

The Growth Responses of Selected Tomato (*Solanum esculentum* Mill) Cultivars to Sea Water Salinity

Mahendran.S¹, Sujirtha.N²

Senior Lecturer, Dept. of Agricultural Biology, Faculty of Agriculture, Eastern University, Sri Lanka¹

Temp. Assistant Lecturer, Dept. of Agricultural Biology, Faculty of Agriculture, Eastern University, Sri Lanka¹

ABSTRACT: An experiment was conducted in the 'Yala' 2015 on a farmer's field near the Eastern University, Sri Lanka to determine the effects of sea water salinity of 1000, 2000 and 3000 ppm on the seed germination, chlorophyll a and b contents of leaves and growth attributes of selected tomato cultivars. Three tomato cultivars namely 'KC 1', 'Roma' and 'Thilina' were tested for this study. The sea water salinization reduced the germination percentage of all the tomato cultivars. The percentage germination decreased with increasing salinity level especially in the "KC 1" and 'Roma' cultivars. Sea water salinity reduced the chlorophyll a and b contents of all the tested cultivars. The highest chlorophyll a and b contents were obtained in the control plants. It was also found that tomato cultivars contained more amount of 'chlorophyll b' than 'chlorophyll a' in the treated salinity levels. The fresh shoot weights of the tested tomato cultivars were reduced with increasing salinization. These values were lower than the control ones. The 'KC 1' tomato cultivar showed only a slight reduction in the fresh shoot weight compared with the other two cultivars. The fresh root weights of the tested tomato cultivars were also reduced with increasing sea water salinity. Results showed that the dry shoot weights of all the tested cultivars were reduced with salinization. 'KC 1' had better tolerance on dry shoot weight under saline condition than 'Roma' and 'Thilina'. The dry root weight of 'Thilina' cultivar decreased with increasing salinity. There was no clear trend on the effect of salinity on the dry root weights of 'KC 1' and 'Roma'. Salinity stress caused a clear stunting of plant growth in all the tested cultivars which resulted in a considerable reduction in the fresh and dry weights of plant organs. Among them 'KC 1' tomato cultivar was identified as the best under saline condition compared with the other two cultivars.

KEYWORDS: Tomato, chlorophyll a, root weight, cultivar, KC 1

I. INTRODUCTION

Valuable agriculture / food production in arid and semi – arid regions of the world, which depends on irrigation, faces a serious challenge because it must increase or at least maintain crop productivity while coping with ever more saline irrigation water [1]. The success of using such water needs advances in the knowledge of the many factors involved in plant salt tolerance. Saline 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 [2]. As stated by Christiansen [3] the accumulation of sodium salts in irrigated regions is of particular concern since 14% of cultivated land that is irrigated supplies about half of the world's food. This has directed researchers to investigate the impact of salinity on crop plants. Many studies exhibited external signs of salt toxicity due to irrigation with saline water.

Tomato is one of the most important horticultural crops. Since tomato (*Solanum esculentum* Mill.) is a major food crop and it is moderately sensitive to salinity, extensive research is needed to develop growing conditions in moderate salinity to produce good vegetative growth. The effect of salinity concentration on plant growth has been studied in different tomato cultivars. As pointed out by Adler and Wilcor [4] salinity adversely affected the vegetative growth of

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tomato and it reduced shoot growth and dry weight. According to Shannon [5] salinity reduced the fresh and dry shoot and root weight of tomato. Increased salinity over 3000 ppm led to reduction in dry weight and roots of tomatoes [6]. As indicated by Al-Rwahy [7], 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. There was a significant reduction in the shoot and root dry weights of tomato irrigated with saline nutrient solution in contrast with control plants [8]. Byari and Almaghrabi [9] found that tomato cultivars varied greatly in their response to different salinity levels. Increasing NaCl concentration in nutrient solution adversely affected tomato shoot and roots, K concentration and K/Na ratio [10].

This study was conducted with the objectives of determining the effects of sea water salinity on the seed germination, chlorophyll content and growth attributes of selected tomato cultivars in the sandy regosols.

II. MATERIALS AND METHODS

An experiment was conducted in the 'Yala' 2015 on a farmer's field near the Eastern University which is located at an elevation of 75 m above mean sea level in the Batticaloa district of Sri Lanka. The annual mean temperature of this district varies from 28 - 32°C and humidity ranges from 60 – 90%. The annual rainfall is from 1800 – 2100 mm. This area is categorized under the agro – ecological zone of Low Country Dry Zone. The soil type of the experimental area is sandy regosols which is the dominant soil type of this district.

