J Agric. Res., 2017, Vol. 55(2):249-265
ISSN: Online: 2076-7897, Print:0368-1157
http://www.jar.com.pk

CHARACTER ASSOCIATION AMONG *BRASSICA CAMPESTRIS* L. GENOTYPES

Muhammad Siddique Depar, Ali Sher Chandio*, Nisar Ahmed Soomro**, Muhammad Waseem Karloo, Attaullah Khan Pathan, Behari Lal Meghwar and Amir Muhammad Laghari*

ABSTRACT

A study was conducted at the research area of Arid Zone Research Institute, Umerkot, Pakistan during the year 2012-13 using RCBD with three replications and six genotypes i.e. P-8 (UCD-8), P-14 (UCD-14), Gaj Sarhein, P-4 (UCD-4), Sindh Raya and S-9 (Check). According to results genotype S-9 (check) surpassed all other genotypes for plant height (208.00 cm). Sindh Raya showed superiority in branches per plant (6.73). Significantly more pods per plant (576.67) were noted in S-9 (check), but candidate genotypes P-4 (UCD-4) and P-14 (UCD-14) (16.33 each) surpassed S-9 (14.0) for seeds per pod. Seed index was also significantly (P<0.05) greater (2.57 g) in candidate genotype P-4 (UCD-4) and surpassed S-9 (2.52 g). None of the genotypes either could surpass or at par with S-9 (check) for seed yield per plant. Correlation results were positively significant among plant stature with pods plant (r = 0.8168), height with yield of single plant (r = 0.6138**), days to flower with seed index (r = 0.5144*), days to flower with yield of single plant (r = 0.7523**), pods per plant with seed index (r = 0.6551**), pods per plant with single plant yield (r = 0.5541**), seed index with single plant yield (r = 0.5980**). Negative and significant relationship was examined between plant height and seeds per pod (r = -0.6832**), branches per plant and ripeness days (r = -0.4740*) and pods per plant and seeds per pod (r = -0.6794**).**

KEYWORDS: ***Brassica campestris;*** **character association; correlation; seed yield; Pakistan.**

INTRODUCTION

In Pakistan, production of oilseed crops could not be increased in accordance with the domestic edible oil needs. The main sources of world edible oils are soybean, sunflower, rapeseed & mustard, cotton and groundnuts (29), whereas in Pakistan the important edible oilseed crops are

***Arid Zone Research Institute (PARC), Umerkot, **Social Sciences Research Institute (PARC), Tandojam, Sindh, Pakistan.**

rapeseed & mustard, sunflower and canola after cotton seed (1). Brassica family consists of a number of crop species containing about 350 genera and 3500 species with a wide range of agronomic traits that mostly produce edible oil (13). Among them *Brassica oleracea, Brassica napus, Brassica rapa, Brassica juncea, Brassica campestris* and *Brassica chinensis* are important but *B. campestris* is mostly grown in the country and subcontinent. It grows very rapidly in the autumn after harvest of grain crops (11). According to Ministry of Food Security and Research, during the year 2011-12, entire need of the country for edible oil was 2.748 million tons while production was 0.636 million tons where edible oil importations were 2.148 million tons costing Rs. 216.4 billions, while during the year 2012-13, 1.738 million tons edible oil at a cost of Rs.153.3 billion was imported, whereas the country production was only 0.612 million tons (9). This situation evidently demands that country's production of edible oil might be enhanced with evolution and improvement of high yielding oilseed crop varieties.

To enhance the yield of oilseed crops a successful breeding programme is a way to tackle the lower yield problem of country through the development of better varieties and hybrids (21). The knowledge of direct and indirect effects of yield and its components and selection offer the source of successful breeding program which in return overcome the problem of increasing yield (16).

The correlation coefficient studies determine the level of association among diverse plant traits and also determine the essential traits on which selection can be based for improvement in yield (12, 30). Simple correlation studies cannot clarify the association between the traits (7). Therefore, it is compulsory to determine the joint relationship among different plant characters so as to find out the component characters for genetic improvement in yield and related traits (24). Correlation studies also help improve different desired traits at the same time (34). In oil producing crops like *Brassica campestris* the investigation of relationship among yield and quality traits like oil content and protein content are of key importance. Therefore it is necessary for plant breeders to investigate the relationships between the traits as to decide for a better breeding program.

The current research work was performed to study association between yield and yield causative traits of *Brassica campestris* L.

MATERIALS AND METHODS

This study was conducted in the research area of Arid Zone Research Institute, Umerkot, Pakistan during the year 2012-13. Layout system was RCBD with three replications; keeping 4.5m x 2.4m plot size and 45 cm row spacing.

