PERFORMANCE OF TOMATO AT DIFFERENT SALINITY LEVELS

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CERTIFICATE

This is to certify that the thesis entitled, **"PERFORMANCE OF TOMATO AT DIFFERENT SALINITY LEVELS"** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (MS) in HORTICULTURE****, embodies the result of a piece of bonafide research work carried out by Md. Tofayel Ahammed, Registration No. 12-04950 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

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TO

MY BELOVED PARENTS

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ABSTRACT

A pot experiment was conducted at the Horticulture Farm in Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period of November, 2018 to March, 2019. The experiment was comprised of five salinity levels *viz*., S_1= 0 dS m^{-1}; S_2= 3 dS m^{-1}; S_3= 6 dS m^{-1}; S_4= 9 dS m^{-1} and S_5= 12 dS m^{-1} combined with seven varieties of tomato *viz.*, V_1= BARI Tomato 2; V_2= BARI Tomato 11; V_3= BARI Tomato 14; V_4= BARI Tomato 15; V_5= BARI Tomato 17; V_6= BARI Tomato 18 and V_7= BARI Tomato 19. The experiment was laid out on Randomized Complete Block Design with three replications. Results revealed that S_1 showed the highest positive result in most of the cases including plant height, number of flower plant^{-1} and fruit weight plant^{-1} (1003.0 g) except total soluble solids (1.64%) that was increased with increase in salinity levels. On the other hand, the lowest results regarding all of the parameters studied except total soluble solids (2.76%) were found from S_5. Though growth and yield of tomato varied with the variation in varieties, BARI Tomato 11 (V_2) showed the best result in terms of plant height (cm), number of flower plant^{-1}, number of fruits plant^{-1} and total soluble solids (3.22%). On the other hand, the lowest result in respect of plant height (cm) was recorded from V_1. However, number of flower plant^{-1}, number of fruits plant^{-1} and total soluble solids (1.80%) were found the lowest from V_3. The highest fruit weight plant^{-1} (1235.90 g) was shown by V_1 and the minimum from V_2 (333.1 g) due to its smaller fruit size. The maximum results of plant height, number of flower plant^{-1} and number of fruits plant^{-1} were found from S_1V_2, whereas, the lowest results of plant height was obtained from $S_5V_{1.}$ However, the lowest number of flower plant^{-1} and number of fruits plant^{-1} were found from S_5V_3. The maximum fruit weight plant^{-1} (1640.09 g) was recorded from S_1V_1 due to its larger fruit length and diameter, whereas, the minimum from S_5V_2 (271.1 g). The maximum total soluble solids was found from S_5V_2 (5.70 %), however, the minimum total soluble solids was obtained from S_1V_6. On the basis of yield S_1V_1 was best among the treatment combinations.

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SOME COMMONLY USED ABBREVIATIONS

Abbreviations	Full meaning	Abbreviations	Full meaning
^0C	Degree Centigrade	%	Percentage
AEZ	Agro- Ecological Zone	var.	Variety
BARI	Bangladesh Agricultural Research Institute	Kg	Kilogram (s)
BAU	Bangladesh Agricultural University	LSD	Least Significant Difference
BBS	Bangladesh Bureau of Statistics	m	Meter
BINA	Bangladesh Institute of Nuclear Agriculture	m^2	Meter squares
Ca	Calcium	Mg	Magnesium
$CaCl_2$	Calcium Chloride	mg	Milligram
Cl	Chlorine	ml	Milliliter
cm	Centimeter	mm	Millimeter
cm^2	Centimeter square	mM	Millimolar
CO_2	Carbon-di-oxide	N	Nitrogen
$CuSO_4.2H_2O$	Copper sulphate dehydrate	Na	Sodium
CV	Coefficient of Variance	NaCl	Sodium Chloride
cv.	Cultivar (s)	No.	Number
DAS	Days after sowing	NS	Non significant
DAT	Days after Transplanting	OM	Organic matter
df	Degrees of freedom	P	Phosphorus
dS m^{-1}	deciSiemens per metre	pH	Negative Logarithm of hydrogen ion concentration
EC	Electrical conductivity	RCBD	Randomized complete block design
et al.	et alia (And others)	S	Sulphur
FAO	Food and Agricultural Organization	SAU	Sher-e- Bangla Agricultural University
FAOSTAT	Food and Agricultural Organization Statistics	Si	Silicon
Fig.	Figure	t ha^{-1}	Ton per hectare
gm	Gram (s)	SRDI	Soil Resources Development Institute
hr	Hour(s)	ppm	Parts per million
Wt.	Weight	K	Potassium

CHAPTER I

INTRODUCTION

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Tomato (*Solanum lycopersicum* L.) is one of the most important vegetable in the world. Botanically tomato is referred as one of the members of Solanaceae family with chromosome number 2n= 24 (Jenkins, 1948). Tomato is a vegetable with high anti-oxidant property and it is popularly called as love apple. It is considered as one of the most important, popular and nutritious vegetables crops that has achieved tremendous popularity around the world (FAOSTAT, 2014) because of its taste, high nutritional value, multipurpose uses and commercial importance's (Demirkaya, 2014). In 2016, tomato was announced as the world's second largest vegetable crop after potato (FAO, 2016).

Tomato can be grown in any types of soil. Loamy soil and sandy land with adequate supply of organic matter, good moisture holding and drainage capacity are ideal for tomato cultivation. Tomato is a warm season crop and cannot withstand frost and high humidity. Also light intensity affects pigmentation, fruit color and fruit set. The plant is highly affected by adverse climatic conditions. It requires different climatic range for seed germination, seedling growth, flower, fruit set and fruit quality. Temperature below 10^0c and above 38^0c adversely affects plant tissues thereby slow down physiological activities. It thrives well in temperature 10^0c to 30^0c with optimum range of temperature is $21\text{-}24^0$c. The mean temperature below 16^0c and above 27^0c is not desirable. Water stress and long dry period causes cracking of fruits. Bright sunshine at the time of fruit set helps to develop dark red colored fruits (Agropedia, 2012).

Tomato is cultivated all over Bangladesh due to its adaptability to wide range of soil and climate (Ahmed *et al*., 2017). Tomatoes are the major dietary source of the antioxidant lycopene, which has been linked to many health benefits, including reduced risk of heart disease and cancer. They are also a great source of vitamin C, vitamin A, potassium, folate and vitamin K. Carbohydrates make up 4% of raw tomatoes. Simple sugars, such as glucose and fructose, make up almost 70% of the carbohydrate content (Healthline, 2015). 100 grams of red, ripe and raw tomatoes contain 18 calories, 0.9 g proteins, 3.9 g carbohydrates, 2.6 g sugar and 1.2 g fiber (USDA, 2019). It can be taken both in raw as ripen and after cooking. Global production is estimated at 170.8 million metric tons with China and India as the leading producers in 2017. China accounted for 31% of the total production. India and the United States followed with the second and third highest production of tomatoes in the world. The global tomato exports the previous year was worth 88 billion USD (Worldatlas, 2019). It is one of the most important and popular vegetable in Bangladesh which cultivated in an area of 68.37 thousand acres of land accounting for production of 388725 metric tons in 2016-2017 (BBS, 2017).

The production potentiality of tomato is decreasing in the recent years due to the changing environmental condition of biotic and abiotic factors and it's becoming a tremendous challenge to face the demand of the vegetables with increasing population in Bangladesh. There are various abiotic environmental factors such as flooding, drought, salinity, high or low temperature, metal toxicity, etc. which pose serious threat to world agriculture. Among these abiotic factor's salinity is becoming a major concern for crop production including tomato in southern districts of Bangladesh. Over 30% of the net cultivable area exists in the coastal regions of Bangladesh. Out of 2.85 million hectares of the coastal and offshore areas, about 0.833 million hectares of the arable lands, which constitutes 52.8% of net cultivable saline area are dispersed in 64 sub-districts of 13 districts. In those areas, the ranges of the salinity are categorized on the basis of electrical conductivity (EC) between 2 dS m^{-1} and 16 dS m^{-1}. The severity of salinity problem in Bangladesh increases from November to May with the desiccation of the soil when concentration of salts in the soil surface builds up by rapid evapo-transpiration (ET). During the wet monsoon, the severity of salt injury is reduced due to dilution of the salt in the root-zone of the standing crop (Ahmed *et al*., 2017). Bangladesh is primarily an agriculture-based economy and agriculture is the main source of employment, income and food and nutrition security (Ferdous *et al*., 2016).

Under conditions of high soil salinity, many crop plants, including tomato, are susceptible and cannot survive or can survive only with decreased yields. To alleviate the deleterious effects of salinity, the measures such as the reclamation of salinized lands, the improvement of irrigation with saline water and the cultivation of salt-tolerant variety have been applied (Tuna *et al*., 2007). The positive changes in tomato quality have been obtained under certain salinity treatments (Zushi *et al*., 2011) but the tomato yield has been reported to be negatively affected by the increasing salinity (Hou *et al*., 2014).

Many factors should be considered in making management strategies, such as crop cultivars, local climate, soil nutrients, type of salt, salinity levels, irrigation method and water management practices (Datta *et al.*, 2015). Elevated salt and Na^+ concentrations in soils may be highly toxic to many plants, although tolerance levels varied among different species. High levels of Na^+ can cause imbalance in the uptake and utilization of other cations and disruption of chloroplasts, which results in reduced photosynthesis (Zhai *et al*., 2015). For this reason, the most sensitive plants may suffer physiological damages with subsequent significant yield loss, while moderately sensitive to tolerant plants are still able to produce acceptable yields (Terre-Gonzalez *et al*., 2017).

At present, very few research works have been conducted in order to solve salinity problem that can provide a sustainable technology towards solving the problem. On the other hand, the salinity problem cannot be neglected as the population size of the country is on continuous increase (Koushafar *et al*., 2011; Munns and Tester, 2008).

The production technology of a crop is very complex in saline affected areas. Intercultural operations like irrigation, drainage, mulching etc. are comparatively expensive. Therefore, it is difficult to carry out the tomato cultivation for the poor farmers especially in coastal region of the country in consideration of cost benefit ratio. Nevertheless, development of genotypes with field tolerance to salinity is considered as a promising approach. Many modern tomato varieties have been developed so far by Bangladesh Agricultural Research Institute which is not properly screened against salinity stress. Therefore, identification of salinity tolerant cultivars for a moderately sensitive crop like tomato becomes an important aspect of research.

Keeping this above view in consideration, the present study has been undertaken with the following objectives:

1. To investigate the growth and yield of tomato varieties grown at different salinity levels.

2. To determine the best performed combination variety used in the experiment.

3. To assess the combined effect of tomato varieties and salinity levels.

CHAPTER II

REVIEW OF LITERATURE

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REVIEW OF LITERATURE

Tomato is one of the crops with the greatest economic importance in the world and salinity stress causes reduction in the quantity and quality of crop production. Today the main challenge in world agriculture is to support the continuously growing global population and this becomes more difficult due to climatic change, as this imposes further abiotic stress like salinity. A limited number of research works has been done in Bangladesh in terms of salinity problem. To facilitate the research works few of the literatures have been reviewed in this chapter.

El-mogy *et al*. (2018); conducted an experiment taking different levels of salinity and reported that salinity affects growth, yield, fruit quality, storability and marker-gene expression in cherry tomato. The influence of different salt concentrations on physiological responses and the expression of some selected genes of cherry tomato (*Solanum lycopersicum* L.), cv. West Virginia 106, was examined. Tomato plants were grown in peat moss substrate and irrigated with 0, 25, 50, 75, 100 or 150 mM sodium chloride (NaCl) in a glasshouse. The NaCl treatments of 75, 100and 150-mM salt resulted in shorter plants, decreased stem width, a lower plant dry weight, fewer flowers, and smaller leaf area while yield was reduced by treatment with concentrations of 50 mM NaCl and above. Average fruit weight and fruit number were also negatively affected by treatment with 50 mM salt and above. Salinity treatment led to increased fruit total soluble solids, titratable acidity and firmness and improved the taste index. Salt-responsive marker genes identified in Moneymaker were also induced in cherry tomato but not at the highest salt concentrations. The results indicated that cherry tomato treated with 25 mM NaCl produced fruit with improved quality in comparison with non-salinized control plants without compromising yield, while at 50 and 75 mM the improved fruit quality was accompanied by a reduction in yield.

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 × 106 ha while 23 % of the 1.5 × 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 varieties. The seedlings 20 genotype were divided into three groups, Sodium chloride (NaCl) dissolved in irrigation water to make variant concentration of 0, 30, 60 mgL^{-1} of salt concentration using E. C meter which were used to water the plants. The result of this research suggest that salinity decline both vegetative and reproductive parameters in tomato (Umar *et al*., 2018).

Heuvelink (2018), said in his book Tomatoes (Crop Production Science in Horticulture) salinity can reduce the fruit growth rate and final fruit size by an osmotic effect. High salinity lower water potential in the plant which was reduce the water flow in the fruit and that therefore the rate of fruit expansion. ECs of 4.6-8 dS

m^{-1} reduced fruit yield because reduction of fruit size whereas ECs of 12 dS m^{-1} reduced number and size of fruit.

Ahmed *et al*. (2017); was conducted an experiment to find out the salinity effect on tomato production at water management research field of Bangladesh Agricultural University (BAU), Bangladesh during October 2007 to April 2008 cropping season. The experiment was carried out in a randomized complete block design (factorial) with 3 replications. The treatments were: T_1= Irrigation with fresh water, T_2= Irrigation with saline water containing 4 dS m^{-1} of Electrical conductivity (Sea water cannot hold as much dissolved oxygen as freshwater due to its high salinity. Conductivity and salinity have a strong correlation.), T_3= Irrigation with saline water containing 6 dS m^{-1} of Electrical conductivity, T_4= Irrigation with saline water containing 8 dS m^{-1} of Electrical conductivity and T_5= Irrigation with saline water containing 10 dS m^{-1} of Electrical conductivity. They found that the plants irrigated with the T_1 treatment was the highest fruit yield plant^{-1} (1.52 kg) whereas, the lowest yield (0.667 kg) was obtained from the higher level of saline water treatment T_5. When the fruit yield was considered the effective treatment for the highest total fruit yield (36.57 t ha^{-1}) was produced by the T_1 treatment (Irrigation with fresh water) and the lowest fruit yield (21.87 t ha^{-1}) was found from the treatment T_5. The effect of different salinity levels of irrigation such as fresh water, 4 dS m^{-1}, 6 dS m^{-1}, 8 dS m^{-1} and 10 dS m^{-1} on total soluble solid was significantly influenced. The highest total soluble solid (2.53) was shown in T_5 treatment whereas the lowest (2.00) in Irrigation with fresh water treatment.

Yang *et al*. (2017); stated that salinity as one of the major environmental constraints hindering crop plant yields around the world. That's why; exploring the salt-tolerant mechanism and developing crops with salt tolerance capability are two of the most effective ways of sustaining crop production worldwide. The variation in metabolite profiles was analyzed between common wild soybean and salt-tolerant wild soybean in response to neutral-salt stress and alkali-salt stress to explore the salt-tolerant mechanism. The findings indicated that the salt-tolerant wild soybean grew better than common wild soybean under both treatments. Differential metabolites profiling noted that the levels of some carbohydrates and fatty acids were minimum in common wild soybean than in salt-tolerant wild soybean under salt stress. These metabolites included lactose, ribose, lauric acid, palmitic acid, stearic acid and linolenic acid. Amino acid accumulation was reported in the two wild soybeans under alkali-salt stress. The amino acids were valine, tyrosine, glutamic acid, leucine and isoleucine. In salt-tolerant wild soybean subjected to alkali-salt stress the content of most organic acids and proline were increased. The organic acids found in the experiment were mucic acid, glutaric acid, galactonic acid, and dehydroascorbic acid. In common wild soybean the TCA cycle was reported to be enhanced in response to both treatments but was reduced in salt-tolerant wild soybean. This study indicated that the salt-tolerant mechanism in common wild soybean may encourage the TCA cycle to generate more ATP. However, salt-tolerant wild soybean may regulate amino acid and organic acid metabolism to produce more compatible solutes.

Rodriguez-Ortega *et al*. (2017); conducted an experiment with tomato variety 'Óptima', using different soilless crop systems (perlite substrate, hydroponics, and the nutrient film technique) and several levels of salinity in the irrigation water. The yield, quality parameters, vegetative growth, mineral composition, water relations, and gas exchange parameters were measured. They found that salinity caused changes in the water status of the plants, toxicity due to Cl^- and Na^+, and nutritional imbalances that altered the physiology of the plants, thereby reducing yield, although the fruit quality was improved.

Zhang *et al*. (2016); conducted an experiment to find out the effects of salinity stress on growth, yield, fruit quality and water use efficiency of tomato under hydroponics system. Salt added to nutrient solution is an easy method that can improve tomato fruit quality but plant growth and fruit production are negatively affected. Salinity reduces tomato root elongation rate and lateral root growth due to restriction of root cell growth and increased root lesion. Tomato leaf, shoot height and stem diameter reduced under salinity stress caused by photosynthesis reduction, tissues expansion reduction and cell divided inhibition. Salinity also reduces leaf chlorophyll content, stomatal resistance and photosynthetic activities. Total yield of tomato is significantly reduced at salinity equal and above 5 dS m^{-1} and a 7.2% yield reduction per unit increase in salinity. Salinity can decrease root water uptake through its osmotic effect and subsequently induce water stress. Fruit quality is the only parameter which is positively affected with increased salinity.

Kayees *et al*. (2016); assayed the emergence percentage, radical length, plumule length, proline content, K^+ or Na^+ of the seedling under five levels salinity; control (0), 4, 8, 12 and 16 dSm^{-1}. The growth and subsequent development of tomato seedling negatively affected with the rising of salinity. Emergence percentage, radical length, plumule length, K^+ or Na^+ ratio were decreased with the increment of salinity. Proline content was increased with the increment of salinity. The overall results of the experiment exhibited that among the varieties BARI Tomato 2, Mintoo and Unnoyon were comparatively more tolerant to higher salinity on the basis of studied parameters.

An experiment was conducted by Mazumder (2016) and reported that the growth, development, yield and yield attributes of tomato varied with the variation of varieties. He carried out his experiment with four tomato genotype (BARI Tomato 2, BARI Tomato 11, BARI Tomato 14 BARI Tomato 15) and four salinity levels (0,5 10 and 15 dS m^{-1}**.** He reported that salt stress greatly affects growth, development, yield and yield attributes of tomato. Growth and yield of tomato decreased with increasing the level of salt stress. Exposure of different level of salt stress decreased plant height, number of leaf $plant^{-1}$ and other growth and biochemical attributes including chlorophyll content. Salt stress decreased number of flower cluster, total flower $plant^{-}$

^{1}, but increased flower dropping. Yield reduction increased with increasing the level of salinity.

Saline water resources are abundant in the coastal areas of south China. Most of these resources still have not been effectively utilized. A 3-year study on the effects of saline water irrigation on tomato yield, quality and blossom-end rot (BER) was conducted at different lower limits of soil metric potential (-10 kPa, -20 kPa, -30 kPa, -40 kPa and -50 kPa). Saline water differing in electrical conductivity (EC) (3 dSm^{-1}, 4 dS m^{-1}, 4.5 dS m^{-1}, 5 dS m^{-1} and 5.5 dS m^{-1}) was supplied to the plant after the seedling establishment. In all three years, irrigation water with 5.5 dS m^{-1} salinity reduced the maximum leaf area index (LAI_m) and chlorophyll contents the most significantly when compared with other salinity treatments. However, compared with the control treatment (CK), a slight increase in LAI_m and chlorophyll content was observed with 3~4 dS m^{-1} salinity. Saline water improved tomato quality, including fruit density, soluble solid, total acid, vitamin C and the sugar-acid ratio. There was a positive relationship between the overall tomato quality and salinity of irrigation water. The tomato yield decreased with increased salinity. The 5.5 dS m^{-1} treatment reduced the tomato yield (Y_t) by 22.4~31.1%, 12.6~28.0% and 11.7~27.3%, respectively in 2012, 2013 and 2014, compared with CK. Moreover, a significant (P 0.01) coupling effect of salinity and soil metric potential on Y_t was detected. Saline water caused Y_t to increase more markedly when the lower limit of soil metric potential was controlled at a relatively lower level. The critical salinity level that produced significant increases in the BERi was 3 dS m^{-1} ~4 dS m^{-1}. Following the increase in BERi under saline water irrigation, marketable tomato yield (Y_m) decreased by 8.9%~33.8% in 2012, 5.1% ~30.4% in 2013 and 10.1%~32.3% in 2014 compared with CK (Zhai *et al.*, 2015).

Semiz *et al.* (2015); carried out an experiment to evaluate the salt tolerance of tomato cv. Big Dena under both non-grafted conditions and when grafted on Maxi fort rootstock, under a series of 5 salinity levels and 2 irrigation water composition types. The salinity levels of the irrigation water were –0.03, –0.15, –0.30, –0.45, and –0.60 MPa osmotic pressure (corresponding to specific electrical conductivity values of 1.2, 4.0, 8.5, 12, and 15.8 dS m^{-1}, respectively). They salinized the irrigation water with either a mixture of salts with a predominant composition consisting of Na^+–Ca^{2+}–Cl^- salts, a composition typical of coastal Mediterranean ground waters or, alternatively, a salt composition that was of mixed Na^+–Ca^{2+}–SO_4^{2-}-Cl^- ions, a water composition more typical of interior continental basin ground waters such as those of the California Central Valley in the US. They determined that there were no statistically significant differences in tomato salt tolerance (fruit yield) relative to water type. This result indicated that in the range of Cl^- concentrations tested in their experiment (up to 150 mmol L^{-1}), Cl^- was not an important factor in tomato yield reduction associated with salinity. The grafted Big Dena on Maxi fort tomato plants exhibited increased yield both under control and elevated salinity levels relative to the no grafted Big Dena plants. In contrast to absolute yield relationships, expression of salt tolerance in terms of relative yield, as salt tolerance was commonly expressed, provides the conclusion that grafted Big Dena on Maxi fort tomato plants were slightly less salt tolerant than no grafted Big Dena plants. Their results also indicated that, for tomato, decreased yield under saline conditions was well related to increased leaf Na^+ concentrations.

Field experiment in calcareous sandy clay loam soil at Maryout Experimental Station Farm, Desert Research Center, Egypt during summer season 2007 was conducted to investigate growth parameters and fruit yield of tomato (*Lycopersicon esculentum*, Mill. cultivator 888) response to salt stress at irrigation water levels during different growth stages under drip and gated-pipe irrigation systems in arid environmental conditions. Under studied irrigation systems, the plant height, fresh, dry weight and fruit yield of tomato plants at the harvesting subjected to salt stress using 9.15 dSm^{-1} and irrigation water levels of 100, 75 and 50 % ETc during development, flowering and harvesting growth stages were significantly decreased by decrement irrigation water levels. However, the results revealed that the tomato leaf water potential values as affected by the studied salt stress at irrigation water levels of % ETc was appeared opposite trend that obtained for the other growth parameters and fruit yield. Also, the results showed that the plant height, fresh, dry weight, leaf water potential and fruit yield of tomato plants at the harvesting stage subjected to studied salt stress and irrigation water depth levels during development, flowering and harvesting growth stages under drip irrigation system, in general higher than that obtained under gated pipe irrigation system. Consequently, the development growth stage of tomatoes subjected to applied irrigation water levels of 100, 75 and 50 % ETc by well water 9.15 dSm^{-1} is the lowest stage affected than other growth stages while the flowering growth stages of tomatoes is more affected to salt stress and deficit irrigation water amount than other growth stages especially at irrigation water level of 50 % ETc, under studied irrigation systems in environmental conditions (Shalaby *et al*., 2015).

An experiment was conducted by Shiam *et al.* (2015) at the Sher-e-Bangla Agricultural University, Bangladesh to evaluate influence of salt (NaCl) on sixteen tomato lines. Sixteen lines coded from V_1 (Line-01) to V_{16} (Line-16) were executed under different NaCl salinity conditions (S_0: Control; S_1: 12dS $m^{-1}$and S_2: 16 dS m^{-1} following completely randomized design with three replications. Apart from control, V_8 provided tallest plant in 12 dS m^{-1} (43.7 cm) and in 16 dS m^{-1} (38.4 cm) salinity level at 60 days after transplanting which was statistically similar with the V_9 tomato line. V_8 line provided the maximum number of leaves per plant except control (24.2 and 21.1 in 12 dS m^{-1} and 16 dS m^{-1}, respectively). V_9 line produced maximum leaf area (123.7 cm^2 and 97.6 cm^2 in 12dS m^{-1} and 16 dS m^{-1}, respectively) under saline conditions which was followed by V_8 line (112.7 cm^2 and 92.6 cm^2 in 12dS m^{-1} and 16 dS m^{-1}, respectively). Maximum number of bunch per plant was observed from V_9 line (10.7 and 9.3 in 12 dS m^{-1} and 16 dS m^{-1}, respectively) followed by V_8 line (9.3 and 9.3 in 12 dS m^{-1} and 16 dS m^{-1}, respectively) except control. Maximum yield was found from V_9 line (0.92 kg $plant^{-1}$) followed by V_2 line (0.493 kg $plant^{-1}$) in 12 dS

m^{-1} salinity level and maximum yield was found from V_9 line (0.593 kg $plant^{-1}$) which was closely followed by V_8 line (0.407 kg $plant^{-1}$) in 16 dS m^{-1} salinity level. Tomato line-09 was found the best tomato cultivar for salt affected areas in Bangladesh.

Liu *et al.* (2014); carried out an experiment to find out differential responses to short-term salinity stress of heat-tolerant cherry tomato cultivars grown at high temperatures. It was hypothesized that cultivars which perform better in high temperatures are also more tolerant to salinity stress. Two highly heat-tolerant cultivars, 'Tainan ASVEG No. 19' (TA19) and 'Taiwan Seed ASVEG No. 22' (TSA22), and one moderately heat-tolerant cultivar, 'Hualien ASVEG No. 21' (HA21), were grown under high temperature conditions and were irrigated with a 0, 50, 150, or 200 mM NaCl solution for 20 days. Number of leaves, leaf area, shoot fresh and dry weight and root fresh weight were generally decreased with increasing level of salinity stress but root dry weight was not affected, resulting in an increase in root to shoot ratio in all three cultivars. Yield was also decreased by salinity treatments in all three cultivars due to reduced number of flowers, fruit set, and fruit size.

The response of tomato varieties [Cal-ji, Flat Chirani, Chef Flat Americ, Primo Earily and Chef] against five salinity levels [distilled water as control, 25, 50, 75 and 100 mM] were studied at germination and early seedling stages. Results obtained in that study indicated that interaction of salt × genotype had significant effect on growth indices in all the cases [$P < 0.05$]. With increase in salinity level, germination percentage was significantly decreased. Increased salt level results in reduction of plumule fresh weight indices (Sardoei *et al*., 2014).

Salinity is a major abiotic stress affecting plant growth and productivity during all plant developmental stages. Fourteen tomato varieties including six commercial cultivars, six improved varieties and two salt-tolerant breeding lines were used in that study to evaluate their salinity tolerance and to explore the expression of some salt-responsive genes under saline conditions. Five salinity concentrations including 0.5 (control treatment), 2.4, 4.8, 7.2 and 9.6 dS m^{-1} NaCl were applied using a drip irrigation system. Based on the evaluation of plant growth and yield component traits, two varieties (L56 and L46) were selected to explore expression of salt-responsive genes to be utilized as biomarkers in breeding programmes. Five important salt-responsive tomato genes (NAC, JERF3, GRX1 TAS14 and NAM) were retrieved from Gene Bank and primers were designed for quantitative real-time PCR (qPCR). Successive increases in salinity levels, starting at 4.8 dS^{-1} were associated with significant decreases in most vegetative, yield and quality traits. However, TSS and pH increased at high salinity levels. Tomato varieties showed a wide range of variability in yield and fruit quality traits in response to salinity. Based on plant growth and yield component traits and according to canonical discriminate multivariate analysis, the salt tolerances of tomato varieties were clustered into three groups: tolerant to salinity (BL 1076, BL 1239, L26, L56, Strain-B and Pakmore), moderately tolerant to salinity (L16, L66, Imperial, and Tnshet star) and susceptible to salinity (L36, L46, Queen, and Sohba). The qPCR screening showed that the salt stress tolerant tomato genotype, L56, prominently expressed the NAC, JERF3, GRX1 and TAS14 encoding genes. The expression of NAM was equally enhanced in both salt-tolerant (L56) and salt-susceptible (L46) tomato varieties (Alsadon *et al.*, 2013).

