SCREENING FOR SALINITY TOLERANCE IN TOMATO GENOTYPES AT AN EARLY PLANT GROWTH STAGE

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SCREENING FOR SALINITY TOLERANCE IN TOMATO GENOTYPES AT AN EARLY PLANT GROWTH STAGE

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*This is to certify that thesis entitled, "**SCREENING FOR SALINITY TOLERANCE IN TOMATO GENOTYPES AT AN EARLY PLANT GROWTH STAGE**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) in HORTICULTURE**, embodies the result of a piece of bona-fide research work carried out by **MD. SUJAUDDAULA**,**Registration no.14-05953**under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

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DEDICATED TO

MY

BELOVED PARENTS

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CHAPTER I

ABSTRACT

Salt stress is the most significant constraint for agricultural production in arid and semi-arid regions. This study was conducted to determine and assess the tolerance of different tomato genotypes under saline conditions. Fourteen tomato genotypes were grown in pots were assayed at three salinity levels viz., 50 mM NaCl, 100 mM NaCl and 150 mM NaCl and compared with control (0 mM NaCl). The detrimental effects of salt stress on the plants were evident with increasing doses of NaCl. Salt stress significantly decreased the shoot and root length, seedling fresh weight, leaf area, chlorophyll content and relative water content of tomato genotypes. The tested tomato genotypes exhibited different responses for salinity severity indices (SSI). In all the salinity treatments, shoot length reduction showed the positive and the highest correlation with STI. Based on the results of the experiment, the genotypes BARI Tomato-11, BARI Tomato-14, BARI Tomato-21 and Manik were found to be tolerant to salinity. Therefore, these three genotypes may be recommended to cultivate under the saline condition of Bangladesh and also may be used in the future breeding program to develop salinity tolerant tomato genotypes.

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ABBREVIATIONS

Full word	Abbreviations	Full word	Abbreviations
Agriculture	Agric.	Milliliter	mL
Agro-Ecological Zone	AEZ	Milliequivalents	Meqs
And others	et al.	Triple super phosphate	TSP
Applied	App.	Milligram(s)	mg
Bangladesh Bureau of Statistics	BBS	Millimeter	mm
Biology	Biol.	Mean sea level	MSL
Biotechnology	Biotechnol.	Metric ton	MT
Botany	Bot.	North	N
Centimeter	Cm	Nutrition	Nutr.
Cultivar	Cv.	Regulation	Regul.
Degree Celsius	°C	Research and Resource	Res.
Department	Dept.	Review	Rev.
Development	Dev.	Science	Sci.
Dry Flowables	DF	Silver nitrate	$AgNO_3$
East	E	Soil plant analysis development	SPAD
Editors	Eds.	Soil Resource Development Institute	SRDI
Emulsifiable concentrate	EC	Technology	Technol.
Entomology	Entomol.	Tropical	Trop.
Environments	Environ.	Thailand	Thai.
Food and Agriculture Organization	FAO	United Kingdom	U.K.
Gram	g	University	Univ.
Horticulture	Hort.	United States of America	USA
International	Intl.	Wettable powder	WP
Journal	J.	Serial	Sl.
Kilogram	kg	Percentage	%
Least Significant Difference	LSD	Microgram	µ
Liter	L	Number	No.

CHAPTER I

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is one of the most popular vegetables in Bangladesh, which is receiving increased of the growers and consumers. It ranks next to potato and sweet potato in respect of vegetable production in the world (FAO, 2010). But in Bangladesh, it ranks 2^{nd} which is next to potato (BBS, 2009) and top the list of canned vegetables. It is a self-fertilized annual crop. Now, tomato is a universally known vegetable and is one of the highest grown vegetables in the world which leads all other vegetables in total volume of production (Ahmad *et al.*, 2012). Its food value is very rich because of higher contents of vitamin A, B and C including calcium, minerals, carotene and iron (Bose and Som, 1990). It is a nutritious and delicious vegetable used in salad, soups and processes into stable products like ketchup, sauce, pickles paste, chutney and juice. Lycopene in tomato is a powerful antioxidant and reduces the risk of prostate cancer (Hossain, 2001). In Bangladesh, tomato has great demand throughout the year especially in early winter and summer, but its production is mainly concentrated during the winter season. Recent statistics showed that tomato was grown in 30756 ha of land and the total production was approximately 414 thousand metric tons in 2015. Thus the average yield of tomato in Bangladesh was 5.47 t ha^{-1} (BBS, 2015), while it was 87.96 t ha^{-1} in USA, 49.87 t ha^{-1} in China and 20.12 t ha^{-1} in India (FAOSTAT, 2012). To meet nutritional demand of population, it is highly important to increase the yield of tomato per unit area of land. Increase of production depends on many factors, such as the use of improved varieties, proper management, quality of seed, awareness about improved production technologies and even conventional breeding methods may improve production level and quality under the existing environmental conditions.

During the lifecycle, tomato crop come across a number of biotic and abiotic stresses which severely limit the production. Among the abiotic stresses salinity, drought, temperature, mineral toxicity are vital for yield constraints. Abiotic factors are considered to be the main cause of yield reduction up to 71 % (Hussein 2006). Salinity is one of the major abiotic stresses which adversely affect the crop yield. It is known to exercise depressive effects on metabolic pathway and energy generating processes in seeds under saline conditions. (Murumkar and Chavan, 1986).

In the world, 900 million hectares of land approximately 20% of the total agricultural land are affected by salt (FAO, 2007) and this amount is supposed to be increase due to climate change (Shabala, 2013; Suzuki *et al*., 2016). In Bangladesh, coastal areas about 2.86 million hectares covered by 30% of the total crop land of the country (SRDI, 2001). Of this, nearly 1.056 million ha are affected by varying degrees of salinity (Karim *et al*., 1990). The severity of salinity of this area increases with the desiccation of the soil. It affects crops depending on degree of salinity at the critical stages of growth and reduces yield and in severe cases, total yield is lost. It has become imperative to explore the possibilities of increasing potential of these (saline) lands for increasing production of crops. Out of coastal cultivable saline area, about 328 (31%), 274 (26%) and 190 (18%) thousand hectares of land are affected by very slight (2.0-4.0 dS m^{-1}), slight (4.1-8.0 dS m^{-1}) and moderate salinity (8.1-12.0 dS m^{-1}), respectively are scope to successfully crop production (SRDI, 2010).

Salt in the soil affects plant growth by restricting the uptake of water and interfering with the balanced absorption of essential mineral ions by plant roots (El-Zanaty *et al.*, 2006). Salt tolerance is a developmentally regulated stage-specific phenomenon. Assessment of salt tolerance should be evaluated separately for every developmental stage of the plant; where seeds germination is the first exposure of the crop to salinity stress (Ozcoban and Demir, 2006). Germination, emergence, and early seedling growth are salinity sensitive stages of crop development (Jamil *et al.*, 2005). Salinity disrupts crop establishment by decreasing the germination percentage and delaying seedling emergence (Siddiky *et al.,* 2014) and decreases the yield at a later stage (Rahman *et al.,* 2018). Excessive uptake of ions causes toxicity, and reduced water availability between the seeds and the outer environment thereby inhibiting primary root emergence (Delachiave and dc-Pinho, 2003). Chloride and sulfate (Khajeh-Hosseini *et al.*, 2003) salts of sodium and calcium (mainly NaCl and $CaSO_4$) are the major soluble salts contributing to the very high salinity level of soils (Auge *et al.,* 2018).

The management of saline conditions in the fields and greenhouses would be expensive and temporary, while the selection for salt tolerance is a wise solution to minimize salinity effects and improve production efficiency (Nasrin and Mannan, 2019). So breeding tolerant cultivars of tomato under saline conditions is needed.

Genetic characterization of useful germplasm is the first step toward releasing tolerant cultivars. Correcting saline condition in field and greenhouse would be expensive and temporary while selection and breeding for salt tolerance can be a wise solution to minimize salinity effects as well as improve production efficiency. However, salt tolerance breeding programs have been restricted by the complexity of the trait, insufficient genetic and physiological knowledge of tolerance-related traits, and lack of efficient selection domain.

Screening of varieties during seed germination is commonly used because the process is rapid and is easily quantifiable. It allows the identification of genotypes that are able to germinate and emerge rapidly in salt-affected soils (Ketema and Dessalegne, 2006). The tolerance of crops to salinity varies among species and genotypes (Campos *et al.,* 2006). Tomato cultivars have significant variations in responses for salinity levels (Kazemi *et al.*, 2014). The germination percentages decline as salinity levels increase (Zhang *et al.*, 2010; Ratnakar and Rai, 2013). Salinity tolerance is critical during the life cycle of any species. Large genetic variation of tolerance to salt level exists among tomato genotypes. So breeding tolerant cultivars of tomato under saline conditions is needed.

It would be difficult to determine the critical parameters under field conditions since any environmental change could result in dramatic change in the plant's response to salinity. This study was designed to evaluate salt tolerance among genotypes under shed house conditions. The identified parameters and evaluation method for salt tolerance can then be applied to breeding practices under field conditions. The objectives of this study were

i To investigate the effect of salinity stress on plant growth of different tomato genotypes and

ii To assess the suitability of various physiological and morphological traits as proxies for tomato salinity tolerance screening of tomato germplasm.

CHAPTER II

REVIEW OF LITERATURE

An attempt was made in this section to collect and study relevant information available regarding to screening for salinity tolerance in tomato genotypes at an early plant growth stage, to gather knowledge helpful in conducting the present piece of work.