Six varieties; three commercial and three elite lines selected from existing germplasm were, P-8 (UCD-8), P-14 (UCD-14), Gaj Sarhein, P-4 (UCD-4), Sindh Raya and S-9 (Check). The genetic traits including correlations among yield and its components were dogged for plant height (cm), number of total branches per plant, days taken to 75% flowering, days taken to 90% maturity, number of total pods per plant, no. of total seeds per pod, seed index/1000 seed weight (g) and seed yield per plant (g). After germination and one month of sowing, thinning was done in experimental crop to maintain plant to plant space. From each variety in each replication, ten plants were randomly selected and tagged to collect the data both in field and laboratory. All the recommended cultural practices were carried out at appropriate time. Compiled data were analyzed by analysis of variance and correlation coefficient was calculated for assessing development and seed yield character of examined lines.

Correlation coefficient: Simple correlation coefficients (r) were computed following Snedecor and Cochran (32) by employ the formula.

$$\text{Correlation Coefficient (r)} = \frac{\textit{Covariance}}{\textit{Geometric mean of covariance}}$$

$$\sqrt{\frac{\sum xy}{(\sum x)^2 (\sum y)^2}}$$

$$\sum xy = \sum XY - \frac{(\sum X)(\sum Y)}{N}$$

$$\sum x^2 = \sum X^2 - \frac{(\sum X)^2}{N}$$

$$\sum y^2 = \sum Y^2 - \frac{(\sum Y)^2}{N}$$

Where:

X = Independent variable
Y = Dependent variable
N = Number of observations recorded

Statistical analysis: The data collected were statistically analyzed employing the computer software MSTAT-C. The variation was compared by least significant difference (LSD) test according to Steel and Torrie (33). Correlation coefficient was worked out after Snedecor and Cochran (32).

RESULTS AND DISCUSSION

The mean squares corresponding to the traits investigated (Table 1) showed that among genotypes excluding branches per plant and days taken to 90% maturity (both were non-significant), all growth and yield components were statistically significant at 0.05 level. Similar significant outcomes were also examined by Huang *et al*. (18) and Turi *et al*. (37) in different traits. The non-significant differences between varieties for branches per plant might be due to their genetic characteristics, but non-significant differentiations for days to maturity may be correlated with the environmental circumstances. The climatic conditions in this region generally modify suddenly and temperature fluctuation may result in unexpected growth and maturity trend in plants.

Table 1. Mean squares from simple analysis of variances for growth and yield characters of *Brassica campestris*

Source of variation	DF	Characters			
		PH	**NBP**	**DF**	**DM**
Replications	2	172.22	0.02000	5.0556	0.3889
Genotypes	5	1733.79**	0.15467^{NS}	21.1556**	3.9556^{NS}
Error	10	70.16	0.47067	1.5889	5.7222
		NPP	**NSP**	**SI**	**SYP**
Replications	2	86.10	0.247	0.0028	0.0078
Genotypes	5	95350.10**	134.448**	0.5415**	8.1938**
Error	10	27.70	0.519	0.0021	0.0020

NS = Non-significant at 0.05 and **Significant at 0.01 levels, PH = Plant height, NBP = No. of branches per plant, DF = Days to 75% flowering, DM = Days to 90% maturity, NPP = No. of pods per plant, NSP = No. of seeds per pod, SI = Seed index and SYP = Seed yield per plant.

Agronomic evaluation

The mean agronomic performance in relation to diverse development and yield components of *Brassica* genotypes is presented in Table 2.

Plant height (cm): The results revealed that among genotypes S-9 (check) surpassed all the candidate and commercial genotypes with 208.00 cm plant height, while candidate genotypes P-14 (UCD-14) and P-8 (UCD-8) produced 192.33 and 191.33 cm plant height, respectively (Table 2). These two candidate genotypes surpassed two commercial genotypes Sindh Raya (177.67 cm) plant height and Gaj Sarhein (140.00 cm). The candidate

genotype P-4 (UCD-4) with 165.00 cm plant height also surpassed Gaj Sarhein. Inayt-ur-Rahman *et al*. (19) reported that dwarf varieties are better than tall varieties for different traits including yield but Miri (25) reported that some high-yielding varieties also show, to some extent, bigger plant height.

Number of branches per plant: All candidate and commercial genotypes including S-9 (check) showed similarity (P>0.05) for the trait number of branches per plant. Comparatively greater number of branches per plant (6.73) was produced by commercial variety Sindh Raya, followed by S-9 (check), P-8 (UCD-8) and P-4 (UCD-4) (6.40, 6.33 and 6.26). Similar outcomes were shown by Naazar *et al*. (27) that *B. napus* genotype (PF-7045/91) formed maximum branches per plant (6.43). Commercial variety Gaj Sarhein resulted in 6.20 branches per plant on average; while candidate genotype P-14 (UCD-14) remained least with 6.06 branches per plant. This indicates that all candidate genotypes were at par with S-9 (check). Also Tahira *et al*. (35) reported maximum branches per plant (10.60) in *B. juncea* genotypes.

