AN AJSS
An Asian Journal of Soil Science
Volume 12 | Issue 1 | June, 2017 | 41-48 | e ISSN–0976–7231 ■ Visit us : www.researchjournal.co.in

Research Article

DOI : 10.15740/HAS/AJSS/12.1/41-48

Alleviation of saline water stress on tomato (*Lycopersicon esculentum* Mill.) plants by irrigation scheduling and foliar application of salicylic acid and potassium sulphate

■ RAMANDEEP KAUR, I. J. GULATI, DINESH KUMAR AND PRAMENDRA SINGH

Received : 18.01.2017; **Revised :** 08.04.2017; **Accepted :** 21.04.2017

MEMBERS OF RESEARCH FORUM:

Corresponding author :
DINESH KUMAR, Department of soil Science and Agricultural Chemistry, College of Agriculture, S.K. Rajasthan Agricultural University, BIKANER (RAJASTHAN) INDIA
Email: dkrachiata@gmail.com

Co-authors :
RAMANDEEP KAUR, I. J. GULATI AND PRAMENDRA SINGH, Department of soil Science and Agricultural Chemistry, College of Agriculture, S.K. Rajasthan Agricultural University, BIKANER (RAJASTHAN) INDIA

Summary

One of the main hurdles in boosting the agricultural production in arid and semi arid areas of world is the scarcity of good quality water for irrigation. The quality of irrigation water plays a key role in judging its suitability for crop production. Soil and water salinity is an abiotic stress and limiting factor which affects almost every aspect of physiology and biochemistry of a plant, resulting in reduction in its yield. The research entitled alleviation of saline water stress on tomato (*Lycopersicon esculentum* Mill.) plants by irrigation scheduling and foliar application of salicylic acid and potassium sulphate. was conducted at Niche area of excellence, S.K. Rajasthan Agricultural University, Bikaner during *Rabi* season of 2015-16. The result shown that biochemical parameters APX, SOD, POX and CAT activity significantly increased with the increase in irrigation interval from daily irrigation to third day irrigation. The effect of irrigation levels on APX, SOD, POX and CAT activity significantly increased from 1.0 vol. (full volume of water required by crop) to 0.8 vol. (80% of full volume of water required by crop) and at par to 0.6 vol. (60% of full volume of water required by crop). The application of salicylic acid and potassium sulphate resulted in significant increase in APX, SOD, POX and CAT activity over control at application of 500 ppm and 15 m mol, respectively. The physiological parameters *viz.*, electrolyte leakage and relative leaf water content (RLWC) decreased with the decreasing irrigation levels from 1.0 vol. to 0.8 vol. and at par to 0.6 vol. The electrolyte leakage and RLWC decreased with the increase in irrigation interval from daily to third day irrigation. With the application of salicylic acid and potassium sulphate the physiological parameters increased significantly. The quality parameters also fluctuate with the treatments. The TSS and ascorbic acid content of tomato decreased with the increase in irrigation levels as well as irrigation intervals and increased with the application of salicylic acid and potassium sulphate. The similar results were found with the yield and yield attributes, the number of fruits per plant, avg. diameter of fruit, avg. weight of fruit and yield of fruits decreased with the increase in the irrigation interval and irrigation levels and increased with the application of salicylic acid and potassium sulphate. The soil was non-significantly affected with all the treatments of research.

Key words : Saline water stress, Irrigation scheduling, Salicylic acid, Potassium sulphate

How to cite this article : Kaur, Ramandeep, Gulati, I.J., kumar, Dinesh and Singh, Pramendra (2017). Alleviation of saline water stress on tomato (*Lycopersicon esculentum* Mill.) plants by irrigation scheduling and foliar application of salicylic acid and potassium sulphate. *Asian J. Soil Sci.*, **12** (1) : 41-48 : **DOI : 10.15740/HAS/AJSS/12.1/41-48.**

Introduction

One of the main hurdles in boosting the agricultural production in arid and semi arid areas of world is the scarcity of good quality water for irrigation. The quality of irrigation water plays a key role in judging its suitability for crop production. Soil and water salinity is an abiotic stress and limiting factor which affects almost every aspect of physiology and biochemistry of a plant, resulting in reduction in its yield. During initial exposure to salinity, plants experience water stress, which in turn reduces leaf expansion. During long term exposure to salinity, plants experience ionic stress, which leads to premature senescence of adult leaves and thus, a reduction in the photosynthetic rate available to support continued growth. The key to the effective use of saline irrigation waters and salinity control is to provide the proper amount of water to the plant at the plant and at the proper time. The ideal irrigation system should provide water as nearly continuously as possible, though not in excess, as needed to keep the soil water content in the root zone. Drip irrigation can also be successfully used with saline water. The salt stress is kept minimized at the root zone of the plant with drip system, as the salts are pushed to the periphery of the wetting zone. The plants defined against these reactive oxygen species by induction of activities of certain anti-oxidative enzyme such as catalase peroxidase, glutathione reductase and super-oxidase dismutase, which scavenge reactive oxygen species. Promising results of some of the bio-regulators in mitigating its effect of salinity might be through scavenging active oxygen species under salt stress. Increase in the germination and fresh and dry weight of the seedling, under salinity conditions can be achieved by the use of salicylic acid and potassium sulphate. Salicylic acid is a naturally occurring plant hormone, is an important signal molecule known to have diverse effects on biotic and abiotic stress tolerance.