The seeds of tomato cultivars namely 'KC 1', 'Thilina' and 'Roma' were obtained from the Department of Agriculture, Batticaloa. A quantity of 10 g of seeds of each of this cultivar was used for this study. Three seed beds each comprising a dimension of 3 m × 1m were made. These beds were sterilized with 'Captan' fungicide (2 gl-1) before sowing. The seeds of these cultivars were treated with 'Captan' solution (2 gl-1) and were sown on the nursery beds. Watering was done twice a day and urea (100 g/bed) was applied thrice at one week interval until transplanting. The nursery practices were followed based on the recommendation of the Department of Agriculture. The vigorous seedlings (28 days old) were transplanted in black polyethylene bags (45 cm height and 30 cm width) filled with washed and dried sandy regosols as growth medium. These seedlings were shaded with plant twigs until they were established. Regular watering was done twice a day from transplanting until the roots were fairly formed. During this time, these plants were irrigated with Hoagland nutrient solution [11]. Thereafter the salt treatment was imposed.

The sea water salinity was prepared by diluting sea water brought from the nearby sea to obtain three concentrations (1000, 2000 and 3000 ppm) using electrical conductivity meter (EC model 2023). The control plants were irrigated with tap water while the others were irrigated with 1000, 2000 and 3000 ppm sea water. Irrigation along with half strength Hoagland solution was applied to the selected treatments. There were four salinity treatments and three cultivars and each treatment was replicated thrice. The experiment was laid out in a Completely Randomized Design. Seed germination and chlorophyll a and b contents of leaves for different treatments were assessed. Fifty six days after germination (before the formation of flowers), the plants were uprooted and the shoots were separated from the roots. Fresh and dry weights of the shoots and roots were obtained.

III. RESULTS AND DISCUSSION

Effects of sea water salinity on the seed germination

The results showed that the concentration of 1000 ppm salinity did not have any effect on the seed germination of all the tested tomato cultivars (Table 1). But, treatment with 2000 ppm salinity, reduced the seed germination of 'KC 1' and 'Roma' cultivars. The highest sea water concentration of 3000 ppm has reduced the seed germination of all the tested tomato cultivars.

Table 1: Effects of sea water concentrations on the seed germination of selected tomato cultivars

Cultivars	Seed germination (%)			
	Control	1000 ppm	2000 ppm	3000 ppm
‘KC 1’	100	100	91	81
‘Thilina’	100	100	100	92
‘Roma’	100	100	90	84

Salinity is one of the main factors that adversely affect crop production in arid regions, which can result in more than 50% yield reduction of major crops. It reduces plant growth, alters ionic relations by ionic and osmotic effects and induces oxidative stress [12]. The physiology of plant responses to salinity and their relation to salinity resistance have been much researched [13]. Salt stress affects some major processes such as germination, growth and chlorophyll content. Three concentrations (1000, 2000 and 3000 ppm) of sea water dilution were used in this study to supply irrigation for three tomato cultivars to determine the effects of sea water salinity in plant germination and growth. The results revealed that an increase in salinization affected seed germination of the selected tomato cultivars and the cultivar ‘Thilina’ was least affected than the other two cultivars at the highest concentration of 3000 ppm salinity. The effect of external salinity on the seed germination may be partially osmotic or ion toxicity which can alter physiological processes such as enzyme activation [14].

Effects of sea water salinity on the leaf chlorophyll contents

It was found that there were significant differences between treatments in the leaf chlorophyll contents of all the tomato cultivars which were subjected to sea water salinity (Table 2). The chlorophyll a and b contents of all the tomato cultivars were reduced with increasing salinity. The highest chlorophyll a and b contents were obtained in the control plants. It was also found that tomato cultivars contained more amount of chlorophyll b than chlorophyll a in all the treated salinity levels.

