African Journal of Biotechnology Vol. 5 (10), pp. 855-861, 16 May 2006
Available online at http://www.academicjournals.org/AJB
ISSN 1684–5315 © 2006 Academic Journals

Full Length Research Paper

Responses of three tomato cultivars to sea water salinity 1. Effect of salinity on the seedling growth

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Accepted 20 February, 2006

The effect of sea water salinity (1500, 2500 and 3500 ppm) on the growth of tomato (*Lycopersicon esculentum*) cultivars (Trust, Grace and Plitz) was studied. The sea water salinity delayed seed germination and reduced germination percentage especially with increasing salinity level. Chlorophyll b content was higher than chlorophyll a, and both of them decreased with increasing salinity. The seedling height increased with time but decreased with increasing salinity in all cultivars. Seedlings fresh and dry shoot and root weights were decreased with increasing salinity. The growth of stem, leave and root after over 80 days of exposure to sea water salinity was affected by sea water dilution especially those of trust and grace cultivars. The grace cultivar was less affected by sea water salinity on the germination stage, while the plitz cultivar has good tolerant to sea water salinity for prolonged period.

Key words: Tomato cultivars, *Lycopersicon esculentum***,** salinity, germination, chlorophyll and growth.

INTRODUCTION

It is well documented that the amount and quality of irrigation water available in many of the arid and semi-arid regions of the world are the main limiting factors to the extension of agriculture (Beck, 1984; Munns, 2002). Saline-sodic irrigation water, coupled with the low annual rainfall and high evaporation and transpiration in the arid and semi-arid regions, have resulted in accumulation of soluble salts in the soil solution and of cations (especially sodium ions) on exchange sites, which can alter the structure and, consequently, affect the soil hydraulic conductivity (Sameni and Morshedi, 2000).

The build up of sodium salts in irrigated regions is of particular concern since 14% of cultivated land that is irrigated supplies approximately half of the world's food (Christiansen, 1982), This has prompted researchers to study the impact of salinity on plant crops. Several studies showed external signs of salt toxicity due to irrigation with saline water such as sclerosis, leaf burning and poor vegetative growth (Gornat et al., 1973; Flowers et al., 1977; Adler and Wilcor, 1987).

Since the tomato (*Lycopersicon esculentum*) is a major food plant, and it is moderately sensitive to salinity (Ayers and Westcot, 1985), extensive research is necessary to develop growing conditions in moderate salinity to produce good vegetative growth. The proposed experiments were performed in soil-less culture under a greenhouse setting. The effect of different concentrations of salinity was determined by growing test plants irrigated with fertilizer mix and various concentrations of diluted sea water. This procedure was performed on three tomato cultivars to determine which of these cultivars have the greatest tolerance to salinity.

The effect of salinity concentration on plant growth has been studied in different tomato cultivars. Adler and Wilcor (1987) found that salinity adversely affected the vegetative growth of the tomato, and it reduced plant length and dry weight. Salinity also reduced the fresh and dry shoot and root weight of tomato (Shannon et al., 1987). Increased salinity over 4000 ppm led to reduction in dry weight, leaf area, plant stem, and roots of tomatoes (Omar et al., 1982). The reduction of dry weights due to increased salinity may be a result of a combination of osmotic and specific ion effects of Cl and Na (Al-Rwahy, 1989). The leaf and stem dry weights of tomato were also reduced significantly in plants irrigated with saline nutrient solution in contrast with control plants (Satti and Al-Yahyai, 1995). Byari and Almaghrabi (1991) found that

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Table 1. Effect of sea water concentrations on the seed germination of the three tomato cultivars.

Cultivars	Seed germination (%)			
	Control	1500 ppm	2500 ppm	3500 ppm
Trust	100	100	93±1.3	80±2.1
Grace	100	100	100	93±3.0
Plitz	100	100	93±2.7	86±4.1

Table 2. Effect of sea water concentrations on the chlorophyll content of the three tomato cultivars.

