GROWTH AND YIELD PERFORMANCE OF TOMATO CULTIVARS UNDER SALINITY STRESS

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CERTIFICATE

This is to certify that the thesis entitled, "**GROWTH AND YIELD PERFORMANCE OF TOMATO CULTIVARS UNDER SALINITY STRESS**" 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 in HORTICULTURE,*** *embodies the result of a piece of bona fide research work carried out by Kayum Mazumder, Registration No. 10-03790 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.

Dated: June, 2016
Place: Dhaka, Bangladesh

Khairul Kabir
Assistant Professor
Supervisor

DEDICATED

TO

MY BELOVED PARENTS

Some commonly used abbreviations

Abbreviations	Full word	Abbreviations	Full word
ABA	Abscisic acid	IAA	Indole Acidic Acid
AEZ	Agro- Ecological Zone	JA	Jasmonic acid
Anon.	Anonymous	K	Potassium
AOS	Active Oxygen Species	K_2O	Potassium Oxide
ASC	Ascorbic acid	Kg	Kilogram (s)
BARI	Bangladesh Agricultural Research Institute	KMP	Potassium Mono Phosphate
BAU	Bangladesh Agricultural University	LRWC	Leaf Relative Water Content
BBS	Bangladesh Bureau of Statistics	LSD	Least Significant Difference
BINA	Bangladesh Institute of Nuclear Agriculture	m	Meter
Ca	Calcium	m_2	Meter squares
$CaCl_2$	Calcium Chloride	Mg	Magnesium
Cl	Chlorine	mg	Milligram
cm	Centi-meter	ml	Milliliter
cm_2	Centimeter square	mm	Millimeter
CO_2	Carbon di oxide	mM	Millimolar
DAT	Days After Transplanting	S	Sulphur
N	Nitrogen	%	Percentage
Na	Sodium	P	Randomized complete block design
NaCl	Sodium Chloride	t ha^{-1}	Ton per hectare
No.	Number	ROS	Reactive Oxygen Species
NS	Non significant	ppm	Parts per million
OM	Organic matter	RCBD	Randomized complete block design

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June, 2016 ***The Author***

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GROWTH AND YIELD PERFORMANCE OF TOMATO CULTIVARS UNDER SALINITY STRESS

BY

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ABSTRACT

A pot experiment was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University to evaluate the performance of different tomato cultivars e.g. BARI Tomato 2 (V_1), BARI Tomato 11 (V_2), BARI Tomato 14 (V_3) and BARI Tomato 15 (V_4) under different level of salinity e.g. 0 (S_1), 5 (S_2), 10 (S_3) and 15 (S_4) ds m^{-1}. The experiment revealed that growth, development, yield and yield attributes of tomato varied with the variation of cultivars and salt stress. V_3 produced highest individual fruit weight (92.33g) as well as fruit yield $plant^{-1}$ (2337.7g). Exposure of different levels of salinity decreased plant height, number of leaf $plant^{-1}$ and other growth and biochemical attributes including chlorophyll content and salt stress also decreased number of flower cluster, total flower $plant^{-1}$, but increased flower dropping. As a result exposure of S_4 salinity level produced lowest fruit length (4.43cm), fruit diameter (4.59cm), and individual fruit weight (58.67g), number of fruit $plant^{-1}$ (41.17). Interaction of cultivars and salinity also affected growth, biochemical parameter, yield and yield attributes. Combination of salt stress with any cultivar reduced growth and yield, compared with those cultivars (under control condition). The highest yield (3008.7g $plant^{-1}$) was recorded in V_3 under control condition (V_3S_1) as its individual fruit weight (94g) was maximum. However, the lowest yield (755.70g $plant^{-1}$) was recorded in V_2 under 15 ds m^{-1} salt stress condition (V_2S_4) as it fruit length (2.6cm), fruit diameter (2cm) and individual fruit weight (7.67g) was lowest. Considering the results, we can concluded that exposure of salt stress in tomato cultivars decreased growth and yield with increasing the level of salinity.

CHAPTER I

INTRODUCTION

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Tomato (*Lycopersicon esculentum* Mill.) is one of the most important vegetable crops grown throughout the world including Bangladesh. Tomato the "Love Apple" is a popular vegetable with high anti-oxidant. Botanically referred to the family Solanaceae with chromosome number 2n=24 (Jenkins, 1948). Because of its taste, high nutritional value, multipurpose uses and commercial importance's (Demirkaya, 2014). Tomato considered as one of the most important, popular and nutritious vegetables crop that has achieved tremendous popularity around the world (FAOSTAT, 2014). At present tomato is the second in world's largest vegetable crop after potato (Rashid, 1993; FAO, 2016) and tops the list of canned vegetables (Chowdhury, 1989). Tomato is a rich source of photochemical such as lycopene which act as an anti-carcinogen, β-carotine, flavonoids, potassium, vitamins E and C, folic acid. Collectively this element play beneficial role in human health (Najla *et al*., 2009; Behrooj *et al*, 2012). It consumed as a raw salad, cooked or as processed food item. It contains Calories 97, Iron 2.7 mg, Protein 4.5 g, Riboflavin 0.15 mg, Calcium 50 mg, Niacin 3.2 mg, Phosphorus 123 mg and Ascorbic acid 102 mg per 1 pound edible portion (Lester, 2006). The world dedicated 5.4 million hectares in 2015 for tomato cultivation and the total production was about 188.8 million tons. The leading top ten tomato producer country in the world are China, India, United States, Turkey, Egypt, Iran, Italy, Spain, Brazil and Mexico (FAO, 2016). It is one of the most important and popular vegetable in Bangladesh which cultivated in an area of 76 thousand hectares accounting for production of 414,000 metric tons with productivity of 5471 kg per hectares (BBS, 2016).

There are various abiotic environmental stresses which pose serious threat to world agriculture, such as flooding, drought, salinity, high or low temperature, metal toxicity, etc. Waisel (1972) observed that saline water cover over four-fifth of the surface of our planet, among many other elements NaCl is approximately 0.5 M. Still only some small groups of higher plants can tolerate such adverse conditions. Cropping intensity is very poor in saline areas (133%), which is much lower than the other cropping areas of countries average cropping intensity (196 percent). For these reasons, plant response to salinity is one of the most widely researched subjects in

plant physiology. Tanji (2002) stated that crop growth and yield reduced more than 50% due to abiotic stress and among them salinity is one of the most brutal environmental factors which hamper the agricultural productivity including tomato. Flowers and Colmer (2008) said that, All over the world salinity is a great threat to agriculture. More than 800 million hectares of land around the world are affected by salinity which results in billions of dollars in crop production losses (Shabala and Cuin, 2008). Ashraf and Foolad (2007) stated that the major abiotic stress that reduces the plant growth as well as fruit yield, salinity is one of them. It causes lower rate of photosynthesis and respiration growth inhibition, nutritional deficiencies and inhibition of protein synthesis crop yield reduction. Munns *et al*. (2006); Chaves *et al*. (2009); Bayuelo-Jimenez *et al.* (2012) stated that salt stress exposed to various plant species leads to the reduction in crop production by declining every aspect of physiology and biochemistry of metabolism and plant growth. Juan *et al.* (2005) observed that phenomena in agricultural and horticultural crops, including tomato. By changing the metabolism of plants the physiology is disturbs by salinity (Garg *et al.*, 2002). Reduction of net rate of CO_2 assimilation, accumulation of dry matter content and leaf area also reduces badly due to salinity (Barnardo *et al.*, 2000). In transpiring leaves cell injuries occurs due to salt stress, thus growth of plant (Munns, 2005). Many reports showed that to provide tolerance against salinity the metabolism in plant tissue impaired that altered growth performance and physiological process (Sairam and Tyagi, 2004; Mahajan and Tuteja, 2005). Separately, to protect themselves from the salinity-induced damages plants have developed a well-organized defense mechanism of biochemical and physiological processes including antioxidant responses, ionic homoeostasis, and/or osmoregulation (Parida and Das, 2005). Depending on cultivars or growth stage tomato plant is sensitive to medium levels of salt stress and for that it holds an important position in agriculture. Almost all the physiological and biochemical attributes of the plant development is affected by salinity and for that yield and quality of tomato reduces from nutritional value and food safety (Foolad, 2004; Sengupta and Majumder, 2009; Koushafar *et al*., 2011). A number of researchers have studied the osmotic and elastic adjustment capacity of different tomato genotypes under salt stress condition and the water relation which showed that root can not extract saline water from soil and unable to transport it to shoot, for that the growth of salt treated tomato plants is often limited (Sancheg-Blanco *et al.,* 1991; Alarcon *et al.,* 1993). The low rate of water uptake due to osmotic

effect, through ion-specific toxic effects caused by ion antagonism, decreased the plant growth affected by salinity (Levitt, 1980). Reina-Sànchez *et al,* (2005), Cuartero *et al.* (2006), said that yield decrease of tomato was 0, 10 and 50% respectively, for 2.5, 3.5 and 7.6 dS m-1 salinity level. In cherry tomatoes sugar and organic acid content may increases if irrigated with saline water (De Pascale *et al*., 2001) and also the flavor of processed tomatoes (Albacete *et al*., 2008).

At present, very few works have been accomplished in order to overcome salinity problem which will generate improved economically viable technological means to facilitate crop production under saline conditions. In agriculture solving salt stress problem cannot be ignored because of increasing demand for food (Koushafar *et al.,* 2011; Munns and Tester, 2008). In saline areas the production technology of a crop is very complex and with increasing salinity level yield of tomato decreased. Intercultural operations like irrigation, drainage, mulching etc. are expensive involvement. For that reason poor farmer cannot bear this expense and especially our coastal belt's vegetable grower did not take advantage by this tomato farming as expected. Nevertheless, development of cultivars with field tolerance to salinity is considered as a promising approach. BARI developed many tomato cultivars but they are not properly screened against salinity stress. For the vast coastal regions, salt tolerant cultivars are required to be screened to overcome the threat posed by salinity. Therefore, identification of salinity tolerance cultivars for a moderately sensitive crop like tomato becomes an important aspect of research.

OBJECTIVES

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

i. To assess the salinity tolerance ability of promising tomato cultivars in respect of different morpho-physiological characters and yield.
ii. To investigate the growth and yield of four released cultivars of tomato under different salinity stress condition.
iii. Finally to find out the best cultivar suitable for growing in saline soils of Bangladesh.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Salinity is a great problem in the coastal region of Bangladesh, where a vast area remains fallow for long time. Tomato is an important crop plant which supply Vitamin C as well as used as a vegetables by the people of Bangladesh. It is a great source of Vitamin C for poor people of the coastal area. The scientists of Bangladesh are conducting different experiments to adopt different crops in the saline area, tomato is one of them. Very limited research works have been conducted to adapt tomato crop in the saline area of Bangladesh. An attempt has been made to find out the performance of tomato at different levels of salinity in the saline stressed tomato plants. To facilitate the research works different literatures have been reviewed in this chapter.

He, Y. *et al.* (2016) to evaluate utility of different salt-tolerant lines, three soybean lines with different resistance to salt were planted in the field under control and salt-stress conditions for two years. The results showed that net photosynthetic rate (P_N) was significantly different among lines at the anthesis stage and decreased on average by 13.6-34.1% under conditions of salt stress. The stomatal conductance was a primary limiting factor for the reduction of P_N under salt stress. Meanwhile, the grain yield (GY) decreased on average by 14.0-35.3% among lines under salt stress. The salt-tolerant lines S111-9 and S113-6 showed higher P_N and GY under salt stress in comparison with the salt-sensitive cultivar Melrose. Regression analysis indicated that there was extremely significantly positive correlation between GY and P_N under field conditions. Therefore, P_N might be used as a physiological index for field resistance of soybean to salt stress.

According to Ali and Rab (2016) salinity decreased the growth such as root and shoots fresh weight; root and shoot dry weight, number of leaves per plant, shoot/ root ratio and yield of tomato. The salinity induced decline in growth and yield could be decreased by the application of supplemental potassium to tomato plants grown under saline condition.

Muchate *et al*. (2016) stated that salinity is an important abiotic environmental stress factor threatening agricultural productivity throughout the world. The detrimental effects of salinity stress are observed at cellular, organ and whole plant level at osmotic phase (early/ short-term response) and ionic phase (late/ long-term response). High salinity exerts its negative impact on major plant processes such as disrupting the osmotic and ionic equilibrium, protein synthesis, photosynthesis, energy, and lipid metabolism. To adapt and tolerate salt stress, plants have evolved physiological and biochemical mechanisms orchestrated by multiple biochemical pathways of ion homeostasis, osmolytes synthesis, ROS scavenging, and hormonal balance. At the molecular level, such adaptation involves activation of cascade(s) of gene modulations and synthesis of defense metabolites. In recent years, several candidate genes have been identified and employed to facilitate genetic engineering efforts to improve salt tolerance in crop plants. However, there is a further need of improvement for successful release of salt tolerant cultivars at the field level. In this article we present the physiological, biochemical and molecular signatures of plant responses to salinity, and outline their use in genetic engineering to improve salt stress tolerance.

Biswas *et al.* (2015) conducted an experiment without salt stress condition to study growth and yield responses of tomato varieties found that the tallest plant height and maximum number of branches was found from BARI Tomato-7. While maximum number of flowers, fruit and clusters were found from BARI Tomato-9.

However, maximum fruit diameter, individual fruit weight and yield were also found from BARI Tomato-7 respectively.

Silambarasan and Natarajan (2014) observed that the sodium chloride salinity levels in *C. inerme* decreased the total sugar content of the leaf, stem and root, but increased the starch content up to 200 mM. The increase in the nitrogen content may be responsible for increase in starch which plays an important role in photosynthesis (Chook hampaeng, 2011).

Feleafel and Mirdad (2014) reported that the tomato plants showed rapid early growth to avoid the deleterious effect of water salinity by using four NPK starter solutions, and three rates of humic acid as well as their interactions. Tomato plants receiving highest dose recorded maximum plant height; at 6, 8 and 10 weeks after transplanting (WAT), and leaves number, at 6 and 8 WAT, as well leaf P content. While, tomato plants receiving medium levels of fertilizer achieved maximum root and shoot fresh weight and highest mean values of the number of flowers per cluster, leaf NK contents and fruit yield per plant.

Shimul *et al*. (2014) conducted a study on the tomato and observed that plant height of tomato genotypes increased significantly with decreasing level of salinity under the effects of different salinity level on growth of plant. The tallest plant height was obtain from 0 dSm^{-1} and shortest with 16 dSm^{-1} salinity level. Sengupta and Mazumder (2009) carried out a study to determine the response of rice with different salinity level and found that the number of branches decreased with the increase in salinity level.

Alaa El-Din Sayed Ewase (2013) reported that, by using selection method a pot experiment was carried out to study the effect of salinity stress on plants growth of Coriander (*Coriandrum sativum* L.). Four treatments of different concentrations of NaCl were used namely 0, 1000, 2000, 3000 and 4000 ppm, for this purpose. Plant

length, number of leaves, roots number and length were recorded. The outcome showed that with increasing NaCl concentration all the growth parameters were reduced. Only up to 3000 ppm NaCl concentration, coriander plants were found to resist salinity.

Alsadon *et al*. (2013) carried out a study in tomato to determine the genotypic responses to salinity tolerance and observed that with successive increases in water salinity levels all the plant growth traits were significantly reduced. At the highest salinity level, the number of leaves per plant was smaller than those at the control level by approximately 13, 11, 17, 16 and 18% for plant height, stem diameter, leaf area, and leaf fresh weight and dry weight, respectively.

Monireh and Hadi (2013) observed that nitrogen concentration fall occurs due to the antagonist effect of Cl^- on nitrate. Tabatabaei (2006) illustrated that rising in NaCl concentration in the nutrient solution reduced nitrogen and nitrate concentration of the olive leaves. In salinity conditions, nitrogen concentration increased as Ca^{2+} and K^+ level were elevated. Levent Tuna *et al*. (2007) stated that the increase in nitrogen concentration resulting from high level of Ca^{2+} in salinity conditions.

Alam (2013) conducted a pot experiment against different salinity level to evaluate the growth and yield of onion varieties. The result showed that plant height, number of leaves per plant, individual weight of bulb, dry matter content of bulb and yield of bulb ha^{-1} was decreased with the highest level of salinity.

Lovelli *et al*. (2012) conducted a detailed study in tomato plant under salt stress conditions to evaluate the responses of leaf growth and development. The result showed that the length of the growth zone was shortened by 20% under salt stress, and that salt stress also reduced the maximal relative elemental growth rate, particularly in the youngest region of the leaf. Nahar and Hasanuzzaman *(*2009)

stated that salt stress induced a dramatic decrease in Ca in the growing sorghum leaf which could be at least partly responsible for leaf growth inhibition. Nazar *et al*. (2011) stated that the consequence of inhibition by salt of symplastic xylem loading of Ca in the root, leading to reduced Ca status in growing region of leaves.

Shameem *et al.* (2012) conducted an experiment of tomato plants to evaluate the yield and quality of fruit under salinity conditions, observed 8 tomato genotypes with different salinity level at early development stages. It was observed that the tomato genotype adapted to salinity, based on number of fruits, number of flowers, K^+ concentration and K^+/Na^+ ratio.

Shabani, *et al.* (2012) reported that fruit number was determined as the total number of fruit per plant. Fruit length was recorded (in cm) from stem end to blossom end, to two decimal place, at maturity from clusters (4 fruit for each plant). Fruit width was recorded (in cm) as the largest diameter of fruits two decimal place at maturity from clusters (4 fruit for each plant). Al-Busaidi *et al.* (2010) studied that different genotypes with higher salinity treatment, varieties number 38 and 46 got the highest values for fruits number, diameter and weight 33.17, 555.23g and 344.34g respectively.

Mirabdulbaghi and Pishbeen (2012) conducted an experiment in two barley varieties namely Afzal and EMB82-12 with increasing levels of salinity. Chlorosis and necrosis of the leaves reduced the photo-synthetically active area, thus results the reduction in shoot biomass production by the plant (Lester, 2006). The decrease in fresh reducing number of fruit and diameter causes the lower yield of 20-40%. Due to soil moisture stress developed under saline conditions and the suppression of growth under salinity stress during the early developmental stages, Potato and cucumber showed no loss in yield and quality.

Ahmad *et al.* (2012) carried out a series of experiments with musterd callus and plants and have shown that the important precursors of Chlorophyll, *i.e*., glutamate and 5-aminolaevulinic acid (ALA), decreased in salt-stressed calli and leaves, which indicates that salt stress affects more markedly Chlorophyll biosynthesis than Chlorophyll breakdown (Khan *et al*., 2009).

Khalid *et al*. (2012) conducted the experiment with three different treatments of Na_2SO_4 to check the effect of salinity on brinjal plant growth. Results showed that replicates with maximum salt concentration i.e. 60 ppm Na_2SO_4 gave best growth and stress showed positive response on the plants. The investigators found that Na_2SO_4 salinity substantially reduced Mo accumulation.

Milne (2012) observed the effect of salinity on lettuce (*Lactuca sativa L*.), grown in hydroponics system with the dose of 30, 60 mM NaCl in additions of 0, 1 and 4 mM Si. Plant height, weight, leaf number, chlorophyll content and elemental analysis of plants were observed and examined.

Nasser (2012) carried out an experiment to find out the plant growth and seed germination severely affected by salinity and observed that, the effect of four levels of salinity on seed germination, plants growth, K^+ and Na^+ content and photosynthetic rate of the four local cultivars and one commercial cultivar was studied. Chook hampaeng *et al.* (2007) stated that with increased in salinity level the fruit yield, number of fruits and fruit weight of tomato cultivars significantly decreased.

Maggio *et al.* (2011) concluded that plant growth and, consequently, plant water usage reduced due to salinization at the root environment. Subsequently, both total and osmotic water potentials in tomato plant gradually reduced due to salinization. Separately, it is hypothesized that protection of salinity in triazole compound-treated plants was associated with longer roots and smaller leaves for absorbing

more water and losing less water, which improve salt tolerance in salt-stressed plants.

Mohammad *et al*. (2011) conducted a study and observed that leaf pheophytin total and carotene content were reduced significantly due to salinity while in contrast application of potassium increase this pigments in the leaf of tomato. K^+ had an ameliorative effect under the salinity stress.

Ferrante *et al*. (2011) observed that, most of the salinity nutrition studies have directed little attention to magnesium nutrition as affected by salinity while analyzed plant tissue for magnesium. Thus, high concentrations of substrate Ca^{2+} often result in increased leaf Ca along with a marked reduction in leaf-Mg (Cachorro *et al.,* 1993). Reina-Sànchez *et al.* (2005) where they found that in citrus leaf Mg^{2+} concentrations reduced because of NaCl salinity. However decreases in leaf Mg^{2+} are not always associated with increases in salinity. Nightingale and Farnham (1936) stated that the amount of soluble organic nitrogen and proteins in sweet peas decreased with increase in osmotic pressure, while the nitrate form of nitrogen accumulated.