2.1 Salt stress

Salinity coupled with low rainfall is one of the most serious factors in arid and semi-arid regions of the world that adversely affect the productivity of present day agricultural crops (Munns and Tester, 2008). Worldwide, more than 45 million ha of irrigated land have been damaged by salt and 1.5 million ha are taken out of production each year as a result of high salinity levels in the soil (Munns and Tester, 2008). The total amount of salinity affected land in Bangladesh was 83.3 million hectares in 1973, which had been increased up to 102 million hectares in 2000 and the amount has risen to 105.6 million hectares in 2009 and continuing to increase, according to the country's Soil Resources Development Institute (SRDI). In the last 35 years, salinity increased around 26 percent in the country, spreading into non-coastal areas as well. The initial and primary effect of salinity, especially at low to moderate concentrations, is due to osmosis (Munns and Termaat, 1986). Most crops tolerate salinity up to a threshold level, above which yields decrease as salinity increases (Maas, 1986). Salinity stress causes extensive oxidative damage, affecting several physiological processes which results in significant reduction of different parameters such as germination capacity, radicle and plumule lengths, fresh and dry mass, yields, seed nutritional quality, productivity, chlorophyll, protein and sugar content, antioxidative enzymes activity as well as nodulation (Asaadi, 2009; Ghorbanpour *et al*., 2011; Tuncturk, 2011; Al-Saady *et al*., 2012; Talukdar, 2012; Kapoor *et al*., 2013; Pour *et al*., 2013).

2.2 Effect of salt stress

Amirjani (2016) at Sweden studied the effect of NaCl induced salinity on rice. Their results indicated that NaCl stress decreased fresh weight, dry weight, relative water content, chlorophyll content and Na^+/K^+ ratio at higher salinity levels.

Forouzandeh and Mirshekari (2014) at Zabol, studied the effect of NaCl and PEG-6000 induced stress on germination and seedling growth of tomato. Result indicated that PEG-6000 and NaCl both decreased germination percentage, germination rate, root and shoot length, seedling fresh and dry weight and radical fresh and dry weight. Ion stress induced by NaCl was more harmful for tomato seedling as compared to PEG-6000.

Shitole and Dhumal (2012) at University of Pune, Maharashtra, studied the effect of PEG-6000 and NaCl stress on Senna. Their results indicated that seed germination percentage, shoot length, root length, fresh weight, dry weight, vigor index were decreased in both PEG and NaCl.

Sozharajan and Natarajan (2014) at Tamilnadu, studied the effect of NaCl induced salinity on maize. Their results indicated that NaCl stress decreased germination percentage germination rate, water uptake, growth and biomass accumulation of the seedlings; both plumule and radical lengths were decreased significantly at higher salinity levels.

Kavandi and Shokoohfar (2014) at Islamic Azad University, Iran, studied germination parameters of sunflower under NaCl induced salinity stress and results showed that germination percentage and rate of germination were decreased at higher salinity level.

Kazemi *et al.* (2014) at Kharazmi University, Iran, studied the effect of salinity on tomato cultivars. Their results indicated that increasing NaCl concentrations reduced germination percentage, radicle and plumule length, and radicle and plumule dry weight.

Shiyab *et al.* (2013) at University of Jordan, Jordan, studied the responses of hydroponic grown tomato to NaCl induced salt stress. Results showed that slight reduction was observed in shoot length, leaf number, and dry weight, shoot and root content of potassium when seedlings were directly exposed to NaCl stress. Tissue contents of sodium (Na) and chloride (Cl) increased with elevated salinity treatments.

Shaheen *et al.* (2013) at Faisalabad, Pakistan studied the effect of NaCl induced salt stress on brinjal. Results showed significant reduction in shoot and root fresh and dry weights, shoot and root length, relative water content, chloroohyll a and b pigments, photosynthetic rate, water use efficiency, stomatal conductance and leaf and root K+content with increasing salinity level.

Sardoei *et al.* (2013) at Islamic Azad University, Iran, studied the responses of tomato against NaCl induced salinity on germination and early seedling growth. Their results showed that maximum germination percentage, maximum root length, shoot length, root and shoot fresh weight observed under control conditions while NaCl induced salinity decreased these parameters.

Mozafariyan *et al.* (2013) at Islamic Azad University, Iran, studied the effects of salinity on growth and photosynthetic features of tomatoes. Results showed that increasing salinity level significantly reduced shoot and root dry and fresh weight, root volume and photosynthetic indexes such as the rate of photosynthesis, stomatal conductance and the efficiency of photosynthetic rate at higher NaCl concentration.

Cokkizgin and Cokkizgin (2012) at Gaziantep University, Turkey, studied germination responses of pea under NaCl induced salt stress and their result showed that radicle length, plumule length, fresh and dry weight of radicle and plumule, germination percentage and vigour index were decreasing at increasing salinity level.

Edris *et al.* (2012) has also reported similar result in that tomato plant shoot fresh weight was highly reduced with increasing NaCl concentration.

Fariduddin *et al.* (2012) at Aligarh Muslim University, Aligarh studied physiogical parameters of tomatoes under NaCl induced salt stress and their results showed significant decline in growth, photosynthetic parameters, maximum quantum yield of PSII and leaf water relations at increasing salinity levels.

Mostafavi (2012) at Islamic Azad University, Iran studied the effect NaCl induced salt stress on germination and early seedling growth of sugar beet genotypes (H30916, H30917, H30918, H30919, H30938 and H30973). Experimental results reveled decrease in germination percentage and there were significant differences between genotypes and salinity stress levels for all investigated traits except mean germination time**.**

Singh *et al.* (2012) at Central Soil Salinity Research Institute, Haryana, studied effect of NaCl induced salinity on germination of tomato and results indicated that increasing salinity had reduced germination rate while root/shoot dry weight ratio and Na+ content increased but K+ content decreased.

Zhani *et al.* (2012) at Tunisia, conducted the research on effect of salinity on chili and they observed decreased in germination percentage, germination time, plant height, root length, leaves number, leaf area and chlorophyll amount with increasing salinity levels.

Keshavarzi *et al.* (2011) at Zabol University, Iran, studied effects of different NaCl induced salinity levels on germination and early growth of spinach seedlings. Experimental results showed that the percentage and speed of germination, plumule length, radicle length, fresh and dry seedling weights were higher in control treatment, and at higher concentration of NaCl, germination decreased significantly.

Kaveh *et al.* (2011) at Ferdowsi University of Mashhad, Iran, studied effect of NaCl induced salinity on germination and emergence of tomato lines. Germination percentage and rate, emergence percentage and rate of all tomato lines were delayed and decreased with increasing salinity level. All seedling growth characteristics, except seedling height, were decreased with increasing salinity levels.

Ramezani and Shekafandeh(2011) reported that deficiency in dry and fresh biomass at higher concentration might be due to poor absorption of water from the growth medium due to physiological drought.

Shahid *et al.* (2011) at University of Agriculture, Pakistan, observed that salinity caused significant reduction in okra seed germination percentage, germination rate, root and shoot lengths and fresh weight of root and shoot.

Smolik *et al.* (2011) reported that root senses the effect of soil salinity and influences root-to-shoot signaling to control shoot growth and physiology via hormonal signals, such as cytokines, ABA and auxin IAA, thus coordinating assimilate production and usage in competing sinks. Salt stress leads to changes in growth, morphology and physiology of the roots that will, in turn, change water and ion uptake and the production of signals (hormones) that can transfer information to the shoot, affecting the whole plant when the roots are growing in a salty medium In spite of the negative effects of salt on roots, the root growth in tomato appears to be less affected whereas, shoot was affected drastically.

Muhammad and Hussain (2010) at University of Peshawar, Pakistan, studied effect of NaCl induced salinity on some medicinal plants. Their results revealed highly significant differences for plumule growth while germination percentage, radicle growth, seedling fresh, dry weight and leaf moisture contents showed non-significant variation under various salt concentrations.

Xu *et al.* (2010) reported that salt stress brings about osmotic stress and subsequently ionic toxicity and oxidative stress. Salt stress limits water available to plants, hence, causes osmotic stress, which leads to loss in turgor pressure of the plant especially in the leaves due to decreased water potential, resulting in wilting that affects plant morphology and biomass production.

Pak *et al*. (2009) at Iran studied the NaCl induced salinity on rape plant. Their result indicated that increasing concentration of NaCl significantly decreased chlorophyll content, fluorescence and K+ content.

Li (2009) at Dezhou University, China studied physiological responses of tomato seedlings under NaCl induced salinity and their results showed that fresh weight, dry weight, K+ content, K+/Na+ ratio and shoot length was decreased with the increasing of NaCl concentration.

Rubio *et al*. (2009) reported that the reduction in tomato leaf area under salt stress might be due to the reduction of growth parameters contributing to photosynthetic products.

Turhan *et al.* (2009) studied the effect of NaCl in tomato cultivars and concluded that dry weight was strongly affected by salinity treatments. Increased salt concentration significantly reduced dry weights of root, stem and leaf in all tomato cultivars at 12 dS m^{-1}. Compared to the control treatment, the decrease in dry weight (g) varied from 66 to 88% in root, 72 to 89% in stem, and 61 to 92% in leaf.

Takagi *et al.* (2009) reported decrease in photosynthesis in response to increasing salt stress condition.

Zadeh and Naeini (2007) reported that root elongation rate may be reduced by salinity due to reduced rates of cell production and growth, reduced final length of epidermal cells, and shorter apical meristem Reduction of root epidermal cell elongation and production may be attributed to accumulation of Na+ to toxic levels in some of the meristematic cells.

Al-Sobhi *et al.* (2006) also reported that decreased in chlorophyll content under salinity stress is a commonly reported phenomenon and in various studies, because of its adverse effects on membrane stability.

