A Study on Effects of Salinity on Growth and Yield of Tomato Genotype (*Solanum lycopersicum*)

Ja'afar Umar^{1,a*}, Adamu Aliyu², Kasimu Shehu², Lawal Abubakar³

¹Department of Biology, Federal University Birnin Kebbi, Nigeria

²Department of Biological Sciences, Usmanu Danfodiyo University, Sokoto, Nigeria

³Department of Crop Science, Usmanu Danfodiyo University, Sokoto, Nigeria

*realumar2001@gmail.com

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Abstract. Saline water occupies 71% of the Earth area. It is thought that even a quarter of the whole pedosphere is affected by salts amounting to 950 x 106 ha while 23 % of the 1.5 x 109 ha cultivated land is considered as saline. This study was carried out to investigate the influence of salinity on the on growth and yield of tomato genotypes. The seedlings 20 genotype were divided into three groups, Sodium chloride (NaCl) dissolved in irrigation water to make variant concentration of 30, 60 mg/L of salt concentration using E. C meter which were used to water the plants. Vegetative and reproductive characterization was evaluated. Data obtained were subjected to one way analysis of variance using SPSS (20) Statistical Software. All the genotypes exhibited a decline significantly in vegetative and reproductive parameters measured, with increasing salt concentration. In conclusion, the result of this research suggest that salinity decline both vegetative and reproductive parameters in tomato.

Introduction

Nigeria is the largest producer of tomato in Sub- Saharan Africa and 13th in the world with an annual output of 2.4 million tones. Notwithstanding, the production faces challenges with distribution, storage, biotic and abiotic stress [5]. The decline in agricultural production in recent times in Nigeria (which declined from 7.2 percent in 2007 to 5.7 percent in 2011 [3]. This is not resultant of variations in rainfall but to other indicators of climate change such as increase in temperature and evaporation, drought and wind [21]. He also suggested that climate change measured by variation in rainfall may not directly affect agricultural production but indirectly through of the aftermaths of such rainfall such as erosion. Tomato plant suffers from various physiological problems in soil (abiotic stress) around the world. Until now, the causes behind such abnormalities in tomato cultivation have not been well understood. Wada et al. [20] reported that calcium concentration of young fruit decreased quickly when fruit fresh weight reaches an average of 20g. There is paucity of information on salt responsive candidate gene in tomato which could be useful in alleviating loss and low yield in tomato production.

Salinity is one of the major limitations on plant growth and productivity throughout the world. Damage caused to plants by high salinity is observed as either loss of plant productivity or plant death. Water sources on earth contain 30 g of sodium chloride per liter, making earth been referred to as a salty planet [4]. With the increase of soil salinity over the years due to poor irrigation and chemical application to the soil, it's expected that by 2050, more than 50% of the land available for agriculture will be lost because of salinity [7]. Most tomato cultivars are sensitive to moderate levels of salinity [18]. Indeed, all plant development stages, including seed germination, vegetative growth and reproduction, show salinity sensitivity, that leads to poor harvests and reduced economic yield [23]. Tomato production has been limited due to high salinity level of the soil or of the irrigation water [22].

Materials and Methods

Plant Materials

The field experiment was conducted in the Biological garden of the Usmanu Danfodiyo University, Sokoto located at latitude 13° 0' 21.1428" N and longitude 5° 14' 51.1872" E. Selected tomato landraces genotypes were obtained from local markets around Sokoto and Zamfara State Nigeia metropolis. These were identified in Heberium of Ahmadu Bello University, Zaria. While accessions genotypes seeds were obtained from Zamfara State Agricultural Development Project, Gusau (ZADP) and Institute for Agricultural Research (IAR) Ahmadu Bello University Zaria. The seeds of 20 genotypes of tomato were grouped into landraces and accessions, the collection location, type and common name of the cultivar are summarized on Table 1.

