Pak. J. Agri. Sci., Vol. 49(2), 163-168; 2012
ISSN (Print) 0552-9034, ISSN (Online) 2076-0906
http://www.pakjas.com.pk

INFLUENCE OF DIFFERENT LEVELS OF POTASSIUM ON GROWTH, YIELD AND QUALITY OF CANOLA (*Brassica napus* L.) CULTIVARS

Mumtaz A. Cheema, M.A. Wahid, Abdul Sattar*, F. Rasul and M.F. Saleem

Department of Agronomy, University of Agriculture, Faisalabad-38040, Pakistan
*** Corresponding author's e-mail: abdulsattar04@gmail.com**

Potassium is one of the major nutrients whose deficiency decreased the growth and yield of canola. Current knowledge regarding K requirement of canola is limited. Thus the field study was carried out to assess the influence of different levels of K fertilization (0, 30, 60, 90,120 kg ha^{-1}) on two canola cultivars viz. Bulbul-98 and Zafar-2000. Results revealed that increasing rate of K enhanced leaf area index and crop growth rate in both cultivars. Highest seed yield (3067.24 kg ha^{-1}) was obtained when K was applied at 120 kg ha^{-1}. While minimum seed yield (2353.85 kg ha^{-1}) was recorded in case of control. Variety, Zafar-2000 produced more seed yield than Bulbul-98. Oil content progressively decreased with increase of K level with highest (42.46%) in case of control and lowest (39.25%) with a K level of 120 kg ha^{-1}. Similarly Zafar-2000 and Bulbul-98 produced 40.80% and 41.04% oil contents, respectively. From these results, it is concluded that potassium application at the rate of 120 kg ha^{-1} increased the growth, yield, and oil quality of canola.
Keywords: Canola, Oil contents, Potassium Fertilizer, yield and yield components

INTRODUCTION

Pakistan has been facing a scarcity of edible oils. As a result large quantities of edible oil are being imported from other countries annually. Our country is third largest importer of the edible oil in the world (Anjum, 1993). Only 23% of the total consumption was fulfilled by local oilseed production while the remaining 77% was fulfilled through imports (Govt of Pak., 2011). After Cotton, Rapeseed-mustard is the second most important source of domestic oil production. Oil obtained from conventional rapeseed and mustard is not considered as regular cooking oil because of its inferior quality due to the presence of high erucic acid (more than 40%) and glucosinolates (more than 100 micromole/g of dry meal) and low level of oleic and linoleic acids (Hassan *et al*., 2005).

In Pakistan, "Canola" (*Brassica napus* L.) is attaining the status of leading oilseed crop, both as a source of edible oil for human and a protein supplement for animals. It is cultivated throughout the country, either alone as main crop or intercrop with the other winter crops. Area under canola cultivation (223 thousand acres) with total production of the crop (136 thousand tons oilseed and 52 thousand tons oil) is much lower than the other oil producing countries (Govt of Pak, 2011).

The relative decrease in maximum crop potential yield associated with abiotic stress varies between 54-82% (Bray *et al.,* 2000). Among the environmental abiotic stresses, nutrients stress is one of the most severe stresses for plant growth and productivity. Also it is estimated that around 60% of cultivated soils have growth-limiting problems associated with mineral-nutrient deficiencies and toxicities (Cakmak, 2005; Fazili *et al*., 2010). Nutrients have pivotal role in increasing crop production. Besides N and P, the use of K has been reported to influence seed yield and seed oil contents (Ghosh *et al*., 1995; Pervez *et al*., 2004). K plays a vital role in photosynthesis, translocation of photosynthates, protein synthesis, control of ionic balance, regulation of plant stomata and water use, activation of plant enzymes and many other processes (Marschner, 1995; Reddya *et al*., 2004). It is not only an essential macronutrient for plant growth and development, but also is a primary osmoticum in maintaining low water potential of plant tissues. Efficient use of nutrients by canola cultivars are capable of producing high yields with low nutrient inputs and therefore have the potential to increase the productivity in soil with low nutrient availability. Many studies have reported the significant variation among the canola genotypes in efficiency of N and P uptake and utilization (Yau and Thurling, 1987; Svecnjak and Rengel, 2006). Limited study has investigated the requirement of K in canola. Keeping in view the importance of K in affecting quantitative and qualitative parameters of canola, the present experiment was conducted to investigate growth, yield and oil quality response of canola to different potassium levels.

