Sarsoon differed non-significantly from each other while both had significant relation with all others accessions. The means of accessions sharing common letters were non-significantly differed from each other. On the other hand, significant relation existed between the means of accessions sharing different letters. Iqbal *et al.,* (2014), Ali *et al*., (2003) and Ivanovska *et al*., (2007) elaborated the highest genotypic and phenotypic values of variances for plant height.

Primary branches

The significant results were found for different accessions. Means for primary branches of different accessions are arranged in descending sequence in this table. 6.6667 was the maximum value of mean of accession Shiralee while 4.000 was the minimum value of mean of Zn-M-9 accession. Shiralee and Zn-M-9 differed significantly from each other. While both had non-significant relation with all other accessions by sharing common letters. Similarly, the means of all other accessions were non-significantly different by sharing common letters. Khan *et al* (2000), and Basalma (2008) illustrated the significant variation between primary branches of a plant and seed yield in different genotypes in the analysis of variance.

Table 1. Mean comparison test of *Brassica napus* accessions for yield related traits

Genotype	PH	PB	SB	SP	SS	SY	1000 SW
DGL	177.33 c	4.33 ab	7.00 def	212.00 f	11.667 cdefg	11.61 fg	3.50 i
Cyclone	146.33 de	5.33 ab	3.00 g	274.67 e	10.00 defg	12.87 f	3.68 hi
Punjab Sarsoon	195.33 b	5.33 ab	12.33 b	286.67 de	13.00 bcdef	26.75 a	3.91 gh
Zn-R1	182.00 c	6.00 ab	3.33 fg	291.00 de	24.66 a	23.34 b	3.12 j
Shiralee	181.00 c	6.66 a	5.66 defg	357.00 a	11.667 cdefg	18.66 cd	4.30 ef
Zn-M-5	136.00 ef	5.00 ab	11.33 bc	207.00 f	10.66 defg	1.05 i	4.56 e
Zn-M-6	135.00 ef	4.33 ab	19.33 a	297.67 cd	8.66 efg	8.08 h	3.87 gh
Zn-M-9	152.00 d	4.00 b	7.33 de	290.33 de	7.00 g	8.79 gh	4.01 fg
Chakwal Sarsoon	198.00 b	6.33 b	12.66 b	314.33 bc	25.33 a	21.55 bc	3.15 j
Napus-2	240.67 a	4.33 ab	14.67 b	349.00 a	17.66 b	14.53 ef	5.28 d
Zm-21	137.33 ef	5.00 ab	8.00 cd	137.00 h	15.33 bcd	12.47 f	6.89 a
Ah-Rooh	126.00 f	4.33 ab	5.33 defg	154.33 gh	13.33 bcdef	16.34 de	6.75 a
Zn-R-8	181.33 c	6.00 ab	7.33 de	331.00 b	17.00 bc	19.27 cd	
Dunkled	78.37 g	6.33 ab	4.00 efg	161.00 c	14.33 bcde	13.23 f	5.90 c
Rainbow	77.23 g	5.33 ab	3.67 efg	150.67 gh	8.00 fg	3.46i	6.42 b
Mean square of genotypes	5851.38**	3.26**	60.33**	17617.4**	89.84**	152.70**	5.18**

Table 2. Mean comparison test of *Brassica napus* accessions for quality related traits

Genotype	Oil %	Pro %	OA%	LA %	EA %
DGL	38.83 abcd	26.43 abcde	38.45 i	13.84 ab	44.55 a
Cyclone	41.33 ab	25.30 def	53.32 d	9.80 g	32.58 b
Punjab Sarsoon	40.33 abc	26.90 adcd	53.53 d	8.68 h	21.90 d
Zn-R1	40.16 abc	26.40 abcde	37.27 j	8.40 h	31.20 b
Shiralee	38.50 abcd	27.45 a	57.43 c	12.40 d	9.50 i
Zn-M-5	42.33 a	21.50 g	51.42 e	12.48 cd	28.51 c
Zn-M-6	37.00 bcde	27.03 abc	44.08 g	12.21 de	46.27 a
Zn-M-9	39.33 abc	25.86 abcdef	65.75 b	13.36 bc	15.52 gh
Chakwal Sarsoon	36.66 cde	27.40 ab	67.81 a	14.33 a	17.31 fg
Napus-2	41.00 abc	25.39 cdef	68.17 a	12.65 cd	16.50 fg
Zm-21	39.33 abc	24.70 f	35.27 l	11.32 ef	14.40 h
Ah-Rooh	36.66 cde	24.80 ef	36.41 k	8.31 hi	17.65 ef
Zn-R-8	39.00 abc	25.55 cdef	45.30 f	7.41 i	44.29 a
Dunkled	34.33 de	25.76 bcdef	35.17 l	11.23 f	19.70 e
Rainbow	33.33 e	24.86 ef	39.53 h	9.68 g	18.32 ef
Mean square of genotypes	19.25**	6.55**	435.17**	14.69**	433.87**

Means of accessions sharing common letters have non-significant difference.

