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Using of Growth Regulators for Improving Water Use Efficiency of Canola under Water Deficit

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ABSTRACT

In order to maximize the water use efficiency of canola under deficit irrigation conditions (100%, 75% and 50% of the Etc), two growth regulators [150 ppm and 300 ppm of citric acid (organic acid) and 150 ppm and 300 ppm of glutamic acid (amino acid)] are sprayed to study the response of growth, yield and yield components of canola plants. A field experiment was conducted in the two winter growing seasons of 2011/2012 and 2012/2013 at the Research and Production Farm of the National Research Centre, El-Nubaria Sector, El-Beheira Governorate, Egypt. The results indicated that there were clear positive effects of using 75% of the Etc on all growth parameters of canola plants (Plant height, root length, dry weight of stem, root, leaves and whole plant, and number of leaves and branches per plant), as well as the seed and oil yields and 100 seed weight, except for number of capsules per plant where the highest number was obtained by using 100% of the Etc. Generally, spraying plants by 300 ppm of the citric acid improved the growth, yield and its components. The highest water use efficiency was obtained by using 50% of Etc and spraying plants by 150 ppm glutamic acid, followed by spraying plants by 300 ppm citric acid and irrigation with 75% of the Etc. So, spraying canola plants by 300 ppm citric acid improved the response of canola plants under the moderate deficit conditions (75% of the Etc), as well as spraying with 150 ppm glutamic acid under the highest level of water deficit (50% Etc).

Key words: Canola - water use efficiency - growth regulators - water deficit.

Introduction

Gap of oil in Egypt nowadays is considered one of the major problems in food security. For increasing the cultivated area of oil crops it is very difficult because of the competition with the other winter crops. Therefore, for extending in the new areas, it's preferable in the desert areas. Drought is the major stress factor which limits crop production beside salinity problems and poverty in nutrients (Moslev, 1983 and Abbasian and Rad, 2011).

Canola is a very important oil seed crop in the world. Its oil is of premium quality with low erusic acid and glucasinalates contents (Din, *et al*. 2011). Relatively, this crop is considered a new oil crop in Egypt. However, it achieved an important position due to filing well in the local winter cropping system. Canola is generally considered to be more susceptible to drought. The yield is mainly affected by water shortage which occurs during the different stages of growth. Drought affects canola growth and yield as mentioned by: Robertson and Holand (2004) and Toihidi-Moghan, *et al*. (2009).

Tesfamerian *et al*. (2010) found that the well watered canola plants (control) gave the highest value for leaf area index of 8, water use of 709 mm, seed yield of 3831 kg ha^{-1}, and seed oil content of 398 g kg^{-1}. Canola stressed at flowering stage gave the lowest values for seed yield of 1361 kg ha^{-1}, seed oil content of 340 g kg^{-1}, and water use of 332 mm. Canola seed and oil yield are most sensitive to water stress at flowering stage and less sensitive during the vegetative and seed filling stages. Ahmadi and Bahrani (2009) concluded that pods per plant values were the most sensitive yield component to water stress during reproductive growth in both growing years.

Antioxidants play important role in drought tolerance of crop plants which helps plants to ameliorate the bad effects of stresses (Singh *et al*., 2010, Hussein *et al*., 2008, and Hussein and Kamilea, El-Diewny, 2011) Organic acids and amino acids play an important role in plant metabolism (Singh *et al*., 2010 and Amino Acids are fundamental ingredients in the process of Protein Synthesis (Cerdan, *et al*., 2006 and Shehata *et al*., 2011). Concerning the organic acids effect on plant growth, it was found that plant height, stem diameter, biomass, relative yield, root volume and root activity were increased significantly, while the root surface acid phosphatase activity and root tissues acid phosphatase activity decreased under three types of organic acids (citric acid, malic acid and oxalic acid) conditions. The requirement of amino acids in essential quantities is well known as a means to increase yield and overall quality of crops. The application of amino acids for foliar use is based on its requirement by plants in general and at critical stages of growth in particular. Plants absorb amino acids through stomata and this is proportional to environment temperature. Amino acids are fundamental ingredients in the process of protein synthesis. About 20 important amino acids are involved in the process of each function. Studies have proved that amino acids can directly or indirectly influence the physiological

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activities of the plant. L-Proline helps in fertility of Pollen. L-Lysine, L-Methionine, L-Glutamic acids are essential amino acids for pollination. These amino acids increase the pollen germination and the length of the pollinic tube. Amino acids have a chelating effect on micronutrients. When applied together with micronutrients, the absorption and transportation of micronutrients inside the plant is easier. Amino acids are precursors or activators of phytohormones and growth substances. L - Methionine is a precursor of ethylene and of growth factors such as Espermine and Espermidine, which are synsthesized from 5-Adenosyl Methionine. Glycine and Glutamic acid are fundamental metabolites in the process of formation of vegetable tissue and chlorophyll synthesis. These amino acids help to increase chlorophyll concentration in the plant leading to higher degree of photosynthesis. This makes crops lush green.