Salinity Inducement

The experiment was laid down in completely randomized design (CRD) consisting of three treatments (control with no concentration of Salt, 30 and 60 mgL⁻¹ of salt using E.C meter model, ORP 850081); the seedlings of each accession was divided into three groups: The first group represent the control where no salt was added. The second and third groups received 30 and 60 mgL⁻¹ of Salt respectively and replicated three times. The seeds were surface sterilized by soaking in 5% sodium hypochlorite and rinsed three times in distilled water. The seeds were first sown in nursery beds and uniformly germinated seedlings (2 weeks old) were selected and transferred to poly bags containing a mixture of river sand and organic manure in 3:1 ratio.

Table 1. Different tomato genotypes used and their locations.

Genotype	Type	Collection Locatity
Dangainakawa	Landrace	Market
Bahaushe	Landrace	Market
Dandino	Landrace	Market
Daneka	Landrace	Market
Dan Gombe	Landrace	Market
Dan Mazari	Landrace	Market
Dandubukamiya	Landrace	Market
Dankwandawa	Landrace	Market
Ganwon falke	Landrace	Market
Dan dogarawa	Landrace	Market
Roma	Released	ZADP
UTC	Released	ZADP
Rio grande	Released	ZADP
Giofranco F	Released	ZADP
UC82B	Released	IARI
Indian tomato	Released	IARI
Tomato peto	Released	IARA
Tropimech	Released	ZADP
Cherry	Released	IARI
Heirloom Tomato	Released	IARI

Plant Height and Root Length

After 28 days of salt treatment, salt tolerance was asses in both relative performance under salinity compared with control conditions for various yield parameters according to the method of Munns and James [13]. Plant height and root length parameters were assessed according to the International Plant Genetic Institute [9]. Plant height was measured from the base of the plant to the tip of the meristem, and root length was determined by measuring the length of the underground system using centimeter rule.

Number of Leaves, Floral Count and Number of Fruits

The average number of leaves, number of flowers and number of fruits were determined by counting the entire number of leaves, flower and fruits divided by the number of plant in each pot [8].

$$TNP \div NP = \text{Parameter} / \text{plant}$$

where TNP = Total number of parameters and NP= Number of plant.

Leaf area and Dry Matter Accumulation

Leaf area was measured using Bohnert and Jensen [2] method by laying the leaves to be measured on a 1cm grid and trace their outlines. The number of square centimeters the leaf covered was counted and estimated the area of the partial squares, at least half covered by the leaf [10]. Constant dry weight was determined after drying in an oven at 80°C to dry the entire moisture content and weighted. All the vegetative parameters were computed according to the Hunt [8] formula, to evaluate the physical level of salt tolerance in the selected cultivars.

Fruit Size and Weight of Fruit at Harvest

The size of the fruit was determined according to IPGRI descriptors of tomato chart [10]. The length was recorded from stem end to blossom end, to one decimal place at maturity. The fruit width was recorded at the largest diameter of cross-sectioned fruits to one decimal Place, at maturity. Fruits < 3cm were described as very small while 3-5cm small, 5.1- 8cm intermediate, 8-10 cm large and > 10 cm were described as very large respectively. The weight of fruit of each plant at different treatments was determined by weighting the number of fruits in gram using weighing scale model CBB 600 [19].

Fruit Shelf Life

The shelf life of the fruits from different cultivars was determined by keeping the fruits at room temperature (35±2), for 10 day after harvesting, between 5–8 days is considered to have long shelf life, 3- 5 days medium shelf life and 0- 3 days short shelf life [10].

Results

Phenotypic and Biochemical Responses of Tomato to Salinity

Salinity significantly reduced plant vegetative parameters (number of leaves, plant height, root length, leaves area and Dry Matter Accumulation) in concentration dependent manner in all the twenty genotype. The highest number of leaves were recorded in control of Riogrande and Daneka with 88.67 leaves per plant each and the lowest leaves count were recorded in Dankwandawa and Dan gainakawa treated with 60 mgL-1 of salt with 16.67 and 17.00 leaves per plant (Table 2). However, Plant height significantly ($P<0.05$) affected by salt concentration in all the genotype used. Daneka recorded the highest plant height of 61.00 at control and Dandubukamiya recorded the highest plant height in plant treated with 60mgL-1 of salt with 38.67cm (Table 2).