Rahil *et al.* (2013), reported that the reduction in fruit number observed in the present study appeared to be related to a reduction in the average number of flowers per trees, fruits per cluster and per plant observed with increasing salinity.

Singh *et al*. (2012); carried out an experiment to find out the effect of salinity on tomato (*Lycopersicon esculentum* Mill.) during seed germination stage. The study was conducted using ten genetically diverse varieties along with their 45F1 (generated by diallel mating) under normal and salt stress conditions. Although, tomato (*Lycopersicon esculentum* Mill.) was moderately sensitive to salinity but more attention to salinity was yet to be required in the production of tomato. In their study, germination rate, speed of germination, dry weight ratio and Na^+/K^+ ratio in root and shoot, were the parameters assayed on three salinity levels; control, 1.0 % NaCl and 3.0 % NaCl with Hoagland's solution. Increasing salt stress negatively affected growth and development of tomato. When salt concentration increased, germination of tomato seed was reduced and the time needed to complete germination lengthened, root/shoot dry weight ratio was higher and Na^+ content increased but K^+ content decreased. Among the varieties, Sel-7 followed by Arka Vikas and crosses involving them as a parent were found to be the more tolerant varieties in their study on the basis of studied parameters.

Edris *et al*. (2012); reported that salinity treatment strongly affected the yield in cherry tomato. Addition of supplemental Ca^+ and K^+ can ameliorate negative impact of high salinity. Small fruit development in salinity conditions could be related to disorder in water relations and decrease in photosynthetic productions (due to leaf area reduction) as well as chlorophyll content.

A research was conducted by Boamah *et al*. (2011); was conducted a research to determine the salinity level of irrigation water from a dug well, pond and tap water as well as its effect on the yield of a tomato crop at the University of Cape Coast Teaching and Research Farm. Water samples were taken at fortnight intervals to determine the electrical conductivity (dS m^{-1}) using the TOA water quality checker 20A. The averages of the four batches were computed and used as the three sources for the period of assessment. Flowering and yield of crop were the parameters used to assess the effect of salinity level on the tomato crop. Electrical conductivity as a measure of salinity was higher in the pond (0.25 dS m^{-1}) than the well and tap water (0.07 dS $m^{-1}$and 0.02 dS m^{-1}, respectively). Flowering and yield of tomato was high with crops treated with well water (45.22%; 99.08 kg ha^{-1}) followed by the pond (27.70%; 43.76 kg ha^{-1}) and tap water (27.08%; 27.25 kg ha^{-1}) in that order. There was no significant difference in flowering and in yield of crops between the tap and pond treatments at both 0.05 and 0.01 levels but there was a significant difference in yield between the well treated crops and other sources.

A pot experiment was carried out to study the salt tolerance of eight tomato varieties *viz*., J-5, Binatomato-5, BARI tomato 7, CLN-2026, CLN-2366, CLN-2413, CLN-2418 and CLN-2443 at Bangladesh Institute of Nuclear Agriculture. Three levels of salinity *viz*., control 0, 6 and 10 dS m^{-1} were imposed at pre-flowering stage of tomato varieties. Plant height, primary branches, flower cluster, fruit cluster, number of fruits and total fruit yield/plant, individual fruit weight, amino acid content in leaves gradually decreased while total sugar and reducing sugar content in leaves increased with the increase in salinity levels. BARI tomato 7, CLN-2026, CLN-2413, CLN-2418, CLN-2366 and CLN-2443 had shown better performance with salinity and identified to be better tolerant (Islam *et al*., 2011).

Al-Yahyai *et al*. (2010); conducted a two-factor experiment at the Agricultural Research Station, Rumais, Oman to evaluate the performance of yield and quality of tomato (*Lycopersicon esculentum* L.) with three levels of saline water (3, 6 and 9 dS m^{-1}) and three types of fertilizers viz, inorganic NPK, organic (cow manure), and a mixed fertilizer of both. Results indicated that growing tomatoes under 3 and 6 dS m^{-1}irrigation water produced the highest yield whereas, irrigating with 9 dS m^{-1}significantly reduced the final fruit number and fruit weight. Tomatoes grown using cow manure produced the least amount of yield compared to those with inorganic and mixed fertilizers.

Hajiboland *et al*. (2010); conducted an experiment where plants treated with the arbuscular mycorrhizal fungi *Glomus intraradices* (+AMF) showed beneficial effect in salt condition. Tomato (*Solanum lycopersicum* L.) cultivars Behta and Piazar were cultivated in soil without salt (EC= 0.63 dS m^{-1}), with low (EC= 5 dS m^{-1}), or high (EC= 10 dS m^{-1}) salinity. Growth and plant yield reduction affected by salinity can be the reason of variation in photosynthetic products translocation toward root, decrease of plant top especially leaves, partial or total enclosed of stomata, chlorophyll content, direct effect of salt on photosynthesis system and ion balance. Mycorrhization alleviated salt-induced reduction of P, Ca, and K uptake. Ca or Na and K or Na ratios were also better in +AMF. Mycorrhization improved the net assimilation rates through both elevating stomatal conductance and protecting photochemical processes of PSII against salinity.

Yong-Gen *et al*. (2009); conducted an experiment to elucidate the mechanisms, of the transport of carbohydrates into tomato fruits and the regulation of starch synthesis during fruit development in tomato plants. Tomato plants cv. ‘Micro-Tom’ exposed to high levels of salinity stress were examined. Growth with 160 mM NaCl doubled starch accumulation in tomato fruits compared to control plants during the early stages of development, and soluble sugars increased as the fruit matured. Tracer analysis with 13C confirmed that elevated carbohydrate accumulation in fruits exposed to salinity stress was confined to the early development stages and did not occur after ripening. Salinity stress also up-regulated sucrose transporter expression in source leaves and increased activity of ADP-glucose pyrophosphorylase (AGPase) in fruits during the early development stages. The results indicate that salinity stress enhanced carbohydrate accumulation as starch during the early development stages and it is responsible for the increase in soluble sugars in ripe fruit.

Al-Ormran (2008), conducted an experiment to study the effect of saline water and drip irrigation on tomato yield in sandy calcareous soil amended with natural conditioners. The results showed a significant decrease in yield with saline water in both season and the decrease was more apparent in the open field experiment compared to green house.

Magan *et al*. (2008); conducted an experiment to find out the effect of seven salinity levels on the growth and yield of two tomato cultivars (Daniela and Boludo). The effect of salinity on fruit yield, yield components and fruit quality of tomato grown in soil-less culture in plastic greenhouses in Mediterranean climate conditions was evaluated. Two spring growing periods and one long season, autumn to spring growing period studies were conducted. Two cultivars, 'Daniela' and 'Boludo' were used. Seven levels of electrical conductivity (EC) in the nutrient solution were compared in experiment 1 (2.5–8.0 dS m^{-1}) and five levels in experiments 2 and 3 (2.5–8.5 dS m^{-1}). Total and marketable yield decreased linearly with increasing salinity above a threshold EC value (ECt). There were only small effects of climate and cultivar on the ECt value for yield. The linear reductions of total and marketable yield with EC above ECt showed significant differences between experiments, the slope varying from 7.2% (autumn to spring period, 'Boludo') to 9.9% (spring period, 'Boludo') decreases per dS m^{-1} increase in EC for total yield, and from 8.1% (spring period, 'Daniela') to 11.8% (spring period, 'Boludo') for marketable yield. The decrease of fresh fruit yield with salinity was mostly due to a linear decrease of the fruit weight of 6.1% per dS m^{-1} from an ECt of 3.0 dS m^{-1} for marketable fruits. Reduction in fruit number with salinity made a smaller relative contribution to reduced yield. Blossom end rot (BER) increased with increasing salinity. There was a higher incidence of BER with spring grown crops, and 'Boludo' was more sensitive than 'Daniela'. Increasing salinity improved various aspects of fruit quality, such as: (i) proportion of 'Extra' fruits (high visual quality), (ii) soluble solids content and (iii) titratable acidity content.

Agrawal *et al*. (2005); conducted an experiment on the effect of water salinity on tomato under drip irrigation and reported that the tomato yield was drastically affected when the salt was increased in the root zone. This also decreased the number of fruits cluster-1, fruits plant-1, fruit weight, fruit maturity and other yield contributing characters.

Maggoi *et al*. (2004); demonstrated in field grown tomato plants exposed to increasing NaCl concentration, that the physiological basis for short (24h) and long term (entire growth season) osmotic adjustment may respond to different biological and environmental cures, since plants that best somatically adjusted to short term stress were not necessarily those that best adjusted to a long term stress.

Olympios *et al*. (2003); found that salinity negatively affects the size of the plant and total weight of fruits: the higher the concentration, the lower the growth and yield. Four levels of salinity in the irrigation water (I: 1.7 dS m^{-1}(control), II: 3.7 dS m^{-1}, III: 5.7 dS $m^{-1}$and IV: 8.7 dS m^{-1}) were applied to tomato plants at various stages of growth and for different time duration. The number of fruits and the average weight of fruit were reduced at the highest salinity especially when applied at an early stage of growth. When good quality water was applied at the beginning of growth, followed later by salinity, the negative effect on plant height, fresh and dry weight of shoots, leaf area, yield, average weight of fruits and the percentage of fruit with blossom-end-rot was less severe.

Hernandez *et al*. (2003); stated that cell division and expansion inhabited by salt stress. Salinity also inhibited growth of leaf area. Lacerda (2003) studied one salt tolerant variety (CSF 20) and other salt sensitive cultivars (CSF 18) of sorghum where they were grown in nutrient solution of different concentration for seven days, where salt sensitive variety showed higher reduction of P mostly due to larger accumulation of sodium and chlorine ion that probably exceeded the amount needed for the osmotic adjustment.

Tomato plants were grown over a 9-month period (from November till July) under unheated glasshouse conditions in an NFT system. Plant density was 2.7 plants m^{-2}. The examined factors were N: K ratio and addition of sodium chloride (NaCl). Two N: K ratios (1:1.5 and 1:3) were applied with and without addition of NaCl (600 ppm).Target Electrical Conductivity and pH of the nutrient solution in all the treatments were 4.8 mS cm^{-1} and 6.0 mS cm^{-1}, respectively. Total yield, number of fruits produced, fruit firmness and total soluble solids were measured. NaCl saline solution resulted in decreased yield. Higher yield and fruit firmness were recorded with increased K concentration in the NaCl saline nutrient solution, suggesting that increased potassium concentration could alleviate detrimental effects of NaCl when saline water is used (Economakis and Daskalaki, 2003).

Munns *et al*. (2002); studied the salinity stress resulted in a clear stunting of plant growth, which results in a considerable decrease in the fresh weight of leaves and stems. Increasing salinity was accompanied also by significant reductions in shoot weight and plant height.

Del Amor *et al.* (2001); conducted an experiment to find out the effect of salinity on tomato. In order to simulate the usage of brackish irrigation water in greenhouse tomato (*Lycopersicon esculentum* Mill. *cv. Daniela*) culture in perlite, plants were supplied with nutrient solutions containing 0, 20, 40, and 60 mM NaCl. The three highest salinity treatments were applied at three different plant growth stages, during early vegetative growth [16 days after transplanting (DAT)], beginning of flowering (36 DAT), and starting fruit development (66 DAT). Salt tolerance of tomato plants increased when the application of salinity was delayed. Salinity significantly decreased size and number of marketable fruits, but increased fruit quality by increasing total soluble solids and sugar content. Leaf and fruit calcium and potassium concentrations were decreased significantly by increasing salinity levels. This was compensated for the accumulation of sodium. Anion accumulation was increased by increasing chloride concentration.

Leperen, W.V. (1996), conducted three different experiments at different time to find out the effect of salinity on tomato and they reported separately that, the number of cluster plant^{-1} was reduced both with high salinity and long salinization periods in case of tomato.

Grunberg *et al*. (1995); found the number of leaves developed per plant, flowering from the number of clusters per plant and the number of flowers per cluster, the mean numbers of pollen grains per flower and fruit-set were reduced in the salt-treated plant. Tomato plants of cv. 'Moneymaker' were grown in gravel culture received a basic nutrient solution, either with or without the addition of NaC1 (10mM). Salt-treated plants produced about 50% fewer flowers per plant than the controls. The mean numbers of pollen grains per flower decreased progressively form the beginning to the end of the salt treatment and the counted pollen was about 30% of that of the control plants. Reduction in the number of fruits per plant produced by saline conditions was probably due to a decrease in the number of flowers per plant.

Sarg *et al.* (1993); reported that the fruit yield was less affected by salinity treatment in Edkawy than in Ace and the fruit number of Edkawy cv. was slightly affected in 100 mM. However, the total soluble salt concentration (TSS), acidity, electrical conductivity (EC), vitamin C, reducing sugars K^+ and Na^+ were increased by increasing salinity levels while pH was decreased. Less than 150 mM NaC1 salinity the yield of both cv. was affected but the reduction in Edkawy cv. was clearly less than in Ace.

Cruz and Cuartero (1990); reported that shoot length is one of the responsive indicators for a wide range of tomato varieties under salinity stress.

Shannon *et al*. (1978); reported that salinity stress reduces elongation rate of the main stem in tomato.

The yield of tomatoes for processing (*Lycopersicon esculentum var. VF145B.7879*) grown in artificially salinized plots was reduced by 10% for every 1.5 mmhos cm^{-1} increase in EC_e above 2.0 mmhos cm^{-1}. Yield reduction was the same for equal mean soil salinities regardless of leaching and the rate of salt accumulation in the soil. Total soluble solutes content increased with increasing salinity to offset, to a large extent, the yield reduction. Reduction in water uptake, as a result of an increase in soil salinity was directly related to fruit yield reduction but not to stover yield which was not affected by salinity. The salt tolerance during germination was similar to subsequent growth in the salinity range of this experiment (Shellavet and Yaron, 1973).

CHAPTER III

MATERIALS AND METHODS

CHAPTER III
MATERIALS AND METHODS

The experiment was conducted during the period from November 2018 to March 2019. The materials and methods those were used and followed for conducting the experiment have been presented under the following headings.

3.1 Experimental site

This study was conducted in the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. The location of the experimental site is 23°74′ N latitude and 90°35′ E longitude at an altitude of 8.6 meter above the sea level.

3.2 Characteristics of soil

The soil of the experimental area belongs to the Modhupur Tract under AEZ No. 28. The characteristics of the soil under the experiment were analyzed in the Laboratory of Soil Resources Development Institute (SRDI), Dhaka (Appendix II).

3.3 Condition of the experimental site

The experimental site is located in the subtropical monsoon climatic zone, which is characterized by high rainfall during the months from April to September (Kharif season) and least rainfall during rest of the year (Rabi season). Ample sunshine and moderately low temperature appear during October to March (Rabi season), which are useful for growing of tomato in Bangladesh. The weather report regarding temperature, rainfall, relative humidity and sunshine hours prevailed at the experimental site during the cropping season November 2018 to March 2019 have been presented in Appendix II.

3.4 Planting materials

BARI Tomato 2, BARI Tomato 11, BARI Tomato 14, BARI Tomato 15, BARI Tomato 17, BARI Tomato 18 and BARI Tomato 19 varieties of Tomato was developed by the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, Bangladesh. The seeds were healthy, vigorous, well matured and free from other crop seeds and inert materials. The seedlings of tomato were grown at the nursery of Horticulture Farm in Sher-e-Bangla Agricultural University. Seedlings of 20 days were used.

3.5 Preparation of soil and filling of pots

Silt Loam soil was used for pot preparation. A total of 105 earthen pots were prepared each with 10 kg of air dried soil. The size of the pot was 30 cm top diameter with a height of 25 cm. Thus, the surface area of an individual pot was 706.5 sq cm. Collected soil was dried under the sun. Plant parts, inert materials, visible insects and pests were dispelled from soil by sieving. The dry soil was thoroughly mixed with well rotten cow dung and fertilizers before filling the pots. The pots were placed under polyshed.1.7 kg well rotten cow dung, 15gm TSP, 7gm MoP and 10 kg soil were mixed for each pot and pots were filled 15 days before transplanting. All 105 pots were filled on November 2018.

3.6 Experimental treatments and design

Five levels of saline water irrigation (0, 3, 6, 9 and 12 dS m^{-1}) were imposed to seven varieties of tomato. The experiment was performed following Randomized Complete Block Design with three replications (Appendix III). Thus 105 experimental pots were placed in ambient air at the Horticulture Farm premises of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh.

3.7 Treatments of the experiment

Factor A: Tomato varieties

1. **V_1:** BARI Tomato 2
2. **V_2:** BARI Tomato 11
3. **V_3:** BARI Tomato 14
4. **V_4:** BARI Tomato 15
5. **V_5:** BARI Tomato 17
6. **V_6:** BARI Tomato 18
7. **V_7:** BARI Tomato19

Factor B: Salinity levels (dS m^{-1})

1. **(S_1):** 0 dS m^{-1}
2. **(S_2):** 3 dS m^{-1}
3. **(S_3):** 6 dS m^{-1}
4. **(S_4):** 9 dS m^{-1}
5. **(S_5):** 12 dS m^{-1}

3.8 Application of manure and fertilizer in the pots

Total 1.7 Kg rotten cow dung, 15 g Urea, 18 g TSP and 9 g MoP were applied in each pot during the production of tomato. Entire amount of cow dung, 5 g of Urea, 15 g of TSP and 7 g of MoP were mixed with the soil in each pot during pot preparation before sowing. 5 g of urea and rest of the TSP and MoP were applied as side dressing at 30 days after transplanting. Rest of the urea was applied at 50 days after transplanting.

3.9 Imposition of salinity treatments

Salinity was imposed as per treatments at the pre flowering stage three times at 25, 50 and 75 DAT. The developed irrigation water salinity and pot soil salinity were measured by using an electrical conductivity meter (HANNA HI 993310 Direct Salinity Meter) which was expressed in dS m^{-1}.

3.10 Preparation of stock solution

Saline water was adjusted by using a mixture of 1.75 g NaCl for 3 dS m^{-1}, 3.51 g NaCl for 6 dS m^{-1}, 5.27 g NaCl for 9 dS m^{-}1 and 7.02 g for 12 dS m^{-1} so that their composition was almost alike with the average composition of the saline ground water.

3.11 Sowing of seeds

The seeds of seven tomato varieties were sown on the 13th November 2018 by hand in individual pot to raise the seedling. Proper care was taken following recommended measures for the development of healthy seedlings.

3.12 Seedling raising

A common procedure was followed in raising of seedlings in the pot. Tomato Seedlings were raised inpots at Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka. After sowing, seeds were covered with light soil to a depth of about 0.6 cm. Heptachlor 40 WP was applied @ 4 kg ha^{-1} in each pot as precautionary measure against ants and worm. After 5 days of seeds sowing germination was visible. The emergence of the seedlings took place within 6 to 7 days after sowing. Necessary shading was provided over the pot by polythene to protect the young seedlings from scorching sunlight or heavy rain.

3.13 Transplanting of seedling

Healthy tomato seedlings of 20 days old were uprooted separately from the pots. The seedlings were watered before uprooting so as to reduce damage of roots. Two seedlings were transplanted in each experimental pot in the afternoon during the 3rd December 2018. Light irrigation was given immediately after transplanting by using water cane. One seedling was kept in each pot and another seedling was discarded after seedling establishment.

3.14 Intercultural operations

Proper intercultural operations were done for better growth and development of tomato plants in pots. Weeding and mulching were done to keep the crop free from weeds, better soil aeration.

3.14.1 Stalking

At pre flowering stage, the juvenile plants were stalked with bamboo sticks to keep them erect and to protect from damage caused by storm and strong wind. The plants were tied by plastic rope with bamboo slices.

3.14.2 Irrigation

Immediately after transplanting, light irrigation was given to each pot to overcome water deficit. After establishment of seedlings, each pot was watered in alternate days to keep the soil moist for normal growth and development of the plants. Irrigation was done with saline water as per treatments thrice at 25, 50 and 75 DAT. Thereafter, no irrigation was given.

3.14.3 Plant protection measures

Plant protection measures were done whenever it was necessary. To prevent plants from insect infection, Volume Flexi was applied @ .5 ml L^{-1} of water at the early stage of tomato. Virtako was also applied for virus infection @ 0.3g$L^{-1}$of water. Volume Flexi and Virtako were applied at 10 days alternatively from plant establishment to 15 days before first harvesting.

3.15 Harvesting of fruits

Harvesting was started on 21 February 2019 and completed by 29 March2019.

3.16 Parameter Studied:

Data on the following parameters were recorded:

3.16.1 Measurement of morphological characters

1. Plant height (cm)

2. Stem base diameter (cm)

3. Number of leaf plant^{-1}

4. Total leaf area (cm^2)

5. Leaf chlorophyll content (SPAD value)

6. Number of branch plant^{-1}

3.16.2 Measurement of yield and yield contributing characters

1. Days to first flowering

2. Number of flower cluster plant^{-1}

3. Number of flower plant^{-1}

4. Fruit length (cm)

5. Fruit diameter (cm)

6. Number of fruits plant^{-1}

7. Individual fruits weight (g)

8. Fruit weight plant^{-1}(g)

9. Total soluble solids (%)

3.17 Detailed Procedures of Recording Data

A brief description of data collection and recording procedure which was followed during the study is given below:

A. Measurement of morphological characters

1. Plant height (cm)

Plant heights were measured in centimeter (cm) from the ground level to the tip of the longest stem at 40, 60 and 80 DAT, respectively.

2. Number of leaves plant^{-1}

The leaf number of individual plant was counted and recorded.

3. Leaf area (cm^2) plant^{-1}

The length and width of green leaves were measured using a meter rule. The product of the length and width of each leaf was multiplied by 0.45 to derive the area for each leaf (Fageria *et al*., 2006).

4. Chlorophyll contents (SPAD value)

Leaf chlorophyll content as SPAD values were measured from the youngest fully-expanded leaf in the third position from the tip by a portable chlorophyll meter (SPAD-502, Konica Minolta Sensing, Inc., Japan). The SPAD-502 chlorophyll meter can estimate total chlorophyll in the leaves of a variety of species with a high degree of accuracy and is a nondestructive method.

5. Number of branch plant^{-1}

The branch number of individual plant was counted.

6. Stem base diameter (cm):

Diameter of the stem base was measured in centimeter (cm) at40 DAT, 60 DAT and 80 DAT.

B. Measurement of yield and yield contributing characters

7. Days to first flowering

Days to first flowering was determined by the first flower commencement (DAT)

8. Number of flower cluster plant^{-1}

The number of flower cluster of individual plant was recorded.

9. Number of flower plant^{-1}

The number of flowers of individual plant was recorded.

10. Fruit length (cm)

The length of fruit was measured with a slide calipers from the neck of the fruit to the bottom of 5 fruits from each plant and their average was taken and expressed in cm.

11. Fruit diameter (cm)

Diameter of fruit was measured at middle portion of 5 fruits from each plant with a slide calipers. Their average was taken and expressed in cm.

12. Number of fruits plant^{-1}

The number of fruits of individual plant was recorded.

13. Individual fruit weight (g)

From first to final harvest of fruits was recorded and averaged to get individual fruit weight (g).

14. Fruit weight plant^{-1} (g)

Fruit weight plant^{-1} was calculated from the weight of total number of fruits harvested from individual plant and expressed in gram (g).

15. Total soluble solids (%)

Total soluble solids present in tomatoes was measured by Refractometer and expressed in percentage (%).

3.18 Analysis of data

The data in respect of growth, yield contributing characters and yield were statistically analyzed to find out the statistical significance of the experimental results. The means for all the treatments were calculated and the analyzed with the statistical software package Statistix-X. The significance of the difference among the means was evaluated by the least significant difference test (LSD) at 5% level of significance.

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

The experimental work was accomplished for the evaluation of seven tomato varieties to different salinity treatment. In this experiment seven tomato varieties BARI Tomato 2, BARI Tomato 11, BARI Tomato 14, BARI Tomato 15, BARI Tomato 17, BARI Tomato 18 and BARI Tomato 19 were used with five salinity treatment (0, 3 dS m^{-1}, 6 dS m^{-1}, 9 dS m^{-1} and 12 dS m^{-1}). The results of the study on performance of tomato at different salinity levels have been presented and possible interpretations have been made in this chapter. Data have been presented in table(s) and figure(s) for easy discussion, comprehension and understanding.

4.1 Effect on plant height (cm) of tomato

4.1.1 Effect of salinity on plant height (cm) of tomato

The effect of salinity on plant height (cm) is shown in the Figure 1. From the experiment, it was found that the salinity levels had significant effect on plant height (cm). The highest plant height (41.46 cm, 66.71 cm and 74.37 cm at 40, 60 and 80 DAT, respectively) was shown by S_1. The lowest plant height (38.00 cm, 61.57 cm and 70.00 cm at 40, 60 and 80 DAT, respectively) was recorded from S_5. Cell division, cell elongation and finally plant growth (plant height) become inhibited due to salinity in crop (Munns and Tester, 2008). These results were similar with the results found by Siddiky *et al*. (2012) who also reported the decrease in plant height of the same variety with the exposure of different salinity level. Islam *et al*. (2011) also reported the decreased plant height as well as plant growth due to salinity inclusion.

4.1.2 Effect of variety on plant height (cm) of tomato

Figure 2 shows the effect of variety on plant height (cm). Variety poses significant effect on plant height (cm). The maximum plant height (45.46 cm, 74.79 cm and 79.99 cm at 40, 60 and 80 DAT respectively) was recorded from V_2. On the other hand, the minimum plant height (35.13 cm) at 40 DAT was observed from V_6. However, the minimum plant height at 60 DAT (55.20 cm) and 80 DAT (59.79 cm) was recorded from V_1. These findings were closer to the findings of Siddiky *et al.* (2012) while conducting an experiment on screening of different tomato varieties in saline areas of Bangladesh.

4.1.3 Effect of salinity and variety interaction on plant height (cm) of tomato

The combined effect of salinity and variety is placed in the Table 1. From the table it can be found that the maximum plant height (48.00 cm, 82.00 cm and 88. 33 cm at 40, 60 and 80 DAT, respectively) is shown by S_1V_2. The minimum plant height 33.00 cm was shown by S_5V_6 at 40 DAT whereas, the minimum plant height of 46.33 cm, 51.66

cm at 60 and 80 DAT, respectively) was shown by S_5V_1. The treatment combinations were statistically significant from each other. Sardoei *et al*. (2014) reported that interaction of salt × genotype had significant effect on growth indices like plant height.