Table 2. Mean performance of *Brassica campestris* genotypes for plant height, number of total branches per plant, days taken to flowering and days taken to maturity

Genotypes	Characters							
	PH	NBP	DF	DM	NPP	NSP	SI	SYP
P-8 (UCD-8)	191.33	6.33	74.00	132.00	209.67	13.40	1.50	5.05
P-14 (UCD-14)	192.33	6.06	76.00	131.67	193.00	16.33	1.90	5.55
Gaj Sarhein	140.00	6.20	75.33	134.00	43.33	30.40	1.75	2.96
P-4 (UCD-4)	165.00	6.26	77.33	134.00	248.33	16.33	2.57	4.73
Sindh Raya	177.67	6.73	70.00	132.67	329.33	12.33	1.98	1.97
S-9 (Check)	208.00	6.40	76.66	134.33	576.67	14.00	2.52	6.35
LSD 0.05	15.238	NS	2.2932	NS	9.5788	1.3102	0.0842	0.0813

PH = Plant height, NBP = No. of branches per plant, DF = Days to 75% flowering, DM = Days to 90% maturity, NPP = No. of pods per plant, NSP = No. of seeds per pod, SI = Seed index and SYP = Seed yield per plant.

Days to 75% flowering: Significantly (P<0.05) greater number of days to flowering were taken by lines P-4 (UCD-4), S-9 (check), P-14 (UCD-14) and Gaj Sarhein with 77.33, 76.66, 76.00 and 75.33, respectively. Candidate genotype P-8 (UCD-8) took 74.00 days to 75% flowering while minimum days to 75% flowering were taken by Sindh Raya (70.00). This suggests that Sindh Raya initiated flowering earlier than rest of the genotypes tested in this study. Naazar *et al*. (27) found that *B. napus* genotype SYN-1 took more days (32.25) to flower whereas Miri (25) showed lengthy sowing to flowering period upto 172 days.

Days to 90% maturity: All genotypes showed similarity (P>0.05) in days to 90% maturity; relatively more days to 90% maturity were taken by genotypes S-9 (check), P-4 (UCD-4) and Gaj Sarhein i.e. 134.33, 134.00 and 134.00, respectively; while Sindh Raya and P-8 (UCD-8) took 132.67 and 132.00 days to 90% maturity, respectively. Minimum days to 90% maturity (131.67) were taken by P-14 (UCD-14). Hence, S-9 (check), P-4 (UCD-4) and Gaj Sarhein showed slight delay in maturity; but differences among genotypes for this trait were non-significant (P>0.05). However, genotypes P-14 (UCD-14) was earlier than others in maturity. Naazar *et. al*. (27) found that *B. napus* genotype SYN-1 matured in less days (246) where highest maturity days (253) were obtained by genotypes Licord and SLM-046.

Number of pods per plant: Significantly more pods per plant (576.67) were shown by S-9 (check), followed by Sindh Raya, P-4 (UCD-4), P-8 (UCD-8) and P-14 (UCD-14) i.e. 329.33, 248.33, 209.67 and 193.00 pods per plant, respectively; while Gaj Sarhein produced minimum (43.33). This indicates that none of the varieties could surpass check variety (S-9), but all candidate genotypes surpassed Gaj Sarhein for pods per plant. Inayt-ur-Rahman *et. al*. (19) and Miri (25) observed more pods in maximum grain yielding genotypes and found the genotypes having 136.52 pods per plant under rainfed conditions.

Number of seeds per pod: Similarly, greater number of seeds per pod (30.40) was produced by Gaj Sarhein (30.40), followed by candidate genotypes P-4 (UCD-4), P-14 (UCD-14) and P-8 (UCD-8) i.e. 16.33, 16.33 and 13.40, respectively; against S-9 (check) (14.00). The lowest number of seeds per pod (12.33) was noted in Sindh Raya. Candidate genotypes P-4 (UCD-4) and P-14 (UCD-14) surpassed S-9 for seeds per pod, where Gaj Sarhein showed capability to bear more than double seeds per pod as compared to rest of genotypes tested. Similarly up to 23.6 and 25.97 seeds per pod were found in brassica genotypes by Miri (25) and Inayt-ur-Rahman *et al*. (19), respectively.

Seed index/1000 seed weight (g): Seed index was significantly (P<0.05) greater in candidate genotype P-4 (UCD-4) (2.57 g) against S-9 (check) (2.52 g), followed by Sindh Raya (1.98 g), P-14 (UCD-14) (1.90 g) and Gaj Sarhein (1.75 g). While the lowest seed index 1.50 g was determined in P-8 (UCD-8). This indicates that candidate genotype P-4 (UCD-4) surpassed check variety (S-9) for this trait while other candidate genotypes also showed promising performance for seed index. Inayt-ur-Rahman *et al*. (19) noted maximum value (3.17) of 1000 seed weight for genotypes Oscar and MRS-1. Ahmad (3) also reported significant results for seed index.