Root length significantly affected by salinity in concentration dependant manner. However, the lowest length of root at control of 3.03cm was recorded in Dankwandawa followed by Ganwon falke with 3.70cm. The highest root length in plants treated with 30mgL-1 of Salinity was recorded in Daneka with 10.17cm and the lowest root length in plant treated with 30mgL-1 of Salinity was observed in UTC and Dandogarawa with 2.27cm each (Table 2). Leaf area also significantly ($P<0.05$) affected by salinity. The largest leave area of 27.30sq/m was recorded in Tropimech followed by Roma with 24.67sq/m (Table 2). Dry Matter Accumulation significantly affected by salinity episode in all the genotypes. The lowest Dry Matter Accumulation of 0.90g was recorded in Dangainakawa treated with 60mgL-1 of Salinity followed by Dandogarawa with 1.60g respectively (Table 2). Number of flowers, number of fruits and fruit weight at harvest were significantly

($P < 0.05$) affected by salinity in concentration dependent manner. Highest number of flowers (35/plant) was recorded at control in Dan Mazari followed by Indian tomato (released cultivar) with 33 flowers per plant (Table 3). The lowest number of flowers was recorded on plant treated with 60 mgL⁻¹ of Salinity on Dan Gainakawa with 5.67 flowers per plant followed by Dan Eka with 6.67 flowers (Table 3).

Highest number of fruit was recorded at control on Indian tomato with 28 fruits followed by Tomato Peto with 26 fruits. The lowest number of fruits was recorded at plant treated with 60mgL⁻¹ of Salinity on Dan Gombe with 8 fruits followed by Dandino with 10 fruits (Table 3). Fruit weight at harvest also significantly ($P < 0.05$) affected by salinity. Highest fruit weight was observed in control among the twenty accessions and decreased as the salt concentration increased. The highest fruit weight of 136.03g/fruit was recorded in control in Dan Dogarawa followed by Dan Gombe with 107.50g. The lowest fruit weight of 15.00g/fruit was recorded in Dan Gainakawa. However, UC 82B and UTC recorded the same fruit weight in control with 104.30g each respectively (Table 3).

Table 2: Effects of Salt Concentration on Vegetative Characters in Different Tomato Genotypes.

