Performance of Tomato (*Solanum lycopersicum* L.) Lines and Cultivars Resistant to Salinity

Nnungu, S.I.[1]*, Nyomora, A.M.S.[2] and Tibazarwa, F.I.[1]

[1]Department of Botany, University of Dar es Salaam, P.O. Box 35060, Dar es Salaam, Tanzania
[2]St. Augustine University of Tanzania

*Corresponding author e-mail: *nnunguh@gmail.com, Phone: +255782560444*

Abstract

The low yield of tomatoes (Solanum lycopersicon, L.) along the coast of Tanzania is influenced by abiotic stresses, including salinity. Tomatoes in Tanzania are produced in various environments, from wet lowlands to dry highlands. Lowland areas are generally warmer than the highlands and have more saline soils. Two commercially available Tanya and Tengeru 97' tomato cultivars and seventeen advanced lines from the World Vegetable Research Center in Arusha have been developed for tolerance to biotic stresses. This study tested the advanced lines and commercially available cultivars (Tanya and Tengeru 97') for salinity tolerance to expand their potential utilization in marginal areas. The experiment included two factors; tomato cultivars/lines and level of salinity replicated three times in a Completely Randomized Design. Varying salinity levels (45mM, 90mM and 150mM NaCl) were applied to study their effects on growth. There were significant differences ($p<0.05$) due to the effect of different salt concentrations in the parameters studied. Increased salinity delayed and reduced seed germination, which varied among cultivars/lines. Seedling growth in terms of height increased with time but decreased with salinity, except in the CLN series, where only very slight decreases in height were observed. The stem and leaf growth were negatively correlated with increasing salinity levels in Tanya and Tengeru. CLN series were also found to yield reasonably in terms of fruit number and size at all salinity levels, especially CLN 5915-93-D4-1-0-3. From the results, it could be concluded that CLN lines could increase tomato growth and production on salt affected soils.

Keywords: Tomato, *Solanum lycopersicum*, salt stress, salt tolerance, germination, growth and yield.

Introduction

Tomato (*Solanum lycopersicum*) is one of the most important vegetables in Tanzania. The vegetable is grown by smallholder farmers. It is estimated that 314,986 tonnes of tomatoes are produced annually, thus surpassing all other vegetables grown in Tanzania (FAOSTAT, 2014). In Tanzania, tomatoes are cultivated for domestic and commercial consumption (Msogoya and Mamiro, 2016), where the fruits are used fresh in salads or cooked as a vegetable processed into tomato paste, tomato sauce, puree, ketchup, and juices (Dubois, 2015).

Tomatoes can grow well in temperatures ranging from 18 to 27°C (Quezada *et al.* 2023), and well-drained sandy loams have adequate water-holding capacity (Fagwalawa, 2015). The pH ranges from 5.5 to 6.8, and a salinity of 2.5d S/m ~ 30 mM NaCl (Thakur *et al.* 2022) is suitable for optimal seed germination, seedling growth, flowering and fruit set and fruit quality. Without these conditions, tomatoes become prone to biotic (diseases) and abiotic stresses (heat, drought and salinity).

Tomato production occurs in a range of environments from wet lowlands to the dry highlands up to 2500 m (Trindade *et al.* 2019). The lowland areas of Tanzania, such as the coastal zone, are generally warmer than the highlands (Msuya, 2013) and have more saline soils where more than 2 million ha of land are salt - affected (Omar *et al,* 2023). The common soluble salts contributing to this salinity are the chlorides and sulphates of sodium, calcium, magnesium and nitrates, with sodium and chloride being the most dominant ions, particularly in highly saline soils. High salinity affects seed germination, vegetative growth, flower and fruit set, and fruit quality,which may reduce yield and quality of tomato fruits (Guo *et al.* 2022; Ibrahim, 2018; Zaki and Yokoi, 2016)). The complexity of salt stress responses in tomato plants throughout their growth cycle depends on several interacting factors and the magnitude of stress, which depends on salt concentration and exposure time (Zizkova *et al.* 2015)). However, these effects vary among tomato cultivars and lines thus, the response to salinity depends mainly on the tomato genotyes (Zaki and Yokoi, 2016). It has also been demonstrated that salt tolerance is controlled by several gene families (Ali *et al.* 2021).

