Evaluation of salicylic acid foliar application and drought stress on the physiological traits of sesame (*Sesamum indicum*) cultivars

Ebrahim Bagheri[1]*, Jafar Masood Sinaki[1], Mahdi Baradaran Firoozabadi[2] and Mohammad Abedini Esfhlani[3]

1. Agriculture Department, Islamic Azad University, Damghan Branch, Damghan, Iran
2. College of Agriculture, Shahrood University of Technology, Shahrood, Iran
3. Agriculture Research Center of Semnan (Shahrood), Shahrood, Iran

Abstract

A split plot factorial experiment in RCBD with 3 replications was performed in 2012-2013. Three sesame cultivars namely Biarjomand native, Dashtestan 2, and Darab 1 in the main plot were subjected to drought stress at different growth stages, i.e., control (full irrigation), withdrawing irrigation at 69 BBCH (end of flowering stage) and withdrawing irrigation at 79 BBCH (fully grown fruits). Two levels of the foliar application of salicylic acid (0, 0.6 mM) were considered as sub plot. Results indicated that the highest level of carotenoid rate was 0.265 mg/g FW measured at 69 BBCH stage 69 cut of irrigation. The maximum of height, oil percentage, harvest index and grain yield under control treatment were 99.67 cm, 48.26%, 18.2%, and 1147.33 kg, respectively. The results showed that withdrawing irrigation at 69 BBCH caused a significant increase in carotenoid concentration and best results under control conditions were obtained in Darab 1.

Keywords: salicylic acid; withdrawing irrigation; foliar application; physiological traits; sesame *(Sesamum indicum)*

Abbreviations:
RCBD: Randomized Complete Block Design; BBCH: Biologische Bundesanstalt,Bundessortenamt and

Bagheri, E., J. Masood Sinaki., M. Baradaran Firoozabadi and **M. Abedini Esfhlani**. 2013. 'Evaluation of salicylic acid foliar application and drought stress on the physiological traits of sesame *(Sesamum indicum)* cultivars'. *Iranian Journal of Plant Physiology* 3(4), 809 - 816.

Introduction

The lack of water sources is a main factor preventing the production of agricultural systems in dry and semidry environments limiting the efficient use of other resources (Kenan et al., 2007).Iran is considered as one of the dry and semidry areas in the world, therefore the designation of plant cultivar immune to drought is a key goal in the country's plant correction program (Dane et al., 2006).

Based on FAO statistics for the year 2011, arable lands in Iran covered about 17 million acres. From this amount, 9 million acres are used for irrigated plantings. 92.2% of Iran's water supply is used for agricultural purposes. Based on

*Corresponding author
E-mail address: eb.gahad@yahoo.com
Received: June, 2013
Accepted: August, 2013

the high usage of vegetable oils per person in Iran, up to about 12 kilograms per year, and the import of this product, the farming of this plant is of high importance. Based on the statistics in PGRO (Plant Genetic Resources Center for Conservation Research Center), Iran is 8th on the list for sesame genetic resources. Therefore the analysis and discovery of new and effective methods to achieve high output from these plant cultivars, especially considering each environment's climatic conditions, are researchers' focuses. Sesame (*Sesamum indicum*) is a plant that, because of its high oil capacity (47-52%), has an important role in human health (Kassab et al., 2005; Hibasam et al., 2000; Miyahara et al., 2001). Sesame seed is known as a drought resistant product, but moisture is needed for its growth and for high plant output. This plant has strong, straight, and expanded roots shaped differently based on the stem growth pattern and the amount of moisture in the different layers of the rhizosphere (Golestani and Pakniat, 2008). In their research, Mensah et al. (1997) showed that lack of water reduces the growth and output of the sesame seed.

The first study on plant growth patterns based on BBCH was performed in 1974 (Agusti et al., 1997). BBCH is a scale that serves as a check list to report or analyze IT systems in agriculture (Michel et al., 2007). The World Meteorological Organization (WMO) defines the physiological levels of plants based on BBCH codes in their own seasons (Koch et al., 2007). Attibayéba and his associates explained the physiological growth steps of the plant based on the BBCH coding and reached the conclusion that this type of system can answer many questions about the effect of different factors on growth (Attibayéba et al., 2010).

The use of endogenous salicylate increases the plant's resistance to stress from salt and dryness (Tari et al., 2002). Salicylate is a flavoring agent that also serves as a regulator for plant growth (Hayat et al., 2005).

