Nigerian Journal of Botany, Volume 33(1), 25 -33, June, 2020

EFFECT OF ABIOTIC STRESS (SALINITY) ON THE FRUIT QUALITY OF TOMATO *(SOLANUM LYCOPERSICUM* L*)*

Latara R. Ibarhim* and Ajala, B. A.
Department of Plant Science and Biotechnology, University of Jos, Jos, Nigeria
Correspondence: aisha_latara@yahoo.com

Received 9th January, 2020; accepted 25th March, 2020

ABSTRACT

This research was conducted to evaluate the effect of salinity on the fruit quality of three varieties of tomato. The work was carried out at the nursery of the Federal College of Forestry Jos, Plateau State within the dry season between January and April, 2018 by irrigation. After the plants of the three varieties of tomato (Roma vf, Tima and UTC) had grown in their various bags for four weeks, four different salt concentrations including the control (0.00M, 0.05M, 0.08M and 0.10M) were added to the various bags accordingly. These treatment-combinations were replicated three times and laid out using the Randomized Block Design. The parameters assessed include number of fruits per plant, fresh weight of fruits at maturity, thickness of pericarp, shoot fresh weight, shoot dry weight and salt tolerance index. The data collected were subjected to Analysis of Variance and the means were separated using the Least Significant Difference. No significant differences (due to the effect of different salt concentrations) were observed in all the parameters studied except for pericarp thickness. There were significant differences ($p \leq 0.05$) due to variety in the number of fruits per plant, fresh weight of fruit and fruit pericarp. The study revealed that Tima variety had the best pericarp thickness of about 6.00 cm (fruit quality), highest number of fruits and heaviest fruits. Roma vf had the highest salt tolerance index (127.70%). A mild salt concentration (0.08M) improved the pericarp thickness.

Key words: Abiotic stress, salinity, fruit quality, pericarp thickness, salt tolerance index

INTRODUCTION

Plant stress implies some adverse effect on the physiology of a plant induced by sudden transition from some optimal environmental condition where homeostasis is maintained to suboptimal condition which disrupts this initial homeostatic state (Munns, 2002). Plant stress can be biotic or abiotic. Biotic stress is a biological abnormality, (insects or diseases), to which a plant is exposed during its lifetime. Abiotic stress is a physical or chemical anomaly that the environment may impose on a plant. Plants may experience physiological stress when an abiotic factor is deficient or in excess (Skiyez and Inze, 2010). The deficiency or excess may be chronic or intermittent imbalance of abiotic factors in the environment which causes primary and secondary effects in plants. Primary effects such as reduced water potential and cellular dehydration directly alters the physical and biochemical properties of the cells, which then lead to secondary effects (Tang

*Author for correspondence

and Boyer, 2002). These secondary effects, such as reduced metabolic activity and ion cytotoxicity, initiate and accelerate the disruption of cellular integrity, and may lead ultimately to cell death. Severe stress due to abiotic factors may prevent flowering, seed formation and induced senescence that leads to plant death (Skiyes and Inze, 2010).

Salinity stress and injury involve many aspects of the plant's life. Plants growing on saline soils are usually subjected to three types of stress: water stress generated by osmoticum (salt in solution), mineral toxicity stress caused by the salt and disturbances in mineral nutrition of the plants and nutrient-imbalance (Munns, 2002).

Salinity stress limits the productivity of agricultural crops, with adverse effects on germination, plant vigour and crop yield (Munns and Tester, 2008). Studies have shown that exposure of tomato plants to high concentrations of salt in their root zone caused the reduction of growth, fruit size and fruit yield (Mohammad *et al*., 1998; Scholberg and Locascio, 1999; Magan *et al*., 2008).

The tomato is a highly perishable crop and cannot be stored for extended periods. The internal structure of tomato varies from fruit to fruit and plays an important role in qualities such as uniformity of shape, size and firmness. Firmness is a quality consideration that impacts storability and shelf- life of the fruit (Wu and Abbot, 2002) and is strongly affected by cultivar, environment, nutrition and physiological disorders. The texture of the flesh itself, which includes the radial wall, locular cavities and the outer pericarp, affects the quality of the fruit (Wu and Abbot, 2002). The pericarp is the outer wall of the fruit that gives it form. According to Kumari and Sharma (2011), pericarp thickness is an important feature of the tomato fruit as varieties with thicker pericarp are better able to withstand travel over long distances and remain firm for a longer period, when compared with thinly fleshed tomatoes. Khanbabaloo *et al*. (2018) reported that salinity caused a reduction in pericarp thickness and that there were differences between varieties in this regard. Azarmi *et al*. (2010) reported that total soluble solids and titratable acidity were significantly increased at EC of above 3 dS m^{-1}; EC increased from 2.5 to 6 dS m^{-1}; total soluble solid and titratable acidity were increased to 13.4% and 28.9%, respectively. Qaryouti *et al*. (2007) also reported that tomato (*Lycopersicon esculentum M*. cv. 'Durinta F_1) fruit quality parameters (fruit dry matter %, total soluble solids and titratable acidity) increased with increasing salinity up to 5 dS m^{-1} when compared with the control, while fruit firmness decreased with increasing salinity.