There are continued efforts to improve the production of this important crop in Tanzania and The World Vegetable Research Center in Arusha (AVDRC-Arusha) has developed and released some cultivars such as Tengeru 97, which is resistant to root-knot nematodes, fusarium wilt, Tomato mosaic virus (TOMV) and Tomato yellow leaf curl virus (TYLV), and Tanya which is resistant to root-knot nematode, TOMV and TYLV. In addition, AVDRC-Arusha has developed seventeen advanced lines that have been evaluated for resistance to insect pests and diseases. However, the developed lines have never been tested for biotic stresses such as salinity in lowland areas. The lowlands present an additional challenge to the biotic stresses of pests and diseases in the form of abiotic stresses such as heat, drought, and salinity, which are closely interrelated. Evaluating the available cultivars and advanced lines from AVDRC-Arusha for the abiotic stresses would provide insight into the capacity of the lines to tolerate stresses that were not part of the initial breeding objective. If some lines show tolerance to the abiotic stresses, this would add value to the breeding programme as minimal additional breeding activity would be required before the lines are submitted to the market. Therefore, this study evaluated the growth and yield performance of tomato (*Solanum lycopersicum* L.) lines and cultivars resistant to salinity.

Materials and Methods

Seeds from different lines were obtained from The World Vegetable Centre (AVRDC) headquarters in Taiwan, and the AVDRC-Arusha, Tanzania. Eight lines from AVDRC head quarters in Taiwan included CLN 5915-93-D4, CLN 1621L, CLN 2418A, CLN 2413R, BL 1173, BL 1174, BL 1175, BL 1176, which have been improved for heat and drought tolerance. Four lines from AVDRC-Arusha (ARP 365-2-5, ARP 367-1, ARP 366-4-23 and ARP 365-3-25) have been improved for tomato leaf curl and bacterial blight tolerance. In addition, twocommercial cultivars, Tanya and Tengeru 97’, originally developed at AVDRC-Arusha, were included in this study.

The tomato seeds were tested for germination by placing 20 seeds on a filter paper moistened with distilled water as control and salinity dilutions of 45mM, 90mM, and 150mM NaCl. The germination of seeds was counted daily for 15 days, and seeds were considered to have germinated when a 2cm long radicle was visible outside the seed coat.

Tomato seeds from the above list were sown in a plastic tray filled with soil and organic manure at a ratio of 3:1. Three (3) weeks after planting, the seedlings were transplanted into 5 L plastic pots filled with soil and organic manure at a ratio of 2:1. The experiment was carried out in the greenhouseat the Department of Botany, University of Dar es Salaam, in Tanzania. Treatments comprised four different levels of salinity, including tap water, 45mM, 90mM and 150mM NaCl. The treatments were set in factorial combination with the 19 tomato lines/cultivars and arranged in a Completely Randomized Design with four replicates. The pots were irrigated every two or three days. The electrical conductivity of soil water was measured before and after irrigation to monitor the level of salt within the water used. Collection plates were placed under the pots so that the water, salt, and minerals leached through were recycled tomaintain the balance. Plant growth and yield parameters, i.e., plant height, days to the first flower, plant fresh weight, number of flowers, and fruit weight, were monitored and measured.

Data analysis

The data was analyzed using Genstat Release 10.3 DE Discovery, 4th Edition software. Two-way analysis of variance (ANOVA) was used to determine the effect of the treatments and mean separation was tested using Duncan's multiple-range test.

Results

The results showed that a low concentration of salt (45 mM NaCl) had no effect on seed germination for all 19 tested cultivars/lines in terms of time taken to germinate (Table 1) and percentage germination. Most of the lines could also germinate at higher salt concentrations of 90 mM and 150 mM NaCl. However, the number of days from sowing to germination was longer at higher salinity than control and lower salinity (45 mM). Tanya, Tengeru 97', and ARP 366-4-23 showed tolerance to 90 mM NaCl but were limited at 150 mM NaCl.