The goal of our current study was to learn the carotenoid-changing capability, growth status, oil percentage, harvest index, and output levels of different cultivars of sesame in conditions of limited moisture and moisture stress at the end of the season and their regulatory effects on the amount of growth.

Materials and Methods

The experiment was conducted in Biarjomand, with longitude of 55.48, latitude of 36.05 and an altitude of 1099.3 meters above sea level. According to its synoptic meteorological station, Biarjomand has a warm and dry climate with an average annual rainfall of 120-130 mm. Therefore, water is of utmost importance here. Split plot factorial tests were performed on three cultivars of sesame seeds in 3 random complete blocks with three replications. The treatment included the main factor, no irrigation stress (complete irrigation as the control, no irrigation stress in levels BBCH 69 and BBCH 79), and kinds of sesame (native, Dashtestan 2 and Darab 1) different levels of the foliar application of salicylic acid (concentrations of 0, 0/6 mM) were known as subsidiary factors.

Before starting the preparation operations, the soil was tested at the plant site. The soil structure was a sandy loam soil with a PH at 7.35 and organic carbon of about 0.37. After testing, the ground was prepared for planting. Stack and stream were made using a furrower, after which manual planting took place in the last ten days of June in lines with depths of 2 cm. The crops were first irrigated immediately after planting; second irrigation took place after 15 days, and then, according to the tradition of the area, crops were watered once every 7 days. Afterwards, the stresses on the aforementioned levels, i.e., BBCH 69 (90% of flowers bloomed) and BBCH 79 (90% of the capsules in their final state), were applied. Before inducing the stress from no irrigation, the necessary blocks received a foliar application of salicylic acid at a concentration of 0.6 mM. The entire experiment included 54 plantings, each one having 6 lines measuring 4 meters in length, a respective distance of 50 cm, and a repeat distance of 2 meters. After including all of the treatments and omitting the side effects, samples and measurements were collected from the plants in the experiment area for some of their traits, such as height, carotenoid using the Arnon method (1967), oil percentage using the Soksele device

Table 1
Physical and chemical characteristics of the used soil

EC dS /m	pH	T.N/C %	O.C %	P mg/kg	K mg/kg	Sand %	Silt %	Clay %	Texture
4/5	7/35	24/25	0/37	5/4	280	52	36	12	L.S

Table 2
Analysis of variance (mean squares) of some physiological & morphological characteristics, , under irrigation stress treatments, Varieties and foliar application

S.O.V	DF	Height	Grain yield	Carotenoids	Oil content	Harvest index
Block	2	1219/185	81682	0/00033**	7/899	9533/9
Cut of irrigation	2	182/35	66249/28	0/0047**	42/743	7989/1
Error a	4	686/71**	75689/47	0/000009	16/615*	**15518/1
variety	2	124/74	1198434/8**	0/00071	25/747**	*11001/3
foliar application	1	54	351635/72**	0/00022	0/919	3182/1
variety × Cut of irrigation	4	265/35	222098/31**	0/0014*	8/406	3774/3
Cut of irrigation × foliar application	2	19/39	42457/73	0/0043**	3/115	755/7
variety × foliar application	2	10/89	2670/15	0/0014	3/081	1113/4
Cut of irrigation × variety × foliar application	4	111/61	39408/21	0/00144*	12/437*	1891/5
Error b	30	141/87	43523/95	0/00045	4/143	1692/2

* and **: Significant at 5% and 1% probability levels, respectively

(Joshi et al., 1998), output and harvest index calculated by the following formula (Imam, 2007):

HI= ((GY/BY) ×100)

where HI is the harvest index, GY the seed output and BY is physiological response.

The SAS (version 9.1) software was used to statistically analyze the data at P≤0.01 and P≤0.05 levels, and the data was compared using the LSD method. Excel software was used to draw pictures and graphs.

Results

Plant height

The inducement of stress during the plants' last growth stages had only a slight impact on the plants' bush height which was not significant (Table 2). The impact of cultivar on height was also insignificant, although Dashtestan 2 had the highest height with an average of 97.66 cm, and the native cultivar was the lowest with an average of 93 cm (Table 2). The results showed that there were no differences between cultivars, no irrigation stress, foliar application and also their mutual effect on bush height (Table 1).