Seed yield per plant (g): Similarly, yield per plant was significantly (P<0.05) higher (6.35 g) in S-9 (check), followed by candidate genotypes P-14 (UCD-14 and P-8 (UCD-8) with 5.55 and 5.05 g seed yield per plant, respectively. Genotypes P-4 (UCD-4) and Gaj Sarhein also produced 4.73 g and 2.96 g seed yield per plant, respectively. While variety Sindh Raya produced lowest (1.97 g) seed yield per plant. This indicates that none of the varieties either could surpass or at par with the S-9 (check) for seed yield per plant, P-14 (UCD-14), P-8 (UCD-8) and P-4 (UCD-4) surpassed Sindh Raya and Gaj Sarhein for seed yield per plant. Tahira *et al*. (35) reported maximum (29.31 gm) seed yield per plants *B. juncea* genotypes whereas Naazar *et al*. (27) found highest yield 6.77 g yield per plant in *B. napus* varieties.

Correlation studies

To determine the association between different crop characters correlation coefficient has been used by Yagdi and Sozen (39). The correlation coefficient studies show association between autonomous variables and the extent of linear associations between the variables (14). Ali *et al*. (8) observed positive correlation among yield components in all brassica genotypes. Even very small correlations among traits can be helpful for genotype selection; small correlations among desirable traits alter considerably the necessary progeny size (38).

Plant height with number of branches per plant: The data (Table 3) showed, positive but non-significant association ($r = 0.032^{NS}$) between branches per plant and plant height advising that as plant height increases the branches per plant may also raise slightly in *Brassica campestris,* Whereas Farooq *et. al*. (17) reported positive and significant correlation but Basalma (10) reported negative connection of plant height with number of branches in *Brassica*.

Plant height with days to 75% flowering: Relationship of plant stature with days to flower was positive but non-significant ($r = 0.2067^{NS}$) (Table 3). It points out that when plant height of *Brassica campestris,* genotypes enhances, the days to flower may also enlarge to some level. However Khan *et al*. (22) and Malik *et al*. (23) found negatively significant correlation between plant height and days to flowering.

Plant height with days to 90% maturity: The correction between plant tallness and days to ripeness was positive but non-significant ($r=0.1631^{NS}$) this shows that any enhancement in plant stature of *Brassica campestris*,

also create a little addition in days to ripeness. Naazar *et. al*. (27) also investigated negative but highly significant correlations for plant height with days to maturity.

Plant height with number of pods per plant: Positive and highly significant (r = 0.8168**) (Table 3) relationship among plant height and pods per plant advocates that as plant stature enlarged, the pods on plant were also increased extraordinarily. Khan *et al*. (22) and Farooq *et al*. (17) also obtained positively significant results between plant altitude and number of pods per plant.

Plant height with number of seeds per pod: The data (Table 3) indicated negative but highly significant relation(r = -0.6832**) which points out that with any addition in plant height, the seeds in pods were drastically decreased. While Khan *et al*. (22) reported significant correlation among plant height and number of seeds per pods.

Plant height with seed index (1000 seed weight): Table 3 indicates that interrelationship between both traits plant height and seed index was positive but non-significant ($r = 0.3836^{NS}$) (Table 3). This reveals that any increase in plant stature, the seed weight value of *Brassica campestris* may raise to some extent. Same results also were found by Akbar *et al*. (5).

Plant height with seed yield per plant: The positive and highly significant ($r= 0.6138^{**}$) association was noted between plant elevation with yield of single plant in *Brassica campestris* It indicates that when height of plant increases, the single plant yield also boosts significantly. Khan *et al*. (22) also reported positive significant and Tuncturk and Ciftc (36) reported positive and non-significant correlation among plant height and yield per plant.

Number of branches per plant with days to 75% flowering: Both traits days to flower and twigs of plant show negative and non-significant association ($r = -0.4070^{NS}$) which validate that increased number of twigs on plant may result in decrease of flowering. Similar negative and non-significant correlation results were also noted by studied Naazar *et al*. (27) for branches per plant with flower duration.

Number of branches per plant with days to 90% maturity: Total branches of plant and maturity showed negative but significant (r = -0.4740*) association among themselves (Table 3). It indicates that as number of twigs on plant raises a decrease in total maturity days occur. Similarly Naazar *et al*.

(27) also stated negative and non-significant correlation between branches per plant and maturity duration.

Number of branches per plant with number of pods per plant: The results show that twigs on plant and number of pods on plant show positive but non-significant association ($r = 0.1466^{NS}$) which suggests that any increase or decrease in total branches on the plant in *Brassica campestris* may also raise or drop the pods on plant to some level. Significant correlation was found by Ali *et al*. (8) among number branches and pods per plant in *Brassica* varieties.

Number of branches per plant with number of seeds per pod: The negative and non-significant ($r = -0.2623^{NS}$) relationship between twigs on plant and the seeds in pod was noted (Table-3), it indicates that as number of branches on plant enhances, the seeds in pod decrease to some extent in *Brassica campestris*. However, negatively significant results were reported for twigs on plant and seeds in pod by Ali *et al*. (8).

Number of branches per plant with seed index (1000 seed weight): Table-3 shows that branches on plant had positive but non-significant ($r = 0.1012^{NS}$) association with seed weight. It suggests that as number of branches increase on plant, a minor raise in seed weight of *Brassica campestris* is anticipated. Same positive and non-significant correlations were also reported by Naazar *et al*. (27) for branches per plant with seed weight in *B. napus* genotypes.

