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ROLE OF HUMIC ACID AND SALICYLIC ACID ON YIELD ATTRIBUTES, YIELD AND ECONOMICS OF TOMATO UNDER SALINE STRESS CONDITION

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ABSTRACT

The present investigation was conducted at College of Agriculture, S.K. Rajasthan Agricultural University Bikaner, during kharif season of 2014 to evaluate the effect of different level of humic acid and salicylic acid on yield attributes, yield and economics of tomato (Lycopersicon esculentum Mill.) under saline stress condition. Results revealed that the fruits / plant, average diameter, average weight, fruit yield, net returns and B: C ratio decreased significantly with 4 and 8 dSm^{-1} levels of salinity of irrigation water over control. Application of both HA and SA significantly increased fruits / plant, average diameter, average fruit weight, fruit yield, net returns and B: C ratio. The saline water 0.25 dSm^{-1} (control) along with1.5 mM SA produced maximum fruits / plant (52.08) and average diameter (6.09 cm). The combined application of 1500 ppm HA and 1.5 mM SA recorded maximum average diameter (6.32 cm). Similarly the combined effect of saline water 0.25 dSm^{-1} (control) and 1500 ppm HA fetched the maximum net returns (₹ 71850.03 ha^{-1}) and B: C ratio (1.79). Combined soil application of HA (1500 ppm) with SA (1.5 mM), was found most effective which alleviated the deleterious impacts of salinity stress on tomato.

Key words: Saline water irrigation, humic acid, salicylic acid, tomato, yield, economics.

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is an important vegetable crop in India and its popularity is increasing constantly. The high consumption of fresh, cooked or processed tomatoes makes it one of the principal sources of vitamins and minerals in the human diet. In the areas with optimal climate for tomato cultivation, salinity is a serious constraint (Yurtseven *et al.,* 2005). The progressive salinization of land is considered a major environmental factor limiting plant growth and productivity of the arid and semi arid regions. Scarcity of good quality water is another problem of the world. Quantity and quality of available irrigation water in many arid and semi arid regions of the world are considered the limiting factors for undertaking agriculture (Munns, 2002). The deleterious effects of salinity on plant growth are associated with low osmotic potential of soil solution, nutritional imbalance, specific ion effect, hormonal imbalance and induction of oxidative stress, or a combination of these factors (Rahnama *et al.,* 2010). Salinity also reduced the fresh and dry shoot and root weight, no. of tomato per plant, average diameter and average fruit weight of tomato. Also decreased the net returns and B: C ratio (Magan *et al*., 2008). Therefore, studies are needed to find the best cultivation conditions for tomato in saline soils as salinization of soil is a serious problem and is increasing steadily in many parts of the world, in particularly in the arid and semi arid areas (Latef, 2010). Plant growth regulators, such as humic acid (HA) and salicylic acid (SA) can be used to promote growth and yield of plants under various stress conditions including salt stress. Feleafel and Mirdad (2014) reported that increasing HA rate up to 1500 ppm led to significantly increased total dry matter, number of fruits per plant, fruit mass and yield ha^{-1} traits compared to control treatment. Soil HA treatments positively affected fruit characteristics including fruit diameter, fruit height, fruit weight and fruit number per plant of tomato (Yildirim, 2007). HA application increases the water availability and nutrient supply to plants also activate hormones like auxine and cytokinine and increase the cell division and enlargement by this way increases the yield of crop and higher net returns and B: C ratio (Rajaraman and Pugalendhi, 2013). SA is a naturally occurring plant hormone, is an important signal molecule known to have diverse effects on biotic and abiotic stress tolerance. The positive effects of SA on tomato plant have also been reported under salinity stress condition (Stevens *et al*., 2006). Agamy *et al.* (2013)

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evaluated that exogenous application of SA promoted growth and yield and counteracted the salt stress-induced growth inhibition of salt stressed tomato plants. Low concentration of SA usually improves plant growth under salinity due to decreased concentrations of Na, Cl and H_2O_2 in plants, decreased electrolyte leakage, increased N and Ca contents and increased antioxidant enzyme activity (Khan *et al*., 2010). Application of SA resulted in significant increase in the net returns and B: C ratio (Marimuthu and Surendran, 2015). The present investigations were, therefore, undertaken to evaluate the role of HA and SA in mitigating the adverse effect of saline water on yield attributes, fruit yield and economics of tomato under saline water irrigation.

