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Response of various brassica cultivars to yield under agro-ecological condition of Quetta

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Abstract

This study was carried out 2013-2014 under the agro-ecological condition of Quetta in order to evaluate the yield response of four Brassica cultivars viz sultan Raya, Bard-1, Dunkled and cont-II . Tested Brassica cultivars were sown on 6th march 2014 at experimental area of Agriculture research institute (ARI), Quetta by maintaining same plot size (5.0 m long and 3m wide), seed rate (60 kg hac^{-1}) and fertilizer dose (90 kg N hac^{-1}and 60 kg P hac^{-1}). The experiment was laid as Randomizes complete block Design(RCBD) replicated thrice. Result showed that maximum plant height of 123.00 cm was recorded in Bard-1 followed by 121.33 cm in Sultan Raya and minimum was 98.67 cm in Dunkled. Similarly, maximum but non-significant No of pods plant^{-1} of 293.67 and 285.67 were recorded in con-II and dunkled and minimum was 248 in Sultan Raya followed by 264 in Bard-I. Number of pods plant^{1} were positively and significantly correlated with seed index, grain yield and harvest index with coefficient of determination (R^2) of 74, 79, and 74% respectively. While in case of number of seeds pod^{-1}seed index, grain yield and harvest index, their mean maximum value of 24 seeds pod^{-1}, 4.47g, 2791.00 kg hac-1 and 15.67 % were found in Con-II followed by Dunkled and minimum of 16.00 seeds pod^{-1} , 3.33g 1742.00 kg hac^{-1} and 8.54 % were present Sultan Raya and Bard-I. Among them, the canola type cultivars i-e. Dunkled and con-II performed better than Sultan Raya and Bard-I. Whereas, the maximum Biological yield of 21380 kg hac^{-1} and minimum was 17771 kg hac^{-1} in con-II. The positive and significant correlation was found among the yield components which showed that the high yield of Dunkled followed by con-II can be grown successfully in Quetta valley and it can further be evaluated for other locations in Balochistan.

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Introduction

Rapeseed (*Brassica rapa* and *B. napus*) and mustard (*B. juncea*) are the important crop of Brassica group grown as oilseed crops in Pakistan. These have remained one of the major sources of oil in the sub-continent for centuries. Rapeseed and mustard are rich source of oil and contains 44-46% good quality oil. In addition, its meal has 38-40% protein that has a complete profile of amino acids including lysine, methionine and cystine. The meal from canola quality rapeseed varieties is an excellent feed for animals and birds especially for poultry (Rashid, 2010).

Edible oil is one of the important commodities of everyday use. Pakistan has been constantly and chronically deficient in its production. Local production of edible oil is remained 0.636 million tonnes while imports were 2.148 million. During the year 2012-2013 (July-March), 1.738 million tonnes of edible oil valued at Rs. 153.3 billion (US $1.595 billion) have been imported. The local production during 2012-2013 (July-March) was 0.612 million tonnes. Total availability of edible oil from all sources is provisionally estimated at 2.35 million tonnes during 2012-2013 (July-March). The contribution of rapeseed and canola in term of area is 0.482 million hectares with a production of 176 million tonnes' seeds (Anonymous, 2013).

In Pakistan, The area under oilseed crops during 2009-10 was 693 thousand hectares with total production of 4940 thousand tonnes. Sunflower and Canola with high oil yield per unit area have emerged major oilseed crops and have the potential to narrow the gap between production and consumption of edible oil (Anonymous, 2010). However, among oil seed crops, the rapeseed and mustard were grown on area of 224 and 198 thousand hectares with total production of 205 and 181 thousand tonnes during 2012-13 and 2013-14 (GOP, 2014). Province wise, area and production of rapeseed/mustard and canola crops in Pakistan revealed that Punjab contributed largely with area of 111.5 (5.7) thousand hectare producing 96.3 (6.4) thousand tonnes while the area and production of Sindh, Khyber Pakhtonkhwa, and Balochistan was 40.7 (1.9), 15.3 (1.0) and 22.8 (4.0) thousand hectares and 46.5 (2.4), 7.3 (0.4) and 12.1 (2.4) thousand tonnes respectively (Anonymous, 2010).

Rapeseed-mustard is a traditional crop of Pakistan. The oil extracted from indigenous varieties of rapeseed-mustard is not being used in the manufacture of vegetable ghee or as vegetable oil because of high erucic acid (40-70% in oil) which is harmful to human health. Canola belongs to a rapeseed group (*Brassica napus* L.). It is a future hope of Pakistan as it can play a significant role for the enhancement of edible oil production in the country. It is infect simply a variety of rapeseed with certain defined characteristics especially low erucic acid in oil and low glucosinolates in oilseed cake. Canola oil contains no cholesterol and low erucic oils are nutritional more desirable for human health (Rashid, 2010).

Canola has been successfully on soil from pH 5.0 to 8.0. Canola has higher requirement for nitrogen, phosphorus and sulphur than cereals and other crops and will not produce high yields unless all three elements are present. Canola needs approximately 40 to 50 kg of nitrogen i.e. 30% more than wheat, 8 kg phosphorus and 10 kg sulphur per tonne of grain produced (Colton and Sykes, 1992). In general, the optimal germination conditions for canola are 20°C, high water availability (i.e. -0.2 MPa) and exposure to light (Pekrun *et al.,* 1998). Whereas, soil temperature below 10°C result in progressively poorer germination and emergence. However, germination is also influenced by the genetic variety, growth conditions as the seed matures, how the seed was stored and seed treatments (CCC, 2007).

Studies pertaining to comparative yield performance of different Brassica varieties were carried out by Cheema *et al.* (2001) at the Agronomic Research Area, University of Agriculture, Faisalabad, during 1998-99. Their comparative treatments were comprised of six varieties including BSA, Shiralee, Westar, Rainbow, Dunkled and Oscar. Among them,

the Oscar variety produced maximum seed yield (1843 kg ha^{-1}) with improved yield components like number of branches, pods $plant^{-1}$, and 1000 seed weight as compared to other varieties. Oscar also proved best in qualitative traits like erucic acid, glucosinolates and seed oil contents. The climatic effect on yield performance of different canola varieties were investigated by Ali *et al.* (2011) in four regions in Oman in order to comprehend their response and adaptability to these different agro-climate regions. In this study they used three varieties of canola (Canola 1, Hyola 43 and Hyola 60) and their results demonstrated that there were significant differences for location (Region) with respect to both seed yield and plant height. There were no significant differences among the varieties in seed yield during 2004/2005 and 2005/2006 in Jimah, Sohar and Salalah, while interestingly significant differences were found during 2004/2005 in Al-Kamil and during 2006/2007 in Salalah and Sohar. These results indicated that canola is highly adaptable to different regions of Oman with relative advantage for certain regions for both seed yield productivity and oil content. The adaptability of canola varieties such as Raya Anmol and Faisal Canola under coastal climatic conditions of Lasbela were tested in Balochistan at Lasbela University of Agriculture, Water and Marine Science, Uthal, Lasbela. This study showed that yield and yield contributing traits were significant and seed yield of Faisal Canola was better as compared to that of Raya Anmol (Waseem *et al.*, 2014).