Carotenoid rate

The results acquired from the variance analysis (Table 1) indicated that the no irrigation stress on level 1 (P≤0.001) had a significant effect on carotenoid. The results from the comparison (Table 2) showed that the maximum effect came from the no irrigation stress in BBCH 69 at the amount of 0.265 mg per grams wet weight and the minimum effect was 0.264 mg per grams wet weight less than the no irrigation stress in complete irrigation.

Results of the variance analysis (Table 1) indicated that the mutual effects of no irrigation stress treatment and cultivar on carotenoid activity at was significant (P≤0.05). Results of comparison (Table 3) showed that the maximum carotenoid was measured in the plot of complete irrigation on Dashtestan 2 cultivar with 91.5 mg per grams wet weight. Comparison also showed the minimum carotenoid (81.66 mg per grams wet weight) belonged to the treatment with no irrigation stress in BBCH 69 on the Darab 1 cultivar.

Table 3
Mean comparison of squared solution no irrigation stress and foliar application on some morphological characteristics, physiological, sesame seed yield and harvest index

Treatment	High (Cm)	Grain yield (Kg/ha)	Carotenoids (mg/g.Fw)	Oil content %	Harvest index %
69 BBCH no irrigation	93/72	1026/14	0/265[a]	45/88	15/4
79 BBCH no irrigation	94/72	1081/65	0/24[b]	45/36	14/7
control	99/67	1147/33	0/234[c]	48/26	18/2
Biarjomand Native	93	866/9[c]	0/2395	45/722[b]	13/9[b]
Dashtestan 2	97/66	1018/3[b]	0/2509	45/9[b]	16/2[ab]
Darab 1	97/44	1369/9[a]	0/2497	47/88[a]	18/23[a]
Non- foliar application	95/04	1004/35[b]	0/2447	46/63	15/4
foliar application	97/04	1165/74[a]	0/2487	46/37	16/8

data that have at least one common letter are not significantly different.

Moreover, the variance analysis results (Table 1) showed that the mutual effect of no irrigation stress treatment and foliar application treatment had a significant effect on carotenoid activity (P≤0.01). Results obtained from the comparison of data (Table 4) also showed the maximum carotenoid activity belonged to the no irrigation stress in BBCH 69 on the foliar application treatment at 0.28 mg per grams wet weight and the minimum activity was 0.22 mg per grams wet weight from the no irrigation stress in BBCH 79 on the treatment including no foliar application.

Grain yield

Results of the variance analysis (Table 1) indicated that the no irrigation stress effect was not so significant on the yield. The maximum effect belonged to complete irrigation conditions at 1147 kg per acre, and the least was in no irrigation stress conditions in BBCH 69 at 1026 kg per acre (Table 2).

The variance analysis (Table 1) showed that the effect of cultivcar on level 5 (P≤0.05) was significant on the output. The comparison results (Table 2) indicated that the highest output came from the Darab 1 cultivar with 1370 kg per acre, and the least output came from the native cultivar with 870 kg per acre.

The variance analysis results (Table 1) showed that the foliar application effect on level 1 (P≤0.01) was significant on the output. Results obtained from the comparison (Table 2) showed that the highest output came from foliar application treatment (1165.74 kg per acre), and the least came from the treatment which included no foliar application (1004.35 kg per acre). Foliar application of salicylic acid increased the output by 16% (Table 2). Variance analysis results (Table 1) showed that the mutual effect of no irrigation stress treatment and cultivar treatment was significant (P≤0.01) on the output. The results of the comparison of the averages (Table 3) indicated that the maximum performance occurred in the complete irrigation on the Darab 1 cultivar (1591.67 kg per acre), and the least (778.08 kg per acre) occurred in the complete irrigation on the native cultivar.

Oil percentage

Based on the obtained results, the oil percentage in the no irrigation stress treatment and foliar application of salicylic acid showed no difference (Table 1). In the no irrigation stress treatment, the highest percentage of oil belonged to complete irrigation (48.26%) and the least percentage was observed for the no irrigation stress in BBCH 69 (45.36%). The foliar application of salicylic acid reduced the percentage of oil in the sesame seeds (Table 2).

As for the cultivars, the results from variance analysis (Table 1) showed that there was a significant difference in oil percentage (P≤0.01). The results from the comparison of averages (Table 2) show that the maximum oil belonged to the Darab 1 cultivar at an average of 47.88%, and the least was of the native cultivar with an average of 45.72%.