Therefore, this work is designed to evaluate the effect of glutamic acid and citric acid on growth and yield of canola plants.

Materials And Methods

A field experiment was conducted in the two winter growing seasons of 2011/2012 and 2012/2013 at the Research and Production Farm of the National Research Centre, El-Nubaria Sector, El-Beheira Governorate, Egypt.

The physical and chemical properties of soil are presented in **Table, 1** to evaluate of the effect of citric acid (organic acid) and glutamic acid (amino acid) on growth and yield of canola plants grown under different water regimes. The treatments were as Follows:

1. Irrigation treatments: irrigation with 100%, 75%, and 50% of the Etc.
2. Spraying citric and glutamic acids in the rate of 150 and 300 ppm and control plots were not sprayed.

Table 1: Some physical and chemical properties of the experimental site soil.

Particles size distribution (%)			Texture soil	Ec dSm^{-1}	pH
Sand	Silt	Clay			
90	5	5	sandy	1.50	8.2

The design of the experiment was split plot in sex replicates, two replicates were devoted to samples for growth measurements and chemical analysis and the rest for yield and yield traits. The treatments of irrigation regime were laid in the mean-plots and the chemicals treatments were distributed randomly in the sub-plots. Area of every sub-plot was 10.5 m^2 which 3 m in width and 3.5 m in length.

Canola seeds (*Brassica napus* L) cv. Sirio 1 were sown in the 1^{st} of Dec. in the two successive winter seasons. Calsium super phosphate (15.5 % P_2O_5) and potassium sulfate (48.5 % K_2O) in rate of 200 and 100 kg/ fed. were broadcasted before sowing. Ammonium sulfate (20.5 % N) was added in two equal portions, the 1^{st} was added after 21 days from sowing and the 2^{nd} portion was applied two weeks later. Chemical treatments i.e. citric acid and glutamic acid were sprayed twice, at 22 days and 36 days after sowing. The all other cultural practices were done as in the province. Evapotranspiration was calculated from the metrological data of the NRC Metrological Station of the NRC in Nubaria using the imperical equation of Benman- Monteith. Water use efficiency was determined using the following equation:

WUE (kg/m^3) **= Economical yield** (kg/fed.)/**quantity of water** (m^3/fed.)

All collected date were subjected to the proper statistical analysis using the methods described by Snedecor and Cochran (1990).

Results And Discussion

I- Irrigation water regimes:

Growth:

Irrigating canola plants with 75% of the Etc (935 m^3/fed.) showed the highest values of plant height, root length, number of green leaves and stem, root, leaves and whole plant dry weight (Table, 2). However, the number of branches gave its higher values with 100% of the Etc treatment (1336 m^3/fed.) and declined as the Etc percentage was decreased. The differences in canola growth parameters were clearly significant, except for number of branches, dry weight of leaves and number of leaves per plant (Table, 2). Robertson *et al*. (2007) pointed out that water quantity affected growth of canola plants. Herdart (2012) exposed canola and chamomile plants to 0, 4, 8 and 12 inches prior to harvest and found that as the season progressed, plants exposed to greater irrigation level grow larger than those under low irrigation. Al-Barak (2006) noticed that the highest values of plant height, stem diameter, number of pods/plant were obtained with irrigation every 7 or 14 days. Youssifi *et al*. (2011) mentioned that the results of combined analysis of variances showed that drought stress affected plant height. Reasons of this difference under drought stress condition may be due to the reduction of soil moisture storage to pods No. per plant, seeds per pod, number of lateral branches and plant height. These reductions cause shortening of flowering period, non-fertilization of some flowers and reduction of photosynthetic resources (Gan *et al*., 2007; Sinaki *et al*., 2007 and Naseri *et al*., 2008). However, Good and MacLagan (1993) mentioned that the adverse effect of water stress may be due to the effect on water status in the plant tissue. Hussein *et al*., (2010) related this effect to the disturbance in endogenous hormones under the unbalanced water supply.