Rapeseed and mustard are the conventional oil seed crops in Pakistan and rank second after seed cotton in oil production in the country. In recent years, many canola varieties have been imported and cultivated in Pakistan but their yield potentials and production technologies have yet not been explored.Keeping in view the importance of brassica cultivars as oil crops and due to diversified agro-climatic zones, there is great potential for production of these crops in Balochistan. So, the present study was designed to evaluate the growth and yield components of different brassica cultivars under the agro-climatic condition of Quetta with the following objectives:First, to test the growth performance of various brassica cultivars under the agro-climatic conditions of Quetta.Second, to evaluate the yield response of different brassica cultivars associated with influence of Quetta climate.

Materials and methods

For the investigation of growth and yield performance of different brassica cultivars under the Agro-ecological condition of Quetta, a field experiment was carried out during 2014 at the experimental field of Agriculture Research Institute Sariab Quetta with Latitude of 30° 6'50.27"N and Longitude of 66°58'44.17"E. The research trial was based on complete randomized block design (RCBD) of single factorial with four brassica cultivars as treatments and were replicated thrice. The experimental details are as under:

Treatments

T_1 = Sultan Raya

T_1 = Bard-1

T_1 = Dunkeld

T_1 = Con-II

Source of Seeds

The seed of four brassica cultivars were collected from the Directorate of Agriculture Research Oil Seed Crop, ARI Sariab Quetta.

Land preparation

Before the preparation of land, the field was irrigated using tube well water. When the soil moisture level was reached to field capacity after one week of irrigation then land was prepared as per agronomic procedure with two ploughing by cultivator followed by blanking. Then field was laid out according to the plan of study with plot size of 5.0 x 3.0 m and total of 12 plots of same size were made.

Seed sowing and fertilizer application

The seeds of four brassica cultivars were sown on 6th March 2014 with single row hand drill using seed rate of 5 kg ha^{-1} while keeping planting distance at 30 cm. Thinning was done twice up to the age of one month

to maintain a distance of 10 cm between the plants. Nitrogen and phosphorus in the form of urea and triple super phosphate were applied @ 90 kg N ha^{-1} and at 60 kg P ha^{-1}, respectively. Whole of the phosphorus and 1/3 of nitrogen was applied as a basal dose while remaining 2/3 nitrogen was applied in two equal splits half at first irrigation and half at development stage.

Irrigation

The crop was irrigated three times during the entire period of growth using tube well water. First irrigation was applied 30 days after sowing, second at flowering and third at the start of seed development.

Weed and pest control

Two hoeing were given to keep the field free from weeds. Insecticides were sprayed for the control of aphids. All the other agronomic practices were kept normal and uniform for all the experimental units.

Soil analysis

Before the installation of experiment, composite soil sample was collected and analyzed for texture, EC, pH, organic matter, totol N, P and K contents. The detailed methods of soil analysis are described below under separate heading:

Electrical conductivity and pH

For measurement of electrical conductivity (EC) and pH, soil water extracts in 1:5 soil-water were prepared. Twenty gram soil along with 100 ml distilled water in a 250 ml conical flask on mechanical shaker was shaken for 30 minutes at 180 rpm.

The suspension was filtered and used for determination of EC and pH. For pH measurement, pH meter (ModelWTW pH 720) with glass electrode was used. The pH meter was calibrated by using buffers of pH 7.0 and 9.2 before recording the sample readings. For EC measurement, EC meter (ModelHI 8033) based on Wheatstone bridge circuit was calibrated by using 0.02 M KCl solution. Before EC measurement, both KCl solution and soil-water extracts were maintained at 25 ^{o}C (McLean, 1982).

Organic matter

Two g soil was taken in to 500 ml conical flask and 10 ml of Potassium dichromate ($K_2Cr_2O_7$)solution and 20 ml concentrated H_2SO_4 were added. The flask was swirled for complete contact of soil with the reagent and kept for 30 minutes.

The contents of flask were diluted by adding 200 ml water followed by 30 drops of diphenylamine indicator and then titrated against 0.5N $(NH_4)_2SO_4$. $6H_2O$ until the colour sharply shifted from violet blue to brilliant green.

Nitrogen, phosphorus and potassium in soil

All the samples were analyzed for Kjeldahl's N, and ABDTPA extractable P and K. Kjeldahl's N was estimated by digesting the contents in H_2SO_4 followed by distillation and finally titrating the distillate with acid (Jones, 1991). Available P and K were extracted with AB-DTPA (Soltanpour and Schwab, 1977) and the P in the extracts was determined by developing a blue color method as given by Cotteni (1962), while K was analyzed directly by emission spectroscopy using flame photometer (Knudsen *et al.*, 1982).

Study parameters

Plant height (cm):Height of ten plants from each plot was measured from ground level to the top of the plant at harvest through measuring tape which were selected randomly and then calculated the average plant height.

Number of pods $plant^{-1}$:Randomlyten plants from each plot were tagged and all the pods $plant^{-1}$ were manually counted and averaged to no. of pods $plant^{-1}$.

Number of seeds pod^{-1}:Ten pods were randomly selected from each plot and number of seeds pod^{-1} of each one was counted and the average number of seeds pod^{-1} were calculated.

Seed index: 1000 grains were weighed on an electric balance after sun drying.

Biological yield (kg ha^{-1}):Biological yield was obtained from harvest of m^2, weighed and computed for ha^{-1} at harvest.

Grain yield (kg ha^{-1}):Grain yield was recorded after harvesting and threshing as per treatment with plot size of 15 m^2 and then converted them into kg ha^{-1} with simple conversion calculation.

Harvest Index:Harvest index was calculated through the following formula:

$$\text{Harvest index} = \frac{\text{Grain yield}}{\text{Biological}} \text{ x100}$$

Statistical analysis

The randomized complete block design was carried out through Statistix 8.1 computer software. The LSD value for mean comparison was calculated only if the general treatment F test was significant at probability of ≤0.05 (Gomez and Gomez, 1984). Correlation was carried out to know the strength of relationship between yield components and growth components.

Results

The results of this study regarding plant height, number of pods plant^{-1}, number of seeds pod^{-1}, seed index, biological yield, grain yield and harvest index are described in Table-1, Fig. 1 to 7 and appendix I-VII. While the correlation among them where possible are presented in Fig. 8-12.

Table 1. Pre-soil analysis of the experimental site.

Soil properties	Units	Value
Sand	%	60.1
Silt	%	12.6
Clay	%	27.3
Texture Class		Sandy clay loam
Organic matter	%	0.78
EC (1:5)	dSm^{-1}	2.31
pH (1:5)		8.10
Calcium	meq/100g soil	15.6
Magnesium	meq/100g soil	8.4
Total nitrogen (N)	%	0.041
AB-DTPA extractable Phosphorus (P)	Ppm	2.33
AB-DTPA extractable Photassium (K)	Ppm	180.60

Table 2. Mean, minimum and maximum values of Brassica yield.