Amirjani (2011) observed that carbons needed for adaptive and /or defensive responses to stresses while sugars are source of energy. Proline accumulation was primarily induced by increased NO^{-3} in leaves whereas the high salinities stimulated sugar accumulation in leaves (Bayoud, 2010) and in addition, sugars such as raffinose and sucrose are indicated to have important roles in protecting cells from water stress (Ashraf and Foolad, 2007).

Islam *et al*. (2011) illustrated that flower cluster, fruit yield and vegetative growth of tomato were unaffected up to a soil salinity of 2.6 dS m^{-1} but yield reduced 6.32% and vegetative growth by 5.38% where yield were positively associated with K and/or K:Na ratio in leaves and negatively associated with Cl and/or Na concentration in leaves.

Saberi *et al.* (2011) observed the response of salinity and irrigation frequency in two forage sorghum varieties (Speedfeed and KFS4). Two varieties were grown under salinity levels of 0, 5, 10 and 15 dSm^{-1}. Maximum number of leaves was produced in non-saline soil with normal irrigation. The number of leaves as well as the number of tillers produced reduced by high salinity and low soil water condition. Leaf area of plants also reduced in response to salinity and decreasing soil water availability, while the suppressive effect was magnified under the combined effect of the two factors. The maximum total leaf area was obtained in the control treatment but with increasing salinity and infrequent irrigation, this parameter was found to decrease.

Wahid *et al.* (2011) reported that inhibition effect of salt on chlorophylls could be due to suppression of specific enzymes responsible for the synthesis of green pigments. The decrease in chlorophyll may be attributed to increased chlorophyllase activity. Decrease in chlorophyll content under salt stress could be due to the effect on membrane stability (Bidel *et al*., 2007).

Loukehaich *et al*. (2011) observed the response of plants to high salinity and studied the differences in crop response to chloride. Sulphate salinity has measured in terms of identical electrical conductivities (Awada *et al.*, 1995) molar or equivalent basis or iso-osmotic potentials. In the straw, chloride-salinity reduced the sulphur content. Sulphur accumulation in the roots, however, that was enhanced by Cl^- salinity. For most vegetable crops the salt tolerance would $2dSm^{-1}$

greater than in a sulphate system as opposed to chloride system reported by (Mori *et al*., 2007).

Dolatabadian *et al*. (2011) reported that salinity stress significantly decreased shoot and root weight, total biomass, plant height and leaf number of soybean. However, leaf area was not affected by salinity stress. Kaouther *et al*. (2012) studied the salt stress (NaCl) Tunisian cultivars of chili pepper and showed that the growth, chlorophyll content and fluorescence were severely affected.

Islam *et al.* (2011) observed in tomato genotypes for salt tolerance and observed that primary branches significantly decreased with increasing salinity levels. Rahman *et al*. (2006) reported that increase in plant height, number of leaves plant^{-1} and total leaf area of tomato mulched with rice straw while lowest height was observed in control (un-mulched) under saline soil.

Abdelhamid *et al*. (2010) carried out a study to determine the effect of NaCl stress on the growth of tomato plants is reflected in lower dry weights. The reduction of the dry weights due to increased salinity may be a result of a combination of osmotic and specific ion effects of Cl and Na. The results indicated that the stems, leaves and roots dry weights decreased in saline condition, due to the exposure to salinity stress.

Azarmi *et al.* (2010) carried out an experiment on the effects of salinity on morphological and physiological changes and yield of tomato on growth, yield and quality of greenhouse tomato grown in hydroponics culture. The results of this experiment showed that growth parameters and yield reduced with increasing salinity, but qualitative properties were improved by salinity.

Hassine and Lutts *(*2010) stated plant height, number of flower cluster, fruit number and yield were not adversely affected up to 8 dS m^{-1} but ripening was delayed. Increased yield over the control was noted with salt concentrations of 4 and 6 dS m^{-1}.

Perveen *et al*. (2010) reported that salt-induced osmotic effect may induce a gradual decline in photosynthesis due to stomata closure under saline regimes. Salt stress imposed at the reproductive stage was reported to decrease the net CO_2 assimilation rate and stomatal conductance of intact leaves in various wheat genotypes (Shahbaz and Ashraf, 2007).

Hamayun (2010) reported that soybean cv. Hwangkeumkong showed the adverse effects of NaCl, due to salt stress on growth attributes and endogenous levels of gibberellins (GA), abscisic acid (ABA), jasmonic acid (JA) and salicylic acid (SA). In response 70 mM and 140 mM concentrations of NaCl, 1000 seed weight and yield significantly decreased.

Nawaz *et al.* (2010) said that applications of salt in the growth medium of sorghum cultivars caused reduction in shoot length. Under saline conditions 100 mM proline was less affected to reduce the effect of NaCl than 50 mM proline in both cultivars. Proline level 50 mM showed 26.58% and 11.78% increased shoots length as compared to NaCl stress plants. However low concentration of proline (50 mM) was much effected as compared to high concentration i.e. 100 mM.

Patel *et al.* (2010) stated that increase in Na^+, Cl^- and proline concentrations significantly induced by salinity, while reduced the accumulation of K^+ and Ca^{2+} in leaves of all the cultivars of cowpea.

Hamayun (2010) reported that, in soybean cv. Hwangkeumkong growth characters and endogenous levels of GA (gibberellins), ABA (abscisic acid) and salicyclic acid was adversely affected by NaCl induced salt stress. NaCl with concentration of 70 and 140 mM reduces the chlorophyll content of plant.

Jafari *et al.* (2009) observed the combined effect of calcium, potassium and salinity on physio-morphological traits of sorghum (*Sorghum bicolor L.*) in a green-house experiment. Treatments included 2 levels of $CaCl_2$ (0 and 20 mM), 2 levels of KCl (0 and 20 mM) and 4 levels of NaCl (0, 80, 160, and 240 mM NaCl). Salinity frequently reduced the plant growth as reflected by a decrease in the plant height, shoot and root weight.

Khan *et al.* (2009) stated that with increased salinity that number of fruit cluster, fruit size, fresh and fruit dry weight of wheat decreased. Under moderate and high salinities fruit yield of tomato was reduced by 16% and 60% and the shoot biomass by 30% and >75%, respectively.

Nahar and Hasanuzzaman (2009) conducted a field experiment to investigate the performance of mungbean genotypes under saline irrigation and observed that the yield components of *V. radiata* were significantly affected by salinity stress. The reproductive growth of *V. radiata* was also affected by salinity as the number of pods per plant substantially decreased with increasing salinity levels.

Hasanuzzaman *et al*. (2009) conducted a field experiment to investigate that in plants, where sodium and chlorine ion build up in the transpiring leaves over a long period of time, resulting in high salt concentration and leaf death. Leaf injury and death are attributed to the high salt load in the leaf that exceeds the capacity of salt compartmentation in the vacuoles, causing salt to build up in the cytoplasm to toxic levels.

Saibo *et al*. (2009) observed that in saline conditions increased radicle to primary shoot (Root/Shoot) ratio more than 1%. Reduction in potassium absorption, coupled with a sharp increase in sodium accumulation had a negative impact on photosynthesis, therefore reducing growth and the accumulation of dry matter (Maggio *et al.,* 2007).

Tantawy *et al*. (2009) observed the effect of salinity on plant height. In salt condition, decrease in stem fresh weight may be related to lack of water and lower plant height due to toxicity of Na^+ and Cl^-. In case of lentil result showed that plant height, number of leaves and leaf area gradually decreased with the increase in salinity levels (4 to 6 dS m^{-1}).

Rafat and Rafiq (2009) observed that with the increase in salinity levels up to 0.4% sea salt solution total chlorophyll content in tomato plant proportionally decreased. Amini and Ehsanpour (2006) reported that due to salt stress in tomato cultivar chlorophyll content decrease.

Chaves *et al*. (2009) stated that that photosynthesis and the rhythm of cell growth are the first processes to be compromised by salinity. The maximum photochemical efficiency (Fv/Fm) indicates the capacity of absorption of excitation energy by leaves and it is usually decreasing thereafter as a consequence of leaf senescence and decrease of photosynthetic assimilation (Munns *et al*., 2006).

Zhang *et al*. (2009) stated that salinity-induced osmotic effect on plants consequently leads to a partial stomata closure thereby lowering the stomatal conductance as well as substomatal CO_2 concentration. It is evident that photosynthetic capacity has a positive association with a biomass production or a seed yield in plants under saline stress, including the crops.

Jampeetong and Brix (2009) reported that salinity adversely affected various growths and development process such as germination, growth, flowering and fruiting resulting reduction in yield and quality.

Manikandan and Desingh (2009) conducted an experiment on the effects of different sodium chloride concentrations on the growth and photosynthesis parameters of tomato and found that the shoots fresh weights were significantly reduced with the 50 mM sodium chloride treatment showing the least fresh weight. The photosynthetic rate was 53% lower than that of the control treatment and the efficiency of photosynthetic water consumption was 29% less than treatment.

Yildirim *et al*. (2009) found that the lack of water through a salt stress may result in slowing down the metabolism of plants grown on saline soils. Nitrogen concentration in salt stressed plants was lower than in control plants. Different studies showed nitrogen concentration decrease in salinity conditions (Kumar *et al.*, 2008).

Munns and Tester (2008) stated that the main contributor in growth reduction in the initial stages of plant growth is osmotic effect which developed in root medium due to increasing salt concentration. In this stages reduction of generation of new leaves, leaf expansion, development of lateral buds leading to lesser branches or lateral shoots formation in plants.

Liu *et al*. (2008) reported that the dry biomass of halophyte *Suaeda salsa* significantly reduced when exposed to different concentration of salinity levels under different water regimes. Zuccarini (2008) studied the effect of two levels of salinity on *Phaseolus vulgaris* L. with Si. His result showed that stomatal conductance and net photosynthetic rate reduced by salinity stress. Tomato plant

when treated with 70 mM of NaCl in a sand culture, a significant decrease in the stomatal density was recorded (Romero-Aranda *et al*. 2001).

Ashraf *et al*. (2008) conducted an experiment where genotypes of tomato were grown at salinity (100 mM NaCl) significantly reduced leaf growth and shoot development. Application of K^+ could be useful to overcome the adverse effect of salinity (NaCl) on the leaf area of tomato. Application of K^+ ameliorated partially the adverse effects of high levels of salinity.

Piao and Fried (2008) executed a study on the effects of different salinity level on plant growth and reveal that carbon dioxide exchange characteristics have been regarded an important indicator of the growth of plants, because of their direct link to net productivity. Kronzucker and Britto (2011); Pardo and Rubio (2011) observed that due to competition, high Na^+ in soil solution causes intracellular K^+ deficiency that leads to K^+/Na^+ disequilibrium.

Xinwen *et al.* (2008) found that the Chlorophyll level is an index of the photosynthesis and decrease in Chlorophyll level lead to reduction in growth parameters. Salinity can lead to oxidative stress and causing significant decrease to photosynthetic systems.

Shibli *et al.* (2007) reported that salinity reduced the fresh and dry shoot and root weight of tomato. Increased salinity over 4000 ppm led to reduction in dry weight, leaf area, plant stem, and roots of tomatoes. Majkowska *et al.* (2008) observed that the rise in root/shoot dry weight in tomato under salt stress must be accompanied by the allocation of assimilates between root and shoot.

Levent Tuna *et al*. (2007) reported that the increase in soil salinity, total removal of nitrogen through the yield often decreases. Reduction in nitrogen fertilizer use efficiency is primarily a result of reduction of plant growth rate rather than the

reduction of nitrogen uptake rate. Due to the toxic effects of salts on rhizobium the metabolism of nodulating bacteria can drastically alter.

Karim (2007) observed in an experiment that all parameters including panicle length decreased with increased salinity under the effect of different levels of salinity. Most of the researchers stated that soil salinity adversely affected the panicle length o f rice plant (Islam *et al.,* 1998; Hossain, 2002; Islam, 2004).

KyuSeeong *et al*. (2007) grew rice varieties in nutrient solution with NaCl and reported that with increasing salinity levels total dry mass (TDM) was decreased. Rana (2007) conducted a pot experiment with 5 levels of salinity on three rice verities viz, BRRI dhan 42, STM^{-1} and STM^{-2} and reported that plant height, number of tillers per hill, TMD per hill, leaf area per hill root dry weight per hill and yield contributing characteristics and yield decreased significantly with increases in salinity levels. Among the advanced rice lines BRRI dhan 42 showed more tolerance for all studied parameters compared to STM^{-1} and STM^{-2}.

Memon *et al.* (2007) conducted a pot experiment at Sindh Agriculture University, in Tando Jam, Pakistan on silty clay loam soil. Sarokartuho variety of Sorghum (*Sorghum bicolor L*.) was continuously irrigated with fresh (control) and marginally to slightly saline EC 2, 3, 4 and 5 (dSm^{-1}) waters. Plant height and fodder yield (fresh and dry weight) per plant progressively decreased with increasing water salinity.

Mortazainedzhad *et al*. (2006) had studied that in all growth stages in rice tiller number decreased with increased salinity. Soil salinity affects rice plant growth. Depending on the growth stages of plant the degree of deleterious effect may vary. During germination stage of rice it is salt tolerant but during early seedling stage it becomes very sensitive. Similar result was also reported by many workers in rice (LingHe *et al*., 2000; Burman *et al*., 2002; Weon young *et al*., 2003; Islam, 2004;

Rashid, 2005; Karim, 2007). LingHe *et al*. (2000) further reported that the major cause of yield loss was due to decreased tiller number.

Hajer *et al.* (2006) conducted two different experiments separately on tomato and reported that with increased salinity fruit yield decreased separately under saline condition.

Rahman *et al*. (2006) reported that increase in plant height of tomato mulched with rice straw while lowest height was observed in control (un-mulched) under saline soil. Furthermore, they have observed lower salinity (approx. 4 dS m^{-1}) in mulched plots than that of non-mulched plots (approx. 6 to 7 dS m^{-1}).

Ali *et al*. (2005) carried out an experiment on two soybean varieties viz. Ertou and S-95-1 to know the effect of four levels of salinity (0, 3.0, 4.5 and 6.5 dSm^{-1}) on plant biomass production, leaf area and yield attributes. They found that salinity induced a marked reduction in yield attributes like siliqua $plant^{-1}$ and 1000 seed weight and seed yield. Debnath (2003) and Rahman (2003) conducted an experiment on mustard to know the yield attributes and dry meter partitioning under different levels of salinity and reported that harvest index decreased with increased salinity levels.

Uddin *et al*. (2005) carried out an experiment under saline conditions to study salt tolerance of *Brassica napus* and *Brassica campestris* varieties and also observed that increased salinity decreased the number of branches as well as siliqua number and seed per siliqua.

Claussen (2005) said that induction of proline biosynthesis enzymes may be caused proline accumulation under salt stress condition. Additionally decrease utilization of proline in protein synthesis and enhancing protein turnover. It has been reported that increase in soluble proteins (Shaddad *et al*., 2005) or an increase in the N^- contents and high protein content in some glycophytic plants

(Abed El-Baki, 1996; Jones and mac Millan, 1987) caused by high saline concentration.

Sixto *et al*. (2005) said that vegetative growth has been reduced in plants depending on increasing salinity levels. Stem, shoot and root development, leaf area yield has been observed in plants to reduce/ decreased due to salinity stress. Munns (2005); Munns and Tester (2008), reported that growth reduction at initial stage of salt stress occurs due to salt-induced osmotic stress, while at later stages reduction of plant growth occurs as accumulation of Na^+ in the leaves. Cicek and Cakirlar (2002) observed that decrease in shoot length, fresh and dry weights of shoot caused by salt stress.

Sairam and Tyagi (2004) reported that soil salinity affects plant growth and development by way of osmotic stress, injurious effects of toxic Na^+ and Cl^- ions and to some extend Cl^- and $SO4^{2-}$ of Mg^{2+} and nutrient imbalance caused by excess Na^+ and Cl^- ions. Netondo (2004) carried out an experiment with two Kenyan sorghum varieties grown in a greenhouse in sand supplied with a complete nutrient solution to which different concentration of salt were added. Mature leaves contained more Ca^{2+} and Mg^{2+} than young ones.

Fricke *et al*. (2004) due to osmotic stress and local synthesis of ABA immediate and significant drop in stomatal conductance occurs in barley because of short term exposure of high salinity. Sairam and Tyagi (2004); Grewal (2010) observed that plant physiology affected by soil salinity though the injurious effects of toxic ions, osmotic stress, reduced water use efficiency and the resulting nutrient imbalance. (Schwanz *et al*., 1996; Halliwell and Gutteridge, 1999) said that reactive oxygen species such as superoxide, hydrogen per oxide, hydroxyl radical, proteins and nucleic acids can be imbalanced by saline induced salt stress in plant. Ali and Awan (2004) observed in an experiment which was conducted on eighteen advanced rice varieties under artificially salinized soil conditions after ninety days

of transplanting. The results showed that salinity reduced the chlorophyll concentration of rice plant.

Netondo *et al*. (2004) conducted an experiment in greenhouse conditions where sorghum plants were grown in sand culture. Concentration of NaCl in complete nutrient solution was control (0), 50, 100, 150 and 250 mM. In the two sorghum varieties, with the increased salinity levels chlorophyll a and b, net assimilation, stomatal conductance and transpiration rate were decreased significantly and for both the varieties the phenomena were similar. Leaf growth, gas exchange and chlorophyll fluorescence of two sorghum varieties (Serena and Seredo) were measured in response to increased NaCl concentration. The result indicates that salinity affected photosynthesis per unit area indirectly through stomatal closure. In addition salinity restrict leaf area expansion thus decreases whole plant photosynthesis. This affects starts from lower levels of sodium chloride. In contrast reductions of net photosynthesis per unit area occurs at higher levels of salinity concentration. It has been stated that decrease in chlorophyll amount have been observed in plants depending on increasing levels of salinity in saline stress condition.

Ali and Awan (2004) conducted an experiment with eighteen advanced rice genotypes and observed the result under an artificially salinized soil conditions after 90 days of transplanting. The result showed that salinity reduced the yield per plant, number of productive tillers, panicle length and number of primary branches per panicle of all the cultivars.

Islam (2004) conducted an experiment in pot to observe the impact of salinity on growth and development of rice under induced salinity condition. He stated that the with increased salinity levels the number of leaves decreased. Rashid (2005) also observed similar phenomena in rice plant. Mustafa (2004) observed that sugars and total carbohydrates were decreased at low and moderate salinity levels

conditions. Response to salinity soluble protein concentration generally decreased (Parida *et al*., 2002 and Abed-Latef, 2005).

Hernandez *et al*. (2003) stated that cell division and expansion inhabited by salt stress. Salinity also inhibited growth of leaf area. Lacerda *et al.* (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.

Shabala *et al.* (2003); Akram *et al.* (2007) observed that salt stress increases the concentration of Na+ in most of crop species thereby resulting in reduced growth and yield while limits the accumulation of essential nutrients such as K^+, Mg^{2+} and Ca^{2+}. This argument is further supported by a number of studies in which it was found that exogenous application of salt-induced deficient nutrient such as Ca, K or N can mitigate the adverse effects of salinity on growth of many crops e.g., wheat, sunflower and beans etc. Leena and Kiron (2003) conducted a field experiment in India on *Sorghum bicolor* L. to test the effect of salt stress. Though the plants were subjected to salt stress there was a reduction in the chlorophyll content. Only at the early stages of the plant fresh and dry weights of the plants were reduced.

Parida *et al*. (2002) observed a significant decline in the net photosynthesis as an immediate effect of photorespiration in plants exposed to high saline condition. This short term response to salinity exposure completely ceases photosynthesis which last for about 24-48 hours. Parida and Das (2005) observed that some major process of plant such as root/shoot dry weight and Na^+/K^+ ratio in root and shoot affected by salt stress.

Hossain (2002) reported that dry weight of roots and shoots, shoot/root ratios and yields of tomato increased with increasing moisture content and decreased with increasing salinity. The adverse effect of salinity on growth and yield could be reduced by increasing the moisture regimes up to field capacity. In case of higher salinity also promoted to uptake Cl in tomato plants which was exhibited in shoot and root dry matter and induced mineral nutrition disturbance. Javaid *et al.* (2002) investigated the plant height in four rice variety with different salinity effect (0, 20, 50 and 75 mM NaCl) and stated that the morphological characters of the studied plants are affected by salinity and with increased salinity levels plant height decreased.

Parti *et al*. (2002) in an experiment by adding chloride, sulphate salts of sodium, calcium and magnesium they observed and obtained salinity levels of 4, 8 and 12 dSm^{-1}. Salinity treatments considerably affected Plant growth. Javaid *et al*. (2002) observed the salinity effect on plant height, TDM, stem diameter, leaf number and area in four *Brassica* species and said that morphological characteristics of the plant negatively effected by salinity. With increasing salinity levels leaf number as well as leaf area also decreased. Moreover Chakroborti and Basu (2001) conducted a pot experiment on sesame under induced salinity condition to study the effect of salinity on growth and development of sesame plant. Also observed with the increased salinity levels the number of leaves decreased.

