Pak. j. sci. ind. res., vol. 32, no. 2, February 1989

EFFECT OF SALT STRESS ON GROWTH OF TOMATO

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(Received May 3, 1988; revised February 4, 1989)

A glasshouse experiment in gravel beds, was conducted to evaluate the response of tomato cultivars to varying levels of salinity. Three tomato cultivars 'Marglobe', 'Marmande' and 'Roma VF' were grown at four salinity levels. The gravel bed was salinized prior to transplanting by irrigating with tap water supplemented with NaCl and $NaHCO_3$. Salinity concentrations of irrigation water were control 41.8, 63.14, 97.05 and 132.23 m mol^{-1}. The fruit yield, number of fruit and weight per fruit of all the three tomato cultivars were significantly decreased with the increase in salinity levels. Concentrations of Na, N and K increased in plant leaves with increasing salinity, whereas the concentrations of P, Ca, Fe and Mn decreased.

Key words: Salt stress, Tomato, Plant nutrients.

INTRODUCTION

Tomato (*Lycopersicum esculentum*) is one of the most important vegetable crops grown in Sind. Much of the tomato crop is grown in open fields generally in winter season. In most of the areas, salinity problems already exist because the fields soils contain high amount of soluble salts, mainly chlorides and sulphates. This problem is grown year by year due to the low rainfall, lack of drainage system and the ever growing demand of water for agriculture.

Shortage of good quality water for irrigation has forced mankind to look into the possibility of using waters which heretofore have been considered unsuitable for irrigation. Recent work in the field of plant physiology has pointed out the utility of underground saline water for growing salt tolerant plants on sandy deserts.

Sandy deserts constitute a great part of Thar desert. Good quality irrigation water is limited in these areas and subsoil water is generally brackish. With intelligent management these vast resources can however, be utilized for cultivation. Sand provides an excellent medium for quick percolation of water and can serve as a medium for plant support. The short contact of saline water with plant root generally avoids ion injury to some extent and with proper chemical amendments this injurious effect could further be minimized allowing better growth.

Salt tolerance of tomato has been widely studied through out the world [1-4]. Summarizing this information, Maas and Hoffman [5], classified this species as moderately sensitive (MS) with a 50 % yield reduction at an electrical conductivity of 7.5 dS/m in the saturation extract. In recent past, native tomato cultivars have been replaced by new tomato hybrids imported from Holland which are characterized by higher yields and resistance to diseases. Due to the importance of this crop and lack of information about the behaviour of these new tomato hybrids under saline conditions, a study was carried out to evaluate the effect of saline irrigation water on yield and leaf mineral composition of three tomato cultivars 'Marglobe', 'Marmande' and 'Roma VF', grown in gravel material (collected from Umerkot, district Tharparkar, Sind) under glasshouse conditions.

MATERIALS AND METHODS

Water of the tube-well of AEARC, Tando Jam (Table 1) was amended with Hoagland nutrient solution to give nutrient wise balanced irrigation water covering four levels of salinity treatments i.e. 41.80, 63.14, 97.05 and 132.23 $mmol^{-1}$ (Table 2) equivalent to 1.95, 3.13, 4.69 and 6.25 mS/cm of electrical conductivity of irrigation water. The salinity levels were made up by using commercial grade salts of NaCl, $NaHCO_3$, $CaSO_4$, $MgSO_4$, KNO_3, NH_4NO_3, single superphosphate (SSP) and supplemented with essential micronutrients: Mn 0.008, Zn 0.0013, Cu 0.0008, Mo 0.0003 and Fe 0.09 $mmol^{-1}$. The nutrient solution with each salinity level was stored in a separate tank.

Table 1. Ionic composition of tube-well water (m mol^{-1}).