MATERIALS AND METHODS

A field experiment was conducted to assess the influence of different levels of potassium fertilization (0, 30, 60, 90,120 kg K ha^{-1}) on two canola cultivars viz. Bulbul-98 and Zafar-2000 at Agronomic Research Area, University of Agriculture, Faisalabad-Pakistan during 2008-2009. It is grown from 24º N to 37º N, from 61º E to 76º E and from sea level to about 3000 m below snowline. The soil of experimental field was sandy loam that contained 0.929% organic matter (O.M.), 0.042% N, 6.7 ppm available phosphorus and 131 ppm available K with pH 8.0. Temperature and rainfall during the crop growing season have been shown in Fig.1. Weather data was collected from Agricultural Meteorology Cell, Department of Crop Physiology, University of Agriculture Faisalabad, Pakistan . Seed of canola cultivars were obtained from Ayub Agriculture Research Institute (AARI) Faisalabad, Pakistan. Experiment was laid out in Randomized Complete Block Design (RCBD) with factorial arrangement with three replications and net plot size was 1.8m x 5m. Crop was sown on October 5, using seed rate of 5 kg ha^{-1} in 30 cm apart rows with a single row hand drill. Nitrogen and phosphorous were applied at the rate of 90-60 kg ha^{-1} in the form of urea and di-ammonium phosphate while potassium sulphate was used as the sources of K respectively. All P, K and 1/2 N were side drilled at the time of sowing and remaining 1/2 N was top-dressed at early flowering stage.

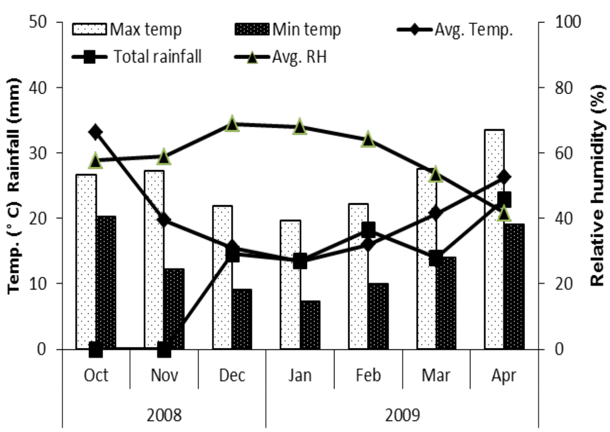

Figure 1. Summary of meteorological data (2008-2009)

At harvest, all yield and yield parameters were examined following standard procedure. After the 30 days of sowing, growth traits were examined five times during growth season at 15-days interval. Leaf area index (LAI) was calculated using the plant samples taken from a randomly selected unit area of each plot. Leaves were removed and measured the leaf area and dry matter accumulation. Leaf area index was calculated by taking the ratio of leaf area to ground surface area. Crop growth rate (CGR) was determined by the following formula derived by Hunt (1978): $CGR = (w_2 - w_1)/(t_2 - t_1)$

The oil contents of canola seeds were obtained by using Rooskvisky's method. Diethyl ether (of low boiling point i.e. 40-60) is used for extraction of fat from dry powdered material. "Soxhlet" apparatus is usually used for this routine analysis. The apparatus consists of an extraction tube, condenser and flask. Ether is poured in the flask that on heating evaporates and passes into the condenser from where it falls back in the extraction tube. The sample in the extraction tube comes in intimate contact with the solvent, when extract ether reaches the extraction tube; it is siphoned back in flask along with fat. Usually 4-6 siphonings are required to complete the extraction (A.O.A.C., 1984). For the determined protein contents seed sample were taken randomly from each plot, grinded and subjected to chemical analysis by using Gunning and Hibbard's method of H_2SO_4 digestion and using Micro Kjeldahl's method for distillation. From this whole process N % is obtained which then multiplied with a constant factor of 6.25 for protein content in the seed. The data collected were analyzed statistically by using Fisher's analysis of Variance technique and LSD test was employed at 5 % probability level to test the significance of difference among treatments' means (Steel *et al.,* 1997).