Resource and Research Methods

Geographical location of Bikaner is 74.12°E longitude and 27.11°N to 29.03°N latitude at an altitude of 228.35 meters above mean sea level. Bikaner falls in agro climatic zone Ic (Hyper Arid Partially Irrigated North Western Plain Zone). According to national planning commission, Bikaner falls under Agro climatic zone XIV (Western dry region) of India. In all, 24 combinations comprising of three levels of irrigation water volume (1.0 volume, 0.8 volume and 0.6 volume), two levels of irrigation schedule (Daily and third day irrigation) in plots and two levels of salicylic acid (Control and 1.5mM) and two levels of potassium sulphate (Control and 500 ppm) in sub-plots were tested. The treatment combinations were replicated three times in SPD and allocated randomly to different plots by using random number from the table of Fisher (1950). The variety of tomato crop used was selection-7. The different irrigation levels were set as one volume *i.e.* 100 per cent of total water required by the experimental crop, 0.8 volumes *i.e.* 80 per cent of total water required by the experimental crop and 0.6 volumes *i.e.* 60 per cent of total water required by the experimental crop. To apply these different quantities of water to the experimental crop the laterals of drip irrigation system were operated for the different times a day. All the two intervals of irrigation schedule were maintained in field after transplanting of tomato as daily and third day irrigation. The two levels of potassium sulphate (0 ppm and 500 ppm) were applied as foliar application first at 30 DAT and second at 55 DAT. Salicylic acid (1.5mM) was applied twice as foliar application first at 30 DAT and second at 55 DAT. Enzyme quantification and activities of antioxidant enzymes determined by Bradford assay (Bradford, 1976).The ascorbate peroxidase (APX) activity was measured by the decrease in absorbance at 290 nm as the absorbance was oxidized (Nakano and Asada, 1987). The POX and CAT activity determined according to the method of Chance and Maehly (1955). The SOD activity was measured using the method of Dhindsa and Motowe (1981). The data were statically analyzed using CPCS1 software to calculate CD at 5 per cent level of significance. The relative leaf water content (RLWC) was estimated according to Slavik (1974). The RLWC was calculated as RLWC = 100 x [(Fresh mass – dry mass) /(Saturated mass - dry mass)]. Saturated mass determined after incubation of the leaf in water for 24 hours

at room temperature. Dry mass was measured following oven drying at 75 °C to a constant mass. The electrolyte leakage from membranes of leaf tissue was estimated by the method described by Bajji *et al.* (2001) and expressed as per-cent electrolyte leakage. The total soluble solids (TSS) (%) were determined by the help of digital refractometer. The ascorbic acid (mg 100 g^{-1}) in fruits was determined using the standard methods as given by A.O.A.C. (1970). Number of fruits per plant, fruit diameter (cm), average fruit weight (g) and fruit yield (q/ha) were calculated. The diameter of fruit was measured with the help of varneer calipers in centimeters at its central point.

Research Findings and Discussion

Antioxidant enzymes as APX, SOD, POX and CAT activities increased significantly with the increase in irrigation interval (daily to third day), decrease in irrigation level (1.0 vol. to 0.8 vol. and 0.6 vol.), significantly increased with the application of salicylic acid (1.5mM) and potassium sulphate (500ppm) as shown in Table 1 and Fig. 1,2,3 and 4. According to Simaei *et al.* (2011) application of salicylic acid increases the activity of anti oxidant enzymes. Sevengor *et al.* (2011) reported that the exogenous salicylic acid application significantly increased the activity of APX in pumpkin genotypes.