Harvest index

The harvest index is a criterion which shows the effectiveness of transporting the products of photosynthesis produced in the plant to the seed. The variance analysis results indicated that no irrigation stress, foliar application of salicylic acid and the interaction of the effects of irrigation stress, cultivar and foliar application of salicylic acid did not have significant effects on the sesame seed harvest index. The results from the variance analysis (Table 1) showed that the effect of cultivar was significant (P≤0.05) on the harvest index, the highest index belonging to the Darab 1 cultivar (18.23%) and the lowest belonging to the native cultivar (13.9%) (Table 2).

Discussion

When the plants detect a reduction in the moisture content of the soil, the roots send signals to the air glands to increase resistance. Under these conditions, the air glands first resist against dryness by reducing transpiration and retaining the leaf moisture; secondly, they stop their growth (Chiatante et al., 2006; Masinde et al., 2006).

Kurt et al. (1993) reported that in the *(Cicer arietinum)* plant, a reduction in available water during the initiation of blooming, in addition to reducing the plants growth rate and shortening its developing growth, also had a negative impact on its bush height. Many analyses showed that plant height decrease if the available water is reduced (Kurt et al. (1993)

When water stress is increased the daily turgor pressure is reduced, and growth speed, photosynthesis, and morphological properties are affected (Blum, 2005; Kafi and Damghani, 2000).

Table 4
Mean comparison of Interaction effects of cut of irrigation on yield and carotenoid of sesame variety

Treatment	carotenoid (5%) (mg/g.Fw)	Grain yield (1%) (Kg/ha)
T1v1	87/48^{f}	950.38^{cd}
T1v2	85/04^{h}	1177.58^{bc}
T1v3	81/66^{i}	1116.98^{bc}
T2v1	86/69^{g}	872^{cd}
T2v2	88/25^{e}	978^{cd}
T2v3	89/55^{d}	1401^{ab}
T3v1	89/89^{c}	778.08^{d}
T3v2	91/5^{a}	899.34^{cd}
T3v3	91/38^{b}	1591.67^{a}
LSD	0/025	331.2

T1, T2, T3 treatments at 69 BBCH, 79 BBCH cut of irrigation and control V1, V2, V3 biarjomand Native, Dashtestan 2 and Darab 1.

Table 5
Mean comparison of Interaction effects of no irrigation stress and foliar application out on carotenoid

Treatment	Carotenoids(1%) (mg/g.Fw)
T1M1	0/28^{a}
T1M2	0/25^{ab}
T2M1	0/22c
T2M2	0/25^{ab}
T3M1	0/24^{bc}
T3M2	0/24bc
LSD	0/028

T1, T2, T3 treatments at 69 BBCH, 79 BBCH cut of irrigation and control M1, M2 are not foliar application and foliar application.

There are contradicting reports available on the effect of salicylic acid on the photosynthetic pigments (Liusia et al., 2005). Based on the report from Navvabi (1996), increasing the irrigation cycle up to 150 mm vapor from the evaporation pan had no such effect on output.

The decrease in oil percentage because of drought stress corresponds with the results reported by (Jensen et al., 1996). Actually the oil percentage because of watering and no stress environment until the harvest (maximum gathering of oil in the seeds) increases by incorporation of stress factors into the equation.

Sesame seed has an average of 45% oil and 19-25% protein, but these amounts depend on their cultivar and the environmental factors (Weiss, 2000). The oil percentage in cultivars of *(Brassica napus)* in addition to their genetic properties depend on factors such as temperature, feeding conditions, planting date, harvest date, and moisture (Sepeardaiizadeh, 1999). Jabari et al. (2008) also reported that with the application of drought stress, traits such as the weight of a thousand seeds, the seed count, the refresh rate, and the harvest index of *(Helianthus annuus)* hybrids were reduced.

More severe decrease of seed weight compared to the decrease in growth indices due to lack of photosynthesis in no irrigation stress conditions led to a severe fall in the harvest index rate during the present experiment. The harvest index decrease is also mentioned in some other studies such as those by Gimenez and Fereres (1986) and Jabari et al. (2008).