RESULTS

Results reveal that application of sulphur and nitrogen significantly influences the growth, yield and quality of canola.Leaf area index (LAI) and crop growth rate (CGR) was significantly affected by the application of potash in both cultivars. Both cultivar Zafar-2000 and Bulbul-98 attained maximum LAI at 75 days after sowing (DAS). LAI was increased slightly up to 75 days after sowing (DAS) and there was significant difference among all the treatments. After this LAI was decreased and minimum was recorded at 105 days after sowing (DAS) Fig.3. Different levels of potash fertilizer significantly influence the number of plants per m^2 and plant height (cm) at maturity. Number of plants per m^2 of cultivars was non significant whereas interactive effect of potassium levels and cultivars was found to be significant. Maximum plant population per m^2 and plant height (cm) was recorded in cultivar Zafar-2000 when potassium was applied at the rate of 120 kg ha^{-1} whereas minimum population per m^2 was observed in cultivar Zafar-2000 but plant height was recorded in Bulbul-98 in control treatment (Table 1). All yield and yield components were significantly affected by the application of different levels of potassium and cultivars. The interaction of the potassium levels and cultivars was found to be significant effect on yield and yield components. Maximum number of pods per plant, number of seeds per pod, 1000 seed weight (g), biological yield (ton ha^{-1}) and grain yield (ton ha^{-1}) were recorded in cultivar Zafar-2000 when potassium fertilizer was applied at the rate of 120 kg ha^{-1} which were statistically at par with cultivar Bulbul-98 at same potassium levels. Minimum number of pods per plant, number of seeds per pod, 1000 seed weight (g), biological yield (ton ha^{-1}) and grain yield (ton ha^{-1}) were observed in cultivar Bulbul-98 at control treatment when no potassium was applied. In case of harvest index (%) that was significantly affected by interactive effect of potassium application and canola cultivars. Highest harvest index was recorded in cultivar Zafar-2000 at 60 kg ha^{-1} potassium application level that was statistically at par with Bulbul-98 at same potash level (Table 2). In case of qualitative parameters, application of the K significantly increases the protein contents among the cultivars. Significantly higher protein contents were achieved in cultivar Zafar-2000 when K was applied @ 120 kg ha^{-1} which was statistically similar to K applied 90 kg ha^{-1} and cultivar Bulbul-98 at same potash level. But increasing the levels of potash oil content in the canola seed was decreased. Maximum oil contents were recorded in cultivar Bulbul-98 and Zafar-2000 at control treatment when K was not applied (Table 3).

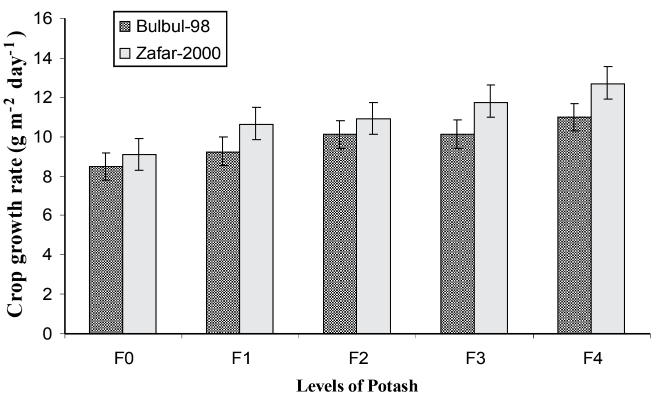

Figure 2. Effect of different levels of potassium on Crop growth rate (g m^{-2} per day) of two canola cultivars ± Standard error