Table 3. Correlation (r) coefficients between different traits in *campestris* cultivars

Character	Plant height	No. of branches per plant	Days to 75% flowering	Days to 90% maturity	No. of pods per plant	No. of seeds per pod	Seed index
No. of branches / plant	0.032^{NS}						
Days to 75% flowering	0.2067^{NS}	-0.4070^{NS}					
Days to 90% maturity	0.1631^{NS}	-0.4740*	0.4081^{NS}				
No. of pods per plant	0.8168**	0.1466^{NS}	0.1040^{NS}	0.1749^{NS}			
No. of seeds per pod	-0.6832**	-0.2623^{NS}	0.2542^{NS}	0.1853^{NS}	-0.6794**		
Seed index	0.3836^{NS}	0.1012^{NS}	0.5144*	0.3557^{NS}	0.6551**	-0.3764^{NS}	
Seed yield per plant	0.6138**	0.2018^{NS}	0.7523**	0.1911^{NS}	0.5541**	-0.1948^{NS}	0.5980**

Number of branches per plant with seed yield per plant: The correlation studies for these two traits branches on plant and yield of single plant suggested positive and non-significant association ($r = 0.2018^{NS}$) (Table 3). Which points out that with minor addition in branches on plant, a small raise

occur in single plant yield. Current outcomes are also along the lines of Ali *et al*. (7) but Ali *et al*. (8) reported negative and non-significant results for these traits. However, positive significant results were noted by Muhammad *et al*. (26), Malik *et al*. (23) and Tuncturk and Ciftc (36) between branches on plant and single plant yield.

Days to 75% flowering with days to 90% maturity: According to Table 3, days to blossoming had non-significant but positive association ($r = 0.4081^{NS}$) with days to ripeness; a sign that if blossoming days increase a slighter raise in days to ripeness will take place in *Brassica campestris*. Naazar *et al*. (27) reported negative and non-significant correlations but reported positive and non-significant correlation of flower duration with maturity duration.

Days to 75% flowering with number of pods per plant: The alliance of 75% flower opening and amount of pods on plant of *Brassica campestris* shows positive but non-significant connection ($r = 0.1040^{NS}$) (Table 3), demonstrating that if duration of days to flower increases, the magnitude of pods on plant might also raise as well. Sabaghnia *et al*. (28) stated negative but non-significant association, where positive and significant correlation was also stated by Khan *et al*. (22) for same traits in brassica.

Days to 75% flowering with number of seeds per pod: The correlation studies for these traits showed (Table 3) positive but non-significant relationship ($r = 0.2542^{NS}$) among blossoming days and quantity of seeds in pod of *Brassica campestris*. This condition implies that as days for flowering increase an inappropriate raise in quantity of seeds in pod is expected. Sabaghnia *et al.* (28) reported negative and non-significant association, whereas Khan *et al*. (22) stated positively significant correlation in brassica for 75% flower opening and seeds per pod.

Days to 75% flowering with seed index (1000 seed weight): Correlation among flowering days and the seed weight was positive and significant (r=0.5144*). This situation points out that increase in blossoming period will result in considerable increase in seed weight of *Brassica campestris*. Naazar *et al*. (27) also noted positively significant correlations of seed weight with flower duration.

Days to 75% flowering with seed yield per plant: Union between blossoming days and single plant yield was positive and highly significant (r = 0.7523**), which stated that as blossoming duration rises; the single plant yield is imagined to enhance simultaneously in *Brassica campestris*. Similarly

Khan *et al*. (22) and Ali *et al*. (7) stated positive but significant relationship among flowering days and yield per plant in brassica.

Days to 90% maturity with number of pods per plant: The results indicate positive but non-significant association ($r = 0.1749^{NS}$) between ripeness duration and amount of pods on plant. This shows that with the raise in maturity days, a small boost in quantity of pods on plant in *Brassica campestris*. Ejaz *et al*. (15) described positive and significant correlation but Naazar *et al*. (27) reported negative and non-significant correlations among maturity duration and pods per plant in *B. napus* genotypes.

Days to 90% maturity with number of seeds per pod: Correlation among maturity duration and seeds in pod was positive but non-significant ($r = 0.1853^{NS}$). This condition states that an increase in days to ripeness results in a minor raise in quantity of seeds in pod of *Brassica campestris*. Ejaz *et al*. (15) indicated negative and significant correlations but Naazar *et al*. (21) reported negative and non-significant correlations among maturity duration and number of seeds per pods in *B. napus* genotypes.

Days to 90% maturity with seed index (1000 seed weight): Positive but non-significant connection ($r = 0.3557^{NS}$) among days to ripeness and seed weight of *Brassica campestris*. This accentuates that as the days of ripeness raise, the seed weight value increases to some extent, but Naazar *et al*. (27) reported negative and significant correlations where Ejaz *et al*. (15) informed positive and significant correlation among maturity duration and number of seeds $pods^{-1}$ in *B. napus* genotypes.