Hajer *et al.* (2006) studied the Responses of three tomato cultivars to salinity and found that Chlorophyll a and b content of tomato cultivars leaves decreased in general with increasing sea water salinity. The highest chlorophyll content was in control plant leaves, while the lowest content was in the salt sensitive cultivar leaves for plants grown under salinity stress.

Bruria (2005) reported that during the onset and development of salt stress within a plant, all the major processes such as photosynthesis, protein synthesis, energy, and lipid metabolism are affected. The earliest response is a reduction in the rate of leaf surface expansion, followed by a cessation of expansion as the stress intensifies. Growth resumes when the stress is relieved

Jamil *et al.* (2005) at Sunchon National University, Korea, studied the effect of salinity on four vegetables species viz. sugar beet, cabbage, amaranth and pak-choi. Results revealed significant decreased in germination, germination rate, root and shoot length with increasing salt concentrations.

Al-Karaki (2001) reported that the increase in osmotic pressure around the roots, as a result of saline environment, can also prevent water uptake by root and results with shorter root and shoot length. Moreover, under saline condition, CO_2 assimilation of plant become decreased and shoot photosynthetic rate was decreased. It is the major energy source for growth and development, so, ultimately root and growth decreases due to low assimilate supply.

Sultana *et al.* (1999) suggested that salinity resulted in dehydration at cellular level and dehydration symptoms were greater in higher NaCl concentration treatment because of the increasing cellular water loss. Moreover, decrease in relative water content in plants under stress may results in plant vigor reduction.

Khavari *et al.* (1998) studied the effect of NaCl on photosynthetic pigments of four tomato cultivars and found that at 100 mM NaCl concentration, chlorophyll a, chlorophyll b decreased as compared to control.

Neumann (1993) reported that salt induced death of root cells result in osmotically induced turgor loss and Na+ ion toxicity in root meristem, causing reduced instant cell extension rates. The reduced cell length as a result of salinity may be a result from reduced cell extension rates and or in the duration of extension period.

Kirst (1989) reported that accumulation of Na+ and/or Cl- takes place in the chloroplasts of higher plants which affects growth rate, and is often associated with a decrease in photosynthetic electron transport activities in photosynthesis.

2.3 Variability among tomato varieties for salt response

Al-Daej (2018) carried out a study toknowthe salt tolerance of some tomato (*Solanumly coversicum* L.) cultivars under laboratory conditions using different levels of NaCl. The experiment was carried out in vitro under laboratory conditions. Out of 10 varieties, only two cultivars namely “Rams” and “C10” were selected for investigation based on their physical characteristics. Both cultivars were subjected to 0, 20, 40, 60, 80 and 100 mM NaCl concentrations. The physiological characters such as seed germination, plant length, fresh weight, dry weight and number of leaves were studied against the salt stress. Also, the concentration of K, N, Na and Ca was determined in plant leaves. The results showed that the cultivar Rams performed better than C10 for all the physical properties i.e., germination (%), fresh and dry matter yield etc. Also, the cultivar Rams accumulated less Na and K ions compared to cultivar C10. The cultivar Rams proved more salt tolerant even at high levels of salinity.

Rupali (2018) undertaken a study was to assess the genotypic variation for salinity tolerance in five commercial cultivars of tomato (*Solanum lycopersicum* L.) grown in Maharashtra. Growth parameters such as shoot length, root length, fresh weight and dry weight were assessed at control, 50 mM and 100 mM NaCl with Hoagland’s solution. The shoot/root length and fresh/dry weight declined at 100 mM stress.

Proline accumulated as a consequence of salt stress. On the basis of growth parameters and proline accumulation cultivars Abhinav and Rohini were tolerant, TO1389 and N2535 moderately tolerant and Naina sensitive towards salinity stress.

Rashed *et al.* (2016) concluded that seedling pretreatment with NaCl are interesting strategies to be applied when tomato plants have to be grown in saline soils or soils irrigated with saline water.

FAO (2014) reported that salinity tolerance for cultivated crops vary depending upon climate, soil conditions and cultural practices. Crops are often less tolerant during germination and seedling stage. The Electric Conductivity threshold for tomato ranges from 0.9 to 2.5 dSm^{-1} This indicates that some tomato varieties are salt tolerant where yield reductions do not decline at up to 2.5 dSm^{-1} while some varieties are salt susceptible as their yield reduction would start to decline at 0.9 dSm^{-1}.

Kumar *et al.* (2013) reported that growth vigor is such a mechanism which can avoid the toxic effects of salinity and vigor is an avoidance mechanism rather than tolerance mechanism which works as far as the productivity is concerned.

Siddiky *et al.* (2012) found some salt tolerant tomato cultivars at the salinity areas of Bangladesh that maintained their salt tolerance at later growth stages.

Jogendra *et al.* (2011) found a great magnitude of genotypic variability in tomato cultivars (*Lycopersicon esculentum* L.) for salt tolerance at the germination stage. They identified some salt tolerant cultivars with higher root growth and mineral nutrient accumulations.

Kahlaoui *et al*. (2011) included a field experiment where the effect of drip irrigation and surface drip irrigation with saline water on three tomato cultivars ‘Rio Tinto, ‘Rio Grande’ and ‘Nemador’ were studied to elucidate physiological responses from each variety to salinity conditions. The study was performed in clay soil with three irrigation schedulings at either 100%, 85% or 70% of total crop water requirement respectively. Growth parameters recorded included the leaf area, chlorophyll content and mineral composition of above- and below ground components. Results showed that petioles, stems and roots were significantly affected by the different irrigation treatments, whereas the fruit organs were less affected. Plants exposed to drip irrigation showed a high accumulation of Na and Cl, along with a reduction in the content of Ca, Mg, K and P. The accumulation of Na and Cl however varied between varieties.

Kaveh *et al.* (2011) concluded that, according to germination and seedling emergence for tomato, germination percentage and germination rate, for all lines, was most optimum at the lowest level of salinity 0.5 $dS.m^{-1}$. In addition, the final germination percentages decreased and the germination rate was delayed as salinity increased.

Akram *et al.* (2010) reported that sodium concentration increases in plants under salt stress and suppresses the potassium concentration. The salt tolerant genotypes transport very small amount of toxic ions ($Na+$) to the upper areas like leaf, they store them in their roots that iswhy the phenomenon of photosynthesis proceeds normally in tolerant genotypes. That is an adaptation mechanisms of tolerant plant species to withstand the adverse conditions that sensitive species substantially lack.

Ashraf (2009) reported that salt tolerance should be evaluated at germination, seedling and adult (reproductive) stages.

Turhan *et al.* (2009) reported that K/Na ratio in tolerant cultivars was less affected by NaCl treatment than sensitive cultivars of tomato.

Al-Harbi *et al.* (2008) studied the effects of four irrigation water salinity levels (0.5, 2.5, 5, and 10 dsm^{-1}) on germination, emergence, and seedling growth of tomato cvs. Pascal, Red Stone, Shohba, Super Marmand, and Tanshet Star. Germination percentage, germination rate, emergence percentage, and emergence rate were decreased and delayed with increasing salinity, from 2.5 $dsm^{-1}$to 10 dsm^{-1} in all cultivars. All seedling growth characters, except seedling height, were decreased with increasing salinity levels and. At the germination and emergence stages, cvs. Pascal and Tanshet Star were more tolerant to salinity level than cvs. Shohba, Super Marmand, and Red Stone.

Hajer *et al*. (2006) conducted an experiment to investigate the effect of sea water salinity (1500, 2500 and 3500 ppm) on the growth of tomato (Lycopersicon esculentum) cultivars (Trust, Grace and Plitz). The sea water salinity delayed seed germination and reduced germination percentage especially with increasing salinity level. Chlorophyll b content was higher than chlorophyll a, and both of them decreased with increasing salinity. The seedling height increased with time but decreased with increasing salinity in all cultivars. Seedlings fresh and dry shoot and root weights were decreased with increasing salinity. The growth of stem, leave and root after over 80 days of exposure to sea water salinity was affected by sea water dilution especially those of trust and grace cultivars. The grace cultivar was less affected by sea water salinity on the germination stage, while the plitz cultivar has good tolerant to sea water salinity for prolonged period.

According to Chen *et al*. (2005) reported that in better salt adapted or salt tolerant plants, the Na/K and Na/Ca ratios are vital. Salt tolerant plants contain less dynamic Na nevertheless more Ca and K in their cells.

Dasgan *et al.* (2002) suggested the screening at the seedling stage is not only less laborious, less time consuming and less expensive, but also has a high reliability.

Al-Karaki *et al.* (2001) reported that when three tomato cultivars were grown in NaCl, K/Na ratio was adversely affected. In salt sensitive cultivars, Na concentration increased with increasing salt concentration while in salt tolerant cultivars greater Na exclusion and higher K uptake.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted in the Horticulture farm at Sher-e-Bangla Agricultural University farm, Dhaka to screening for salinity tolerance in tomato genotypes at an early plant growth stage. Materials used and methodologies followed in the present investigation have been described in this chapter.

3.1 Experimental period

The experiment was conducted during the period fromFebruary-April 2020

3.2 Description of the experimental site

3.2.1 Geographical location

The experiment was conducted in the Horticulture farm at Sher-e-Bangla Agricultural University (SAU). The experimental site is geographically situated at 23°77′ N latitude and 90°33′ E longitude at an altitude of 8.6 meter above sea level (Anon., 2004).

3.2.2 Agro-Ecological Zone

The experimental site belongs to the Agro-ecological zone (AEZ) of “The Modhupur Tract”, AEZ-28 (Anon., 1988 a). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as ‘islands’ surrounded by floodplain (Anon., 1988 b). For better understanding about the experimental site has been shown in the Map of AEZ of Bangladesh in Appendix-I.