The percentage germination of seeds was observed to decrease from 90 mM NaCl for most lines/cultivars except for the CLN and BL series, ARP 367-1 and ARP 365-2-5. This decrease was more pronounced at 150 mM NaCl (Table 1).The results revealed that therewas a variation in plant height among the cultivars/lines. The trend showed significant ($p = 0.001$) variation in plant height among lines and cultivars evaluated. The plant height decreased with increasing salinity concentration. The height of plants irrigated with distilled water ranged from 29.19cm for CLN 2001A to 54.86 cm for BL 1176. At 45 mM NaCl, no reduction in height was observed among the cultivars/lines; at 90 mM and 150 mM NaCl, drastic height reduction was observed in all lines/cultivars except for the CLN series.

High salinity levels were found to retard reproductive growth, thus affecting fruit yield. Variation in fruit yield was extrapolated from differences observed when assessing parameters such as number of flowers per plant, number of fruits per plant, total weight per plant, fruit circumference, and fruit set. Both days to the first flower and the number of flowers were recorded and used to assess the effect of salinity. The days to the first flowering were determined and compared to the control. The days ranged from 18-25 days for different cultivars/lines and linearly decreased with increasing salinity from 45 mM NaCl to 150 mM NaCl. Further, the commercial cultivars Tanya and Tengeru 97' recorded slightly reduced numbers of fruits in higher salinity concentrationsthan the control.

Table 1: Effect of salinity on growth parameters of tomato

Parameters	Salt concentration levels				p-value
	No salt	45mM NaCl	90mM NaCl	150mM NaCl	
Days for germination	4.8±0.9	4.8±0.9	7.1 ± 1.4	13.5 ± 2.6	<0.001
Seed germination (%)	99.3± 2.1	94.4± 6.4	79.9± 15.1	74.3± 14.0	<0.001
Plant height	43.9±8.3	39.9±8.2	34.8±4.8	31.4±3.9	<0.001
Fruit set (%)	70.6±11.4	67.5±12.6	55.3±16.9	53.2±18.5	<0.001
Numbers of fruit	71.2±35.4	61.9±35	37±24.1	44.1±9.9	<0.001
Plant fresh weight	241.4±15.8	232.3±12.4	159.7±22.3	114.1±26	<0.001
Fruit weight	86.8±29.3	81.2±28.1	63.9±21.4	-	<0.001

The number of flowers per truss varied among tomato lines/cultivars.The CLN series had a higher number of flowers per truss than the other cultivars/lines with the exception of CLN 2418A. At 45 mM NaCl, there was no reduction in number of flowers observed for all lines. The number of flowers at 90 mM NaCl and 150 mM NaCl were less when compared to tomato cultivars/lines for the control and 45 mM NaCl. The reduction was more pronounced in Tanya and Tengeru 97' and less in CLN 5915-93-D4-1-0-4, CLN 1621, CLN 2001A, and CLN 2413R.

A significant variation ($p<0.01$) in fruit fresh weight was observed among tomato lines/

cultivars. An average of 150.2g was recorded for ARP 366-2 as the heaviest and 34.6g for CLN 5915 as the lightest. Moreover, a significant reduction in fresh fruit weight was recorded with increasing salinity.

The result reveals statistically significant

Table 2: Two way anova for the effect of tomato cultivars/lines and salt concentration

Source of variation	Model summary				p-value
	df	SS	MS	F	
Days of germination					
Tomato types	17	357.1	21	108.7	<0.001
Salt concentration	3	2351.4	783.8	4056.1	<0.001
Interaction	48	129.4	2.7	14.0	<0.001
error	138	26.7	0.2		
Seed germination percent					
Tomato types	17	11950	703	167.4	<0.001
Salt concentration	3	23552	7851	1870.1	<0.001
Interaction	48	8170	170	40.6	<0.001
error	138	579	4		
Plant height					
Tomato types	17	5325	313.2	20.0	<0.001
Salt concentration	3	4912	1637.5	10.4.7	<0.001
Interaction	51	1744	34.2	2.2	<0.001
error	144	2252	15.6		
Plant fresh weight					
Tomato types	17	26552	1562	17.0	<0.001
Salt concentration	3	556626	185542	2024.1	<0.001
Interaction	49	48428	988	10.8	<0.001
error	140	12833	92		
Fruit set percent					
Tomato types	17	39281	2311	231.9	<0.001
Salt concentration	3	13102	4367	438.4	<0.001
Interaction	49	4543	93	9.3	<0.001
error	140	1395	10		
Fruit number					
Tomato types	17	131609	7742	95.1	<0.001
Salt concentration	3	49667	16556	203.3	<0.001
Interaction	37	7837	212	2.6	<0.001
error	114	9283	81		
Single fruit weight					
Tomato types	17	107149	6303	612.1	<0.001
Salt concentration	2	15431	7716	749.3	<0.001
Interaction	34	3350	99	9.6	<0.001
error	108	1112	10		

interaction across all the measuredparameters (p<.001). Similarly, the main effects for tomato types and salt concentration were statistically significant (p<.001).