Plant traits	Minimum	Maximum	Mean	SE±
Plant height (cm)	96.00	134.00	110.83	3.91
Number of pods plant^{-1}	224.00	301.00	272.83	7.03
Number of seeds pod^{-1}	15.00	25.00	19.50	0.996
Seed index	3.10	4.90	3.87	0.185
Biological yield (kg ha^{-1})	15827	22326	19839	554.30
Gain yield (kg ha^{-1})	1422	3285	2302.3	161.49
Harvest index	6.57	17.93	11.83	1.01

Plant height (cm)

The data regarding plant height of four brassica cultivars is given in Table-2 & 3, Fig.-1 and appendix-I. All the four cultivars showed significant variations in plant height. The overall plant height was ranged between 96.00 and 134.00 cm with mean value of 110.83 cm. The analysis of variance showed a significant (P≤0.01) differences in plant height with F value of 25.13 (Appendix-I). The LSD test for comparison of means (P≤0.05) showed a significant plant height within brassica cultivars. The mean maximum plant height of 123.00 was recorded in

Bard-1.

Number of pods plant^{-1}

The data regarding number of pods plant^{-1} of four brassica cultivars is given in Table-2 & 4, Fig.-2 and appendix-II. All the four cultivars showed significant variations in number pods plant^{-1}. The overall number of pods plant^{-1} were ranged between 224 and 301 with mean value of 272.83 The analysis of variance showed a significant (P≤0.01) differences in number of pods plant^{-1} with F value of 18.92 (Appendix-II). The LSD test for comparison of means (P≤0.05) showed significant variations in no. of pods plant^{-1} within brassica cultivars.

Table 3. Plant height (cm) of four Brassica cultivars.

Brassica cultivars	Plant height (cm)
Sultan Raya	#121.33 a
Bard-1	123.00 a
Dunkeld	98.67 b
Con-II	100.33 b
S.E. ±	3.70
LSD at P value of 0.05	9.06

The mean maximum but significant number of pods plant^{-1} of 293.67 and 285.67 were recorded in Con-II and Dunkeld and minimum was 264 in Sultana Raya followed by 248 in Bard-I. Statistically, the two brassica cultivars i.e. Bard-I and Sultan Raya did not differed from each and both were non-significantly lower than other two cultivars. Among them, the canola type cultivars i.e. Dunkeld and Con-II. Produced higher number of pods plant^{-1}.

Table 4. Number of pods plant^{-1} of four Brassica cultivars.

Brassica cultivars	Number of pods plant^{-1}
Sultan Raya	248.00 b
Bard-1	264.00 b
Dunkeld	285.67 a
Con-II	293.70 a
S.E. ±	6.75
LSD at P value of 0.05	16.52

* Mean bearing the same letters is statistically non-significant.

Number of seed pod^{-1}

The data regarding number of number of seeds pod^{-1} of four brassica cultivars is given in Table-2 & 5, Fig.3 and Appendix-III. All the four cultivars showed significant variations in number of seeds pod^{-1}.

The overall number of seeds pods^{-1} were ranged between 15.00 and 25.0 with mean value of 19.50. The analysis of variance showed a significant (P≤0.01) differences in no. of seeds pod^{-1} with F value of 37.85 (Appendix-III). The LSD test for comparison of means (P≤0.05) showed significant variations in no. of seeds pod^{-1} within brassica cultivars.

The mean maximum no. of seeds pod^{-1} of 24.0 in Con-II followed by 21.0 in Dunkeld and minimum was 16.0 in Sultana Raya. Statistically, the two brassica cultivars i.e. Bard-I and Sultan Raya did not differed from each and both were non-significantly lower than other two cultivars. Among them, the canola type cultivars i.e. Dunkeld and Con-II. Produced higher number of seeds pod^{-1}.

Table 5. Number of seeds pod^{-1} of four Brassica cultivars.

Brassica cultivars	Number of seeds pod^{-1}
Sultan Raya	16 c
Bard-1	17 c
Dunkeld	21 b
Con-II	24 a
S.E. ±	0.85
LSD at P value of 0.05	2.08

Mean bearing the same letters is statistically non-significant.

Table 6. Seed index of four Brassica cultivars.

Brassica cultivars	Seed index
Sultan Raya	3.33 b
Bard-1	3.33 b
Dunkeld	4.30 a
Con-II	4.47 a
S.E. ±	0.09
LSD at P value of 0.05	0.23

*Meanbearing the same letters is statistically non-significant.

Seed index

The data regarding seed index of four brassica cultivars is given in Table-2 & 6, Fig.4 and Appendix-IV. All the four cultivars showed significant variations in seed index. The overall seed index was ranged between 3.1 and 4.90 with mean value of 3.87. The analysis of variance showed a significant (P≤0.01) differences in seed index with F value of 86.0 (Appendix-IV). The LSD test for comparison of means (P≤0.05) showed significant variations in seed index within brassica cultivars.

Table 7. Biological yield (t ha^{-1}) of four Brassica cultivars.

Brassica cultivars	Biological yield (t ha^{-1})
Sultan Raya	20.77 ab
Bard-1	21.38 a
Dunkeld	19.44 ab
Con-II	17.77 b
S.E. ±	1.32
LSD at P value of 0.05	3.25

*Mean bearing the same letters is statistically non-significant.

Table 8. Grain yield (kg ha^{-1}) of four brassica cultivars.

Brassica cultivars	Grain yield (t ha^{-1})
Sultan Raya	1.74 c
Bard-1	2.08 b
Dunkeld	2.59 a
Con-II	2.79 a
S.E. ±	1.17
LSD at P value of 0.05	2.87

*Mean bearing the same letters is statistically non-significant.

The mean maximum seed index of 4.47 in Con-II followed by 4.33 in Dunkeld and minimum was 3.33 in Sultana Raya and Bard-1. Statistically, the seed index of two brassica cultivars i.e. Bard-I and Sultan Raya did not differed from each and both were non-significantly lower than other two cultivars which were also statistically same. Among them, the canola type cultivars i.e. Dunkeld and Con-II. Produced higher seed index.

Table 9. Harvest index (%) of four brassica cultivars.

Brassica cultivars	Harvest index (%)
Sultan Raya	8.54 c
Bard-1	9.34 c
Dunkeld	13.37 b
Con-II	15.67 a
S.E. ±	0.90
LSD at P value of 0.05	2.21

*Mean bearing the same letters is statistically non-significant.

Biological yield (kg ha^{-1})

The data regarding biological yield of four brassica cultivars is given in Table-2 & 7, Fig.5 and Appendix-V. All the four cultivars showed non-significant variations in biological yield. The overall biological yield was ranged between 1422 and 3285 kg ha^{-1} with mean value of 2302.3. The analysis of variance showed a significant (P≤0.01) differences in grain yield with F value of 8.13 (Appendix-VI). The LSD test for comparison of means (P≤0.05) showed significant variations in grain yield within brassica cultivars.