Days to 90% maturity with seed yield per plant: Association among ripeness days and single plant yield was positive but non-significant ($r = 0.1911^{NS}$) (Table 3). It indicates that as the days of ripeness increases, a little raise in single plant yield of *Brassica campestris*. While Ali *et al*. (7, 8) and Ali *et al*. (8) informed negative and non-significant correlation among maturity duration and per plant yield.

Number of pods per plant with number of seeds per pod: Table 3 discloses negative and significant relationship (r = -0.6794**); for pods on plant with seeds in pod and stated that any raise in amount of pods on plant will result in a considerable decrease in seeds in pod. Alemayehu and Becker (6) also found negative but significant correlation whereas Khan *et al*. (22) reported positive but significant results among pods on plant and seeds in the pod in brassica.

Number of pods per plant with seed index (1000 seed weight): Association between pods on the plant and 1000 seed weight was positive and highly significant (r= 0.6551**). It indicates that increase in pods per plant will also increase significantly seed index (1000 seed weight) of *Brassica campestris.* Whereas Alemayehu and Becker (6) noted negatively significant correlation but Farooq *et al*. (17) informed negative and non-significant correlation between quantity of pods on the plant and seed index in brassica.

Number of pods per plant with seed yield per plant: Among the traits pods on plant and single plant yield showed strong positive and significant (r = 0.5541**) correlation, which suggested that in case any rise in pods on plant of *Brassica campestris,* single plant yield will also rise considerably. Similarly positive significant correlation was founded by Abideen *et al*. (2), Khan *et al*. (22), Malik *et al*. (23) and Tuncturk and Ciftc (36). Whereas negative but significant correlation was noticed by Alemayehu and Becker (6) for pods on the plant and plant yield in brassica.

Number of seeds per pod with seed index: The correlation studies for these traits seeds in the pod and seed weight explained negative and non-significant association ($r = -0.3764^{NS}$). This condition confirms that by the addition in quantity of seeds in pod, will reduce seed weight level slightly in *Brassica campestris*. Same way Alemayehu and Becker (6) reported negative but significant correlation, whereas Farooq *et al*. (17) reported positive but non-significant correlation between seeds per pods and seed index in brassica.

Number of seeds per pod with seed yield per plant: Seeds in pod and single plant yield show negative and non-significant relationship ($r= -0.1948^{NS}$) between each other (Table 3). This situation points out that due to addition in seeds in pod, single plant yield in *Brassica campestris* causes decrease to some extent. Alemayehu and Becker (6) also showed negatively significant correlation but Khan *et al*. (22), Johnson *et al*. (20), and Tuncturk and Ciftc (36) reported positive significant correlation among quantity of seeds in the pod and single plant yield in brassica.

Seed index (1000 seed weight) with seed yield per plant: The results indicated correlation among these traits 1000 seed weight and single plant yield was strongly positive and extremely significant (r= 0.5980**) with each other. This condition explain that when seed weight enhances, the single plant yield increases considerably in *Brassica campestris*. In same way Sheemar *et al*. (31), Johnson *et al*. (20), Aggarwal *et al*. (4), Akbar *et al*. (5),

Ali *et al*. (7,8), and Tuncturk and Ciftc (36) also found positive significant correlation among same traits in brassica.

CONCLUSIONS

1. *B. compestris* genotypes diverged significantly (P<0.05) for plant height, flowering duration, pods per plant, seeds per pod, seed weight and seed yield of single plant; whereas non-significant (P>0.05) for number of branches on plant and ripeness duration.
2. S-9 (check) surpassed all candidate and commercial genotypes for plant height, Sindh Raya showed superiority in branches per plant.
3. Candidate variety Sindh Raya initiated flowering earlier than rest of the genotypes, where genotype P-14 (UCD-14) was earlier from others in maturity.
4. S-9 surpassed all the tested genotypes for pods per plant, but candidate variety Gaj Sarhein and genotypes P-4 (UCD-4) and P-14 (UCD-14) surpassed S-9 for seeds per pod.
5. Candidate genotype P-4 (UCD-4) surpassed S-9 for seed index.
6. None of the varieties could surpass S-9 for seed yield per plant, but P-14 (UCD-14), P-8 (UCD-8) and P-4 (UCD-4) surpassed Sindh Raya and Gaj Sarhein for single plant yield.
7. Positive and significant association was noted for plant height with pods on the plant and single plant yield, days to flower with seed index and single plant yield, pods on plant with seed index and single plant yield, as well as seed index with single plant yield.
8. Significant and negative association was examined for plant height with seeds in the pod, branches on plant with maturity duration and amount of pods on plant with seeds in pod.