Discussion

The 19 cultivars/ lines tested in this study all showed reduced germination as salinity increased, especially at the highest salt concentration of 150mM NaCl. However, some cultivars/ lines were less affected than others, suggesting tolerance, and these were CLN 1621, CLN 2001A, CLN 2413R, 2418A, CLN 5915-93D4-1-0-3, BL 1173, BL 1174, BL1175, BL 1176, ARP 367-1 and ARP 365-2-5. The commercial cultivars Tanya, Tengeru97', and some of the improved lines for Tanzania, ARP 366-4-23, ARP 366-1, ARP 366-2, ARP 366-3, and ARP 365-3 were sensitive to salinity.

The sensitivity to salinity during germination is not a new phenomenon, nor is it restricted to tomatoes. (Sardoei and Mohamed, 2014) postulated that the effect of salinity on germinating seeds in many species not only lowered the germination percentage but also lengthened the time needed to complete germination. In tomatoes, (Ali *et al.,* 2021a) reported that the commercial cultivars they studied were most vulnerable to salinity during seed germination and early seedling growth stages. Similarly, Ali *et al.* (2021a) reported sensitivity to salt concentration of 75mM NaCl while wild tomato showed a significantly higher percentage of germination under both 75 and 100mM.

Salinity affects germination and growth, although the effects vary depending on the growth stage, salinity level, and cultivar/ line. The results obtained in this study were consistent with those of Moles *et al.* (2019), who reported poor shoot growth under higher salinity concentrations.The slow growth of tomato plant is suggested to be due to nutritional imbalance at low concentration of salt EC 3-5dSm-1 equivalent to 30-50mM NaCl at which nutrient uptake become the limiting factors. At moderate to high levels of salt EC ≥ 6dSm-1 the effects are due to nutrient imbalance, osmotic effects and a ion toxicities that contribute to the reduced growth (Guo *et al.,* 2022)). Habibi *et al.* (2021) also reported a reduction of fresh and dry vegetative biomass in tomato cultivars grown under saline conditions. These results are in line with previous reports by Ali *et al.* (2021a), Singh *et al.* (2020), and Pailles *et al.* (2020), arguing that most commercial cultivars of tomatoes are moderately sensitive to salt stress during their vegetative growth stage compared to the wild tomato that can able to maintain biomass growth during salt stress (Ali *et al.,* 2021a). However, the findings contradicted those of Ibarhim and Ajala (2020), who observed no remarkable difference in vegetative growth.

Ibarhim and Ajala (2020) postulated that salt tolerance during the vegetative growth stage is more important than salt tolerance during seed germination and reproduction stage, as in most cases, tomato crops are established by seedling transplantation rather than direct seeding. Similarly, Ibarhim and Ajala (2020) observed that tomato tolerance to salinity generally increases with plant age and plants are usually most tolerant at maturity. The authors also found that at the flowering and fruiting stage, tomato plants can usually withstand salt concentrations that can be fatal at the seedling stage.

Karaca (2022) suggested a positive correlation between tomato yield and plant size during vegetative growth under salt stress that hinted atthe importance of salt tolerance during the vegetative stage. If genetically verified, the observed variations would be potentially useful for developing tomatoes with improved salt tolerance. This study showed a significant reduction in tomato yield in terms of fruit set, number of fruits, and weight of fruits produced by plants. The number of flowers per truss showed a significant variation between the control and salt treatments of 90 and 150mM NaCl. Additionally, intra-varietal variability in the number of flowers per truss was noted among tomato lines/cultivars in which an average of 16.4 flowers per truss was observed from CLN 5915-93D4-1-0-3 as a maximum and an average of 8.9 flowers per truss was observed for ARP 365-3 as a minimum. The number of trusses per plant and flowers per truss remained almost constant in the control and to the lower level (45 NaCl) but decreased at higher salinity levels of 90mM and 150mM NaCl, especially above the fifth truss. The number of flowers per truss under salt stress conditions would be constrained as extra and new flower production was inhibited (Rosca *et al.,* 2023). The fruit set was reduced, particularly on the upper trusses at higher salinity.