Table 2: The effect of water regimes on the growth parameters and productivity of canola plants.

Water regimes	Plant height, cm	No. of branches	Root length, cm	Dry weight of stem, g	Dry weight of root, g	Dry weight of leaves, g	Dry weight of whole plant, g	No. of leaves	No. of capsules	Seed index	Seed yield, t/fed.	Biological yield, t/fed.
1336 (m^3/fed.)	81.87	1.733	16.60	5.94	2.47	3.31	11.72	13.67	152.40	0.25	0.657	1.314
935 (m^3/fed.)	90.20	1.67	20.40	10.72	5.73	3.43	19.88	15.73	108.20	0.30	0.770	2.226
668 (m^3/fed.)	75.46	1.00	15.67	5.87	2.45	3.08	11.40	14.13	97.00	0.24	0.589	1.277
L.S.D. at 5% level	5.87	N.S.	1.75	2.83	2.42	N.S.	5.02	N.S.	18.24	0.02	0.16	0.56

Yield:

Data in presented in Table (2) indicated that irrigating canola plants with 75% of the Etc gave the highest values of seeds, and biological yield (t/fed.). The seed index (100 seed weight, g) showed the same figure, while number of capsules was negatively responded to the decrement in quantity of water. Many authors reported the effect of water supply on yield of canola plants, among them; Baladis and Gaile (2009) and Good and macLagan (1993). Youssefi, *et al.* (2011) stated that mean of seed yield at non-stress conditions was 2869.2 kg/ha and 2114.3 kg/ha under stress conditions. Al-Barak (2006) found that the highest number of seeds/pod, seeds weight/plant, as well as seeds and oil yields were produced when canola plants were irrigated every 7 or 14 days. Al-Habeeb and Al-Hendawi (2002) reported that the optimal seasonal irrigation volume was 3000 m^3/ha. High evapotranspiration, water source limitation and other factors caused lots of limitations in crop production and forced to study effects of drought stress and selection of resistant cultivars. Long-term mild drought stress was found to decrease dry matter (DM), grain yield (GY) and leaf relative water content (RWC) (Sarmadnia and Kocheki, 1989 and Mendham and Salisbury, 1995).

II- Antioxidants:

Growth:

Spraying of citric acid at the rate of 300 ppm was more effective on canola growth parameters than the other treatments (glutamic at the rate of 150 and 300 ppm, and citric at the rate of 150 ppm) (Table, 3). On the contrary, the lowest values of plant height, root length and the dry weight of root, stem, leaves, and whole plant were observed with the control treatment (sprayed with tap water). This may be due to that amino acids are fundamental ingredients in the process of protein synthesis. About 20 important amino acids are involved in the process of each function. Studies have proved that amino acids can directly or indirectly influence the physiological activities of the plant. Glycine and Glutamic acids are fundamental metabolites in the process of formation of vegetative tissues and chlorophyll synthesis. These amino acids help to increase chlorophyll concentration in the plant leading to higher degree of photosynthesis. This makes crops lush green (Rai, 2002). Amino acids can directly or indirectly influence the physiological activities of plant growth and development such exogenous application of amino acids have been reported to modulate the growth, yield and biochemical quality of crops (Abd El-Aal *et al*., 2010 and Shiraishi *et al*., 2010). Khan *et al*. (2012) found that grapevines treated with multiple applications of mixture of amino acids and seaweed extract significantly improved growth of vegetative parts and fruits.

Yield:

The highest seed yield attributes (number of capsules and seed index) were associated with spraying 300 ppm citric acid followed by spraying 150 ppm glutamic acid while the lowest produced in control treatment. The increments in seeds productivity were 16.39, 58.11, 23.68 and 14.03% when canola plants received 150 and 300 ppm citric acid and 150 and 300 ppm glutamic acid compared to control plants, respectively (Table, 3). Biological yield (above ground parts) showed approximately the same trend. Also, the highest 100 seed weight (seed index) was obtained by application of 300 ppm citric acid and the lowest was in the control treatment. Several researches had been done to investigate of the effect of antioxidants on yield and yield attributes (Li *et al*., 2010 and Rezaei *et al*., 2012), who noticed that the grain yield of soybean was increased by foliar applications of Exo-GB. This was due to significant increase in number of lateral branches and pods and weight of thousand grains, without significant differences between cultivars. Sakr and El-Metwally (2009) found that application of antioxidants increased the yield and yield components of wheat plants. Arfan *et al*. (2007) emphasized that, the varying of SA levels used, the most effective levels for promoting growth and grain yield were 0.75 and 0.25 mM. of SA.