PH = Plant height Oil % = Oil proportion
PB = Primary branches Pro % = Protein proportion
SB = Secondary branches OA % = Oleic acid proportion
SP = Silique in a plant LA% = Linolenic acid proportion
SS = Seeds in a silique EA % = Erucic acid proportion
SY = Seed yield 1000 SW = Seed weight

Secondary Branches

The significant results of ANOVA were found for different accessions. The results of Tukey's test are mentioned in the Table 1. Means for primary branches of different accessions are arranged in descending sequence in this table. Means for secondary branches were ranged from 19.333 to 3.000. Zn-M-6 genotype had the maximum range of mean, while Cyclone genotype had minimum range of mean value. The means of accessions sharing common letters were non-significantly differed from each other. On the other hand, significant relation existed between the means of accessions by sharing different letters. Sadat *et al*., (2010) and Ullah *et al*, (2015) computed significant variation for secondary branches among various genotypes.it had significant relation with yield and yield parameters

Silique per plant

Significant results were analyzed after statistical analysis of variance. The result of the mean comparison test (Tukey's test) is showing in Table 1. Means for silique per plant of different accessions are arranged in descending sequence in this table. Shiralee accession had maximum mean of 357 while Zm-21 accession had minimum mean value of 137. There was non-significant relation between Shiralee and Napus-2 while both these accessions had significant relation with all others means of accessions. Similarly, the means of all other accessions sharing common letters were non-significantly differed from each other. On the other hand, significant relation existed between the means of accessions sharing different letters. Awal *et al*., (2015) and Rout *et al*, (2018) elaborated the highest genotypic and phenotypic values of variances for plant height.

Seed per silique

The statistical analysis result of variance for seed per silique in plant is presented in Table 1. The significant results were found for multiple accessions. The results of Tukey's test are demonstrated in the Table 1. Means for seed per silique of different accessions are arranged in descending sequence in this table. The maximum value of mean of accession Chakwal Sarsoon was 25.333 while 7 was the minimum value of mean of Zn-M-9 accession. Means of Chakwal Sarsoon and Zn-R-1 differed non-significantly from each other. While both had significant relation with all other accessions by sharing different letters. So, the means of accessions sharing common letters were non-significantly differed from each other. On the other hand, significant relation occurred between the means of accessions by sharing different letters. Hassan *et al*., (2014) and Nasim et al., (2013) notified significant variation among various genotypes for seeds in a silique by the variance analysis

Seed yield per plant

The conclusion of ANOVA (Analysis of Variance) for seed yield of various accessions was found significant at 0.05 probability level that is shown in Table 1. Furthermore, the results of Tukey's test are elaborated in table 1 that is showing means for the seed yield of multiple accessions. These means values are arranged in descending order in the table. Punjab Sarsoon had greater mean value 26.750 g as compared to other accessions. While lower mean value 1.050 g was found of genotype Zn-M-5. There were significant results of Punjab Sarsoon with all other accessions when its mean was compared with means of all other accessions. Dunkled, Cyclone and Zm-21 shared common letters so their means were non-significant to each other. Mean values of Zn-M-5 and Rainbow accessions differed non-significantly from each other by sharing common letter, while both these accessions differed significantly from all other accessions by sharing different letters. Devi (2017) and Hassan *et al.*, (2014) found out that genotypes were significantly variated from each other for all the yield related traits. They noticed that phenotypic coefficient of variation was more than genotypic coefficient of variation.

1000 Seed Weight

The statistical analysis result of variance for weight of 1000 seeds of various accessions is presented in Table 1. The significant results of ANOVA (Analysis of Variance) were found for different accessions. The results of Tukey's test were evaluated, shown in the Table 1. Means for 1000 seed weight of different accessions are arranged in descending sequence in this table. Means were ranged from 6.8933 g to 3.1267 g. Zm-21 genotype had the maximum range of mean, while Zn-R-1 genotype had minimum range of mean value. Zm-21 was significantly different from Ah-Rooh and non-significantly different from all other accessions. Means of Zn-R-8 and DGL were non-significant, Similarly Zn-R-1 and Chakwal Sarsoon means were also different from each other non-significantly. The means of all others accessions sharing common letters for various yield traits were non-significantly differed from each other. On the other hand, significant relation existed between the means of accessions by sharing different letters. Meena *et al* (2017) and Sabaghnia *et al*., (2010) illustrated the significant variation for weight of 1000 seeds among multiple genotypes.