Cultivar	Chlorophyll	Amount of chlorophyll (mg/g fresh weight)			
		Control	1500 ppm	2500 ppm	3500 ppm
Trust	a	7.2±3.8	6.2±1.0	5.7±1.6	5.2±1.2
	b	10.8±0.1	9.3±1.1	9.0±2.0	7.5±0.03
Grace	a	6.0±1.3	5.8±1.9	5.7±1.1	5.4±0.5
	b	10.6±0.6	9.7±1.9	9.4±0.7	8.3±0.6
Plitz	a	6.8±1.4	6.2±1.1	6.1±1.0	5.7±1.9
	b	9.6±0.7	9.4±0.1	9.4±0.03	9.1±2.0

tomato cultivars varied greatly in their response to different salinity levels. Increasing NaCl concentration in nutrient solution adversely affected tomato shoot and roots, plant height, K concentration, and K/Na ratio (Al-Karaki, 2000).

In this study, the effect of sea water salinity in the growth of three tomato cultivars (Trust, Grace and Plitz) was studied.

MATERIAL AND METHODS

The seeds of three tomato cultivars (Trust, Grace, and Plitz) were brought from USA Seeds Company (De Ruiter Seeds) sowed in small pots containing pro-mix culture. The seeds were irrigated with tap water until the first true leaf stage appeared, after that the seedlings were irrigated for three weeks with a fertilizer mix solution prepared by diluting Hydrosol (1814 g), calcium nitrate (1184 g), and magnesium sulfate (572 g) in 1000 gallon tap water. The sea water salinity was prepared by diluting sea water brought from the Red Sea to obtain three concentrations (1500, 2500 and 3500 ppm) using electrical conductivity meter (EC Model 20234571).

The first group of seedlings was used for studying the effect of salinity on this stage (seedlings growth). The control plants were irrigated with tap water while the others were irrigated with these sea water salinity treatments (1500, 2500, 3500 ppm). In completely randomized block design, there were four treatments, three cultivars, and three replicates. Seed germination, plant height, chlorophyll a and b content of the leaves of the seedlings grown at various treatments were documented. Eighty days after germination (before flower cluster form), the seedlings were harvested and the vegetative shoot tissue were separated from the root tissue. Fresh and dry weights for the shoot and root were determined. A root/shoot ratio was calculated for plants growing under various salinity treatments.

The second group of seedlings, however, was used for studying the effect of salinity on pre-flowering plant stage. The plants were irrigated with these sea water salinity treatments (2500, 3500 ppm) and a fertilizer mix solution as a control. In completely randomized design, there were three replicates, three tomato cultivars, and two saline regime treatments and fertilizer mix treatment as a control. Plant samples were harvested every 5 days and there were six harvests over 30-days period, leaves, stems and roots were separated. The roots were washed with tap water to remove growing media and nutrient solutions. The tissues were dried to determined dry weight.

RESULTS

Effect of sea water concentration on the seed germination

The results on one hands show that the low concentration (1500 ppm) of sea water dilution has no effect on the seed germination for all three tested cultivars (Table 1). Put there was salinity effect on seed germination of trust and plitz cultivars seeds under 2500 ppm treatment, and for all three cultivars seeds under the highest sea water concentration (3500 ppm).

Effect of sea water salinity on the leave chlorophyll content

The effects of sea water salinity on the leave chlorophyll content differ in all three cultivars (Table 2). The chlorophyll a and b content in all three cultivers decreased with increasing salinity. The highest chlorophyll content was extracted from the leaves of the control plants and then decreased with rising salinity levels. It was obvious that the tomato cultivars had more chlorophyll b content in all treated levels than chlorophyll a.

Table 3. Effect of sea water concentrations on the shoot dry weight of tomato cultivars seedlings.