Table 2: Effects of sea water concentrations on the chlorophyll contents of selected tomato cultivars

Cultivars	Chlorophyll	Amount of chlorophyll (mgg ⁻¹ fresh weight)			
		Control	1000 ppm	2000 ppm	3000 ppm
‘KC 1’	a	7.4 a	6.0 a	5.4 a	5.1 a
	b	10.6 c	9.5 b	9.2 b	8.3 b
‘Thilina’	a	6.1 b	5.6 a	5.5 a	5.2 a
	b	10.9 c	9.8 b	9.5 b	8.5 b
‘Roma’	a	6.6 b	6.3 a	6.0 a	5.6 a
	b	9.7 d	9.3 b	9.1 b	8.8 b

Results showed that the chlorophyll a and b contents of leaves of the selected tomato cultivars were reduced with increasing sea water salinity. The highest chlorophyll a and b contents were observed in the ‘Roma’ cultivar and the lowest ones were found in the ‘KC 1’ cultivar. As stated by [15], the chlorophyll contents of leaves of different tomato cultivars decreased by NaCl stress. Under salinity stress, leaf pigments studied in nine genotypes of rice reduced in general [16]. As pointed out by Al-Sobhi et al. [17], the reduction in chlorophyll content under salinity stress is a commonly reported phenomenon and in different studies, because of its adverse effects on membrane stability.

Effects of sea water salinity on the fresh and dry weights of tomato plants

It was found that the fresh shoot weights of the tested tomato cultivars were reduced with increasing salinization levels (Table 3). These values were lower than the control ones.

Table 3: Effects of sea water concentrations on the shoot and root weights of tomato cultivars

Cultivars	Plant organ	Fresh and dry weight (g)			
		Control	1000 ppm	2000 ppm	3000 ppm
‘KC 1’	Fresh shoot	241.2 a	173.3 a	133.2a	102.6 a
	Fresh root	7.6 b	7.9 b	6.3 b	7.3 c
	Dry shoot	27.3 c	21.6 c	16.4 d	15.9 e
	Dry root	0.9 d	1.2 d	0.8 e	1.1 h
‘Thilina’	Fresh shoot	251.3 a	161.4 a	127.8 a	76.5 b
	Fresh root	8.2 b	7.1 b	4.7 c	4.0 d
	Dry shoot	26.9 c	19.3 c	15.6 d	7.9 f
	Dry root	0.8 d	0.6 e	0.6 e	0.4 i
‘Roma’	Fresh shoot	237.6 a	176.2 a	119.3 a	93.5 a
	Fresh root	7.4 b	9.0 b	5.2 c	5.0 d
	Dry shoot	25.9 c	23.7 c	14.8 d	12.3 g
	Dry root	0.8 d	1.3 d	0.9 e	0.7 j

The ‘KC 1’ cultivar exhibited a slight decrease in the fresh shoot weight compared with the other two cultivars. The fresh root weights of the tested tomato cultivars were also reduced with increasing sea water salinity. The fresh root weight of ‘Thilina’ cultivar was reduced with increasing salinization compared with the control values. The fresh root weight of ‘Roma’ cultivar increased in the low salinity level (1000 ppm) and then decreased with increasing salinity. The ‘KC 1’ tomato cultivar was the best under saline condition compared with the other two cultivars.

Results also showed that the dry shoot weights of all the tested cultivars were reduced with salinization. Compared with ‘Thilina’ and ‘Roma’ tomato cultivars, ‘KC 1’ showed better tolerance on dry shoot weight under saline condition. The data indicated that the dry root weight of ‘Thilina’ cultivar decreased with increasing salinity. It was found that there was no clear trend in the effect of salinity on the dry root weights of ‘KC 1’ and ‘Roma’.

Salt stress reduces the free energy of water in soils available to plants and results in negative water potential in soils. This drop in water potential is accompanied by specific ion toxicities, deficiencies, retardation of water uptake and nutritional imbalances in plants, which affect enzymatic and physiological functions reducing growth and yield of crops. The saline conditions reduced the growth parameters such as fresh and dry shoot and root weights and pre-harvesting growth stages of the three tested cultivars as have been similarly reported by several authors [18]. Although salt caused a negative impact on the roots, the root growth in tomato appears to be less affected by salinity treatments than the shoot growth and hence root / shoot dry weight ratio is higher in plants grown under salt stress compared to the control ones. This is in agreement with the findings of Cruz and Cuartero [18]. The effect of NaCl stress on the growth of tomato plants is reflected in lower dry weights. 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.

IV. CONCLUSIONS

Salinity stress caused a clear stunting of plant growth which resulted in a considerable reduction in the fresh and dry weights of vegetative organs. Increasing salinity is also accompanied by significant reduction in the chlorophyll contents of leaves of the selected tomato cultivars.