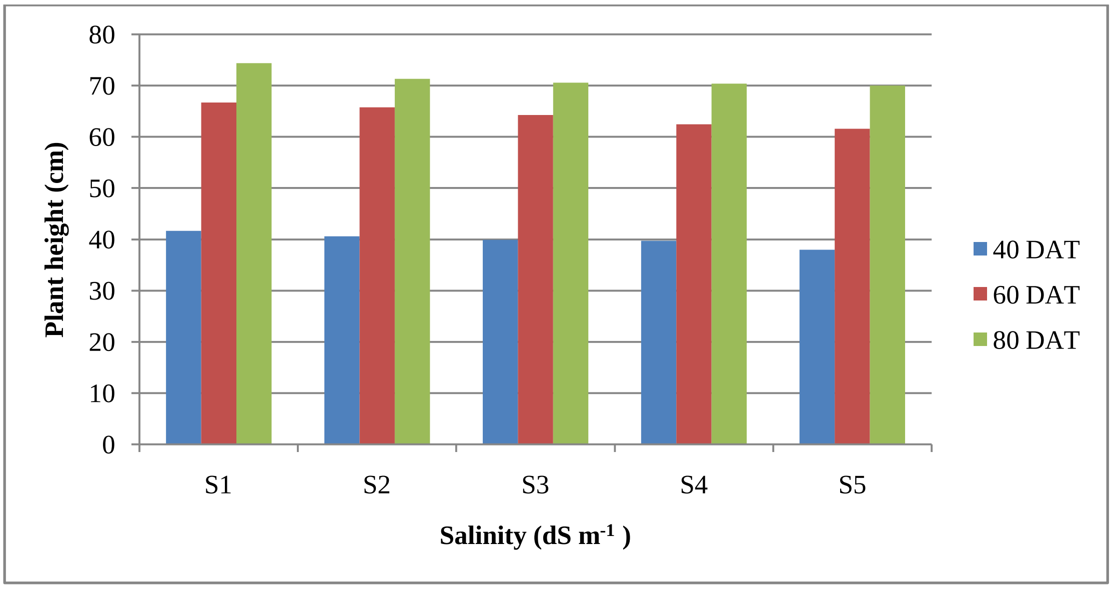

Figure 1. Effect of salinity on plant height (cm) of tomato

Here, S_1= 0 dS m^{-1}, S_2= 3 dS m^{-1}, S_3= 6 dS m^{-1}, S_4= 9 dS m^{-1}, S_5= 12 dS m^{-1}; $lsd_{0.05}$= 2.69, 4.06 and 4.18 at 40, 60 and 80 DAT, respectively

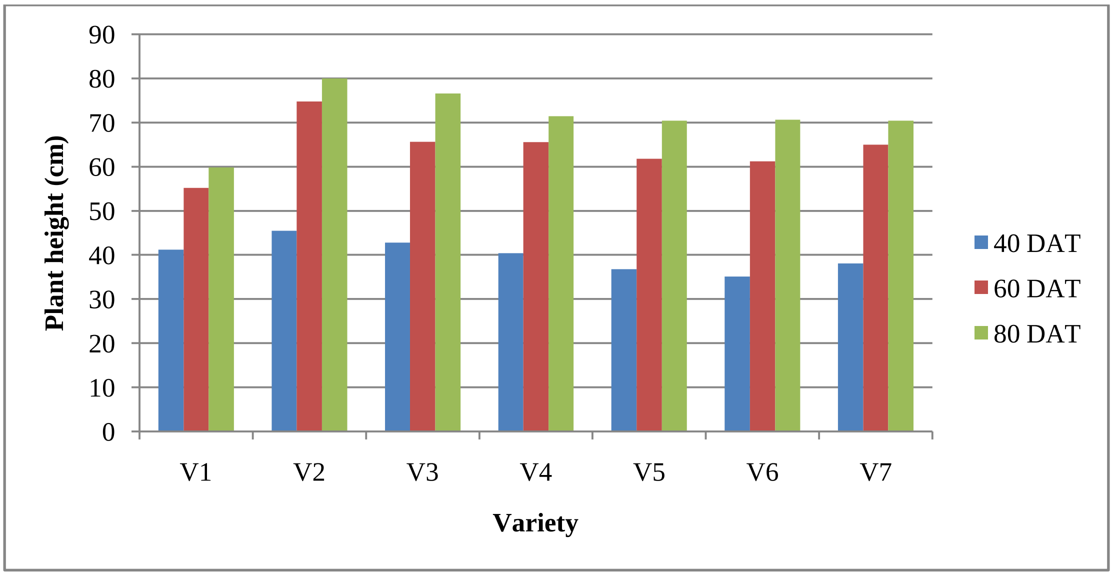

Figure 2. Effect of variety on plant height (cm) of tomato

Here, V_1= BARI Tomato 2, V_2= BARI Tomato 11, V_3= BARI Tomato 14, V_4= BARI Tomato 15, V_5= BARI Tomato 17, V_6= BARI Tomato 18, V_7= BARI Tomato 19; $lsd_{0.05}$= 3.19, 4.81 and 4.94 at 40, 60 and 80 DAT, respectively

Table 1. Combined effect of salinity and variety on plant height (cm) of tomato

Treatment Combinations	Plant height (cm)		
	40 DAT	**60 DAT**	**80 DAT**
S_1V_1	41.000 a-h	56.000 j-m	55.330 jk
S_1V_2	48.000 a	82.00 a	88.330 a
S_1V_3	46.667 ab	71.667 a-f	85.330 ab
S_1V_4	43.667 a-f	64.333 e-j	77.330 a-e
S_1V_5	38.000 d-j	62.667 f-k	71.330 c-g
S_1V_6	37.667 e-j	63.000 f-k	72.330 c-g
S_1V_7	40.000 b-j	70.000 b-g	70.660 c-g
S_2V_1	41.333 a-g	53.333 k-m	56.000 i-k
S_2V_2	46.333 a-c	77.330 a-c	80.000 a-c
S_2V_3	43.667 a-f	66.330 d-j	80.000 a-c
S_2V_4	40.333 b-i	74.667 a-e	67.667 d-h
S_2V_5	35.000 g-j	66.330 d-j	77.667 a-e
S_2V_6	38.000 d-j	60.000 g-l	69.667 c-h
S_2V_7	39.333 c-j	65.333 e-j	68.330 d-h
S_3V_1	37.667 e-j	50.333 lm	77.330 a-e
S_3V_2	45.000 a-d	70.000 b-g	78.330 a-d
S_3V_3	44.000 a-f	63.000 f-k	67.000 e-i
S_3V_4	44.333 a-f	67.667 b-h	69.330 c-h
S_3V_5	35.000 g-j	60.330 g-l	72.000 c-g
S_3V_6	34.000 h-j	62.333 f-k	68.000 d-h
S_3V_7	40.333 b-i	77.000 a-d	62.000 g-k
S_4V_1	40.333 b-i	49.667 lm	58.667 h-k
S_4V_2	44.667 a-e	77.660 ab	78.000 a-e
S_4V_3	38.000 d-j	61.667 f-k	76.667 b-e
S_4V_4	40.333 b-i	62.000 f-k	74.000 c-f
S_4V_5	37.333 f-j	57.000 h-m	63.667 f-j
S_4V_6	33.000 j	56.667 i-m	70.333 c-g
S_4V_7	45.667 a-c	66.333 d-j	78.333 a-d
S_5V_1	45.667 a-c	46.333 m	51.660 k
S_5V_2	43.333 a-f	67.000 b-i	75.333 b-e
S_5V_3	41.667 a-g	65.333 e-j	74.000 c-f
S_5V_4	33.333 ij	59.000 h-l	69.000 c-h
S_5V_5	38.333 d-j	62.667 f-k	67.333 d-h
S_5V_6	33.000 j	64.000 e-k	73.000 c-g
S_5V_7	25.000 k	66.667 c-j	72.667 c-g
$LSD_{(0.05)}$	**7.13**	**10.76**	**11.06**
CV (%)	**10.96**	**10.29**	**9.52**

Here, S_1= 0 dS m^{-1}, S_2= 3 dS m^{-1}, S_3= 6 dS m^{-1}, S_4= 9 dS m^{-1}, S_5=12 dS m^{-1} and V_1= BARI Tomato 2, V_2= BARI Tomato 11, V_3= BARI Tomato 14, V_4= BARI Tomato 15, V_5= BARI Tomato 17, V_6= BARI Tomato 18, V_7= BARI Tomato 19

4.2 Effect on stem base diameter (cm) of tomato

4.2.1 Effect of salinity on stem base diameter (cm) of tomato

The effect of salinity is shown in the Figure 3. No statistically significant difference was found among the treatments at 40 DAT but statistically significant difference was found among the treatments at 60 and 80 DAT. The maximum stem base diameter (0.68 cm, 0.71 cm and 0.87 cm at 40, 60 and 80 DAT, respectively) was shown by S_1. On the other hand, the minimum stem base diameter (0.62 cm, 0.66 cm and 0.74 cm at 40, 60 and 80 DAT, respectively) was recorded from S_5. These findings were in line with that of Mazumder (2016) who also reported similar pattern of stem base diameter (cm) while working with different salinity levels in tomato cultivation.

4.2.2 Effect of variety on stem base diameter (cm) of tomato

The effect of variety on stem base diameter (cm) is shown in the Figure 4. There was statistically significant difference among the treatments. From the experiment it was found that the maximum stem base diameter (0.75 cm, 0.77 cm and 0.91 cm at 40, 60 and 80 DAT, respectively) was shown by V_2. Whereas, the minimum stem base diameter (0.57 cm, 0.59 cm and 0.68 cm at 40, 60 and 80 DAT, respectively) was reported from V_7. Mazumder (2016) also reported the closer findings while working with different tomato varieties.

4.2.3 Effect of salinity and variety interaction on stem base diameter (cm) of tomato

Table 2 shows the effect salinity and variety interaction on stem base diameter (cm). In case of stem base diameter at 40 DAT, S_1V_3 showed the maximum stem base diameter (0.83 cm). However, at 60 DAT and 80 DAT, the maximum stem base diameter was reported from S_1V_2 (0.83 cm and 1.03 cm, respectively). On the other hand, the minimum plant height (0.47 cm, 0.50 cm and 0.60 cm at 40, 60 and 80 DAT, respectively) was recorded from S_5V_6, S_5V_4 and S_5V_7, respectively. There was statistical variation among the treatment combinations. The results were in line with that of Mazumder (2016) while working with different salinity levels and tomato varieties.

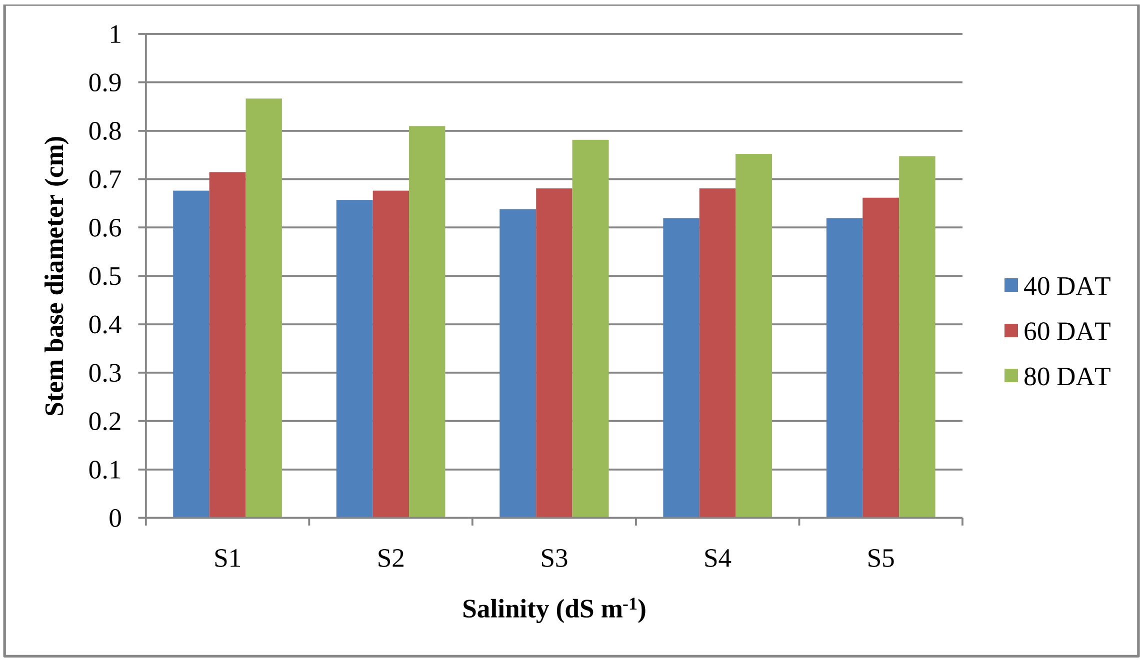

Figure 3. Effect of salinity on stem base diameter (cm) of tomato

Here, S_1= 0 dS m^{-1}, S_2= 3 dS m^{-1}, S_3= 6 dS m^{-1}, S_4= 9 dS m^{-1}, S_5= 12 dS m^{-1}; $lsd_{0.05}$= 0.06, 0.04 and 0.06 at 40, 60 and 80 DAT, respectively

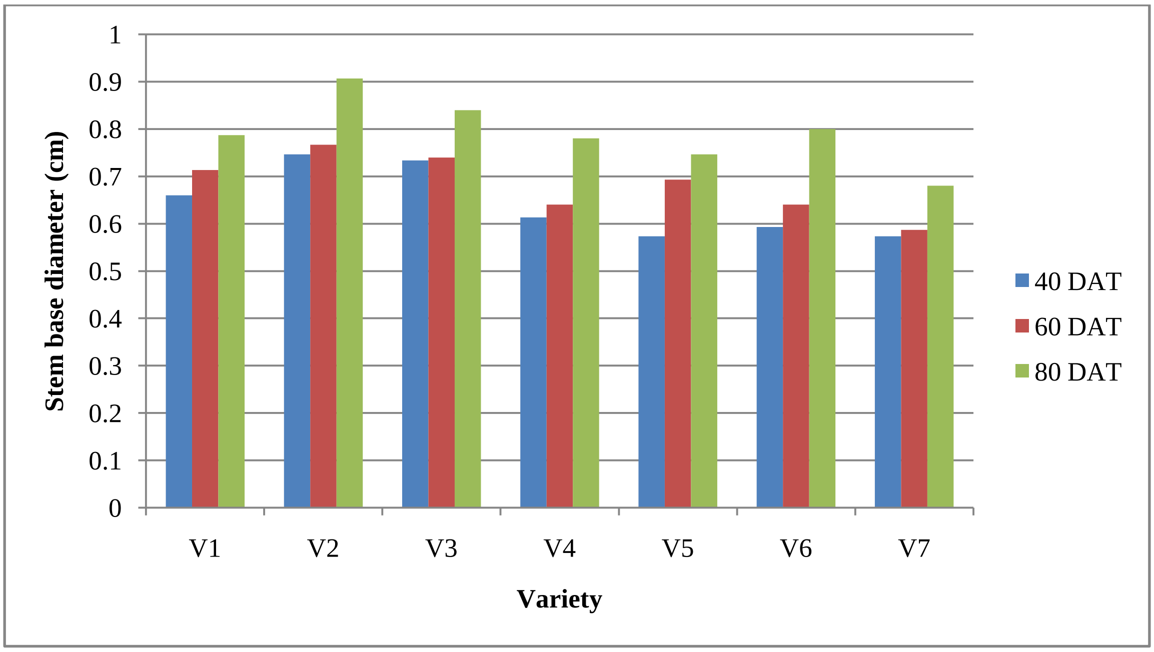

Figure 4. Effect of variety on stem base diameter (cm) of tomato

Here, V_1= BARI Tomato 2, V_2= BARI Tomato 11, V_3= BARI Tomato 14, V_4= BARI Tomato 15, V_5= BARI Tomato 17, V_6= BARI Tomato 18, V_7= BARI Tomato 19; $lsd_{0.05}$= 0.07, 0.05 and 0.07 at 40, 60 and 80 DAT, respectively

Table 2. Combined effect of salinity and variety on stem base diameter (cm) of tomato

Treatment Combinations	Stem base diameter (cm)		
	40 DAT	**60 DAT**	**80 DAT**
S_1V_1	0.633 b-e	0.733 a-d	0.833 b-d
S_1V_2	0.766 ab	0.833 a	1.033 a
S_1V_3	0.833 a	0.733 a-d	0.866 a-d
S_1V_4	0.633 b-e	0.633 d-f	0.833 b-d
S_1V_5	0.633 b-e	0.733 a-d	0.833 b-d
S_1V_6	0.633 b-e	0.700 b-e	0.833 b-d
$S\ V_7$	0.600 c-f	0.633 d-f	0.833 b-d
S_2V_1	0.700 a-d	0.666 c-e	0.900 a-c
S_2V_2	0.766 ab	0.633 d-f	0.900 a-c
S_2V_3	0.633 b-e	0.766 a-c	0.766 b-f
S_2V_4	0.633 b-e	0.666 c-e	0.766 b-f
S_2V_5	0.566 d-f	0.700 b-e	0.866 a-d
S_2V_6	0.700 a-d	0.666 c-e	0.866 a-d
S_2V_7	0.600 c-f	0.633 d-f	0.733 c-f
S_3V_1	0.633 b-e	0.733 a-d	0.700 d-f
S_3V_2	0.800 a	0.800 ab	0.900 a-c
S_3V_3	0.733 a-c	0.700 b-e	0.900 a-c
S_3V_4	0.600 c-f	0.700 b-e	0.866 a-d
S_3V_5	0.533 ef	0.633 d-f	0.733 c-f
S_3V_6	0.600 c-f	0.666 c-e	0.766 b-f
S_3V_7	0.566 d-f	0.533 fg	0.600 f
S_4V_1	0.700 a-d	0.800 ab	0.766 b-f
S_4V_2	0.600 c-f	0.766 a-c	0.933 ab
S_4V_3	0.766 ab	0.733 a-d	0.866 a-d
S_4V_4	0.566 d-f	0.700 b-e	0.700 d-f
S_4V_5	0.566 d-f	0.700 b-e	0.600 f
S_4V_6	0.566 d-f	0.533 fg	0.766 b-f
S_4V_7	0.566 d-f	0.533 fg	0.633 ef
S_5V_1	0.633 b-e	0.633 d-f	0.733 c-f
S_5V_2	0.800 a	0.800 ab	0.766 b-f
S_5V_3	0.700 a-d	0.766 a-c	0.800 b-e
S_5V_4	0.633 b-e	0.500 g	0.733 c-f
S_5V_5	0.566 d-f	0.700 b-e	0.700 df
S_5V_6	0.466 f	0.633 d-f	0.766 b-f
S_5V_7	0.533 ef	0.600 e-g	0.600 f
$LSD_{(0.05)}$	**0.15**	**0.13**	**0.17**
CV (%)	**15.22**	**11.87**	**13.22**

Here, S_1= 0 dS m^{-1}, S_2= 3 dS m^{-1}, S_3= 6 dS m^{-1}, S_4= 9 dS m^{-1}, S_5= 12 dS m^{-1} and V_1= BARI Tomato 2, V_2= BARI Tomato 11, V_3= BARI Tomato 14, V_4= BARI Tomato 15, V_5= BARI Tomato 17, V_6= BARI Tomato 18, V_7= BARI Tomato 19

4.3 Effect on number of leaf plant^{-1} of tomato

4.3.1 Effect of salinity on number of leaf plant^{-1} of tomato

Effect of salinity was found to have a significant effect on number of leaf plant^{-1} at 60 DAT. The effect of salinity on number of leaf plant^{-1} is showed in Figure 5. From the experiment it was found that the maximum number of leaf plant^{-1} (11.57 and 19.14 at 40 DAT and 60 DAT, respectively) was shown by S_1. Whereas, the minimum number of leaf plant^{-1} (8.86 and 14.78 at 40 DAT and 60 DAT, respectively) was obtained from S_5. Umar *et al.* (2018) and (Mazumder, 2016) reported that number of leaf plant^{-1} reduced with the increase in salinity levels.

4.3.2 Effect of variety on number of leaf plant^{-1} of tomato

The effect of variety on number of leaf plant^{-1} is shown in the Figure 6. The highest number of leaf plant^{-1} (11.93 and 21.47 at 40 DAT and 60 DAT, respectively) was reported from V_7. On the other hand the lowest number of leaf plant^{-1}8.73 (40 DAT) and 15.47 (60 DAT) was obtained from V_5 and V_6, respectively. Umar *et al.* (2018) conducted an experiment on effects of salinity on growth and yield of tomato genotype and reported that different genotype had various numbers of leaves.

4.3.3 Effect of salinity and variety interaction on number of leaf plant^{-1} of tomato

The interaction effect of salinity and variety is placed on the Table 3. From the table it can be found that the maximum number of leaf plant^{-1} (14.33 and 25.0 at 40 DAT and 60 DAT) was obtained from S_1V_7. However, the minimum number of leaf plant^{-1} 7.0 and 9.33 (at 40 DAT and 60 DAT, respectively) from S_5V_7 and S_5V_6, respectively.

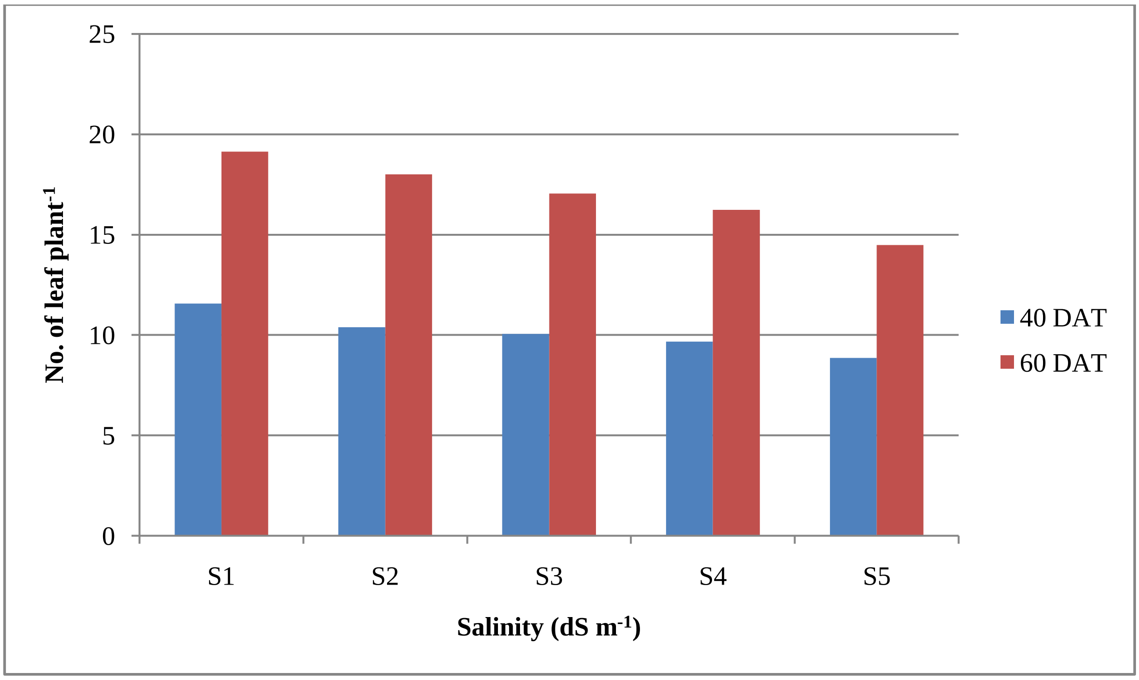

Figure 5. Effect of salinity on number of leaf plant^{-1} of tomato

Here, S_1= 0 dS m^{-1}, S_2= 3 dS m^{-1}, S_3= 6 dS m^{-1}, S_4= 9 dS m^{-1}, S_5= 12 dS m^{-1}; $lsd_{0.05}$= 0.44 and 0.55 at 40 and 60 DAT, respectively

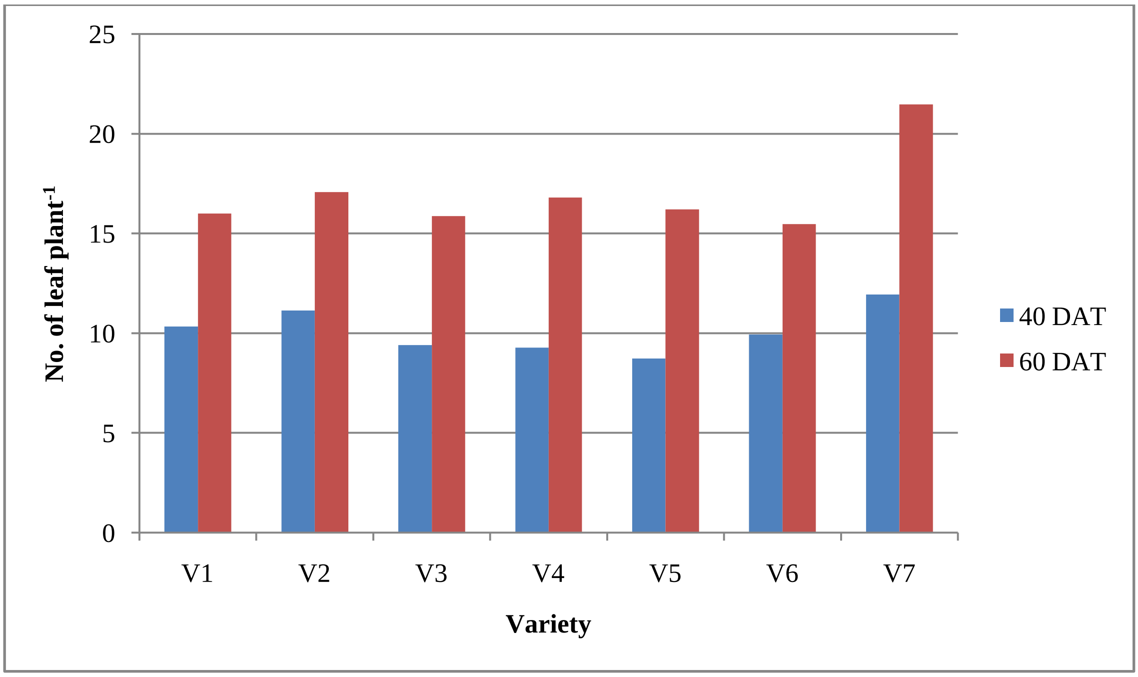

Figure 6. Effect of variety on number of leaf plant^{-1} of tomato

Here, V_1= BARI Tomato 2, V_2= BARI Tomato 11, V_3= BARI Tomato 14, V_4= BARI Tomato 15, V_5= BARI Tomato 17, V_6= BARI Tomato 18, V_7= BARI Tomato 19; $lsd_{0.05}$= 0.51 and 0.65 at 40 and 60 DAT, respectively

Table 3. Combined effect of salinity and variety on number of leaf plant^{-1} of tomato

Treatment Combinations	Number of leaf plant^{-1}	
	40 DAT	**60 DAT**
S_1V_1	11.000 d-f	20.667 bc
S_1V_2	13.333 ab	18.333 d-f
S_1V_3	11.333 c-e	18.667 de
S_1V_4	9.667 g-j	17.333 e-h
S_1V_5	10.333 e-h	19.333 cd
S_1V_6	11.333 c-e	18.000 d-g
S_1V_7	14.000 a	25.000 a
S_2V_1	11.000 d-f	12.667 mn
S_2V_2	10.667 e-g	18.667 de
S_2V_3	9.000 i-l	17.333 e-h
S_2V_4	9.333 h-k	16.667 g-j
S_2V_5	8.000 lm	17.000 f-i
S_2V_6	10.333 e-h	18.667 de
S_2V_7	14.333 a	24.000 a
S_3V_1	9.000 i-l	19.333 cd
S_3V_2	10.667 e-g	20.667 bc
S_3V_3	9.333 h-k	17.000 f-i
S_3V_4	10.667 e-g	16.667 g-j
S_3V_5	8.333 kl	13.667 lm
S_3V_6	10.000 f-i	12.667 mn
S_3V_7	12.333 bc	21.667 b
S_4V_1	10.667 e-g	16.000 h-k
S_4V_2	10.333 e-h	15.667 i-k
S_4V_3	9.000 i-l	15.000 kl
S_4V_4	8.667 j-l	15.667 i-k
S_4V_5	8.000 lm	15.333 jk
S_4 V_6	9.000 i-l	18.667 de
S_4V_7	12.000 cd	17.333 e-h
S_5V_1	10.000 f-i	11.333 n
S_5V_2	10.667 e-g	12.000 n
S_5V_3	8.333 kl	11.333 n
S_5V_4	8.000 lm	17.667 e-g
S_5V_5	9.000 i-l	15.667 i-k
S_5V_6	9.000 i-l	9.333 o
S_5V_7	7.000 m	19.333 cd
$LSD_{(0.05)}$	**1.15**	**1.46**
CV (%)	**7.03**	**5.30**

Here, S_1= 0 dS m^{-1}, S_2= 3 dS m^{-1}, S_3= 6 dS m^{-1}, S_4= 9 dS m^{-1}, S_5= 12 dS m^{-1} and V_1= BARI Tomato 2, V_2= BARI Tomato 11, V_3= BARI Tomato 14, V_4= BARI Tomato 15, V_5= BARI Tomato 17, V_6= BARI Tomato 18, V_7= BARI Tomato 19

4.4 Effect on leaf area plant^{-1} (cm^2) of tomato

4.4.1 Effect of salinity on leaf area plant^{-1} (cm^2) of tomato

Salinity had a significant effect on leaf area plant^{1}. Figure 7 shows the effect of salinity on leaf area plant^{1}. From the experiment it was found that the highest leaf area plant^{1} (177.82 cm^2 and 210.58 cm^2 at 40 DAT and 60 DAT, respectively) was given by S_1. On the other hand, the lowest leaf area plant^{-1} (10.86 cm^2 and 118.4 cm^2) was shown by S_5. Leaf area of tomato was reduced due to rising salinity reported by Umar *et al.* (2018) and Mazumder (2016). Leaf area reduced due to cell division and cell elongation inhibition because of rising salinity reported by Hernandez *et al*. (2003).