Cultivars	Plant organ	Fresh and dry weight (g)			
		Control	1500	2500	3500
Trust	Fresh shoot	236.5±4.1	168.8±6.3	138.4±9.5	107.4±2.7
	Fresh root	7.1±0.8	7.5±1.8	6.6±1.6	7.0±0.6
	Dry shoot	26.5±2.5	22.2±0.4	17.6±2.2	16.3±0.1
	Dry root	0.9±0.1	1.1±0.1	0.8±0.2	1.0±0.1
Grace	Fresh shoot	248.9±12.3	153.2±0.8	125.2±19	71.9±1.7
	Fresh root	7.7±0.8	6.1±2.1	4.6±1.9	3.9±1.3
	Dry shoot	26.7±0.9	18.6±1.3	15.2±2.9	8.8±2.1
	Dry root	0.9±0.1	0.7±0.3	0.7±0.2	0.5±0.2
Plitz	Fresh shoot	221.4±7.4	181.8±3.0	121.1±7.5	97.4±9.8
	Fresh root	6.5±1.8	9.7±0.9	5.0±1.8	5.0±1.5
	Dry shoot	26.4±4.3	22.2±1.8	15.0±2.5	12.1±2.2
	Dry root	0.9±0.3	1.2±0.1	0.7±0.1	0.8±0.2

LSD at 5 %:
Fresh shoot weight/ salinity: 0.0005, Cultivars: 0.406, interaction: 0.37
Fresh root weight/ salinity: 0.085, Cultivars: 0.30, interaction: 0.48
Dry shoot weight/ salinity: 0.005, Cultivars: 0.215, interaction: 0.599
Dry root weight/ salinity: 0.138, Cultivars: 0.613, interaction: 0.613

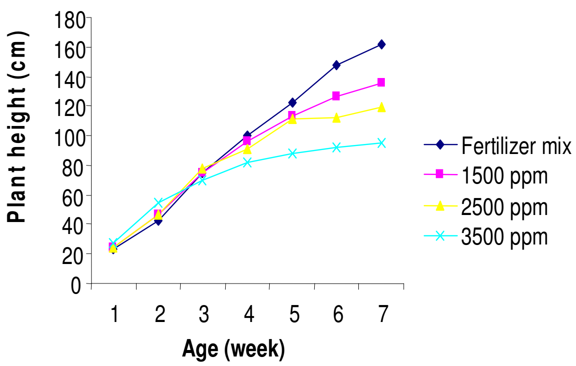

Figure 1. Plant height (cm) of trust tomato seedling cultivar grown under saline conditions.

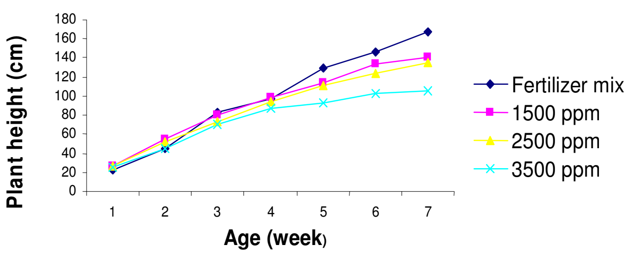

Figure 2. Plant height (cm) grace tomato seedling cultivar grown under saline conditions.

Effect of sea water salinity on stem height

The effects of three saline levels on the plant height of tomato seedlings are shown in Figures 1, 2 and 3. The stem height decreased with increasing salinity. The reduction of plant height was significant at four weeks until the end of the experiment. It was clear that there is a pronounced increase in the plant height with time in plants under saline conditions and great increase in the plant height of control. It is obvious that the Plitz cultivar showed high degree of response to saline conditions much more than the other two cultivars, Grace and Trust.