REFERENCES

- [1] Del Amor, F.M., Martinez, V. and Eerda, A. Salt tolerance of tomato plants as affected by stage of plant development. *Hort. Sc.* 36 (7):1260 - 1263, 2001.
- [2] Sameni, A.M. and Morshedi, A. Hydraulic conductivity of calcareous soils as affected by salinity and sodicity. II. Effect of gypsum application and flow rate of leaching solution carbohydrate. *Pol. Soil. Sci. Plant Anal.* 31: 69-80, 2000.

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(An ISO 3297: 2007 Certified Organization)

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- [3] Christiansen, M.N. World environmental limitation to food and fibre culture. In: Breeding plants for less favourable environment. MN Christiansen and CF Lewis Edition. Wiley, New York. Pp: 1-11, 2003.
- [4] Adler, P.R. and Wilcor, G.E. Salt stress, mechanical stress or chloromequet chloride effects on morphology and growth recovery of hydroponic tomato transplants. *J. Amer. Hort. Sci.*, 132: 22-25, 2004.
- [5] Shannon, M.C., Gronwald, J.W. and Tal, M. Effect of salinity on growth and accumulation of organic and inorganic ions in cultivated and wild tomato species. *J. Am. Hort. Sci.*130: 516-523, 2005.
- [6] Omar, M.A., Omar, F.A. and Samarrai, S.M. Effect of different soil treatments on tomato plants grown in Wadi Fatima soil. B. Effect of salinity treatments. Technical Report, Faculty of Meteorol – Environ and Arid Land Agric. P.26, 2001.
- [7] Al-Rwahy, S.A. Nitrogen uptake, growth rate and yield of tomatoes under saline condition. PhD Dissertation, University of Arizona, Tucson, p.118, 2003.
- [8] Satti, S.M. and Al-Yahyai, R.A. Salinity tolerance in tomato: implications of potassium, calcium and phosphorus. *Soil. Sci. Plant. Anal.* 26: 2749-2760, 1995.
- [9] Byari, S.H. and Al-Maghrabi, A.A. Effect of salt concentration on morphological and physiological traits of tomato cultivar. *Al-Azhar J. Agric. Res.*, 23:91-111, 2000.
- [10] Al-Karaki, G.N. Growth, water use efficiency and sodium and potassium acquisition by tomato cultivars grown under salt stress. *J. Plant Nutr.* 28: 1-8, 2005.
- [11] Hoagland, D.R. and Arnon, O.I. The water culture methods for growing plants without soil, 1950.
- [12] Khan, N.A., Syeed, S., Masood, A., Nazar, R. and Iqbal, N. Application of salicylic acid increases contents of nutrients and anti-oxidative metabolism in mung bean and alleviates adverse effects of salinity stress. *Int. J. Plant Biol.* 1: e1, 2010.
- [13] Lu, C., Qiu, N., Wang, B. and Zhang, J. Salinity treatment shows no effects on photosystem II photochemistry, but increases the resistance of photosystem II to heat stress in halophyte *Suaeda salsa*. *J. Exp. Bot.* 54: 851-860, 2003.
- [14] Essa, A.T. and Al-Ani, D.H. Effect of salt stress on the performance of six soybean genotypes. *Pak. J. Biol. Sci.* 4: 175-177, 2001.
- [15] Khavarinejad, R. A. and Mostofi, Y. Effects of NaCl on photosynthetic pigments, saccharides and chloroplast ultra-structure in leaves of tomato cultivars. *Photosynthetica.* 41: 151-154, 2004.
- [16] Alamgir, A.N. and Alli, M.Y. Effect of salinity on leaf pigments, sugar and protein concentrations and chloroplast ATPase activity of rice (*Oryza sativa* L.). *Bangladesh J. Bot.* 36: 145-149, 2006.
- [17] Al-Sobhi, O.A., Al-Zahrani, H.S. and Al-Ahmadi, S.B. (2005). Effect of salinity on chlorophyll and carbohydrate contents of *Calotropis procera* seedlings. *King Fasil University J.*
- [18] Shannon, M.C., Gronwald, J.W. and Tal, M. (2005). Effect of salinity on growth and accumulation of organic and inorganic ions in cultivated and wild tomato species. *J. Am. Hort. Sci.*130: 516-523, 2005.
- [19] Cruz, V. Cuartero, J. Effect of salinity at several developmental stages of six genotypes of tomato (*Lycopersicon* spp). In: Cuartero, J. Gomez-Guillamon, M. Fernandez-Munaz R. (Eds.). Malaga, Spain. Pp.81-86, 2000.