3.2.3 Climate and weather

The climate of the experimental site was subtropical, characterized by the winter season from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris*et al.*, 1979). Meteorological data related to the temperature, relative humidity and rainfall during the experiment period of was collected from Bangladesh Meteorological Department (Climate division), Sher-e-Bangla Nagar, Dhaka and has been presented in Appendix-II

3.3 Experimental materials

Fourteen varieties of tomato namely BARI Tomato-2, BARI Tomato-11,BARI Tomato-14, BARI Tomato-15,BARI Tomato-16,BARI Tomato-17, BARI Tomato-18, BARI Tomato-19, BARI Tomato-20, BARI Tomato-21, Manik, Pathorkuchi, Pusha Rubi and VF Roma were used as planting materials. The seeds of different genotypes of tomato were obtained from the Bangladesh Agricultural Research Institute (BARI), Gazipur and Siddique Bazar, Dhaka, Bangladesh.

3.4 Growing conditions

The experiment was carried out using fourteen tomato genotypes in a shed house at Sher-e-Bangla Agricultural University, Dhaka 1207, Bangladesh under natural lighting conditions during the experimental period February-April 2020. The seeds will be sown in Poly (vinyl) chloride (PVC) tanks (1.2×0.6×0.6 m) using soil mixture with slow releasing mixed fertilizers. At 25 days after sowing (DAS), seedlings were transplanted to the maintained pots (5 seedlings/pot), filled with soil, and recommended doses of fertilizer. Three replications were applied for all the treatments.

3.5 Treatments and sample collection

Different concentrations of salt solution (0, 50, 100, and 150 mM)were used to wash through the pots several times until the solution drained out from the pots had consistent salt concentration. NaCl solutions were provided in 35-day-old seedlings for seven days in order to provide the required salinity level. The third leaves from the bottom of fourteen genotypes were collected 10 days after NaCl treatment for the measurement relative water content. Chlorophyll contents were measured in the first fully expanded leaves.

3.6 Scoring for salinity stress tolerance

Five seedlings (25 days old) of fourteen genotypes were transplanted in each pot with 3 replications and grown under the same shed house conditions described above. Ten days after transplanting, the treatments(0, 50, 100, and 150 mM) were applied for 1 week, and then the degree of leaf injury and the number of surviving plants were recorded and scored. The extent of leaf injury was then ranked on a scale of 0 to 5 (score 0= whole plant without symptoms; score 1= few leaves showing discoloration;

score 2= about 20% leaf area has discoloration; score 3= 40% leaf area shows yellowing; score 4, 60%, leaf area shows yellowing; score 5, most of plant affected.

Plate 1: Salinity severity score in tomato seedlings. Score 0, whole plant without symptoms; score 1, few leaves showing discoloration; score 2, about 20% leaf area has discoloration; score 3, 40% leaf area shows yellowing; score 4, 60%, leaf area shows yellowing; score 5, most of plant affected.

3.7 Chlorophyll content (measured by SPAD meter)

Leaf chlorophyll content was tested in first fully expanded leaves using SPAD-502 chlorophyll meter (Minolta, Tokyo, Japan). Measurements were recorded from the middle of the leaf lamina of each salinity treated and control plants.

3.8 Determination of shoot length

Five plants in each treatment and each replication were used for shoot length at harvest. Shoot length was measured from the base of the plant to the top of the plant.

3.9 Determination of root length

The roots were carefully washed with tap water to separate substrates. The longest root length (cm $plant^{-1}$) was measured as the distance from soil surface to the end of the longest root.

3.10 Biomass production

10 days after salinity treatments, three plants in each treatment and each replication were used for shoot and root fresh weight. We estimated root fresh weight by hand-washing roots to remove all soil and debris and weighed to determine fresh weights.

3.11 Relative Water Content measurement

Relative water content (RWC) was determined according to Smart and Bingham (1974). For each replicate, three leaves were pooled, and their fresh weights (FW) were determined. The leaves were then immersed into water for twelve hours at room temperature to regain turgidity; the turgid tissue was then quickly blotted to remove excess water and then their turgid weights (TW) were measured. The samples were then dried in an oven at 65 °C for 24 h to determine the dry weights (DW). The RWC was calculated using the following formula:

$$RWC\ \% = ((FW-DW)/(TW-DW))*100.$$

3.12 Measurement of leaf area

Ten days after salinity stress leaves were collected from 3 plants of each pot and leaf area was measured. A ruler was used to measure the maximum width (W) and length (L) of each sampled leaf. The length was measured as the distance between the insertion of the first leaflet on the rachis to the distal end, while the width was measured on the widest leaflet.

3.13 Data analysis

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program name Statistix 10 Data analysis software and the mean differences were adjusted by Least Significant Difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).All results were presented with mean ± SE from the replicates. Graphs were drawn using the Microsoft Excel program.

CHAPTER IV

RESULTS AND DISCUSSION

Results obtained from the present study have been presented and discussed in this chapter with a view to screening for salinity tolerance in tomato genotypes at an early plant growth stage. The data are given in different tables and figures. The results have been discussed, and possible interpretations are given under the following headings.

4.1 Reduction of shoot length (%)

The new growth from seed germination that grows upward is a shoot where leaves will develop. Different salinity level (*viz,*50 mM, 100 mM and 150 mM) significantly effect on reduction of shoot length (%) of different tomato genotypes (Figure 1.).At 50 mM NaCl salinity level, BARI Tomato2 variety recorded the highest reduction of shoot length (39.67 %) of tomato whereas BARI Tomato21 variety recorded the lowest reduction of shoot length (1.21 %) of tomato. At 100 mM NaCl salinity level, BARI Tomato16 variety recorded the highest reduction of shoot length (54.44 %) of tomato which was statistically similar with; BARI Tomato17 variety recorded reduction of shoot length (53.96 %) of tomato and with Pathorkuchi variety recorded reduction of shoot length (53.76 %) of tomato. Whereas BARI Tomato21 variety recorded the lowest reduction of shoot length (7.82 %) of tomato. At 150 mM NaCl salinity level, BARI Tomato19 variety recorded the highest reduction of shoot length (77.60 %) of tomato. Whereas BARI Tomato21 variety recorded the lowest reduction of shoot length (27.37 %) of tomato.

Salinity-induced osmotic stress, as a result water uptake by plant is hampered and plant suffers from physiological drought. This led to the interruption of nutrient uptake. Sozharajan and Natarajan (2014) reported that NaCl stress decreased germination percentage germination rate, water uptake, growth and biomass accumulation of the seedlings; both plumule and radical lengths were decreased significantly at higher salinity levels. Shoot length of a plant is determined by genetical character and under a given set of environment different variety will varies their shoot length according to their genetical makeup of the variety. The result obtained from the present study was similar with the findings of Turhan *et al.* (2009)

and they reported that K/Na ratio in tolerant cultivars was less affected by NaCl treatment than sensitive cultivars of tomato.

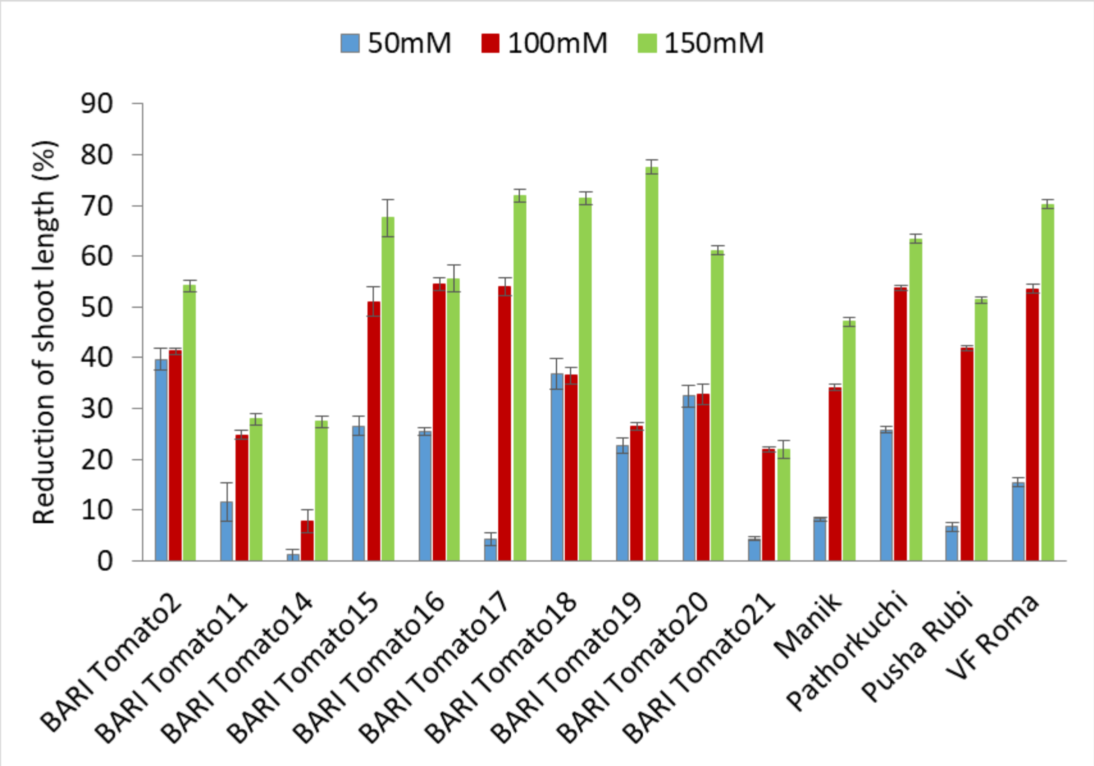


Figure 1: Reduction of shoot length in different salinity treated tomato plants (expressed as a percentage of the control). Values are mean ±standard error.