Oil content

The results of the variance analysis of oil content are represented in Table 2. It indicates that the results were highly significant for oil content among different genotypes. Oil content means of different Brassica genotypes are arranged in descending order along with their statistical significance in the Table 2. The range of oil content means lied between 42.333 and 33.333. Mean value of Zn-M-5 was maximum while Rainbow accession had minimum value of mean of oil contents. There were significant results of Zn-M-5 were observed in mean comparison with Zn-M-6, Ah-Rooh, Chakwal Sarsoon, Dunkled and Rainbow. Zn-M-5 showed significant results with remaining accession. Rainbow accession differed non-significantly from Zn-M-6, Ah-Rooh, Chakwal Sarsoon and Dunkled. Similarly, the means of accessions sharing common letters were non-significantly differed from each other. On the other hand, significant relation occurred between the means of accessions by sharing different letters. Khayat *el al*., (2010) determined both genotypic and phenotypic coefficient of variation and elaborated the significant variation for oil content of various varieties.

Protein content

The statistical analysis result of variance for protein content present in various genotypes is showing in Table 2. The significant results were found for multiple accessions. The Table 2 is demonstrating the Mean Standard deviation, variation coefficient and statistical significance for variety of accessions. Means for protein content of different accessions are arranged in descending sequence in this table. The maximum value of mean of accession Shiralee was 27.450 while 21.503 was the minimum value of mean of Zn-M-5 accession. Means of Shiralee has non-significant difference from Chakwal Sarsoon, Zn-M-6, Punjab Sarsoon, DGL, Zn-R-1 and Zn-M-9 and has significant difference from remaining accessions. So, the means of accessions sharing common letters were non-significantly differed from each other. On the other hand, significant relation occurred between the means of accessions by sharing different letters. Ali *et al*., (2017) and Balalić *et al*. (2017) represented the highest significant differences for protein contents among various genotypes.

Fatty Acid contents

All accessions differed from each other possessing significant results for fatty acid contents. Results for oleic acid having mean standard deviation and statistical significance are indicating in Table 2. The accession Napus-2 possessed maximum mean value 68.173 and Dunkled had minimum mean value 35.170. Napus-2 and Chakwal Sarsoon had non-significant difference while both of these were significantly differed from all other accessions. Similarly means of Dunkled and Zm-21 were non-significant from each other and significantly differed from all remaining accessions. Results for oleic acid, linolenic acid and erucic acid having mean standard deviation and statistical significance are indicating in Table 2. Chakwal Sarsoon accession along with 14.337 had maximum mean value for linolenic acid contents. While Zn-R-8 accession consisted lower value of mean from linolenic acid. Chakwal Sarsoon was non-significantly differed from DGL and had significant difference from all other accession. So, the means of accessions sharing common letters were non-significantly differed from each other. On the other hand, significant relation occurred between the means of accessions by sharing different letters. Ali *et al*., (2017) notified the significant differences among multiple genotypes for oleic acid, linolenic acid and erucic acid proportion.

Correlations Analysis yield characters of various genotypes

The analysis of correlation reveals the association between morphological and physiological including quantitative and quantitative yield traits and yield of a plant. All the studied traits were analyzed by genotypic and phenotypic correlations for the available breeding material. Mostly phenotypic correlation coefficients were lower than that of genotypic correlation coefficients which concluded that genetic factors participated more than environmental factors in all possible character's combination. Table 3 and 4 are illustrating the genotypic and phenotypic correlation coefficients respectively among various traits.

Genotypic Correlation Analysis

Correlation between plant height and yield of seed and related traits

Correlation effects between height of plant and yield and its parameters are illustrating in table 3. There was noticed positive and highly significant relationship among height of plant and secondary branches, silique of plant, oil proportion and oleic acid proportion. While height of plant was correlated highly significantly and negatively with weight of 1000 seeds. There was noticed positive and significant relationship among height of plant and protein and positive and non-significant relationship with primary branches, yield of seed, linolenic and erucic acid proportion. Negative and non-significant effects occurred between height of plant and seeds of a silique. Meena *et al*. (2017) illustrated identical results of highly positive and significant impacts of correlation of height of plant on yield of seed, weight of 1000 seeds, oil contents, seeds of a silique and primary and secondary branches.

Correlation between primary branches and yield of seed and related traits

Correlation effects between primary branches and yield and its parameters are illustrating in table 3. There was noticed positive and highly significant relationship among primary branches and seed of silique, protein proportion and yield of seed. While it had non-significant negative correlation with weight of 1000 seeds, oleic acid, linolenic acid and erucic acid Proportion. Primary branches possessed positive and non-significant relation with silique of plant. Seed yield and primary branches were also positively correlated with primary branches in the work of Khan *et al.* (2000) and Khan *et al.* (2013).

Correlation between Secondary branches and yield of seed and related traits

Correlation effects between secondary branches and yield and its parameters are illustrating in table 3. There was noticed positive and highly significant relationship among secondary branches and oleic acid and linolenic acid proportion. Positive significant relation existed between secondary branches and silique of a plant. Non-significant negative correlation was occupied by secondary branches and weight of 1000 seeds. Secondary branches possessed positive and non-significant relation with primary branches, oil proportion, protein proportion and erucic acid proportion. While negative and highly significant association occurred among secondary branches and primary branches and seeds of a silique. Sadat *et al*., (2010) also proved the same results on the yield aspects and highlighted the positive correlation between secondary branches and yield of seed and noted the high and positive significance between secondary branches and seeds in a silique.