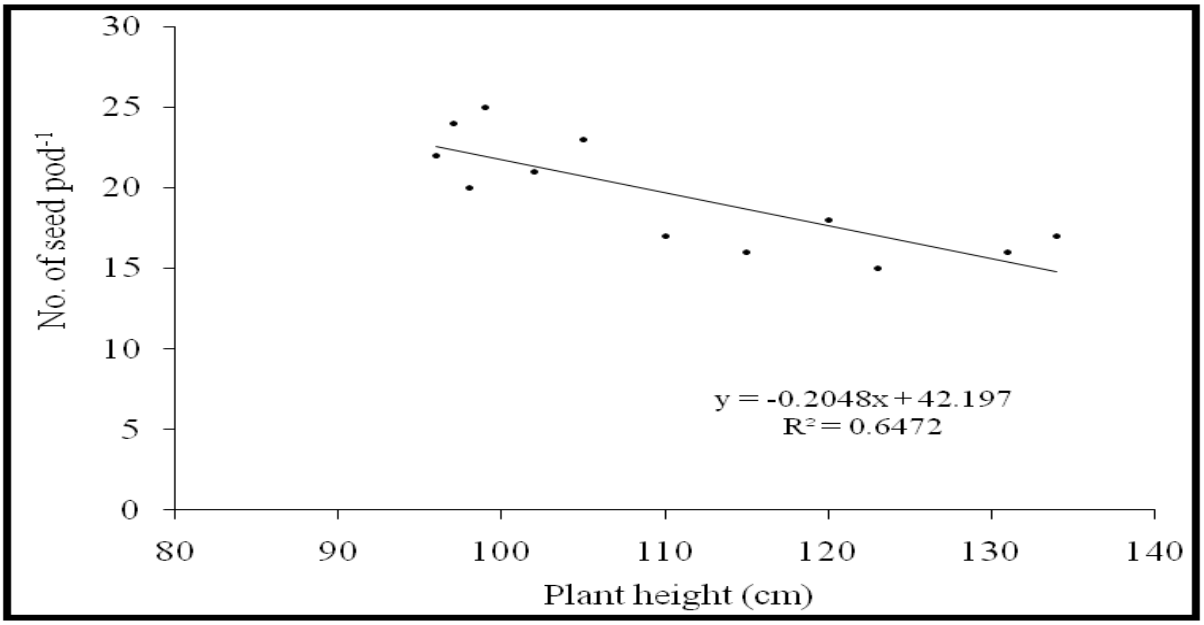

Fig. 8. Linear correlation between plant height and number of seeds pod^{-1}.

The mean maximum biological yield of 21380 kg ha^{-1} in Bald-I and minimum was 17771 kg ha^{-1} in Cont-II. Statistically, the biological yield of two brassica cultivars i.e. Sultan Raya and Dunkeld did not differed from each other. Among them, the canola type cultivars i.e. Dunkeld and Con-II produced lower biological yield.

Grain yield (kg ha^{-1})

The data regarding grain yield of four brassica cultivars is given in Table-2 & 8, Fig.6 and Appendix-VI. All the four cultivars showed significant variations

in grain yield. The overall grain yield was ranged between 15827 and 22326 with mean value of 19839. The analysis of variance showed a non-significant (P≤0.01) differences in biological yield with F value of 2.91 (Appendix-V). The LSD test for comparison of means (P≤0.05) showed no-significant variations in biological yield within brassica cultivars. The mean maximum but non-significant grain yield of 2791.0 and 2592 kg ha^{-1} was found in Con-II and Dunkeld and minimum was 1742.0 kg ha^{-1} in Sultana Raya.. Statistically, the biological yield of two brassica cultivars i.e. Sultan Raya and Dunkeld did not differed from each other. Among them, the canola type cultivars i.e. Dunkeld and Con-II produced higher grain yield kg ha^{-1}.

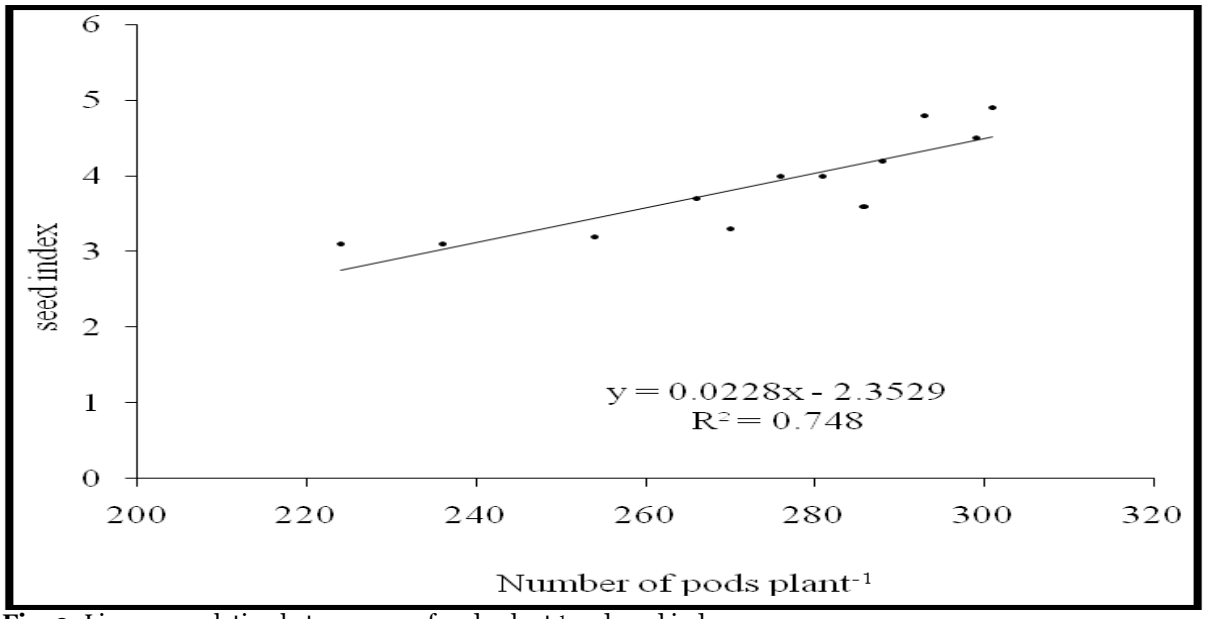

Fig. 9. Linear correlation between no. of pods plant^{-1} and seed index.

Harvest index

The data regarding harvest index of four brassica cultivars is given in Table-2 & 9, Fig.7 and Appendix-VII. All the four cultivars showed significant variations in harvest index.

The overall harvest index was ranged between 6.57 and 17.93 with mean value of 11.83. The analysis of variance showed a significant (P≤0.01) differences in harvest index with F value of 0.03 (Appendix-VII).

The LSD test for comparison of means (P≤0.05) showed significant variations in harvest index within brassica cultivars.