Table 3: The effect of spraying by growth regulators on the growth parameters and productivity of canola plants:

Growth regulators	Plant height, cm	No. of branches	Root length, cm	Dry weight of stem, g	Dry weight of root, g	Dry weight of leaves, g	Dry weight of whole plant, g	No. of leaves	No. of capsules	100 seeds weight, g	Seed yield, t/fed.	Biological yield, t/fed.
150 *ppm ctitric acid*	83.11	1.67	18.11	8.02	3.04	2.78	13.84	14.22	83.00	0.23	0.639	1.550
300 ppm ctitric acid	93.56	2.11	19.56	12.62	6.81	4.77	24.20	16.33	198.67	0.30	0.868	2.711
150 ppm glutamic acid	82.56	0.67	17.56	7.11	3.28	3.09	13.48	15.33	110.33	0.28	0.679	1.511
300 ppm glutamic acid	81.33	1.67	17.78	5.75	2.70	3.18	11.63	12.89	112.33	0.27	0.626	1.303
Control	72.00	1.22b	14.78b	4.06	1.91	2.53	8.50	14.11	91.67	0.23	0.549	0.953
L.S.D. at 5% level	7.41	0.62	2.34	2.75	1.80	1.99	4.89	1.99	34.21	0.04	0.111	0.548

III- The interaction between water regimes and antioxidants:

Growth:

Data illustrated in **Table (4)** showed the interactive effect of water supply and some antioxidants on growth of canola plants. These data indicated that application of both used antioxidants affected the growth parameters of canola plants. Under irrigation with 1336 m^3/fed., plant height, number of branches, number of capsules and stem, root and whole plant dry weight gave their highest values when plants were sprayed with 300 ppm citric acid, but for root length, number of leaves and dry weight of leaves, the highest values were obtained by application of 300 ppm glutamic acid. Plants received 935 m^3/fed. water regime gave the highest values of all measured growth parameters and showed the same response to citric acid, except the number of capsules which was high by spraying 150 ppm glutamic acid. Application of 668 m^3/fed. water regime in irrigating of canola plants and spraying 150 ppm citric acid gave the highest effect on root length, and number of leaves, while the same quantity of water and the highest percentage of this acid (300) ppm gave the highest effect on plant height, number of branches and number of capsules and dry weight of leaves. On the other hand, the application of the lowest concentration of glutamic acid (150 ppm) under the same quantity of irrigation water showed the highest values of root, stem, and whole plant dry weight. Arfan, *et al*. (2007) reported that by varying SA levels for spring wheat, the most effective levels for promoting growth and grain yield were 0.75 and 0.25 mM under normal and saline conditions, respectively. The improvement in growth and grain yield of S-24 due to SA application was associated with improved photosynthetic capacity. Changes in photosynthetic rate due to SA application were not due to stomatal limitations, but were associated with metabolic factors, other than photosynthetic pigments and leaf carotenoids**.**

Yield:

Concerning the effect of the interaction between water quantity and antioxidants on yield of canola and its attributes, seed productivity of treated canola plants with 300 ppm citric acid was superior among other treatments under 1336 and 935 m^3/fed. water regimes, meanwhile, spraying of 150 ppm glutamic acid was the superior when plants received 668 m^3/fed water. This was true for biological yield (Fig., 1). On the other hand, Fig. (2) shows the values of seed index, data showed that there were no significant differences in this trait under the different experimental treatments, but it has the same trend of seed yield. Din, *et al*. (2011) observed that drought treatment at different growth stages reduced grain yield significantly. Greater reduction in grain yield was observed under the high stress water regime. The yield and biochemical composition of a plant mainly depends on growth conditions, which is markedly affected by water availability (Paclik *et al*., 1996). The most pronounced effects are observed when the water shortage occurs during the flowering period or pod-filling stages. At reproductive phase, water stress accelerates the process of flower and fruit drop and decreased seed yield (Sinaki *et al*., 2007).