Correlation between Silique per plant and yield of seed and related traits

Correlation effects between silique of plant and yield and its parameters are illustrating in table 3. There was noticed positive and highly significant relationship among Silique of a plant and plant height, oleic acid and oil proportion. While negative and high significant correlation occurred between silique of plant and weight of 1000 seeds. Positive significant relation existed between silique of plant and secondary branches. Non-significant negative correlation was occupied by silique of plant and seeds of a silique. Silique of a plant possessed positive and non-significant relation with primary branches, protein, linolenic acid and erucic acid proportion and yield of seed. Awal *et al*., (2015), and Khan *et al*., (2000), also notified the significant positive relationship among silique of a plant with seed yield. They concluded that selection of this parameter of yield could be fruitful for improvement of yield.

Correlation between Seed per silique and yield of seed and related traits

Correlation effects between seeds of silique and yield and its parameters are illustrating in table 3. There was noticed positive and highly significant relationship among Seed of a silique and primary branches, yield of seed and secondary branches. While negative and high significant correlation occurred between seed of a silique and oleic acid and linolenic acid proportion. Non-significant negative correlation was occupied by seed of a silique and height of plant, silique of a plant and weight of 1000 seeds and protein proportion. Seeds of a silique possessed positive and non-significant relation with oil contents, and erucic acid proportion. A discussion of positive correlation of seeds of a silique and yield of a plant presented by the Rameeh (2015).

Correlation between 1000 seed weight and yield of seed and related parameters

Correlation effects between weight of 1000 seeds and yield and its parameters are illustrating in table 3. There was noticed positive and highly significant relationship among weight of 1000 seeds and oil proportion and height of plant. On the other hand, negative and high significant correlation occurred between weight of 1000 seeds and silique of a plant, protein, oleic acid and erucic acid proportion. Non-significant negative correlation was occupied by weight of 1000 seeds and seeds of a silique, primary and secondary branches and yield of seeds. Meena *et al*., (2017) elaborated the positive significant correlation between weight of seeds and height of plant. Sabaghnia *et al*., (2010) elaborated the significant and positive correlation with seed yield.

Correlation between oil proportion and yield of seed and related traits

Correlation effects between oil proportion and yield and its parameters are illustrating in table 3**.** There was noticed positive and highly significant relationship among proportion of oil and plant height and silique of a plant. While negative and non-significant correlation occurred between oil proportion and primary branches and protein proportion. Weight of 1000 Seeds and proportion of oleic acid possessed positive and significant relation with proportion of oil. While *brassica napus* accessions undergone positively and non-significantly correlated with seeds of silique, secondary branches, seeds of a silique, proportion of linolenic acid and erucic acid and ultimately with yield of seed. Golparvar (2011) notified the positive and significant correlation between the oil proportion and yield of seed.

Correlation between protein proportion and yield of seed and related traits

Correlation effects between protein proportion and yield and its parameters are illustrating in table 3. Proportion of protein showed positive high significance with primary branches and yield of plant and positive significance with height of plant. While it was positively, non-significantly correlated with secondary branches, silique of a plant, seeds of silique, linolenic acid and oleic acid proportion. On the other hand, negative and highly significant results were observed with weight of 1000 seeds. The occurrence of negative and non-significant was found among proportion of oil and protein. Balalić *et al*., (2017), Ali *et al*., (2017) worked on *Brassica napus* and his results of experiments were based on negative and significant correspondence between proportion of protein and oil. While Aytac & Kinaci (2009) discussed positive and significant association between protein content and oil proportion.

Correlation between Oleic acid proportion and yield of seed and related traits

Correlation effects between oleic acid proportion and yield and its parameters are illustrating in table 4.2.1. Proportion of protein showed positive high significance with height of plant, Secondary branches and siliques of a plant. While it was negatively, non-significantly correlated with primary branches, and yield of seed. On the other hand, positive and non-significant association of oleic acid proportion with proportion of linolenic acid, protein and oil. The occurrence of negative and highly significant results was indicated among seeds of a silique and 1000 seeds weight. In contrast to this, negative and significant association of oleic acid with erucic acid proportion. Ahmad *et al*., (2015), Abideen *et al* (2013) and Ali *et al*., (2017) revealed the same negative and significant relationship among oleic acid and linolenic acid, erucic acid proportion.

Correlation between linolenic acid proportion and yield of seed and related traits

Correlation effects between linolenic acid proportion and yield and its parameters are illustrating in table 3. The conclusion of correlation analysis revealed that positive and high significant association existed among linolenic acid proportion and secondary branches and proportion of oleic acid. While linolenic acid proportion undergone negatively and highly significant associated with seeds of a silique and yield of seeds. It had non-significant relation with all other traits.