The mean maximum harvest index of 15.67 in Con-II followed by 13.37 in Dunkeld and minimum was 8.54in Sultan Raya. Statistically, the harvest index of two brassica cultivars i.e. Sultan Raya and Bald-I did not differed from each other. Among them, the canola type cultivars i.e. Dunkeld and Con-II produced higher harvest index.

Correlation

The linear correlation was found between plant height and number of seeds pod^{-1}, number of pods plant^{-1} and seed index, number pods plant^{-1} and grain yield, number of seeds pod^{-1} and harvest index as well as biological yield and harvest index under the influence of different brassica cultivars in field study which are presented in Figure 8-12. According to Fig.8, there was negatively significant correlation between plant height and number of seed pod^{-1}. The coefficient of determination (R^2) showed that variation in number of seed was due to its association with plant height (64%).

The correlation coefficient indicated that a unit increase in plant height resulted in corresponding increase of number of seeds pod^{-1} by 0.2%. Likewise,

number of pods plant^{-1} was positively and significantly correlated with seed index as indicated by coefficient of determination (R^2) of 74%. The correlation coefficient showed that a unit increase in number of pods plant^{-1} have resulted in the corresponding increase in seed index by 0.02% (Fig. 9). While, in case of number of pods plant^{-1} and grain yield, the yield was positively and significantly correlated to number of pods plant^{-1} with coefficient of determination (R^2) of 79% while the correlation coefficient indicated that a unit increase in number of pods plant^{-1} was resulted in increase of yield by 20.45% (Fig. 10).

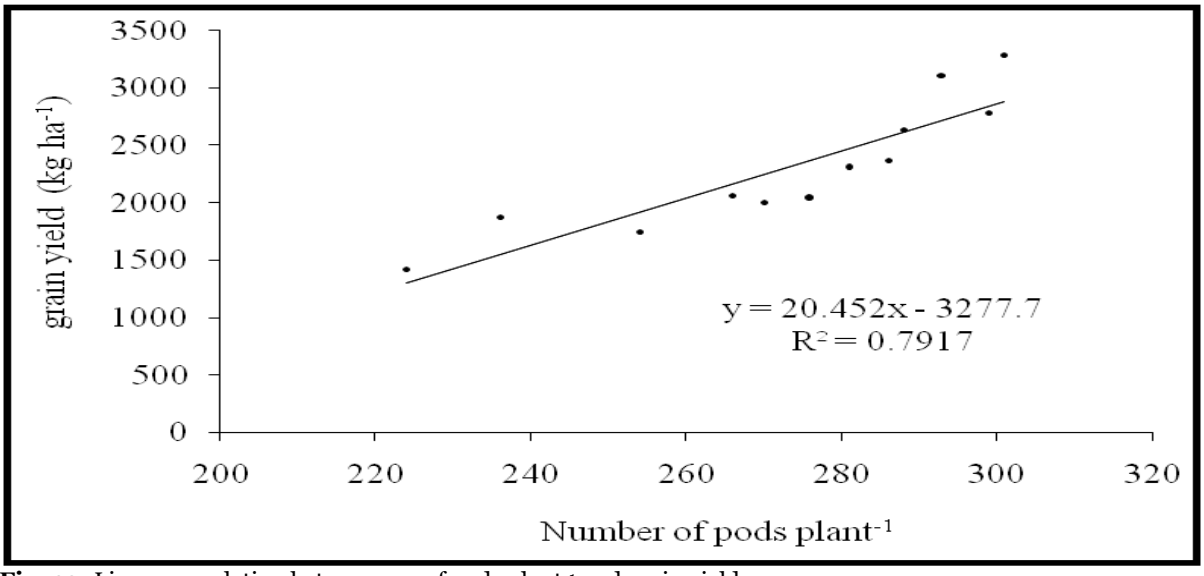

Fig. 10. Linear correlation between no. of pods plant^{-1} and grain yield.

Number of pods plant^{-1} were also correlated to harvest index with coefficient of determination (R^2) of 74% while the correlation coefficient indicated that a unit increase in number of pods plant^{-1} was resulted in increase of harvest index by 0.12% (Fig. 11). However, a negatively significant correlation was found between biological yield and harvest index with the coefficient of determination (R^2) of 52% while the correlation coefficient showed that a unit increase in biological yield resulted in increase of harvest index by 0.001% (Fig.12).

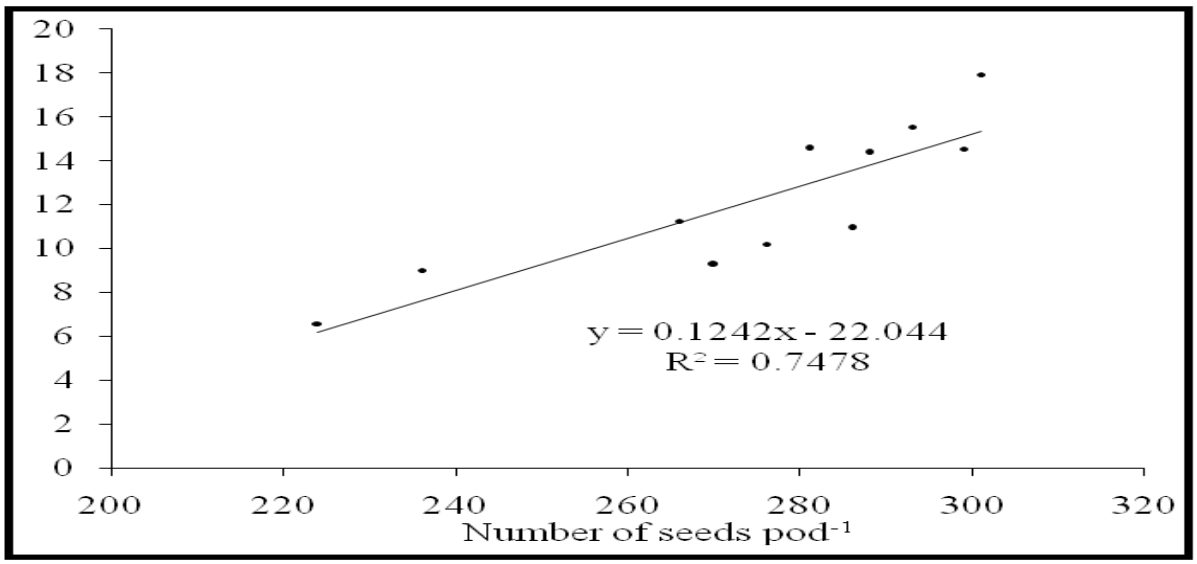

Fig. 11. Linear correlation between no. of pods plant^{-1} and harvest index.

Discussion

Plant height

As regard to plant height, present investigation showed significant variations in plant height under the influence of cultivars and the maximum plant height of 123.00 cm was recorded in Bard-1 followed by 121.33 cm in Sultan Raya and minimum was 98.67 cm in Dunkeld. Statistically, the two brassica cultivars i.e. Bard-I and Sultan Raya did not differed from each and both were non-significantly higher over other two cultivars Dunkeld and Con-II which were also statistically same from each other. Among them, Sultana Raya and Bard-1 were non-canola type while Dunkeld and Con-II were canola type. So, the plant height of non-canola types was higher as compared to canola types.