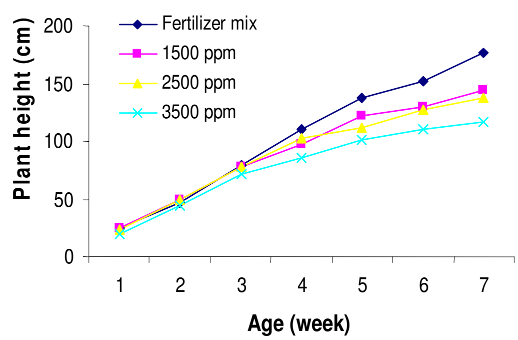

Figure 3. Plant Height (cm) of plitz tomato seedling cultivar grown under saline conditions.

Effect of sea water salinity on seedlings fresh and dry weights

The values of the fresh vegetative seedling weight of the three tested tomato cultivars were found to be generally lowered with the rise of salinization level. Data presented in Table 3 shows that the fresh vegetative weight was obviously decreased in all cultivars with salinity on comparing with the control. The Trust cultivar showed only a slight decrease in the fresh vegetative weight

Table 4. Effect of sea water concentrations (ppm) on the stem dry weight of tomato cultivars harvested before flowering stage.

Age (days)	Treatments (ppm)	Stem dry weight (g)		
		Trust	Grace	Plitz
	Control	7.1±0.1	6.1±0.6	9.8±2.0
85	2500	3.2±0.5	4.4±0.2	7.5±1.1
	3500	3.0±0.1	3.3±0.8	5.2±0.1
	Control	8.4±0.6	7.7±1.1	11.4±0.9
90	2500	5.6±0.6	4.7±0.3	8.9±1.1
	3500	3.6±0.1	4.1±0.3	5.8±0.3
	Control	9.4±0.4	9.5±1.4	14.7±1.6
95	2500	6.4±0.2	6.0±0.8	10.7±0.6
	3500	4.1±2.9	4.3±3.1	8.5±1.6
	Control	9.9±1.7	10.1±1.4	17.4±0.8
100	2500	6.8±0.5	6.3±0.2	11.8±0.2
	3500	5.3±0.0	5.0±0.3	9.3±0.7
	Control	11.2±1.6	12.6±0.6	22.2±0.3
105	2500	7.2±1.0	8.3±0.4	14.9±0.6
	3500	5.6±0.7	7.2±0.2	10.8±0.5
	Control	17.8±1.1	18.5±1.9	23.2±0.2
110	2500	11.3±1.3	15.4±0.6	18.2±0.1
	3500	9.4±0.1	10.1±0.3	13.8±2.0

LSD at 5 %:
Cultivars: 0.0001, Age: 0.0001, Salinity: 0.0001,
Salinity X cultivar: 0.0005, Age X salinity: 0.0001, Interaction: 0.139

compared with the two other tested cultivars at seedling stage.The fresh root weight of tomato tested cultivars also decreased with increasing sea water salinity (Table 3). It is clear that the fresh root weight was lowered in Grace cultivar when treating the plants with salinization comparing with the control treated seedlings, while the fresh root weight for Plitz cultivar seedlings increased in the low salinity level (1500 ppm) and then decreased with increasing salinity in the last two treatments (2500 and 3500 ppm). The Trust cultivar, however, was the best under saline condition compared with the other two cultivars.

Results in Table 3 also showed that saline conditions reduced the dry vegetative weight in all three mentioned cultivars. Trust cultivar had good tolerance on dry vegetative weight under the stress of saline conditions in comparison with Grace and Plitz cultivars. The data indicated that the dry root weight of Grace cultivar decreased with increasing of the saline level. On the other hand, there was no clear trend on the effect of salinity on Trust and Plitz cultivars.

Effect of sea water salinity on the growth of tomato cultivars before flowering stage

The second group of seedlings harvested after 80 days before the flowering stage at five days intervals for six harvests. Treating plants with sea water saline dilution resulted in remarkable decrease of dry stem weight in both three tested tomato cultivars compared with control plants (Table 4). It was obvious that, there was slight increasing in dry stem weight with increasing age in plants treated with sea water dilution and great increase in the dry stem weight of control plants. Data recorded indicated that Plitz cultivar was less affected by saline stress than the other two cultivars. The same trend was appeared in the leaves of tomato cultivars (Table 5). The leave dry weight increased in all three cultivars with increasing age, but the highest dry weight was in plitz cultivar.