Accessions/ Landraces	Treatment (mgL ⁻¹)	Number of leaves	Plant Height	Root Length	Leaf Area (Sq/m)	Dry Mass Accumulation (g)
D/ Gainakaw	0	79.00 ^a ±21.78	45.67 ^a ±2.50	13.67 ^a ±5.51	6.30 ^a ±0.57	4.60 ^a ±0.66
	30	45.00 ^b ±12.10	40.67 ^b ±1.16	7.67 ^b ±0.58	5.30 ^b ±0.57	1.97 ^b ±0.58
	60	17.00 ^c ±15.13	9.18 ^c ±10.00	4.50 ^c ±3.90	2.67 ^c ±2.52	0.90 ^c ±0.80
	LSD	4.45	1.30	0.80	0.56	0.45
Bahaushe	0	74.30 ^a ±6.10	40.30 ^a ±5.63	12.80 ^a ±4.50	10.30 ^a ±3.20	4.40 ^a ±0.46
	30	48.67 ^b ±3.78	28.00 ^b ±5.59	7.47 ^b ±1.27	8.67 ^b ±0.58	3.67 ^b ±0.12
	60	33.67 ^c ±4.64	24.30 ^c ±3.79	3.97 ^c ±0.50	7.30 ^c ±0.58	1.87 ^c ±0.15
	LSD	4.35	2.05	1.00	0.95	0.65
Dandino	0	79.30 ^a ±13.60	54.20 ^a ±6.42	12.80 ^a ±4.50	20.67 ^a ±4.04	5.70 ^a ±1.60
	30	58.30 ^b ±7.64	40.90 ^b ±4.40	7.47 ^b ±1.27	8.67 ^b ±2.08	4.87 ^b ±0.15
	60	43.00 ^c ±2.00	33.40 ^c ±2.98	4.00 ^c ±0.56	4.67 ^c ±1.53	4.00 ^c ±0.10
	LSD	5.07	2.00	1.03	0.76	0.50
Dan Eka	0	88.67 ^a ±3.20	61.00 ^a ±5.57	14.67 ^a ±4.07	18.67 ^a ±2.31	5.93 ^a ±0.40
	30	62.67 ^b ±24.83	48.07 ^b ±7.20	10.17 ^b ±2.78	15.30 ^b ±0.58	4.30 ^b ±1.94
	60	34.67 ^c ±13.70	30.30 ^c ±8.90	6.60 ^c ±2.90	13.00 ^c ±1.00	2.00 ^c ±0.30
	LSD	4.90	1.65	1.07	1.03	0.65
Dan Gombe	0	58.30 ^a ±6.66	43.47 ^a ±5.62	13.60 ^a ±2.14	21.30 ^a ±2.30	3.67 ^a ±0.70
	30	39.67 ^b ±9.50	33.07 ^b ±2.90	7.80 ^b ±3.90	16.30 ^b ±0.58	2.07 ^b ±0.21
	60	24.00 ^c ±12.53	20.17 ^c ±2.63	3.50 ^c ±0.48	14.30 ^c ±2.08	1.47 ^c ±0.30
	LSD	3.68	2.03	1.00	1.04	0.39