4.2 Reduction of root length (%)

The part of a plant that grows downward and holds the plant in place, absorbs water and minerals from the soil, and often stores food Known as root of a plant. Different variety of tomato plants showed significant different response in root growth when exposed to different level of salinity (Figure 2). While under salt stress reduction in root length is being seen generally.

At 50 mM NaCl salinity level, BARI Tomato15 variety recorded the highest reduction of root length (23.29 %) of tomato whereas BARI Tomato11 variety recorded the lowest reduction of root length (2.86 %) of tomato. At 100 mM NaCl salinity level, BARI Tomato15 variety recorded the highest reduction of root length (72.60 %) of tomato. Whereas BARI Tomato14 variety recorded the lowest reduction of root length (4.26 %) of tomato. At 150 mM NaCl salinity level, BARI Tomato15 variety recorded the highest reduction of root length (76.37 %) of tomato. Whereas Manik variety recorded the lowest reduction of root length (16.67 %) of tomato.

The presence of high concentration of salt (NaCl) around the root zone also reduces plant growth by ionic toxicity through over accumulation of Na^+ and Cl^-. Zadeh and Naeini (2007) reported that root elongation rate may be reduced by salinity due to reduced rates of cell production and growth, reduced final length of epidermal cells, and shorter apical meristem Reduction of root epidermal cell elongation and production may be attributed to accumulation of Na^+ to toxic levels in some of the meristematic cells. The differences of tolerance of different salt level may be due to the genetic make of the variety. Jogendra *et al.* (2011) found a great magnitude of genotypic variability in tomato cultivars (*Lycopersicon esculentum* L.) for salt tolerance at the germination stage. They identified some salt tolerant cultivars with higher root growth and mineral nutrient accumulations. Salinity can rapidly inhibit root growth and hence capacity of water uptake and essential mineral nutrition from soil (Neumann, 1995). Cuartero and Fernandez-Munoz (1999) suggested that exposure of plants to salt stress usually begins with exposure of the roots. Salt stress leads to changes in growth, morphology and physiology of the roots that will in turn change water and ion uptake and the production of signals (hormones) that can transfer information to the shoot. Then the whole plant is affected when the roots are growing in a salty medium.

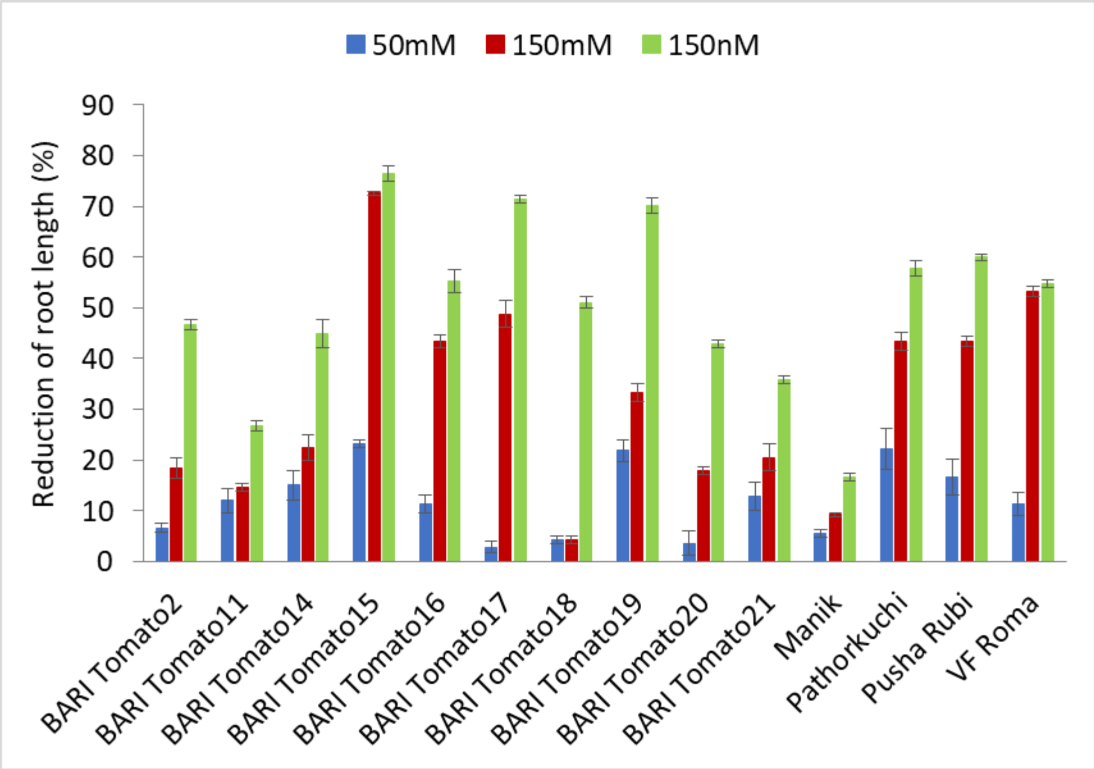


Figure 2: Reduction of root length in different salinity treated tomato plants (expressed as a percentage of the control). Values are mean ±standard error.

4.3 Reduction of shoot fresh weight (%)

Tomato genotypes treated with different level of salinity significantly effect on reduction of shoot fresh weight (%) of tomato (Figure 3). At 50 mM salinity level, the highest reduction of shoot fresh weight of tomato was recorded in BARI Tomato15 (67.03%) variety, whereas and the lowest reduction of shoot fresh weight was found in BARI Tomato 11 (1.24%) variety. At 100 mM salinity level, the highest reduction of shoot fresh weight of tomato was recorded in BARI Tomato15 (85.00 %) variety, whereas and the lowest reduction of shoot fresh weight was found in BARI Tomato 14 (40.94 %) variety which was statistically similar with, BARI Tomato 19 variety recorded reduction of shoot fresh weight (41.98 %). At 150 mM salinity level, the highest reduction of shoot fresh weight of tomato was recorded in BARI Tomato15 (92.39 %) variety, whereas and the lowest reduction of shoot fresh weight was found in BARI Tomato21 (51.61 %) variety.

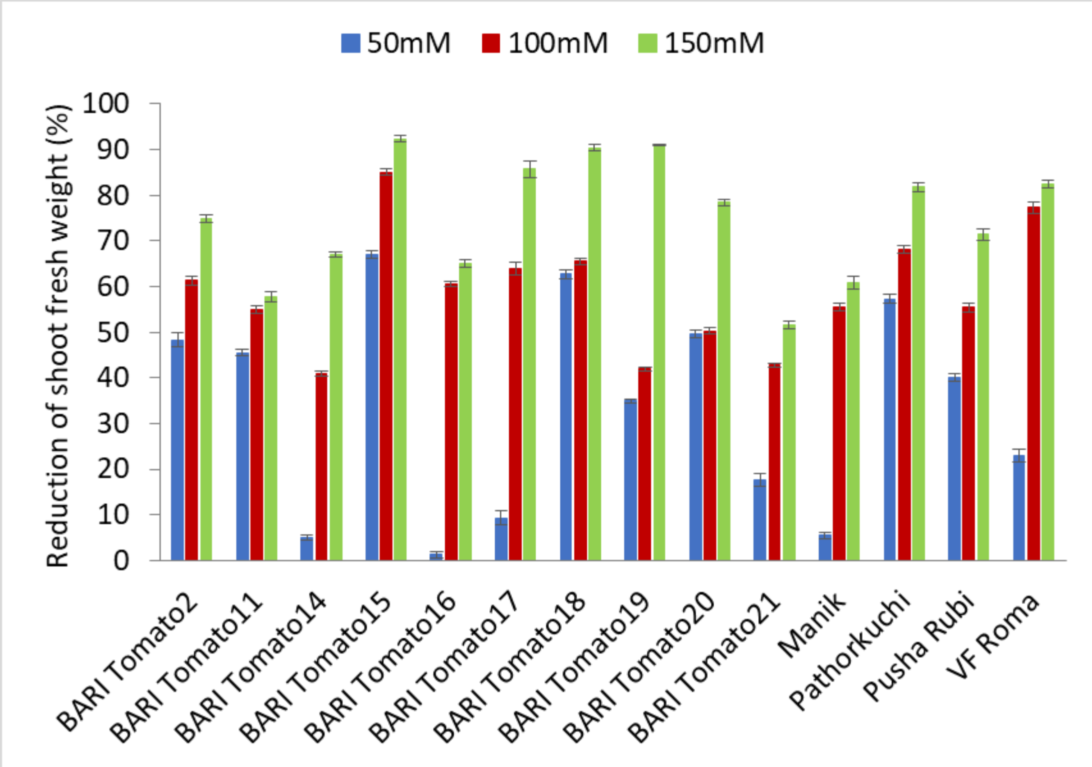


Figure 3: Reduction of shoot fresh weight in different salinity treated tomato plants (expressed as a percentage of the control). Values are mean ±standard error.

It is possible that the decrease of fresh weight in salinized plants were due to several reasons. One possibility is that salinity reduced photosenthesis, which in turn limited the supply of carbohydrate needed for growth. Shaheen *et al.* (2013) found significant reduction in shoot and root fresh and dry weights, shoot and root length, relative water content, chloroohyll a and b pigments, photosynthetic rate, water use efficiency, stomatal conductance and leaf and root K+content with increasing salinity level. Kahlaoui *et al*. (2011) reported that the accumulation of Na and Cl however varied between varieties.