MATERIALS AND METHODS

The present investigation was carried out at College of Agriculture, S.K. Rajasthan Agricultural University Bikaner, during *kharif* season of 2014. Bikaner has arid climate with an average annual rainfall of 263 mm. More than 80 per cent rainfall is received in the monsoon season (July-September) by the south-west monsoon. During summer the maximum temperature may go as high as 48^0C, while in the winter it may fall as low as -3^0C. The soil of experimental site was sand in texture with pH_2 8.1, EC_2 0.43 dSm^{-1} and CEC 4.39 cmol (p^+) kg^{-1}. Tomato plants variety Pusa ruby were transplanted in open field during 1st week of August with 30 cm x 30 cm spacing. The experiment was carried out using 18 treatment combinations comprising three levels of saline water [control (0.25 dSm^{-1}), 4 and 8 dSm^{-1}], three levels of HA (control, 750 and 1500 ppm) and two levels of SA (control and 1.5 mM) were tested. The treatment combinations were replicated three times in factorial randomized block design and allocated randomly to different plots. All the three levels of saline water (0.25 dSm^{-1}, 4 dSm^{-1} and 8 dSm^{-1}) were applied in field after transplanting of tomato as per crop irrigation requirement. HA (750 ppm and 1500 ppm) were applied in soil just after transplanting along with fertigation. SA (1.5 mM) was applied twice as foliar application first at 30 and second at 55 DAT. A uniform basal dose of 80 kg P_2O_5 ha^{-1}, 60 kg K_2O ha^{-1} and half dose of 60 kg N ha^{-1} through SSP, MOP and urea was applied at the time of transplanting and remaining half dose of N was top dressed through urea at 45 DAT. Five fresh fruits harvested randomly from selected five plants were taken during harvesting to get the total number of fruit per plant, average diameter and average weight. The yield of fruits per hectare was calculated by multiplying the average yield of fruits per sq. meter and expressed in q ha^{-1}.

RESULTS AND DISCUSSION

Yield attributes and yield

Saline water irrigation resulted in significant decrease in fruits / plant, average diameter, average weight and fruit yield (Table 1). The fruits / plant decreased significantly by 6.6 and 22.5 %, average diameter by 11.2 and 29.8 %, average fruit weight by 10.9 and 24.7 % and fruit yield by 3.8 and 8.2 % with 4 and 8 dSm^{-1} level of salinity of irrigation water respectively, over control. Salinity adversely affects the plant growth and these adverse effects may be attributed to non availability of water, disturbance in nutrients causing deficiency or ion toxicity in plants. Extra expenditure of energy for osmotic adjustment or in repair system under salinity causes significant reduction in yields (Azeem *et al.,* 2011). Munnus *et al.* (1995) stated that salts within plants reduced growth and yield causing premature senescence of olds leaves and hence reduce supply of assimilates to the growing regions. The deleterious effects of salinity might also be due to adverse effect on translocation and partitioning of assimilates towards sink and metabolic process (Ragab *et al*., 2008). HA application significantly increased the fruits / plant; average diameter, average fruit weight and fruit yield (Table 1). Fruits/plant increased significantly by 10.7 and 18.9 %, average diameter by 21.9 and 47.4 %, average fruit weight by 8.0 and 15.2 % and fruit yield by 3.9 and 7.1 % with 750 and 1500 ppm levels of HA application, respectively over control. Under salinity stress condition, application of HA probably not only improved the antioxidant defense enzymes system but also triggered the non-enzymatic antioxidants in plants. HA increased the yield attributes by activating hormones like auxine and cytokinine and increasing the cell division and enlargement (Feleafel and Mirdad, 2014). HA improved plant physiological processes by enhancing the availability of major and minor nutrients as well

Table 1: Effect of saline water irrigation, HA and SA on yield attributes, fruit yield and economics of tomato

Treatments	Fruits / plant	Average Diameter (cm)	Average fruit weight (g)	Fruit yield (q ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio
Saline water (dSm^{-1})						
Control	49.66	5.53	59.33	154.85	64111.17	1.71
4	46.38	4.91	52.86	148.90	54966.17	1.58
8	38.50	3.88	44.66	142.12	44980.62	1.46
S.Em.±	0.42	0.07	0.50	0.93	926.41	0.01
C.D. (P = 0.05)	1.20	0.21	1.43	2.66	2662.53	0.03
Humic acid (ppm)						
Control	40.80	3.88	48.52	143.38	49980.10	1.54
750	45.19	4.73	52.43	148.96	55022.29	1.59
1500	48.54	5.72	55.91	153.54	59055.59	1.63
S.Em.±	0.42	0.07	0.50	0.93	926.41	0.01
C.D. (P = 0.05)	1.20	0.21	1.43	2.66	2662.53	0.03
Salicylic acid (mM)						
Control	43.36	4.28	51.13	146.19	52281.73	1.56
1.5	46.33	5.27	53.44	151.06	57090.25	1.61
S.Em.±	0.34	0.06	0.41	0.76	756.41	0.01
C.D. (P = 0.05)	0.98	0.17	1.16	2.17	2173.95	0.02

as enhancing the vitamins, amino acids and ABA contents of the plants (Vanitha and Mohandass, 2014).Application of SA resulted in significant increase in fruits / plant, average diameter, average fruit weight and fruit yield (Table 1). The fruits / plant increased significantly by 6.8 %, average diameter by 23.1 %, average fruit weight by 4.5 % and fruit yield by 3.3 % with 1.5 mM SA application over control. SA is a potent signaling molecule in plants and is involved in eliciting specific responses to abiotic stresses. Therefore, increased tomato yield receiving SA, might be due to enhancing the antioxidant and build-up of a protective mechanism to reduce oxidative damage induced by salt stress (Agamy *et al.,* 2013).