The results indicate that the number of fruits remains unchanged at low salt concentrations of 45 mM NaCl. In contrast,thedecreased number of fruits observed at higher salinity levels of 90mM and 150mM NaCl result from fruit inhibition, particularly above the fifth truss. However, reductions in fruit weight were observed even at the lower salinity level (45mM NaCl). Tomato fruit weight showed significant variation in both the control and the salinity levels among tomato cultivars/lines. The highest fruit weight of 150.2g was observed with ARP 366-2 while the lowest of 34.6g was from CLN 5915-93-D4 1-0-3 in the control and decreased as salinity level increased from 45mM to 150mM NaCl (Table 2.). These tomato cultivars/lines were reduced in size, but not to the same extent, but there were variations among cultivars/lines. Furthermore, upper inflorescences were more sensitive to salinity. Thus, when breeding for salt tolerance in tomatoes, it would be better to develop cultivars with compact plant types and short life cycles with only 4-6 trusses.

It can be postulated that tomato yield reduction when grown under 80mM NaCl is mainly caused by reduced fruit weight while the number of fruits remains unchanged. Similar results were found by Botella *et al.* (2021). The observed reduction in fruit weight may be due to the decrease in enlargement rate during the exponential growth phase due to sensitivity to ionic and osmotic damage of ions accumulated in the tomato plant throughout the growth season (Helaly *et al.* 2017)). Approximately 10, 30, and 50% reductions in fruit size were observed following irrigation with 5-6, 8, and 9 dS/m saline water, respectively. Similarly, Albacete *et al.* (2014) also reported that the major cause of yield reduction in tomatoes grown under low to moderate salinity levels (3-9 dS/m) is the reduction in fruit size, not fruit number.

Conclusion

Soil salinity is a major constraint to the economic use of land for agriculture, especially in the coastal belt of Tanzania. This study shows that salt stress affects tomato cultivars/lines in terms of seed germination, vegetative growth, and reproductive growth (fruit yield). The results also indicate variation in salt tolerance in seed germination, vegetative growth, and reproductive growth for the tomato cultivars/lines tested in this study. Generally, the CLN line series (CLN 1621, CLN 2001A, CLN 2413R, CLN 2418A and CLN 5915-93D4-1-0-3) were found to be the most tolerant followed by the BL line series (BL 1173, BL1174, BL 1175 and BL 1176) and lastly the ARP lines (ARP 365-3, ARP 365-2-5, ARP 366-1, ARP 366-2, ARP367-1, ARP 365-1-4, ARP 366-3 and ARP 366-4-23). The studies showed that the least tolerant tomatoes under this study were the two commercial varieties, Tanya and Tengeru. Some lines, such as CLN 5915-93D4-1-0-3, CLN 1621, ARP 367-1, and ARP 365-2-5 showed an optimistic response to saline irrigation, worth further developing. However, recommendations from tomato farmers and local users on the marketable fruit size are required for market acceptance.

Acknowledgments

The Authors wish to thank the Sida/SAREC project coordinated by the University of Dar es Salaam (UDSM), School of Graduates Studies through the Open Postgraduate Scholarship project for their financial support and also to the Asian Vegetables Research Development Center (AVRDC) at Arusha, Tanzania for providing tomato seeds used in this study.

References

Albacete, A., Navaro, E.C., Balibrea, M.E., Gronkinsky, D.K., Gonzalez, M., Andujar, C., Smigocks, A., Roitech, T. and Altocea, F. (2014). Hormonal and metabolic regulation of tomato fruit sink activity and yield under salinity . T. Exp Bot. 65 (20) : 6081 – 6085

Ali, M., Romdhane, A.M., Tarroum, M., Al Dakhil, M., Al – Dos, A. and Alsadon, A. (2021a). Analysis of salinity tolerance in tomato introgression lines based on morpho-physiological and molecular traits. Plant 10: 2594.