DISCUSSION

It is evident from these results that potassium supply in canola increased LAI and CGR (Fig. 2, 3) that might be better utilization of carbohydrates to form more protoplasm. The cells produced under such conditions tend to be large and to have thin walls (Black, 1967), which may cause an increase in leaf area index. Leaf area index of the crop at a particular growth stage indicates its photosynthetic potential or the level of its dry matter accumulation. LAI increased due to increase in dry matter accumulation, with the progressive increase in plant growth under different treatments. With time it reached its maximum value showing significant variation among different treatments and there after decline up to harvest of crop (Dar *et al.*, 2009). The higher LAI and CGR indicate better leaf area expansion. This leaf expansion helps in subsequent interception and efficient utilization of solar radiation, resulting in increased accumulation of dry matter in leaves and shoots (Sattar *et al.*, 2011). Because of osmotic activity of potassium provides the physical force that expands cells during growth. New cells accumulate K in the large central vacuole that occupies 80 to 90% of the cell volume. The K attracts water and inflates the cell, stretching it to a new larger size. Potassium-deficient plants can exhibit low growth rates and small cells (Khan *et al.*, 2004).

The selected traits contribute to the understanding of the influence of K supply in yield and yield components of canola. Data presented in table 1,2 and 3 show that yield and yield components " plant height, number of seeds per pod, 1000 seeds weight, biological yield, seed yield" as well as protein contents of canola were significantly increased with the increasing level of K.

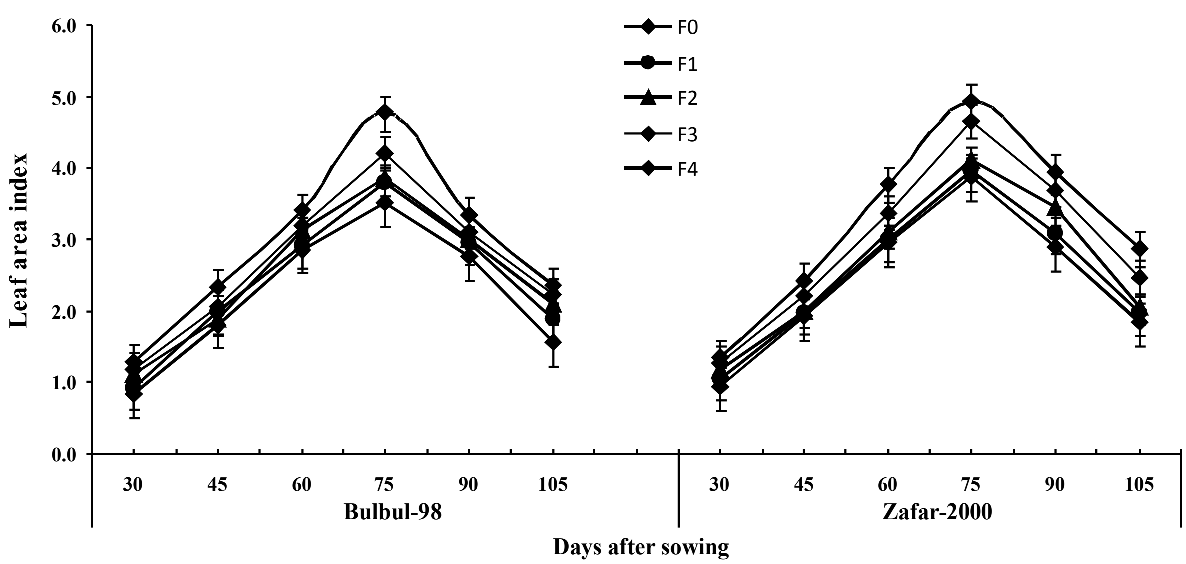

Figure 3. Effect of different levels of potassium on leaf area index (LAI) of two canola cultivars ± Standard error

Table 1. Effect of different levels of potassium on different agronomic parameters of canola cultivars