REFERENCES

1. Abbas, S. J., Farhatullah, K. B. Marwat , I. A. Khan and I. Munir. 2009. Molecular analysis of genetic diversity in brassica species. Pak. J. Bot., 41(1):167-176.
2. Abideen, S.N.U., F. Nadeem and S.A. Abideen. 2013. Genetic variability and correlation Studies in *Brassica napus* L. genotypes. Int. J. Innovat. Appl. Stud. 2(4):574–581.
3. Ahmad, H. 2009. Genome Biology of Rapeseed and Mustard. Phylogenetic elaboration through Manipulation and Preferential pairing. Published by VDM Verlogy Dr. Muller Aktingesellschaft Co. Kg

Germany. ISBN: 978-3-639-14898-5, pp.40-41.

4. Aggarwal, R.A., K.R. Sharma, R. Kumar, T. Mohapatra, and R.P. Sharma. 2003. Molecular mapping of loci affecting the contents of three major fatty acids in Indian mustard (*Brassica juncea* L). J. Pl. Biochem. and Biotech. 12:131-137.
5. Akbar, M., M. Tariq, M. Yaqub, M. Anwar, M. Ali and N. Iqbal. 2003. Variability, correlation and path coefficient studies in summer Mustard (*Brassica Juncea* L.). Pak. Asian J. Pl. Sci. 2(9): 696-698.
6. Alemayehu, N. and H. Becker. 2002. Genotypic diversity and patterns of variation in a germplasm material of Ethiopian mustard (*Brassica carinata* A. Braun). Genetic Resour. Crop Evol. 49: 573-582.
7. Ali, N., F. Javaidfar and A.A. Attary. 2002. Genetic variability, correlation and path analysis of yield and its components in winter rapeseed (*Brassica napus* L). Pak. J. Bot. 34(2): 145-150.
8. Ali, N., F. Javidfar, J.Y. Elmira and M.Y. Mirza. 2003. Relationship among yield components and selection criteria for yield improvement in winter rapeseed (*Brassica napus* L). Pak. J. Bot. 35(2): 167-174.
9. Anon. 2013. Economic Survey of Pakistan, 2012-2013. Pakistan Bureau of Statistics, Ministry of Food Security and Research, Government of Pakistan, Islamabad, Pp. 23.
10. Basalma, D. 2008. The correlation and path analysis of yield and yield components of different winter rapeseed (*Brassica napus* ssp. oleifera L.) cultivars. Res. J. Agri. Bio. Sci. 4(2): 120-125.
11. Bayer, 2010. Bayer Sequence Genome of Canola. Bayer Crop Science: The Bio-energy Site, Retrieved 8 November 2010.
12. Bocanski, J., Z. Sreckov and A. Nastic. 2009. Genetic and phenotypic relationship between grain yield and components of grain yield of maize (*Zea mays* L.). - Genetika, 41(2): 145 -154.
13. Christopher, G.L., J.R. Andrew, A.C.L. Geraldine, J.H. Clare, B. Jacqueline, B. Gary , C.S. German, and E. David. 2005. Brassica ASTRA: an integrated database for Brassica genomic research. Nucleic Acids Res. 1(33): 656-659
14. Dokuyucu, T., A. Akkaya and M. Akcura. 2002. Path analysis of yield and some yield related traits of Durum wheat genotypes grown in rain fed conditions of Mediterranean Region. Turkish Journal of Field Crops, 7 (1): 31-39.
15. Ejaz, U.H., H.S.B. Mustafa, B. Tahira and T. Mahmood. 2014. Genetic

variability, correlation and path analysis in advanced lines of rapeseed (*Brassica napus* L.) for yield components. Cercetări Agron. în Moldova. 47(1):71-79.

16. Emrani, S.N., A. Arzani, G. Saeidi, M. Abtahi , M. Banifatemeh , M.B. Parsa and M. H. Fotokian. 2012. Evaluation of induced genetic variability in agronomic traits by gamma irradiation in canola (*Brassica napus* L.). Pak. J. Bot., 44(4):1281-1288.
17. Farooq, A.K., M. Younas and G. Mustafa .2005. Correlation and factor wise contribution of the characters related to yield and quality of *Brassica juncea* L. Int. J. Agri. & Biol. 07(2):257–259.
18. Huang, Z., P. Laosuwan, T. Machikowa and Z. Chen. 2009. Combining ability for seed yield and other characters in rapeseed. Suranaree J. Sci.Techn. 17(1):39-47.
19. Inayt-ur-Rahman, H. Ahmad, Inamullah, Sirajuddin, I. Ahmad, F.M. Abbasi, M. Islam and S. Ghafoor. 2009. Evaluation of rapeseed genotypes for yield and oil quality under rainfed conditions of district Mansehra. Afric. J. Biotech. 8(24):6844-6849
20. Johnson, R.C., L. Dajue and V. Bradley. 2006. Autumn growth and its relationship to winter survival in diverse safflower germplasm. Canadian J. Pl. Sci. 86(3):701-709.
21. Kang, S.A. and F.A. Khan. 2015. Technical Articles: Present status, Heterosis and combining ability studies of inbred lines for the development of hybrid genotypes in *Brassica juncea* L. http:www.pakissan.com/English/technical.articles/present.status. heterosis.
22. Khan, S., Farhatullah and I.H. Khalil. 2008. Phenotypic correlation analysis of elite $F_{3:4}$ *Brassica* populations for quantitative and qualitative traits. Biol. Sci. 3(1):109-116.
23. Malik M. A., A S. Khan, Shafiullah and M. K. Ayub. 2000. Study of correlation among morphological parameters in different varieties / accessions of *Brassica* species. Pak. J. Bio. Sci. 3(7):1180-1182.
24. Memon, S., M. J. Baloch, G. M. Baloch and M. I. Keerio. 2014. Heritability and correlation studies for phenological, seed yield and oil traits in sunflower (*Helianthus annuus* L.) Pak. J. Agri. Engg. Vet. Sci. 30(2):159-171.
25. Miri, H. R. 2007. Morphophysiological basis of variation in rapeseed (*Brassica napus* L.) yield. Int. J. Agric. & Biol., 9 (5):701–706