Table 4: The effect of the interaction between water regimes and antioxidants on the growth and yield parameters of canola plants:

Water regimes	Growth regulators	Plant height, cm	No. of branches	Root length, cm	Dry weight of stem, g	Dry weight of root, g	Dry weight of leaves, g	Dry weight of whole plant, g	No. of leaves	No. of capsules
1336 (m^3/fed.)	150 *ppm ctitric acid*	83.67	2.33	13.67	4.71	1.51	2.55	8.77	13.33	95.00
	300 ppm ctitric acid	88.33	2.67	18.33	9.57	4.45	3.74	17.76	14.33	302.00
	150 ppm glutamic acid	77.00	0.67	15.33	4.08	1.44	2.65	8.17	13.00	89.00
	300 ppm glutamic acid	84.67	2.00	21.00	7.64	3.52	4.97	16.13	15.00	182.00
	control	75.67	1.00	14.67	3.71	1.45	2.66	7.82	13.67	94.00
935 (m^3/fed.)	150 *ppm ctitric acid*	89.00	1.67	20.67	14.95	5.86	1.83	22.64	12.00	40.00
	300 ppm ctitric acid	108.33	2.00	22.33	21.05	12.94	6.16	40.15	19.67	124.00
	150 ppm glutamic acid	103.67	1.00	20.33	6.31	4.03	3.88	14.22	18.00	166.00
	300 ppm glutamic acid	75.67	2.00	20.67	6.19	3.02	2.70	11.91	12.00	107.00
	control	74.33	1.67	18.00	5.08	2.79	2.57	10.44	17.00	104.00
668 (m^3/fed.)	150 *ppm ctitric acid*	76.67	1.00	20.00	4.38	1.77	3.95	10.10	17.33	114.00
	300 ppm ctitric acid	84.00	1.67	18.00	7.25	3.04	4.42	14.71	15.00	170.00
	150 ppm glutamic acid	83.67	0.33	17.00	10.93	4.37	2.77	18.07	15.00	76.00
	300 ppm glutamic acid	83.67	1.00	11.67	3.41	1.57	1.88	6.86	11.67	48.00
	control	66.00	1.00	11.67	3.39	1.50	2.38	7.27	11.67	77.00
L.S.D. at 5% level		12.85	1.08	4.06	4.76	3.11	3.45	8.48	3.45	59.25

Data illustrated in Fig. (3) shows the effect of the interaction between the experimental treatments on the oil % and the oil yield (t/fed.). It is clear that there were no significant differences between the values of oil % under the effect of different experimental treatments, and oil yield has the same trend of seed productivity, where the highest oil yield was obtained by spraying plants with 300 ppm citric acid and applying 75% of the Etc water regime.

Water use efficiency:

Fig. (4) shows the calculated values of WUE (kg/m^3) under the interaction between the experimental water regimes and sprayed concentrations of citric and glutamic acids. The highest values WUE was obtained by irrigating plants by 668 m^3/fed. (50% of the Etc) water regime and spraying plants by 150 ppm glutamic acid, followed by spraying plants by 300 ppm citric acid and irrigation with 935 m^3/fed. (75% of the Etc). So, spraying plants by 300 ppm citric acid decrease the harmful effect of the moderate water stress, and spraying of 150 ppm glutamic acid has more effect on plants which irrigated by the lowest quantity of water. Leilah *et al*. (2002) stated that the irrigating canola plants every 14 days was associated with highest WUE. Hussein *et al*. (2008) demonstrated that WUE of grain sorghum increased with moderate drought and decreased with the severe one.

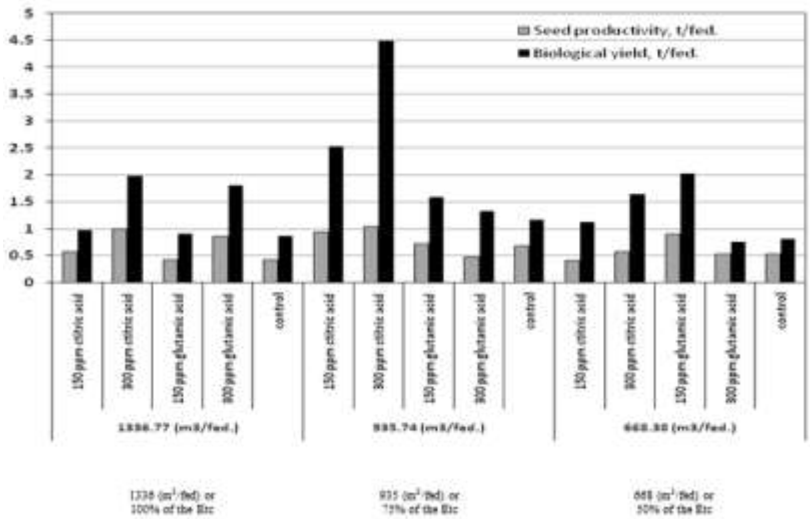

Fig. 1: The effect of the interaction between water regimes and spraying 150 and 300 ppm of citric and glutamic acids on the seed and biological yields (t/fed.).