Botella, M.A., Hernandez, V., Mestre, T., Hellin, P., Garcia – Legaz, M.F., Rivero, R.M., Martinez, V., Feroll, J. and Flores, P. (2021). Bioactive compound of tomato fruits in response to salinity, heat and their combination. Agriculture.11 (6) : 534.

Dubois, T., Nenguwo, N. and Dinssa, F. (2015). Processing tomatoes in Tanzania: A taste of seed and ketchup. International platform by Rural 21.

Fagwalawa, L.D., Yahaya, S.M. and Fatima Y.U. (2015). Effect of soil type on the growth of tomato. Gbtech jornal of Bio protocols. 4 (3): 17 – 23.

FAOSTAT (2014). Food and Agricultural commodities production. Retrieved from http://faostat.fao.org/site/339/default.aspx. The site visited on 10 September, 2014.

Guo, M., Guo, H., Khan, A., Gao, Y., Wang, X. S., Bai, S., Wang, X.M. and Li, J. (2022). Tomato salt tolerance mechanism, and their potential application for fighting salinity: A review. Front. Plant Sci: 13.

Habibi, N., Sediqui, N., Terada, N. and Sanada, A. (2021). Effect of salinity on growth, physiological biochemical responses of tomato. Journal of the International society for south east Asian Agricultural science. 27(2): 14 – 28.

Helaly, A.A., Goda,Y., Abdi - Elrehim, A.S., Mohamed A.A. and El Zeiny, O.A.H. (2017) Effect of irrigation with different level of saline water type on husk tomato productivity. *Plant & Agriculture Research.* 6 (4) : 114 – 120.

Ibarhim, L.R. and Ajala B.A. (2020). Effect of abiotic, stress on the fruit quality of tomato (*Solanum lycopesicum*). Nigeria Journal of Botony. 33(1) 25-30.

Ibrahim, M. (2018). Salt tolerance of some tomato cultivars for salinity under controlled conditions. A.M.J Plant physiol. 13:58 – 64.

Karaca, C., Aslan, G., Buyuktas, D., Kuruna, A., Bastug, R. and Navaro, A. (2022). Effect of Salinity stress on Drip - irrigated tomatoes grown under mediterranean – Agronomy 13(1): 36.

Moles, T.M., Guglielminetti and Reyes T.H. (2019). Differential effects of sodium chloride m germination and post – germination stages of two tomato genotypes. Sci Hortic. 257: 108730.

Msogoya, T.J. and Mamiro, D. (2016). The effect of improved cultuors on productivity and profitability in Morogoro region, Tanzania. Journal of Animal & plant serius. 30(3): 4774 – 4780.

Msuya, A.M. (2013). Impact of climate variability on coffee production and farmers copping and adaptation strategies in highlands of Kigoma District, Tanzania. MSc thesis, Sokoine University of Agriculture.

Omar, M.M., Shitindi, M.J., Massawe, B.H.J., Fue, K.G., Meliyo, J.L. and Pedersen, O. (2023). Salt – affected soil in Tanzanian agricultural lands. Types of soils and extent of the problem. Sustainable environment. 9(1): 1-19.

Pailles, Y., Awlia, M, Julkowska, M., Passone, L., Zemmouri, K. and Negrao, S. (2020). Diverse traits contribute to salinity tolerance of wild tomato seedling from the Galapagos Islands. *Plant physiol.* 182: 534 – 546.

Quezada, E.M., Taveras, R.J. and Cruz, S.P. (2023). Basic tomato (*Lycopersicon esculentum*) physiology and morphology. Virginia cooperation extension. Virginia tech. SPES – 508.

Rosca, M., Mihalache, G. and Stoleru, V. (2023) Tomato responses to salinity stress : From morphological traits to genetic changes. Front plant Sci:14.

Sardoei, A.S. and Mohammadi, G.A. (2014). Study of salinity effect on germination of tomato (*Lycopersicon esculentum*. L) genotype. European Journal of experimental biology.

Singh, H., Kumar, P., Kumar, A., Kyriacou, M.C., Colla, G. and Rouphael, Y. (2020). Grafting tomato as a tool to improve salt tolerance. Agronomy 10:263.

Thakur, S., Sinha, A., Singh, V. and Avnee. (2022). Impact of saline irrigation water on yield art quality of tomato (*Solanum lycopersicum,* L). Chemical Science Review and Letters. 11(41):83 -86.