Potassium	No. of plants (m^2)			Plant Height (cm)			No. of Pods/ plant			No. of Seed/ pod		
Levels ($kg\ ha^{-1}$)	Bulbul-98	Zafar-2000	MEAN	Bulbul-98	Zafar-2000	MEAN	Bulbul-98	Zafar-2000	MEAN	Bulbul-98	Zafar-2000	MEAN
0	22.00 bcd	21.33 d	21.7 c	182.3 f	188.2 e	185.2 e	494.7 f	506.3 e	500.5 d	18.3 e	21.4 cd	19.8 d
30	21.66 cd	22.33 a-d	22.0 bc	186.8 e	190.4 d	188.6 d	496.7 f	508.3 e	502.5 d	20.7 d	23.8 b	22.3 c
60	21.66 cd	22.33 a-d	22.0 bc	187.2 e	194.6 c	190.9 c	505.3 e	522.0 d	513.7 c	22.4 bc	25.5 a	23.9 b
90	23.66 abc	24.00 ab	23.5 ab	191.4 d	197.7 b	194.4 b	522.0 d	537.7 c	529.8 b	23.5 b	26.5 a	25.0 ab
120	22.66 a-d	24.33 a	23.8 a	193.6 c	201.1 a	197.3 a	546.7 b	566.7 a	556.7 a	23.6 b	26.9 a	25.3 a
MEAN	22.33 A	22.86 A		188.2 B	194.4 A		513.1 B	528.2 A		21.7 B	24.8 A	

Means followed by the same small letters within a column and same capital letters within a row do not differ significantly ($P < 0.05$)

Table 2. Effect of different levels of potassium on yield and yield components of canola cultivars

Potassium	1000 seed weight (g)			Biological Yield (ton/ha)			Seed yield (ton/ha)			Harvest Index (%)		
Levels ($kg\ ha^{-1}$)	Bulbul-98	Zafar-2000	MEAN	Bulbul-98	Zafar-2000	MEAN	Bulbul-98	Zafar-2000	MEAN	Bulbul-98	Zafar-2000	MEAN
0	3.11 c	3.18 c	3.14 c	14.86 e	15.66 e	15.26 d	2.29 g	2.4 f	2.4 e	15.34 d	15.97 d	15.66 b
30	3.27 b	3.21 b	3.24 b	17.38 d	18.31 d	17.84 c	2.5 f	2.7 e	2.6 d	17.10 bc	17.62 ab	17.36 a
60	3.30 b	3.32 b	3.31 b	18.56 cd	18.81 cd	18.69 c	2.9 d	3.2 c	3.1 c	17.54 ab	18.44 a	17.99 a
90	3.29 b	3.23 b	3.26 b	19.76 bc	19.99 bc	19.88 b	3.2 c	3.4 b	3.3 b	16.40 cd	16.20 cd	16.30 b
120	3.47 a	3.51 a	3.49 a	20.66 ab	21.66 a	21.16 a	3.4 b	3.6 a	3.5 a	15.96 d	15.39 d	15.67 b
MEAN	3.29 A	3.27 A		18.24 A	18.89 A		2.9 B	3.1 A		16.47 A	16.72 A	

Means followed by the same small letters within a column and same capital letters within a row do not differ significantly ($P < 0.05$).

Table 3. Effect of different levels of potassium on protein and oil contents of canola cultivars.

Potassium Levels	**Protein contents (%)**			**Oil contents (%)**		
($kg\ ha^{-1}$)	Bulbul-98	Zafar-2000	**MEAN**	Bulbul-98	Zafar-2000	**MEAN**
0	20.26 c	21.50 b	20.88 c	42.16 ab	42.76 a	42.46 a
30	21.48 b	21.78 b	21.63 b	41.59 abc	41.91 ab	41.75 a
60	21.54 b	21.94 b	21.74 b	40.85 bcd	41.57 abc	41.21 ab
90	22.66 a	22.84 a	22.75 a	40.01 cd	39.85 cd	39.93 bc
120	22.80 a	22.92 a	22.86 a	39.40 d	39.10 d	39.25 c
MEAN	21.75 B	22.19 A		40.80 A	41.04 A	