Munns (2002) reported that plant started to die when salt concentration increases inside the plant as a result salt starts to accumulate inside the older leaves. If new leaves generate at a rate lower than that at which older leaves die, it reduces the capacity of plants to supply the carbohydrate requirements of younger leaves leading to reduction in their growth rate (Munns *et al*., 2006).

Cicek and Cakirlar (2002) observed the physiological attributes of maize varieties affected by salinity. They found that shoot length, fresh and dry weight, leaf area

of maize plants markedly decreased due to salinity. Salinity inhabited microsporogenesis, stamen filament elongation, ovule abortion and senescence of fertilized embryos which adversely affects reproductive development of plants.

Thimmaiah (2002) conducted an experiment under different levels of salinity in irrigation water where sorghum (*Sorghum bicolor*) was grown and investigated for yield and yield components and biochemical composition. Salinity significantly differ the K^+ and Ca^{2+}, protein content and total amylolytic enzyme activity. However, these parameters were, more or less, at par with each other in the range of 2 to 8 dSm^{-1}. Among the chemical constituents, increased salinity levels increased Ca^{2+} content and decreased K^+ content. Essa (2002) reported that the main response of the plant to salt stress is a change in Ca^{2+} homeostasis and attributed that the salt tolerance of plants is their ability to avoid Na^+ toxicity and to maintain Ca^{2+} and K^+ concentrations. Romero-Aranda *et al*. (2001) and Soussi *et al.* (1998) reported that photosynthesis reduced under increasing salinity condition.

Babu and Thirumurugan (2001) conducted a pot experiment on sesame to study the effect of salt priming on growth and development under salinity condition. To create three levels of salinity, it was induced by addition of 35, 70 and 140 mM NaCl solution, and observed that with increasing salinity level plant height decreased. Ragiba (2000) also observed the similar results in sesame by many researchers. Abdullah *et al*. (2001) conducted an experiment for finding out the effect of salinity stress on seed set of IR-28 rice variety under different salinity levels and found that due to the stress panicle length was significantly decreased.

Lacerda *et al.* (2001) observed the effect of high saline concentration on plant growth, on inorganic transfer to shoot and on the accumulation and distribution of inorganic solutes. This was evaluated using two sorghum cultivars under salt stress condition. Samples were collected to evaluate the root dry matter yield and to

determine ion contents in the shoot after the beginning of NaCl treatment at 0, 4 and 8 days of salt application. With increasing saline treatment in both cultivars the sodium and chlorine ion transfer rates to the shoot during the experimental period of 0-4 days increased an average of about five times. Angrish *et al*. (2001) conducted an experiment in pot and observed that the leaf number of wheat plant decreased with the increased levels of chloride and sulfate salinity. Similar phenomena also observed by (Khan *et al*., 1997) in rice plant.

El-Midaoui *et al*. (1999) conducted an experiment under four salinity levels with three sunflower cultivars (cv. Oro 9, Flamme pinto and ludo). They reported that with increasing salinity plant growth was adversely affected. Leaf numbers and leaf area were mostly affected 72% followed by plant height 67% among the studied parameter. Excess production of reactive oxygen species (ROS), oxidative damage and a change in concentrations of antioxidants are occurred due to salinity stress (Gao *et al*., 2008). For cellular indicator stress ROS are very good parameter (Mittler, 2002). Cellular homeostasis, enhancing the production of ROS is disturbed by the plant stresses, including salinity stress (Dat *et al*., 2000). One of the most foremost stresses associated with high salinity levels are osmotic stress, has shown to shown to cause the production of ROS (Xiong and Zhu, 2002).

Mohammad *et al.* (1998) conducted a pot experiment of tomato where four levels of NaCl salt (0,50,100 and 150 mM NaCl) with three levels of (0.5, 1 and 2 mM) P for making nine combination are used in 500 ml glass jars containing Hoagland's solution to grow tomato seedling (cv. *riogrande)*. The result indicates that significant reductions in plant height, shoot weight and number of leaves per plant were accompanied by increasing salinity stress. El-Midaoui *et al.* (1999) conducted a greenhouse experiment under four salinity levels of 0, 50, 75 and 100 mM NaCl with three sunflower cultivars (cv. Oro 9, Flamme pinto and Ludo).

They stated negative relationship between plant growths with increasing salinity. In sunflower (Steduto *et al.*, 2000) also reported similar result.

Salinity stress known to be associated with the increases in GSH concentration (Ruiz and Blumwald, 2002; Leyva *et al*., 2011). Active plant growth retardation, as opposed to stress limiting growth has been associated with surviving adverse environmental conditions and this is interesting if we consider it contrary to conventional thought (Harberd *et al*., 2009), It also includes salinity stress (Magome *et al*., 2008). Higher concentrations of GSH would infer superior antioxidentative defense thus we all know GSH are well known antioxidants (Tausz *et al*., 2004), and salinity stress logically decrease the concentration of ROS (Foyer *et al*., 2005). When tomato and alfalfa leaves exposed to 100 mM of salinity stress they showed significant reduction in total chlorophyll content (Khavari and Mostofi, 1998). Several experiment showed that salt stress can reduce K^+, Ca^{2+} and N accumulation in different crop plants, e.g. wheat (Raza *et al.*, 2006), sunflower (Akram *et al.*, 2009), radish, cabbage (Jamil *et al.*, 2007) and canola (Ulfat *et al.*, 2007).

From the above review of literature, it may be concluded that salinity has marked effect on plant growth and development as well as yield of crops.

CHAPTER III

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted during the period from October 2016 to March 2017. The materials and methods those were used and followed for conducting the experiment have been presented under the following headings.

3.1 Location of the experiment

This study was conducted at 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. The experimental site is shown in the map of AEZ of Bangladesh in Appendix I.

3.2 Climatic condition of the experimental site

The experimental site is situated in the subtropical monsoon climatic zone, which is characterized by heavy rainfall during the months from April to September (Kharif season) and scanty of rainfall during rest of the year (Rabi season). Plenty of sunshine and moderately low temperature prevail during October to March (Rabi season), which are suitable for growing of tomato in Bangladesh. The weather information regarding temperature, rainfall, relative humidity and sunshine hours prevailed at the experimental site during the cropping season October 2016 to March 2017 have been presented in Appendix II.

3.3 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 at the SRDI, Dhaka in Appendix III.

3.4 Planting materials

Seedlings of 30 days of BARI Tomato- 2, BARI Tomato- 11, BARI Tomato- 14 and BARI Tomato- 15 were used. The seedlings of tomato were grown at the Horticulture Farm in Sher-e-Bangla Agricultural University. BARI Tomato-2, BARI Tomato-11, BARI Tomato-14 and BARI Tomato-15, cultivar 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.

3.5 Preparation of soil and filling of pots

A total of 48 earthen pots were prepared with 10 kg air dried soil. The size of the pot was 30 cm top diameter with a height of 25 cm. Plant parts, inert materials, visible insects and pests were removed from soil by sieving. Collected soil was dried under the sun. The dry soil was thoroughly mixed with well rotten cow dung and fertilizers before filling the pots. The pots were placed in the shade.

3.6 Pot preparation

A ratio of 1:3 well rotten cow dung and soil were mixed and pots were filled 15 days before transplanting. Silt Loam soils were used for pot preparation. All 48 pots were filled on October 2016. Weeds and stubbles were completely removed from the soil.

3.7 Experimental treatments and design

Four levels (0, 5, 10 and 15 dS m^{-1}) of saline water irrigation were imposed to four cultivars of tomato (BARI Tomato-2, BARI Tomato-11, BARI Tomato-14 and BARI Tomato-15), which composed of 4 treatments altogether. The experiment was set up in a two factor completely randomized design with three replications. Thus 48 experimental pots were placed in ambient air at the Horticulture farm premises of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh.

3.8 Treatments of the experiment

Factor A: Tomato cultivars

1. BARI Tomato 2 (V_1)
2. BARI Tomato 11 (V_2)
3. BARI Tomato 14 (V_3)
4. BARI Tomato 15 (V_4)

Factor B: Salinity levels (dSm^{-1}**)**

1. 0 (S_1)
2. 5 dSm^{-1} (S_2)
3. 10 dSm^{-1} (S_3)
4. 15 dSm^{-1} (S_4)

3.9 Application of manures and fertilizer in the pot

The required amount of fertilizers (N, P, K, and S kg ha^{-1}) and manure (cow dung @ 10 t ha^{-1}) was estimated on the basis of initial soil test result following Fertilizer Recommendation Guide (BARC, 2012). As per recommendation urea 7.0g, triple super phosphate (TSP) 7.0g, muriate of potash (MoP) 3.0g, gypsum 2.0g, and 100.0g cow dung pot^{-1} was applied. One third of urea and entire amount of cow dung, TSP and MoP, were mixed with the soil in each pot before sowing. Rest of the urea was applied as side dressing at 25 and 45 days after transplanting.

3.10 Imposition of salinity treatments

Salinity was imposed as per treatments at the pre-flowering stage four times at 20, 30, 40 and 50 DAT. The developed irrigation water salinity and pot soil were measured by using an electrical conductivity meter (HANNA HI 993310, Direct Salinity Meter) which was expressed in dSm^{-1}.

3.11 Preparation of stock solution

Saline water was synthesized by using a mixture of 3.285g NaCl for 5 dSm^{-1}, 6.570g NaCl for 10 dSm^{-1}, 11.175 g NaCl for 15 dSm^{-1}, so that their composition was almost alike with the average composition of the ground water.

3.12 Sowing of seeds

The seeds of four tomato cultivars were sown on the 3rd week of October 2016 by hand in separate pot to raise the seedling due to lack of seedbed in the experimental site. Proper care was taken following recommended measures for the development of healthy seedlings.

3.13 Seedling raising

A common procedure was followed in raising of seedlings in the pot. Tomato seedlings were raised in four pot at Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka. The size of the pot was 30cm in top area and 25 cm in bottom area. The soil was well prepared with spade and made into loose friable and dried mass to obtain fine tilth. All weeds and stubbles were removed and 5 kg well rotten cow dung was applied during pot preparation. The seeds were sown in the pot at 18 October, 2016 to get 30 days old seedlings. Germination was visible 5 days after sowing of seeds. After sowing, seeds were covered with light soil to a depth of about 0.6 cm. Heptachlor was applied @ 4 kg ha^{-1} around each seedbed as precautionary measure against ants and worm. The emergence of the seedlings took place within 6 to 7 days after sowing. Necessary shading by banana leaves was provided over the pot to protect the young seedlings from scorching sun or heavy rain. Weeding, mulching and irrigation were done from time to time as and when required and no chemical fertilizer was used in this pot.

3.14 Transplanting of seedling

Healthy 30 days old tomato seedlings were uprooted separately from the pots. The seedlings were watered before uprooting so as to minimize damage of roots. Two seedlings were transplanted to the each experimental pot in the afternoon during the last week of November 2016. Light irrigation was given immediately after transplanting by using water can. One seedling was uprooted leaving one seedling in each pot after seedling establishment.

3.15 Intercultural operations

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

3.15.1 Staking

At pre-flowering stage, the juvenile plants were staked with bamboo sticks to keep them erect and to protect from damage caused by storm and strong wind. The plants were tied by plastic ropes to the stems with bamboo slices which are hung above them.

3.15.2 Irrigation

Immediately after transplanting, light irrigation to the individual pot was provided 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. During pre-flowering stage, irrigation was done with saline water as per treatments upto 50 DAT. Thereafter, no irrigation was given. However, water was sprayed over the foliage at regular intervals.

3.15.3 Plant protection measures

Plant protection measures were done whenever it was necessary.

3.15.4 Insect pests and Diseases

As a preventive measure against the insect pest Ripcord was applied @ 2.0 ml L^{-1}. To prevent plants from insect infection, Volume flexi was applied @ 0.5 ml L^{-1} at the early stage of tomato. Virtako was also applied for controlling virus.

3.16 Harvesting of fruits

Fruits were harvested during early ripening stage when they attained red color. Harvesting was started on 15 January, 2017 and completed by 15 March, 2017.

3.17 Parameter Studied:

Data on the following parameters were recorded:

3.17.1 Measurement of morphological characters

1) Plant height (cm)
2) Number of primary branch Plant^{-1}
3) Number of leaves Plant^{-1}
4) Total Leaf Area (cm^2)
5) Diameter of the stem (cm)
6) Days of first flowering
7) No. of dropped flower plant^{-1}
8) Leaf chlorophyll content

3.17.2 Measurement of yield and yield contributing characters

1) Number of Flower Cluster Plant^{-1}
2) Number of Fruits Cluster Plant^{-1}
3) Number of Fruits Plant^{-1}
4) Individual Fruit Weight (g)
5) Fruit length (cm)
6) Fruit diameter (cm)
7) Average fruit weight (g)
8) Total fruit yield Plant^{-1} (g)

3.18 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 from 20 DAT to 60 DAT at 10 days interval.

2. Number of primary branch plant^{-1}

The branch number of individual plant was counted at 10 days interval from 20 DAT to 60 DAT and the average number of branch plant^{-1} was calculated.

3. Number of leaves plant^{-1}

The leaf number of individual plant was counted at 10 days interval from 20 DAT to 60 DAT and the average number of leaves plant^{-1} was calculated.

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

Leaf area was measured by non-destructive method using CL-202 Leaf Area Meter, (USA). Mature leaves were measured all the time and were expressed in cm^2.

5. Diameter of the Stem (cm)

Diameter of the stem were measured in centimeter (cm) from the basal, middle and top part of the stem from 20 DAT to 60 DAT at 10 days interval. After collecting data the average value of three parts were used as standard value.

B. Measurement of yield and yield contributing characters

6. Days of first flowering

In different tomato plant flower starts to bloom after 15 DAT and continued up to 20 DAT depending on the variety and environmentl conditions.

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

The number of flower cluster of individual plant was recorded at 10 days interval from 20 DAT to 60 DAT and the average number of clusters was recorded.

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

The number of dropped flower plant^{-1} was calculated by subtracting the total number of fruits plant^{-1} from the total number of flowers plant^{-1}.

9. Number of fruits cluster plant^{-1}

The number of fruit cluster of individual plant was recorded and the average number of cluster was recorded.

10. Number of fruits plant^{-1}

The number of fruits of individual plant was recorded and the average number of fruit was recorded.

11. Individual fruits weight (g)

The fresh weight of individual fruits from individual plant was recorded by an electric balance and the mean value was calculated.

12. Fruit length (cm)

The length of fruit was measured with a slide calipers from the neck of the fruit to the bottom of 10 fruits from each plant and their average was taken and expressed in cm.

13. Fruit diameter (cm)

Diameter of fruit was measured at middle portion of 10 fruits from each plant with a slide calipers. Their average was taken and expressed in cm.

14. Wt. of individual fruit (g)

Among the total number of fruits during the period from first to final harvest, fruit was considered for determining the individual fruit weight by the following formula:

Weight of individual fruit (g) = Total weight of fruits/ Total number of fruits

15. Fruit wt. plant^{-1} (g)

Fruit weight of tomato plant^{-1} was calculated from the whole fruit plant^{-1} and was expressed in gram (g).

16. Average fruit wt. plant^{-1} (g)

The average fruits weight of in individual plant was recorded by an electric balance and then the fruit yield was calculated.

16. 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 amounts in the leaves of a variety of species with a high degree of accuracy and is a nondestructive method.

3.19 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 analyses of variance for all the characters were performed by LSD test. The analyses were done following the software STATISTIX 10. The significance of the difference among the means was evaluated by the Least Significant Difference Test (LSD) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV

RESULT AND DISCUSSION

The experimental work was accomplished for the evaluation of four tomato cultivars to different salinity treatment. In this experiment four tomato cultivars BARI Tomato-2, BARI Tomato-11, BARI Tomato-14 and BARI Tomato-15 were used with four salinity treatment (0, 5 dSm^{-1}, 10 dSm^{-1} and 15 dSm^{-1}). In this chapter the findings of executed experiment work have been put forwarded and discussed. Data have been presented in table(s) and figure(s) for easy discussion, comprehension and understanding.

4.1 Effect on plant height

4.1.1 Effect of cultivars on plant height

Significant variation was observed in plant height with different cultivars. Plant height increased with advancement of Plant age (Figure1). The longest plants were observed in BARI Tomato 11 variety (V_2) at 30, 40, 50 and 60 DAT compared to other variety. In contrast, the shortest plant was observed in BARI Tomato 2 (V_1) variety throughout entire growth period. The natural plant height increased with increasing age. Similar results were also recorded by many other authors like Mohammad *et al.* (1998) and Parvin, 2013) in tomato, Jafari (2009) and Nawaz (2010) in sorghum, Milne (2012) in lettuce, Alaa El-din Sayed Ewase (2013) in coriander etc. The reduction of plant height may be due to inhibitory behavior of salt stress on cell division and cell expansion (Hernandez *et al*., 2003).

4.1.2 Effect of salinity on plant height

Soil salinity is one of the principal abiotic factors affecting crop yields in the arid and semi-arid irrigated areas. Plant growth was significantly affected by different cultivars as well as saline irrigation. Treatment with lower salinity gave the higher values of most plant parameters as compared to the high salinity. Different doses of salinity had no effect on plant height at early stage (upto 30 DAT) of tomato plant but at later stage (after 40 DAT) plant height decreased with increasing the dose of salinity (Figure 2). At 60 DAT, 5, 10 and

15 dsm^{-1} (S_2, S_3 and S_4 respectively) decreased plant heights by 3, 12 and 14%, respectively, compared with control plant. Salt stress inhibits cell division, cell elongation as well as plant growth (Munns and Tester, 2008). As salt stress inhibits growth that's why salt stress decreased growth of plant. These results also supported by Islam *et al*. (2011) and Al-Busaidi *et al.* (2010) who reported that salt stress inhibit plant height as well as plant growth.

4.1.3 Combined effect of cultivars and salinity on plant height

Interaction of variety and salinity showed significant effect on plant height throughout the life cycle of tomato cultivars (Table 1). At 60 DAT, V_1S_4 treatment (application of 15 dsm^{-1} salinity on BARI Tomato 2) showed the shortest plant (49 cm) which was statistically similar with V_1S_3 treatment. However, the longest plant (99.67 cm) was observed in V_2S_1 treatment which was statistically similar with V_2S_2 treatment. The results are in conformity with the results of Javed *et al*. (2002) who observed decreased plant height in tomato under salinity stress. These results also supported by Islam *et al*. (2011).

4.2 Effect on number of leaves $plant^{-1}$

4.2.1 Effect of variety on number of leaves $plant^{-1}$

Number of leaves $plant^{-1}$ was varied with different tomato cultivars throughout growth period except 50 DAT (Figure 3). At 60 DAT, the maximum number of leaf $plant^{-1}$ (40.42) was observed in V_1 variety (BARI Tomato 2) which was statistically similar with V_2 and V_3. This phenomenon was supported by (Biswas *et al*., 2015; Parvin, 2013).

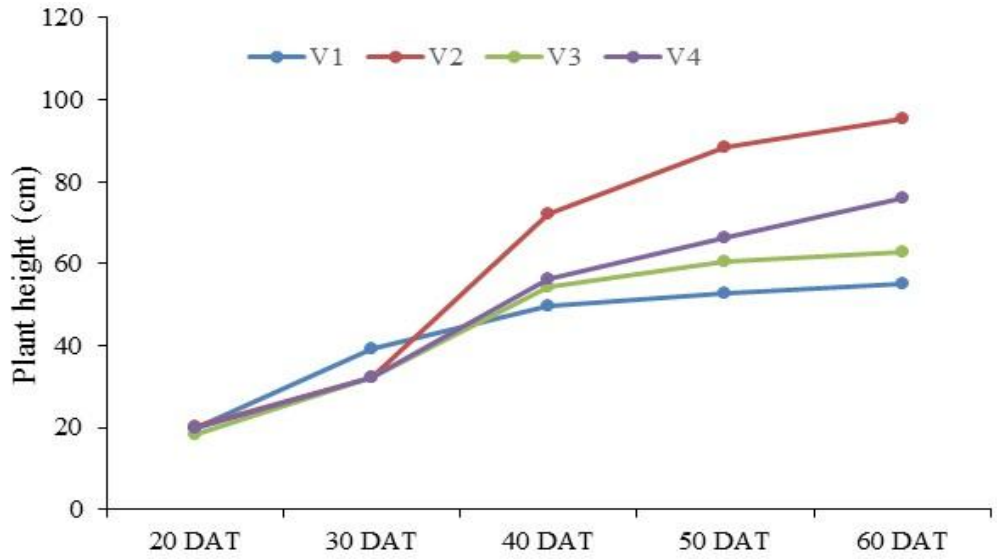

Figure 1: Effect of variety on plant height of tomato at different growth period

(V$_1$, V$_2$, V$_3$ and V$_4$ indicate BARI Tomato 2, BARI Tomato 11, BARI Tomato 14 and BARI Tomato 15, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at P≤0.05 applying the LSD test.)