4.4 Reduction of root fresh weight (%)

Tomato genotypes treated with different level of salinity significantly effect on reduction of root fresh weight (%) of tomato (Figure 4). At 50 mM salinity level, the highest reduction of root fresh weight of tomato was recorded in BARI Tomato15 (51.25 %) variety, whereas and the lowest reduction of root fresh weight was found in BARI Tomato14 (5.56 %) variety. At 100 mM salinity level, the highest reduction of root fresh weight of tomato was recorded in BARI Tomato15 (83.51 %) variety, whereas and the lowest reduction of root fresh weight was found in BARI Tomato21

(12.29 %) variety. At 150 mM salinity level, the highest reduction of root fresh weight of tomato was recorded in VF Roma (88.00 %) variety, which was statistically similar with BARI Tomato18 variety recorded reduction of root fresh weight (87.70) of tomato whereas and the lowest reduction of shoot fresh weight was found in BARI Tomato21 (22.35 %) variety. Root systems have been considered as the basic system to counteract salinity stress (Smith *et al*., 1992).

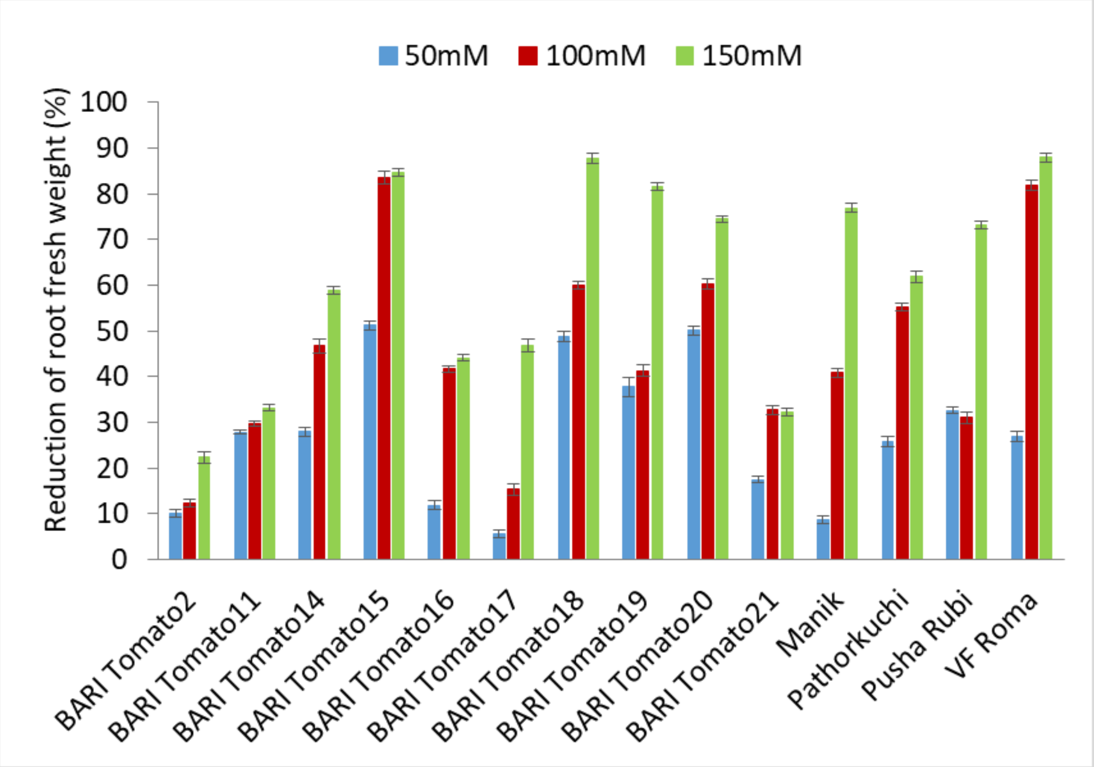


Figure 4: Reduction of shoot fresh weight in different salinity treated tomato plants (expressed as a percentage of the control). Values are mean ±standard error.

4.5 Reduction of leaf area (%)

Leaves are one of the most important organs that plants have. Photosynthesis, is the process by which plants produce food using light, carbon dioxide (CO_2), and water, takes place in leaves. Different level of salinity significantly effect on reduction of leaf area (%) of tomato (Figure 5). At 50 mM salinity level, BARI Tomato2 variety recorded the highest reduction of leaf area (58.41 %) of tomato whereas BARI Tomato21 variety the lowest reduction of leaf area (1.91 %) of tomato. At 100 mM salinity level, BARI Tomato17 variety recorded the highest reduction of leaf area (73.78 %) of tomato which was statistically similar with BARI Tomato15 variety recorded reduction of leaf area (73.14 %) of tomato. whereas BARI Tomato14 variety the lowest reduction of leaf area (24.56 %) of tomato. At 150 mM salinity level, BARI Tomato17 variety recorded the highest reduction of leaf area (86.92 %) of tomato which was statistically similar with BARI Tomato2 variety recorded reduction of leaf area (84.67 %) of tomato. Whereas Manik variety recorded the lowest reduction of leaf area (51.36 %) of tomato which was statistically similar with BARI Tomato14 variety recorded reduction of leaf area (52.43 %) of tomato.

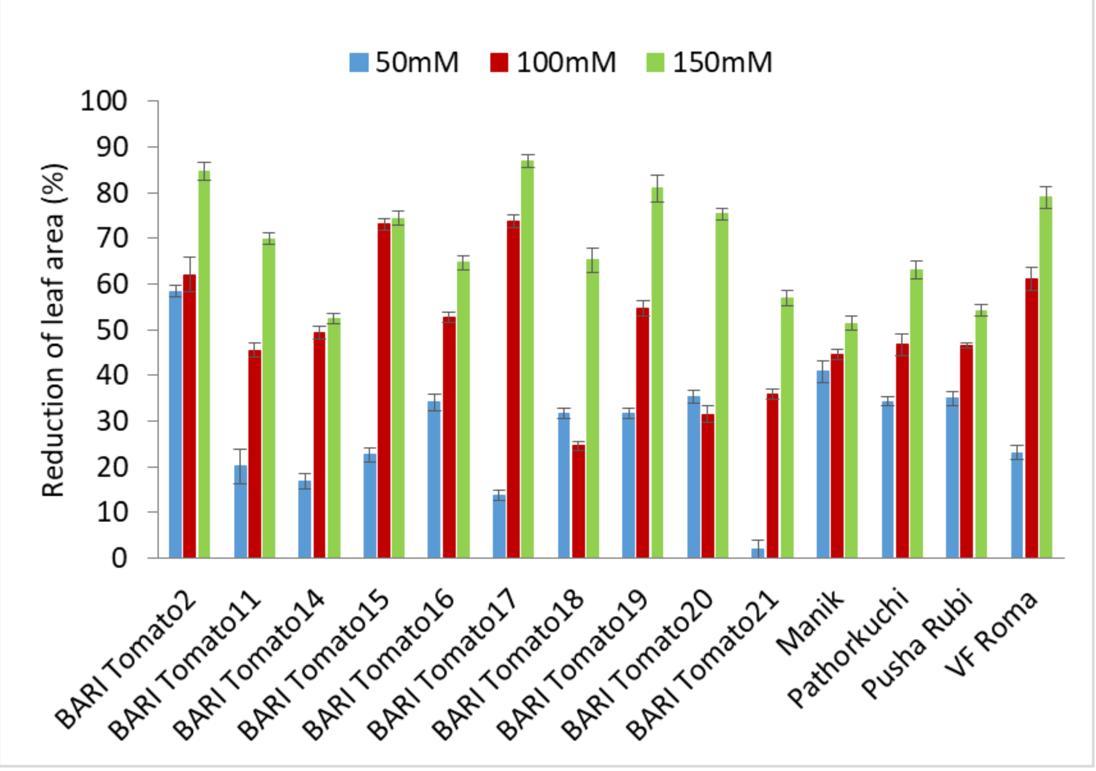


Figure 5: Reduction of leaf area in different salinity treated tomato plants (expressed as a percentage of the control). Values are mean ±standard error.

Rubio *et al*. (2009) reported that the reduction in tomato leaf area under salt stress might be due to the reduction of growth parameters contributing to photosynthetic products. Akram *et al.* (2010) reported that salt tolerant genotypes transport very small amount of toxic ions (Na+) to the upper areas like leaf, they store them in their roots that iswhy the phenomenon of photosynthesis proceeds normally in tolerant genotypes. That is an adaptation mechanisms of tolerant plant species to withstand the adverse conditions that sensitive species substantially lack.

4.6 Reduction of chlorophyll content (%)

Chlorophyll is the natural compound present in green plants that gives them their color. It helps plants to absorb energy from the sun as they undergo the process of photosynthesis. In this experiment, different salinity condition significantly effect on chlorophyll content of tomato varieties (Figure 6). Experimental result showed that,

At 50 mM salinity level, BARI Tomato16 variety recorded the highest reduction of chlorophyll content (11.71 %) of tomato whereas Manik variety the lowest reduction of chlorophyll content (1.80 %) of tomato. At 100 mM salinity level, Pathorkuchi variety recorded the highest reduction of chlorophyll content (27.39 %) of tomato. Whereas BARI Tomato11 variety recorded the lowest reduction of chlorophyll content (9.06 %) of tomato which was statistically similar with BARI Tomato19 variety recorded reduction of chlorophyll content (9.98 %) of tomato and with BARI Tomato20 variety recorded reduction of chlorophyll content (9.76 %) of tomato. At 150 mM salinity level, BARI Tomato17 variety recorded the highest reduction of chlorophyll content (53.53 %) of tomato, whereas BARI Tomato11 variety recorded the lowest reduction of leaf area (17.27 %) of tomato.