26. Muhammad, A., M. Tariq, Y. Muhammad, A. Muhammad and I. Nasim. 2003. Variability, correlation and path coefficient studies in summer mustard (*Brassica Juncea* L.). Asian J. Pl. Sci. 1(3):78-82.
27. Naazar, A., F. Javidfar, J. Y. Elmira and M. Y. Mirza. 2003. Relationship among yield components and selection criteria for yield improvement in winter rapeseed (*Brassica napus* L.). Pak. J. Bot., 35(2):167-174.
28. Sabaghnia, N., H. Dehghani, B. Alizadeh and M. Mohghaddam. 2010. Interrelationships between seed yield and 20 related traits of 49 canola (*Brassica napus* L.) genotypes in non-stressed and water-stressed environments. Spanish J. Agric. Res. 8(2):356-370.
29. Sarwar, M. F., M. H. Sarwar, M. Sarwar, N. A. Qadri and S. Moghal. 2013. The role of oilseeds nutrition in human health: A critical review. J. Cereals and Oilseeds. 4(8):97-100.
30. Shazia S., S. Abro , A. Rehman and K. Iqbal. 2010. Correlation analysis of seed cotton yield with some quantitative traits in upland cotton (*Gossypium hirsutum* L.). Pak. J. Bot. 42(6):3799-3805.
31. Sheemar, G., D. Singh, A. Malik and A. Kumar. 2012. Correlation and path analysis studies of economic traits in cauliflower (*Brassica oleracea* var botrytis L.). Int. J. Agri. Tech. 8(5):1791-1799.
32. Snedecor, G.W. and W.G. Cochran. 1980. Statistical Methods. Seventh Edition. Ames Iowa: The Iowa State University Press. Weiss, E. A. 1983. Oilseed crops. p. 161-215. Longman Group Limited.
33. Steel, R.G.D. and J.H. Torrie. 1984. Principles and Procedures of Statistics (2nd Ed.). MC Graw Hill Book Co; Singhapore p. 172-177.
34. Sujatha, K. and H. L. Nadaf. 2013. Correlation for yield and yield related traits in mutant and segregating genotypes in sunflower (*Helianthus annus*. L). Molecular P. Breed. 32:265-266.
35. Tahira, T. Mahmood, M. S. Tahir, U. Saleem, M. Hussain and M. Saqib. 2011. The estimation of heritability, association and selection criteria for yield components in mustard (*Brassica juncea*). Pak. J. Agri. Sci., Vol. 48(4):251-254.
36. Tuncturk, M. and V. Ciftc .2007. Relationships between yield and some yield components in rapeseed (*Brassica napus* ssp. Oleifera l.) cultivars by using correlation and path analysis. Pak. J. Bot. 39(1):81-84

37. Turi, N.A., Raziuddin, N. Farhatulla, U. Khan, G. Hassan, J. Bakhat, S.Khan and M. Shafi. 2011. Combining ability for yield related traits in *Brassica juncea*. Pak. J. Bot. 43(2):1241-1248.
38. Turk, M. and N. Celik. 2006. Correlation and path coefficient analyses of seed yield components in the Sainfoin (*Onobrychis sativa* L.). J. Bio. Sci. 6(4):758-762.
39. Yagdi, K. and E. Sozen. 2009. Heritability, variance components and correlations of yield and quality traits in durum wheat (*Triticum durum* desf.). Pak. J. Bot. 41(2):753-759.

Received: January 12, 2015 Accepted: June 22, 2016

***

CONTRIBUTION OF AUTHORS:

Muhammad Siddique Depar	**:**	**Conducted the experiment, took observations and analyzed data**
Ali Sher Chandio	**:**	**Contributed in drawing conclusions**
Nisar Ahmed Soomro	**:**	**Statistically analysed data**
Muhammad Waseem Karloo	**:**	**Helped in arranging experimental layouts**
Attaullah Khan Pathan	**:**	**Facilitated the research work**
Behari Lal Meghwar	**:**	**Reviewed the writeup**
Amir Muhammad Laghari	**:**	**Helped in data collection**