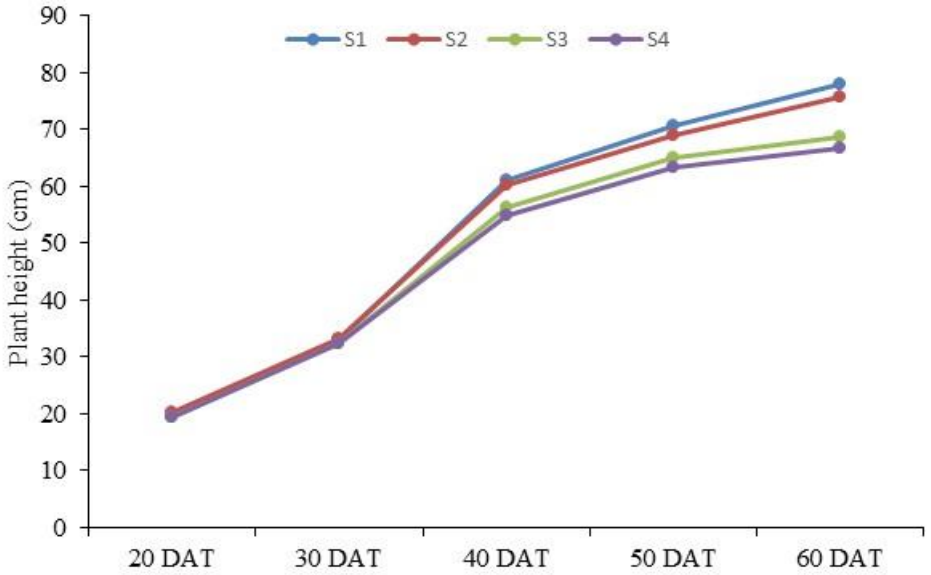

Figure 2: Effect of salinity on plant height of tomato at different growth period

(S$_1$, S$_2$, S$_3$ and S$_4$ indicate 0, 5, 10 and 15 ds m^{-1} salinity, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at P≤0.05 applying the LSD test.)

Table 1: Combined effect of cultivars and salinity on plant height of tomato at different days of growth period

Treatments	Plant height (cm)				
	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
V_1 S_1	20.17 ab	32.33 ab	52.00 fg	57.33 gh	62.33 fg
V_1 S_2	20.00 ab	32.66 ab	51.00 g	53.67 hi	57.67 h
V_1 S_3	20.33 ab	32.00 ab	48.66 gh	50.67 ij	51.33 i
V_1 S_4	19.67 ab	31.83 b	46.33 h	48.67 j	49.00 i
V_2 S_1	19.83 ab	34.60 a	74.67 a	91.33 a	99.67 a
V_2 S_2	20.33 ab	34.16 ab	73.33 ab	89.67 ab	98.67 a
V_2 S_3	20.17 ab	33.50 ab	71.00 ab	87.33 bc	92.33 b
V_2 S_4	20.50 ab	33.33 ab	69.67 b	85.33 c	90.67 b
V_3 S_1	18.16 b	32.00 ab	57.00 c-e	63.33 e	67.67 de
V_3 S_2	18.50 b	32.66 ab	56.33 d-f	61.67 ef	65.00 ef
V_3 S_3	18.16 b	32.33 ab	52.67 e-g	58.83 fg	61.00 f-h
V_3 S_4	18.16 b	32.00 ab	51.67 g	58.00 fg	58.33 gh
V_4 S_1	19.67 ab	32.66 ab	61.00 c	70.33 d	82.33 c
V_4 S_2	21.83 a	32.83 ab	60 cd	70.33 d	81.67 c
V_4 S_3	19.50 ab	32.00 ab	52.67 e-g	63.00 e	70.33 d
V_4 S_4	19.00 ab	31.83 b	52 fg	61.33 ef	69 de
$LSD_{0.05}$	2.85	2.67	4.58	3.96	4.03
CV %	8.71	4.90	4.73	3.55	3.44

(V_1, V_2, V_3 and V_4 indicate BARI Tomato 2, BARI Tomato 11, BARI Tomato 14, and BARI Tomato 15, respectively, & S_1, S_2, S_3 and S_4 indicate 0, 5, 10 and 15 ds m^{-1} salinity, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at $P \leq 0.05$ applying the LSD test.)

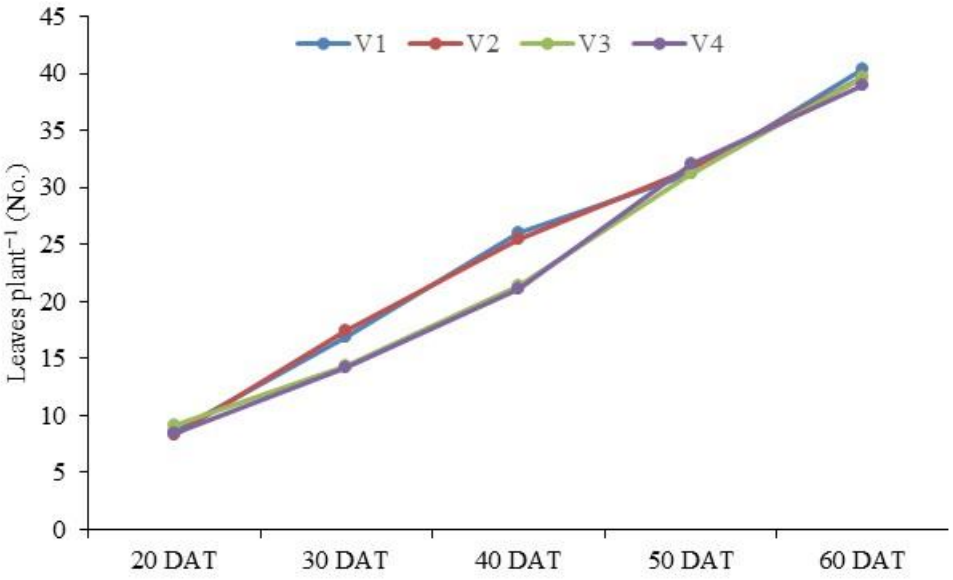

Figure 3: Effect of cultivars on number of leaves plant^{-1} of tomato at different days of growth period

(V_1, V_2, V_3 and V_4 indicate BARI Tomato 2, BARI Tomato 11, BARI Tomato 14 and BARI Tomato 15, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at P≤0.05 applying the LSD test.)

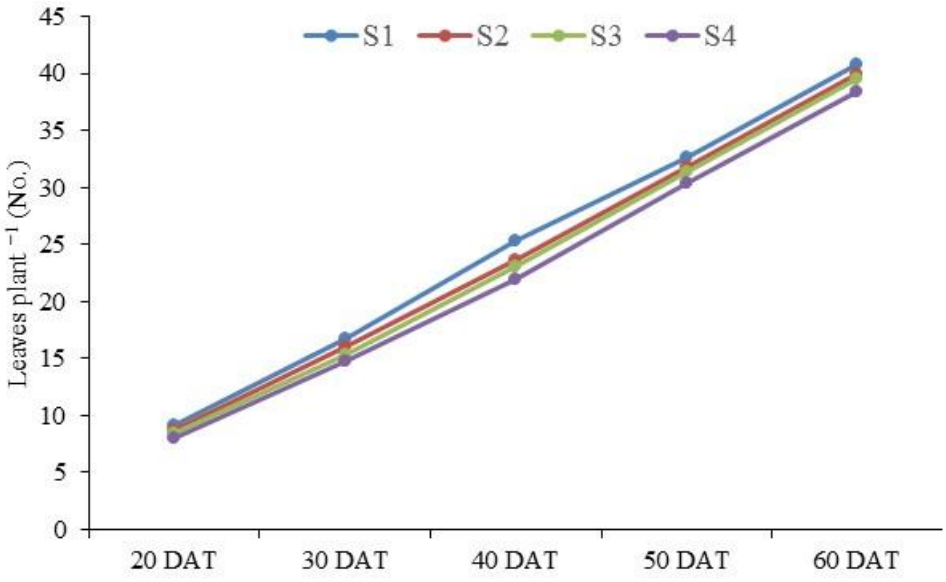

Figure 4: Effect of salinity on number of leaves plant^{-1} of tomato at different days of growth period

(S_1, S_2, S_3 and S_4 indicate 0, 5, 10 and 15 ds m^{-1} salinity, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at P≤0.05 applying the LSD test.)

4.2.2 Effect of salinity on number of leaves plant^{-1}

The mean number of leaves per plant decreased significantly with the increasing levels of salinity. Number of leaf plant^{-1} significantly decreased with increasing the level of salt stress (Figure 4). Exposure of 15 ds m^{-1} salinity (S_4) showed minimum number of leaf plant^{-1} at 20 (8.08), 30 (14.75), 40 (22), 50 (30.33) and 60 (38.42) DAT. S_2 and S_3 treatment showed statistically similar results where control plant (S_1 treatment) showed maximum number of leaf throughout the life cycle. This result was supported by (Ali and Rab, 2016).

Table 2: **Combined effects of cultivars and salinity on number of leaves plant^{-1} of tomato at different days of growth period**

Treatments	Number of leaves (No.)				
	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
V_1 S_1	9.33 ab	17.67 a-c	27.00 ab	32.67 ab	41.67 a
V_1 S_2	8.67 a-d	17.33 a-d	26.33 a-c	31.67 a-d	41.00 ab
V_1 S_3	8.33 b-d	16.67 a-e	25.67 a-d	30.67 cd	40.00 b-d
V_1 S_4	8.00 c-d	16.00 b-f	25.00 d-e	30.00 d	39.00 de
V_2 S_1	9.00 a-c	19.00 a	27.67 a	32.67 ab	40.67 a-c
V_2 S_2	8.33 b-d	18.00 ab	25.67 a-d	32.00 a-c	39.33 c-e
V_2 S_3	8.33 b-d	16.67 a-e	24.67 c-e	31.00 b-d	40.00 b-d
V_2 S_4	7.67 d	16.00 b-f	24.00 de	30.67 cd	38.67 de
V_3 S_1	9.67 a	15.33 b-f	23.67 d-f	32.00 a-c	41.00 ab
V_3 S_2	9.33 ab	14.33 ef	21.00 g-i	31.33 a-d	40.00 b-d
V_3 S_3	9.00 a-c	14.00 ef	20.67 hi	31.00 b-d	39.67 b-d
V_3 S_4	8.67 a-d	13.67 f	19.00 i	30.33cd	38.00 e
V_4 S_1	8.67 a-d	15.00 c-f	23.00 e-g	33.00 a	40.00 b-d
V_4 S_2	8.67 a-d	14.67 d-f	21.67 f-h	32.00 a-c	39.33 c-e
V_4 S_3	8.33 b-d	14.00 ef	21.00 g-i	32.67 ab	38.67 de
V_4 S_4	8.00 c-d	13.33 f	20.00 hi	30.33 cd	38.00 e
$LSD_{0.05}$	1.275	2.79	2.22	1.98	1.52
CV %	8.89	10.62	5.67	3.81	2.30

(V_1, V_2, V_3 and V_4 indicate BARI Tomato 2, BARI Tomato 11, BARI Tomato 14, and BARI Tomato 15, respectively, and S_1, S_2, S_3 and S_4 indicate 0, 5, 10 and 15 ds m^{-1} salinity, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at P≤0.05 applying the LSD test.)

4.2.3 Combined effect of cultivars and salinity on number of leaf plant^{-1}

Number of leaf plant^{-1} varied significantly with the interaction effect of variety and salinity at 20, 30, 40, 50 and 60 DAT (Table 2). At 60 DAT, maximum number of leaf plant^{-1} (41.67) was observed in V_1 S_1 which was statistically similar with V_1S_2, V_2S_1 and V_3S_1 treatments. The lowest number of leaf plant^{-1} (38) was observed in V_3S_4 and V_4S_4 treatment which were statistically similar with V_1S_4, V_2S_4, V_4S_2 and V_4S_3 treatments. This phenomenon was supported by (Islam *et al*., 2011; Alsadon *et al*., 2013).

4.3 Effect on number of branch plant^{-1}

4.3.1 Effect of cultivars on number of branch plant^{-1}

Number of branch plant^{-1} was varied significantly at early stage of plant (Up to 50 DAT) with different cultivars (Figure 5). At 60 DAT, there was no significant differences observed on branch plant^{-1}among the cultivars. This finding was supported by (Shimul *et al*., 2014; Parvin, 2013; Biswas *et al*., 2015).

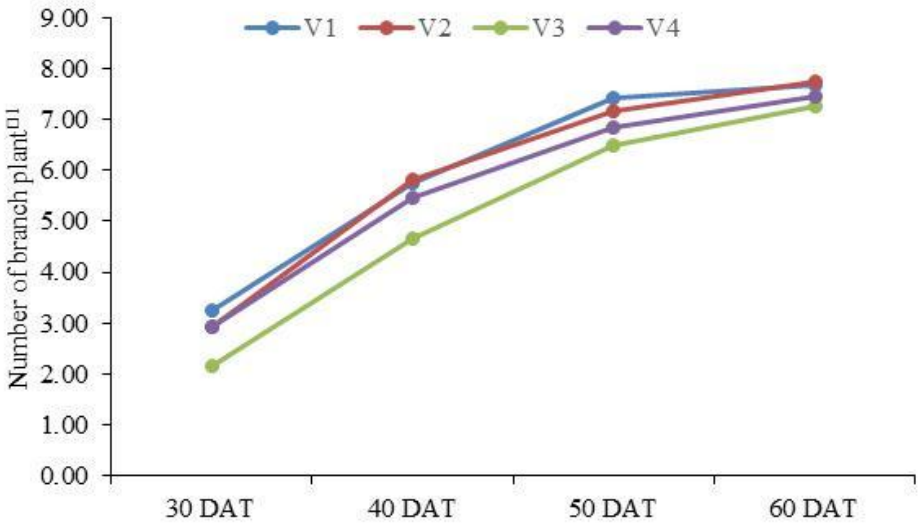

Figure 5: Effect of cultivars on number of branch plant^{-1} of tomato at different days of growth period.

(V_1, V_2, V_3 and V_4 indicate BARI Tomato 2, BARI Tomato 11, BARI Tomato 14 and BARI Tomato 15, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at P≤0.05 applying the LSD test.)

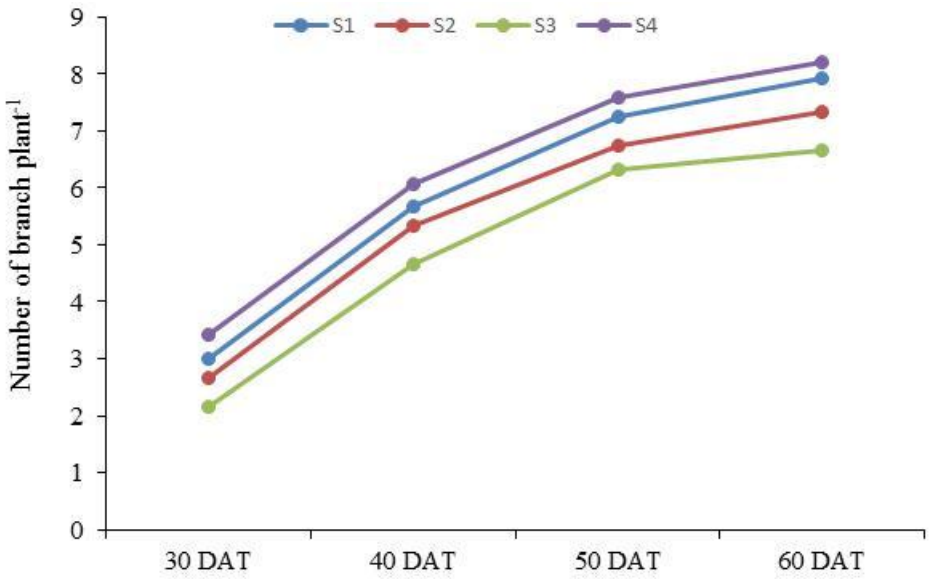

Figure 6: Effect of salinity on number of branch plant^{-1} of tomato at different days of growth period.

(S_1, S_2, S_3 and S_4 indicate 0, 5, 10 and 15 ds m^{-1} salinity, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at P≤0.05 applying the LSD test.)

4.3.2 Effect of salinity on number of branch plant^{-1}

Different doses of salinity also significantly affect branch plant^{-1} in tomato cultivars. Maximum number of branch plant^{-1} was observed in S_4 (15 ds m^{-1}) throughout the growth period which was statistically similar with control plant at 30, 40, 50 and 60 DAT (Figure 6). This result was supported by (Shimul *et al*., 2014; Islam *et al*., 2011; Alsadon *et al*., 2013; Parvin, 2013).

4.3.3 Combined effect of cultivars and salinity on number of branch plant^{-1}

Interaction of variety and salinity had significant effect on branch plant^{-1} (Table 3). AT V_1S_4 treatment, highest number of branch plant^{-1} was observed at 40 (7), 50 (8.33) and 60 (9.33) DAT. The lowest number of branch plant^{-1} (5.63) was observed in V_1S_3 treatment which was statistically similar with V_3S_3 treatment. This result was supported by (Shimul *et al*., 2014; Islam *et al*., 2011; Alsadon *et al*., 2013).

Table 3: **Combined effects of cultivars and salinity on number of branch plant^{-1} of tomato at different days of growth period**

Treatments	Number of branch (No.)			
	30 DAT	40 DAT	50 DAT	60 DAT
V_1 S_1	3.67 ab	5.67 b-d	7.67 ab	8.33 ab
V_1 S_2	3.00 b-d	5.33 cd	7.00 bc	7.33 b-d
V_1 S_3	2.67 c-d	5.00 cd	6.67 b-d	5.67 e
V_1 S_4	3.67 ab	7.00 a	8.33 a	9.33 a
V_2 S_1	3.33 a-c	6.67 ab	7.67 ab	8.33 ab
V_2 S_2	3.00 b-d	6.00 a-c	7.00 bc	7.67 b-d
V_2 S_3	2.33 d-f	5.33 cd	6.67 b-d	7.33 b-d
V_2 S_4	3.00 b-d	5.33 cd	7.33 a-c	7.67 b-d
V_3 S_1	2.00 ef	4.67 d	6.67 b-d	7.33 b-d
V_3 S_2	2.00 ef	4.67 d	6.33 cd	7.00 c-d
V_3 S_3	1.67 f	3.33 e	5.67 d	6.67 de
V_3 S_4	3.00 b-d	6.00 a-c	7.33 a-c	8.00 bc
V_4 S_1	3.00 b-d	5.67 b-d	7.00 bc	7.67 b-d
V_4 S_2	2.67 c-e	5.33 cd	6.67 b-d	7.33 b-d
V_4 S_3	2.00 ef	5.00 cd	6.33 cd	7.00 cd
V_4 S_4	4.03 a	5.90 a-c	7.36 a-c	7.78 b-d
$LSD_{0.05}$	0.75	1.03	1.19	1.22
CV %	15.62	11.18	9.74	10.85

(V_1, V_2, V_3 and V_4 indicate BARI Tomato 2, BARI Tomato 11, BARI Tomato 14, and BARI Tomato 15, respectively, and S_1, S_2, S_3 and S_4 indicate 0, 5, 10 and 15 ds m^{-1} salinity, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at $P \leq 0.05$ applying the LSD test.)

4.4 Effect on leaf area

4.4.1 Effect of cultivars on leaf area (LA)

Significant variation was observed on leaf area with varietal variation. Maximum leaf area meter (135.94 cm^2) was observed on BARI Tomato 2 cultivar (V_1) and minimum leaf area was observed on BARI Tomato 11 cultivar (V_2) cultivar (Figure 7). This variation might be due to genetical variation.

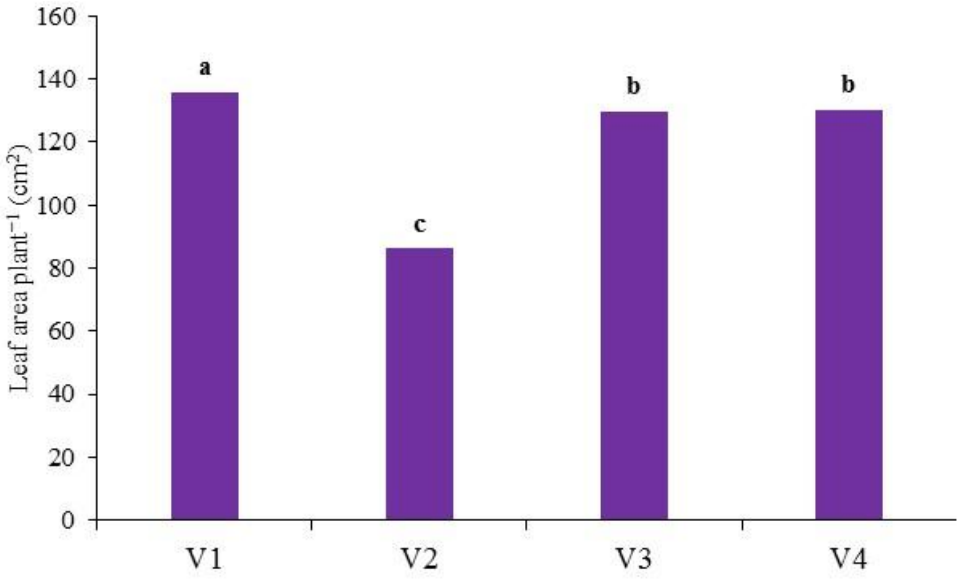

Figure 7: Effect of variety on LA of tomato at different days of growth period

(V_1, V_2, V_3 and V_4 indicate BARI Tomato 2, BARI Tomato 11, BARI Tomato 14 and BARI Tomato 15, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at P≤0.05 applying the LSD test.)