Photosynthetic pigments, chla and chl b, are greatly affected by different abiotic stresses including salinity. Accumulation of toxic Na+ reduces the content of precursor of chl biosynthesis (such as glutamate and 5-aminolevullinic acid) and thus interrupts chl biosynthesis under saline condition. Pak *et al*. (2009) at Iran studied the NaCl induced salinity on rape plant. Their result indicated that increasing concentration of NaCl significantly decreased chlorophyll content, fluorescence and K+ content. Turhan *et al.* (2009) reported that K/Na ratio in tolerant cultivars was less affected by NaCl treatment than sensitive cultivars of tomato. Al-Sobhi *et al.* (2006) also reported that decreased in chlorophyll content under salinity stress is a commonly reported phenomenon and in various studies, because of its adverse effects on membrane stability. Khavari *et al.* (1998) studied the effect of NaCl on photosynthetic pigments of four tomato cultivars and found that at 100 mM NaCl concentration, chlorophyll a, chlorophyll b decreased as compared to control.

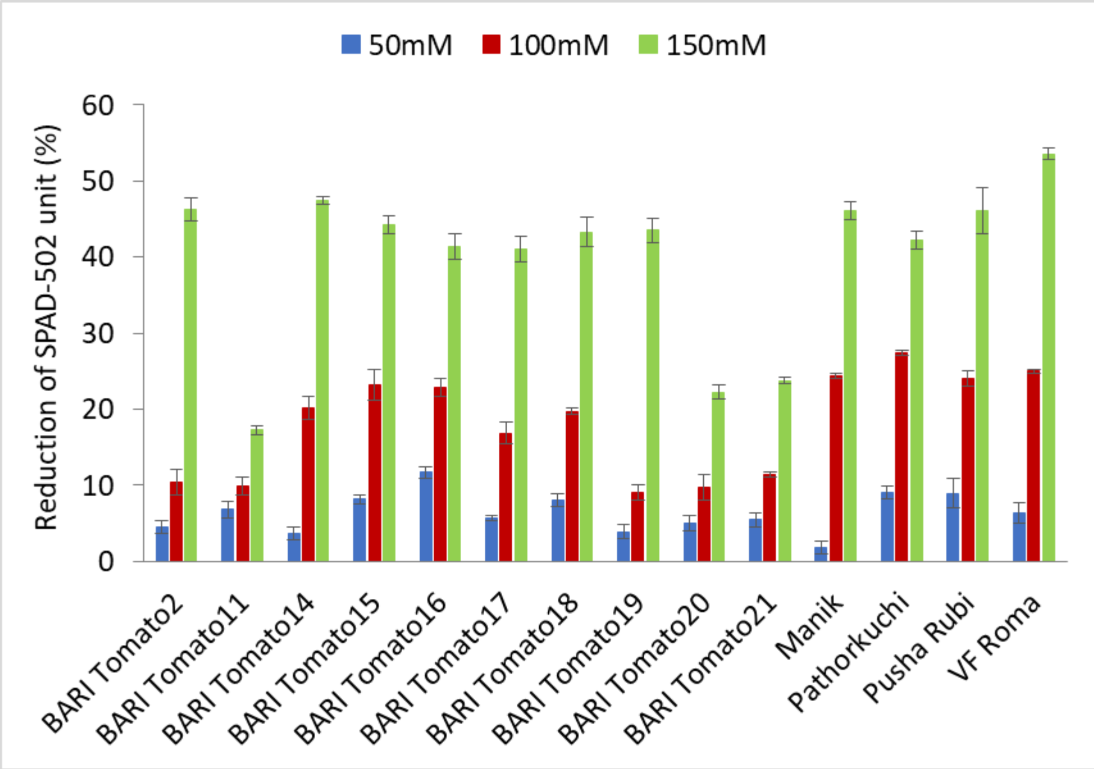


Figure 6: Reduction of leaf chlorophyll content in different salinity treated tomato plants (expressed as a percentage of the control). Values are mean ±standard error.

4.7 Reduction of relative water content (%)

Relative water content is described as the amount of water in a leaf at the time of sampling relative to the maximal water a leaf can hold. Different salinity level significantly effect on different tomato genotype and reduce relative water content of tomato (Figure 7). At 50 mM salinity level, BARI Tomato15 variety recorded the highest reduction of relative water content (17.43 %) of tomato whereas Manikvariety recorded the lowest reduction of relative water content (0.66 %) of tomato. At 100 mM salinity level, BARI Tomato15 variety recorded the highest reduction of relative water content (31.91 %) of tomato. Whereas BARI Tomato21 variety recorded the lowest reduction of relative water content (3.38 %) of tomato which was statistically similar with BARI Tomato18 variety recorded reduction of relative water content (4.39 %) of tomato. At 150 mM salinity level, BARI Tomato15 variety recorded the highest reduction of relative water content (50.00 %) of tomato. Whereas BARI Tomato21 variety recorded the lowest reduction of relative water content (4.73 %) of tomato.

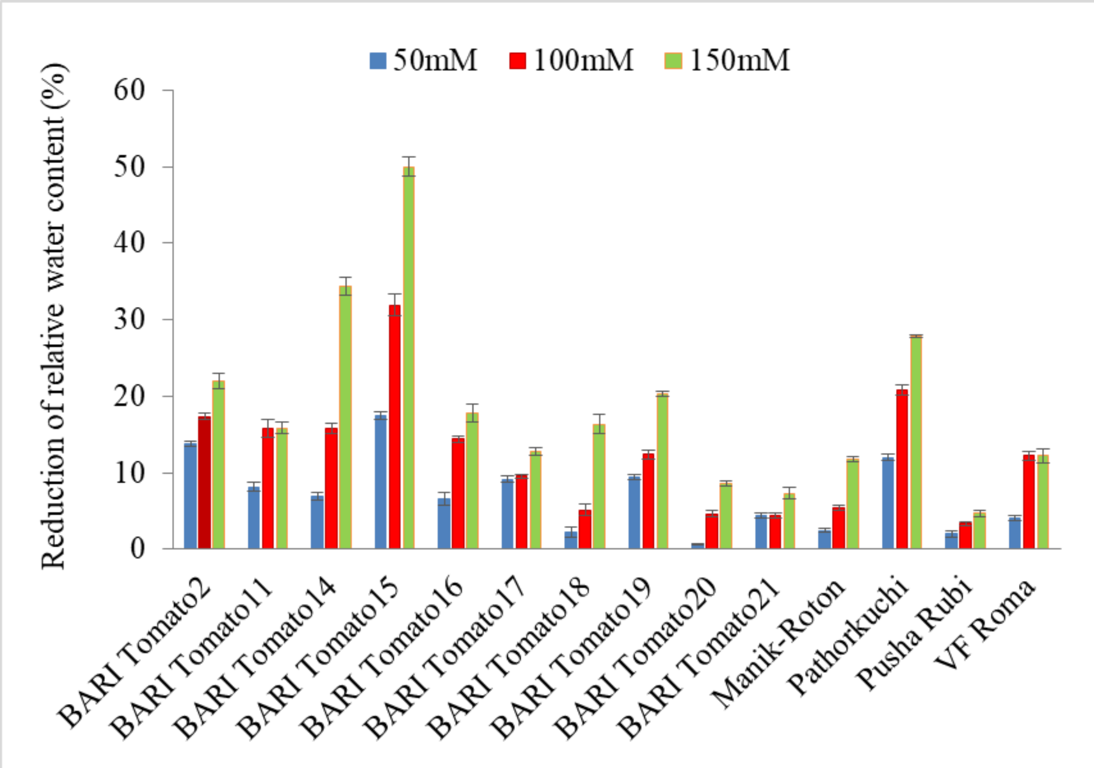


Figure 7: Reduction of relative water content in different salinity treated tomato plants (expressed as a percentage of the control). Values are mean ±standard error.

Xu *et al.* (2010) also found similar result which supported the present finding and reported that salt stress brings about osmotic stress and subsequently ionic toxicity and oxidative stress. Salt stress limits water available to plants, hence, causes osmotic stress, which leads to loss in turgor pressure of the plant especially in the leaves due to decreased water potential, resulting in wilting that affects plant morphology and biomass production. Al-Karaki *et al.* (2001) also reported that when three tomato cultivars were grown in NaCl, K/Na ratio was adversely affected. In salt sensitive cultivars, Na concentration increased with increasing salt concentration while in salt tolerant cultivars greater Na exclusion and higher K uptake. Balibrea *et al.* (2000) reported that increase in total soluble sugar was mainly in sensitive cultivars while tolerant remained unchanged.

4.8 Salinity severity score (SSS)

Salinity severity score varies on the basis of genotype performance under different salinity level. Different salinity severity score had different meaning, in where, score 0, represent whole plant without symptoms; score 1 represent few leaves showing discoloration; score 2 represent about 20% leaf area has discoloration; score 3 represent 40% leaf area shows yellowing; score 4 represent 60%, leaf area shows yellowing and score 5 represent, most of plant affected. (Figure 8). At 50 mM salinity level, BARI Tomato2 variety recorded the highest salinity severity score (2) of tomato, following by BARI Tomato16 recorded salinity severity score (1). Whereas the lowest salinity severity score was recorded all the genotype except BARI Tomato2 and BARI Tomato16 genotype variety. At 100 mM salinity level, BARI Tomato15 variety recorded the highest salinity severity score (3) of tomato, following by Pusha Rubi (3), BARI Tomato16 (2.5), BARI Tomato17 (2.5), VF Roma (2.5). Whereas the lowest salinity severity score was recorded BARI Tomato11 (0.5), BARI Tomato14 (0.5) and BARI Tomato21 (0.5) genotype. At 150 mM salinity level, BARI Tomato15 variety recorded the highest salinity severity score (4) of tomato, following by BARI Tomato16 (4), BARI Tomato17 (4), BARI Tomato2 (4) and Pusha Rubi (4). Whereas the lowest salinity severity score was recorded BARI Tomato11 (1.5), BARI Tomato14 (1.8) BARI Tomato21 (1.5) and Manik (2.5) genotype. Stress tolerance index is a more stable character and can be considered as a useful tool to screen abiotic stress tolerant genotypes (Dutta and Bera, 2008).