Salinity is an abiotic stress condition which is increasingly affecting arable lands and many farmers are either ignorant of it or they do not know what to do. Therefore, this study was designed to investigate the effect of salinity on the fruit quality of three commonly grown varieties of tomato and to bring relevant facts to the fore.

MATERIALS AND METHODS

Study Site

The study was carried out at the nursery of the Federal College of Forestry, Jos, Plateau State between January and April, 2018 by irrigation.

Source of Materials

Seeds of three tomato varieties (Roma vf, Tima and UTC) used for the experiment were obtained from Plateau State Agricultural Development Programme (PADP) headquarters, Dogan-Dutse, Jos.

Nursery Preparation

Perforated plastic containers were used as nursery trays. The soil used for both the nursery and the main work was a mixture of loam, river sand and organic manure (poultry droppings) in the ratio of 3:2:1.

Seed Planting

Thirty seeds of each variety were broadcast on the soil in separate trays. The trays were watered daily. Two seedlings of about 6-7cm (Tindal, 1978) were transplanted into perforated bags. Weeds were regularly hand-picked to prevent competition for nutrients with the tomato seedlings and also to prevent incidence of diseases.

Salt Solution Preparation and Application

The different salt concentrations that were used for this experiment were derived from the report by Hillel (2000) on the optimum electrical conductivity (EC) for good tomato growth. The optimum EC he reported was 2.5dm/s. This translates to 0.04M salt concentration. The three concentrations that were chosen for this investigation were 0.05M, 0.08M and 0.1M, equivalents of 106.4 g/l, 170.4 g/l and 212.9 g/l of salt, respectively. A treatment without salt was

added as the control. The different concentrations of sodium chloride solution were applied on the soil on which the four week-old plants were growing according to Christos *et al*. (2015).

Experimental Design

The various treatment-combinations were replicated thrice and arranged in the field using the Randomized Block Design (RBD). Different parameters were measured and data were collected on the thirty-six pots at maturity as follows:

Number of fruits per plant at maturity: Fruits were picked as they matured. The overall total number picked per plant were counted and recorded.

Fresh weight of fruit at maturity: The fresh fruits were weighed as they were picked using the electronic precision balance (LP502A) and the total weight for all the fruits per plant were added up and recorded at maturity.

Thickness of pericarp: The transverse sections of three matured fresh fruits per plant were obtained by cutting through the fruits horizontally. The pericarp of each fruit was measured with a calibrated meter rule and the average of the three thicknesses of the pericarps was recorded.

Shoot fresh weight (g): At the end of the experiment, individual plants were harvested and weighed.

Shoot dry weight: Plant materials were harvested, oven-dried at 70^0 C for two days and the dry weights were determined.

Salt tolerance index: Salt tolerance index was computed as the ratio of total above-ground dry weight (shoot) of the plants that were treated with the different salt concentrations to the ratio of the shoot dry weight of the control and expressed as percentage (Christos *et al.*, 2015). Matured tomato shoot (total above-ground portion of the plants) were weighed and the shoot fresh weights were recorded. The dry weight was determined after drying the above- ground parts of the tomato plants in an oven at 70°C until the samples reached a stable weight. Salt Tolerance Index was calculated using the formula below:
S.T.I. = Wx/Wo x 100

Where,
Wx= Dry weight of shoots of the stressed plants
Wo= Dry weight of shoots of unstressed plant

Data Analysis
The data collected for the various parameters were subjected to analysis of variance (ANOVA) to test the treatment effect for significance using F-test as described by Snedecor and Cochran (1980). Significant mean differences were tested using the Least Significant Difference (LSD) (Hayer, 1986).

RESULTS

The results obtained from the investigation are presented in Tables 1 and 2. The effects of the different concentrations of salt and variety on the total number of fruits per plant, total fresh weight of fruits per plant and fresh weight of a single fruit per plant are presented in Table 1. There were no significant differences in the total number of fruits at maturity due to the different concentrations of salt. The total number of fruits at harvest due to variety were significantly different ($p \leq 0.005$) from one another. Tima variety recorded the highest number of fruits.

There were no significant differences in the total fresh weight of fruits per plant due to the different salt concentrations. However, there were significant differences in the fruit fresh weight due to variety. Fruit fresh weight of Tima variety was significantly heavier than UTC. Differences in average weight of fruits per plant due to salt concentration and variety were not significant.