The physiological parameters as relative leaf water content (RLWC) and electrolyte leakage decreased significantly with increase in the irrigation interval (daily to third day) and decrease in irrigation level (1.0 vol. to 0.8 vol. and 0.6 vol.) and significantly increased with the application of salicylic acid (1.5mM) and potassium sulphate (500ppm) as shown in Table 1. Reduced RLWC under the influence of salt stress has been reported by El-Basiouny and Bekheta (2005) in wheat and Mohammadreja *et al.* (2012) in brassica napus. He also reported an increase in electrolyte leakage in salt stressed brassica napus seedlings. Salinity induced increase in electrolyte leakage and its amelioration by salicylic acid application has been reported earliar by Gunes *et al.* (2007) in maize and Khan *et al.* (2010) in cucumber.

The yield and yield attributes of the tomato crop investigated decreased significantly over control with the increase in the irrigation interval (daily to third day) and decrease in irrigation level (1.0 vol. to 0.8 vol. and 0.6

Table 1 : Effect of salicylic acid, potassium sulphate, irrigations intervals and irrigation levels on biochemical parameters and physiological parameters of tomato

Treatments	APX	SOD	POX	CAT	RLWC	Eletrolyte leakage
Irrigation intervals						
I_1	215.72	42.11	290.27	23.32	76.25	26.29
I_2	262.63	45.04	305.13	27.44	64.81	22.35
S.E. ±	13.60	1.08	11.49	0.58	0.68	0.40
C.D. (P=0.05)	42.86	3.41	36.20	1.84	2.15	1.25
Irrigation levels						
I_{l1}	188.04	36.52	234.81	23.30	73.12	25.22
I_{l2}	262.46	47.02	326.15	26.19	71.99	24.81
I_{l3}	267.02	47.19	332.14	26.64	66.48	22.93
S.E. ±	16.66	1.33	14.07	0.71	0.84	0.48
C.D. (P=0.05)	52.49	4.18	44.34	2.25	2.64	1.53
Salicylic acid						
S_0	209.47	41.20	272.52	24.10	69.12	23.46
S_1	268.88	45.95	322.88	26.65	71.94	25.18
S.E. ±	0.47	0.08	0.58	0.05	0.14	0.05
C.D. (P=0.05)	1.35	0.24	1.67	0.14	0.39	0.13
Potassium sulphate						
K_0	228.37	42.56	282.27	25.16	69.89	24.10
K_1	249.98	44.59	313.13	25.59	71.17	24.54
S.E. ±	0.47	0.08	0.58	0.05	0.14	0.05
C.D. (P=0.05)	1.35	0.24	1.67	0.14	0.39	0.13

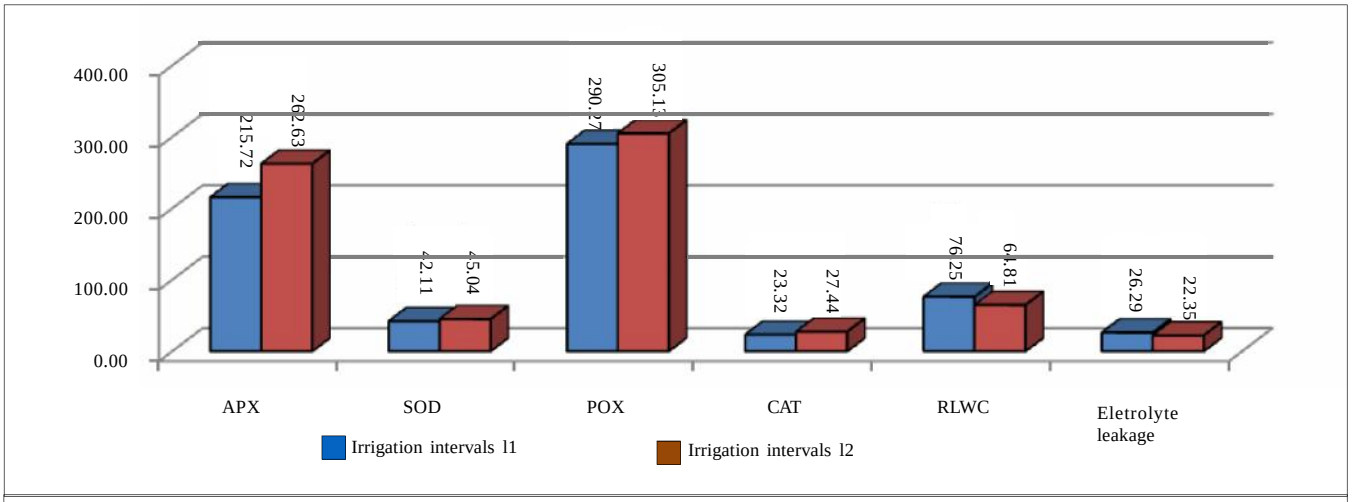

Fig. 1 : Effect of irrigation intervals on biochemical and physiological parameters