Correlation between erucic acid proportion and yield of seed and related traits

Correlation effects between erucic acid proportion and yield and its parameters are illustrating in table 3. The conclusion of correlation analysis revealed that positive and high significant association of erucic acid was not existed with any of trait. Proportion of erucic acid was non- significantly associated with some yield traits like height of plant, seeds of a silique, secondary branches, silique of a plant, and oil and protein percentages. Negatively and non-significantly relationship of erucic acid proportion with yield of seeds and all other parameters of yield was noticed. Ahmad *et al*., (2015) also notified the same results of correlation among these traits and proved that less than 2% erucic acid could be used as a selection criterion because it had negative impacts on yield and parameters of yield.

Table 3. Genotypic correlation analysis of yield traits of various genotypes of *Brassica napus*

	PB	SB	SP	SS	SW	SY	OC	Pro	OA	LA	EA
PH	-0.01^NS	0.4**	0.63**	-0.18^NS	0.56**	0.17^NS	0.62**	0.31*	0.60**	0.17^NS	0.06^NS
PB		-0.40**	0.06^NS	0.50**	-0.25^NS	0.75**	-0.31*	0.38**	-0.04^NS	-0.22^NS	-0.23^NS
SB			0.34*	0.73**	-0.21^NS	0.28^NS	0.23^NS	0.13^NS	0.44**	0.41**	0.17^NS
SP				-0.09^NS	-0.65**	0.07^NS	0.61**	0.07^NS	0.57**	0.06^NS	0.23^NS
SS					-0.09^NS	0.36*	0.06^NS	0.13^NS	-0.44**	-0.62**	0.20^NS
SW						-0.26^NS	0.43**	-0.38**	-0.42**	-0.14^NS	-0.49**
SY							0.24^NS	0.59**	-0.11^NS	-0.47**	-0.12^NS
OC								-0.33*	0.29^NS	0.04^NS	0.24^NS
Pro									0.14^NS	0.12^NS	-0.00^NS
OA										0.46**	-0.31*
LA											-0.14^NS

Significant at 0.05 Probability | High significance at 0.01 Probability
PH = Plant height | Oil % = Oil proportion
PB = Primary branches | Pro % = Protein proportion
SB = Secondary branches | OA % = Oleic acid proportion
SP = Silique in a plant | LA% = Linolenic acid proportion
SS = Seeds in a silique | EA % = Erucic acid proportion
SY = Seed yield | SW = Seed weight

Phenotypic Correlation analysis of yield traits of various genotypes of *Brassica napus*

Correlation between plant height and yield of seed and related traits

Correlation effects between height of plant and yield and its parameters are illustrating in table 4. There was noticed positive and highly significant relationship among height of plant and secondary branches, silique of plant, oil proportion and oleic acid proportion. While height of plant had high significant and negative correlation with weight of 1000 seeds. Height of plant was positively correlated with protein and possessed positive and non-significant relation with primary branches, yield of seed, linolenic and erucic acid proportion. Negative and non-significant effects occurred between height of plant and seeds of a silique. Ara *et al*. (2013) reported the same results that plant height possessed highly positive and significant correlation impacts on yield of seed, weight of 1000 seeds, oil contents, seeds of a silique and primary and secondary branches.

Correlation between primary branches and yield of seed and related traits

Correlation effects between primary branches and yield and its parameters are illustrating in table 4. There was noticed positive and highly significant relationship among primary branches and yield of seed. While it had non-significant negative correlation with weight of 1000 seeds, oil proportion, oleic acid, linolenic acid and erucic acid Proportion. Primary branches possessed positive and non-significant relation with protein proportion, height of plant, secondary branches and seeds of a silique. Akbar et al. (2003) concluded that significant positive correlation was notified between primary branches and yield of seed in *Brassica juncea*, Seed yield and primary branches were also positively correlated with primary branches in the work of Ullah *et al*, (2015).

Correlation between Secondary branches and yield of seed and related traits

Correlation effects between secondary branches and yield and its parameters are illustrating in table 4. There was noticed positive and highly significant relationship among secondary branches and plant height, seeds of a silique, oleic acid and linolenic acid. Positive significant relation existed between secondary branches and silique of a plant. Non-significant negative correlation was occupied by secondary branches and weight of 1000 seeds. Secondary branches possessed positive and non-significant relation with primary branches, oil proportion, protein proportion and erucic acid Proportion. Rameeh (2015) also proved the same results on the yield aspects and highlighted the positive correlation between secondary branches and yield of seed and noted the high and positive significance between secondary branches and seeds in a silique.

Correlation between Silique per plant and yield of seed and related traits

Correlation effects between silique of plant and yield and its parameters are illustrating in table 4. There was noticed positive and highly significant relationship among Silique of a plant and plant height, oleic acid and oil proportion. While negative and high significant correlation occurred between silique of plant and weight of 1000 seeds. Positive significant relation existed between silique of plant and secondary branches. Non-significant negative correlation was occupied by silique of plant and seeds of a silique. Silique of a plant possessed positive and non-significant relation with primary branches, protein, linolenic acid and erucic acid proportion and yield of seed. Golparvar (2011) also notified the significant positive relationship among silique of a plant with seed yield. They concluded that selection of this parameter of yield could be fruitful for improvement of yield.