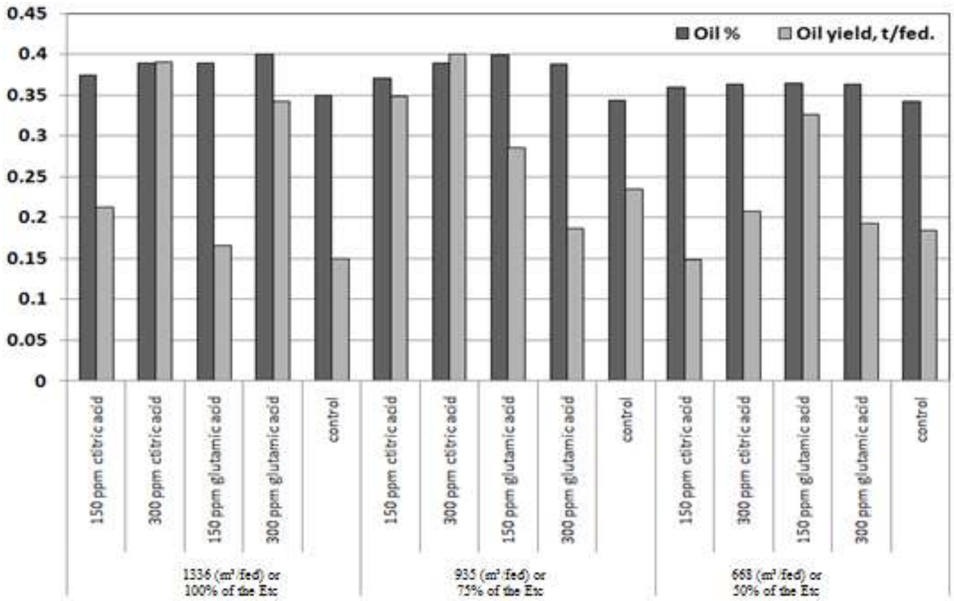

Fig. (3): The effect of the interaction between water regimes and spraying 150 and 300 ppm of citric and glutamic acids on oil % and oil yield (t/fed.).

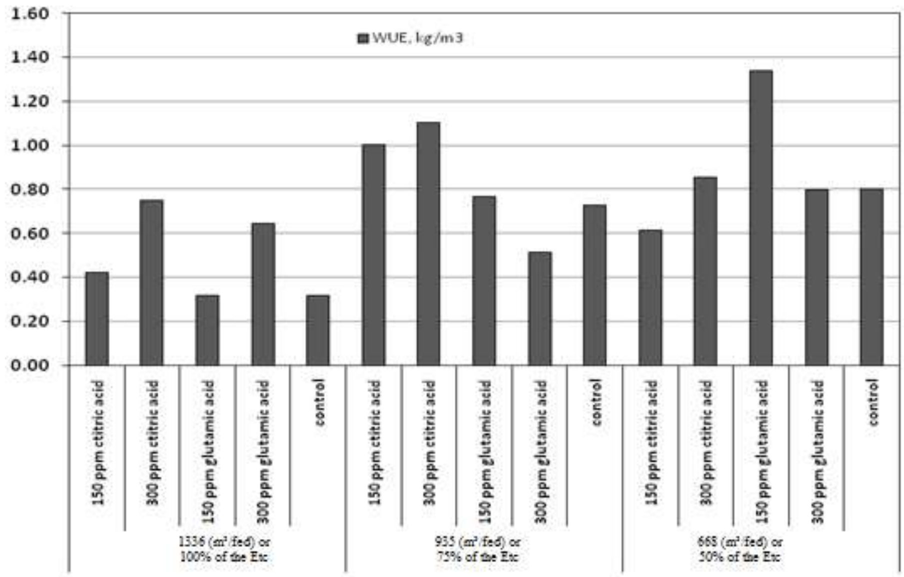

Fig. 4: The effect of the interaction between water regimes and spraying 150 and 300 ppm of citric and glutamic acids on WUE (kg/m^3).