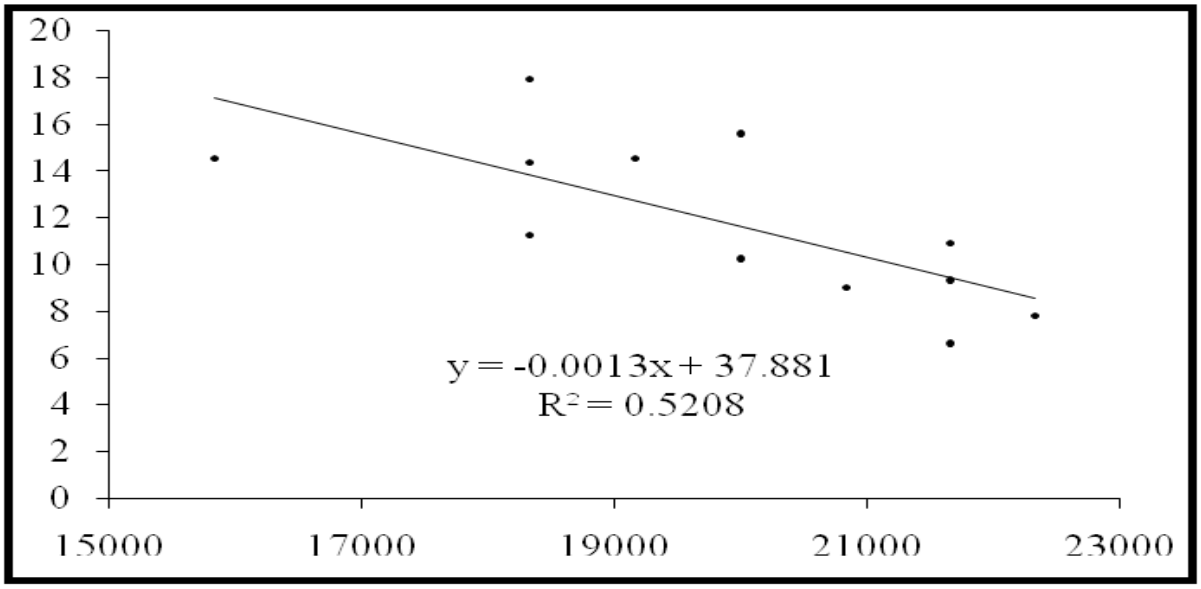

Fig. 12. Linear correlation between biological yield and harvest index.

This variation in plant height might be due to the genetic characteristics of the canola and non-type cultivars rather than climate change as the agro ecological zone of Quetta because there is non-significant differences within non-canola and canola type brassica cultivars. Such variability in plant height was also reported by Khatri *et al.,* (2004) who reported variability of plant height among different brassica genotypes under rainfed conditions. Similarly, El-Nakhlawy and Ahmed (2009) also reported that Sero-4 genotype produced taller plants in comparison to others composite brassica genotype under different irrigation regimes and nitrogen fertilizer application, respectively.

Growth of plant depends on cell expansion and enlargement which is probably the most sensitive physiological aspect of a plant with regard to water deficit leading to reducing plant productivity (Larson, 1992) and thus affects plant height. Mastro (1995), Reddy and Reddy (1998) and Ozer (2003) reported that different brassica varieties differed significantly with regard to their plant height. Cheema *et al.,* (2001) recorded a range of 178-215 cm of plant height while Sana *et al.,*(2003) recorded 198-229 cm plant height of brassica varieties but in our experiment, a range of 96-134 cm was recorded.

Among the study parameters, linear correlation was found between plant height and number of seeds pod^{-1}. But this correlation was negatively significant with 64% coefficient of determination (R^2) and showed that variation in number of seed was due to its association with plant height. However, a different correlation was found by Ansar *et al.* (2014) who reported the relationship between plant height and number of branches that showed a linear regression with each other. The number of branches per plant increased by 0.08 with each cm increase in plant height of brassica varieties.

Number of pods plant^{-1}

As regard to number of pods plant^{-1}, The mean maximum but significant no. of pods plant^{-1} of 293.67 and 285.67 were recorded in Con-II and Dunkeld and minimum was 248 in Sultana Raya followed by 264 in Bard-I. Statistically, the two brassica cultivars i.e. Bard-I and Sultan Raya did not differed from each and both were non-significantly lower than other two cultivars. Among them, the canola type cultivars i.e. Dunkeld and Con-II. Produced higher number of pods plant^{-1}. Number of pods plant^{-1} were positively and significantly correlated with seed index, grain yield and harvest index showing coefficient of determination (R^2) of 74, 79 and 74%. Similar correlation was found by Shi *et al.* (2009) who reported a significant positive relationship between seed yield, seeds per silique, siliques per plant, plant height and seed weight. They further revealed that the results from each study represent different environments, locations and years, so clearly more studies need to be completed in specific environments. Chay and Thurling (1989) also reported a positive correlation between seeds per silique and silique length, but a negative correlation between seeds per silique and seed weight.

Number of seeds pod^{-1},seed index, grain yield and harvest index

In case of number of seeds pod^{-1}, seed index, grain yield and harvest index, their mean maximum values of 24.0 seeds pod^{-1}, 4.47 g, 2791.0 kg ha^{-1} and 15.67% were found in Con-II followed by Dunkeld and minimum of 16.0 seeds pod^{-1}, 3.33 g, 1742.0 kg ha^{-1} and 8.54%were present in Sultana Raya. Statistically, the canola type cultivars i.e. Dunkeld and Con-II. Produced higher number of seeds pod^{-1}, seed index, grain yield and harvest index.

Among them, the canola type cultivars i.e. Dunkeld and Con-II performed better than Sultana Raya and Bard-I. However, successes regarding use of yield components to increase seed yield in rapeseed have been variable. The components most predictive of yield reported in scientific literature include siliques per plant, (for which siliques per main raceme is often used as a proxy), seeds per silique, plant height, silique length, seed weight and oil content (Marjanovic-Jeromela *et al.*, 2011). Different researcher have been conducted studies to examine correlations of these traits to yield, which have been valuable with respect to dissecting this complex trait. However, these results have been inconsistent in the literature. For example, Chay and Thurling (1989) reported a positive correlation between seeds per silique and silique length, but a negative correlation between seeds per silique and seed weight. Although this negative relationship was also reported by Zhang *et al.* (2011).

Biological yield

As regard to biological yield, the mean maximum biological yield of 21380 kg ha^{-1} in Bard-I and minimum was 17771 kg ha^{-1} in Cont-II. Statistically, the biological yield of two brassica cultivars i.e. Sultan Raya and Dunkeld did not differed from each other. Among them, the canola type cultivars i.e. Dunkeld and Con-II produced lower biological yield. However, a negatively significant correlation was found between biological yield and harvest index with the coefficient of determination (R^2) of 52% while the correlation coefficient showed that a unit increase in biological yield resulted in increase of harvest index by 0.001%.