Conclusion

Based on the results obtained in this study, it was observed that the no irrigation stress did not have a significantly positive effect on most properties other than carotenoid. Therefore, the maximum yield and oil percentage was achieved by the complete irrigation. Regarding the no irrigation conditions on BBCH 79 of Darab 1 and the control conditions on BBCH 69 of Dashtestan 2, Darab 1 had the highest output, because Darab 1 is more resistant to the high humidity and warm climate of Biarjomand. Research results also demonstrated that cultivar has a significant and positive effect on most of the analyzed properties, particularly oil percentage and harvest index of the Darab 1. The foliar application also had a positive and significant effect on the output and the maximum observed for the foliar application of salicylic acid. Therefore, the use of the Darab 1 cultivar and foliar application of salicylic acid are highly recommended in the study area of Biarjomand and places with similar conditions.

References

Arnon, A. N. 1967.' Method of extraction of chlorophyll in the plants'. *Agron. J.* 23:112-121.

Agusti, M., S. Zaragoz, H. Bleiholde, L. Buhr, H. Hack, R. Klose and **R. Stauss**. 1997. 'Adaptation de l'echelle BBCH a la description des stades phénologiques des agrumes du genre Citrus'. *Fruits*, 52: 287- 295.

Attibayéba, Nsika-Mikoko, E. N., J. Kounkou., J. Sérina, C. Galet, Dianga and **F. Mandoukou-Yembi.** 2010. 'Description of Different Growth Stages of *(Sesamum indicum* L). Using the Extended BBCH Scale'. *Pakistan Journal of Nutrition*, 9 (3): 235-239.

Blum, A. 2005. 'Drought resistance, water-use efficiency, and yield potential-are they compatible, dissonant, or mutually exclusive?' *Australian Journal of Agriculture*, 56: 1159-1168.

Chiatante D., A. Di-Iorio, S. Sciandra, G. Stefani and S. Mazzoleni. 2006.' Effect of drought and fire on root development in *Quercus pubescens* wild and *Fraxinus ornal* seedlings'. *Environmental and Experimental Botany*, 56: 190-197.

Dane, J.H., R.H. Walker, L.B. Kamwe and **J. L. Belcher**. 2006. 'Tall fescue and hybrid bluegrass response to soil water metric head limits'. *Agriculture and Water Management,* 86: 177-186.

Emam, Y. 2007. 'Cereal production'. Shiraz University Press, 190 p.

Emam, Y. 2008. 'Water relation in plant'. In: Koocheki, A., and Khaje Hosseini, M., Eds. Modern Agronomy. Jihad Daneshgahi Mashhad Press. 163-187.

Gimenez, C. and **E. Fereres**. 1986. 'Genetic variability in sunflower cultivars under

drought. II-Growth and water relations. *Aust. J. Agric. Res*, 37: 583-597.

Hack, H., H. Bleiholder, L. Buhr, U. Meier, E. Schnock-Fricke, E. Weber and **A. Witzenberger**. 1992. 'Einheitliche codierung de phänologischen entwicklungsstadien mono-und dikotyler Pflanzen'. Erweiterte BBCH-Skala, Allgemein. Nachrichtenbl. Deut. Pflanzenschutzd. 44: 265-270.

Hayat, S., Q. Fariduddin, B. Ali, and **A. Ahmad.** 2005. 'Effect of salicylic acid on growth and enzyme activities of wheat seedlings'. *Acta Agron. Hung.* 53:433-437.

Hibasami, H., T. Fujikawa, H. Takeda, S. Nishibe, T. Satoh, T. Tujisawa and **K. Nakashima.** 2000. 'Induction of apoptosis by *Acanthopanax senticosus* harms and its components, sesamin in human stomach cancer'. *International Journal of Medicine*, 7: 1213-1216.

Jabbari, H., GH. A. Akbari, J. Daneshian, I. Alahdadi and **N. Shahbazian.** 2008. 'Effect of water deficit stress on agronomic characteristics of sunflower hybrids'. 5th International Crop Science Congress & Exhibition, Jejo, Korea, April 13-18: 190.

Jensen, C. R., V. O. Mogensen, J. K. fieldsen and **J. H. Thage.** 1996. 'Seed glucosinolate, oil and protein contents of field-grown rape (*Brassica napus* L.) affected by soil drying and evaporative demand'. *Field Crops Res*. 47: 93-105.