Correlation between Seed per silique and yield of seed and related traits

Correlation effects between seeds of silique and yield and its parameters are illustrating in table 4. There was noticed positive and highly significant relationship among Seed of a silique and yield of seed and secondary branches. While negative and high significant correlation occurred between seed of a silique and oleic acid and linolenic acid proportion. Non-significant negative correlation was occupied by seed of a silique and height of plant, silique of a plant and weight of 1000 seeds. Seeds of a silique possessed positive and non-significant relation with primary branches, protein, oil contents, and erucic acid proportion. A discussion of positive correlation of seeds of a silique and yield of a plant presented by the Ivanovska *et al*., (2007), and Lodhi *et al*., (2014).

Correlation between 1000 seed weight and yield of seed and related parameters

The results of correlation among weight of 1000 seeds and yield and its parameters are illustrating in table 4. There was noticed positive and highly significant relationship among 1000 seeds weight and height of plant While negative and high significant correlation occurred between weight of 1000 seeds and silique of a plant, protein, oleic acid and erucic acid proportion. Non-significant negative correlation was occupied by weight of 1000 seeds and seeds of a silique, primary and secondary branches and yield of seeds. 1000 Seeds weight possessed positive and significant relation with proportion of oil. Singh *et al*., (2016) elaborated the positive significant correlation of weight of seeds and silique of plant, oil percentage and yield of seed.

Correlation between oil proportion and yield of seed and related traits

Correlation effects between oil proportion and yield and its parameters are illustrating in table 4. There was noticed positive and highly significant relationship among proportion of oil and plant height and silique of a plant. While negative and non-significant correlation occurred between oil proportion and primary branches and protein proportion. Weight of 1000 Seeds and proportion of oleic acid possessed positive and significant relation with proportion of oil. While *brassica napus* accessions undergone positively and non-significantly correlated with seeds of silique, secondary branches, seeds of a silique, proportion of linolenic acid and erucic acid and ultimately with yield of seed. Singh *et al.* (2017) and Golparvar (2011) noticed the same results and identified the positive and significant correlation between oil content and seed yield.

Correlation between protein proportion and yield of seed and related traits

Correlation effects between protein proportion and yield and its parameters are illustrating in table 4. Proportion of protein showed positive high significance with yield of plant and positive significance with height of plant. While it was positively, non-significantly correlated with primary branches, secondary branches, and silique of a plant, linolenic acid, erucic acid, oleic acid and seeds of a silique. On the other hand, negative and highly significant results were observed with weight of 1000 seeds. The occurrence of negative and non-significant was found among proportion of oil and protein. Balalić *et al*., (2017) worked on *brassica napus* and his results of experiments were based on negative and high significant correspondence between proportion of protein and oil.

Correlation between Oleic acid proportion and yield of seed and related traits

Correlation effects between oleic acid proportion and yield and its parameters are illustrating in table 4. Proportion of protein showed positive high significance with height of plant, Secondary branches and siliques of a plant. While it was negatively, non-significantly correlated with primary branches, and yield of seed. On the other hand, positive and non-significant association of oleic acid proportion with proportion of linolenic acid, erucic acid, protein and oil. The occurrence of negative and highly significant results was indicated among seeds of a silique and weight of 1000 seeds. Ahmad *et al*., (2015) also discussed the positive correlation among quality parameters *Brassica* species and revealed that these parameters could be used as a selection criterion to some extent

Correlation between linolenic acid proportion and yield of seed and related traits

Table 4. Phenotypic correlation analysis of yield traits of various genotypes of *Brassica napus*.

	PB	SB	SP	SS	SY	SW	Oil %	Pro %	OA %	LA %	EA %
PH	0.00^{NS}	0.39**	0.62**	-0.20^{NS}	0.17^{NS}	0.55**	0.53**	0.34*	0.61**	0.17^{NS}	0.04^{NS}
PB		0.24^{NS}	0.04^{NS}	0.26^{NS}	0.43**	-0.15^{NS}	-0.18^{NS}	0.15^{NS}	-0.02^{NS}	-0.16^{NS}	-0.13^{NS}
SB			0.33**	0.65**	0.28^{NS}	-0.19^{NS}	0.16^{NS}	0.10^{NS}	0.40**	0.29**	0.19^{NS}
SP				-0.15^{NS}	0.11^{NS}	0.61**	0.56**	0.10^{NS}	0.57**	0.04^{NS}	0.22^{NS}
SS					0.37**	0.06^{NS}	0.02^{NS}	0.08^{NS}	-0.46**	-0.59**	0.23^{NS}
SY						-0.25^{NS}	0.17^{NS}	0.56**	-0.13^{NS}	-0.48**	-0.28^{NS}
SW							0.36**	-0.41**	-0.41**	-0.15^{NS}	-0.51**
Oil								0.15^{NS}	0.32*	0.03^{NS}	0.13^{NS}
Pro									0.18^{NS}	0.10^{NS}	0.02^{NS}
OA										0.48**	-0.31*
LA											-0.16^{NS}