Zaki, H. E. and Yokos, S. (2016). A comparative in vitro study of salt tolerance in cultivated tomato and related wild species. Plant Biotechnol. 33: 361 – 375.

Zizkora, E., Dobrev, P., Muhorski, Y., Hosek, P., Hoyerova, K., Haisel, D., Prochazkova, D, Lutts, S., Motyka, V. and Hichri, I. (2015). Tomato. SIIPT3 and SIIPT4 isopentenyltranferases mediate salt stress ress response is tomato. BMC Plant Biology 15:85.

Supplementary information

Table 3: Plant growth parameters as affected by saline irrigation

Treatments: Saline water	Treatments: Tomato cultivars/lines	Days for germination	Seed germination (%)	Plant height (cm)	Plant fresh weight	No. of Fruits	Fruit weight
Control (No salt)	ARP 365-2-5	5.3e	100.0r	48.6y	250.9ai	69.3w	92.2z
	ARP 365-3	5.3e	100.0r	47.8x	248.3ah	37.3l	103.5af
	ARP 366-1	5.7f	100.0r	48.9y	248.6ah	56.0t	85.0r
	ARP 366-2	6.0f	100.0r	51.7y	252.4ai	30.3i	150.1aj
	ARP 366-3	5.7f	100.0r	49.2y	249.4ah	44.3o	90.1x
	ARP 366-4-23	5.7f	95.0p	54.2z	250.67ai	34.7k	97.1ac
	ARP 367-1	5.7f	100.0r	53.3z	260.2aj	58.7u	85.0r
	BL 1173	4.3c	100.0r	42.6v	250.5ai	86.6ac	71.9m
	BL 1174	4.3c	100.0r	38.1r	244.3ag	50.0r	69.7l
	BL 1175	4.0c	100.0r	31.5h	240.9af	83.3ab	105.0ag
	BL 1176	4.7d	100.0r	52.9y	246.0ag	80.0z	88.0v
	CLN 1621	4.0c	100.0r	35.6m	214.9u	126.7ah	34.9f
	CLN 2001A	4.0c	100.0r	29.6e	215.0u	130.0ai	35.8f
	CLN 2413R	4.0c	100.0r	37.9q	224.5y	93.3ad	92.0y
	CLN 2418A	4.0c	100.0r	38.6s	223.0y	76.6y	96.6ab
	CLN 5915-93D4-1-0-3	4.0c	100.0r	35.7m	220.9x	150.0aj	34.6f
	TANYA	3.7b	100.0r	39.9t	244.8ag	42.0n	110.7ah
	TENGERU 97	6.0f	93.0p	53.8z	260.0aj	32.6j	120.3ah
45mM NaCl	ARP 365-2-5	5.3e	92.0p	44.5s	228.5r	66.7v	89.2j
	ARP 365-3	5.3e	93.0p	45.5x	231.2ab	32.7l	99.7ad
	ARP 366-1	5.7f	88.0m	41.9v	239.3af	46.7q	80.0o
	ARP 366-2	6.0f	88.0m	45.6x	239.8af	21.0f	136.7ai
	ARP 366-3	6.0f	88.0m	45.6x	243.6ag	35.0k	86.9u
	ARP 366-4-23	6.0f	78.0d	48.3t	239.3k	29.3i	92.5j
	ARP 367-1	5.7f	99.0r	46.8x	238.5ae	54.0s	79.7o
	BL 1173	4.3c	99.0r	34.4k	246.0ag	70.0w	69.2l
	BL 1174	4.7d	99.3r	36.4n	235.2ac	43.3n	68.3k
	BL 1175	4.0c	100.0r	30.3g	236.3ad	80.0z	99.7ad
	BL 1176	4.7d	99.6r	48.7y	243.2ag	50.0	81.7q
	CLN 1621	4.0c	99.3r	35.5m	210.9t	116.7ag	29.8d
	CLN 2001A	4.0c	99.0r	28.7b	211.0t	113.3af	33.0e
	CLN 2413R	4.0c	99.6r	36.4n	219.8w	76.6y	81.2p