Conclusion

From this study, it was concluded that under agro-climatic condition of Quetta the brassica cultivar Dunkeld performed best in respect of seeds pod^{-1}, number of seeds pod^{-1}, seed index, grain yield and harvest index but its plant height and biological yield was lower as compared to other cultivars.

The positive and significant correlation was found among the yield components which showed that the high yield of Dunkeld followed by Cont-II was due to the enhancement of these components. Among the four cultivars, two non-canola types such as Sultana Raya and Bard-1 did not prove better yield performance under Quetta conditions. So, it is suggested that the canola type's cultivars *viz.* Dunkeld

and Cont-II can be grown successfully in Quetta valley and it can further be evaluated for other locations in Balochistan.

References

Ali HG, Saleem KN, Saif AL, Ahmed NA. 2011. Adaptability of canola (Brassica junicea) varieties in different regions of Oman. International Journal of Agriculture and Biology **13(5),** 831-834.

Ali I, Ahmed HM, Shah SA. 2013. Evaluation and selection of rapeseed (Brassica napus L.) mutant lines for yield performance using augmented design. The Journal of Animal and Plant Sciences **23(4),** 1125-1130.

Anonymous. 2010. Economic Survey of Pakistan, Ministry of Finance, Government of Pakistan, Islamabad.

Anonymous. 1995. Oilseeds Development Strategy NODP, MINFAL, Govt. of Pakistan, Islamabad, Pakistan.

Anonymous. 2012-13. Economic Survey of Pakistan. Government of Pakistan, Finance and Economic Affairs Division, Islamabad, 21.

Ansar M, Ahmed S, Asim M, Mubashir H, Muhammad I, Majid M. 2014. Comparison of Hybrids verses Composite Brassica Varieties for Forage and Seed Yield under Rainfed Conditions of Pothwar. Life Sciences Journal **11(10),** 149-154.

Baig A, Ali N. 1982. Rape and Mustard-Invaluable Edible Oils Crops in Pakistan, Progressive Farming, **2(5),** 20-26.

Balodis O, Zinta G. 2012. Oil seed rape (Brassica napus sp. Oleifera) seed yield depending on several agro-ecological factors. Renewable Energy and Energy Efficiency, p 39-44.

Bouyoucos GJ. 1962. Hydrometer method improved for making particle-size analysis of soils. Agron. J., **53,** 464-465.

Canola Council of Canada. 2009. Canola Meal: Feed industry guide (4th ed.)[Brochure] Available at http://www.canolacouncil.org.

CCC. 2007. Canola Growers Manual; Canola Council of Canada.

Champiri RM, Hossein B. 2013. Yield and yield component canola cultivars (Brassica napus L.) under influence by planting densities in Iran. International Research Journal of Applied and Basic Sciences **4(2),** 353-355.

Chay, Thurling. 1989. Identification of genes controlling pod length in spring rapeseed, Brassica napus L., and their utilization for yield improvement. Plant Breed **103,** 54-62.

Cheema MAM, Asghar M, Basra SMA. 2001. Comparative growth and yield performance of different brassica varieties. International Journal of Agriculture and Biology **3(1),** 135-137.

Colton RT, Sykes JD. 1992. Canola (Agfact P5.2.1). NSW Agriculture, p 1-52.

Coonrod D. 2005. Inheritance of oleic, eicosenoic and erucic acid in canola. (M.S. thesis) Colorado State University, Fort Collins, CO.

Cottenie A. 1980. Soil and plant testing as a basis of fertilizer recommendations. FAO Soil Bulletin 38/2.

Delourme R, Falentin C, Huteau V, Clouet V, Horvais R, Gandon B, Specel S, Hanneton L, Dheu JE, Deschamps M, Margale E, Vincourt P, Renard M. 2006. Genetic control of oil content in oilseed rape (Brassica napus L.). Theor. Appl. Genet., **113,** 1331-1345.

Elewa TA, Mekki BB, Bakry BA, El-Kramany MF. 2014. Evaluation of some introduced Canola (Brassica napus L.) varieties under different Nitrogen

Fertilizer levels in Newly Reclaimed Sandy soil. Middle-East Journal of Scientific Research **21(5),** 746-755.

El-Nakhlawy FS, Ahmed AB. 2009. Performance of canola (Brassica napus L.) seed yield, yield components and seed quality under the effects of four genotypes and nitrogen fertilizer rates. Met., Env. & Arid Land Agric.Sci., **20(2),** 33-47.

Gomez KA, Gomez AA. 1984. Statistical procedures for agricultural research. John Wiley and sons, Inc. London, UK (2nd edtn), 13-175.

Government of Pakistan. 2014. Pakistan Bureau of Statistics, Islamabad.

ICE. 2007. The IntercontinentalExchange (ICE) became the center of global trading in canola with its acquisition of the Winnipeg Commodity Exchange at the end of 2007. ICE Futures Canada, p 1-5. theice.com/canola

Jianyi Z, Zhartg D, Chen A, Wang BF. 1993. Analysis of yield stability and adaptability of some rapeseed cultivars with high quality and genetic effects of yield components. Acta Agriculturae Universitis Chekianensis **19(3),** 367-372.

Jones Jr. JB. 1991. Kjeldahl's method for nitrogen determination. Micro-Macro Publishing Inc., Athens, GA, USA.

Khatri A, Khan IA, Saddique MA, Nizamani G. Raza HS. 2004. Performance of oilseed brassica in different water regime. Pak.J. Bot., **36(2),** 351-357.

Kimber D, McGregor DI. 1995. Brassica oilseeds: Production and utilization. Wallingford, UK: CAB International.

Knudsen D, Peterson GA, Pratt PF. 1982. Lithium, sodium and potassium. P. 225-245. In: A.L page (Ed.), Methods of Soil Analysis, Part 2: Chemical and microbiological properties. Am. Soc. Agron, Madison WI, USA.

Larson KL. 1992. Drought injury and resistance of crop plants. In: Physiological aspects of dry land farming (Ed.): S.U. Gupta. pp. 147-162. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.

Lefsrud MG, Kopsell DA, Kopsell DE, Curran-Celentano J. 2005. Air temperature affects biomass and carotenoid pigment accumulation in kale and spinach grown in a controlled environment. HortScience **40,** 2026-2030.

Luo Q. 2011. Temperature thresholds and crop production: a review. Climate Change **109,** 538-598.

Marjanovic-Jeromela A, Marinkovic R, Ivanovska S, Jankuovska M, Mijic A, Hristov N. 2011. Variability of yield determining components in winter rapeseed (Brassica napus L.) and their correlation with seed yield. Genetika, **43(1),** 51-66.

Mastro G. 1995. Rape, Metapontum area. Informatore Agrario **51,** 26-27.