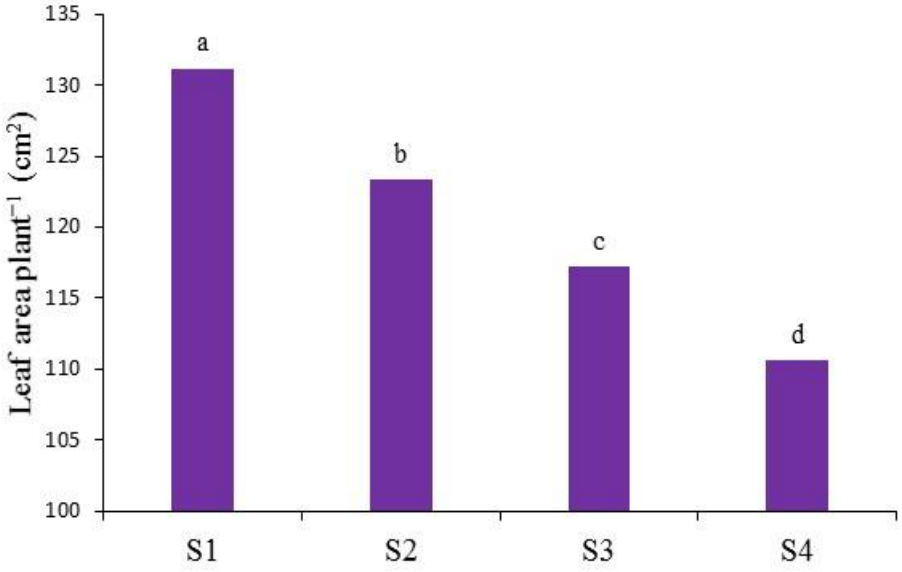

Figure 8: Effect of salinity on LA of tomato at different days of growth period

(S_1, S_2, S_3 and S_4 indicate 0, 5, 10 and 15 ds m^{-1} salinity, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at P≤0.05 applying the LSD test.)

4.4.2 Effect of salinity on leaf area

Salt stress decreased cell division, cell expansion as well as leaf area (Munns and Tester, 2008). In our study, we observed that, leaf area decreased with increasing level of salt stress in tomato cultivar (Figure 8). Compared with control plant, leaf area was decreased by 6, 11 and 17 % with 5, 10 and 15 ds m^{-1} salinity, respectively. Decreasing of leaf area with increasing salinity might be due to inhibition of cell division and cell expansion. This result was in agreement with (Hernandez *et al*., 2003) who noted that salt stress decreased leaf area.

Table 4: Combined effect of cultivars and salinity on leaf area and chlorophyll content of tomato

Treatments	Leaf area (cm^2)	SPAD unit
V_1 S_1	142.40 a	45.77 a
V_1 S_2	138.53 b	44.03 b
V_1 S_3	134.27 c	39.20 cd
V_1 S_4	128.57 d	37.60 de
V_2 S_1	96.27 g	40.40 c
V_2 S_2	88.90 h	39.53 c
V_2 S_3	84.87 i	35.90 f-h
V_2 S_4	74.50 j	34.97 g-j
V_3 S_1	142.53 a	36.83 ef
V_3 S_2	132.40 c	35.43 f-i
V_3 S_3	124.70 e	33.97 i-k
V_3 S_4	119.63 f	32.93 k
V_4 S_1	143.30 a	36.43 e-g
V_4 S_2	133.50 c	35.80 f-h
V_4 S_3	124.87 e	34.70 h-j
V_4 S_4	119.63 f	33.73 jk
$LSD_{0.05}$	2.06	1.61
CV %	1.03	2.60

(V_1, V_2, V_3 and V_4 indicate BARI Tomato 2, BARI Tomato 11, BARI Tomato 14, and BARI Tomato 15, respectively, and S_1, S_2, S_3 and S_4 indicate 0, 5, 10 and 15 ds m^{-1} salinity, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at $P \leq 0.05$ applying the LSD test.)

4.4.3 Combined effect of cultivars and salinity on leaf area

Interaction of variety and salinity significantly affect leaf area meter of different tomato cultivar. The highest leaf area (143.3 cm^2) was observed in V_4S_1 treatment which was statistically similar with V_1S_1 and V_3S_1. The lowest leaf area (74.50 cm^2) was observed in V_2S_4 treatment. The lowest leaf area in V_2S_4 treatment due to combination of genetical character and higher dose of salinity (S_4, 15 ds m^{-1}) as V_2 variety provided lowest leaf area compared with other cultivar (Table 4) and salinity decreased leaf area (Munns and Tester, 2008). Similar results also observed in previous studies (Hernandez *et al.*, 2003; Saberi *et al.*, 2011) where reported that leaf area decreased with increasing the level of salinity.

4.5 Effect on chlorophyll content (SPAD value)

4.5.1 Effect of cultivars on chlorophyll content (SPAD value)

Different cultivar showed different chlorophyll content (SPAD units). In the present study, we have recorded highest SPAD value (41.65 SPAD units) in BARI Tomato 2 cultivar (V_1). The lowest SPAD units (34.79) were observed in V_3 which was statistically similar with V_4 (Figure 9). This result was supported by (Ahmad *et al*., 2012).

4.5.2 Effect of salinity on chlorophyll content (SPAD value)

Salt stress decreased chlorophyll content and photosynthetic pigment (Munns and Tester, 2008). In our experiment we noticed that, chlorophyll content (SPAD value) decreased with increasing level of salt stress. Compared with control plant (S_1), 5, 10 and 15 ds m^{-1} (S_1, S_2 and S_3) salinity decreased chlorophyll content (SPAD units) by 3, 10 and 13%, respectively (Figure 10). Similar results reported in previous studies (Parvin, 2013) who noted that salt stress decreased chlorophyll and carotenoid content.

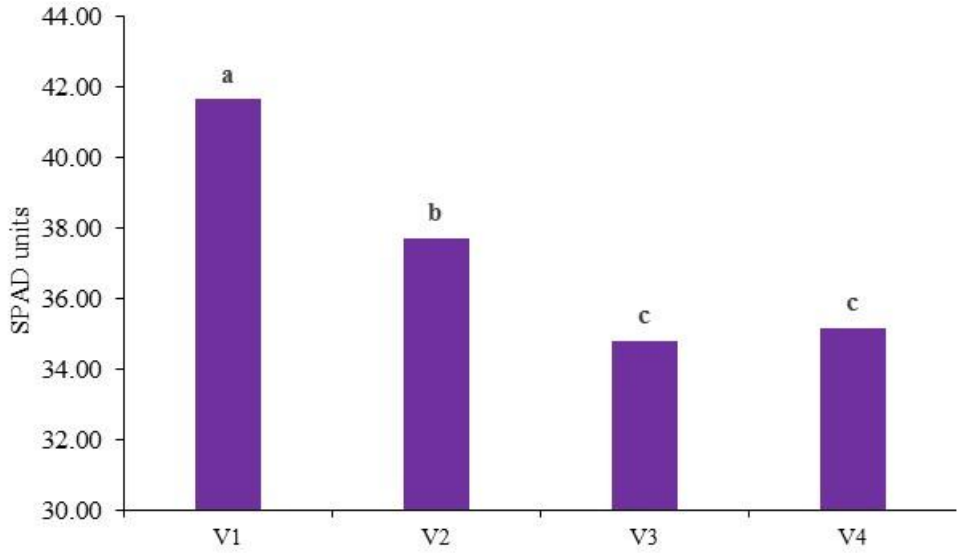

Figure 9: Effect of cultivars on chlorophyll content (SPAD units) of tomato

(V_1, V_2, V_3 and V_4 indicate BARI Tomato 2, BARI Tomato 11, BARI Tomato 14 and BARI Tomato 15, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at $P \leq 0.05$ applying the LSD test.)

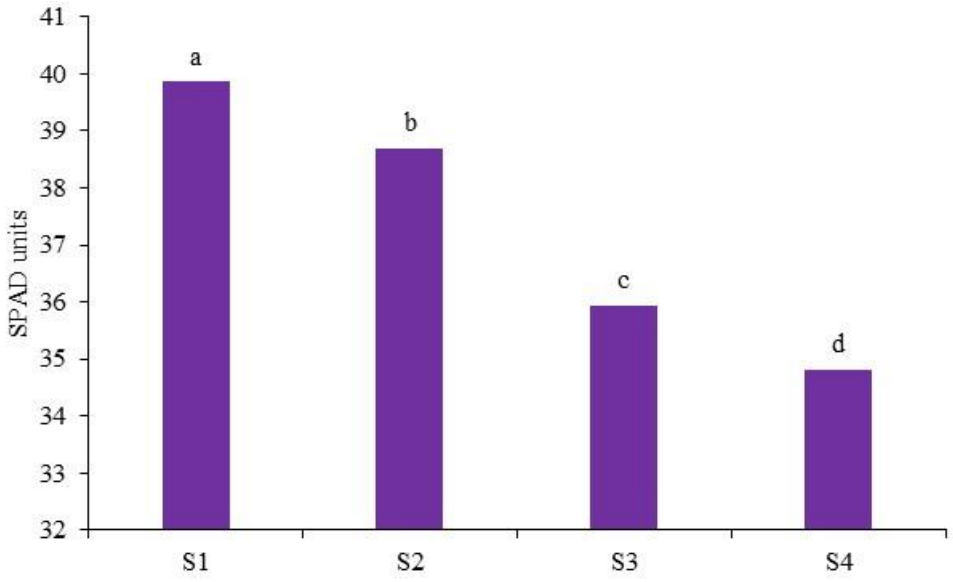

Figure 10: Effect of salinity on chlorophyll content (SPAD units) of tomato

(S_1, S_2, S_3 and S_4 indicate 0, 5, 10 and 15 ds m^{-1} salinity, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at $P \leq 0.05$ applying the LSD test.)

Table 5: Effect of cultivars, salinity and their combination on stem diameter of tomato at different days of growth period

Treatments	Stem diameter (cm)				
	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
V_1	0.57 bc	0.68 b	0.74 b	0.78 ab	0.83 ab
V_2	0.53 c	0.67 b	0.75 b	0.74 b	0.78 b
V_3	0.67 a	0.83 a	0.88 a	0.88 a	0.93 a
V_4	0.62 ab	0.80 a	0.94 a	0.85 ab	0.91 a
$LSD_{0.05}$	0.05	0.07	0.07	0.13	0.11
S_1	0.59 ab	0.75	0.87	0.78	0.83
S_2	0.63 a	0.75	0.82	0.79	0.82
S_3	0.59 ab	0.74	0.81	0.82	0.89
S_4	0.57 b	0.73	0.83	0.87	0.89
$LSD_{0.05}$	0.05	NS	NS	NS	NS
$V_1 S_1$	0.60 b-d	0.73 d-f	0.80 bc	0.83 a-c	0.87 b-d
$V_1 S_2$	0.63 a-d	0.73 d-f	0.80 bc	0.93 ab	1.03 ab
$V_1 S_3$	0.57 c-e	0.70 ef	0.73 cd	0.77 a-c	0.77 c-e
$V_1 S_4$	0.47 e-f	0.53 gh	0.63 d	0.60 c	0.63 e
$V_2 S_1$	0.43 f	0.63 fg	0.67 cd	0.67 bc	0.70 de
$V_2 S_2$	0.53 d-f	0.53 gh	0.67 cd	0.67 bc	0.67 de
$V_2 S_3$	0.47 ef	0.50 h	0.63 d	0.60 c	0.70 de
$V_2 S_4$	0.67 a-c	1.00 a	1.03 a	1.03 a	1.03 ab
$V_3 S_1$	0.70 ab	0.83 b-d	1.00 a	0.87 a-c	0.93 a-c
$V_3 S_2$	0.73 a	0.90 a-c	0.90 ab	0.80 a-c	0.83 b-e
$V_3 S_3$	0.70 ab	0.93 ab	0.90 ab	0.97 a	1.00 ab
$V_3 S_4$	0.53 d-f	0.67 f	0.73 cd	0.90 ab	0.93 a-c
$V_4 S_1$	0.63 a-d	0.80 c-e	1.00 a	0.77 a-c	0.83 b-e
$V_4 S_2$	0.60 b-d	0.83 b-d	0.90 ab	0.77 a-c	0.73 c-e
$V_4 S_3$	0.63 a-d	0.83 b-d	0.97 a	0.93 ab	1.10 a
$V_4 S_4$	0.60 b-d	0.72 d-f	0.91 ab	0.93 ab	0.96 a-c
$LSD_{0.05}$	0.11	0.15	0.15	0.27	0.23
CV %	11.42	24.29	22.24	8.91	9.21

(V_1, V_2, V_3 and V_4 indicate BARI Tomato 2, BARI Tomato 11, BARI Tomato 14, and BARI Tomato 15, respectively, and S_1, S_2, S_3 and S_4 indicate 0, 5, 10 and 15 ds m^{-1} salinity, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at $P \leq 0.05$ applying the LSD test.)

4.5.3 Combined effect of cultivars an salinity on chlorophyll content (SPAD value)

There are significant variation observed on chlorophyll content or SPAD units on combination of variety and salinity. The highest SPAD units (45.77) were observed in V_1S_1 treatment. The lowest SPAD unit (32.93) observed in V_3S_4

treatment which was statistically similar with V_3S_3 and V_4S_4 (Table 4). The lowest chlorophyll content was found in V_3S_3 because of combination of genetical character and higher level of salinity. In our study we recorded that BARI Tomato 14 (V_3) and 15 ds m^{-1} (S_4) showed lowest chlorophyll content individually (Figure 9 and Figure 10). These results also supported by (Parvin, 2013) who reported that chlorophyll content decreased with increasing the level of salinity.

4.6 Effect on stem diameter

4.6.1 Effect of cultivars on stem diameter

In our study, we observed different diameter of plant with different cultivars. BARI Tomato (V_3) consistently showed widest diameter of stem throughout the life cycle where BARI Tomato 16 (V_4) consistently showed statistically similar results (Table 5). This result was supported by (Biswas *et al*., 2015).

4.6.2 Effect of salinity on stem diameter

There are no significant variation observed on stem diameter at 30, 40, 50 and 60 DAT with different level of salinity (Table 5).

4.6.3 Combined effect of cultivars and salinity on stem diameter

Combination of variety and stem resulted in significant variation on diameter of stem. In our study, diameter of stem changed varied with irrespective of variety and salinity (Table 5).

4.7 Effect on days of first flowering

4.7.1 Effect of cultivars on days of first flowering

There is no significant variation observed on days of first flowering with different cultivars. Almost all cultivars started flowering at 21 DAT (Figure 11).

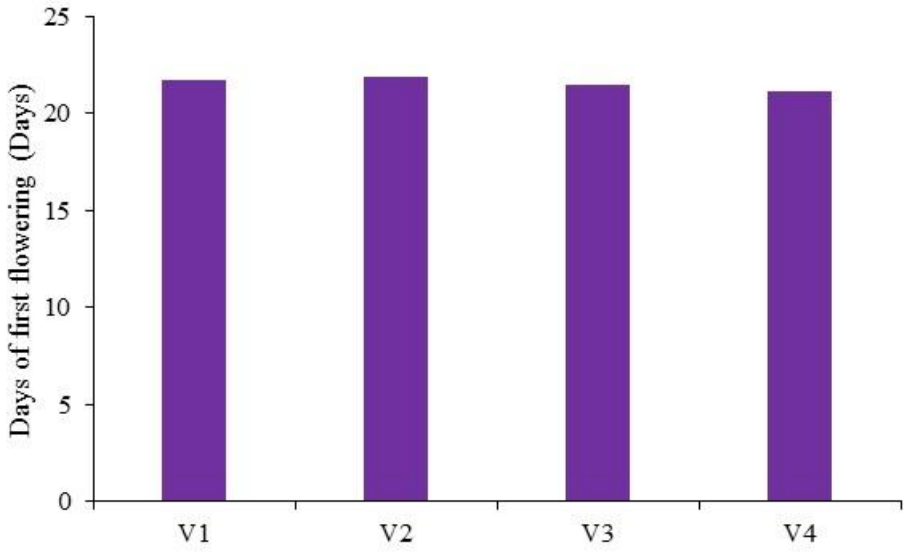

Figure 11: Effect of cultivars on days of first flowering of tomato

(V_1, V_2, V_3 and V_4 indicate BARI Tomato 2, BARI Tomato 11, BARI Tomato 14 and BARI Tomato 15, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at P≤0.05 applying the LSD test.)

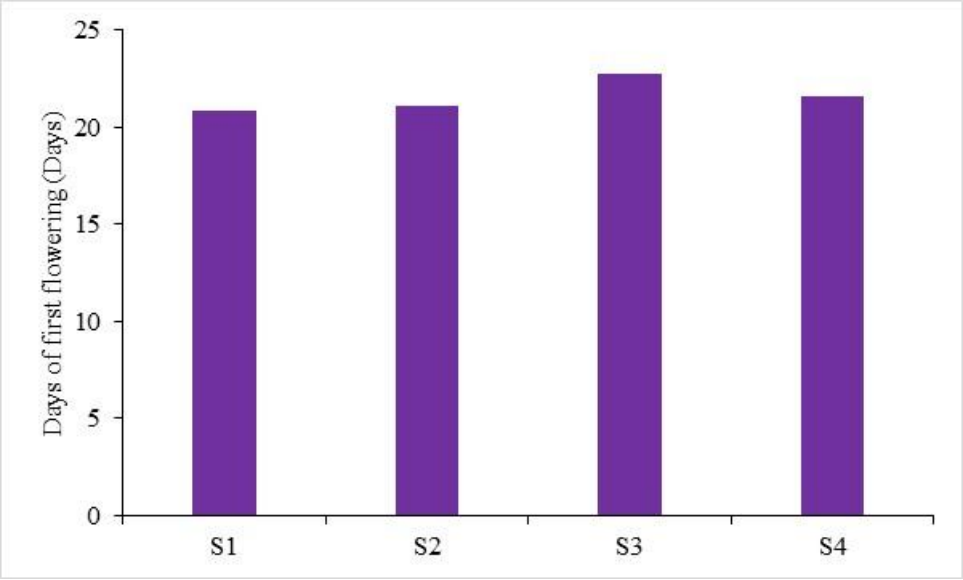

Figure 12: Effect of salinity on days of first flowering of tomato

(S_1, S_2, S_3 and S_4 indicate 0, 5, 10 and 15 ds m^{-1} salinity, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at P≤0.05 applying the LSD test.)

4.7.2 Effect of salinity on days of first flowering

There is no significant variation observed on days of first flowering with different level of salt stress. Probably, salinity have no effect on days of first flowering of tomato cultivars as we observed that different level of salinity started flowering almost in similar time (Figure 12). This result was supported by (Shimul *et al*., 2014).

Table 6: Combined effect of cultivars and salinity days of first flowering and number of flower cluster per plant of tomato at different days of growth period

Treatments	Days of first flowering	Number of flower cluster			
		30 DAT	40 DAT	50 DAT	60 DAT
V_1 S_1	21.00 ab	4.67 a	5.67 a	9.33 c	10.67 c
V_1 S_2	21.33 ab	4.33 ab	5.33 ab	8.67 cd	10.33 c
V_1 S_3	22.00 ab	4.00 a-c	5.00 a-c	8.33 cd	9.67 c
V_1 S_4	22.67 ab	3.67 a-d	4.33 b-d	8.00 d	9.67 c
V_2 S_1	21.00 ab	3.33 b-e	4.33 b-d	16.33 a	17.33 a
V_2 S_2	21.33 ab	3.00 c-f	4.00 c-e	16.00 a	17.00 ab
V_2 S_3	23.00 ab	2.67 d-g	3.67 d-f	15.67 a	17.00 ab
V_2 S_4	22.33 ab	2.33 e-g	3.33 d-g	13.67 b	15.67 b
V_3 S_1	21.67 ab	1.67 g	3.00 e-h	4.00 g-i	5.33 d-f
V_3 S_2	21.00 ab	1.67 g	2.67 f-i	3.67 hi	5.00 d-f
V_3 S_3	22.00 ab	2.00 fg	2.00 h-i	3.33 hi	4.67 ef
V_3 S_4	21.33 ab	1.67 g	1.67 i	3.00 i	4.33 f
V_4 S_1	19.67 a	1.67 g	3.00 e-h	5.67 e	6.33 d
V_4 S_2	20.67 ab	1.67 g	2.67 f-i	5.33 ef	6.00 de
V_4 S_3	24.00 a	1.67 g	2.33 g-i	5.00 e-g	5.67 d-f
V_4 S_4	20.17 ab	1.67 g	2.00 hi	4.33 f-h	5.33 d-f
$LSD_{0.05}$	4.19	1.05	1.27	1.21	1.44
CV %	5.18	4.81	1.22	1.41	7.69

(V_1, V_2, V_3 and V_4 indicate BARI Tomato 2, BARI Tomato 11, BARI Tomato 14, and BARI Tomato 15, respectively, and S_1, S_2, S_3 and S_4 indicate 0, 5, 10 and 15 ds m^{-1} salinity, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at $P \leq 0.05$ applying the LSD test.)