Significant at 0.05 Probability
High significance at 0.01 Probability
PH = Plant height
Oil % = Oil proportion
PB = Primary branches
Pro % = Protein proportion
SB = Secondary branches
OA % = Oleic acid proportion
SP = Silique in a plant
LA% = Linolenic acid proportion
SS = Seeds in a silique
EA % = Erucic acid proportion
SY = Seed yield
SW = Seed weight

Correlation effects between linolenic acid proportion and yield and its parameters are illustrating in table 4. The conclusion of correlation analysis revealed that positive and highly significant association existed among linolenic acid proportion and secondary branches and proportion of oleic acid. While linolenic acid proportion undergone negatively and highly significant associated with seeds of a silique and yield of seeds. It had non-significant relation with all other traits. Ahmad *et al*., (2015), Manda *et al*., (2001) and Khan *et al*, (2008) also discussed the correlation of same parameters and revealed that these parameters could be used as a selection criterion.

Correlation between erucic acid proportion and yield of seed and related traits

Correlation effects between erucic acid proportion and yield and its parameters are illustrating in table 4. The conclusion of correlation analysis revealed that positive and high significant association of erucic acid proportion was not existed with any of trait. Proportion of erucic acid non-significantly associated with some yield traits like height of plant, seeds of a silique, secondary branches, silique of a plant, and oil and protein percentages. While there existed negative and non-significant correspondence with yield of seeds and relative parameters of yield. Ahmad *et al*., (2015) also notified the same results of correlation among these traits and proved that less than 2% erucic acid could be used as a selection criterion because it had negative impacts on yield and parameters of yield.

Path coefficient analysis of yield traits of various genotypes of *Brassica napus*

Path coefficient analysis was an effort to access the magnitude of contribution of various traits to the yield in the form of cause and effect. It was simply called standardized partial regression coefficient. It estimated the direct impacts of various variables on one another. It split the coefficient of correlation into direct and indirect effect. In this method there was occurrence of cause and effects between different variables. The direction of the experiment required casual system related to evidence of experiment. So, in this way, selection of the best performing traits could be possible in breeding program. Table 5 is presenting the direct and in direct impacts between the variables that resulted from path coefficients analysis of present breeding material. Height of plant directly and positively affected the yield of seed of plant. While height of plant showed indirect and negative effects on yield through silique of a plant, seeds in a silique and proportion of oil, protein, oleic acid and linolenic acid. While height of plant exhibited indirect and positive effects through the left-over parameters of yield. These results were identical to Khan *et al*. (2000) and Yadava *et al*. (2011). They illustrated the direct effects on yield of seed exhibited by the height of plant. The table 5 is presenting the direct and in direct impacts between the variables that resulted from path coefficients analysis of present breeding material. Primary branches directly and positively affected the yield of seed of plant. While primary branches showed indirect and negative effects on yield through height of plant, secondary branches, silique of a plant, yield of seeds and erucic acid proportion. While primary branches exhibited indirect and positive effects through the left-over parameters of yield. These results were identical to those of Akbar *et al*. (2003). They illustrated the positive and direct effects on yield of seed exhibited by the primary branches. The table 4.3 is presenting the direct and in direct impacts between the variables that resulted from path coefficients analysis of present breeding material. Secondary branches directly and positively affected the yield of seed of plant. The indirect positive effects of secondary branches occurred through height of plant, weight of seeds, oleic acid and erucic acid proportion. While all other characters had indirect negative effects on yield through secondary branches. The results were identical to those of Basalma, (2008). They illustrated the positive and direct effects on yield of seed exhibited by the secondary branches. The table 5 is presenting the direct and in direct impacts between the variables that resulted from path coefficients analysis of present breeding material. Silique in a plant directly and positively affected the yield of seed of plant Negative indirect effects occurred through silique of a plant, oil, protein and linolenic acid proportion. While all other characters had positive in direct effects. These results were identical to those of Sadat *et al*, (2010) and Sabaghnia *et al*, (2010). They illustrated the positive and direct effects on yield of seed exhibited by the silique in a plant. The selection of this parameter of yield could be fruitful in the betterment of yield. The table 5 is presenting the direct and in direct impacts between the variables that resulted from path coefficients analysis of present breeding material. Seeds in a silique directly and positively affected the yield of seed of plant. Direct effect of seeds in a silique on seed yield was positive Negative indirect effects occurred through height of plant, secondary branches and oil content. They illustrated the positive and direct effects on yield of seed exhibited by the seeds in a silique. The table 5 is presenting the direct and in direct impacts between the variables that resulted from path coefficients analysis of present breeding material. Weight of 1000 seeds directly and positively affected the yield of seed of plant. The results were identical to those of Yadava *et al.,* (2011) and Khayat *et al*, (2012). They illustrated the positive and direct effects on yield of seed exhibited by the weight of 1000 seeds. The selection of this parameter of yield could be fruitful in the betterment of yield. The table 5 is presenting the direct and in direct impacts between the variables that resulted from path coefficients analysis of present breeding material. Oil proportion directly and positively affected the yield of seed of plant. Negative indirect effects occurred through primary branches, protein, oleic acid and linolenic acid proportion. While all other characters had positive indirect effects. The table 5 is presenting the direct and in direct impacts between the variables that resulted from path coefficients analysis of present breeding material. Protein proportion directly and positively affected the yield of seed of plant. Negative indirect effects occurred through siliques of a plant, seeds of a silique, oil contents, oleic acid and linolenic acid proportion. While all other characters had positive and direct effects. Ali *et al.,* (2017), Balalić *et al*. (2017) evaluated negative effects on oil content. On the other hand, Aytac & Kinaci (2009) concluded that protein proportion and yield had direct positive effects. The table 5 is presenting the direct and in direct impacts between the variables that resulted from path coefficients analysis of present breeding material. Oleic acid proportion directly and negatively affected the yield of seed of plant. Negative indirect effects occurred through primary branches, siliques of a plant, seeds of a silique, oil, linolenic acid and erucic acid proportion. While all other characters had positive indirect effects. Ahmad *et al*., (2015) and Ali *et al*., (2017) showed negative effects of oleic acid on oil, linolenic acid, erucic acid proportion. The table 4.3 is presenting the direct and in direct impacts between the variables that resulted from path coefficients analysis of present breeding material. Linolenic acid proportion directly and negatively affected the yield of seed of plant. The indirect positive effects of linolenic acid proportion occurred through secondary branches, height of plant, and weight of seeds. While all other characters had indirect negative effects on yield through linolenic acid proportion. Ahmad *et al.,* (2015) also concluded the same results that linolenic acid proportion had indirect and negative effects on yield. The table 4.3 is presenting the direct and in direct impacts between the variables that resulted from path coefficients analysis of present breeding material. Erucic acid proportion directly and negatively affected the yield of seed of plant. The indirect negative effects of erucic acid proportion occurred through primary branches and linolenic acid proportion. While all other characters had indirect positive effects on yield through erucic acid proportion.