Joshi, N. L., P. C. Mali and **A. Sexena**. 1998. 'Effect of nitrogen and sulphure application on yield and fatty acid composition of mustard (*Brassica juncea* L.) Oil'. *Journal agronomy and crop Science*, 180: 59-63.

Kafi, M. and **A. Damghani**. 2000. 'Mechanism of environmental stress resistance in plants'. Ferdowi University of Mashhad Publication. (In Persian).

Kassab, O., E. Noemani and **A. H. El-Zeiny**. 2005. 'Influence of some irrigation system and water regimes on growth and yield of sesame plants'. *Journal of Agronomy*, 4: 220-224

Kenan, U., F. Kill, C. Gencoglan and **H. Merdan.** 2007. 'Effect of irrigation frequency and amount on water use efficiency and yield of sesame under field condition'. *Field Crops Research*, 101: 249-254.

Koch, E., E. Dittmann, W. Lipa, A. Menzel, J. Necovar, A. Van Vlieth and **S. Zach.** 2007. COST Action 725. Applications: Overview and erste Ergebnisse. Proceedings of the Meteorologentagung, DACH 2007 Hamburg, 10-14 September 2007. – COST 725, http://top- share.wur.nl/cost725.

Korte, L. L., J.H. Williams, T. E. Specht and **R.C. Sorensen.** 1993. 'Irrigation of soybean genotypes during reproductive ontogeny. I. Agronomic responses'. *Crop Sci*. 28:521-530.

Llusia, J., J. Penuelas and **S. Munne-Bosch.** 2005. 'Sustained accumulation of methyl salicylate alters antioxidant protection and reduces tolerance of holm oak to heat stress'. *Physiol Plantarum,* 124:353-361.

Mensah, J.K., B. Obasami, P. Eruotor and **F. Onomerieguna**. 2006. 'Simulated flooding and drought effects on germination, growth and yield parameters of sesame (*Sesamum indicum*)'. *African Journal of Biotechnology*, 5: 1249-1253.

Masinde, P.W., H. Stutzel, S. Agong and **A. Goand– Fricke.** 2006. 'Plant growth, water relations and transpiration of two species of African nightshade(*Solanum villosum Mill. ssp. Miniatum* (Bernh. Ex Willd.) Edmonds and *S. sarrachoides Sendtn*.) under water-limited conditions'. *Scientia Horticulturae*, 110: 7–15.

Michel, V., G. Zink, J. Schmidtke and **A. Anderl**. 2007. PIAF and PIAF Stat, 278-279. In: BLEIHOLDER, H., H.-P. PIEPHO, (Ed.): Agricultural Field Trials – Today and Tomorrow. Proceedings of the Interna- tional Symposium 08-10 October 2007, Stuttgart-Hohenheim, Germany. Verlag Grauer, Beuren Stuttgart, 284 p.

Miyahara, Y., H. Hibasami, H. Katsuzaki, K. Imai and **Y. Komiya.** 2001.' Sesamolin from sesame seed inhibits proliferation by inducing apoptosis in human lymphoid leukemia' .*International Journal of Medicine*, 7: 369-371.

Najafvand, S.N., F. Alemzadeh and **A. Ansari**. 2008. 'Effect of different level of nitrogen fertilizer with two types of bio-fertilizer on growth and yield of two cultivars of tomato (*Lycopersicon esculentum* Mill)'. *J. of plant Science,* 7(8):757-761.

Tari, I., J. Csiszar, G. Szalai, F. Horvath, A. Pecsvaradi, G. Kiss, A. Szepesi, M. Szabo and **L. Erdei.** 2002. 'Acclimation of tomato plants to salinity stress after a salicylic acid pre-treatment'. *Acta Biol*. 46(3-4):55-56.

Sepeardaiizadeh, R. 1999. ' Effect of harvest time on seed yield and quality and storability of different cultivars of canola'. M. Sc. Thesis. The University of Guilan. 479 pp. (In Persian).

Siddiqu, M.R.B., A. Hamid and **M. S. Islam**. 2000. 'Drought stress effects on water relations of wheat. *Botanical Bulletin Academia Sinica* 41:35-39.

Yasari, E. and **M. Patwardhan**. 2007. 'Effects of Azetobacter and Azospirillum inoculants and chemical fertilizers on growth and productivity of Canola (*Brassica napus* L.)'. *Asian Journal of Plant Sciences,* 6(1): 77-82.