Conclusion:

The interactive effect of water supply and some antioxidants on growth of canola plants indicated that the application of both two used antioxidants affected the growth parameters of canola plants. There were clear positive effects of using 75% of the Etc on all growth parameters of canola plants (Plant height, root length, dry weight of stem, root, leaves and whole plant, and number of leaves and branches per plant), as well as the seed and oil yields and 100 seed weight, except for number of capsules per plant where the highest number was obtained by using 100% of the Etc. Generally, spraying plants by 300 ppm of the citric acid improved the growth, yield and its components. The highest water use efficiency was obtained by using 50% of Etc and spraying plants by 150 ppm glutamic acid, followed by spraying plants by 300 ppm citric acid and irrigation with 75% of the Etc. So, spraying canola plants by 300 ppm citric acid improved the response of canola plants under the moderate deficit condition (75% of the Etc). Moreover, spraying plants with 150 ppm glutamic acid exhibited the same effect under the highest level of water deficit.

References

Abbasian, A.R. and A.H.S. Rad, 2011. Investigation the response of rape seed cultivars to moisture regimes in different growth stages. J. of Central European Agric., 12(2): 353-366.

Abd El-Aal, F.S., A.M. Shaheen, A.A. Ahmed and A.R. Mahmoud, 2010. Effect of foliar application of urea and amino acids mixtures as antioxidants on growth, yield and characteristics of squash. Res. J.Agric. Biol. Sci., 6: 583-588.

Ahmadi, M. and M.J. Bahrani, 2009. Yield and yield components of rapeseed as influenced by water stress at different growth stages and nitrogen levels. American-Eurasian J. Agric. & Environ. Sci., 5(6): 755-761.

Al-Barak, K.M., 2006. Irrigation intervals and nitrogen levels effects on growth and yield of canola. Sci. Fac. J. of King Fiasal Univ., 7(1): 1427H.

Al-Habeeb, A. and A. Al-Hendawi, 2002. Effect of irrigation and seed rate on growth and yield of canola in central region In Proceeding of the 1st Symposium of Saudia Arabia, Fac. of Sci., Righyd 5-7 Feb., pp: 56-66.

Arfan, M., H.R Athar and M. Ashraf, 2007. Does exogenous application of salicylic acid through the rooting medium modulate growth and photosynthetic capacity in two differently adapted spring wheat cultivars under salt stress? Journal of Plant Physiology, 164(6): 685-694.

Baladis, S.O. and Z. Gaile, 2009. Impact of some agronomical factors as winter oil seed rape (*Brassica napus L*.). Plant density ESF project 2009/O225/IDA/ 1.12.1.2/IPIA/ViAA/129.

Cerdán, M., S.A. Sánchez, M. Oliver, M. Juárez and A.J.J. Sánchez, 2006. Effect of foliar and root application of amino acid on iron uptake by tomato plants. Acta Hort., 830: 481-488.

Din, J., S.U. Kans, J. Ali and A.R. Gurmani, 2011. Physiological and agronomic response of canola varieties to drought stress. The J. of Animal & Plant sci., 21(1): 78-82.

Gan, Y., S.S. Malhi, S. Brandt, F. Katepa-Mupondwa and H.R. Kutcherm, 2007. *Brassica juncea* canola in the northern great plains: responses to diverse environments and nitrogen fertilization. Agron. J., 99: 1208-1218.

Good, G. and J. MacLagan, 1993. Effect of drought stress on water relations in Brassica ssp. Cand. J. Plant Sci.,73: 525-529.

Herdart, G., 2012. Canola and chamomile growth under limited irrigation. Panhandle unit edu/c/dec.ujent…./get_file/unid.

Hussein, M.M., S.M. Abd El-Halim, S.W. El-Faham and A. Talaab, 2010. Foliar fertilization and drought and its effect on mineral status of barley grains. Accepted in the 12th International Conference of Agronomy, Sept., 2010, El-Ariesh, North Scienie**,** Egypt.

Hussein, M.M., H.A. El-Zieny and A.A. El-Noimani, 2008. Plant nutrition management under water stress conditions. 17th Inter. Symposium of CIEC. Nov., NRC, Cairo, II: 278-288.

Hussein, M.M. and Kamilea Y. El-Diewny, 2011. Mineral Constituents of fenugreek varieties grown under water stress condition. Australian Journal of Basic and Applied Sciences, 5(12): 2904-2096.

Khan, A.S., B. Ahmad, M.J. Jaskani, R. Ahmad and A.U. Malik, 2012. Foliar application of mixture of amino acids and seaweed (*Ascophylum nodosum*) extract improve growth and physico-chemical properties of grapes. Int. J. Agric. Biol., 14: 383-388.