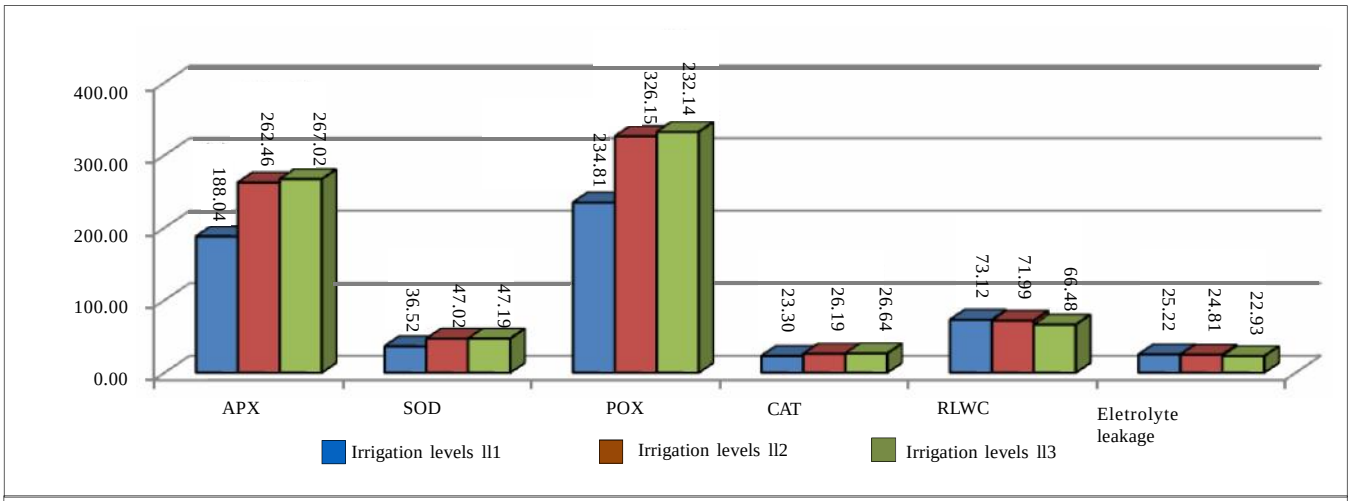

Fig. 2 : Effect of irrigation levels on biochemical and physiological parameters

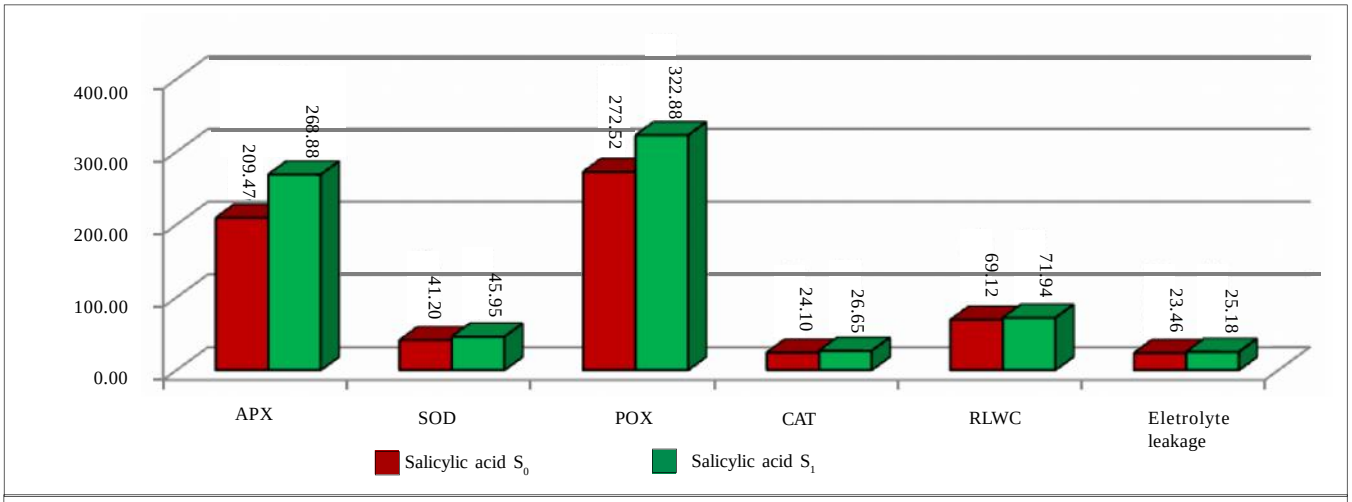

Fig. 3 : Effect of salicylic acid on biochemical and physiological parameters

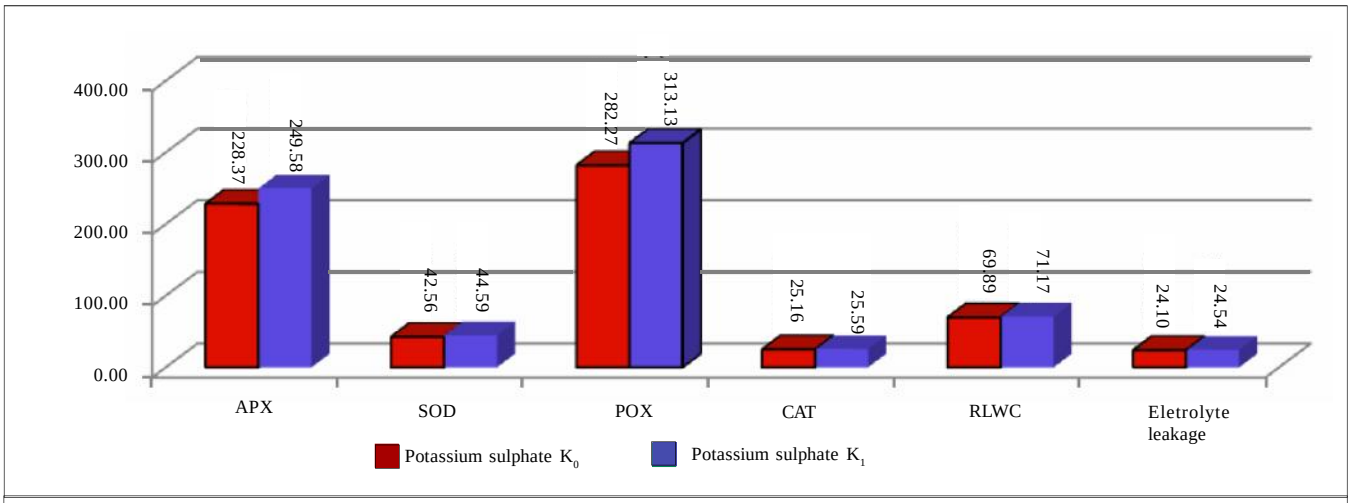

Fig. 4 : Effect of potassium sulphate on biochemical and physiological parameters

vol.) and significantly increased with the application of salicylic acid (1.5mM) and potassium sulphate (500 ppm) as shown in Table 2 and Fig. 5,6,7 and 8. Improvement in yield following salicylic acid application under salt stress has been worked out in mung bean by Pooja and Sharma (2010).

The quality parameters of the investigated crop such as TSS and ascorbic acid content decreased significantly over control with the increase in the irrigation interval (daily to third day), decrease in irrigation level (1.0 vol. to 0.8 vol. and 0.6 vol.) and significantly increased with the application of salicylic acid (1.5mM) and potassium