4.4.2 Effect of variety on leaf area plant^{-1} (cm^2) of tomato

Effect of variety on leaf area plant^{-1} is shown in the Figure 8. In the experiment, V_3 was found to have maximum leaf area plant^{-1} (169.02 cm^2) at 40 DAT whereas; V_4 was reported have maximum leaf area plant^{-1} (174.34 cm^2) at 60 DAT. However, the minimum leaf area plant^{-1} was given by V_1 (116.38 cm^2) and V_6 (140.03 cm^2) at 40 DAT and 60 DAT, respectively. There was significant difference among the treatments. Umar *et al.* (2018) reported that different genotype had different leaf area.

4.4.3 Effect of salinity and variety interaction on leaf area plant^{-1} (cm^2) of tomato

The combined effect of salinity and variety is placed on the Table 4. In the experiment S_1V_3 was found to give the maximum leaf area plant^{-1} (214.70 cm^2) at 40 DAT and at 60 DAT the maximum leaf area plant^{-1} (252.50 cm^2) was shown by S_1V_4. On the other hand, minimum leaf area plant^{-1} (56.83 cm^2 and 74.63 cm^2 at 40 and 60 DAT, respectively) was shown by S_5V_1. There was statistically significant variation among the treatments. Mazumder (2016) also reported the similar pattern of leaf area plant^{-1} while conducting experiment with different tomato varieties.

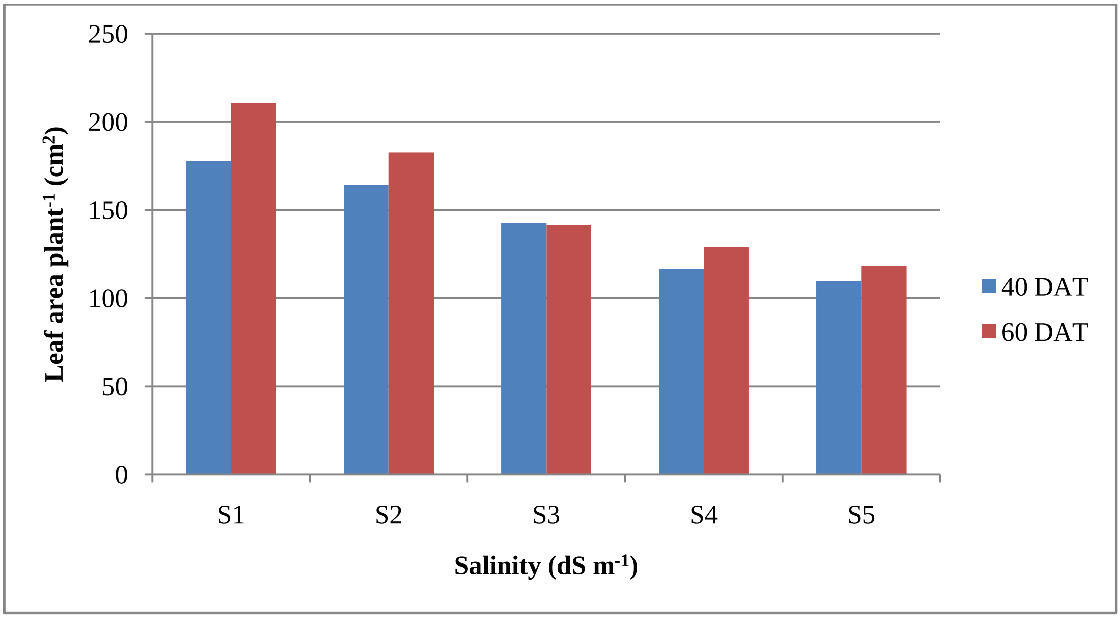

Figure 7. Effect of salinity on leaf area plant^{-1} (cm^2) of tomato

Here, S_1= 0 dS m^{-1}, S_2= 3 dS m^{-1}, S_3= 6 dS m^{-1}, S_4= 9 dS m^{-1}, S_5= 12 dS m^{-1}; $lsd_{0.05}$= 7.41 and 7.50 at 40 and 60 DAT, respectively

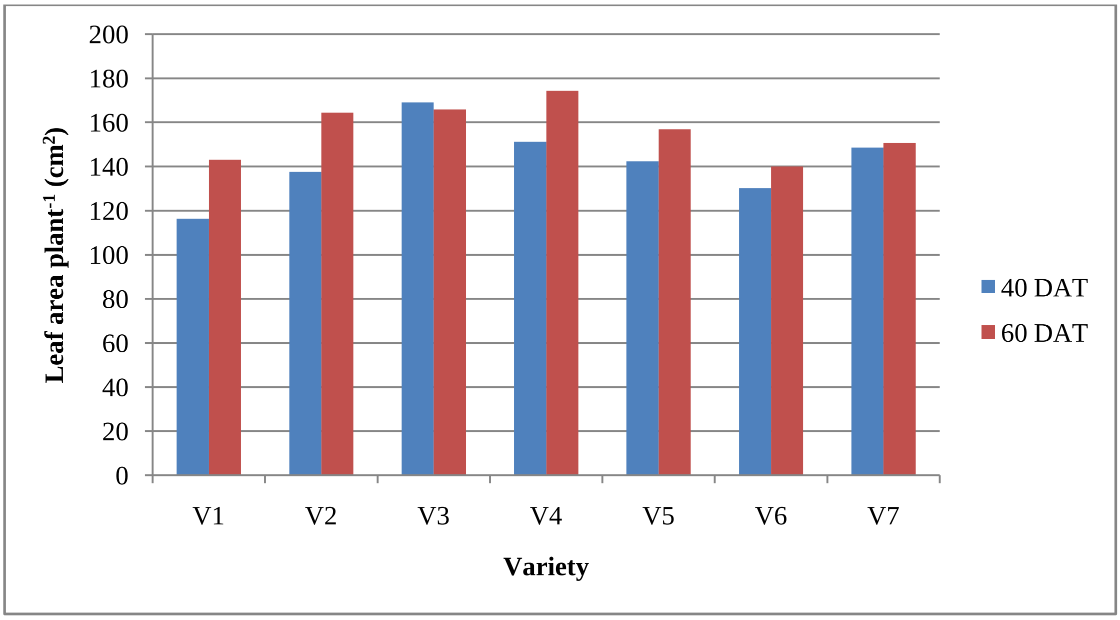

Figure 8. Effect of variety on leaf area plant^{-1} (cm^2) of tomato

Here, V_1= BARI Tomato 2, V_2= BARI Tomato 11, V_3= BARI Tomato 14, V_4= BARI Tomato 15, V_5= BARI Tomato 17, V_6= BARI Tomato 18, V_7= BARI Tomato 19; $lsd_{0.05}$= 8.77 and 8.88 at 40 and 60 DAT, respectively

Table 4. Combined effect of salinity and variety on leaf area plant^{-1} (cm^2) of tomato

Treatment Combinations	Leaf area plant^{-1} (cm^2)	
	40 DAT	**60 DAT**
S_1V_1	175.50 c-e	214.42 b-d
S_1V_2	155.07 g-i	171.67 fg
S_1V_3	214.70 a	225.80 bc
S_1V_4	186.87 c	252.50 a
S_1V_5	166.50 d-g	232.27 b
S_1V_6	162.22 e-g	171.00 f-h
S_1V_7	183.87 cd	206.40 cd
S_2V_1	155.87 f-h	201.30 de
S_2V_2	165.57 d-g	180.77 f
S_2V_3	190.22 bc	206.13 cd
S_2V_4	208.30 ab	229.13 b
S_2V_5	161.53 e-g	144.55 i-m
S_2V_6	139.65 h-k	170.63 f-h
S_2V_7	127.73 kl	145.50 i-m
S_3V_1	93.70 n	91.50 qr
S_3V_2	148.55 g-j	184.07 ef
S_3V_3	167.13 d-g	151.23 h-l
S_3V_4	174.75 c-f	156.08 g-j
S_3V_5	127.60 kl	143.47 i-m
S_3V_6	123.75 kl	134.50 k-n
S_3V_7	162.07 e-g	130.87 mn
S_4V_1	100.00 mn	133.33 l-n
S_4V_2	131.13 j-l	159.15 g-i
S_4V_3	155.63 f-i	137.30 j-n
S_4V_4	84.75 n	153.20 g-k
S_4V_5	117.23 lm	126.33 m-o
S_4V_6	90.60 n	118.17 n-p
S_4V_7	136.20 i-l	134.70 k-n
S_5V_1	56.83 o	74.63 r
S_5V_2	87.20 n	126.73 m-o
S_5V_3	148.23 g-j	109.03 o-q
S_5V_4	101.33 mn	126.87 m-o
S_5V_5	138.47 h-k	137.67 j-n
S_5V_6	134.58 j-l	105.87 pq
S_5V_7	102.37 mn	89.33 qr
$LSD_{(0.05)}$	**19.62**	**19.84**
CV (%)	**8.47**	**7.79**

Here, S_1= 0 dS m^{-1}, S_2= 3 dS m^{-1}, S_3= 6 dS m^{-1}, S_4= 9 dS m^{-1}, S_5= 12 dS m^{-1} and V_1= BARI Tomato 2, V_2= BARI Tomato 11, V_3= BARI Tomato 14, V_4= BARI Tomato 15, V_5= BARI Tomato 17, V_6= BARI Tomato 18, V_7= BARI Tomato 19

4.5 Effect on leaf chlorophyll content (SPAD Unit) of tomato

4.5.1 Effect of salinity on leaf chlorophyll content (SPAD Unit) of tomato

The effect of salinity on leaf chlorophyll content (SPAD Unit) is shown in the Figure 9. S_1 at both stages (40 DAT and 60 DAT) gave the maximum leaf chlorophyll content of 51.09 SPAD Unit and 56.324 SPAD Unit, respectively. On the other hand, the minimum leaf chlorophyll content (38.59 SPAD Unit and 43.41 SPAD Unit at 40 DAT and 60 DAT, respectively) was obtained from S_5. Chlorophyll content decreased with increased level of salinity. The inhibitory effect of the accumulated ions of salts on the biosynthesis of the different chlorophyll fractions might be reason behind the reduction in chlorophyll content. Salinity affects the strength of the forces brings the complex pigment protein-liquid, in the chloroplast structure. As the chloroplast in membrane bound its stability is dependent on the membrane stability which under high salinity condition seldom remains intact and decrease the chlorophyll content Edris *et al*. (2012); Hajiboland *et al*. (2010). The result was in line with that of Jiang *et al*. (2017) who also reported the decreasing trend of leaf chlorophyll content (SPAD Unit) with an increase in salinity levels with few exceptions.

4.5.2 Effect of variety on leaf chlorophyll content (SPAD Unit) of tomato

Data regarding the effect of variety on leaf chlorophyll content (SPAD Unit) is shown in the Figure 10. At 40 DAT, the highest leaf chlorophyll content (46.73 SPAD Unit) was recorded from V_6 and it was statistically similar with V_1, V_2 and V_7 whereas, the lowest leaf chlorophyll content (41.68 SPAD Unit) was recorded from V_4. On the other hand, at 60 DAT the maximum leaf chlorophyll content (55.88 SPAD Unit) was reported from V_1 and it was statistically similar with V_3 whereas, the lowest leaf chlorophyll content (45.24 SPAD Unit) was found from V_5. Islam *et al.* (2011) also indicated the similar result while conducting with experiment with J 5, BINA Tomato5, BARI Tomato 7, CLN 2026, CLN 2366, CLN 2413, CLN 2418 and CLN 2443.

4.5.3 Effect of salinity and variety interaction on leaf chlorophyll content (SPAD Unit) of tomato

The combined effect of salinity and variety is placed on the Table 5. The maximum leaf chlorophyll content (54.50 SPAD Unit and 71.10 SAD Unit at 40 DAT and 60 DAT, respectively) was recorded from S_1V_6 and S_1V_3, respectively. On the other hand, the minimum leaf chlorophyll content (34.53 SPAD Unit and 39.93 SPAD Unit, respectively) was recorded from S_3V_5 and S_5V_6, respectively at 40 DAT and 60 DAT.

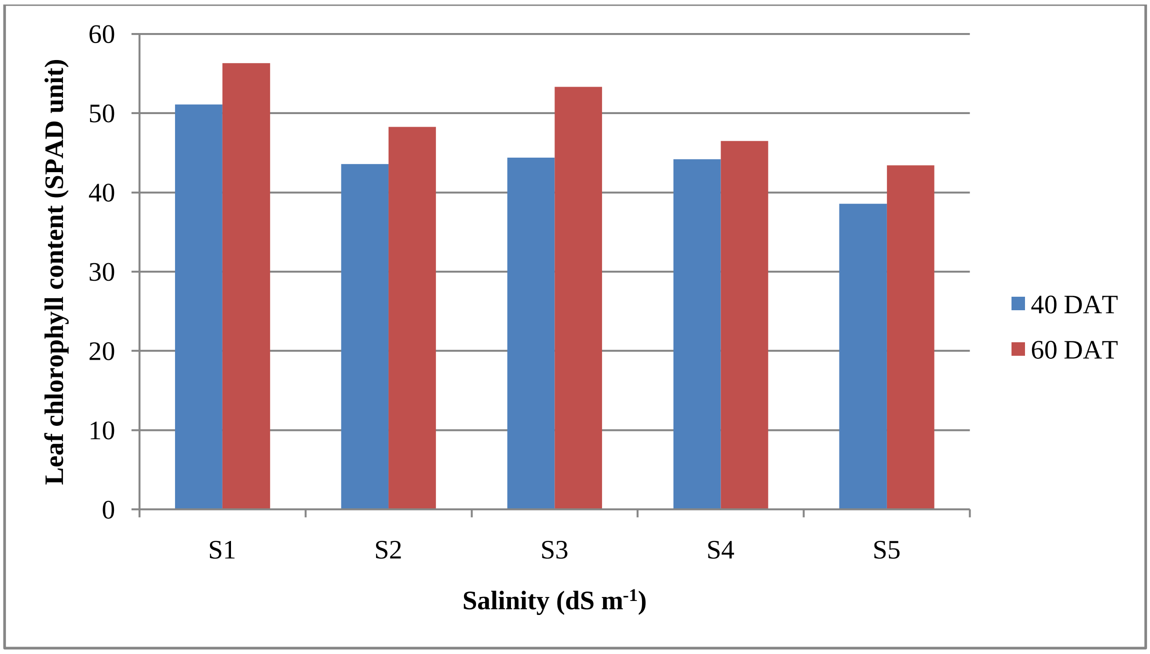

Figure 9. Effect of salinity on leaf chlorophyll content (SPAD Unit) of tomato

Here, S_1= 0 dS m^{-1}, S_2= 3 dS m^{-1}, S_3= 6 dS m^{-1}, S_4= 9 dS m^{-1}, S_5= 12 dS m^{-1}; $lsd_{0.05}$= 2.70 and 2.98 at 40 and 60 DAT, respectively

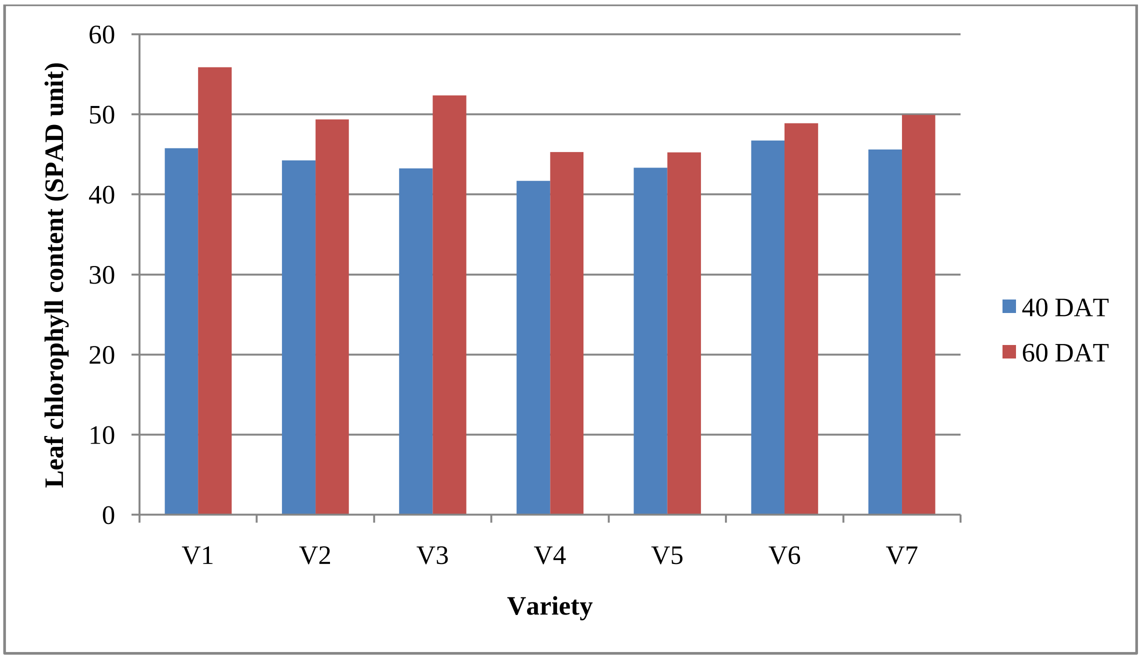

Figure 10. Effect of variety on leaf chlorophyll content (SPAD Unit) of tomato

Here, V_1= BARI Tomato 2, V_2= BARI Tomato 11, V_3= BARI Tomato 14, V_4= BARI Tomato 15, V_5= BARI Tomato 17, V_6= BARI Tomato 18, V_7= BARI Tomato 19; $lsd_{0.05}$= 3.19 and 3.53 at 40 and 60 DAT, respectively

Table 5. Combined effect of salinity and variety on leaf chlorophyll content (SPAD Unit) of tomato

Treatment Combinations	Leaf chlorophyll content (SPAD Unit)	
	40 DAT	**60 DAT**
S_1V_1	51.600 ab	62.100 b
S_1V_2	49.900 a-d	57.200 b-d
S_1V_3	52.167 ab	71.100 a
S_1V_4	46.767 b-h	44.433 h-l
S_1V_5	54.100 a	52.767 c-g
S_1V_6	54.500 a	58.000 bc
S_1V_7	48.633 a-f	48.667 e-k
S_2V_1	42.933 d-j	54.367 b-f
S_2V_2	44.267 c-j	50.867 c-i
S_2V_3	42.700 e-j	47.100 f-l
S_2V_4	39.200 i-k	43.600 i-l
S_2V_5	42.133 e-j	43.533 i-l
S_2V_6	45.133 b-i	45.800 g-l
S_2V_7	48.833 a-e	52.533 c-g
S_3V_1	51.367 a-c	61.767 b
S_3V_2	47.400 a-g	49.567 d-j
S_3V_3	41.600 f-k	57.033 b-d
S_3V_4	41.500 f-k	51.300 c-i
S_3V_5	34.533 k	40.100 l
S_3V_6	48.900 a-e	58.267 bc
S_3V_7	45.367 b-i	55.200 b-e
S_4V_1	42.867 d-j	54.333 b-f
S_4V_2	40.467 g-k	44.100 h-l
S_4V_3	41.800 e-j	45.500 g-l
S_4V_4	42.367 e-j	40.467 l
S_4V_5	48.500 a-f	46.867 f-l
S_4V_6	47.633 a-f	42.433 j-l
S_4V_7	45.633 b-i	51.800 c-h
S_5V_1	40.133 h-k	46.833 f-l
S_5V_2	39.167 i-k	45.033 g-l
S_5V_3	37.900 jk	41.067 kl
S_5V_4	38.567 i-k	46.633 f-l
S_5V_5	37.300 jk	42.933 j-l
S_5V_6	37.500 jk	39.933 l
S_5V_7	39.533 i-k	41.433 kl
$LSD_{(0.05)}$	**7.15**	**7.89**
CV (%)	**9.97**	**9.78**

Here, S_1= 0 dS m^{-1}, S_2= 3 dS m^{-1}, S_3= 6 dS m^{-1}, S_4= 9 dS m^{-1}, S_5= 12 dS m^{-1} and V_1= BARI Tomato 2, V_2= BARI Tomato 11, V_3= BARI Tomato 14, V_4= BARI Tomato 15, V_5= BARI Tomato 17, V_6= BARI Tomato 18, V_7= BARI Tomato 19

4.6 Effect on the number of branch plant^{-1} of tomato

4.6.1 Effect of salinity on the number of branch plant^{-1} of tomato

The effect of salinity on number of branch plant^{-1} is given in the Figure 11. The maximum number of branch plant^{-1} (3.71 and 4.71 at 40 DAT and 60 DAT, respectively) was found from S_1. The minimum number of branch plant^{-1} (2.57 and 2.71 at 40 DAT and 60 DAT, respectively) was obtained from S_5. Study referred that increase in salinity level results in decrease in number of branch per plant. Mazumder (2016) and Islam *et al*. (2011) reported that number of branches reduced by increasing salinity levels.

4.6.2 Effect of variety on number of branch plant^{-1} of tomato

Effect of variety on number of branch plant^{-1} is given in the Figure 12. At 40 DAT, the highest number of branch plant^{-1} (4.13) was reported from V_7 whereas at 60 DAT the highest number of branch plant^{-1} (4.73) was obtained from V_1 and it was statistically similar with V_2. Mazumder (2016) reported almost similar findings while experimenting on varietal response of tomato cultivars due to salinity.

4.6.3 Effect of salinity and variety interaction on number of branch plant^{-1} of tomato

Interaction effect of salinity and variety is placed on the Table 6. From the experiment it was found that the maximum number of branch plant^{-1} at 40 DAT and at 60 DAT was given by S_1V_7 (5.67) and S_1V_1 (7.0), respectively. The minimum number of branch plant^{-1} at 40 DAT was recorded from S_5V_5 (2.0) and at 60 DAT was shown by S_5V_3 (2.0).

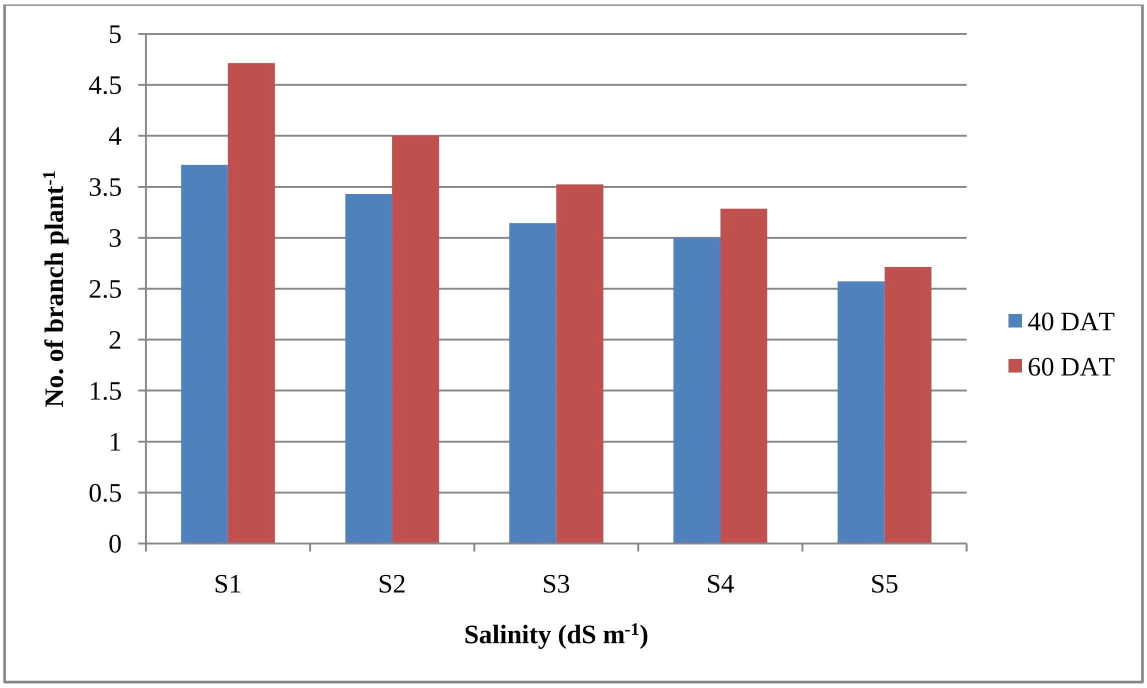

Figure 11. Effect of salinity on number of branch plant^{-1} of tomato

Here, S_1= 0 dS m^{-1}, S_2= 3 dS m^{-1}, S_3= 6 dS m^{-1}, S_4= 9 dS m^{-1}, S_5= 12 dS m^{-1}; $lsd_{0.05}$= 0.28 and 0.32 at 40 and 60 DAT, respectively

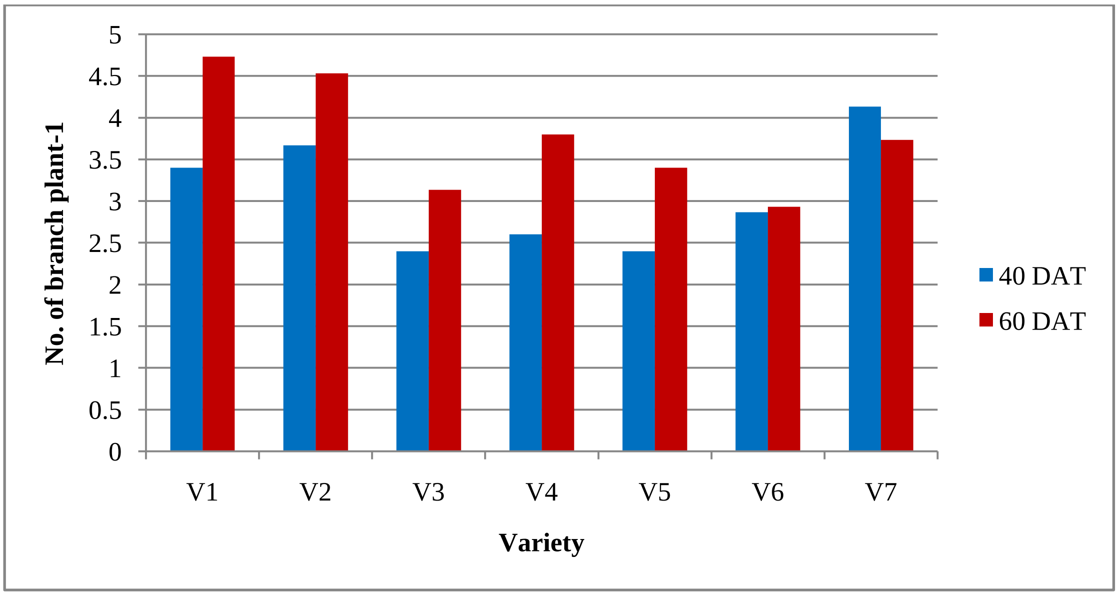

Figure 12. Effect of variety on number of branch plant^{-1} of tomato

Here, V_1= BARI Tomato 2, V_2= BARI Tomato 11, V_3= BARI Tomato 14, V_4= BARI Tomato 15, V_5= BARI Tomato 17, V_6= BARI Tomato 18, V_7= BARI Tomato 19; $lsd_{0.05}$= 0.33 and 0.38 at 40 and 60 DAT, respectively

Table 6. Combined effect of salinity and variety on number of branch plant^{-1} of tomato

Treatment Combinations	Number of branch plant^{-1}	
	40 DAT	**60 DAT**
S_1V_1	4.000 b-d	7.000 a
S_1V_2	4.000 b-d	5.000 b
S_1V_3	3.000 e-g	3.000 f-h
S V_4	3.000 e-g	5.000 b
S_1V_5	3.000 e-g	4.000 c-e
S_1V_6	3.333 d-f	4.000 c-e
S_1V_7	5.666 a	5.000 b
S_2V_1	3.666 c-e	5.000 b
S_2V_2	4.333 bc	5.000 b
S_2V_3	3.333 d-f	2.000 i
S_2V_4	3.000 e-g	3.000 f-h
S_2V_5	2.000 h	3.666 d-f
S_2V_6	3.000 e-g	4.333 b-d
S_2V_7	4.666 b	5.000 b
S_3V_1	2.666 f-h	4.333 b-d
S_3V_2	4.000 b-d	4.666 bc
S_3V_3	4.333 bc	2.666 g-i
S_3 V_4	2.000 h	4.000 c-e
S_3V_5	2.666 f-h	3.666 d-f
S_3V_6	3.000 efg	2.333 hi
S_3V_7	3.333 d-f	3.000 f-h
S_4V_1	3.333 d-f	3.666 d-f
S_4V_2	3.666 c-e	5.000 b
S_4V_3	3.000 e-g	2.333 hi
S_4V_4	3.000 e-g	3.666 d-f
S_4V_5	2.333 gh	3.000 f-h
S_4V_6	2.000 h	2.000 i
S_4V_7	4.000 b-d	3.333 e-g
S_5V_1	3.333 d-f	3.666 d-f
S_5V_2	2.333 gh	3.000 f-h
S_5V_3	2.000 h	2.000 i
S_5V_4	2.000 h	3.333 e-g
S_5V_5	2.000 h	2.666 g-i
S_5V_6	3.000 e-g	2.000 i
S_5V_7	3.000 e-g	2.333 hi
$LSD_{(0.05)}$	**0.74**	**0.85**
CV (%)	**14.42**	**14.41**

Here, S_1= 0 dS m^{-1}, S_2= 3 dS m^{-1}, S_3= 6 dS m^{-1}, S_4= 9 dS m^{-1}, S_5= 12 dS m^{-1} and V_1= BARI Tomato 2, V_2= BARI Tomato 11, V_3= BARI Tomato 14, V_4= BARI Tomato 15, V_5= BARI Tomato 17, V_6= BARI Tomato 18, V_7= BARI Tomato 19

4.7 Effect on days to first flowering (DAT) of tomato

4.7.1 Effect of salinity on days to first flowering (DAT) of tomato

Figure 13 shows the effect of salinity on days to first flowering (DAT). Salinity had no significant effect on days to first flowering (DAT). First flowering occurred at 35.24 (DAT) simultaneously at S_3 and S_4 treated pots whereas the last flower commencement day was recorded at 35.62 (DAT) simultaneously at S_5 and S_1 treated pots. Mazumder (2016) and Boamah *et al*. (2011) reported that effect of salinity levels on days to first flowering non-significant.