The maximum potassium dose achieve the highest yield due to more leaf area index, better crop growth rate and higher number of seeds per pod. Number of seeds per pod showed the similar trend to seed yield. High seed yield of canola could be attained by balance nutrients. Maximum number of seeds per pod was recorded from 120 kg K ha^{-1} against the minimum was recorded from control treatment. Reduction in number of seeds per pod as a consequence of reduced K Levels (Kakar and Soomro, 2001). Final seed yield is the function of combined effect of all the yield components under the influence of a particular set of environmental conditions (Calvino *et al*., 2004). When supply of K limits crop water use, seed yields are frequently limited as well. The possible reason could be that the balance K gave favorable environment to the plants, which helped in the absorption of more nutrients and hence more yield was produced (Ahmad *et al*., 2000).

Decrease in the yield and yield components in control treatment is mainly due to a reduction in the seed set in the fruit which may be attributed to decrease in number of seeds per pod and 1000 seed weight (El-Hadidi *et al*., 2007) .

The comparison of treatment means given in Table 3 reflects that the maximum protein content was recorded in treatment when K applied at the rate of 120 kg ha^{-1} which was statistically at par with treatment when K was applied at the rate of 80 kg ha^{-1}. These results are in agreement with the findings of Nordestgaard *et al*. (1984) who reported that nitrogen and potassium applications increased protein contents. Oil content progressively decreased with increase of K level with highest (42.46%) in case of control and lowest (39.25%) with a K level of 120 kg ha^{-1}. Similarly Zafar-2000 and Bulbul-98 produced 40.80% and 41.04% oil contents, respectively. These results are in agreement with that of Ved (1983) who reported that seed oil content increased with decreasing NPK rates.

The significant differences between two canola cultivars in attributes might be due to the differences in genetic background and the genetic × environment interaction effects. Certain cultivar may be sensitive to environmental factors while other may be tolerant (Sana *et al*., 2003). Reddy and Reddy (1998) reported that different *Brassica* varieties differed significantly regarding their plant heights and other attributes. Sana *et al*. (2003) concluded that the variation in different varieties may be attributed to their genetic potential.

CONCLUSION

On the basis of these results it may be concluded that potassium fertilization promoted growth, yield and quality of canola. Zafar-2000 produced more yield and yield related parameters as compared to Bulbul-98. Potassium application at the rate of 120 kg ha^{-1} was better for all growth, yield quality of canola.

REFERENCES

Ahmad, G., Z. Quresh and H. Ullah. 2000. Effect of different sowing methods on the performance of sunflower. Pak. J. Biol. Sci. 3: 1829–1830.

Anjum, M.S. 1993. Marketing Constraints and Development Strategy for Edible Oil in Pakistan. A World Bank/MINFAL/PARC study. Winrock International, Islamabad.

Anonymous. 2011. Economic Survey of Pakistan. Finance and Economic Affairs Division, Ministry of Finance, Govt. of Pakistan, Islamabad, Pakistan.

AOAC. 1970. Methods of Analysis. *Association of Official Analytical Chemists*. 11th ed. Washington, DC, USA.

Black, C.A. 1967. Soil-Plant Relationship. 2nd ed. John Wiley and Sons. New York.

Bray, E.A.J., S.E. Bailey and E. Weretilnyk. 2000. Responses to abiotic stresses. In Biochemistry and Molecular Biology of Plants. Buchanan W., Gruissem R Jones (Eds.). Amer. Soc. Plant Physiol. pp 1158-1176.

Cakmak, I. 2005. K alleviates detrimental effects of abiotic stresses in plants. J. Plant Nutri. 168: 521-530.

Calvino, P., V. Sadras and M.M. Canepa. 2004. Yield responses to narrow rows as related to interception of radiation and water deficit in sunflower hybrids of varying cycle. Field Crop Res. 88: 261–267.