Dan Mazari	0	33.30 ^a ±4.10	26.67 ^a ±1.53	5.90 ^a ±0.80	16.30 ^a ±0.58	4.20 ^a ±0.21
	30	28.00 ^b ±1.00	20.50 ^b ±2.10	4.50 ^b ±0.36	14.67 ^b ±0.58	3.10 ^b ±0.10
	60	23.67 ^c ±0.57	18.00 ^b ±0.30	3.50 ^c ±0.26	12.00 ^c ±1.00	1.87 ^c ±0.50
	LSD	4.53	2.90	0.89	0.90	0.40
Dan Dubu	0	55.30 ^a ±2.08	48.67 ^a ±1.53	6.77 ^a ±0.21	18.67 ^a ±6.58	5.10 ^a ±0.10
	30	50.00 ^b ±1.00	44.00 ^a ±1.00	3.80 ^b ±1.32	15.00 ^b ±2.00	4.00 ^b ±0.06
	60	47.67 ^b ±0.58	38.67 ^b ±2.52	2.60 ^b ±1.40	13.67 ^b ±1.53	3.27 ^c ±0.06
	LSD	3.00	4.48	1.21	2.90	0.54
D/ Kwandawa	0	23.30 ^a ±1.53	19.67 ^a ±4.73	3.03 ^a ±0.06	7.10 ^a ±1.88	3.67 ^a ±1.53
	30	19.67 ^b ±4.04	19.67 ^b ±1.53	2.40 ^a ±0.04	2.07 ^b ±0.21	2.00 ^b ±1.70
	60	16.67 ^b ±1.55	10.67 ^c ±0.58	1.67 ^a ±0.10	1.90 ^c ±0.93	1.67 ^b ±1.10
	LSD	3.04	0.90	1.50	2.01	1.00
Ganwon Falke	0	33.67 ^a ±4.73	20.30 ^a ±2.52	3.70 ^a ±0.67	23.00 ^a ±2.65	4.17 ^a ±0.15
	30	19.30 ^b ±2.08	17.00 ^b ±1.70	1.37 ^b ±0.12	17.30 ^b ±0.58	3.20 ^a ±0.26
	60	16.30 ^b ±0.58	10.30 ^c ±1.50	0.97 ^b ±0.10	14.30 ^b ±0.58	2.00 ^a ±0.10
	LSD	5.89	2.78	1.98	3.97	2.86
D. Dogarawa	0	32.30 ^a ±1.10	23.77 ^a ±3.30	2.77 ^a ±0.99	12.30 ^a ±1.50	3.60 ^a ±0.78
	30	23.00 ^b ±2.00	18.57 ^b ±1.60	2.27 ^a ±0.76	8.67 ^b ±0.58	2.70 ^b ±0.38
	60	20.00 ^c ±3.60	15.20 ^c ±0.71	0.97 ^b ±1.50	7.00 ^b ±1.00	1.60 ^c ±0.30
	LSD	2.09	1.09	0.98	1.97	0.87

Table 2 Continued: Effects of Salt Concentration on Vegetative Characters in Different Tomato Cultivars.