Table 2: Interactive effect of saline water irrigation and SA on fruit / plant and average diameter (cm) of tomato

Salicylic acid (mM)	Saline water (dSm^{-1})					
	Control	4	8	Control	4	8
	Fruits / plant			Average diameter (cm)		
Control	47.23	45.28	37.58	4.98	4.23	3.63
1.5	52.08	47.47	39.42	6.09	5.58	4.14
S.Em.±		0.59			0.11	
C.D. (P = 0.05)		1.70			0.30	

The positive effect of SA could be attributed to an increased CO_2 assimilation and photosynthetic rate and increased mineral uptake by the stressed plant. Yield is the final manifestation of the growth and photosynthetic processes (El-Hak *et al.*, 2012).The interactive effect (Table 2) of saline water 0.25 dSm^{-1} (control) and 1.5 mM SA level recorded maximum fruits / plant (52.08) and average diameter (6.09 cm). SA is a phenolic compound altered the auxine, cytokinine and ABA balances in plants and increased the growth and yield under both normal and saline conditions. (Yildirim and Dursun, 2009; Qados, 2015). Increasing of yield, under foliar application of salicylic acid could be ascribed to the well-known roles of salicylic acid on photosynthetic parameters and plant water relations (Fariduddin *et al.,* 2003). The interactive effect of 1500 ppm HA and 1.5 mM SA level (Table 3) recorded maximum average diameter (6.32 cm). The additive effect of HA and SA in enhancing the activity of antioxidants in plants which probable resulted in an increase in the average diameter of fruit (El-Hak *et al.,* 2012).

Table 3: Interactive effect of HA and SA on average diameter (cm) of tomato

Salicylic acid (mM)	Humic acid (ppm)		
	Control	750	1500
Control	3.56	4.17	
1.5	4.20	5.30	
S.Em.±		0.11	
C.D. (P = 0.05)		0.30	

Economics

Application of saline water irrigation significantly decreased the net returns and B: C ratio (Table 1). The net returns decreased significantly by 14.3 and 29.8 % and B: C ratio by 7.6 and 14.6 % with 4 and 8 dSm^{-1} level of salinity of irrigation water, respectively over control (Magan *et al.,* 2008). Salinity generally affects the plant growth adversely resulted in significant reduction in yield. HA application significantly increased the net returns and B: C ratio (Table 1). The net returns increased significantly by 10.1 and 18.1% and B: C ratio by 3.2 and 5.8 % with 750 and 1500 ppm levels of HA application, respectively over control. HA application increases the water availability and nutrient supply to plants by this way increases the yield of crop which resulted in higher net returns and B: C ratio (Rajaraman and Pugalendhi, 2013). Application of SA resulted in significant increase in the net returns and B: C ratio (Table 1).

Table 4: Interactive effect of water salinity and HA on net return and B: C ratio of tomato

Humic acid (ppm)	Saline water (dSm^{-1})					
	Control	4	8	Control	4	8
	Net return (₹ ha^{-1})			B: C ratio		
Control	57055.10	50848.43	42036.76	1.63	1.54	1.44
750	63428.40	56483.40	45155.06	1.70	1.60	1.46
1500	71850.03	57566.70	47750.03	1.79	1.61	1.49
S.Em.±		1604.59			0.02	
C.D. (P = 0.05)		4611.64			0.05	

The net returns increased significantly by 9.2 % and B: C ratio increased by 3.2 % with 1.5 mM SA application over control. Low concentration of SA usually improves plant growth under salinity due to increased N and Ca contents and increased antioxidant enzyme activity (Khan *et al*., 2010), ultimately increased the crop yield, net returns and B: C ratio of tomato. (Muhal *et al*., 2014).The interactive effect of saline water irrigation and HA application was found significant in improving net returns and B: C ratio (Table 4). The maximum net returns (₹71850.03 ha^{-1}) and B: C ratios (1.79) were recorded with the good quality of irrigation water 0.25 dSm^{-1} (control) and 1500 ppm HA level. HA application activates the hormones like auxine and cytokinine which results in increase in cell division and enlargement and consequently increase the yield of crop and higher net returns and B: C ratio (Rajaraman and Pugalendhi, 2013). Salt stress is one of the major abiotic stress factors that affect almost every aspect of physiology and biochemistry of a plant, resulting in reduction in yield. From the study it may be concluded that for realizing higher yield and economics of tomato, combined application of HA (1500 ppm) with SA (1.5 mM) was found most effective which alleviated the deleterious impacts of salinity stress on tomato.

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