McLean EO. 1982. Soil pH and lime requirement P. 199-224. In: Page, A.L. (Ed.), Methods of Soil Analysis, Part 2: Chemical and microbiological properties. Am. Soc. Agron, Madison WI,USA.

Mehmood T, Ejaz-ul-Hasan Muhammad A, Makhdoom H. 2012. Faisal canola: a new high yielding canola variety for general cultivation in Punjab. J. Agric. Res., **50(3),** 321-328.

Nesi N, Delourme R, Bregeon M, Falentin C, Renard M. 2008. Genetic and molecular approaches to improve nutritional value of Brassica napus L. seed. C. R. Biology **331,** 763-771.

Nuttall WF, Downey RK, Raney JP. 1993. The effect of Climate on the yield and growth of canola in Western Canada. Agriculture and Agri-Food Canada, p 122-127.

Oad FC, SoAzsssssswlangi BK, Samo MA, Lakho AA, Zia-ul-Hassan, Oad NL. 2001. Growth, yield and relationship of rapeseed (Brassica napus L.) under different row spacing. International Journal of Agriculture and Biology **03(4),** 475-476.

Ozer H. 2003. The effect of plant population densities on growth, yield and yield components of two spring rapeseed cultivars. Plant Soil Environ., **49(9),** 422-426.

Pek Z, Daood H, Nagyne MG, Berki M, Tothne MM, Nemenyi A, Helyes L. 2012. Yield and phytochemical compounds of broccoli as affected by temperature, irrigation, and foliar sulfur supplementation. HortScienc **47,** 1646-1652.

Pekrun C, Hewitt JDJ, Lutman PJW. 1998. Cultural control of volunteer oilseed rape. Journal of Agricultural Science **130,** 155-163.

Polowick PL, Sawhney VK. 1988. High temperature induced male and female sterility in canola (Brassica napus L.). Annals of Botany **62,** 83-86.

Potter T, Macroft S, Walton, Parker P. 1999. Climate and Soils. Chapter 2. In: Canola in Australia: the first thirty years, P.A. Saliburry, T.C. Potter, G. McDonald, A.G. Green, eds., p 5-8.

Rashid A. 2010. Rapeseed-Mustard. Pakistan Agriculture Research Council, Islamabad.

Reddy CS, Reddy PR. 1998. Performance of mustard varieties on alfisols of Rayalaseema Region of Andhra Pradesh. J.Oilseeds Res., **15,** 379-380.

Richards LA. 1954. Diagnosis and improvement of saline and alkali soils. USDA Agric. Handbook 60. Washington, D.C.

Sana M, Ali A, Malik MA, Saleemand MF, Rafiq M. 2003. Comparative yield potential and oil contents of different canola cultivars (Brassica napus L.). Pak. J.Agron. **2(1),** 1-10.

Shahid LA, Mohammad AS, Nadeem A. 2010. Present status and future prospects of mechanized production of oilseed crops in Pakistan-a review. Pakistan J. Agric. Res., **23(1-2),** 83-93.

Shahidi F. 1990. Canola and Rapeseed: Production, Nutrition, and Processing Technology. New York USA: Van Nostrand Reinhold Publishing.

Shahraki M, Rasolov S, Mohammad G, Haimidreza F. 2012. Investigation of correlation yield and yield components of 12 spring canola hybrids in Iranshahr climatic region. African Journal of Agricultural Research **7(20),** 3134-31.38.

Shi J, Li R, Qiu D, Jiang C, Long Y, Morgan C, Bancroft I, Zhao J, Meng J. 2009. Unraveling the complex trait of crop yield with quantitative trait loci mapping in Brassica napus. Genetics **182,** 851–861.

Soltanpour PN, Schwab AP. 1977. A new soil test for simultaneous extraction of macro-micro nutrients in alkaline soils. Commun. Soil Sci. Plant Anal., **8,** 195-207.

Taiz L, Zeiger E. 2002. Plant physiology. Sinauer Associates Inc. Publishers.

Walkley A, Black IA. 1934. An examination of the method for determining soils organic matter and a proposed modification of the chromic acid titration method. Soil Sci., **37,** 29-38.

Waseem M, Dost MB, Imran K. 2014. Influence of various row spacing on the yield and yield components of Raya Anmol and Faisal Canola under Coastal Climatic conditions of Lasbella. American Journal of Plant Science **5,** 2230-2236.

Wittkop B, Snowdon RJ, Friedt. 2009. Status and perspectives of breeding for enhanced yield and quality of oilseed crops for Europe. Euphytica **170,** 131-140.

Zhang L, Yang G, Liu P, Hong D, Li S, He Q. 2011. Genetic and correlation analysis of silique-traits in Brassica napus L. by quantitative trait locus mapping Theor Appl Genet **122,** 21-31.

Appendix-I. Analysis of variance pertaining to plant height of Brassica crop under the influence of cultivars.

Source	DF	SS	MS	F	P
Replication	2	348.67	174.33		
Cultivars	3	1549.67	516.56	25.13**	0.001
Error	6	123.33	20.60		
Total	11	2021.70			
CV %	4.10				

Appendix-II. Analysis of variance pertaining to no. of pods plant^{-1} of Brassica under the influence of cultivars.

Source	DF	SS	MS	F	P
Replication	2	2225.17	1112.58		
Cultivars	3	3880.33	1293.44	18.92**	0.0018
Error	6	410.17	68.36		
Total	11	6515.67			
CV %	3.03				

Appendix III. Analysis of variance regarding no. of seed pod^{-1} of Brassica plant under the influence cultivars.

Source	DF	SS	MS	F	P
Replication	2	1.50	0.750		
Cultivars	3	123.00	41.000	37.85**	0.0003
Error	6	6.50	1.083		
Total	11	131.00			
CV %	5.34				

Appendix-IV. Analysis of variance regarding seed index of brassica under the influence of cultivars.

Source	DF	SS	MS	F	P
Replication	2	1.007	0.503		
Cultivars	3	3.440	1.145	86.00**	0.000
Error	6	0.080	0.013		
Total	11	4.530			
CV %	3.00				

Appendix-V. Analysis of variance regarding biological yield of brassica crop under the influence of cultivars.

Source	DF	SS	MS	F	P
Replication	2	1671648	835824		
Cultivars	3	2.31E+07	7682344	2.91NS	0.123
Error	6	1.583E+07	2639639		
Total	11	4.01E+07			
CV %	8.19				

Appendix-VI. Analysis of variance regarding seed grain yield of brassica crop under the influence of cultivars.

Source	DF	SS	MS	F	P
Replication	2	1263865	631933		
Cultivars	3	2054631	684877	33.15**	0.0004
Error	6	123956	20659		
Total	11	3442453			
CV %	6.24				

Appendix-VII. Analysis of variance regarding harvest index of brassica under the influence of cultivars.

Source	DF	SS	MS	F	P
Replication	2	29.963	14.981		
Cultivars	3	96.950	32.317	26.36	0.0007
Error	6	7.357	1.226		
Total	11	134.270			
CV %	9.36				