4.7.2 Effect of variety on days to first flowering (DAT) of tomato

Figure 14. shows the effect of variety on days to first flowering (DAT). From the experiment it was revealed that the first flowering occurred at 34.6 (DAT) at V_3 whereas, the last flowering occurred at 36.13 (DAT) at V_6. Here also variety had no significant effect on days to first flowering.

4.7.3 Effect of salinity and variety interaction on days to first flowering (DAT) of tomato

Data regarding the effect of salinity and variety interaction on days to first flowering (DAT) is placed on the Table 7. Treatment combinations had no statistically significant effect on days to first flowering. However, the first flowering date was recorded from S_3V_3 and S_4V_3 simultaneously at 34.00 (DAT). Whereas the last flower commencement day (36.33 DAT) was recorded from S_1V_6, S_2V_7 and S_5V_6.

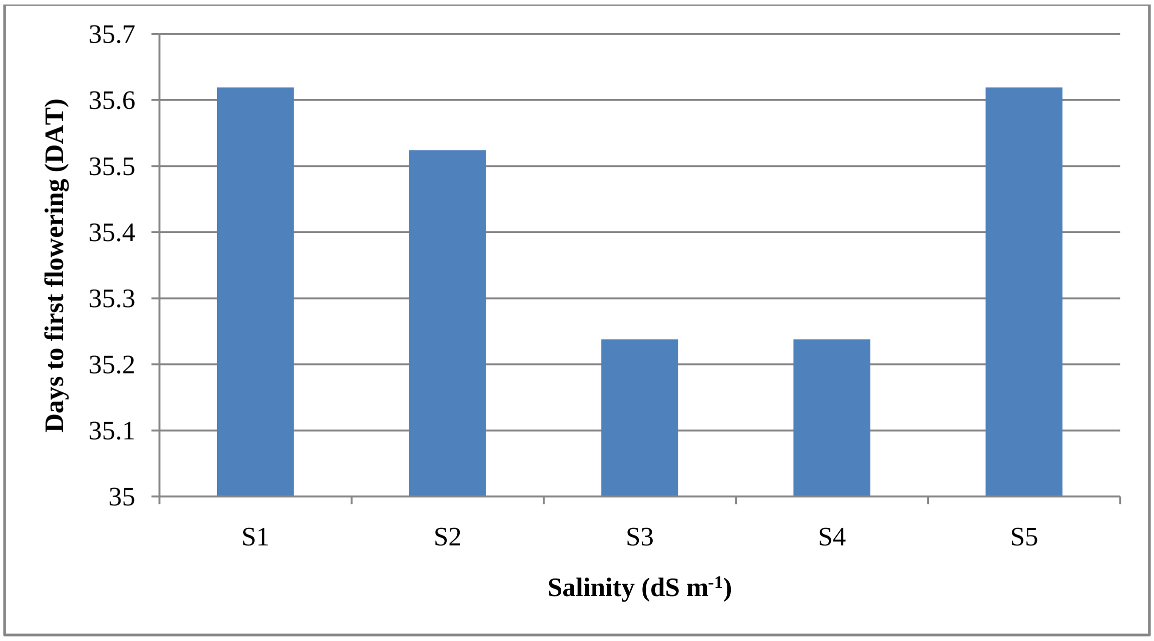

Figure 13. Effect of salinity on days to first flowering (DAT) of tomato

Here, S_1= 0 dS m^{-1}, S_2= 3 dS m^{-1}, S_3= 6 dS m^{-1}, S_4= 9 dS m^{-1}, S_5= 12 dS m^{-1}; $lsd_{0.05}$= 0.50

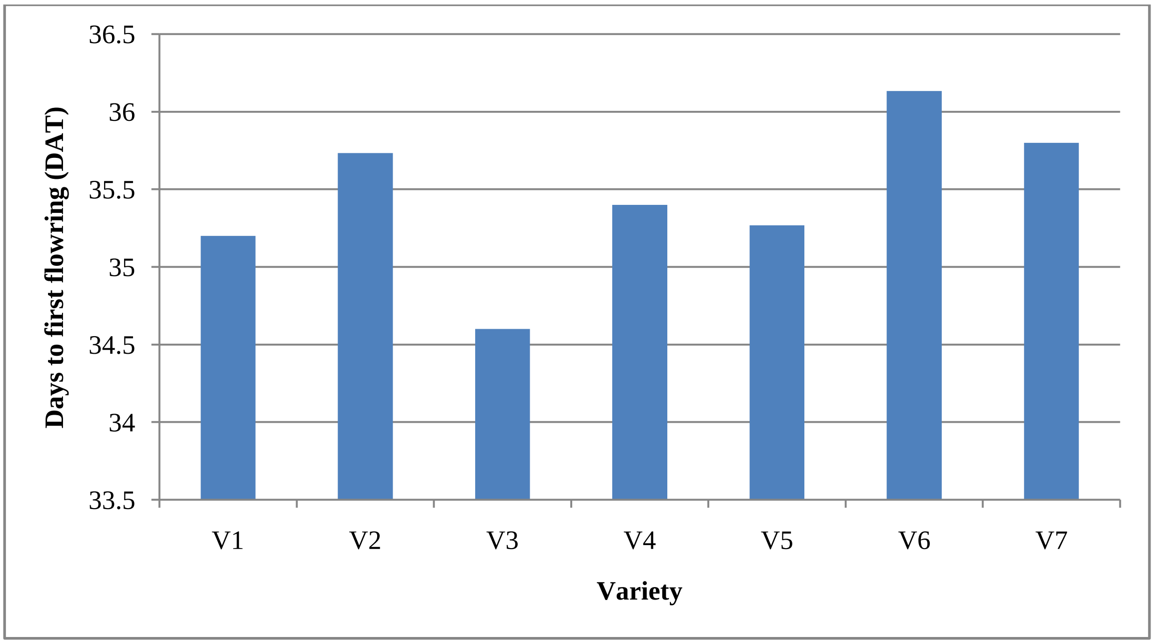

Figure 14. Effect of variety on days to first flowering (DAT) of tomato

Here, V_1= BARI Tomato 2, V_2= BARI Tomato 11, V_3= BARI Tomato 14, V_4= BARI Tomato 15, V_5= BARI Tomato 17, V_6= BARI Tomato 18, V_7= BARI Tomato 19; $lsd_{0.05}$= 0.59

Table 7. Combined effect of salinity and variety interaction on days to first flowering (DAT) of tomato

Treatment Combinations	Days to First Flowering (DAT)
S_1V_1	35.667 a-c
S_1V_2	36.000 ab
S_1V_3	35.667 a-c
S_1V_4	35.000 a-d
S_1V_5	35.000 a-d
S_1V_6	36.333 a
S_1V_7	35.667 a-c
S_2V_1	35.333 a-d
S_2V_2	36.000 ab
S_2V_3	34.333 cd
S_2V_4	35.667 a-c
S_2V_5	35.000 a-d
S_2V_6	36.000 ab
S_2V_7	36.333 a
S_3V_1	34.667 b-d
S_3V_2	35.667 a-c
S_3V_3	34.000 d
S_3V_4	35.667 a-c
S_3V_5	35.333 a-d
S_3V_6	36.000 ab
S_3V_7	35.333 a-d
S_4V_1	35.000 a-d
S_4V_2	35.333 a-d
S_4V_3	34.000 d
S_4V_4	35.000 a-d
S_4V_5	35.667 a-c
S_4V_6	36.000 ab
S_4V_7	35.667 a-c
S_5V_1	35.333 a-d
S_5V_2	35.667 a-c
S_5V_3	35.000 a-d
S_5V_4	35.667 a-c
S_5V_5	35.333 a-d
S_5V_6	36.333 a
S_5V_7	36.000 ab
$LSD_{(0.05)}$	**1.33**
CV (%)	**2.31**

Here, S_1= 0 dS m^{-1}, S_2= 3 dS m^{-1}, S_3= 6 dS m^{-1}, S_4= 9 dS m^{-1}, S_5= 12 dS m^{-1} and V_1= BARI Tomato 2, V_2= BARI Tomato 11, V_3= BARI Tomato 14, V_4= BARI Tomato 15, V_5= BARI Tomato 17, V_6= BARI Tomato 18, V_7= BARI Tomato 19

4.8 Effect on number of flower cluster plant^{-1} of tomato

4.8.1 Effect of salinity on number of flower cluster plant^{-1} of tomato

The effect of salinity on number of flower cluster plant^{-1} is shown in the Figure 15. S_1 was found to give the maximum number flower cluster plant^{-1} (2.67 and 10.09 at 40 DAT and 60 DAT, respectively). At both 40 DAT and 60 DAT, S_1 was statistically significant over all other levels of salinity. However, the minimum number of flower cluster plant^{-1} (2.33 and 7.04 at 40 DAT and 60 DAT, respectively) was obtained from S_5. Mazumder (2016) and Agrawal *et al*. (2005) resulted that flower cluster reduced by rising salinity level.

4.8.2 Effect of variety on number of flower cluster plant^{-1} of tomato

Effect of variety on number of flower cluster plant^{-1} is shown in the Figure16. In the experiment V_2 was reported be given the maximum number of flower cluster plant^{-1} (3.06 and 10.67 at 40 DAT and 60 DAT, respectively). On the other hand, at 40 DAT the minimum number of flower cluster palnt^{-1} (1.87) was reported from V_6 whereas, at 60 DAT V_3 and V_7 were simultaneously reported to give the minimum number of flower cluster plant^{-1} (6.27). At 40 DAT, V_2 had a statistically significant relationship with all other treatments except V_1. V_1 was statistically similar with V_2. However, at 60 DAT, V_2 was statistically similar with V_4. These results were similar with that of Islam *et al.* (2011) while carrying out an experiment to identify tomato varieties for salt tolerance.

4.8.3 Effect of salinity and variety on number of flower cluster plant^{-1} of tomato

Data regarding the combined effect of salinity and variety on number of flower cluster plant^{-1} is given in the Table 8. At both 40 DAT and 60 DAT, S_1V_2 was reported to provide the maximum number of flower cluster plant^{-1} (3.67 and 18.0 at 40 and 60 DAT, respectively). On the other hand, at 40 DAT, the minimum number of flower cluster palnt^{-1} (1.0) was obtained from S_5V_6 whereas, at 60 DAT the minimum number of flower clusters plant^{-1} (4.0) was recorded from S_5V_7 and S_5V_3, simultaneously.

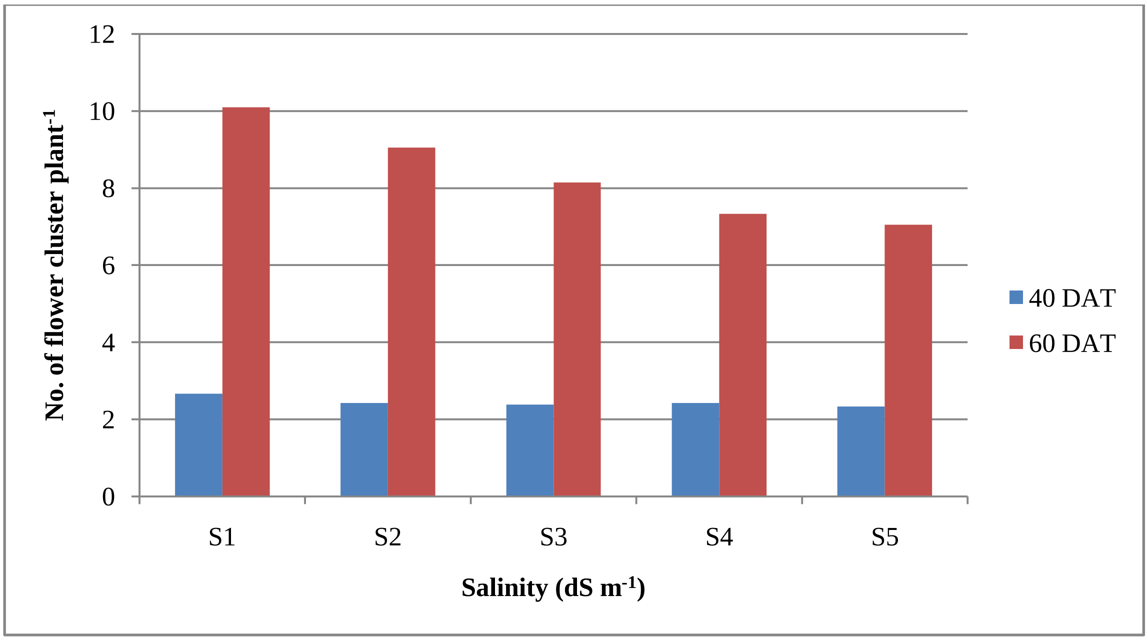

Figure 15. Effect of salinity on number of flower cluster plant^{-1} of tomato

Here, S_1= 0 dS m^{-1}, S_2= 3 dS m^{-1}, S_3= 6 dS m^{-1}, S_4= 9 dS m^{-1}, S_5= 12 dS m^{-1}; $lsd_{0.05}$= 0.23 and 0.69 at 40 and 60 DAT, respectively

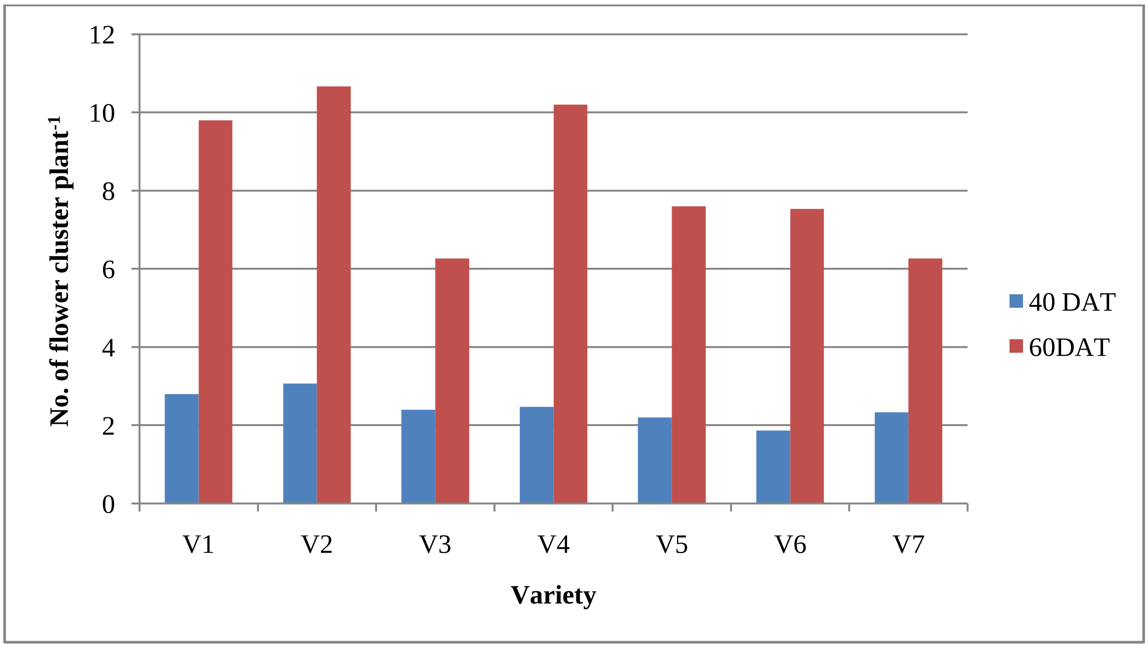

Figure 16. Effect of variety on number of flower cluster plant^{-1} of tomato

Here, V_1= BARI Tomato 2, V_2= BARI Tomato 11, V_3= BARI Tomato 14, V_4= BARI Tomato 15, V_5= BARI Tomato 17, V_6= BARI Tomato 18, V_7= BARI Tomato 19; $lsd_{0.05}$= 0.28 and 0.82 at 40 and 60 DAT, respectively

Table 8. Combined effect of salinity and variety interaction on number of flower cluster plant^{-1} of tomato

Treatment Combinations	Number of flower cluster plant^{-1}	
	40 DAT	60 DAT
S_1V_1	2.000 e	11.333 bc
S_1V_2	3.666 a	18.000 a
S_1V_3	2.666 cd	5.667 m-p
S_1V_4	3.000 bc	9.000 e-i
S_1V_5	2.333 de	8.667 f-j
S_1V_6	2.333 de	8.667 f-j
S_1V_7	2.666 cd	9.333 d-h
S_2V_1	2.333 de	10.667 b-e
S_2V_2	3.000 bc	10.667 b-e
S_2V_3	2.333 de	8.000 g-k
S_2V_4	2.333 de	11.000 b-d
S_2V_5	2.000 e	7.667 h-l
S_2V_6	2.000 e	9.000 e-i
S_2V_7	3.000 bc	6.333 k-n
S_3V_1	3.333 ab	9.667 c-g
S_3V_2	2.000 e	8.667 f-j
S_3V_3	3.000 bc	7.333 i-m
S_3V_4	2.000 e	9.333 d-h
S_3V_5	2.333 de	10.000 c-f
S_3V_6	2.000 e	8.000 g-k
S_3V_7	2.000 e	5.667 m-p
S_4V_1	2.666 cd	10.667 b-e
S_4V_2	3.666 a	9.000 e-i
S_4V_3	2.000 e	6.333 k-n
S_4V_4	2.333 de	12.000 b
S_4V_5	2.333 de	5.333 n-p
S_4V_6	2.000 e	4.333 op
S_4V_7	2.000 e	6.000 l-o
S_5V_1	3.666 a	6.667 k-n
S_5V_2	3.000 bc	7.000 j-n
S_5V_3	2.000 e	4.000 p
S_5V_4	2.666 cd	9.667 c-g
S_5V_5	2.000 e	6.333 k-n
S_5V_6	1.000 f	7.667 h-l
S_5V_7	2.000 e	4.000 p
$LSD_{(0.05)}$	**0.62**	**1.83**
CV (%)	**15.73**	**13.52**

Here, S_1= 0 dS m^{-1}, S_2= 3 dS m^{-1}, S_3= 6 dS m^{-1}, S_4= 9 dS m^{-1}, S_5= 12 dS m^{-1} and V_1= BARI Tomato 2, V_2= BARI Tomato 11, V_3= BARI Tomato 14, V_4= BARI Tomato 15, V_5= BARI Tomato 17, V_6= BARI Tomato 18, V_7= BARI Tomato 19

4.9 Effect on number of flower plant^{-1} of tomato

4.9.1 Effect of salinity on number of flower plant^{-1} of tomato

The effect of salinity on number of flower plant^{-1} is given in the Figure 17. S_1 was statistically significant over all other treatments at both 40 and 60 DAT. The highest number of flower plant^{-1} (1.04 and 17.76 at 40 DAT and 60 DAT, respectively) was counted from S_1 and it was followed by S_2. On the other hand, the lowest number of flower palnt^{-1} (0.048 and 13.714 at 40 DAT and 60 DAT, respectively) was counted from S_5. These outcomes were in line with that of El-mogy *et al*. (2018) and Rodriguez-Ortega *et al*. (2017). They also found fewer flower in higher concentration of salt treatments.

4.9.2 Effect of variety on number of flower plant^{-1} of tomato

Effect of variety on number of flower plant^{-1} is shown in the Figure 18. From the experiment, the maximum number of flower palnt^{-1} (1.27 and 26.87 at 40 DAT and 60 DAT, respectively) was recorded from V_2 and it was followed by V_1. On the other hand, the minimum number of flower plant^{-1} (0.00 and 7.80 at 40 DAT and 60 DAT, respectively) was obtained from V_3. Mazumder (2016) and Umar *et al.* (2018) reported that different variety commenced different number of flower.

4.9.3 Effect of salinity and variety interaction on number of flower plant^{-1} of tomato

The interaction effect of salinity and variety is placed on the Table 9. In the experiment, S_1V_2 was found to have the maximum number of flower plant^{-1} (2.67 and 34.00 at 40 DAT and 60 DAT, respectively). S_1V_2 was statistically similar with S_1V_1 at 40 DAT and at 60 DAT. It was absolutely significant over all other treatment combinations. The lowest number of flower plant^{-1} (0.00) at 40 DAT was found from a number of treatment combinations whereas the lowest number of flower plant^{-1} was recorded from S_5V_3 (5.00) at 60 DAT.