Table 2 shows the effects of different concentrations of salt and variety on the thickness of the fruit pericarp at maturity, shoot fresh and dry weights of tomato plants and salt tolerance index at maturity. There were significant differences ($p \leq 0.05$) due to the different concentrations of salt on the thickness of the fruit pericarp at maturity. Plants which were treated with 0.08M concentration produced fruits that had the thickest pericarp when compared with the control (0.00M), 0.05M and 0.10M concentrations, respectively. Tima variety produced fruits with significantly thicker pericarp than Roma vf and UTC varieties which were statistically at par with each other. No significant interaction was observed between the effects of different concentrations of salt and variety.

Shoot fresh and dry weights decreased with increase in salt concentration. Roma vf variety produced plants with the heaviest shoot weight which was closely followed by UTC and Tima varieties. There were no significant differences observed in the salt tolerance index due to the effects of salt concentrations and variety.

Table 1: Effects of different concentrations of salt (NaCl) and variety on the mean number of fruits per plant, total fresh weight of fruits and average fresh weight of fruits per plant of tomato (*Solanum lycopersicum*) at maturity.

	No. of fruits per plant	Fresh weight of fruits per plant	Fresh weight of a single fruit per plant
SALT CONC (C)			
Control	44	1406.9	31.9
0.05M	40	1168.8	29.9
0.08M	39	1125.6	28.1
0.10M	35	882.8	25.2
LSD	-	-	-
VARIETY (V)			
Roma vf	58a	1433.9	24.7
Tima	72a	2027.1	28.2
UTC	33b	1137.5	34.5
LSD	30.5		-
INTERACTION			
VXC	NS	NS	NS

Means followed by the same letter(s) within the same column and treatment are not significantly different at 5% level of probability using the Least Significant Difference

NS- Not Significant

NJB, Volume 33(1), June 2020 Latara R. Ibrahim and Ajala, B.A.

Table 2: Effects of different concentrations of salt (NaCl) and variety on the pericarp thickness of the fruits, shoot fresh and dry weight and the salt tolerance index of tomato (*Solanum lycopersicum*) at maturity

	Pericarp thickness of fruits (mm)	Shoot fresh weight (g)	shoot dry weight (g)	Salt tolerance index (%)
SALT CONC (C)				
Control	6.33b	102.71	18.0	100
0.05M	5.00a	116.47	27.0	168.5
0.08M	7.33c	92.20	13.9	81.8
0.10M	2.67d		10.0	59.1
LSD	0.96	-	-	-
VARIETY (V)				
Roma vf	5.00b	120.77	18.5	127.7
Tima	6.00a	98.63	16.5	85.9
UTC	5.00b	92.77	17.4	68.5
LSD	0.28	-	-	-
INTERACTION				
VXC	NS	NS	NS^2	NS

Means followed by the same letter(s) within the same column and treatment are not significantly different at 5% level of probability using the Least Significant Difference

NS- Not Significant

DISCUSSION

Though the analysis of data on total number of fruits and total fresh weight of fruits showed no significant differences in the two parameters, the results of these parameters ordinarily showed that the control (0.00M) had the highest total number and the highest total fresh weight of fruits, indicating that the application of salt affected the tomato plants in the experiment. This finding is corroborated by Ali and Ismail (2014), who reported that sodium chloride significantly decreased fruit fresh and dry biomass and several other growth and quality parameters. Similar results were reported for tomato grown in saline soil by Rahman *et al*. (2006) and Saeed and Ahmad (2009).

It was observed in this study that the growth of the tomato plants dropped sharply shortly after application of salt concentrations. This may be due to the poor tolerance capabilities of the plants at this young stage. However, the tomato plants recovered as they grew older. This finding corroborated Bolarin *et al*. (1993) who reported that for tomato production under saline conditions, salt stress during vegetative stage is more important than salt stress during seedling growth stage because most tomato crops are established by seedling transplanting. Salt stress during vegetative stage may also be more important than salt stress during reproduction (flowering and fruit set) as tomato salt stress generally increases with plant age and plants are usually most tolerant at maturation. The 0.08M concentration resulted in a significantly thicker pericarp than all the other concentrations including the control. This result is in agreement with Saito *et al.* (2006) who observed that moderate salinity improved fruit quality. The study also showed that the different varieties had different pericarp thicknesses with Tima being the best. Khanbabaloo *et el*. (2018) also reported that salinity led to a reduction in pericarp thickness and that there were differences between varieties in this regard. It is, therefore, not surprising that tomato plants which had the 0.08M concentration application also had the best tolerance index (Table 2). Kruss *et al.* (2006) reported that plant fresh weight significantly increased under moderate saline conditions in a number of horticultural crops including tomato. Results of this study showed that plants treated with a 0.08M concentration of salt produced plants with the higher shoot dry weight than the other concentrations including the control.