Table 2 : Effect of salicylic acid, potassium sulphate, irrigations intervals and irrigation levels on yield attributes and quality parameters of tomato

Treatments	Fruit per plant	Avg diameter	Avg. weight	Yield	TSS	Ascorbic acid
Irrigation intervals						
I_1	41.83	4.32	47.64	127.45	4.73	18.61
I_2	35.55	3.68	40.50	108.34	4.02	15.81
S.E.±	0.71	0.17	0.43	2.26	0.11	0.48
C.D. (P=0.05)	2.22	0.54	1.36	7.11	0.35	1.50
Irrigation levels						
I_{l1}	43.52	4.26	45.69	133.34	4.58	18.06
I_{l2}	41.38	4.22	44.98	126.51	4.51	17.77
I_{l3}	31.17	3.52	41.54	93.84	4.03	15.80
S.E.±	0.86	0.21	0.53	2.76	0.14	0.58
C.D. (P=0.05)	2.72	0.66	1.67	8.71	0.43	1.84
Salicylic acid						
S_0	37.17	3.62	43.18	113.03	4.13	16.16
S_1	40.21	4.38	44.96	122.76	4.62	18.26
S.E.±	0.07	0.01	0.09	0.23	0.01	0.03
C.D. (P=0.05)	0.21	0.02	0.24	0.66	0.02	0.10
Potassium sulphate						
K_0	37.55	3.91	43.66	114.25	4.11	16.78
K_1	39.83	4.09	44.48	121.54	4.64	17.64
S.E.±	0.07	0.01	0.09	0.23	0.01	0.03
C.D. (P=0.05)	0.21	0.02	0.24	0.66	0.02	0.10