Dar, J.S., M.A. Cheema, M.A. Wahid, M.F. Saleem, M. Farooq and S.M.A. Basra. 2009. Role of planting pattern and irrigation management on growth and yield of spring planted sunflower (*Helianthus annuus* L.). Int. J. Agri. Biol. 11: 701–706

El-Hadidi, M., A.M. Abu Al-Kheer, M.T. Sakr and S.A. Farouk. 2007. Structural and physiological studies and oil constituent of canola plants under salinity conditions. Afri. Crop Sci. Conf. Proc. 8:1679-1684.

Fazili, I.S., M. Masoodic, S. Ahmadad, A. Jamalae, J.S. Khanf and M.Z. Abdina. 2010. Interactive effect of sulfur and nitrogen on growth and yield attributes of oilseed crops (*Brassica campestris* L. and *Eruca sativa* Mill.) differing in yield potential. J. Plant Nutr. 33: 1216 -1228

Ghosh, S.K., S. Pal and A.K. Mukhopadhyay. 1995. Split application of potassium to maximize its efficiency on yield of high yielding rice. Ind. Agric. J. 39: 259-261.

Hassan, F., H. Ali, M.A. Cheema and A. Manaf. 2005. Effects of environmental variation on oil content and fatty acid composition of canola cultivars. J. Res. Sci. 16, 65-72.

Hunt, R., 1978. Plant Growth Analysis. Studies in Biology No.96, pp 8–38. Edward Arnlod (Publ.) Ltd London UK.

Kakar, A.A. and A.G. Soomro, 2001. Effect of water stress on the growth, yield and oil content of sunflower. Pak. J. Agric. Sci. 38: 73–74.

Khan, H.Z, M.A. Malik, M.F. Saleem and I. Aziz. 2004. Effect of different potassium fertilization levels on growth, seed yield and oil contents of canola (*Brassica napus* L.). Int. J. Agri. Biol. 3: 557–559.

Marschner, H. 1995. Mineral nutrition of higher plants. Academic Press, San Diego, USA.

Nordestgaard, A., E. Augustinussen and P. Flengmark. 1984. Influence of nitrogen and potassium fertilizers on seed quality of winter oilseed rape. *Tiddsskrift for planteavl* 88: 327–341.

Reddy, C.S. and P.R. Reddy. 1998. Performance of mustard varieties on alfisols of Rayataseema Region of Andhra Pradesh. J. Oilseeds Res. 15: 379-380.

Pervez, H., M. Ashraf and M.I. Makhdum. 2004. Influence of potassium rates and sources on seed cotton yield and yield components of some elite cotton cultivars. J. Plant Nutr. 27: 1295–317.

Reddya, A.R., K.V. Chaitanya and M. Vivekanandanb. 2004. Drought-induced responses of photosynthesis and antioxidant metabolism in higher plants. J. Plant Physiol. 161: 1189-1202.

Sana, M. A., M. Ali, A. Malik, M.F. Saleem and M. Rafiq. 2003. Comparative yield potential and oil contents of different canola cultivars (*Brassica napus* L.). Pak. J. Agron. 2:1-7.

Sattar, A., M.A. Cheema, M.A. Wahid, M.F. Saleem and M. Hassan. Interactive effect of sulphur and nitrogen on growth, yield and quality of canola. Crop & Environ. 2: 32-37.

Steel, R.D.G., J.H. Torrie and D.A. Dickey. 1997. Principles and procedures of statistics. A biometrical approach. 3rd ed. McGraw Hill Book Co. Inc. New York.

Svecnjak, Z. and Z. Rengel. 2006. Nitrogen utilization efficiency in canola cultivars at grain harvest. Plant Soil 283: 299–307.

Ved, S. 1983. Response of mustard to irrigation and fertilization. Madras Agri. J. 70: 15–8.

Yau, S.K. and N. Thurling. 1987. Variation in nitrogen response among spring rape (*Brassica napus* L.) cultivars and its relationship to nitrogen uptake and utilization. Field Crops Res. 16: 139–155.