Accessions/ Landraces	Treatment (mgL ⁻¹)	Number of leaves	Plant Height	Root Length	Leaf Area (Sq/m)	Dry Mass Accumulation (g)
Roma	0	57.00 ^a ±6.08	46.40 ^a ±5.30	27.10 ^a ±3.80	24.67 ^a ±1.53	5.40 ^a ±0.80
	30	40.00 ^b ±5.00	40.00 ^b ±5.70	3.87 ^b ±0.98	15.67 ^b ±3.20	4.00 ^a ±0.20
	60	26.30 ^c ±5.50	20.30 ^c ±5.50	1.77 ^c ±0.20	11.67 ^c ±2.51	2.80 ^a ±0.29
	LSD	3.87	1.09	1.98	0.43	2.08
UTC	0	69.67a±1.53	45.90a±5.58	9.00a±2.00	13.00a±1.70	6.00a±0.10
	30	56.00a±14.18	33.00b±3.47	4.67b±1.26	9.00b±1.00	5.10a±0.70
	60	47.30a±10.02	31.00b±10.02	2.80c±1.10	7.30c±0.58	3.40b±0.64
	LSD	14.87	3.42	0.54	0.76	1.53
Rio Grande	0	88.67a±3.21	48.10a±2.70	5.50a±0.90	20.00a±3.60	6.70±0.11
	30	70.30b±4.50	33.77b±4.00	3.10b±0.30	15.30b±0.58	5.60±0.46
	60	51.30c±11.00	25.07c±2.83	2.50b±0.50	13.00c±1.00	4.70±0.70
	LSD	5.12	2.07	0.76	0.75	0.87
Gianfranco F.	0	79.00a±16.40	47.27a±2.64	5.07a±0.93	14.67a±0.58	5.97a±0.29
	30	56.67b±10.40	33.90b±5.40	3.30b±0.26	12.67a±0.58	4.70b±0.70
	60	33.67c±5.51	25.50c±4.76	2.80b±0.26	8.67b±1.10	2.89c±0.39
	LSD	5.70	2.97	1.31	2.53	1.02
UC82B	0	70.30a±13.00	44.47a±5.06	11.40a±14.32	16.67a±0.57	5.40a±0.60
	30	58.00b±2.60	29.00b±1.70	2.27b±0.25	14.30b±1.10	4.50ab±0.40
	60	44.30c±5.10	23.97c±4.38	2.30b±0.60	12.30b±0.57	2.80b±0.76
	LSD	6.98	3.86	2.06	2.00	1.96
Indian tomato	0	62.30a±5.86	41.30a±1.50	7.77a±3.00	9.67a±0.57	5.00a±0.58
	30	53.30b±4.90	34.30b±4.00	8.00a±0.60	9.00b±0.00	4.37b±0.40
	60	46.67b±2.89	33.67b±4.00	5.07b±1.08	7.67c±50.90	3.10c±0.10
	LSD	6.87	1.98	0.94	0.56	0.23
Tomato Peto	0	59.00a±5.29	41.30a±1.50	6.00a±0.80	21.30a±1.50	5.27a±0.10
	30	47.67b±9.40	35.00b±4.00	4.70b±0.38	18.67b±1.10	4.17b±0.20
	60	43.67b±8.08	29.67c±0.58	4.10c±1.50	14.30c±1.10	2.00c±0.80
	LSD	4.67	1.04	0.45	0.64	0.50
Tropimech	0	69.30a±5.51	38.30a±1.00	4.00a±0.71	27.30a±2.08	6.00a±0.56
	30	64.00b±2.61	33.00b±2.83	3.17ab±0.10	21.00b±4.00	5.70a±0.61
	60	53.30c±2.52	21.30c±1.50	2.80b±0.10	16.00c±1.70	4.40b±0.66
	LSD	3.23	2.43	0.98	1.00	0.76
Cherry	0	33.67a±3.20	28.87a±3.59	7.87a±2.20	15.30a±0.58	4.17a±0.12
	30	24.30b±3.79	25.17b±0.90	4.07b±2.50	13.30b±1.50	3.10b±0.10
	60	21.00c±2.00	19.43c±3.60	1.97c±0.35	12.67b±1.50	2.00c±0.10
	LSD	1.67	1.54	0.34	0.94	0.45
Heirloom	0	66.67a±3.50	43.23a±2.90	5.70a±0.80	16.67a±2.08	5.30a±0.30
	30	55.00b±2.60	37.87b±1.30	4.17b±0.50	9.00b±1.70	4.30b±0.43
	60	46.00c±4.00	31.07c±1.96	3.20c±0.20	7.00c±0.00	3.00c±0.10
	LSD	4.45	2.76	0.74	0.89	0.54