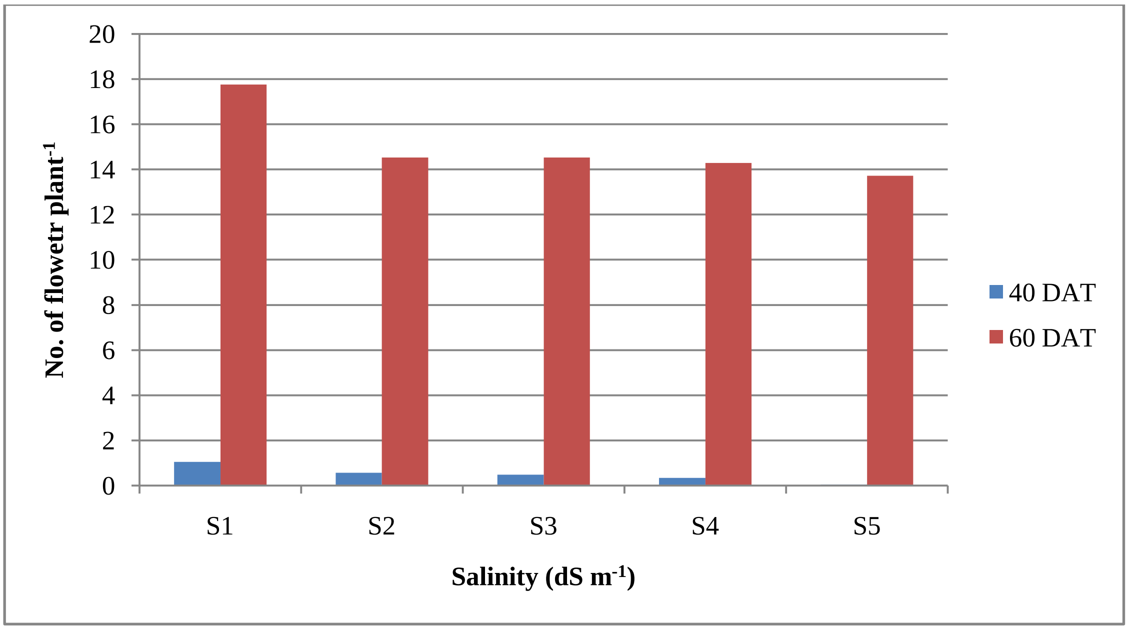

Figure 17. Effect of salinity number of flower plant^{-1} of tomato

Here, S_1= 0 dS m^{-1}, S_2= 3 dS m^{-1}, S_3= 6 dS m^{-1}, S_4= 9 dS m^{-1}, S_5= 12 dS m^{-1}; $lsd_{0.05}$= 0.28 and 2.06 at 40 and 60 DAT, respectively

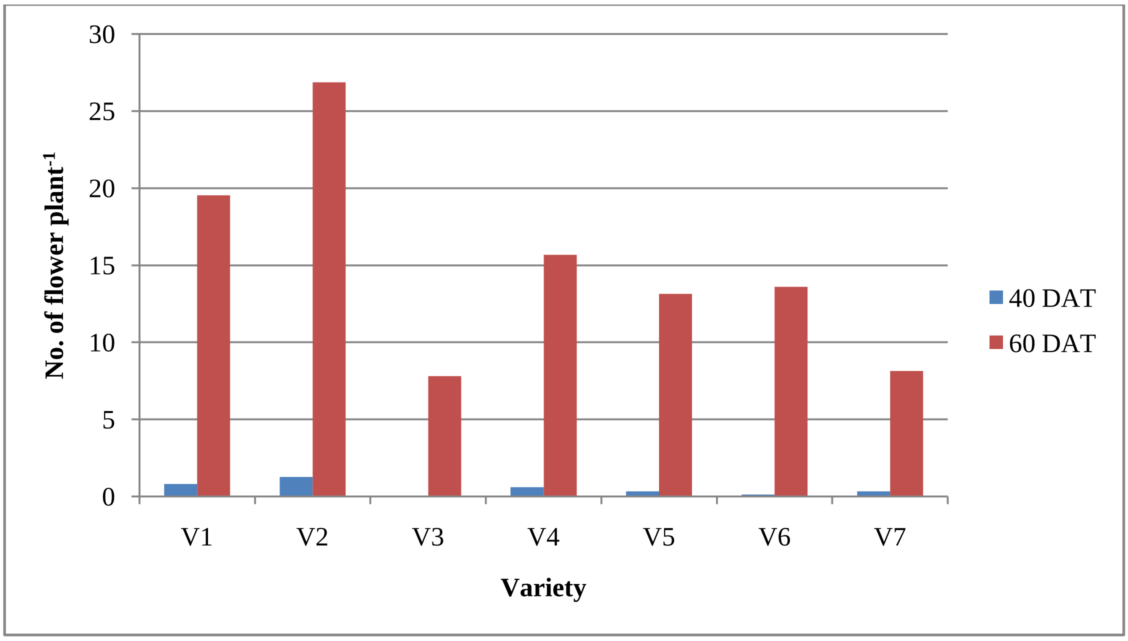

Figure 18. Effect of variety on number of flower plant^{-1} of tomato

Here, V_1= BARI Tomato 2, V_2= BARI Tomato 11, V_3= BARI Tomato 14, V_4= BARI Tomato 15, V_5= BARI Tomato 17, V_6= BARI Tomato 18, V_7= BARI Tomato 19; $lsd_{0.05}$= 0.33 and 2.43 at 40 and 60 DAT, respectively

Table 9. Combined effect of salinity and variety on number of flower plant^{-1} of tomato

Treatment Combinations	Number of flower plant^{-1}	
	40 DAT	**60 DAT**
S_1V_1	2.000 ab	25.000 b-d
S_1V_2	2.666 a	34.000 a
S_1V_3	0.000 e	7.333 n-q
S_1V_4	1.000 cd	11.667 j-o
S_1V_5	0.666 de	15.667 g-k
S_1V_6	0.333 de	17.333 f-i
S_1V_7	0.666 de	13.333 i-m
S_2V_1	1.000 cd	19.000 e-h
S_2V_2	1.666 bc	23.000 c-e
S_2V_3	0.000 e	7.333 n-q
S_2V_4	0.666 de	16.667 g-j
S_2V_5	0.333 de	14.667 g-k
S_2V_6	0.000 e	16.667 g-j
S_2V_7	0.333 de	6.667 o-q
S_3V_1	0.666 de	19.333 e-h
S_3V_2	1.000 cd	28.667 ab
S_3V_3	0.000 e	8.667 m-q
S_3V_4	0.666 de	20.000 d-g
S_3V_5	0.333 de	10.667 k-p
S_3V_6	0.333 de	9.000 l-q
S_3V_7	0.333 de	5.333 pq
S_4V_1	0.333 de	14.333 h-l
S_4V_2	0.666 de	22.667 c-f
S_4V_3	0.000 e	10.667 k-p
S_4V_4	0.666 de	17.667 e-i
S_4V_5	0.333 de	14.333 h-l
S_4V_6	0.000 e	14.000 h-m
S_4V_7	0.333 de	6.333 o-q
S_5V_1	0.000 e	20.000 d-g
S_5V_2	0.333 de	26.000 bc
S_5V_3	0.000 e	5.000 q
S_5V_4	0.000 e	12.333 i-n
S_5V_5	0.000 e	10.333 k-q
S_5V_6	0.000 e	11.000 k-o
S_5V_7	0.000 e	9.000 l-q
$LSD_{(0.05)}$	**0.74**	**5.45**
CV (%)	**92.24**	**22.38**

Here, S_1= 0 dS m^{-1}, S_2= 3 dS m^{-1}, S_3= 6 dS m^{-1}, S_4= 9 dS m^{-1}, S_5= 12 dS m^{-1} and V_1= BARI Tomato 2, V_2= BARI Tomato 11, V_3= BARI Tomato 14, V_4= BARI Tomato 15, V_5= BARI Tomato 17, V_6= BARI Tomato 18, V_7= BARI Tomato 19

4.10 Effect on fruit length (cm) of tomato

4.10.1 Effect of salinity on fruit length (cm) of tomato

The effect of salinity on fruit length (cm) is shown in the Figure 19. From the experiment it was found that salinity had no significant effect on fruit length (cm) irrespective of numerical variation among the treatments. The maximum fruit length of 4.50 cm was recorded from S_1 whereas; the minimum fruit length of 4.24 cm was obtained from S_5.

4.10.2 Effect of variety on fruit length (cm) of tomato

The effect of variety on fruit length (cm) is given in the Figure 20. The maximum fruit length of 4.91 cm was recorded from V_3. On the other hand, the minimum fruit length of 2.54 cm was given by V_2. V_3 was statistically similar with V_7, V_5 and V_1.

4.10.3 Effect of salinity and variety interaction on fruit length (cm) of tomato

Combined effect of salinity and variety on fruit length (cm) is placed on the Table 10. From the experiment it was found that the maximum fruit length 5.29 cm was given by S_1V_3. S_1V_3 was statistically significant with S_3V_7. On the other hand, the minimum fruit length of 2.43 cm was obtained from S_5V_2. The findings were in line with that of Mazumder (2016) during working with different salinity levels and tomato varieties.

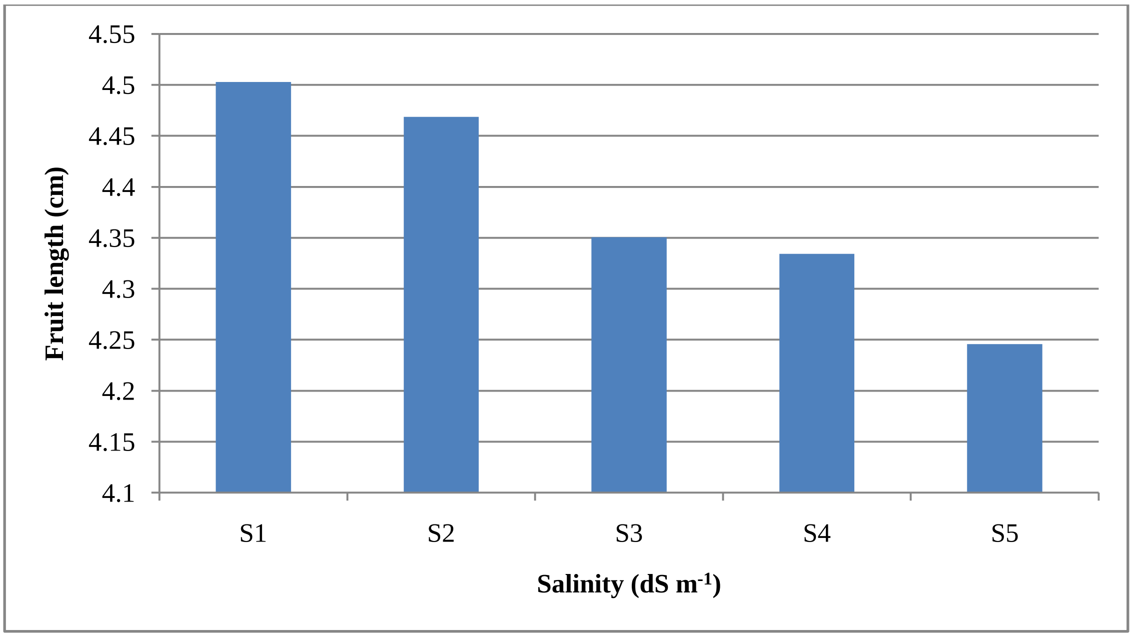

Figure 19. Effect of salinity on fruit length (cm) of tomato

Here, S_1= 0 dS m^{-1}, S_2= 3 dS m^{-1}, S_3= 6 dS m^{-1}, S_4= 9 dS m^{-1}, S_5= 12 dS m^{-1}; $lsd_{0.05}$= 0.29

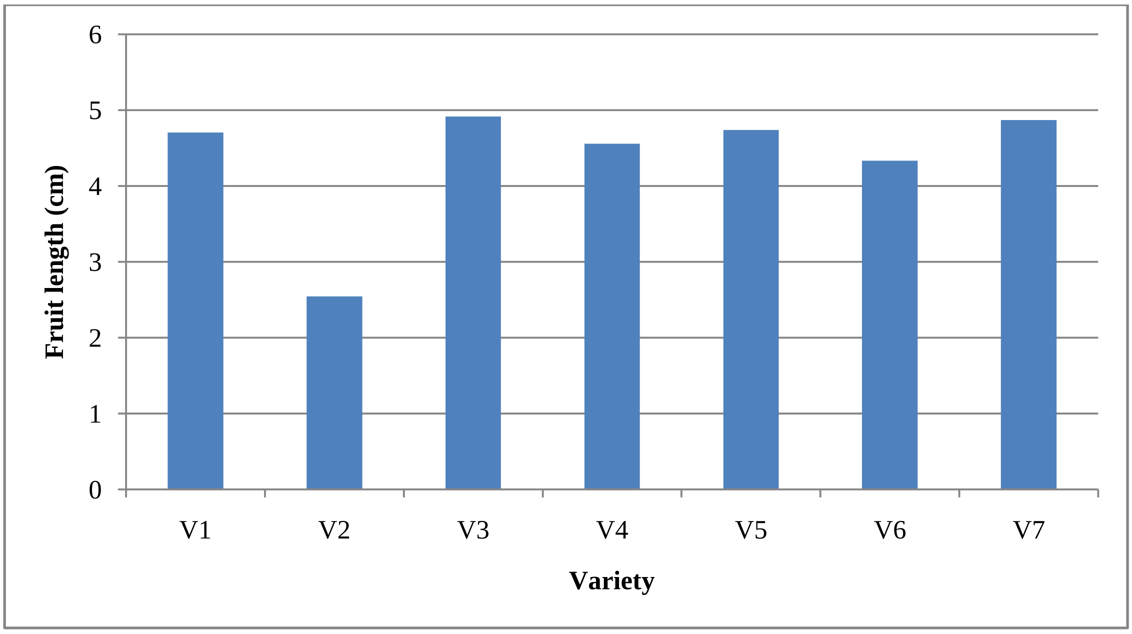

Figure 20. Effect of variety on fruit length (cm) of tomato

Here, V_1= BARI Tomato 2, V_2= BARI Tomato 11, V_3= BARI Tomato 14, V_4= BARI Tomato 15, V_5= BARI Tomato 17, V_6= BARI Tomato 18, V_7= BARI Tomato 19; $lsd_{0.05}$= 0.34

Table 10. Combined effect of salinity and variety on fruit length (cm) of tomato

Treatment Combinations	Fruit Length (cm)
S_1V_1	4.760 a-e
S_1V_2	2.420 g
S_1V_3	5.293 a
S_1V4	4.386 b-f
S_1V_5	5.060 a-d
S_1V_6	4.793 a-e
S_1V_7	4.806 a-e
S_2V_1	4.513 b-e
S_2V_2	2.480 g
S_2V_3	4.980 a-e
S_2V_4	4.893 a-e
S_2V_5	5.086 a-c
S_2V_6	4.393 b-f
S_2V_7	4.933 a-e
S_3V_1	4.560 a-e
S_3V_2	2.820 g
S_3V_3	4.900 a-e
S_3 V_4	4.400 b-f
S_3V_5	4.306 d-f
S_3V_6	4.240 ef
S_3V_7	5.113 ab
S_4V_1	5.040 a-d
S_4V_2	2.560 g
S_4V_3	4.860 a-e
S_4V_4	4.560 a-e
S_4V_5	4.320 c-f
S_4V_6	4.526 a-e
S_4V_7	4.586 a-e
S_5V_1	4.646 a-e
S_5V_2	2.433 g
S_5V_3	4.546 a-e
S_5V_4	4.553 a-e
S_5V_5	4.920 a-e
S_5V_6	3.706 f
S_5V_7	4.913 a-e
$LSD_{(0.05)}$	**0.76**
CV (%)	**10.78**

Here, S_1= 0 dS m^{-1}, S_2= 3 dS m^{-1}, S_3= 6 dS m^{-1}, S_4= 9 dS m^{-1}, S_5= 12 dS m^{-1} and V_1= BARI Tomato 2, V_2= BARI Tomato 11, V_3= BARI Tomato 14, V_4= BARI Tomato 15, V_5= BARI Tomato 17, V_6= BARI Tomato 18, V_7= BARI Tomato 19

4.11 Effect on fruit diameter (cm) of tomato

4.11.1 Effect of salinity on fruit diameter (cm) of tomato

Salinity had no significant effect on fruit diameter (cm). Figure 21 shows the Effect of salinity on fruit diameter (cm). In the experiment, the maximum fruit diameter (4.40 cm) was reported from S_1. On the other hand, the minimum fruit diameter (4.13 cm) was recorded from S_5.

4.11.2 Effect of variety on fruit diameter (cm) of tomato

Figure 22 shows the effect of variety on fruit diameter (cm). The maximum fruit diameter (4.65 cm) was obtained from V_5 whereas; the minimum fruit weight (1.86 cm) was recorded from V_2. V_5, V_3, V_1 and V_2 had a statistically significant to each other and rest of the treatments statistically similar.

4.11.3 Effect of salinity and variety interaction on fruit diameter (cm) of tomato

Combined effect of salinity and variety on fruit diameter (cm) is placed on the Table 11. From the experiment it was found that the maximum fruit diameter 7.18 cm was given by S_1V_5. S_1V_5 was statistically significant with a number of treatment combinations. On the other hand, the minimum fruit diameter 1.65 cm was obtained from S_5V_2. These findings were in line with that of Mazumder (2016) who also reported the similar pattern of fruit diameter (cm).

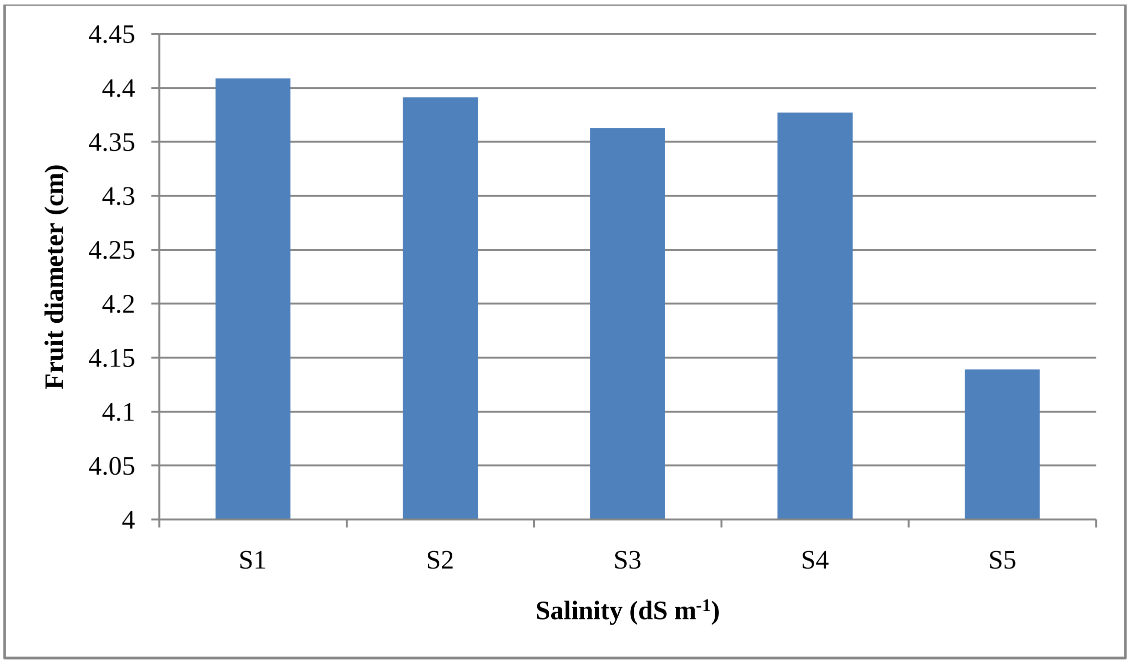

Figure 21. Effect of salinity on fruit diameter (cm) of tomato

Here, S_1= 0 dS m^{-1} , S_2= 3 dS m^{-1}, S_3= 6 dS m^{-1}, S_4= 9 dS m^{-1}, S_5= 12 dS m^{-1}; $lsd_{0.05}$= 0.28

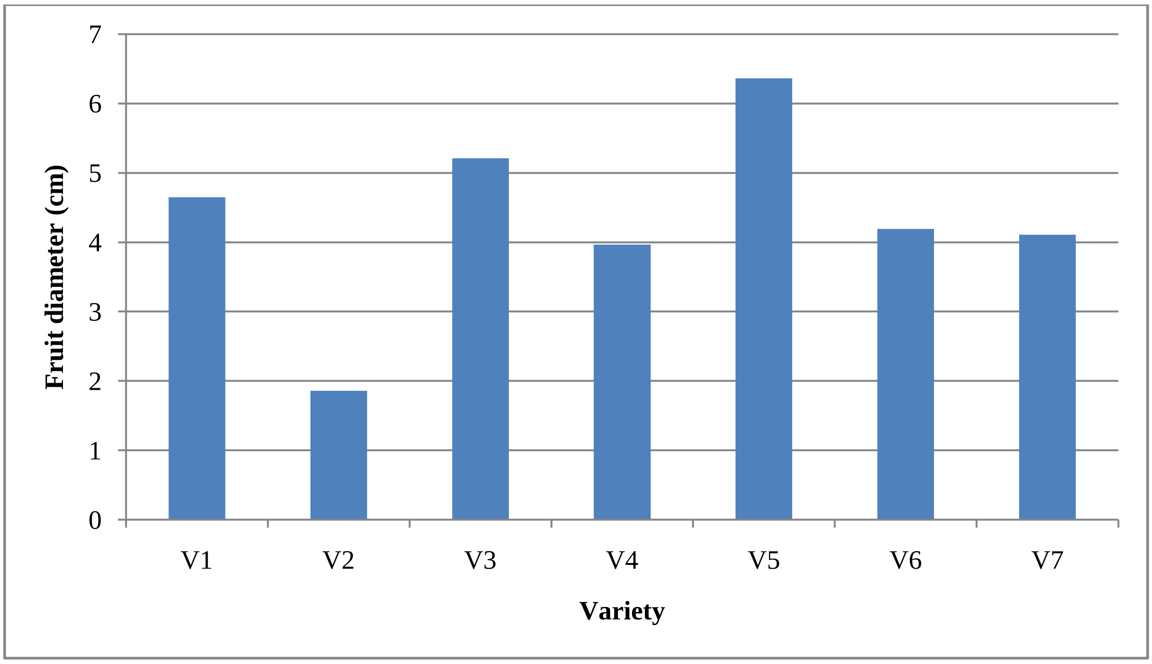

Figure 22. Effect of variety on fruit diameter (cm) of tomato

Here, V_1= BARI Tomato 2, V_2= BARI Tomato 11, V_3= BARI Tomato 14, V_4= BARI Tomato 15, V_5= BARI Tomato 17, V_6= BARI Tomato 18, V_7= BARI Tomato 19; $lsd_{0.05}$= 0.34

Table 11. Combined effect of salinity and variety on diameter (cm) of tomato

Treatment Combinations	Fruit Diameter (cm)
S_1V_1	4.086 h-k
S_1V_2	1.820 l
S_1V_3	5.266 cd
S_1V4	4.240 g-k
S_1V_5	7.181 a
S_1V_6	4.073 h-k
S_1V_7	4.193 h-k
S_2V_1	4.406 f-k
S_2V_2	1.926 l
S_2V_3	5.786 bc
S_2V_4	3.826 jk
S_2V_5	6.440 ab
S_2V_6	4.526 d-j
S_2V_7	4.100 h-k
S_3V_1	4.966 d-g
S_3V_2	1.973 l
S_3V_3	5.246 c-e
S_3 V_4	3.920 i-k
S_3V_5	6.160 b
S_3V_6	4.113 h-k
S_3V_7	4.160 h-k
S_4V_1	4.993 d-g
S_4V_2	1.926 l
S_4V_3	5.133 c-f
S_4V_4	3.966 i-k
S_4V_5	6.180 b
S_4V_6	4.493 e-k
S_4V_7	3.946 i-k
S_5V_1	4.786 d-h
S_5V_2	1.653 l
S_5V_3	4.620 d-i
S_5V_4	3.880 i-k
S_5V_5	5.853 bc
S_5V_6	3.760 k
S_5V_7	4.146 h-k
$LSD_{(0.05)}$	**0.76**
CV (%)	**10.81**

Here, S_1= 0 dS m^{-1}, S_2= 3 dS m^{-1}, S_3= 6 dS m^{-1}, S_4= 9 dS m^{-1}, S_5= 12 dS m^{-1} and V_1= BARI Tomato 2, V_2= BARI Tomato 11, V_3= BARI Tomato 14, V_4= BARI Tomato 15, V_5= BARI Tomato 17, V_6= BARI Tomato 18, V_7= BARI Tomato 19

4.12 Effect on number of fruits plant^{-1} of tomato

4.12.1 Effect of salinity on number of fruits plant^{-1} of tomato

The effect of salinity on number of fruits plant^{-1} is given in the Figure 23. The maximum number of fruits plant^{-1} (7.48 and 24.28 at 60 DAT and 80 DAT, respectively) was recorded from S_1. At 60 DAT, S_1, S_2 and S_3 were statistically similar to each other. However, at 80 DAT, S_1 produced maximum number of fruits per plant (24.286). On the other hand, the lowest number of fruits palnt^{-1} (5.09 and 18.76 at 60 DAT and 80 DAT, respectively) was obtained from S_5. Ahmed *et al.* (2017) and Zhai *et al*. (2015) reported that decrease in number of fruits plant^{-1} with an increase in salinity levels.

4.12.2 Effect of variety on number of fruits plant^{-1} of tomato

The effect of variety on number of fruits plant^{-1} is shown the Figure 24. The highest number of fruits plant^{-1} (11.87 and 46.44 at 60 DAT and 80 DAT, respectively) was recorded from V_2. On the other hand, the lowest number of fruits plant^{-1} (3.73 and 8.6 at 60 DAT and 80 DAT, respectively) was reported from V_3. Umar *et al.* (2018) reported that different variety produced different number of fruit.

4.12.3 Effect of salinity and variety interaction on number of fruits plant^{-1} of tomato

The combined effect of salinity and variety is placed on the Table 12. From the experiment it was found that the maximum number of fruits plant^{-1} (16.00 and 64.33 at 60 and 80 DAT, respectively) was given by S_1V_2 followed by S_2V_2 and S_3V_2. The minimum number of fruits palnt^{-1} (1.67 and 4.67 at 60 DAT and 80 DAT, respectively) was obtained from S_5V_3.

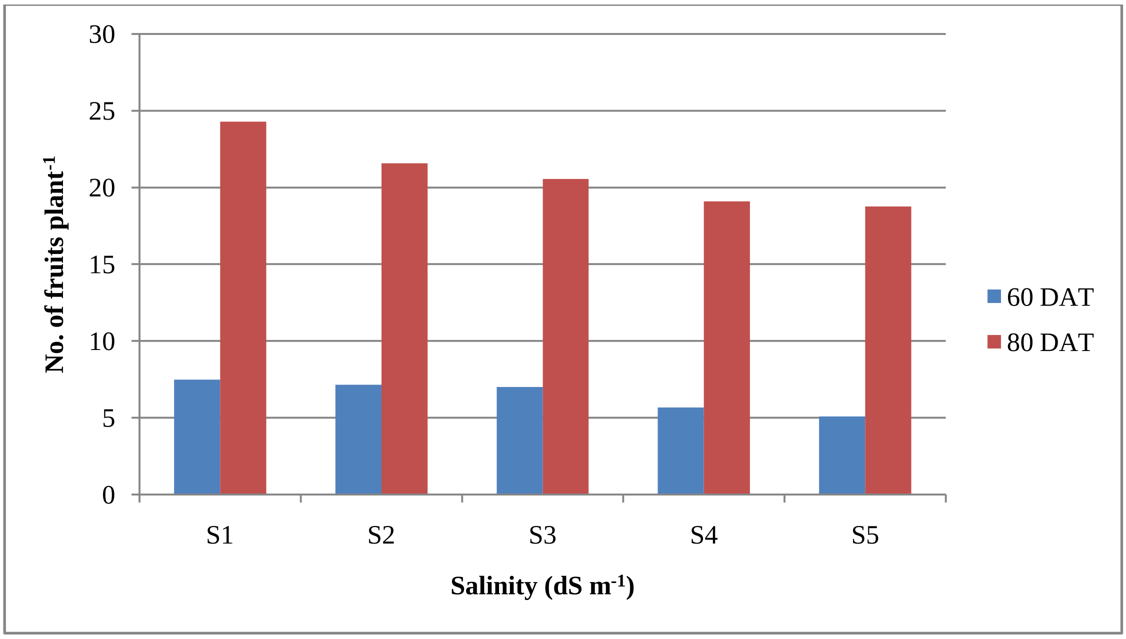

Figure 23. Effect of salinity on number of fruits plant^{-1} of tomato

Here, S_1= 0 dS m^{-1}, S_2= 3 dS m^{-1}, S_3= 6 dS m^{-1}, S_4= 9 dS m^{-1}, S_5= 12 dS m^{-1}; lsd$_{0.05}$= 0.54 and 1.51 at 60 and 80 DAT, respectively

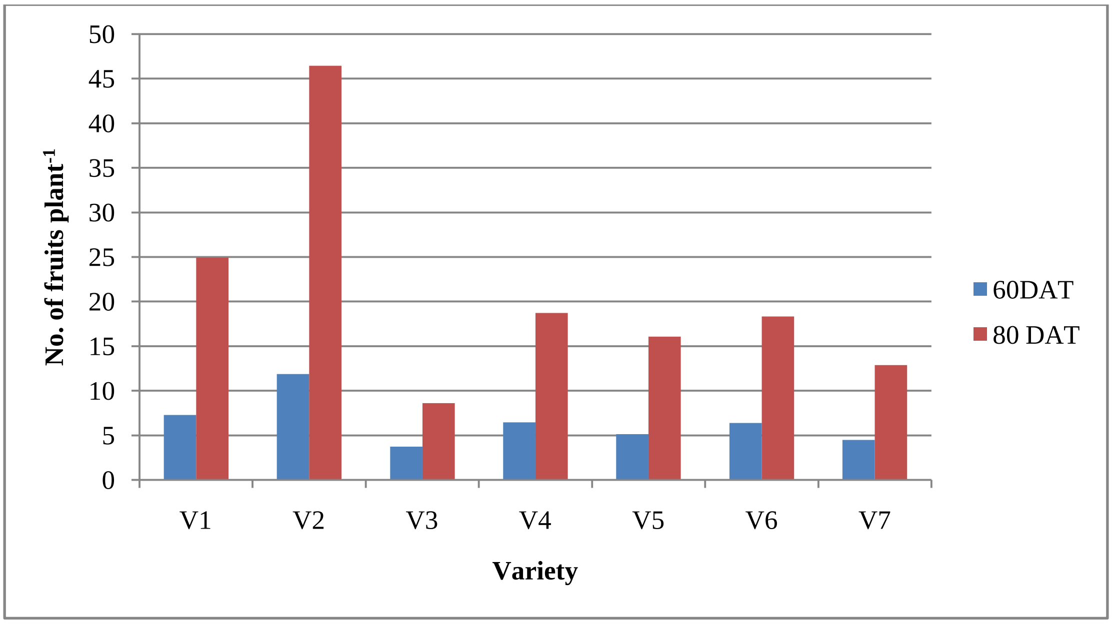

Figure 24. Effect of variety on number of fruits plant^{-1} of tomato

Here, V_1= BARI Tomato 2, V_2= BARI Tomato 11, V_3= BARI Tomato 14, V_4= BARI Tomato 15, V_5= BARI Tomato 17, V_6= BARI Tomato 18, V_7= BARI Tomato 19; lsd$_{0.05}$= 0.64 and 1.79 at 60 and 80 DAT, respectively

Table 12. Combined effect of salinity and variety on number of fruits plant^{-1} of tomato

Treatment Combinations	Number of fruits plant^{-1}	
	40 DAT	**60 DAT**
S_1V_1	8.000 e-g	25.000 de
S_1V_2	16.000 a	64.333 a
S_1V_3	4.667 j-l	13.667 k-n
S_1V_4	9.667n cd	15.000 j-n
S_1V_5	6.667 g-i	15.333j-m
S_1V_6	8.000 e-g	20.667 f-h
S_1V_7	5.333 i-l	16.000 j-l
S_2V_1	5.000 j-l	27.667 d
S_2V_2	12.333 b	44.000 b
S_2V_3	4.333 kl	6.667 p
S_2V_4	7.333 f-h	21.667 e-g
S_2V_5	7.333 f-h	21.667 e-g
S_2V_6	7.667 e-g	16.333 i-l
S_2V_7	6.000 h-j	13.000 l-n
S_3V_1	8.000 e-g	23.000 e-g
S_3V_2	10.000 c	47.220 b
S_3V_3	5.000 j-l	11.000 no
S_3V_4	5.000 j-l	19.000 g-j
S_3V_5	4.000 lm	17.000 h-l
S_3V_6	9.000 c-e	15.333 j-m
S_3V_7	2.667 mn	11.333 mn
S_4V_1	10.333 c	24.000 d-f
S_4V_2	8.333 d-f	37.000 c
S_4V_3	2.000 n	7.000 op
S_4V_4	5.667 i-k	20.667 f-h
S_4V_5	2.667 mn	15.333 j-m
S_4V_6	5.667 i-k	19.000 g-j
S_4V_7	5.000 j-l	13.000 l-n
S_5V_1	5.000 j-l	25.000 de
S_5V_2	12.667 b	39.667 c
S_5V_3	1.667 n	4.667 p
S_5V_4	4.667 j-l	17.333 h-k
S_5V_5	5.000 j-l	11.000 no
S_5V_6	2.000 n	20.333 f-i
S_5V_7	4.000 lm	11.000 no
$LSD_{(0.05)}$	**1.45**	**4.01**
CV (%)	**13.76**	**11.83**

Here, S_1= 0 dS m^{-1}, S_2= 3 dS m^{-1}, S_3= 6 dS m^{-1}, S_4= 9 dS m^{-1}, S_5= 12 dS m^{-1} and V_1= BARI Tomato 2, V_2= BARI Tomato 11, V_3= BARI Tomato 14, V_4= BARI Tomato 15, V_5= BARI Tomato 17, V_6= BARI Tomato 18, V_7= BARI Tomato 19

4.13 Effect on individual fruit weight (g) of tomato

4.13.1 Effect of salinity on individual fruit weight (g) of tomato

Figure 25. shows the effect of salinity on individual fruit weight (g). From the experiment it was reported that the maximum individual fruit weight of 62.62 (g) was obtained from S_1 and it was statistically similar with S_2 and S_3. The minimum individual fruit weight (53.66 g) was recorded from S_5. Excessive amounts of soluble salts in the root surroundings cause osmotic stress, which may result in trouble of the plant water relations, in the uptake and utilization of essential nutrients, and also in toxic ion accumulation Munns *et al*. (2002). Less water flow in the fruit caused reduction in fruit size Epheuvelink (2005) thus reduced the fruit weight Edris *et al*. (2012).