CONCLUSION

Tima variety had the best fruit quality (fruit pericarp thickness), highest number of fruits and the heaviest fruits. Roma vf variety was the most salt-tolerant of the three varieties used in this research with a tolerance index of over 100%. A mild salt concentration (0.08M) improved the fruit quality.

REFERENCES

Ali, H. E. M. and Ismail, G. S. M. (2014). Tomato fruit quality and nitric oxide. *Turkish Journal of Botany*, 38**:** 122-129.

Azarmi, R., Taleshmikail, R. D. and Gikloo, A. (2010). Effects of salinity on morphological and physiological changes and yield of tomato in hydroponic system. *Journal of Food, Agriculture and Environment,* 8: 573-576.

Bolarin, M.C., Fernandez, F.G., Cruz, V. and Cuartero, J. (1998). Salinity tolerance in four wild tomato species using vegetative yield salinity response curves. *Journal of the American Society for Horticultural Science,*118: 655-660.

Christos, K., Chowdhurry, R., Heusden, S., Van de , C., Filfers, R., Visser, R.G. F., Bai, Y. and Van de Linder, G. (2015). Combined biotic and abiotic stress resistance in tomato. *Euphytica,* 202: 317 – 322.

Hillel, D. (2000). *Salinity Management for Sustainable Irrigation*. The World Bank, Washington, D.C., ISBN 08213 4773X.

Khanbabaloo, M., Hanifeh, S. H. and Farhad, B. (2018). Effects of salinity on taste quality and biochemical traits of four tomato varieties (*Solanum lycopersicum)* grown under hydroponic conditions. *Journal of Horticulture and Postharvest Research,*1: 16 – 28.

Kumari, S. and Sharma, M. K. (2011). Exploitation of heterosis for yield and its contributing traits in tomato, *Solanum lycopersicum* L. *International Journal of Farm Science,*1: 45-50.

Kruss, S., Schnitzler, W., Grassmann, J. and Woltike, M. (2006). The influence of different electrical conductivity values in a simplified recirculating soilless system on inner and outer fruit quality characteristics of tomato. *Journal of Agriculture and Food Chemistry,* 54**:** 441-448.

Magan, J. J., Gallardo, M., Thompson, R. B. and Lorenzo, P. (2008). Effects of salinity on fruit yield and quality of tomato grown in soil-less culture in greenhouses in Mediterranean climatic conditions. *Agriculture Water Management*, 95: 1041-1055.

Munns, R. (2002). Comparative physiology of salt and water stress. *Plant, Cell and Environment*, *25*(2): 239-250.

Munns, R. and Tester, M. (2008). Mechanisms of salinity tolerance. *Annnual Review Plant Biology*, 59: 651-681.

Mohammad, M., Shibli, R., Ajouni, M. and Nimri, L. (1998). Tomato root and shoot responses to salt stress under different levels of phosphorus nutrition. *Journal of Plant Nutrients*, 21: 1667-1680.

Rahman, M. J., Uddin, M. S., Bagum, S. A., Mondol, A.T. M. A. and Zaman, M. M. (2006). Effect of mulches on the growth and yield of tomato in the coastal area of Bangladesh under rainfed condition. *International Journal of Sustainable Crop Production***,** 1: 6-10.

Saeed, R. and Ahmad, R. (2009). Vegetative growth of tomato as affected by the application of organic mulch and gypsum under saline rhizosphere. *Pakistani Journal of Botany*, 41: 3093-3105.

Saito, T., Fukuda, N. and Nishimura, S. (2006). Effects of salinity treatment duration and planting density on size and sugar content of hydroponically grown tomato fruits. *Journal of Japan Society of Horticultural Sciences,* 75**:** 392- 398.

Scholberg, J.M.S. and Locascio, S.J. (1999). Growth response of snap bean and tomato as affected by salinity and irrigation method. *Horticultural Science*, 34: 259-264.

Skiyes, A. and Inze, D. (2010). Plant growth under limited water. *Biotechnology,* 21: 197-203.

Snedecor, G.W. and Cochran,W.G. (1980). *Statistical Methods. 6th Edition.* Iowa State University Press, Iowa, USA 507p.

Tang, A. C. and Boyer, J.C. (2002). Growth-induced water potentials and the growth of maize leaves. *Journal of Experimental Botany*, 53: 489- 503.

Tindall, H. D. (1978). Solanaceae in *Vegetables in the tropics*. Macmillan Press, London. Pp 354 –359.

Qaryouti, M. M., Qawasmi, W., Hamdan, H. and Edwan, M. (2007). Influence of NaCl Salinity Stress on Yield, Plant Water Uptake and Drainage Water of Tomato Grown in Soilless Culture. *Acta Horticulturae,* 747: 539-544.

Wu, T. and Abbot, J. (2002). Firmness and force relaxation characteristics of tomatoes stored intact or as slices. *Postharvest Biology and Technology,* 24: 59-68.