Data presented in Table 6 demonstrate the effect of irrigation with saline water on the dry weight of root for tomato cultivars. Increasing levels of salt in irrigation water led to decreasing the dry root weight. The effect of saline conditions on dry root weight was decreased by the time. Plitz cultivar gave a good performance when it was treated by sea water dilution.

DISCUSSION

Salinity is currently one of the most severe abiotic factors limiting agricultural production. In arid and semiarid lands, the plants are subjected through their life cycle to different stresses; some of these plants can tolerate these stresses in different ways depending on plant species and the type of stress. Salinity of soil and water

Table 5. Effect of sea water concentrations (ppm) on the leave dry weight of tomato cultivars harvested before flowering stage.

Age (days)	Treatments (ppm)	Leave dry weight (g)		
		Trust	Grace	Plitz
85	Control	7.2±0.8	8.1±0.7	11.9±0.9
	2500	5.0±0.1	6.0±0.1	8.0±0.5
	3500	3.0±0.2	2.9±0.9	8.0±0.5
90	Control	8.0±0.7	9.5±0.2	14.0±0.5
	2500	5.8±0.4	5.7±0.6	9.9±0.2
	3500	4.5±0.6	3.9±0.2	9.2±0.6
95	Control	9.6±0.1	10.1±0.5	17.1±0.8
	2500	6.8±0.4	6.3±0.3	11.8±1.7
	3500	6.2±1.4	5.6±0.5	10.2±0.4
100	Control	11.9±2.3	11.0±0.3	21.0±0.3
	2500	8.4±0.6	7.6±1.0	12.6±1.5
	3500	7.6±2.3	7.0±1.1	10.5±0.7
105	Control	13.6±3.5	13.5±1.8	17.2±3.1
	2500	10.1±2.0	9.2±0.3	15.4±3.4
	3500	7.7±1.4	8.6±0.3	11.2±1.1
110	Control	22.1±0.1	21.7±2.2	26.1±2.4
	2500	14.5±0.7	19.7±0.6	19.1±3.3
	3500	10.2±0.1	13.3±1.8	15.3±2.5

LSD at 5 %:
Cultivars: 0.0001,Age: 0.0001,Salinity: 0.0001,Salinity X cultivar: 0.4, Age X salinity: 0.0.01, Interaction: 0.4

Table 6. Effect of sea water concentrations (ppm) on the root dry weight of tomato cultivars harvested before flowering stage.

Age (days)	Treatments (ppm)	Root dry weight (g)		
		Trust	Grace	Plitz
85	Control	0.35±0.05	0.40±0.10	0.70±0.14
	2500	0.25±0.05	0.25±0.05	0.45±0.05
	3500	0.15±0.04	0.23±0.03	0.40±0.03
90	Control	0.40±0.05	0.50±0.10	0.80±0.14
	2500	0.30±0.05	0.30±0.03	0.53±0.03
	3500	0.26±0.05	0.29±0.03	0.40±0.03
95	Control	0.60±0.04	0.40±0.04	1.20±0.14
	2500	0.40±0.09	0.42±0.01	0.70±0.05
	3500	0.38±0.09	0.34±0.01	0.66±0.05
100	Control	0.70±0.05	0.70±0.10	1.30±0.20
	2500	0.50±0.06	0.51±0.04	0.84±0.06
	3500	0.44±0.03	0.40±0.01	0.70±0.04
105	Control	0.70±0.00	0.83±0.30	1.73±0.07
	2500	0.60±0.05	0.60±0.01	0.95±0.05
	3500	0.55±0.05	0.45±0.00	0.76±0.05
110	Control	0.90±0.04	0.95±0.05	1.30±1.10
	2500	0.70±0.09	0.70±0.10	1.10±0.20
	3500	0.64±0.06	0.60±0.05	0.82±0.08