4.7.3 Combined effect of cultivars and salinity on days of first flowering

Although combination of variety and salinity showed significant variation on days of first flowering but all combinations were statistically similar (Table 6). In addition, variations on days of first flowering were recorded irregularly with

irrespective of variety and different level of salinity. Our results suggested that variation of variety, salinity or their combination had no effect on starting of flowering. This result was supported by (Shimul *et al*., 2014).

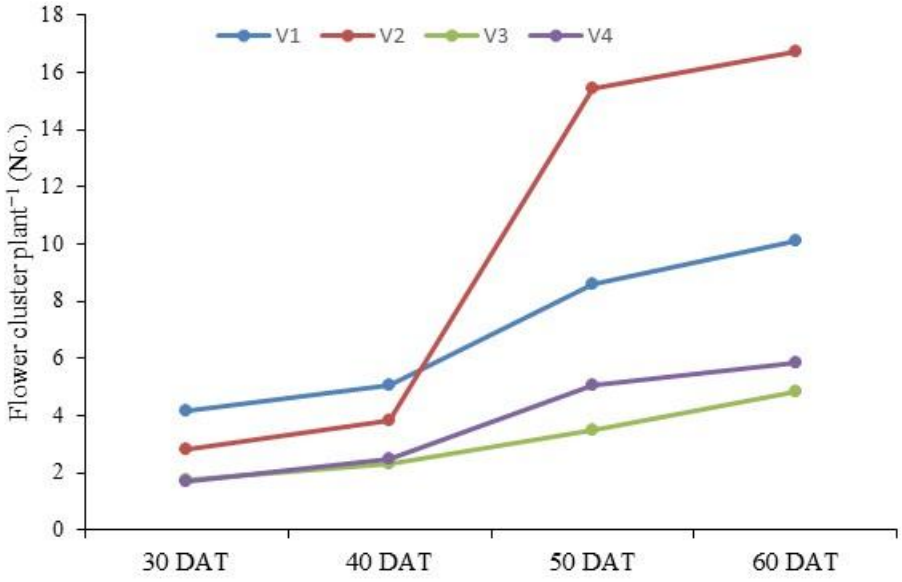

Figure 13: Effect of cultivars on number of flower cluster per plant of tomato

(V_1, V_2, V_3 and V_4 indicate BARI Tomato 2, BARI Tomato 11, BARI Tomato 14 and BARI Tomato 15, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at P≤0.05 applying the LSD test.)

4.8 Effect on flower cluster

4.8.1 Effect of cultivars on flower cluster plant^{-1}

Number of flower cluster per plant varied significantly in different cultivars. BARI Tomato 2 (V_1) cultivar produced highest number of flower cluster at 30 (4.17) and 40 (5.08) DAT. On the other hand, BARI Tomato 11 (V_2) produced highest number of flower cluster at 50 (15.42) and 60 (16.75) DAT. BARI Tomato 15 (V_4) consistently produced lowest number of flower cluster throughout the life cycle (Figure 13). This result was supported by (Shimul *et al*., 2014).

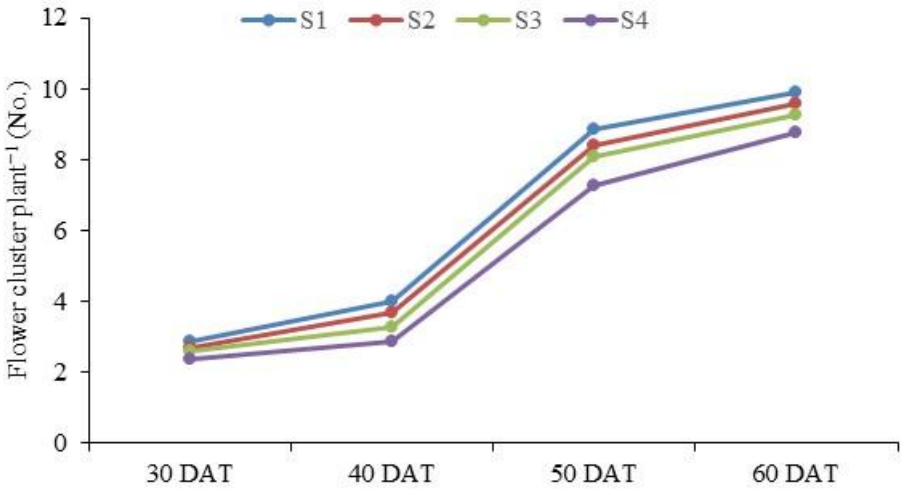

Figure 14: Effect of salinity on number of flower cluster per plant of tomato

(S_1, S_2, S_3 and S_4 indicate 0, 5, 10 and 15 ds m^{-1} salinity, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at P≤0.05 applying the LSD test.)

4.8.2 Effect of salinity on flower cluster plant^{-1}

Salt stress decreased number of flower cluster plant^{-1} with increasing the dose of salt stress. The highest number of flower cluster plant^{-1} was produced consistently in control plant (S_1) where 15 ds m^{-1} salinity (S_4) produced lowest number of cluster consistently at 30, 40, 50 and 60 DAT (Figure14). These results also in agreement with Venleperen (1996) who reported that salt stress decreased the number of flower cluster plant^{-1}.

4.8.3 Combined effect of cultivars and salinity on flower cluster plant^{-1}

The interaction of variety and salt stress showed significant variation on number of flower cluster plant^{-1}. Almost all cultivars showed comparatively higher number of flower cluster plant^{-1} in controlled condition where decreasing with increasing the dose of salinity (Table 6). At 30 and 40 DAT, V_1S_1 treatment produced highest number of flower cluster plant^{-1}. At 40 and 50 DAT, V_2S_1 treatment produced the highest number of flower cluster plant^{-1}. Interaction of BARI Tomato 14 and 15 ds m^{-1} (V_3S_4) produced lowest number of flower cluster plant^{-1} at 40 (1.67), 50 (3) and 60 (4.33) DAT. These results

also supported by Venleperen (1996) who noted salt stress decreased number of flower cluster plant^{-1}.

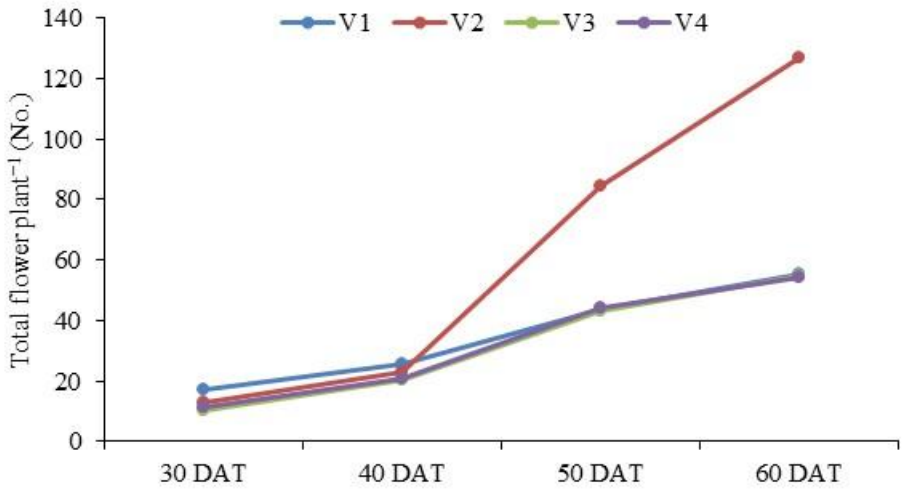

Figure 15: Effect of cultivars on number of total flower per plant of tomato

(V_1, V_2, V_3 and V_4 indicate BARI Tomato 2, BARI Tomato 11, BARI Tomato 14 and BARI Tomato 15, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at P≤0.05 applying the LSD test.)

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

4.9.1 Effect of cultivars on number of total flower plant^{-1}

The number of total flower plant^{-1} was varied significantly among different cultivars throughout entire growth period (Figure 15). The highest number of flower was observed in BARI Tomato 2 cultivar (V_1) at 30 and 40 DAT. AT 50 and 60 DAT, the highest number of flower plant^{-1} was produced in BARI Tomato 11 cultivar (V_2). However, BARI Tomato 15 (V_4) produced lowest number of flower plant^{-1} at 30 and 60 DAT. The variation in total number of flower plant^{-1} was because of genetical variation. Similar results also recorded in previous studies (Biswas *et al.*, 2015) who noted that number of flower cluster varied with the variation of genotypes.

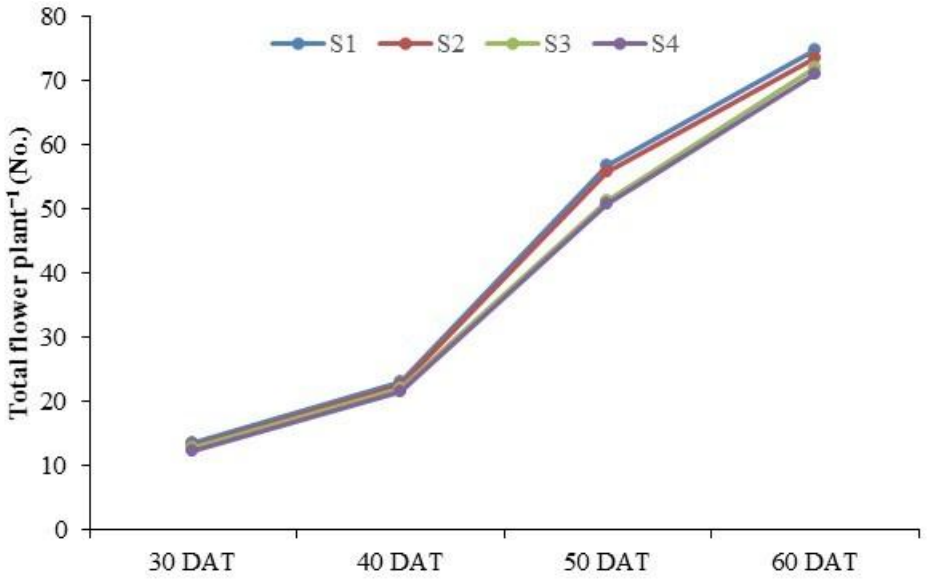

Figure 16: Effect of salinity on number of total flower per plant of tomato

(S_1, S_2, S_3 and S_4 indicate 0, 5, 10 and 15 ds m^{-1} salinity, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at $P \leq 0.05$ applying the LSD test.)

4.9.2 Effect of salinity on number of total flower plant^{-1}

Number of total flower plant^{-1} decreased with increasing the level of salinity (Figure 16). Application of 15 ds m^{-1} salinity (S_4) produced the lowest number of flower plant^{-1} consistently at 30, 40, 50 and 60 DAT. The highest number of total flower plant^{-1} was recorded consistently in entire life cycle in control plant (S_1). Exposure of 15 ds m^{-1} salt stress decreased total number of flower 15 ds m^{-1} by 9, 7 and 11% at 30, 40 and 50 DAT, respectively. This results also in agree with (Islam *et al*., 2011) who noticed that number of flower plant^{-1} decreased under salt stress.

Table 7: Combined effects of cultivars and salinity on number of total flower per plant and number of flower dropping per plant of tomato at different days of growth period

Treatments	Number of total flower				Number of flower dropping
	30 DAT	40 DAT	50 DAT	60 DAT	
V_1 S_1	17.67 a	26.33 a	46.33 d	57.00 c	22.67 i
V_1 S_2	17.33 a	26.00 a	45.67 de	56.33 cd	24.67 g-i
V_1 S_3	17.00 a	25.00 ab	42.00 f	55.00 d-f	29.33 b-d
V_1 S_4	16.67 a	25.00 ab	41.00 fg	54.00 fg	31.00 a-c
V_2 S_1	13.67 b	23.67 bc	87.67 a	129.00 a	15.00 k
V_2 S_2	13.33 b	23.00 cd	87.00 a	128.00 a	19.00 j
V_2 S_3	13.00 bc	22.33 c-e	81.67 b	125.00 b	22.00 ij
V_2 S_4	12.67 bd	22.33 c-e	81.00 b	124.67 b	26.00 e-h
V_3 S_1	11.00 ef	21.00 e-h	46.00 de	57.00 c	25.00 f-i
V_3 S_2	10.33 fg	20.33 f-h	45.00 e	55.00 d-f	28.00 c-f
V_3 S_3	9.67 g	20.00 f-h	40.33 g	54.33 ef	32.00 ab
V_3 S_4	9.33 g	19.33 h	40.33 g	53.33 fg	33.67 a
V_4 S_1	12.00 ce	21.67 d-f	47.67 c	56.00 c-e	22.00 ij
V_4 S_2	11.67 de	21.33 d-g	46.00 de	55.00 d-f	23.67 hi
V_4 S_3	11.33 ef	20.67 e-h	41.33 fg	53.67 fg	27.33 d-g
V_4 S_4	11.00 ef	19.67 gh	41.00 fg	52.33 g	29.00 b-e
$LSD_{0.05}$	1.12	1.79	1.09	1.71	3.28

(V_1, V_2, V_3 and V_4 indicate BARI Tomato 2, BARI Tomato 11, BARI Tomato 14, and BARI Tomato 15, respectively, and S_1, S_2, S_3 and S_4 indicate 0, 5, 10 and 15 ds m^{-1} salinity, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at $P \leq 0.05$ applying the LSD test.)

4.9.3 Combined effect of cultivars and salinity on number of total flower plant^{-1}

Interaction of variety and salt stress showed significant variation in number of flower plant^{-1} (Table 7). Among the all genotypes, number of flower was decreased with increasing the level of salt stress. However, V_3S_4 combination produced lowest number of flower plant^{-1} at 30 (9.33), 40 (19.33) and 50 (40.33) DAT. The lowest number of flower plant^{-1} in (V_3S_4) was produced because of highest dose salt stress (15 ds m^{-1}). In contrast V_2S_1 combination produced the highest number of flower plant at 40 (87.67) and 50 (129) DAT. Similar results also reported by previous resourcer (Islam *et al*., 2011) who concluded that salt stress decreased number of flower per plant.

4.10 Effect on flower dropping

4.10.1 Effect of cultivars on flower dropping

Number of flower dropping varied significantly with the variation of genotypes. In our study, different genotypes showed different number of flower dropping (Figure 17). The highest flower dropping per plant (29.67) occurred in BARI Tomato 14 (V_3) where lowest flower dropping (20.50) occurred in BARI Tomato 11 (V_2). These results also in agree with (Islam *et al*., 2011; Parvin, 2013).

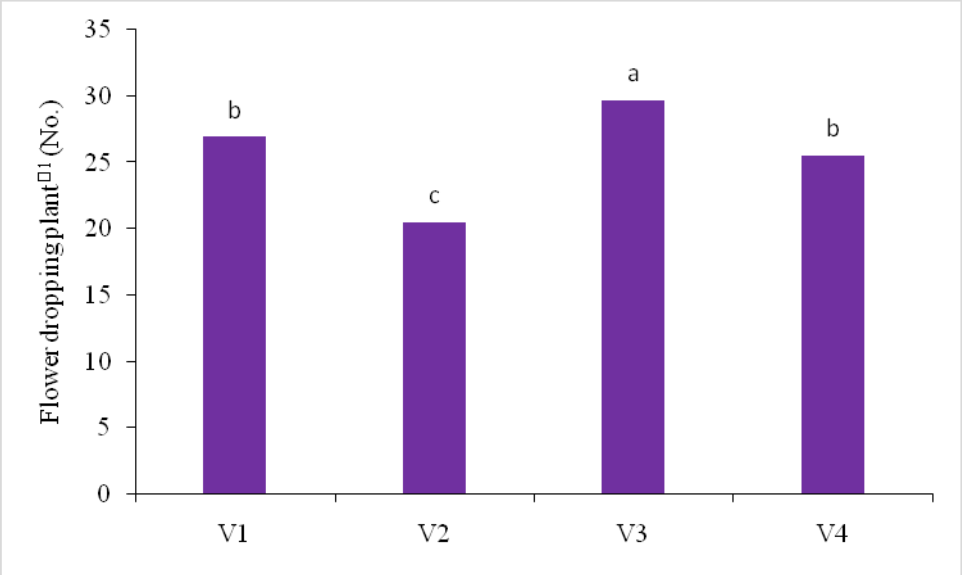

Figure 17: Effect of variety on number of flower dropping per plant of tomato

(V_1, V_2, V_3 and V_4 indicate BARI Tomato 2, BARI Tomato 11, BARI Tomato 14 and BARI Tomato 15, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at P≤0.05 applying the LSD test.)

4.10.2 Effect of salinity on flower dropping

Salt stress increased flower dropping with increasing the level of salt stress. Exposure of salt stress increased flower dropping by 10, 30 and 41% with 5, 10 and 15 ds m^{-1} salinity, respectively, compared with control plant (Figure 18). These results supported by Sun and Hauster (2004) who recorded that salt stress negatively affect reproductive growth and development.

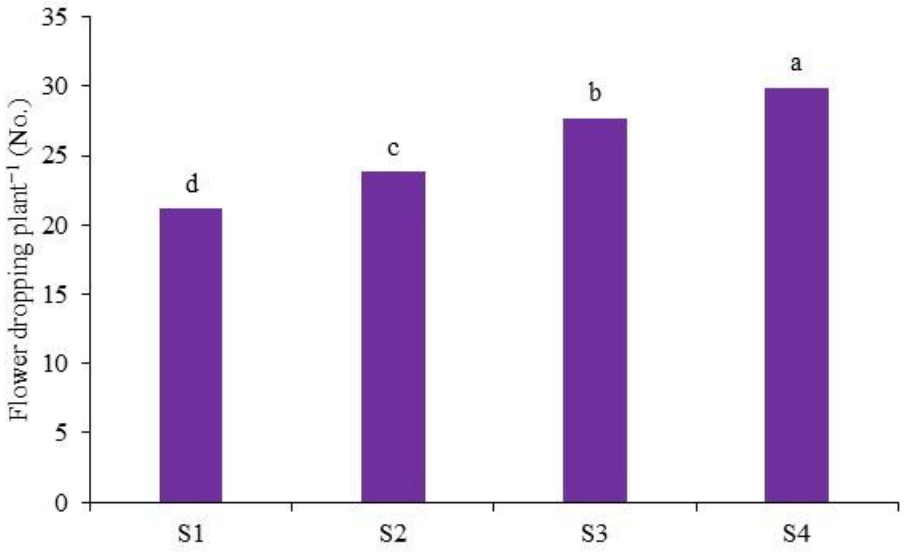

Figure 18: Effect of salinity on number of flower dropping per plant of tomato (S_1, S_2, S_3 and S_4 indicate 0, 5, 10 and 15 ds m^{-1} salinity, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at $P \leq 0.05$ applying the LSD test.)

4.10.3 Combined effect of cultivars and salinity on flower dropping

Interaction of variety and salinity showed significant influence on flower dropping. The highest flower dropping occurred in different cultivars with higher level of salinity (S_3, S_4). The highest flower dropping (33.67) observed in V_3S_4 treatment and lowest flower dropping recorded in V_2S_1 treatment (Table 7). These results also in agree with (Islam *et al*., 2011; Parvin, 2013).

4.11 Effect on number of fruit plant^{-1}

4.11.1 Effect of cultivars on number of fruit plant^{-1}

Significant variation was observed on number of fruit plant^{-1} in different variety. In our experiment, BARI Tomato 11 (V_2) showed highest number of fruit plant^{-1} (106.17) and BARI Tomato 14 (V_3) showed lowest number of number of fruit plant^{-1} (25.25) (Figure19). BARI Tomato 11 (V_2) produced highest number of fruit plant^{-1} as it ensured lowest number of flower dropping (Figure 17). On the other hand, BARI Tomato 14 produced lowest number of number of fruit plant^{-1} due to highest flower dropping (Figure 17). These results in agree with previous studies (Islam *et al*., 2011; Biswas *et al*., 2015) who reported that number of fruit plant^{-1} varied with the variation of genotypes.