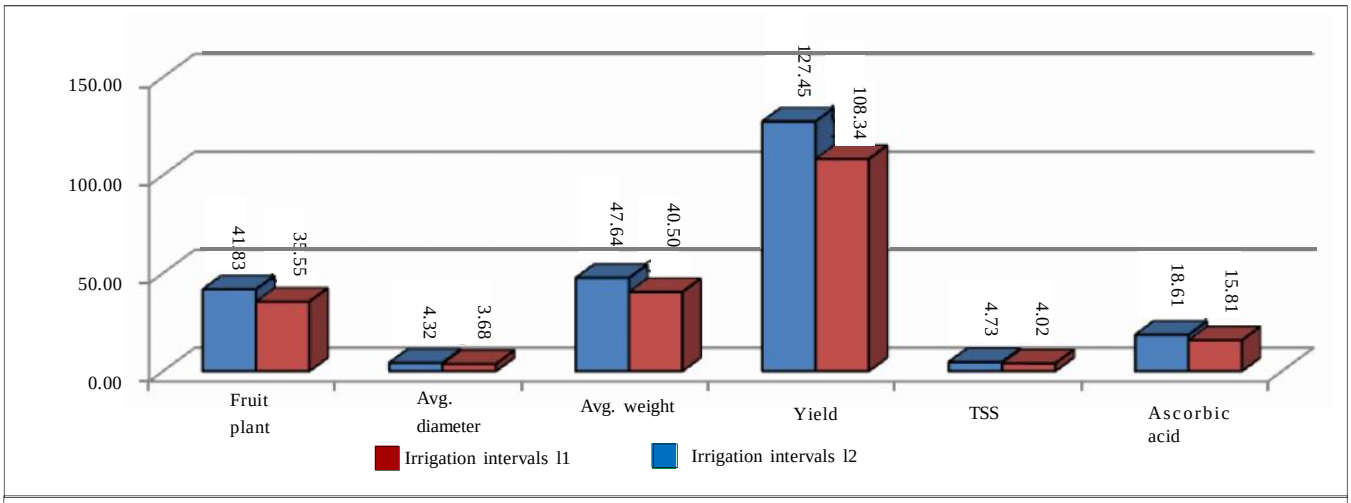

Fig. 5 : Effect of irrigation intervals on yield attributes and quality parameters