is caused by the presence of excessive amounts of salts. Most commonly, high amount of Na^+ and Cl^- cause the salt stress. Salt stress has three fold effects which reduces water potential and causes ion imbalance on disturbances in ion homeostasis and toxicity. This altered water status leads to initial growth reduction and limitation of plant productivity. Salt stress affects some major processes such as germination, growth and chlorophyll content (Parida and Das, 2005); these have been seen in this research and well discussed below.

In this study, three concentrations (1500, 2500 and 3500) of sea water dilution were used to irrigate three tomato cultivars in order to evaluate the effect of sea water salinity in plant germination and growth. The results of this study indicated that the increase of sea water salinity affected seed germination of the three tomato cultivars especially at the highest concentration (3500 ppm) with the cultivar grace was less affected by salinity stress than trust and plitz cultivars. The effect of the external salinity on the seed germination may be partially osmotic or ion toxicity which can alter physiological processes such as enzyme activation (Begum et al., 1992; Croser et al., 2001; and Essa and Al-Ani, 2001).

Chlorophyll a and b content of tomato cultivars leaves decreased in general with increasing sea water salinity. The highest chlorophyll content was in plitz cultivar leaves, while the lowest content was in the trust cultivar leaves for plants grown under salinity stress. The chlorophyll contents of leaves of different tomato cultivars decreased by NaCl stress (Khavarinejad and Mostofi, 1998). Under salinity stress, leaf pigments studied also in nine genotypes of rice reduced in general (Alamgir and Ali, 1999). The decreased in chlorophyll content under salinity stress is a commonly reported phenomenon and in various studies, because of its adverse effects on membrane stability (Ashraf and Bhatti, 2000; Al-Sobhi et al., 2005).

The results also showed that the different growth stages were affected by sea water salinity and the effect was varied depending on the growth stage, salinity level and cultivar. The saline conditions reduced the growth parameter such as fresh and dry vegetative and root weights and preharvesting growth stages of the three tested cultivars as have been similarly reported by several authors (El-Shourbagy and Ahmed, 1975; Dumbroff and Cooper, 1974; Cruze and Cuartero, 1990; Bolarin et al., 1991; Van Iperen, 1996; Aranda et al., 2001; Adler and Wilcor, 1987; Shannon et al., 1987).

In spite of the negative effect of salt on the roots, the root growth in tomato appears to be less affected by salinity treatments than vegetative growth and so the root/vegetative dry weight ratio is higher in plants grown under salt stress than in control plant. This is similar to the result obtained by Cruz and Cuartero (1990). The effect of NaCl stress on the growth of tomato plants is reflected in lower dry weights. The reduction of the dry weights due to increased salinity may be a result of a combination of osmotic and specific ion effects of Cl and Na (Al-Rwahy, 1989).

The results indicated that the stem, leaves and root dry weights are decreased in saline condition, due to the exposure to sea water stress. Similar outcome were obtained earlier by Mohammad et al. (1998) in anther tomato cultivars. Saline stress leads to changes in growth, morphology and physiology of the roots that will in turn change water and ion uptake. The whole plants are then affected when roots are growing in saline medium. The results also indicate that salt tolerance of tomato plants tends to increase with age. Stem growth was observed with time even under saline condition. The same trend was observed on the leaves and roots as also documented by aother workers (Al- Rawahy, 1989; Pessarakli and Tucker 1988; Munns, 2002). Finally, in this study, salinity stress results in a clear stunting of plant growth, which results in a considerable decrease in the fresh and dry weights of leaves, stems and roots. Increasing salinity is accompanied also by significant reductions in shoot weight, plant height and root length.

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