Salinity (m mol^{-1})	Na^+	Ca^{++}	Mg^{++}	HCO_3^-	Cl^-	N	P	CO_3^{--}
11.68	3.91	1.50	2.08	2.37	1.69	0.11	0.02	–

Gravel materials were sterilized in beds with 4 % formaldehyde and washed thoroughly with tap water for several hours prior to transplanting the seedlings. These seedlings were obtained by pre-treating with 3% chlorox solution, the tomato seeds of three varieties (Marglobe, Marmande and Roma VF), and sowing in trays containing coarse sand in a growth room, maintained at $25^{o} \pm 2^{o}$. After germination, the seeds were irrigated with 1/10th Hoagland solution and later on by full strength solution. One month old seedlings were transplanted in gravel beds in a glasshouse. Each bed measuring 38 sq.m was divided into three parts for growing twenty eight hills of each variety. The plants were irrigated with full strength Hoagland solution for 10 days and thereafter with salinized water (Table 2) from separate tanks. The gravel beds were irrigated daily and the plants were sprayed with 0.1 % anthio to protect them against insect attack. Average temperature in the glasshouse varied from 22^{o} to 42^{o} during these studies. The pH of the solution was checked from time to time and maintained between 6.5 to 7.0 with sulphuric acid. To provide support to plants the main stems were tied up with ropes. Fifty five days after the salinity treatments, five leaves from top of each variety were collected, washed with tap water and finally with two lots of distilled water and dried in an oven at 70^{o} for 48 hours and weighed. The leaf samples were ground in a Wiley mill and digested, taking one gram of sample using concentrated sulphuric acid and 30% hydrogen peroxide. Total phosphorus was determined collorimetrically using vanadomolybdo-yellow colour method [6]. Nitrogen by micro-Kjeldahl method, whereas Na, K and Ca by flame photometrically. Iron and manganese colorimetrically using phenanthroline and periodate methods respectively [6]. The fruits were harvested weekly and weighed, total yield was obtained by pooling these data. The results were statistically analyzed to evaluate the treatments effects.

RESULTS AND DISCUSSION

Response of saline irrigation water in gravel medium has significantly negative effects on the yield parameters of tomato cultivars (Table 3). Fruit yield, number of fruits per plant and weight per fruit progressively decreased in all tomato varieties as salinity levels increased. Fruit yield reduction was associated with reduction in the weight per fruit rather than the number of fruits per plant, except in Marglobe where it was slightly increased. Marglobe produced higher fruit yields (average irrespective of salinity levels of 3.96 kg/plant) than the other two varieties (average of salinity levels 3.32 and 3.04 kg/plant for Marmande and Roma VF respectively). At the highest salinity levels the reduction in fruit yield was 69.3, 74.8 and 80 percents for 'Marglobe', 'Marmande and 'Roma VF' respectively. Similar percent reductions in fruit/plant and weight/fruit were observed in all the tomato varieties at the highest salinities. Also, the number of fruits per plant of Marglobe was superior (average 65) to Marmande and Roma VF (53 and 48 respectively). For Roma VF the weight per fruit decreased sharply with increasing salinity levels and produced smaller fruits (45g /fruit) as compared with 59 and 58 for Marglobe and Marmande respectively. The decrease in the number of fruit per plant may be due to decrease in the number of trusses per plant. Similar findings using tomato cultivars have been reported by

Table 2. Ionic composition of amended nutrient solution (m mol^{-1}).

Salinity treatments (mmol^{-1})	Na^{+}	N	P	K^{+}	Ca^{++}	Mg^{++}	HCO_3^-	Cl	SO_4
41.80	3.91	14.28	3.87	4.10	7.50	2.08	2.37	1.69	2.00
63.14	13.48	14.28	3.87	4.10	7.50	2.08	4.02	11.81	2.00
97.05	31.30	14.28	3.87	4.10	7.50	2.08	4.92	27.00	2.00
132.23	53.00	14.28	3.87	4.10	7.50	2.08	5.74.	39.66	2.00

Table 3. Fruit yield parameters for three tomato cultivars in relation to four salinity levels.

Salinity level (m mol^{-1})	Fruit yield (kg/plant)	No. of fruits/ plant	Weight/fruit (g)
Marglobe			
Control (41.80)	6.53 a –	98 a –	67 a –
63.14	4.59 b (−29.7)*	65 b (−33.7)	71 a (+ 5.9)
97.05	2.75 c (−57.9)	51 c (−49.0)	54 b (− 19.4)
132.33	1.98 d (−69.3)	47 d (−52.0)	42 c (− 41.3)
Marmande			
Control (41.80)	5.75 a –	69 a –	83 a –
63.14	3.98 b (−30.8)	55 b (−20.3)	72 b (−13.3)
97.05	2.10 c (−63.5)	47 c (−31.9)	45 c (−45.8)
132.33	1.45 d (−74.8)	41 c (−40.6)	35 d (−57.8)
Roma VF			
Control (41.80)	5.45 a –	78 a –	70 a –
63.14	3.15 b (−42.2)	72 a (−7.8)	44 b (−37.1)
97.05	2.23 c (−59.1)	60 b (−23.1)	37 c (−47.1)
132.33	1.31 d (−80.0)	45 c (−42.3)	29 d (−58.6)