Leilah, A.A., S.A. Al-Khateeb, A. Al-Niem and S. Al-Tahbet, 2002. Response of some canola cultivars to drought in the region of Low Holy Mosques. Agric. and Water Resources Develop., Symposium in King Feizal Univ., Cod. Breled. Hum. 14-16-D. Gyadah, 28-30.

Li, Z., X. Zhao, A.K. Sandhu and L. Gu, 2010. Effects of exogenous abscisic acid on yield, antioxidant capacities, and phytochemical contents of greenhouse grown lettuces. J. Agric. Food Chem., 58(10): 6503-6509.

Mendham, N.J. and P.A. Salisbury, 1995. Physiology, Crop, Development, growth and yield of *Brassica* oil seeds. CAB International, pp: 11-64.

Moslev, G., 1983. Variation in the epiculicular waxcontent of white clover leaves. Grass forage Sci., 38:201-204.

Naseri, M., M. Khalat bari, H. Zahedi, F. Pak nejad and H.R. Tohidi moghadam, 2008. Evaluation of micro and macro Elements in Drought stress condition in some cultivars of Rape seed (*Brassica napus*). Am. J. Agric. Biol. Sci., 3(3): 579-583.

Paclik, R.L., O. Sakova and V. Curn, 1996. Reaction of different cultivars of *Brassica napus* subsp. oleifera to water stress. Fytotechnicka-Rada., 1: 55-62.

Rai, V.K., 2002. Role of amino acids in plant responses to stress. Biol. Plant, 45: 471-478.

Rezaei, M.A., B. Kaviani and A.K. Masouleh, 2012. The effect of exogenous glycine betaine on yield of soybean [*Glycine max* (L.) Merr.] in two contrasting cultivars Pershing and DPX under soil salinity stress. POJ, 5(2):87-93.

Robertson, M.J. and J.F. Holand, 2004. Production risk of canola in the semi and sub-tropical of differential irrigation in the Klamath Basigric Austria. Aust. J. Res., 55: 525-538.

Robertson, R., J.E. Smith and R.A. Shuck, 2007. Growth, yield and oil production of canola varieties in response to differential irrigation in Kalamth Basin, 2007, Researth in the Kalamth Basin 2007 Annual Report.

Sakr, M.T. and M.A. El-Metwally, 2009. Alleviation of the harmful effects of soil salt stress on growth, wield and endogenous antioxidant content of wheat plant by application of antioxidants. Pakistan Journal of Biological Science, 12(8): 624-630.

Sarmadnia, G. and A. Kocheki, 1989. Crops Plant Physiology. Jahad daneshghahi of Masshad Press.

Shehata, S.A., A.A. Gharib, M.M. El-Mogy, K.F. Abdel Gawad and E.A. Emad, 2011. Influence of compost, amino and humic acids on the growth, yield and chemical parameters of straw berries. Journal of Medicinal Plants Research, 5(11): 2304-2308.

Shiraishi, M., H. Hiroyuki Fujishima, and H. Hiroyuki Chijiwa, 2010. Evaluation of table grape genetic resources for sugar, organic acid, and amino acid composition of berries. Euphytica, 174: 1-13.

Sinaki, J.M., E. Majidi Heravan, A.H., Shirani Rad, G. Noormohamadi and G. Zarei, 2007. The effects of water deficit during growth stages of canola (*Brassica napus*). American-Eurasian. J. Agric. Environ. Sci., 2(4): 417-422.

Singh, K.P., V.K. Chaturvedi and B. Bose, 2010. Effects of salicylic acid on seedling growth and nitrogen metabolism in cucumber (*Cucumis sativa L*). Journal of Stress Physiology & Biochemistry, 6(3): 102-113.

Snedecor, G.W. and W.G. Cochran, 1990. Statistical methods. 8th Ed., Iowa State Univ., Press, Iowa ,U.S.A.

Tesfamerian, E.H., J.G. Annandale and J.M. Steyn, 2010. Water stress effect on winter canola growth and yield. Agron. J., 102(2): 658-666.

Tohidi-Morgan, H.R., A.H. Shiran, Rad and G. Nour-Mohamadi, 2009. Response of six oil seed rape genotypes to water stress and hydrojel. Goiânia, 39(3): 243-250.

Youssefi, A., A. Nshanian and M. Azizi, 2011. Evaluation of Influences of Drought Stress in Terminal Growth Duration on Yield and Yield Components of Different Spring Brassica oilseed Species. American-Eurasian J. Agric. & Environ. Sci., 11(3): 406-410.