Values represent means and standard deviation of vegetative parameters. Mean in a column with the same superscript are not significantly different at (P<0.05)

Table 3: Effects of salt concentration on floral characters, number of fruits and fruits weight at harvest in different tomato genotypes studied.

Accessions/	Treatment	Number of Flowers	Number of Fruit	Fruit Weight (g)
Landraces				
D. Gainakawa	0	28.00 ^a ± 7.55	12.00 ^a ± 2.65	15.03 ^a ± 0.58
	30	16.67 ^b ± 4.90	10.00 ^a ± 2.65	14.10 ^b ± 0.58
	60	5.67 ^c ± 5.10	4.00 ^b ± 4.00	9.27 ^c ± 8.01
	LSD	2.67	2.03	1.06
Bahaushe	0	27.00 ^a ± 6.08	13.67 ^a ± 3.79	157.70 ^a ± 2.89
	30	21.30 ^b ± 5.69	9.30 ^b ± 0.58	92.70 ^b ± 1.28
	60	7.00 ^c ± 1.00	3.67 ^c ± 0.58	65.70 ^c ± 3.00
	LSD	2.89	1.02	8.90
Dandino	0	17.00 ^a ± 2.00	10.00 ^a ± 1.00	100.1 ^a ± 1.60
	30	14.67 ^b ± 0.58	8.67 ^b ± 2.00	97.40 ^a ± 0.50
	60	9.00 ^c ± 1.00	4.67 ^c ± 1.53	74.90 ^b ± 1.60
	LSD	2.01	1.00	6.87
Dan Eka	0	21.00 ^a ± 1.70	14.00 ^a ± 1.00	59.80 ^a ± 3.50
	30	13.00 ^b ± 5.20	8.00 ^b ± 5.10	45.70 ^b ± 3.17
	60	6.67 ^c ± 1.53	3.67 ^c ± 1.10	30.70 ^c ± 3.12
	LSD	2.00	1.05	3.67
Dan Gombe	0	12.67 ^a ± 3.79	8.30 ^a ± 3.20	107.50 ^a ± 1.70
	30	9.30 ^b ± 0.58	5.00 ^b ± 1.00	64.10 ^b ± 1.15
	60	6.67 ^c ± 0.58	3.30 ^c ± 1.10	60.87 ^b ± 0.67
	LSD	1.04	0.90	4.89
Dan Mazari	0	35.30 ^a ± 5.50	21.00 ^a ± 2.00	67.20 ^a ± 7.70
	30	26.67 ^b ± 4.04	14.67 ^b ± 1.53	58.60 ^b ± 1.40
	60	18.00 ^c ± 2.65	8.30 ^c ± 1.53	43.90 ^c ± 0.50
	LSD	2.89	1.50	4.02
Dan Dubu	0	5.10 ^a ± 0.10	21.00 ^a ± 6.56	44.30 ^a ± 1.10
	30	4.00 ^b ± 0.58	16.30 ^b ± 2.30	34.30 ^b ± 0.58
	60	3.37 ^c ± 0.58	9.67 ^c ± 3.20	23.00 ^c ± 0.00
	LSD	0.70	1.90	2.06
D. Kwandawa	0	30.30 ^a ± 3.65	23.00 ^a ± 2.00	75.20 ^a ± 1.68
	30	25.67 ^b ± 7.30	18.30 ^b ± 4.10	67.10 ^b ± 3.70
	60	20.00 ^c ± 3.00	15.30 ^c ± 3.20	53.80 ^c ± 3.90
	LSD	2.75	1.95	4.68
Ganwon Falke	0	24.00 ^a ± 1.00	17.67 ^a ± 1.50	95.10 ^a ± 4.50
	30	17.30 ^b ± 2.50	12.67 ^b ± 2.08	89.40 ^b ± 2.90
	60	15.30 ^b ± 0.58	8.30 ^c ± 2.00	83.10 ^b ± 3.80
	LSD	2.39	1.86	4.95
D. Dogarawa	0	28.30 ^a ± 306	22.30 ^a ± 3.20	136.03 ^a ± 32.20
	30	23.30 ^b ± 2.52	15.67 ^b ± 1.10	62.10 ^b ± 13.09
	60	16.30 ^c ± 0.58	11.00 ^c ± 1.00	40.50 ^c ± 9.30
	LSD	2.67	1.90	6.76
Roma	0	19.67 ^a ± 5.00	14.67 ^a ± 1.50	84.60 ^a ± 5.00
	30	14.30 ^b ± 1.10	11.30 ^b ± 1.15	43.60 ^b ± 1.00
	60	9.67 ^c ± 4.90	4.67 ^c ± 2.31	41.10 ^b ± 1.88
	LSD	1.90	1.87	4.78
UTC	0	16.67 ^a ± 1.10	12.00 ^a ± 2.00	104.30 ^a ± 4.01
	30	11.30 ^b ± 2.52	7.30 ^b ± 1.53	76.50 ^b ± 2.62
	60	7.30 ^c ± 1.53	3.67 ^c ± 1.10	67.70 ^c ± 1.15
	LSD	2.01	1.60	5.07
Rio Grande	0	16.67 ^a ± 4.90	11.30 ^a ± 3.79	87.57 ^a ± 1.62
	30	13.00 ^b ± 1.00	8.67 ^b ± 0.58	75.40 ^b ± 1.50
	60	5.30 ^c ± 2.00	3.00 ^c ± 1.00	68.57 ^c ± 0.81
	LSD	2.06	1.57	4.37

Table 3 Continued: Effects of salt concentration on floral characters, number of fruits and fruits weight at harvest in different tomato cultivars studied.