4.13.2 Effect of variety on individual fruit weight (g) of tomato

Effect of variety on individual fruit weight (g) is shown in the Figure26. The tomato varieties showed significant difference regarding individual fruit weight. The maximum individual fruit weight (116.75 g) was obtained from V_5 followed by V_3 whereas; the minimum individual fruit weight (7.21 g) was reported from V_2 in the experiment. This finding was very close to the findings of Mazumder (2016).

4.13.3 Effect of salinity and variety interaction on individual fruit weight (g) of tomato

Data regarding combined effect of salinity and variety interaction on individual fruit weight (g) is placed on the Table 13. The highest individual fruit weight (146.53 g) was obtained from S_1V_5 and it was statistically similar with S_2V_5. On the other hand, the lowest individual weight of fruit (6.80 g) was obtained from S_5V_2

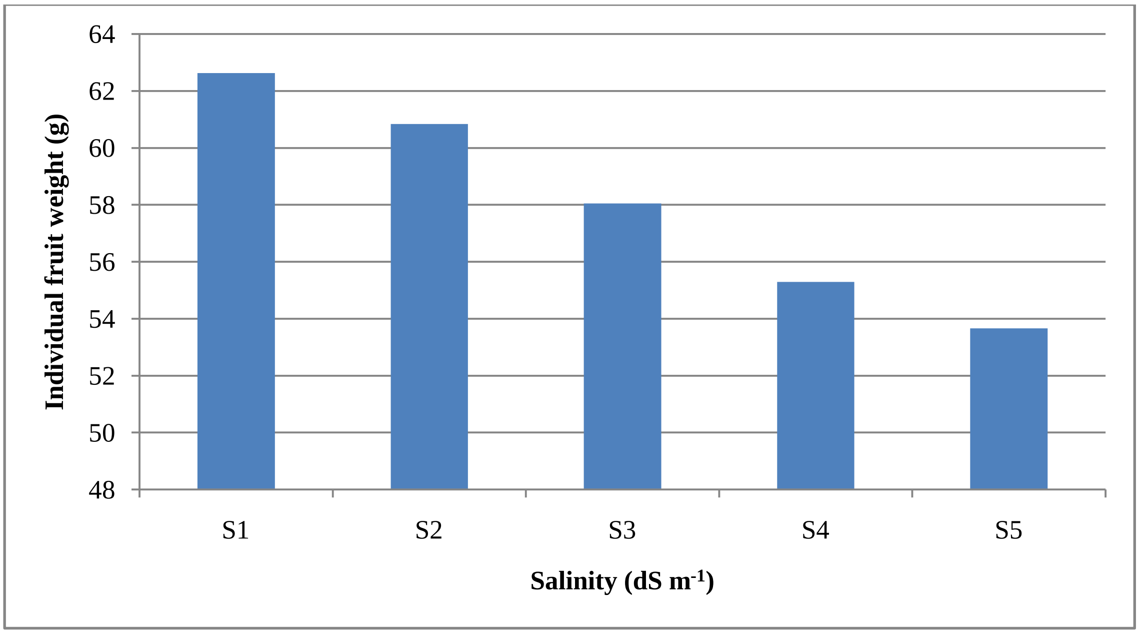

Figure 25. Effect of salinity on individual fruit weight (g) of tomato

Here, S_1= 0 dS m^{-1}, S_2= 3 dS m^{-1}, S_3= 6 dS m^{-1}, S_4= 9 dS m^{-1}, S_5= 12 dS m^{-1}; $lsd_{0.05}$= 5.62

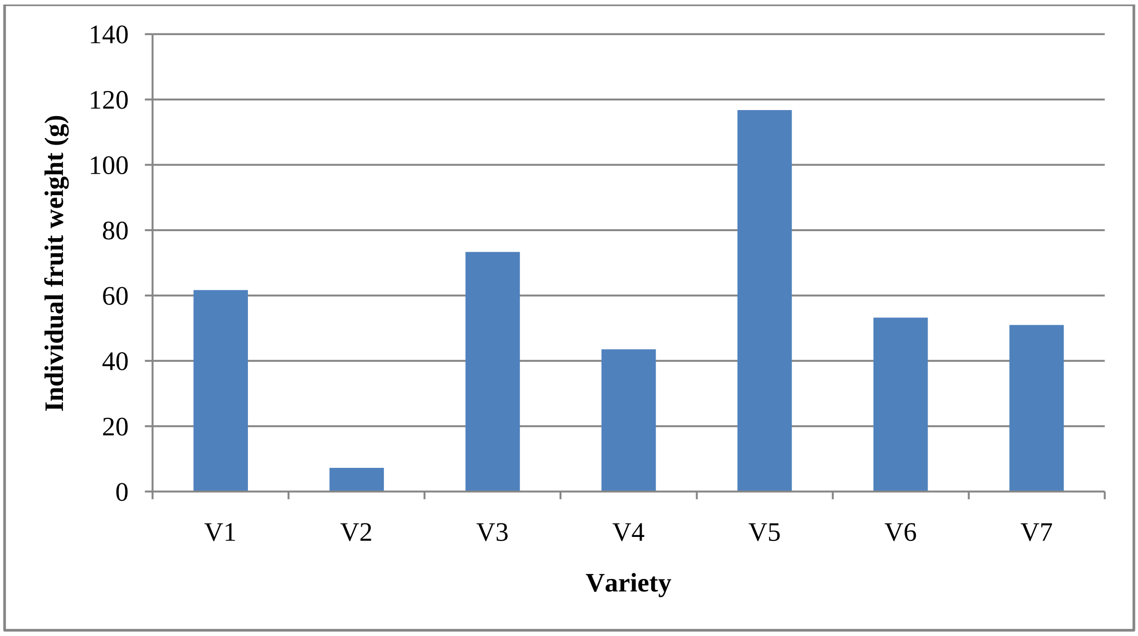

Figure 26. Effect of variety on individual fruit weight (g) of tomato

V_1= BARI Tomato 2, V_2= BARI Tomato 11, V_3= BARI Tomato 14, V_4= BARI Tomato 15, V_5= BARI Tomato 17, V_6= BARI Tomato 18, V_7= BARI Tomato 19; $lsd_{0.05}$= 6.65

Table 13. Combined effect of salinity and variety interaction on individual fruit weight (g) of tomato

Treatment Combinations	Average fruit weight (g)
S_1V_1	52.67 g-k
S_1V_2	7.47 m
S_1V_3	79.87 de
S_1V_4	52.53 g-k
S_1V_5	146.53 a
S_1V_6	47.00 i-l
S_1V_7	52.33 g-k
S_2V_1	57.60 f-j
S_2V_2	7.60 m
S_2V_3	84.60 d
S_2V_4	44.40 j-l
S_2V_5	121.13 b
S_2V_6	62.00 f-h
S_2V_7	49.33 h-l
S_3V_1	66.67 e-g
S_3V_2	7.27 m
S_3V_3	85.53 d
S_3V_4	36.13 l
S_3V_5	106.20 c
S_3V_6	43.87 j-l
S_3V_7	60.67 f-i
S_4V_1	71.60 d-f
S_4V_2	6.93 m
S_4V_3	68.27 ef
S_4V_4	42.70 kl
S_4V_5	105.40 c
S_4V_6	52.13 g-k
S_4V_7	40.93 kl
S_5V_1	59.67 f-i
S_5V_2	6.80 m
S_5V_3	48.50 h-l
S_5V_4	41.73 kl
S_5V_5	104.47 c
S_5V_6	61.07 f-i
S_5V_7	51.63 h-k
$LSD_{(0.05)}$	**14.87**
CV (%)	**15.71**

Here, S_1= 0 dS m^{-1}, S_2= 3 dS m^{-1}, S_3= 6 dS m^{-1}, S_4= 9 dS m^{-1}, S_5= 12 dS m^{-1} and V_1= BARI Tomato 2, V_2= BARI Tomato 11, V_3= BARI Tomato 14, V_4= BARI Tomato 15, V_5= BARI Tomato 17, V_6= BARI Tomato 18, V_7= BARI Tomato 19

4.14 Effect on fruit weight plant^{-1} (g) of tomato

4.14.1 Effect of salinity on fruit weight plant^{-1} (g) of tomato

The effect of salinity on fruit weight palnt^{-1} is shown in the Figure 27. From the experiment it was revealed that the S_1 gave the maximum fruit weight plant^{-1} (1003.00 g) whereas; the minimum fruit weight plant^{-1} (752.40 g) was recorded from S_5. S_1 was statistically similar with S_2. The result was similar with that of Shalhevet and Yaron (1973) who also reported the decrease in fruit weight plant^{-1} with an increase of salinity levels.

4.14.2 Effect of variety on fruit weight plant^{-1} (g) of tomato

Data regarding effect of variety on fruit weight plant^{-1} is shown on the Figure 28. In the experiment, it was revealed that V_1 showed the maximum fruit weight of 1235.90 g having a significant difference over all other varietal treatments. On the other hand, the minimum fruit weight plant^{-1} (333.1 g) was given by V_2 due to its smaller fruit size and it was statistically significant indicating no relationship with other treatments. The result was found to be similar with that of Siddiky *et al.* (2012) who conducted an experiment on screening of tomato varieties by exposure of different salinity levels.

4.14.3 Effect of salinity and variety interaction on fruit weight plant^{-1} (g) of tomato

Table 14. shows the data regarding the effect of salinity and variety interaction on fruit weight plant^{-1} (g). S_1V_1 had a significant difference over all other treatment combinations giving the maximum fruit weight plant^{-1} of 1640.9 g. On the other hand, S_5V_2 showed the minimum fruit weight plant^{-1} (271.1 g) having a non-significant relationship with a number of treatment combinations certainly due to its smaller fruit size. The result was in line with that of Islam *et al.* (2011) while conducting an experiment taking different salinity levels and tomato varieties.

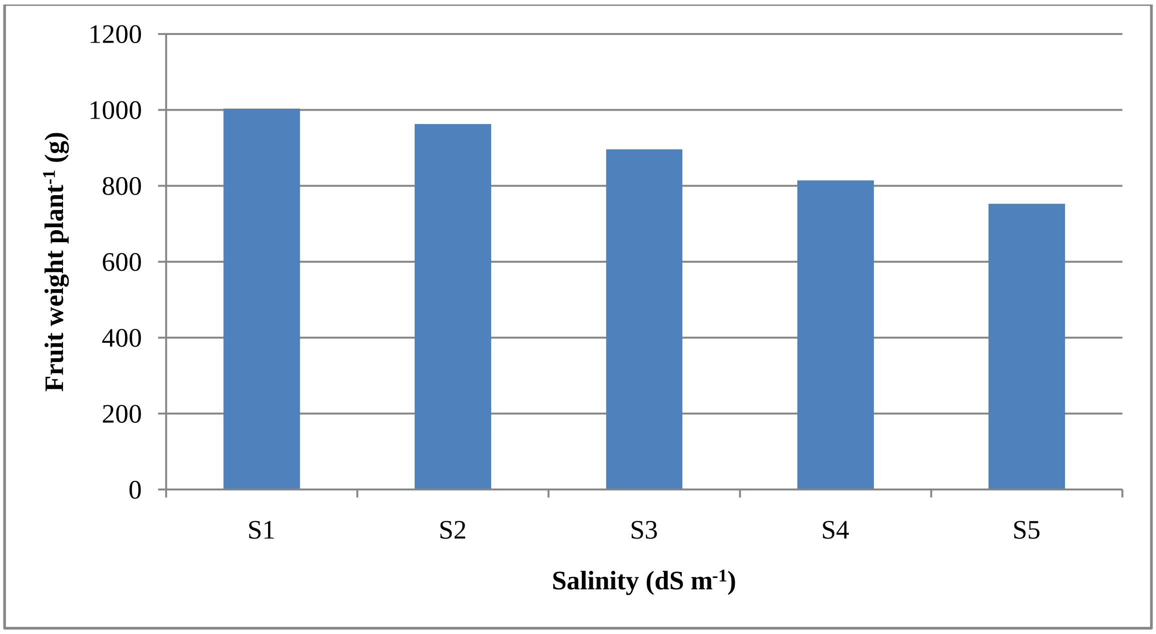

Figure 27. Effect of salinity on fruit weight plant^{-1} (g) of tomato

Here, S_1= 0 dS m^{-1}, S_2= 3 dS m^{-1}, S_3= 6 dS m^{-1}, S_4= 9 dS m^{-1}, S_5= 12 dS m^{-1}; $lsd_{0.05}$= 66.43

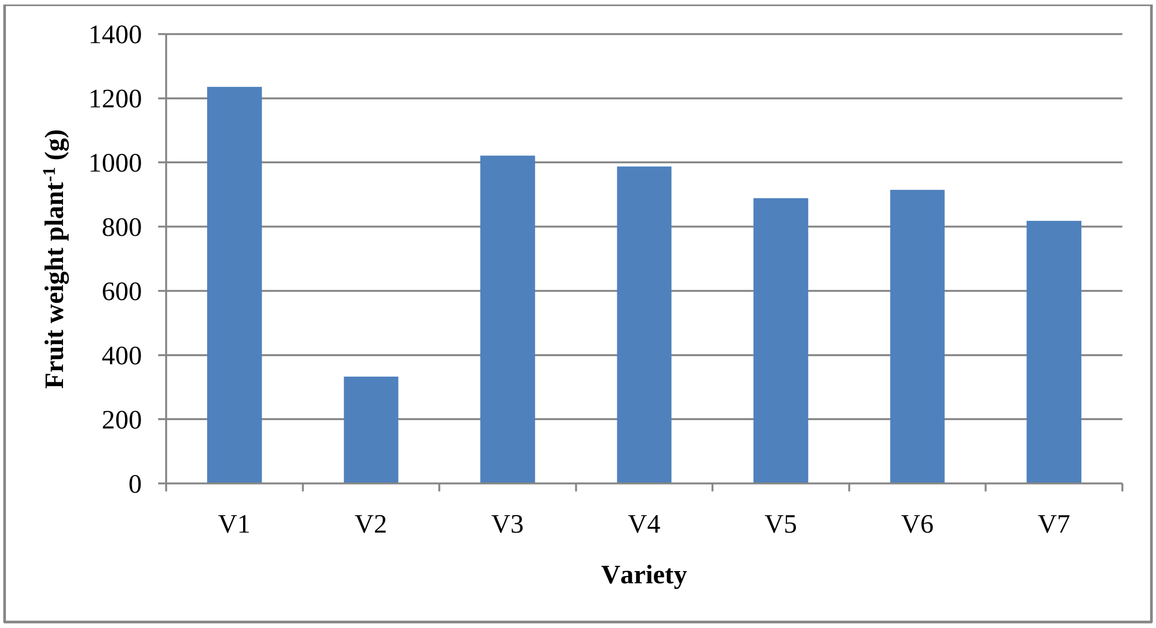

Figure 28. Effect of variety on fruit weight plant^{-1} (g) of tomato

Here, V_1= BARI Tomato 2, V_2= BARI Tomato 11, V_3= BARI Tomato 14, V_4= BARI Tomato 15, V_5= BARI Tomato 17, V_6= BARI Tomato 18, V_7= BARI Tomato 19; $lsd_{0.05}$= 78.60

Table 14. Combined effect of salinity and variety on fruit weight plant^{-1} (g) of tomato

Treatment Combinations	Fruit weight plant^{-1} (g)
S_1V_1	1640.9 a
S_1V_2	485.1 pq
S_1V_3	1131.7 c-e
S_1V_4	1179.7 c-e
S_1V_5	681.6 no
S_1V_6	1275.5 c
S_1V_7	840.6 j-n
S_2V_1	1462.8 b
S_2V_2	323.9 qr
S_2V_3	1034.6 d-h
S_2V_4	861.8 h-m
S_2V_5	1151.4 c-e
S_2V_6	899.6 g-l
S_2V_7	1004.8 e-j
S_3V_1	1123.7 c-f
S_3V_2	297.3 r
S_3V_3	1026.0 d-i
S_3V_4	1166.5 c-e
S_3V_5	1017.8 d-i
S_3V_6	856.4 i-n
S_3V_7	597.8 op
S_4V_1	1048.5 d-g
S_4V_2	288.4 r
S_4V_3	1181.3 cd
S_4V_4	776.4 k-n
S_4V_5	712.6 m-o
S_4V_6	748.2 l-o
S_4V_7	937.9 g-k
S_5V_1	903.5 g-l
S_5V_2	271.1 r
S_5V_3	732.8 l-o
S_5V_4	951.8 f-k
S_5V_5	883.0 g-m
S_5V_6	796.5 k-n
S_5V_7	710.9 m-o
$LSD_{(0.05)}$	**175.77**
CV (%)	**12.18**

Here, S_1= 0 dS m^{-1}, S_2= 3 dS m^{-1}, S_3= 6 dS m^{-1}, S_4= 9 dS m^{-1}, S_5= 12 dS m^{-1} and V_1= BARI Tomato 2, V_2= BARI Tomato 11, V_3= BARI Tomato 14, V_4= BARI Tomato 15, V_5= BARI Tomato 17, V_6= BARI Tomato 18, V_7= BARI Tomato 19

4.15 Effect on total soluble solids (%) of tomato

4.15.1 Effect of salinity on total soluble solids (%) of tomato

Salinity had a significant effect on total soluble solids. The effect of salinity on total soluble solids is shown in the Figure 29. Sarg *et al.* (1993) reported the increasing total soluble solids (%) with an increase in salinity levels due to osmotic process which is in line with this work. From the experiment it was found that S_5 showed the maximum total soluble solids (2.76 %). The minimum total soluble solid (1.64%) was recorded from S_1. Salinity stress also up-regulated sucrose transporter expression in source leaves and increased activity of ADP-glucose pyrophosphorylase (AGPase) in fruits during the early development stages. The results indicate that salinity stress enhanced carbohydrate accumulation as starch during the early development stages and it is responsible for the increase in soluble sugars in ripe fruit Yong-Gen Yin *et al*. (2009).

4.15.2 Effect of variety on total soluble solids (%) of tomato

The effect of variety on total soluble solids (%) is placed in the Figure 30. There was significant difference among the varieties. In the experiment, the highest total soluble solid (3.22%) was obtained from V_2 whereas the lowest total soluble solid (1.80%) was found from V_3. The result was in line with that of Ahmed *et al.* (2017) who carried out an experiment to find out the effect of different salinity level on tomato (*Lycopersicon esculentum*) production under climate change condition in Bangladesh.

4.15.3 Effect of salinity and variety interaction on total soluble solids (%) of tomato

Combined effect of salinity and variety on total soluble solids (%) is placed on the Table 15. From the experiment it was revealed that though there was numerical variation among treatment combinations and statistical difference existed among the treatment combinations. The maximum total soluble solid (5.70 %) was recorded from S_5V_2 whereas; the minimum (0.63%) was reported from S_1V_6. The result was almost similar with that of Alsadon *et al*. (2013) who worked with responsive gene screening and exploration of varieties responses to salinity tolerance in tomato.

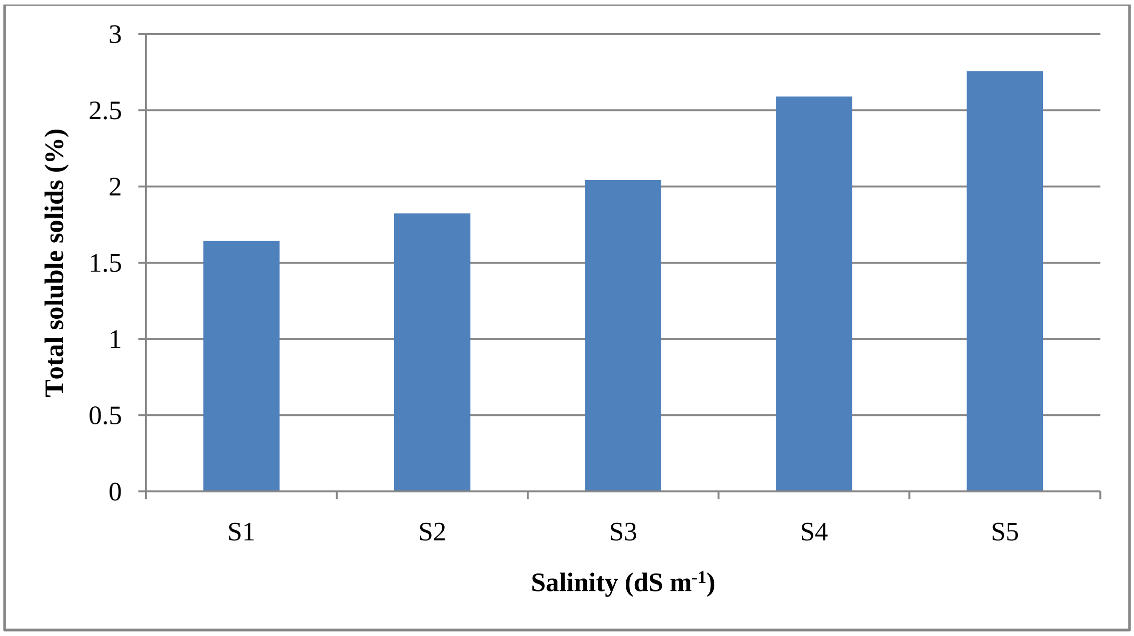

Figure 29. Effect of salinity on total soluble solids (%) of tomato

Here, S_1= 0 dS m^{-1}, S_2 = 3 dS m^{-1}, S_3= 6 dS m^{-1}, S_4= 9 dS m^{-1}, S_5= 12 dS m^{-1}; $lsd_{0.05}$= 0.14

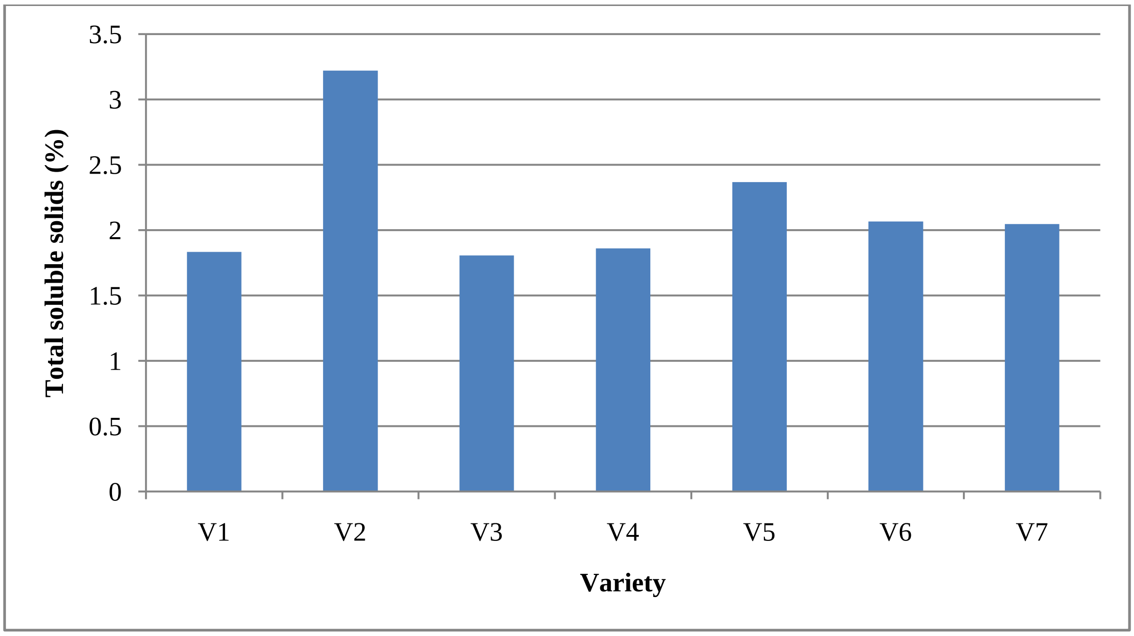

Figure 30. Effect of variety on total soluble solids (%) of tomato

Here, V_1= BARI Tomato 2, V_2= BARI Tomato 11, V_3= BARI Tomato 14, V_4= BARI Tomato 15, V_5= BARI Tomato 17, V_6= BARI Tomato 18, V_7= BARI Tomato 19; $lsd_{0.05}$= 0.16

Table 15. Combined effect of salinity and variety on total soluble solids (%) of tomato

Treatment Combinations	Total Soluble Solids (%)
S_1V_1	0.866 qr
S_1V_2	2.133 i-j
S_1V_3	2.166 ij
S_1V_4	2.233 i
S_1V_5	1.666 mn
S_1V_6	0.633 r
S_1V_7	1.800 k-n
S_2V_1	2.100 i-l
S_2V_2	1.133 pq
S_2V_3	1.266 op
S_2V_4	0.933 p-r
S_2V_5	3.200 de
S_2V_6	2.133 i-k
S_2V_7	1.966 i-m
S_3V_1	1.800 k-n
S_3V_2	2.733 fg
S_3V_3	1.766 l-n
S_3V_4	2.033 i-l
S_3V_5	1.866 j-n
S_3V_6	2.966 ef
S_3V_7	1.100 pq
S_4V_1	1.266 op
S_4V_2	4.400 b
S_4V_3	2.266 hi
S_4V_4	1.800 k-n
S_4V_5	3.466 cd
S_4V_6	1.033 pq
S_4V_7	2.600 gh
S_5V_1	3.100 e
S_5V_2	5.700 a
S_5V_3	1.566 no
S_5V_4	2.300 hi
S_5V_5	1.633 mn
S_5V_6	3.566 c
S_5V_7	2.733 fg
$LSD_{(0.05)}$	**0.37**
CV (%)	**10.34**

Here, S_1= 0 dS m^{-1}, S_2 = 3 dS m^{-1}, S_3= 6 dS m^{-1}, S_4= 9 dS m^{-1}, S_5= 12 dS m^{-1} and V_1= BARI Tomato 2, V_2= BARI Tomato 11, V_3= BARI Tomato 14, V_4= BARI Tomato 15, V_5= BARI Tomato 17, V_6= BARI Tomato 18, V_7= BARI Tomato 19

CHAPTER V

SUMMARY AND CONCLUSION

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SUMMARY AND CONCLUSION

Tomato (*Solanum lycopersicum* L.) belongs to the Solanaceae family is one of the important vegetable in Bangladesh and total production is low as compared to total demand. Large amounts of land in southern region of Bangladesh remain uncultivable due to high level of soil salinity. The affected areas of Bangladesh are increasing rapidly. To overcome the salinity problem saline soils can be used to grow salt-tolerant plants. Thus, development of salt tolerant crops is a key global agricultural goal. Tomato plant is moderately tolerant to salinity stress but exact salinity level may depend on cultivar sensitivity.