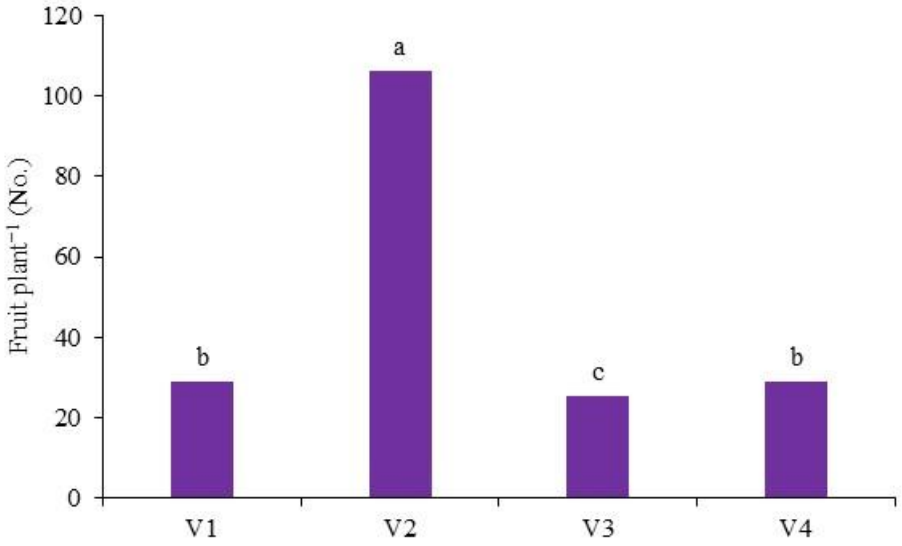

Figure 19: Effect of cultivars on number of fruit per plant per plant of tomato

(V_1, V_2, V_3 and V_4 indicate BARI Tomato 2, BARI Tomato 11, BARI Tomato 14 and BARI Tomato 15, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at P≤0.05 applying the LSD test.)

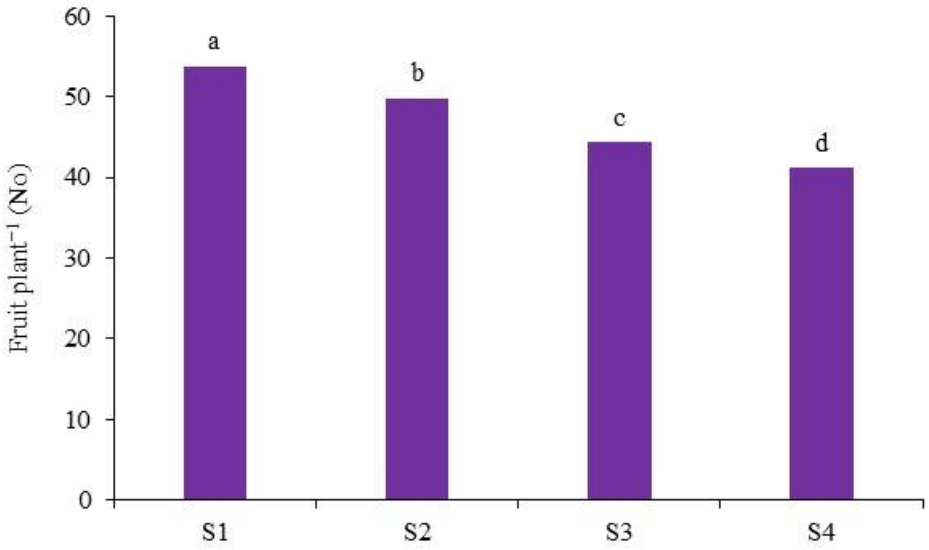

Figure 20: Effect of salinity on number of fruit per plant of tomato.

(S_1, S_2, S_3 and S_4 indicate 0, 5, 10 and 15 ds m^{-1} salinity, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at P≤0.05 applying the LSD test.)

4.11.2 Effect of salinity on number of fruit plant^{-1}

Number of fruit plant^{-1} sharply decreased with increasing the level of salinity. The present study showed that exposure of 5, 10 and 15 ds m^{-1} salinity decreased number of fruit plant^{-1} by 7, 18 and 23%, respectively, compared with control plant (S_1) (Figure 19). Number of fruit plant^{-1} decreased with increasing the level of salinity as flower dropping increased with increasing the level of salt stress. Salt stress decreased the reproductive growth and yield (Sun and Hauster, 2004; Shabani *et al*., 2012). Our results also suggested similar results as salinity decreased number of fruit plant^{-1}.

4.11.3 Combined effect of cultivars and salinity on number of fruit plant^{-1}

Combination of variety and salt stress showed variation in number of fruits plant^{-1}. Combination of highest dose of salinity (15 dsm^{-1}) with different variety showed comparatively lower number of fruit plant^{-1} (V_1S_4, V_2S_4, V_3S_4 and V_4S_4) (Table 8). The highest number of fruits plant^{-1} (114) was recorded in V_2S_1 treatment and lowest number of fruit plant^{-1} (19.67) was produced in V_3S_4) treatment. Our results was supported by previous studies (Sun and Hauster, 2004; Shabani *et al*., 2012).

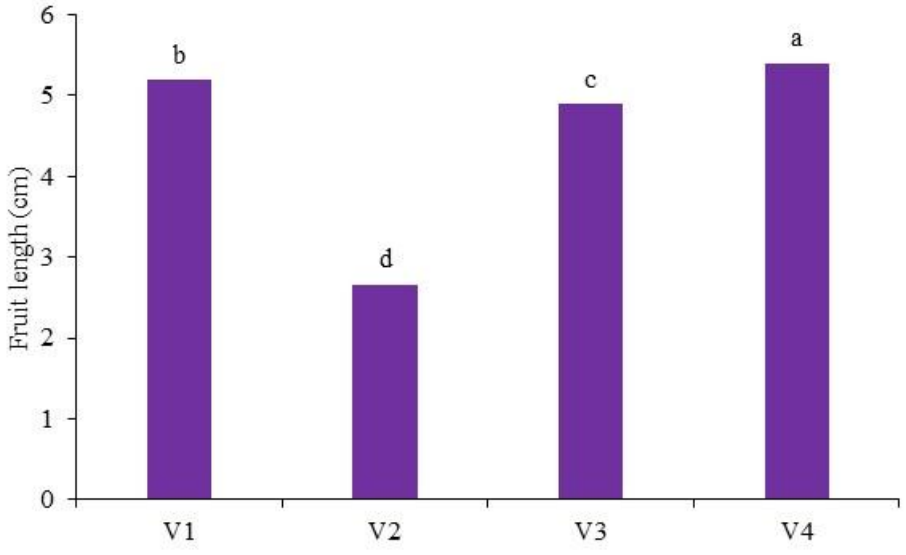

Figure 21: Effect of cultivars on fruit length of tomato

(V_1, V_2, V_3 and V_4 indicate BARI Tomato 2, BARI Tomato 11, BARI Tomato 14 and BARI Tomato 15, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at P≤0.05 applying the LSD test.)

4.12 Effect on fruit length

4.12.1 Effect of cultivars on fruit length

Different length of fruit was observed on different genotypes (Figure 21). In the present experiment we noticed that, BARI Tomato 15 (V_4) produced the longest fruit (5.4 cm) and BARI Tomato 11 (V_2) produced shortest fruit (2.67 cm). Similar results also observed by Kibria *et al*., (2013) who noted that fruit length varied with varietal variation.

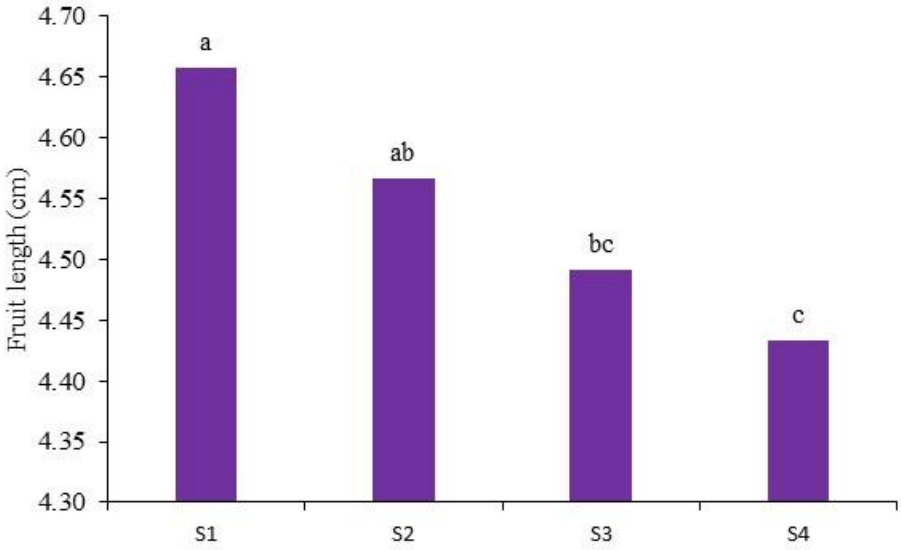

Figure 22: Effect of salinity on fruit length of tomato.

(S_1, S_2, S_3 and S_4 indicate 0, 5, 10 and 15 ds m^{-1} salinity, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at P≤0.05 applying the LSD test.)

4.12.2 Effect of salinity on fruit length

Application of different doses of salinity resulted in different length of fruit (Figure 22). Fruit length was deceased with increasing the level of salt stress. However, exposure of 15 ds m^{-1} (S_4) produced shortest fruit (4.43 cm). These results are in agreement with Hossain. (2002) who reported that length of fruit decreased with increasing salinity.

4.12.3 Combined effect of cultivars and salinity on fruit length

Significant variation was observed on fruit length for the combined effect of variety and salinity (Table 8). Combination of higher level of salinity (S_3, S_4) with different cultivars showed lowest fruit length. In the present study, V_4S_1

showed the highest fruit length (5.54 cm). In contrast, the lowest fruit length was recorded in V_2S_4 treatment which was statistically similar with V_2S_1, V_2S_2, and V_2S_3 (Table 8). Observation of lowest fruit length in V_2 cultivar with combination of all levels of salinity due to genotypic character as V_2 cultivar showed the lowest fruit length (Figure 21).

Table 8: Combined effect of cultivars and salinity on number of fruit per plant, fruit length, fruit diameter, individual fruit weight and yield per plant of tomato

Treatments	Fruit plant^{-1} (No.)	Fruit length (cm)	Fruit diameter (cm)	Individual fruit weight (g)	Yield plant^{-1} (g)
V_1 S_1	35.00 e	5.30 bc	5.60 c-e	80.00 c	2800.00 b
V_1 S_2	31.67 fg	5.23 b-d	5.53 d-f	79.67 c	2523.30 c
V_1 S_3	25.67 hi	5.17 c-e	5.40 ef	76.67 d	1967.30 e
V_1 S_4	23.00 j	5.07 d-f	5.30 f	75.33 d	1730.30 f
V_2 S_1	114.00 a	2.77 h	2.23 g	9.33 h	1064.00 h
V_2 S_2	109.00 b	2.67 h	2.20 g	9.00 h	981.00 h
V_2 S_3	103.00 c	2.63 h	2.13 g	8.67 h	892.70 hi
V_2 S_4	98.67 d	2.60 h	2.00 g	7.67 h	755.70 i
V_3 S_1	32.00 fj	5.00 e-g	5.73 b-d	94.00 a	3008.70 a
V_3 S_2	27.00 h	4.93 f-g	5.67 c-e	92.67 a	2502.70 c
V_3 S_3	22.33 j	4.83 g	5.57 c-f	92.33 a	2062.70 e
V_3 S_4	19.67 k	4.80 g	5.40 ef	90.33 b	1777.00 f
V_4 S_1	34.00 ef	5.57 a	6.10 a	66.00 f	2245.00 d
V_4 S_2	31.33 g	5.43 ab	5.97 ab	64.00 f	2004.70 e
V_4 S_3	26.33 h	5.33 bc	5.83 a-c	62.00 g	1632.70 f
V_4 S_4	23.33 ij	5.27 b-d	5.67 c-e	61.33 g	1431.70 g
$LSD_{0.05}$	2.36	0.22	0.28	1.93	175.95
CV %	2.99	4.53	3.58	1.91	5.75

(V_1, V_2, V_3 and V_4 indicate BARI Tomato 2, BARI Tomato 11, BARI Tomato 14, and BARI Tomato 15, respectively, and S_1, S_2, S_3 and S_4 indicate 0, 5, 10 and 15 ds m^{-1} salinity, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at $P \leq 0.05$ applying the LSD test.)

4.13 Effect on fruit diameter

4.13.1 Effect of cultivars on fruit diameter

The present study resulted in different diameter of fruit in different genotypes (Figure 23). The highest diameter (5.89 cm) was recorded in V_4 genotypes and lowest diameter (2.14) was recorded in V_2 genotypes.

4.13.2 Effect of salinity on fruit diameter

The diameter of fruit length decreased with increasing the level of salinity (Figure 24). Exposure of salinity decreased fruit diameter by 2, 4 and 7% with S_1, S_2 and S_4 salinity compared with control (S_1). These results supported by Islam *et al.* (2011) who noted that reproductive growth (e.g. fruit diameter, fruit length) of tomato decreased under salt stress and the level of deterioration increased with increasing the level of salinity.

4.13.3 Combined effect of cultivars and salinity on diameter

There were significant variation was observed on fruit diameter for the combined effect of variety and salinity (Table 8). The highest value (6.1 cm) was observed in V_4S_1 treatment which was statistically similar with V_4S_2 treatment. In contrast, the lowest fruit diameter (2 cm) was observed in V_2S_4 treatment which was statistically similar with V_2S_1, V_2S_2 and V_3S_3 treatment.

4.14 Effect on individual fruit weight

4.14.1 Effect of cultivars on individual fruit weight

In the present study, we noticed that individual fruit weight varied with different tomato cultivars (Figure 25). The highest individual fruit weight (92.33 g) was observed in BARI Tomato 14 (V_3) genotype where lowest individual fruit weight (8.67) was observed in BARI Tomato 11 (V_2) cultivar. Simillar results were also reported by (Biswas *et al*., 2015; Kibria *et al*., 2013).

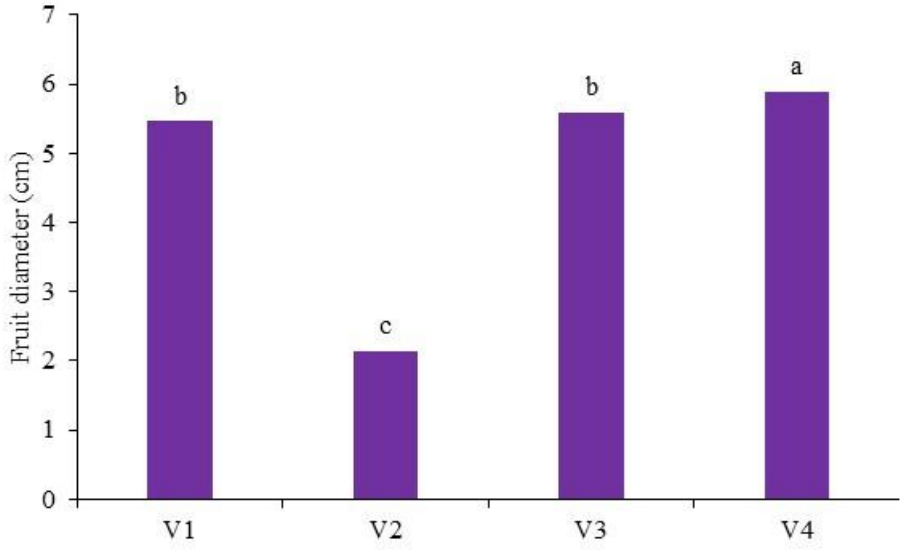

Figure 23: Effect of cultivars on of fruit diameter of tomato

(V_1, V_2, V_3 and V_4 indicate BARI Tomato 2, BARI Tomato 11, BARI Tomato 14 and BARI Tomato 15, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at $P \leq 0.05$ applying the LSD test.)

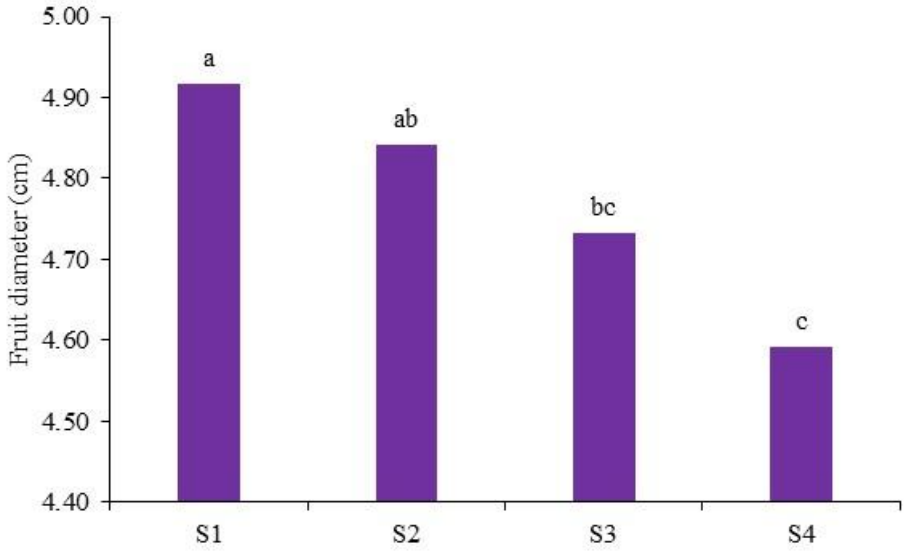

Figure 24: Effect of salinity on fruit diameter of tomato

(S_1, S_2, S_3 and S_4 indicate 0, 5, 10 and 15 ds m^{-1} salinity, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at $P \leq 0.05$ applying the LSD test.)

4.14.2 Effect of salinity on individual fruit weight

The individual fruit weight of tomato sharply decreased with increasing the level of salinity (Figure 26). The lowest individual fruit weight (58.67 g) was recorded in S_4 treatment which is 6% lower than control Plant (S_1). Our finding supported by Islam *et al*. (2011) who noticed that individual fruit weight decreased under salt stress condition and fruit weight decreased with increasing the level of salt stress.

4.14.3 Combined effect of cultivars and salinity on individual fruit weight

Interaction of variety and salinity resulted in significant variation on individual fruit weight (Table 8). In each genotype, combination with higher salinity decreased individual fruit weight. However, the highest individual fruit weight (94 g) was recorded in V_3S_1 treatment which was statistically similar with V_3S_2 and V_3S_3. The lowest value (7.67 g) was observed in V_2S_4 treatment which was statistically similar with V_2S_1, V_2S_2 and V_2S_3 treatment combinations.

4.15 Effect on fruit yield plant^{-1}

4.15.1 Effect of cultivars on fruit yield plant^{-1}

Variation in fruit yield plant^{-1} was recorded in different genotypes (Figure 27). BARI Tomato 14 (V_3) produced highest yield plant^{-1} (2337.7 g) which was statistically similar with BARI Tomato 2 (V_1). Although BARI Tomato 2 produced highest number of fruit plant^{-1}, but it was resulted lowest yield plant^{-1} (923.3 g) because of lowest individual fruit weight. On the other hand, individual fruit weight of BARI Tomato 14 was highest as well as it produced highest yield. Similar results also observed in previous findings (Islam *et al*., 2011; Biswas *et al*., 2015)

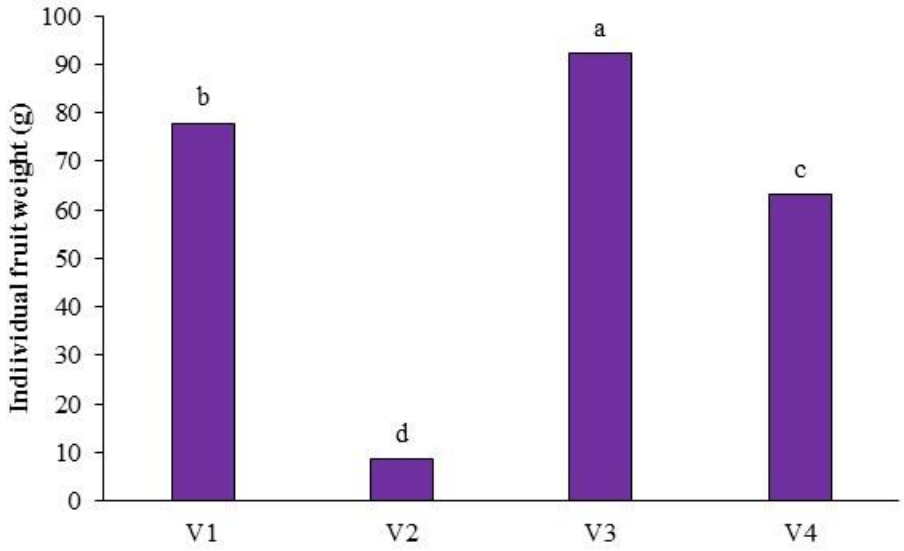

Figure 25: Effect of cultivars on individual fruit weight of tomato

(V_1, V_2, V_3 and V_4 indicate BARI Tomato 2, BARI Tomato 11, BARI Tomato 14 and BARI Tomato 15, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at P≤0.05 applying the LSD test.)