Table 5. Path analysis of yield traits of various genotypes of *Brassica napus*

	PH	PB	SB	SP	SS	1000SW	OC%	Pro%	OA%	LA%	EA%
PH	**0.73**	-0.00	0.07	-0.17	-0.00	0.77	-0.53	-0.11	-0.42	-0.11	0.04
PB	-0.01	**0.02**	-0.08	-0.01	0.00	0.33	0.20	-0.12	0.02	0.15	-0.22
SB	0.29	-0.009	**0.19**	-0.09	-0.00	0.29	-0.16	-0.03	0.29	-0.27	0.19
SP	0.46	0.001	0.06	**0.27**	-0.00	0.86	-0.54	-0.03	-0.39	-0.03	0.22
SS	-0.15	0.01	-0.13	0.04	**0.00**	0.10	-0.05	0.02	0.34	0.43	0.24
1000SW	-0.40	-0.005	-0.04	0.17	-0.00	**-1.38**	0.35	0.14	0.28	0.10	-0.51
OC%	0.48	-0.005	0.03	0.18	0.00	0.607	**0.80**	-0.10	-0.27	-0.01	0.17
Pro%	0.27	0.008	0.02	-0.03	-0.00	0.62	-0.27	**0.31**	-0.13	-0.07	0.02
OA%	0.45	-0.007	0.08	-0.15	-0.00	0.57	-0.31	0.06	**-0.69**	-0.32	-0.32
LA%	0.12	-0.00	0.07	-0.01	-0.00	0.22	-0.02	-0.03	-0.33	**-0.67**	-0.16
EA%	0.12	-0.00	0.19	0.22	0.231	-0.03	0.14	0.35	0.03	-.0.31	**-0.16**

PH = Plant height Oil % = Oil proportion
PB = Primary branches Pro % = Protein proportion
SB = Secondary branches OA % = Oleic acid proportion
SP = Silique in a plant LA% = Linolenic acid proportion
SS = Seeds in a silique EA % = Erucic acid proportion
SY = Seed yield 1000 SW = Seed weight

4. Conclusions:

The results reflected that correlation coefficient yield was positively and significantly correlated with seeds in a silique and protein contents. Whereas yield was negatively correlated with weight of 1000 seeds, oleic acid contents, linolenic acid and erucic acid contents. On the other hand, path analysis revealed the direct and indirect effects between yield and yield parameters. Plant height, primary and secondary branches, silique of a plant, seeds of a silique, oil contents and protein contents had direct and positive effects on yield while weight of 1000 seeds, oleic acid, linolenic acid and erucic acid proportion exhibited direct and negative effects on yield of seeds.

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