***Values in brackets represent percent increase or decrease over control.**

others [4,7]. Considerable differences in the content of mineral elements in the leaves of tomato cultivars have been observed with different salinity levels (Table 4). The

Table 4. Leaf mineral composition of three tomato cultivars grown at four salinity levels.

Salinity level (m mol^{-1})	Na	N	P	K	Ca	Fe	Mn
	Nutrient content (% of dry wt.)					μg/g dry wt.	
Marglobe							
Control (41.80)	0.04	2.85	0.48	3.15	3.68	603	63
63.14	0.15	3.94	0.38	3.21	3.61	581	78
97.05	0.22	2.75	0.35	3.25	3.45	318	59
132.33	0.30	3.83	0.38	3.23	3.55	270	80
LSD 1%	0.07	0.16	0.07	0.21	NS	173	16
Marmande							
Control (41.80)	0.07	3.01	0.44	2.92	4.14	160	112
63.14	0.16	4.10	0.46	2.85	4.00	145	72
97.05	0.18	4.51	0.43	2.96	3.98	94	75
132.33	0.25	4.05	0.38	2.96	3.86	87	53
LSD 1%	0.11	NS	0.06	0.18	NS	27	21
Roma VF							
Control (41.80)	0.04	2.62	0.44	2.93	4.25	244	78
63.14	0.10	3.11	0.40	3.94	3.82	240	73
97.05	0.20	3.94	0.38	3.13	3.45	193	75
132.33	0.24	2.57	0.38	3.03	3.27	160	50
LSD 1%	0.06	0.09	NS	0.16	0.27	28	12

concentration of sodium in all the test plants increased significantly, although no specific salt toxicity symptoms was observed. The Na content of 'Marglobe' was higher (average 0.178 %) than those of 'Marmande' and 'Roma VF (average 0.165 and 0.140 %). Increase in Na concentration with other crops have also been reported [8,9]. Under saline conditions the nitrogen content was increased in the test plants. There are conflicting reports [8,10,11] about the efficacy of nitrogen metabolism under saline conditions. Phosphorus content decreased in tomato leaves with increasing salinity levels. The reports indicate inhibitory [7,12] as well as stimulation [10] effects of salinity on P content. An increase in the content of K in tomato leaves at increasing salinity was noticed. However, adverse [3,7] as well as favourable [13] effects of salinity on K content have been reported. Na is known for inhibiting the uptake of K, which may be the cause for the curtailed uptake of K in salinized tomato plants. The Ca content decreased in the leaves of tomato with increasing salinity levels. Na generally interacts with Ca for common absorption sites in the growth medium [14]. Both Fe and Mn contents decreased in the test plants with increasing salinity levels. Similar results have been reported by others [1,9].

The variation produced by saline irrigation water in the content of nutrients within each variety don't seem high enough to ascribe to fruit yield reduction and decrease in the number of fruits because the levels of nutrients remained within the range of concentrations reported as normal for tomato [2,15].

On the basis of the results obtained in this experiment it seems that yield reduction is mainly related to a water deficit, since tomato is not a specific salt sensitive species as is well known throughout the literature. However, though all the nutrients remained in normal range in all the varieties, Na/Ca and Ca/K ratios increased with salinity which could indicate that some nutritional balance effect may be also involved in reducing yield components. Such effect may alter the activity of some essential plant enzymes, permeability of membranes or the normal metabolism of organic acids and therefore need also to be included in considering the physiological basis for impairment of growth. This may contribute to know the growth retardation processes under saline conditions [4].

The present experiment, although conducted at a very modest scale, effectively demonstrate the potential use of saline irrigation water, with suitable amendments, for growing tomato plants in gravel beds. This could further be exploited for commercial use.

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