Accessions/ Landraces	Treatment (mgL ⁻¹)	Number of Flowers	Number of Fruit	Fruit Weight (g)
Giofranco F.	0	21.30 ^a ±1.53	12.67 ^a ±2.08	92.60 ^a ±2.30
	30	15.67 ^b ±2.89	9.00 ^b ±1.00	79.00 ^b ±0.52
	60	9.67 ^c ±2.00	5.67 ^c ±2.00	68.17 ^c ±0.50
	LSD	2.60	1.87	4.75
UC82B	0	14.30 ^a ±4.51	10.00 ^a ±2.00	104.30 ^a ±3.41
	30	11.00 ^b ±2.00	8.00 ^a ±1.73	88.87 ^b ±1.140
	60	7.67 ^c ±1.53	5.00 ^b ±1.00	67.40 ^c ±7.09
	LSD	2.06	2.65	5.06
Indian tomato	0	33.00 ^a ±3.00	28.00 ^a ±2.65	102.97 ^a ±1.79
	30	25.67 ^b ±1.50	20.67 ^b ±2.08	96.07 ^b ±2.35
	60	19.30 ^c ±0.58	14.30 ^c ±0.58	88.50 ^c ±1.22
	LSD	3.07	2.07	6.09
Tomato Peto	0	32.67 ^a ±1.53	26.67 ^a ±1.10	82.00 ^a ±13.00
	30	30.30 ^a ±0.58	25.30 ^a ±0.58	69.40 ^b ±0.60
	60	25.30 ^b ±2.52	20.00 ^b ±1.00	58.50 ^c ±1.60
	LSD	3.18	2.01	4.90
Tropimech	0	25.30 ^a ±0.57	18.67 ^a ±3.79	98.07 ^a ±4.00
	30	21.30 ^b ±1.50	14.30 ^b ±1.50	78.77 ^b ±4.62
	60	14.00 ^c ±3.40	8.00 ^c ±3.60	67.70 ^c ±1.10
	LSD	2.86	1.90	4.88
Cherry	0	21.30 ^a ±3.20	14.30 ^a ±1.53	85.43 ^a ±2.08
	30	16.30 ^b ±2.00	13.00 ^a ±1.70	66.60 ^b ±7.20
	60	38.30 ^c ±4.60	6.67 ^b ±3.20	60.17 ^b ±7.48
	LSD	2.70	1.70	4.84
Heirloom	0	24.30 ^a ±2.89	18.30 ^a ±2.52	89.37 ^a ±2.30
	30	16.30 ^b ±0.58	12.00 ^b ±1.00	75.50 ^b ±8.20
	60	15.30 ^b ±2.31	9.30 ^c ±2.08	54.90 ^c ±6.18
	LSD	2.76	1.85	4.89

Values represent means and standard deviation of floral count, number of fruit and fruit weight at harvest. Mean in a column of a cultivar with the same superscript are not significantly different ($P < 0.05$).

Discussions

In this study it was observed that salinity significantly decreased vegetative parameters with increase in salt concentration. In all the twenty accessions/landraces studied, control had the highest vegetative parameters (number of leaves, plant height, leaf area, root length and dry matter accumulation) followed by plants treated with 30mgL⁻¹ of Salinity. The lowest vegetative parameters were observed on plants treated with 60 mgL⁻¹ of Salinity. Control had the highest number of leaves, plant height, root length, leaves area and dry matter accumulation. This is in accordance with the findings of Gumi et al. [6] on effect of growth biochemical parameters and ion homeostasis in *Solanum lycopersicum*. Root and shoot length are the most important parameters for salinity because of the direct contact of root with the soil and absorb water and shoot supply to the rest of plant body. For this reason, root and shoot length provides an important clue to the response of plant to salinity [12]. As salinity is first perceived in the root, it is likely that root derived signal, presumably abscisic acid is formed which directly or indirectly down regulates leaf expansion rate [14].

Decrease in number of flowers, number of fruits and fruit weight at harvest had been reported in tomato under salinity in a concentration dependent manner [6, 16]. This is in accordance with the findings of the present study. The chemical potential of saline solution initially establish a water potential imbalance between the apoplast and symplast that lead to turgor decrease, which if severe enough can leads to growth reduction [2]. Similar observations have been reported in *Capsicum annum* and *Capsicum chinense* by Ja'afar et al. [11], the report shows significant decrease in all the vegetative parameters, floral and fruit number in the two species with increasing salt concentration. Salinity induces proteomic changes in tomato [17], proteins and other macro

molecules play a key role in flower formation and fruit quality. Amini et al. [1] reported highest floral count and number of fruit on tomato plant at control, with lowest number at plant treated with salt. Similar result was also reported by Reddy et al. [15] in *Jatropha curcas* and in cabbage, sugar beet, paniculate amaranth and pak-choi by Muhammad et al. [12].

Conclusion

From the findings of this study, controls recorded the highest number of leaves, plant height, root length, leaf area, number of flowers, and number of fruits, dry matter accumulation and weight of fruit at harvest. However, salinity also affected number of flowers and number of fruits.

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