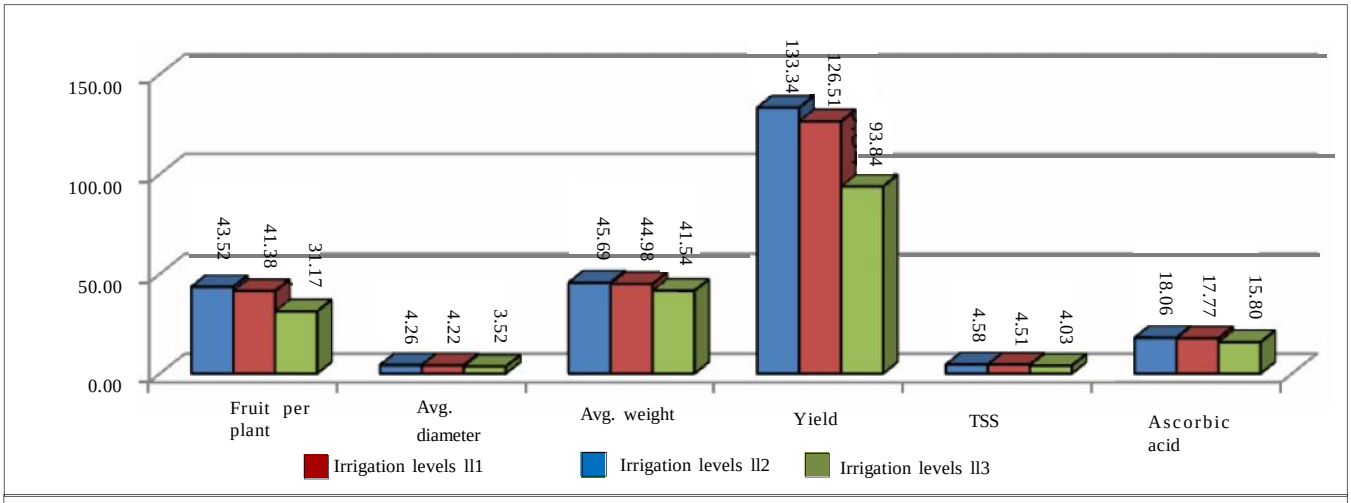

Fig. 6 : Effect of irrigation level on yield attributes and quality parameters

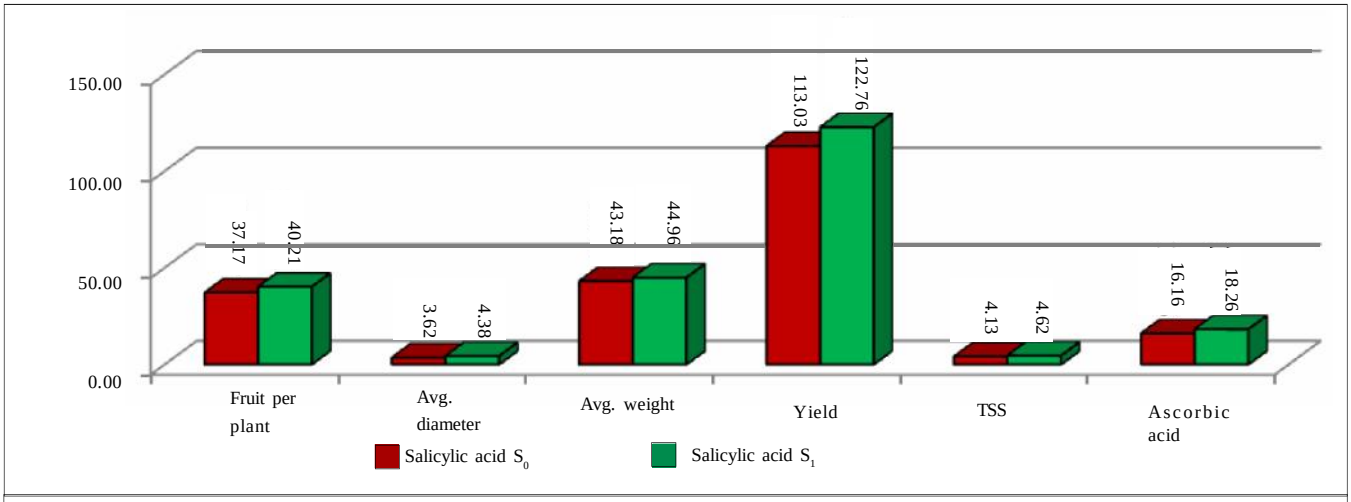

Fig. 7 : Effect of salicylic acid on yield attributes and quality parameters

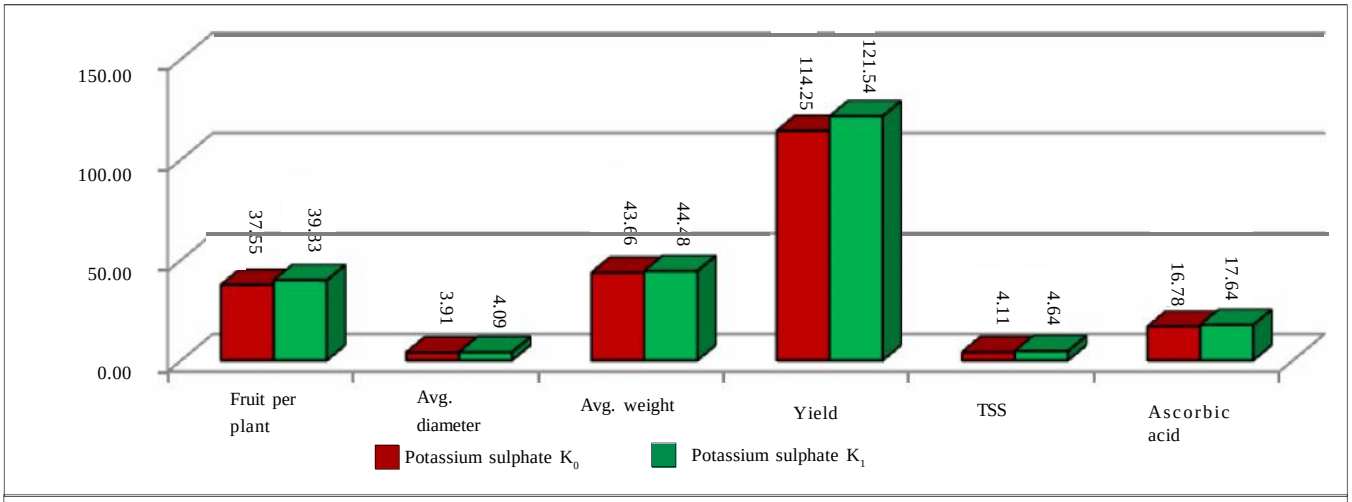

Fig. 8 : Effect of potassium sulphate on yield attributes and quality parameters

sulphate (500ppm) as shown in Table 2. Marchand *et al*. (1999) observed the influence of various potash sources (K_2SO_4, KCl, KNO_3) applied through drip irrigation in potato and found good quality tubers. Kazemi (2014) evaluated that the total soluble solids (TSS), total acidity (TA) and vitamin C content of tomato fruit has significantly increased by the application of salicylic acid.