Treatments		Days for germination	Seed germination (%)	Plant height (cm)	Plant fresh weight	No. of Fruits	Fruit weight
Saline water	Tomato cultivars/lines						
	CLN 2418A	4.0c	98.0q	37.1o	219.4w	73.3x	85.3z
	CLN 5915-93D4-1-0-3	4.0c	100.0r	34.2j	217.8r	143.3aj	29.5b
	TANYA	3.7b	93.0p	34.0k	234.6ac	35.0k	100.3ae
	TENGERU 97	6.0f	87.0k	43.9v	247.7ah	28.0h	118.3ah
90mM NaCl	ARP 365-2-5	8.0g	83.0i	39.0x	185.4z	38.0l	66.2w
	ARP 365-3	7.7g	60.3e	34.9l	150.6m	23.3g	66.8s
	ARP 366-1	8.0g	68.0f	36.1m	146.4l	20.0e	61.9h
	ARP 366-2	8.3h	67.0f	36.0m	134.3j	14.0c	103.9af
	ARP 366-3	9.3j	67.0f	38.7s	156.5n	13.3c	65.6j
	ARP 366-4-23	9.0i	55.0g	39.9x	141.5af	12.0b	66.7j
	ARP 367-1	8.3h	92.0p	37.4p	192.5s	30.0i	73.0m
	BL 1173	6.0f	91.3o	29.2d	174.6q	45.3p	51.7g
	BL 1174	6.0f	90.6m	33.9j	161.4o	30.0i	51.6g
	BL 1175	5.7f	93.0p	29.0d	191.1r	40.0m	76.3n
	BL 1176	6.0f	92.0p	44.6x	122.2h	42.7n	63.3i
	CLN 1621	6.0f	92.0p	31.7h	186.8r	70.7w	23.9b
	CLN 2001A	6.0f	91.0n	28.3c	164.7p	66.7v	27.8c
	CLN 2413R	6.0f	93.0p	35.7m	150.6m	45.3p	70.7l
	CLN 2418A	6.0f	93.0p	36.0m	159.6o	42.7n	79.2o
	CLN 5915-93D4-1-0-3	6.0f	93.0p	32.8k	184.7v	98.6ae	26.4b
	TANYA	5.7f	60.3e	28.7c	132.0i	18.6d	78.3o
	TENGERU 97	9.0i	56.0d	34.6k	140.2k	14.0c	96.3ab
150mM NaCl	ARP 365-2-5	12.3n	60.3e	33.9j	105.2e	40.4m	36.6f
	ARP 365-3	17.7q	55.0d	32.0i	97.9c	19.3e	32.0e
	ARP 366-1	17.3p	50.0b	31.6h	75.2b	21.0f	36.0f
	ARP 366-2	17.0p	60.0e	31.7h	73.9b	10.2b	46.4g
	ARP 366-3	18.3r	53.0c	31.7h	112.8e	10.7b	31.0d
	ARP 366-4-23	0.0a	0.0a	31.0h	101.4c	11.1b	35.0f
	ARP 367-1	12.7o	83.0i	33.3j	153.9n	31.6i	37.7f
	BL 1173	11.3k	85.0j	28.4c	136.0j	40.0m	34.1e
	BL 1174	12.0m	82.0i	31.3h	104.3d	24.3g	33.5e
	BL 1175	12.0m	89.3m	27.3a	106.2e	39.8m	37.5f
	BL 1176	11.7l	80.3h	40.7o	108.2e	38.4l	29.2c

Treatments		**Days for germination**	**Seed germination (%)**	**Plant height (cm)**	**Plant fresh weight**	**No. of Fruits**	**Fruit weight**
Saline water	**Tomato cultivars/lines**						
	CLN 1621	12.0m	82.3i	29.8f	140.9k	66.2v	21.3b
	CLN 2001A	12.0m	82.0i	28.0b	119.9g	58.8u	23.0b
	CLN 2413R	12.0m	80.3h	33.8j	115.2f	48.9q	30.5d
	CLN 2418A	12.0m	81.0h	33.8j	130.2i	36.4k	37.1f
	CLN 5915-93D4-1-0-3	12.0m	90.6m	31.3h	144.7l	118.5	24.3b
	TANYA	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
	TENGERU 97	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a

Means in the column with same letter indicate no difference at Duncan's Multiple Range Test at P< 0.05.