An experiment was conducted at the Horticulture Farm in Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period of November 2018 to March 2019 to study the effect of five salinity levels (S_1= 0 dS m^{-1} ; S_2= 3 dS m^{-1} ; S_3= 6 dS m^{-1} ; S_4= 9 dS m^{-1} ; S_5= 12 dS m^{-1}) on seven tomato varieties (V_1= BARI Tomato 2; V_2= BARI Tomato 11; V_3= BARI Tomato 14; V_4= BARI Tomato 15; V_5= BARI Tomato 17; V_6= BARI Tomato 18; V_7= BARI Tomato 19). There were 35 (5×7) treatment combinations on total. The experiment was laid out in Randomized Complete Block Design with three replications. After seedling transplanting, a number of intercultural operations were performed for better growth and development of plant. Data for different growth and yield parameters were taken as per rule. Data were analyzed statistically to find out the significance of treatments on growth and yield attributes of tomato.

Exposure of different levels of salinity resulted a decrease in plant height (cm), number of leaf plant^{-1}, leaf area (cm^2), leaf chlorophyll content (SPAD Unit), number of branch plant^{-1}, stem base diameter (cm), number of flower cluster plant^{-1}, number of flower plant^{-1}, fruit length (cm), fruit diameter (cm), number of fruits plant^{-1}, individual fruit weight (g) and fruit weight plant^{-1} (g). On the other hand, total soluble solid (%) was increased with the increase in salinity levels. However, in case of days to first flowering, exposure to higher level of salinity resulted in early commencement of flower in two salinity treated pots. After all, gradual increase in salinity levels resulted in negative effect in growth and yield attributes.

Growth and yield attributes of tomato varied with the variation in genotypes. BARI Tomato 11 (V_2) showed best result in terms of plant height (cm), stem base diameter (cm), number of flower cluster plant^{-1}, number of flower plant^{-1}, number of fruits plant^{-1} and total soluble solids. However, BARI Tomato 11 (V_2) showed the lowest result in terms of fruit length (cm), fruit diameter (cm), individual fruit weight (g) and fruit weight plant^{-1} (g) mainly due to its smaller fruit size. Number of leaf plant^{-1} and number of branch plant^{-1} at 40 DAT was shown the highest in V_7 (BARI Tomato 19). In case of leaf area plant^{-1} (cm^2), the maximum leaf area was recorded from V_3 (BARI

Tomato 14) and V_4 (BARI Tomato 15) at 40 DAT and 60 DAT, respectively. The highest fruit length (cm) was also recorded from V_3 (BARI Tomato 14). However, the maximum leaf chlorophyll content (SPAD Unit) and number of branch plant^{-1} was recorded from V_1 (BARI Tomato 2) at 60 DAT. The maximum fruit weight plant^{-1} (g) was also recorded from V_1 (BARI Tomato 2). V_6 (BARI Tomato 18) performed the best in case of leaf chlorophyll content (SPAD Unit) at 40 DAT and days to first flowering. In case of fruit diameter (cm) and individual fruit weight (g) V_5 (BARI Tomato 2) showed the highest result.

Interaction of salinity and variety also affected the growth and yield. In the present study, S_1V_2 was recorded to provide the maximum plant height (cm), stem base diameter at 60 DAT and 80 DAT, number of flower cluster plant^{-1}, number of flower plant^{-1} and number of fruits plant^{-1}. S_1V_7 was reported to show the maximum number of leaf plant^{-1}, leaf area plant^{-1} (cm^2) and number of branch plant^{-1}. The maximum stem base diameter at 40 DAT, leaf chlorophyll content at 60 DAT and fruit length was given by $S_1V_{3.}$ On the other hand, the maximum fruit diameter (cm) and individual fruit weight (g) was recorded from S_1V_5. The first flowering date was recorded from S_3V_3 and S_4V_3, simultaneously at 34.00 (DAT). Whereas, the last flower commencement day (36.33 DAT) was recorded from S_1V_6, S_2V_7 and S_5V_6. The highest fruit weight plant^{-1} (g) was obtained from S_1V_1 and the lowest one was recorded from S_5V_2 certainly due to its smaller fruit size and high level of salt concentration. The maximum total soluble solid (%) was also obtained from S_5V_2.

Considering, the above results it may be concluded that increase in salinity levels result in decrease of quality and quantity in most of the cases. Among the varieties used in the experiment, BARI Tomato 11 (V_2) is the best performer regarding the most of the important parameters but we cannot refer this regarding yield as yield is the ultimate goal for our farmer. On the other hand, in case of yield BARI Tomato 2 was found best over other varieties. Interaction S_1V_2 and S_1V_1 may be referred as the best treatment combinations.

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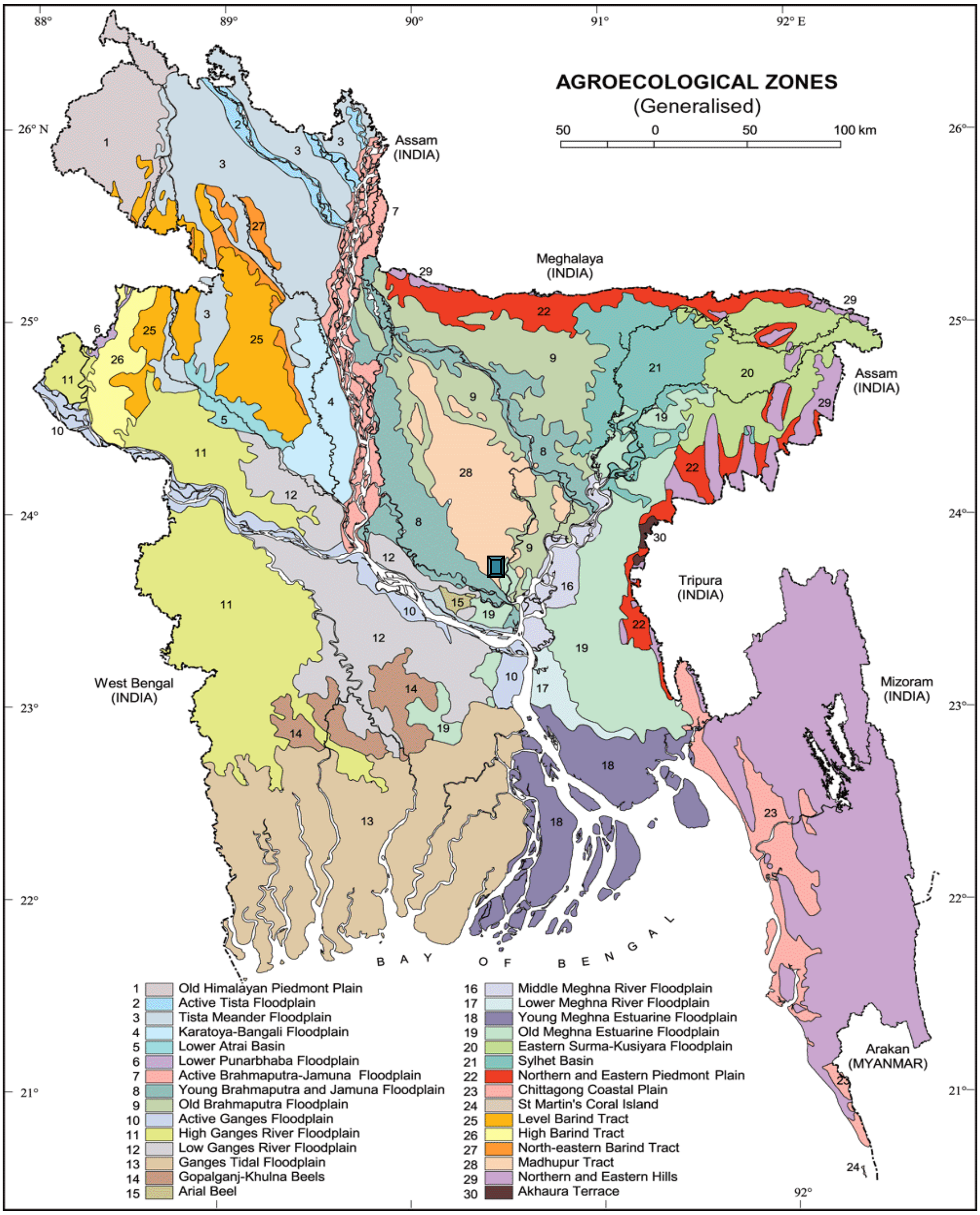
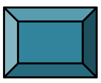
APPENDICES

Appendix I. Map showing the experimental site under the study



 The experimental site under study

Appendix II: Monthly records of air temperature, relative humidity and rainfall during the period from November 2018 to March 2019

Month	RH (%)	Air temperature (^0C)			Rainfall (mm)
		Max.	Min.	Mean	
November	65	32.0	19.0	26.0	35
December	74	29	15	22	15
January	68	26	10	18	7
February	57	15	24	25.42	25
March	57	34	16	28	65

(Source: timeanddate.com)

Appendix III: Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka

A. Morphological characteristics of the experimental field

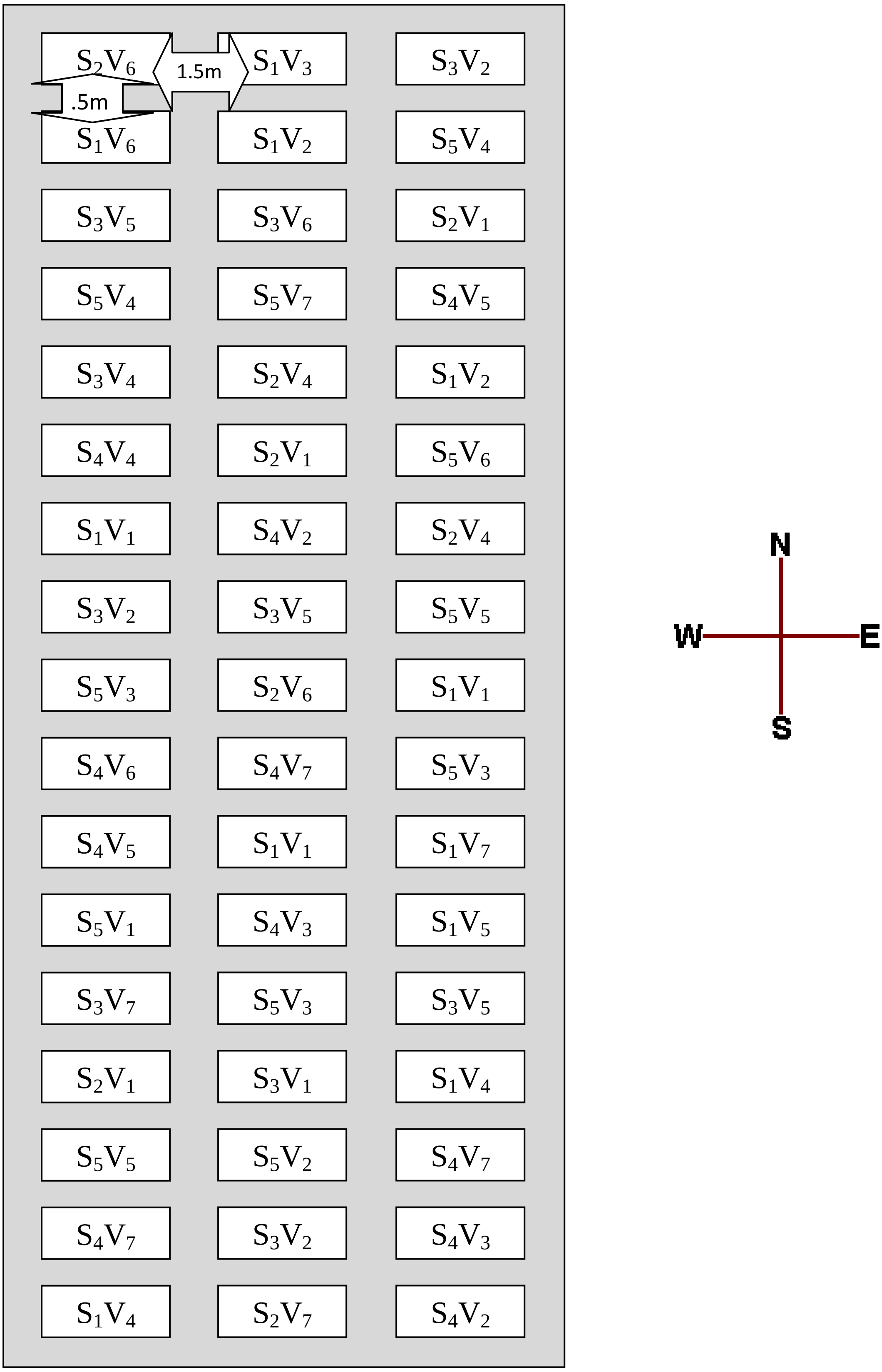
Morphological features	Characteristics
Location	Horticulture Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not Applicable

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of initial soil

Characteristics	Value
Partical size analysis % Sand	27
%Silt	43
% Clay	30
Textural class	Silty Clay Loam (ISSS)
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.1
Available S (ppm)	45

Appendix IV: Layout of the experiment



Layout Cont'd

S_3V_1	S_2V_3	S_2V_3
S_5V_7	S_4V_5	S_2V_7
S_2V_4	S_5V_1	S_4V_4
S_5V_2	S_5V_5	S_3V_4
S_4V_1	S_5V_4	S_3V_7
S_1V_2	S_2V_5	S_1V_3
S_3V_3	S_1V_6	S_4V_6
S_2V_3	S_4V_6	S_5V_2
S_4V_3	S_3V_3	S_3V_3
S_1V_5	S_3V_7	S_2V_6
S_1V_7	S_1V_4	S_4V_1
S_1V_3	S_1V_7	S_2V_5
S_3V_6	S_4V_1	S_2V_2
S_2V_7	S_1V_5	S_3V_6
S_5V_6	S_5V_6	S_1V_6
S_2V_5	S_2V_2	S_5V_7
S_4V_2	S_3V_4	S_3V_1
S_2V_2	S_4V_4	S_5V_1

Appendix V: Analysis of variance of plant height (cm)

A. Plant height (cm) at 40 DAT

Source	DF	SS	MS	F	P
Rep	2	85.77	42.886		
Salinity	4	151.01	37.752	1.97	0.1092
Variety	6	1161.18	193.530	10.09	0.0000
Salinity*Variety	24	1162.72	48.447	2.53	0.0015
Error	68	1304.23	19.180		
Total	104	3864.91			

Grand Mean 39.971
CV 10.96

B. Plant height (cm) at 60 DAT

Source	DF	SS	MS	F	P
Rep	2	5.85	2.924		
Salinity	4	391.45	97.864	2.24	0.0733
Variety	6	3186.74	531.124	12.18	0.0000
Salinity*Variety	24	3044.57	126.857	2.91	0.0003
Error	68	2965.49	43.610		
Total	104	9594.10			

Grand Mean 64.161
CV 10.29

C. Plant height (cm) at 80 DAT

Source	DF	SS	MS	F	P
Rep	2	1.54	0.771		
Salinity	4	263.22	65.804	1.43	0.2348
Variety	6	3571.62	595.270	12.90	0.0000
Salinity*Variety	24	2827.38	117.807	2.55	0.0013
Error	68	3137.79	46.144		
Total	104	9801.55			

Grand Mean 71.332
CV 9.52

Appendix VI: Analysis of variance of stem base diameter (cm)

A. Stem base diameter (cm) at 40 DAT

Source	DF	SS	MS	F	P
Rep	2	0.03105	0.01552		
Salinity	4	0.05181	0.01295	1.36	0.2580
Variety	6	0.48362	0.08060	8.45	0.0000
Salinity*Variety	24	0.24019	0.01001	1.05	0.4227
Error	68	0.64895	0.00954		
Total	104	1.45562			

Grand Mean 0.6419
CV 15.22

B. Stem base diameter (cm) at 60 DAT

Source	DF	SS	MS	F	P
Rep	2	0.00686	0.00343		
Salinity	4	0.03105	0.00776	1.18	0.3265
Variety	6	0.36381	0.06063	9.23	0.0000
Salinity*Variety	24	0.28095	0.01171	1.78	0.0331
Error	68	0.44648	0.00657		
Total	104	1.12914			

Grand Mean 0.6829
CV 11.87

C. Stem base diameter (cm) at 80 DAT

Source	DF	SS	MS	F	P
Rep	2	0.01543	0.00771		
Salinity	4	0.20038	0.05010	4.58	0.0025
Variety	6	0.45429	0.07571	6.91	0.0000
Salinity*Variety	24	0.36762	0.01532	1.40	0.1417
Error	68	0.74457	0.01095		
Total	104	1.78229			

Grand Mean 0.7914
CV 13.22

Appendix VII: Analysis of variance of number of leaf plant^{-1}

A. Number of leaf plant^{-1} at 40 DAT

Source	DF	SS	MS	F	P
Rep	2	0.362	0.1810		
Salinity	4	83.562	20.8905	41.41	0.0000
Variety	6	113.448	18.9079	37.48	0.0000
Salinity*Variety	24	98.171	4.0905	8.11	0.0000
Error	68	34.305	0.5045		
Total	104	329.848			

Grand Mean 10.105
CV 7.03

B. Number of leaf plant^{-1}at 60 DAT (cm)

Source	DF	SS	MS	F	P
Rep	2	0.82	0.4095		
Salinity	4	263.39	65.8476	81.14	0.0000
Variety	6	379.03	63.1714	77.85	0.0000
Salinity*Variety	24	565.54	23.5643	29.04	0.0000
Error	68	55.18	0.8115		
Total	104	1263.96			

Grand Mean 16.981
CV 5.30

Appendix VIII: Analysis of variance of leaf area plant^{-1} (cm^2)

A. Leaf area at 40 DAT (cm^2)

Source	DF	SS	MS	F	P
Rep	2	424	212.2		
Salinity	4	72562	18140.4	125.08	0.0000
Variety	6	25124	4187.4	28.87	0.0000
Salinity*Variety	24	42282	1761.7	12.15	0.0000
Error	68	9862	145.0		
Total	104	150254			

Grand Mean 142.16
CV 8.47

B. Leaf area at 60 DAT (cm^2)

Source	DF	SS	MS	F	P
Rep	2	133	66.7		
Salinity	4	126585	31646.2	213.24	0.0000
Variety	6	14366	2394.3	16.13	0.0000
Salinity*Variety	24	54329	2263.7	15.25	0.0000
Error	68	10091	148.4		
Total	104	205504			

Grand Mean 156.46
CV 7.79

Appendix IX: Analysis of variance of leaf chlorophyll content (SPAD unit)

A. Leaf chlorophyll content (SPAD unit) at 40 DAT

Source	DF	SS	MS	F	P
Rep	2	44.33	22.164		
Salinity	4	1665.61	416.401	21.30	0.0000
Variety	6	281.22	46.869	2.40	0.0370
Salinity*Variety	24	777.42	32.392	1.66	0.0549
Error	67	1310.08	19.553		
Total	103				

Note: SS are marginal (type III) sums of squares
Grand Mean 44.368
CV 9.97

B. Leaf chlorophyll content (SPAD unit) at 60 DAT

Source	DF	SS	MS	F	P
Rep	2	22.19	11.094		
Salinity	4	2284.15	571.037	24.30	0.0000
Variety	6	1280.05	213.342	9.08	0.0000
Salinity*Variety	24	1970.64	82.110	3.49	0.0000
Error	68	1597.84	23.498		
Total	104	7154.87			

Grand Mean 49.562
CV 9.78

Appendix X: Analysis of variance of number of branch plant^{-1}

A. Number of branch plant^{-1} at 40 DAT

Source	DF	SS	MS	F	P
Rep	2	1.7714	0.88571		
Salinity	4	15.7714	3.94286	18.84	0.0000
Variety	6	33.5810	5.59683	26.75	0.0000
Salinity*Variety	24	25.5619	1.06508	5.09	0.0000
Error	68	14.2286	0.20924		
Total	104	90.9143			

Grand Mean 3.1714
CV 14.42

B. Number of branch plant^{-1} at 60 DAT

Source	DF	SS	MS	F	P
Rep	2	1.219	0.6095		
Salinity	4	47.867	11.9667	43.33	0.0000
Variety	6	61.829	10.3048	37.31	0.0000
Salinity*Variety	24	30.267	1.2611	4.57	0.0000
Error	68	18.781	0.2762		
Total	104	159.962			

Grand Mean 3.6476
CV 14.41

Appendix XI: Analysis of variance of days to first flowering

Source	DF	SS	MS	F	P
Rep	2	0.3619	0.18095		
Salinity	4	3.2000	0.80000	1.19	0.3223
Variety	6	22.3619	3.72698	5.55	0.0001
Salinity*Variety	24	10.4000	0.43333	0.65	0.8838
Error	68	45.6381	0.67115		
Total	104	81.9619			

Grand Mean 35.448
CV 2.31

Appendix XII: Analysis of variance of number of flower cluster plant^{-1}

A. Number of flower cluster plant^{-1} at 40 DAT

Source	DF	SS	MS	F	P
Rep	2	0.5905	0.29524		
Salinity	4	1.3905	0.34762	2.35	0.0632
Variety	6	13.8286	2.30476	15.55	0.0000
Salinity*Variety	24	20.0762	0.83651	5.65	0.0000
Error	68	10.0762	0.14818		
Total	104	45.9619			

Grand Mean 2.4476
CV 15.73

B. Number of flower cluster plant^{-1} at 60 DAT

Source	DF	SS	MS	F	P
Rep	2	2.362	1.1810		
Salinity	4	132.381	33.0952	26.08	0.0000
Variety	6	312.000	52.0000	40.97	0.0000
Salinity*Variety	24	306.286	12.7619	10.06	0.0000
Error	68	86.305	1.2692		
Total	104	839.333			

Grand Mean 8.3333
CV 13.52

Appendix XIII: Analysis of variance of number of flower plant^{-1}

A. Number of flower plant^{-1} at 40 DAT

Source	DF	SS	MS	F	P
Rep	2	0.4762	0.23810		
Salinity	4	11.2952	2.82381	13.53	0.0000
Variety	6	16.9143	2.81905	13.51	0.0000
Salinity*Variety	24	9.3714	0.39048	1.87	0.0232
Error	68	14.1905	0.20868		
Total	104	52.2476			

Grand Mean 0.4952
CV 92.24

B. Number of flower plant^{-1}at 60 DAT

Source	DF	SS	MS	F	P
Rep	2	1.16	0.581		
Salinity	4	214.99	53.748	4.80	0.0018
Variety	6	3993.58	665.597	59.38	0.0000
Salinity*Variety	24	773.94	32.248	2.88	0.0003
Error	68	762.17	11.208		
Total	104	5745.85			

Grand Mean 14.962
CV 22.38

Appendix XIV: Analysis of variance of fruit length (cm)

Source	DF	SS	MS	F	P
Rep	2	0.7170	0.3585		
Salinity	4	0.9226	0.2306	1.03	0.3957
Variety	6	62.5753	10.4292	46.79	0.0000
Salinity*Variety	24	5.5579	0.2316	1.04	0.4335
Error	68	15.1553	0.2229		
Total	104	84.9280			

Grand Mean 4.3804
CV 10.78

Appendix XV: Analysis of variance of fruit diameter (cm)

Source	DF	SS	MS	F	P
Rep	2	0.038	0.0188		
Salinity	4	1.041	0.2603	1.19	0.3253
Variety	6	169.647	28.2746	128.73	0.0000
Salinity*Variety	24	7.756	0.3232	1.47	0.1094
Error	68	14.936	0.2196		
Total	104	193.418			

Grand Mean 4.3359
CV 10.81

Appendix XVI: Analysis of variance of number of fruit plant^{-1}

A. Number of fruit plant^{-1} at 60 DAT

Source	DF	SS	MS	F	P
Rep	2	1.96	0.981		
Salinity	4	89.90	22.476	28.28	0.0000
Variety	6	645.79	107.632	135.44	0.0000
Salinity*Variety	24	320.50	13.354	16.80	0.0000
Error	68	54.04	0.795		
Total	104	1112.19			

Grand Mean 6.4762
CV 13.76

B. Number of fruit plant^{-1} at 80 DAT

Source	DF	SS	MS	F	P
Rep	2	36.7	18.36		
Salinity	4	416.9	104.22	17.14	0.0000
Variety	6	13788.2	2298.04	377.87	0.0000
Salinity*Variety	24	1541.8	64.24	10.56	0.0000
Error	68	413.5	6.08		
Total	104	16197.2			

Grand Mean 20.854
CV 11.83

Appendix XVII: Analysis of variance of individual fruit weight (gm)

Source	DF	SS	MS	F	P
Rep	2	72	36.1		
Salinity	4	1168	292.1	3.51	0.0116
Variety	6	98427	16404.5	196.94	0.0000
Salinity*Variety	24	8101	337.6	4.05	0.0000
Error	68	5664	83.3		
Total	104	113433			

Grand Mean 58.092
CV 15.71

Appendix XVIII: Analysis of variance of fruit weight plant^{-1} (gm)

Source	DF	SS	MS	F	P
Rep	2	34530.5	17265		
Salinity	4	862873	215718	18.54	0.0000
Variety	6	6931014	1155169	99.26	0.0000
Salinity*Variety	24	2438984	101624	8.73	0.0000
Error	68	791376	11638		
Total	104	1.106E+07			

Grand Mean 885.78
CV 12.18

Appendix XIX: Analysis of variance of total soluble solids (%)

Source	DF	SS	MS	F	P
Rep	2	0.296	0.14781		
Salinity	4	19.740	4.93490	98.00	0.0000
Variety	6	22.721	3.78686	75.20	0.0000
Salinity*Variety	24	68.082	2.83674	56.33	0.0000
Error	68	3.424	0.05036		
Total	104	114.262			

Grand Mean 2.1695
CV 10.34

PLATES

PLATES

Plate I: Tomato seedling raising

Plate II: Tomato seedling transplanting and establishment in pot

Plate III: Intercultural operations

Plate IV: Data collection

Plate V: Harvesting