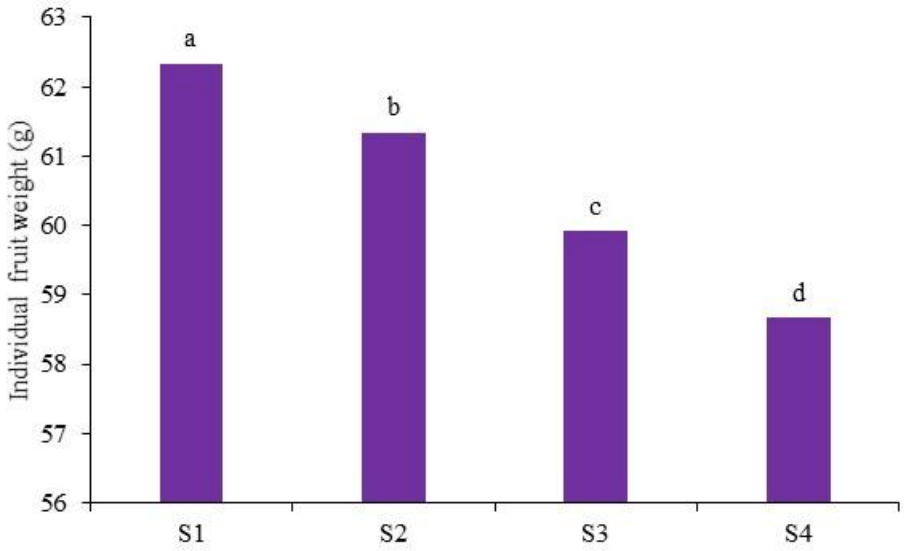

Figure 26: Effect of salinity on individual fruit weight of tomato

(S_1, S_2, S_3 and S_4 indicate 0, 5, 10 and 15 ds m^{-1} salinity, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at P≤0.05 applying the LSD test.)

4.15.2 Effect of salinity on fruit yield plant^{-1}

Salt stress decreased reproductive growth and fruit yield (Islam *et al*., 2011). In the present study, we noticed that fruit yield decreased with increasing the dose of salinity (Figure 28). Salt-induced stress by 5, 10 and 15 ds m^{-1} salinity decreased fruit yield by 12, 28 and 38%, respectively compared with control plant. Salt stress decreased total flower plant^{-1}, number of fruit plant^{-1}, individual fruit weight as well as fruit yield. These results are in agreement with previous findings (Islam *et al*., 2011and Kibria *et al*., 2013)

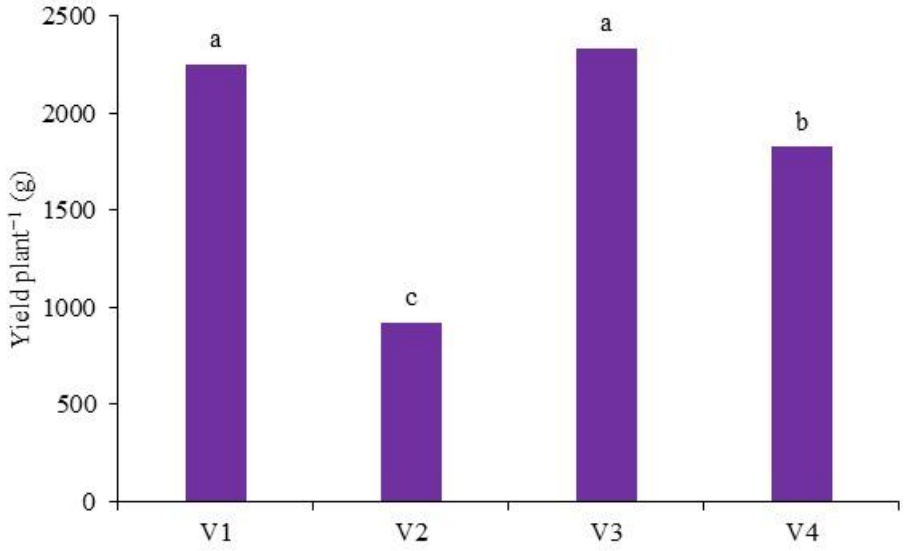

Figure 27: Effect of cultivars on fruit yield per plant of tomato

(V_1, V_2, V_3 and V_4 indicate BARI Tomato 2, BARI Tomato 11, BARI Tomato 14 and BARI Tomato 15, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at P≤0.05 applying the LSD test.)

4.15.3 Combined effect of cultivars and salinity on fruit yield plant^{-1}

Yield variation was observed for the combined effect of variety and salinity. Combination of high doses salinity (e.g. 15 dsm^{-1}) with any genotypes decreased fruit yield compared within that genotypes (Table 8). Interaction of 15 dsm^{-1} salinity with V_1 (V_1S_4), V_2 (V_2S_4), V_3 (V_3S_4) and V_4 (V_4S_4) genotypes reduced yield by 38, 29, 41 and 36%, respectively compared with control conditions (V_1S_1, V_2S_1, V_3S_1 and V_4S_1). However, the lowest fruit yield (755.7 g) was resulted in BARI Tomato 11 cultivar under 15 dsm^{-1} salt stress condition (V_2S_4 treatment) which was statistically similar with V_2S_3. This

combination consistently produced comparatively lower number of fruit, fruit length, fruit diameter, individual fruit weight as well as fruit yield. However, the highest fruit yield (3008.7 g) was harvested from the combination of BARI Tomato 14 with no salinity (V_3S_1) as it showed consistently higher yield attributes. Similar results also recorded in previous findings (Islam *et al.*, 2011 and Kibria *et al.*, 2013).

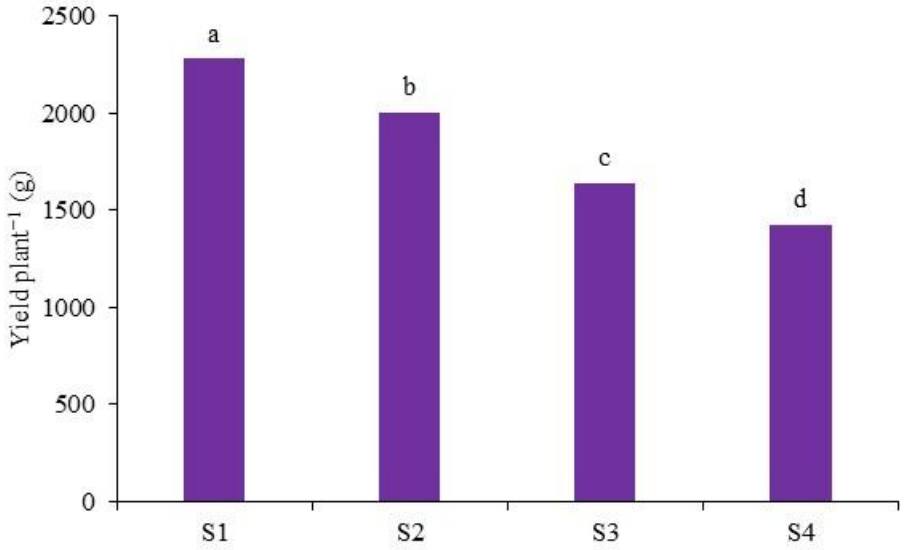

Figure 28: Effect of salinity on fruit yield per plant of tomato

(S_1, S_2, S_3 and S_4 indicate 0, 5, 10 and 15 ds m^{-1} salinity, respectively. Means (±SD) were calculated from three replicates for each treatment. Values with different letters are significantly different at $P \leq 0.05$ applying the LSD test.)

CHAPTER V

SUMMARY AND CONCLUSION

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A pot experiment was conducted to find out the effects of salinity on morphological, yield and yield attributes of tomato cultivar. The experiment was carried out at the Horticulture Farm, Sher-e-Bangla Agricultural University (SAU) Dhaka, during the period from October, 2016 to March, 2017. The experiment consisted of four salinity level viz., (i) 0 dSm^{-1} (control) (ii) 05 dSm^{-1} (iii) 10 dSm^{-1} and (iv) 15 dSm^{-1} and four tomato cultivar namely, BARI Tomato-2 (Ratan) BARI Tomato-11 (Jhomka), BARI Tomato-14 and BARI Tomato-15.

The results suggested that, growth, development, yield and yield attributes of tomato varied with the variation of genotypes. BARI Tomato 14 (V_3) produced highest fruit length, fruit diameter, and individual fruit weight as well as fruit yield $plant^{-1}$. Yield of V_1 genotypes (BARI Tomato 2) also statistically similar with highest yield because of better yield contributing characters and attributes. On the other hand, although BARI Tomato 2 (V_1) produced highest number of total flower and fruit $plant^{-1}$ but, yield was not satisfactory as fruit length, fruit diameter and individual fruit weight was lowest.

Salt stress greatly affects growth, development, yield and yield attributes of tomato. Growth and yield of tomato decreased with increasing 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. As a result number of fruit $plant^{-1}$ decreased under salt stress condition. Salt stress also decreased fruit length, fruit diameter and individual fruit weight. Consequence of flower dropping and deterioration of yield attributes caused yield reduction under salt stress condition. So yield reduction increased with increasing level of salinity.

Interaction of cultivar and salinity also affected growth, biochemical parameter, yield and yield attributes. Combination of salt stress with any cultivar reduced growth and yield, compared with those genotypes (under control condition). In our study, the highest yield was recorded in BARI Tomato 14 under control condition (V_3S_1) as it individual fruit weight was maximum. However, the lowest yield was recorded in BARI Tomato 11 under 15 ds m^{-1} salt stress condition (V_2S_4) as it fruit length, fruit diameter and individual fruit weight was lowest. Considering the present results, we can concluded that growth and yield of tomato varied with and without salt stress. Exposure of salt stress in tomato cultivar (BARI Tomato 2, BARI Tomato 11, BARI Tomato 14 and BARI Tomato 15) decreased growth and yield with increasing the level of salinity.

Results of the experiment showed that BARI Tomato-14 was comparatively more salt tolerant than the other cultivar used in this experiment followed by BARI Tomato-2, BARI Tomato-15 and BARI Tomato-11 respectively.

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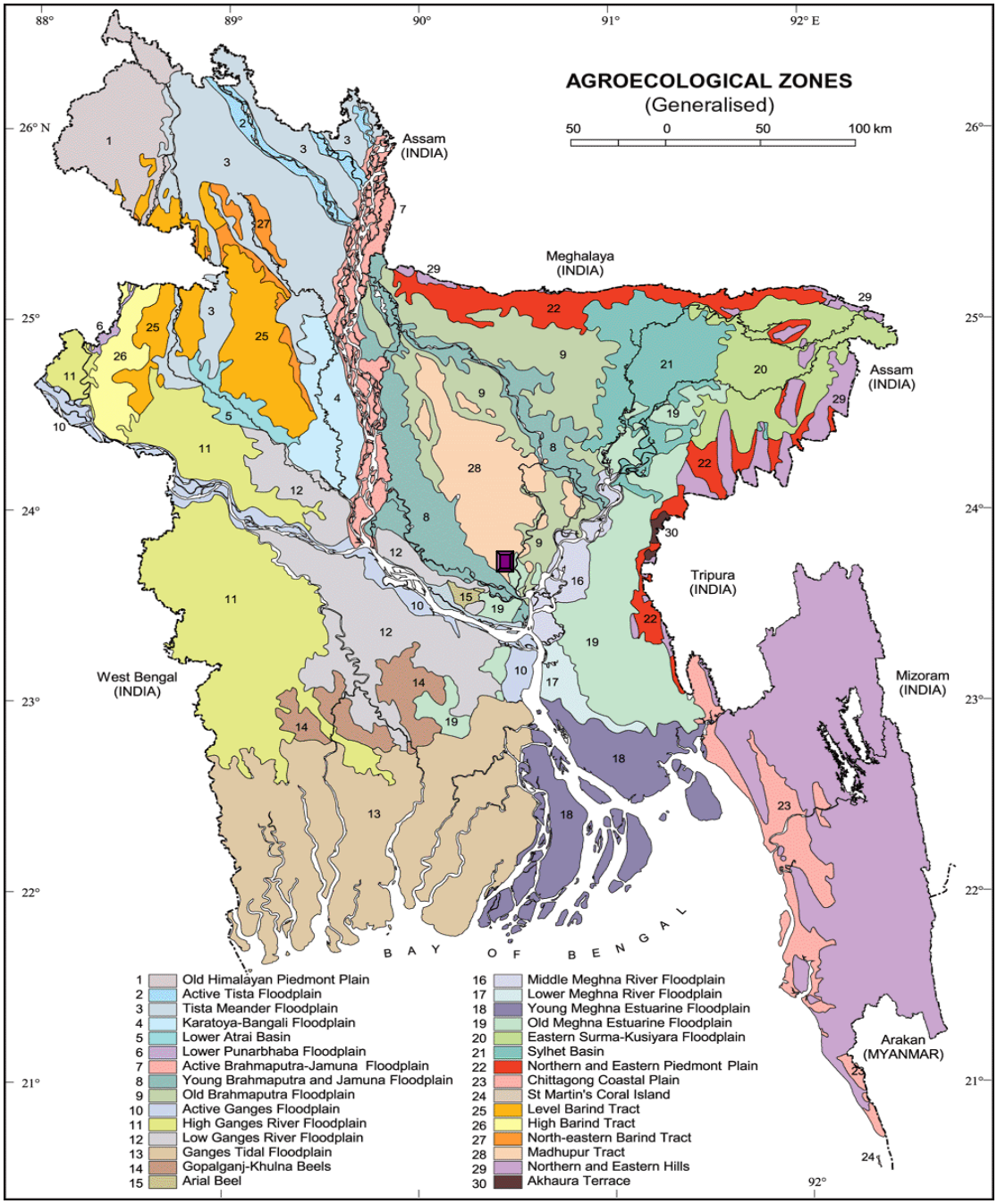
APPENDICES

APPENDICES

Appendix I. Map showing the experimental site under the study



The experimental site under study

Appendix II. Monthly average Temperature, relative humidity and total rainfall and sunshine of the experimental site during the period from October, 2016 to March, 2017.

Month	Air temperature (ºC)		Relative humidity	Rainfall	Sunshine
	Maximum	Minimum	(%)	(mm)	(h)
October, 2016	30.5	18.53	75.60	Trace	6.1
November, 2016	32.8	17.52	74.2	Trace	5.8
December, 2016	32.3	16.3	69	Trace	7.9
January, 2017	29.0	13.0	79	4.02	3.9
February, 2017	28.1	11.1	72	3.22	5.7
March, 2017	33.0	22.05	71.90	4.5	6.0

Source: Bangladesh Meteorological Department (Climate and Weather Division), Agargoan, Dhaka - 1212

Appendix III: Morphological, physical and chemical characteristics of initial soil (0-15 cm depth) of the experimental site.

A. Physical composition of the soil

Particle size	constitution
Sand	40%
Silt	40%
Clay	20%
Texture	Sandy loamy

B. Chemical composition of the soil

Soil characters	**Value**
Organic matter	1.44 %
Potassium	0.15 meq/100 g soil
Calcium	3.60 meq/100 g soil
Magnesium	1.00 meq/100 g soil
Total nitrogen	0.072
Phosphorus	22.08 µg/g soil
Sulphur	25.98 µg/g soil
Boron	0.48 µg/g soil
Copper	3.54 µg/g soil
Iron	262.6 µg/g soil
Manganese	164 µg/g soil
Zinc	3.32 µg/g soil

Source: Soil Resources Development Institute (SRDI), Khamarbari, Dhaka

Appendix IV: **Analysis of variance of the data on plant height of tomato under different salinity.**

Source of variation	Degrees of freedom	Error mean square				
		Plant height (cm)				
		20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
Replication	2	3.06	0.39	0.44	15.79	3.25
Genotypes	3	10.18*	8.22*	1152.9*	2839.3*	3703.6*
Salinity	3	1.65*	1.81*	108.9*	135.17*	351.19*
Genotypes× Salinity	9	1.21*	0.25*	4.64*	4.94*	8.19*
Error	30	2.92*	2.56*	7.57*	5.64*	5.85*

*significance at 5% level of probability

**significance at 1% level of probability

NS-non significant

Appendix V: **Analysis of variance of the data on number of leaves plant^{-1} of tomato under different salinity.**

Source of variation	Degrees of freedom	Error mean square				
		Number of leaves plant^{-1}				
		20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
Replication	2	1.18	0.14	3.06	0.43	0.81
Genotypes	3	1.69	33.57**	81.72**	1.72	4.02**
Salinity	3	2.47	9.13	23.55**	10.50**	11.96**
Genotypes× Salinity	9	0.08	0.37	0.75	0.59	0.40
Error	30	0.58	2.79	1.77	1.43	0.83

*significance at 5% level of probability

**significance at 1% level of probability

NS-non significant

Appendix VI: **Analysis of variance of the data on diameter of the stem (cm) of tomato under different salinity.**

Source of variation	Degrees of freedom	Error mean square				
		Diameter of the stem (cm)				
		20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
Replication	2	1.54	0.013	0.010	0.03	0.01
Genotypes	3	0.10 **	0.27**	0.21**	0.18**	0.17**
Salinity	3	6.87	0.00076	0.008	0.01	0.01
Genotypes× Salinity	9	3.17	0.01	0.02	0.02	0.04
Error	30	3.78	0.006	0.007	0.02	0.03

*significance at 5% level of probability

**significance at 1% level of probability

NS-non significant

Appendix VII: **Analysis of variance of the data on number of branches plant^{-1} of tomato under different salinity.**

Source of variation	Degrees of freedom	Error mean square			
		Number of branch plant^{-1}			
		30 DAT	40 DAT	50 DAT	60 DAT
Replication	2	0.43	2.08333	7.27083	8.06250
Genotypes	3	3.13**	6.25**	2.47**	2.08
Salinity	3	3.35**	4.75**	5.02**	8.02**
Genotypes× Salinity	9	0.13	0.17	0.08	0.91
Error	30	0.19	0.37	0.47	0.68

*significance at 5% level of probability

**significance at 1% level of probability

NS-non significant

Appendix VIII: Analysis of variance of the data on days of first flowering, leaf area, chlorophyll content of leaves and flower dropping palnt^{-1} of tomato under different salinity.

Source of variation	Degrees of freedom	Error mean square			
		Days of first flowering	Leaf area (cm^2)	Chlorophyll content of leaves (SPAD)	Flower dropping plant^{-1}
Replication	2	8.89	3.1	0.96	14.64
Genotypes	3	1.61*	6411.33**	119.69**	177.13**
Salinity	3	8.72*	921.21**	66.22**	182.68**
Genotypes× Salinity	9	2.29*	17.5**	4.38**	1.72
Error	30	6.07361	1.53	0.942	3.89

*significance at 5% level of probability
**significance at 1% level of probability
NS-non significant

Appendix IX: Analysis of variance of the data on number of fruit plant^{-1}, fruit length, fruit breadth, individual fruit weight and fruit yield plant^{-1} of tomato under different salinity.

Source of variation	Degrees of freedom	Error mean square				
		Number of fruit plant^{-1}	Fruit length (cm)	Fruit Breadth (cm)	Individual Fruit weight (g)	Fruit Yield plant^{-1} (g)
Replication	2	5.7	0.01	0.002	0.2	39553
Genotypes	3	18546.4**	19.18**	37.26**	16045.6**	5042161**
Salinity	3	376.1**	0.11**	0.23**	31.0**	1733491**
Genotypes× Salinity	9	2.5	0.002	0.004	2.2	104500**
Error	30	2.0	0.017	0.029	1.3	11134

*significance at 5% level of probability
**significance at 1% level of probability
NS-non significant

Appendix X: **Analysis of variance of the data on number of flower cluster plant^{-1} of tomato under different salinity.**

Source of variation	Degrees of freedom	Error mean square			
		Number of flower cluster plant^{-1}			
		30 DAT	40 DAT	50 DAT	60 DAT
Replication	2	0.33	3.56	5.77	11.81
Genotypes	3	16.40**	19.85**	336.07**	352.25**
Salinity	3	0.52	3.07**	5.41**	2.97
Genotypes× Salinity	9	0.22	0.03	0.46	0.17
Error	30	0.40	0.5847	0.52	0.74

*significance at 5% level of probability

**significance at 1% level of probability

NS-non significant

Appendix XI: **Analysis of variance of the data on number of flower plant^{-1} of tomato under different salinity.**

Source of variation	Degrees of freedom	Error mean square			
		Number of flower plant^{-1}			
		30 DAT	40 DAT	50 DAT	60 DAT
Replication	2	0.89	1.02	16.19	3.1
Genotypes	3	112.57**	71.02**	4991.06**	15447.7**
Salinity	3	3.07**	5.90**	116.28**	32.0**
Genotypes× Salinity	9	0.07	0.16	0.63	0.8
Error	30	0.45	1.15	0.43	1.1

*significance at 5% level of probability

**significance at 1% level of probability

NS-non significant