Conclusion :

On the basis of results obtained from the present investigation antioxidant enzymes activity increased significantly with increase in irrigation interval , application of salicylic acid (1.5mM) and potassium sulphate (500 ppm). RLWC and electrolyte leakage decreased significantly with increased in the irrigation interval and decrease in irrigation level and and significantly increased with the application of salicylic acid (1.5mM) and potassium sulphate (500ppm). The yield and quality of tomato were higher with application of salicylic acid (1.5mM) and potassium sulphate (500ppm). However, these results are only indicative and require further experimentation for conformation before making final recommendation to the farmers.

Literature Cited

A.O.A.C. (1970). *Official methods of analysis*. 11th Ed. Association of Official Analytical Chemists, Washington, D.C. U.S.A.

Bajji, M., Kinet, J.M. and Lutts, S. (2001). The use of electrolyte leakage method for assessing cell membrane stability as a water stress tolerance test in durum wheat. *Plant Growth Regulations*, **1**: 1-10.

Bradford, M.M. (1976). A rapid and sensitive method for the quantification of microgram quantities of protein utilizing the principle of protein dye binding. *Analyt. Biochem.*, **72** (1) : 248-254.

Chance, M. and Maehly, A.C. (1995). Assay of catalases and peroxidases, *Methods Enzymology*, **2** : 764-817.

Dhindsa, R.S. and Motowe, W. (1981). Drought tolerance in two mosses: correlation with enzymatic defense against lipid peroxidation. *J. Exp. Bot.*, **32**: 79-91.

El-Basiouny, Hala, M.S. and Bekheta, M.A. (2005). Effect of salt stress on relative water content, lipid peroxidation, polyamines, amino acid and ethylene of two wheat cultivars. *Internat. J. Agric. & Biol.*, **10** (30) : 5713-5718.

Fisher, R.A. (1950). *Statistical methods for research workers*. Biological monographs and manuals. No. V. 1950 No. 11th Ed. pp.xv + 354 pp.

Gunes, A., Inal, A., Alpaslan, M., Eraslan, F., Bagei, E.G. and Cicek, N. (2007). Salicylic acid induced changes on some physiological parameters symptomatic for oxidative stress and mineral nutrition in maize (*Zea mays* L.) grown under salinity. *J. Plant Physiol.*, **164**: 728-736.

Kazemi, M. (2014). Vegetative and reproductive growth of tomato plants affected by calcium and salicylic acid. *Bull. Environ., Pharmacol. & Life Sci.*, **2**(11) : 24-29.

Khan, N.A., Syeed, S., Masood, A., Nazar, R. and Iqbal, N. (2010). Application of salicylic acid increases contents of nutrients and antioxidative metabolism in mungbean and alleviates adverse effect of salinity stress. *Internat. J. Plant Biol.*,**1**: 1-8.

Marchand, M., Bourrie, B., Anac, D. and Martin-Prevel, P.,

(1999). Use of potash fertilizers through different application methods for high yield and quality of crops. *Imp. Crop Qual. Nutri. Mang,* **5** : 13-17.

Mohammadreja, S., Amin, B., Forogh, A., Hossin, M. and Sorayya, S. (2012). Response of *Brassica napus* L. grains to the effect of salinity and salicylic acid. *J. Stress Physiol. & Biochem.*, **8** (2) : 61-68.

Nakano, Y. and Asada, K. (1987). Purification of ascorbate peroxidase from spinach chloroplasts: its activation in ascorbate–depleted medium and reactivation by monodehydro - ascorbate radical. *Plant Cell Physiol.*, **28**: 131-140.

Pooja and Sharma, K.D. (2010). Salicylic acid induced amelioration in growth, biochemical metabolites and yield of mung bean (*Vigna radiata* L.) under salinity stress. *Indian J. Plant Physiol.*, **15** (3): 219-225.

Sevengor, S., Fikret, Y., Kusvuran, S. and Ellialtioglu, S. (2011). The effect of salt stress on growth, chlorophyll content, lipid peroxidation and antioxidative enzyme of pumpkin seedling. *African J. Agric. Res.*, **6** (21): 4920-4924.

Simaei, I.M., Nejad, R.A.K., Saadatmand, S., Bernard, F. and Fahami, H. (2011). Effects of salicylic acid and nitric oxide on antioxidant capacity and proline accumulation in glysine max L. treated with NaCl salinity. *African J. Agric. Res.*, **6** (16):3775 - 3782.

Slavik, B. (1974). *Methods for studying plant water relations*. Ecological Studies, Vol. **9**, Springer-Verlag, Berlin and New York, U.S.A.