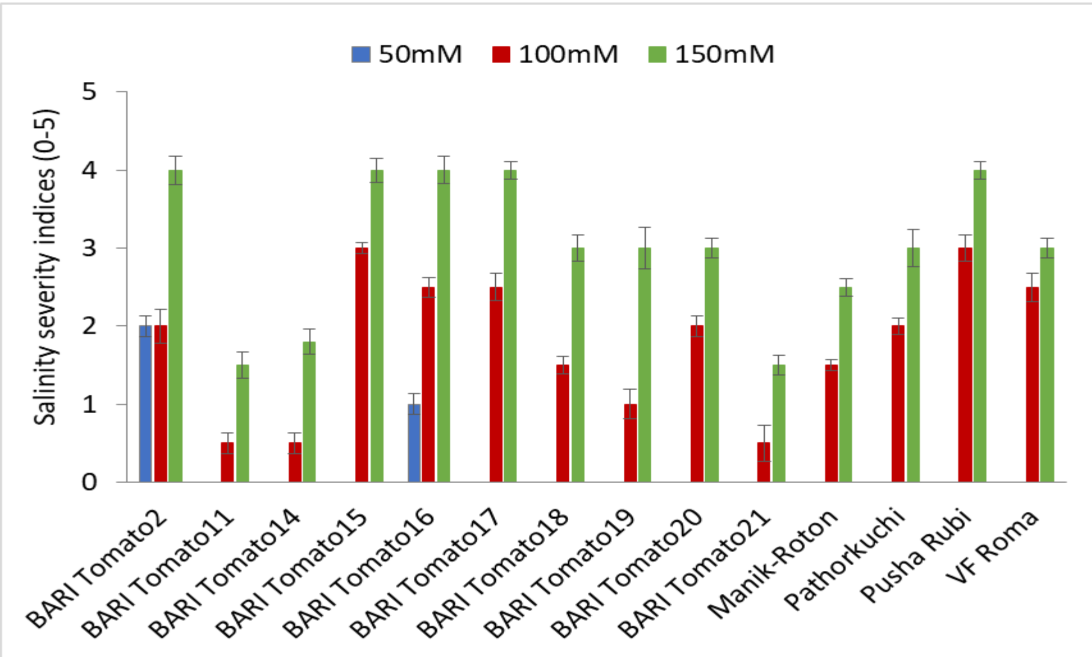


Figure 8: Salinity severity indices in tomato seedlings. Score 0, whole plant without symptoms; score 1, few leaves showing discoloration; score 2, about 20% leaf area has discoloration; score 3, 40% leaf area shows yellowing; score 4, 60%, leaf area shows yellowing; score 5, most of plant affected.

Table 1: Correlation between salinity severity score and percentage reduction of various growth and physiological traits of tomato genotypes under salinity stress

Salinity severity Score			
Traits	50 mM	100 mM	150 mM
Root length	-0.21939*	0.353158**	0.488061**
Shoot length	0.50294**	0.858258**	0.67461**
SPAD value	0.084669**	0.546147**	0.529715**
Shoot fresh weight	-0.01295	0.705173**	0.583623**
Root fresh weight	-0.42712**	0.26501**	0.129513*
Leaf area	0.636454**	0.47412**	0.436762**
Relative water content	0.348665**	0.204574**	0.160789**

At 50 mM NaCl most of the plant does not show any visible symptoms but as the salinity levels increases plant start to show visible symptoms. Correlation between salinity severity score and percentage reduction of various growth and physiological traits of tomato genotypes under salinity stress showed positive correlation when salinity severity increases (Table 2)

Among all the parameters, shoot length was the most responsive under all salinity stress and may be suitable for screening salinity tolerance.

CHAPTER V

SUMMARY AND CONCLUSION

A pot experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka during the period from January 2020 to February 2020, to screening for salinity tolerance in tomato genotypes at an early plant growth stage.The experiment consisted of fourteen tomato varieties namely BARI Tomato2, BARI Tomato11,BARI Tomato14, BARI Tomato15,BARI Tomato16,BARI Tomato17, BARI Tomato18, BARI Tomato19, BARI Tomato20, BARI Tomato21, Manik-Roton, Pathorkuchi, Pusha Rubi and VF Roma were treated with 3 levels of salinity *viz.*50 mM, 100 mM and 150 mM. The experiment was laid out in completely randomized design (CRD) and followed three replications. Data on different parameters were collected for assessing results for this experiment and showed that salinity levels significantly effect on different physiological parameters of tomato seedlings.

At 50 mM salinity level, experimental result revealed that, BARI Tomato21 variety recorded the lowest reduction of shoot length (1.21 %) of tomato. BARI Tomato11 variety recorded the lowest reduction of root length (2.86 %) of tomato. The lowest reduction of shoot fresh weight was found in BARI Tomato 11 (1.24%) variety. The lowest reduction of root fresh weight was found in BARI Tomato14 (5.56 %) variety. BARI Tomato21 variety the lowest reduction of leaf area (1.91 %) of tomato. Manik variety had the lowest reduction of chlorophyll content (1.80 %) of tomato. Manik variety recorded the lowest reduction of relative water content (0.66 %) of tomato.BARI Tomato21 variety recorded the highest salt-tolerance index (0.98) of tomato. The lowest salinity severity score was recorded all the genotype except BARI Tomato2 and BARI Tomato16 genotype variety.

At 100 mM salinity level, BARI Tomato21 variety recorded the lowest reduction of shoot length (7.82 %) of tomato. BARI Tomato14 variety recorded the lowest reduction of root length (4.26 %) of tomato. The lowest reduction of shoot fresh weight was found in BARI Tomato 14 (40.94 %). The lowest reduction of root fresh weight was found in BARI Tomato21 (12.29 %) variety. BARI Tomato14 variety the lowest reduction of leaf area (24.56 %) of tomato. BARI Tomato11 variety recorded the lowest reduction of chlorophyll content (9.06 %) of tomato. BARI Tomato21 variety recorded the lowest reduction of relative water content (3.38 %) of tomato. At

100 mM salinity level, BARI Tomato14 variety recorded the highest salt-tolerance index (0.75) of tomato. The lowest salinity severity score was recorded BARI Tomato11 (0.5), BARI Tomato14 (0.5) and BARI Tomato21 (0.5) genotype.

At 150 mM salinity level, BARI Tomato21 variety recorded the lowest reduction of shoot length (27.37%) of tomato,Manik variety recorded the lowest reduction of root length (16.67 %) of tomato. The lowest reduction of shoot fresh weight was found in BARI Tomato21 (51.61%) variety. The lowest reduction of root fresh weight was found in BARI Tomato21 (22.35%) variety. Manik variety recorded the lowest reduction of leaf area (51.36 %) of tomato. BARI Tomato11 variety recorded the lowest reduction of leaf area (17.27 %) of tomato. BARI Tomato21 variety recorded the lowest reduction of relative water content (4.73 %) of tomato. Manik variety recorded the highest salt-tolerance index (0.49) of tomato. The lowest salinity severity score was recorded BARI Tomato11 (1.5), BARI Tomato14 (1.8) BARI Tomato21 (1.5) and Manik (2.5) genotype.

Based on the above results of the present study, the following conclusions may be drawn:

Salinity of 50, 100 and 150mM of NaCl imposed at seedling (35 days old seedling) stage of tomato genotypes decreased shoot length, leaf area, chlorophyll content, biomass weight and relative water content. Among all the parameters, shoot length was the most responsive under all salinity stress and may be a more efficient screening parameter for salinity tolerance. BARI tomato 11, BARI Tomato 14 and BARI Tomato 21 had shown better performance in all salinity stress and identified to be tolerant genotypes.

REFERENCES

Ahmad, S. (2012). Genetics of fruit set and related traits in tomato under humid conditions. PhD Thesis. BSMRAU, Salna, Gazipur, Bangladesh. pp. 1-23.

Akinci, I. E. Akinc S. I. Yilmaz K. and Dikici, H. (2004). Response of eggplant varieties (*Solanumm elongena*) to salinity in germination and seedling stages. *New Zealand J. Crop and Hort. Sci.***32**(2): 193-200.

Akram. M, Ashraf, M. Y., Ahmad, R., Waraich, E. A., Iqbal, J. and Mohsan, M. (2010). Screening for salt tolerance in maize (*Zea mays* L.) hybrids at an early seedling stage. *Pak. J. Bot.* **42**: 141-154.

Al-Daej, M. I. (2018). Salt Tolerance of Some Tomato (*Solanumly coversicum* L.) Cultivarsfor Salinity under Controlled Conditions. Am. J. Plant Physiol. **13**(2): 58-64.

Al-Harbi, A. R., Wahb-Allah, M. and Abu-Muriefah, S. (2008). Salinity and Nitrogen Level Affects Germination, Emergence, and Seedling Growth of Tomato. *Int. J. Vegetable Sci*. **14**: 380-392.

Al-Karaki, G. N. (2001). Germination, sodium, and potassium concentrations of barley seeds as influenced by salinity. *J. plant nut.* **24** (3): 511-522.

Al-Karaki, G., Hammad, R. N. and Rusan, M. (2001). Response of two tomato cultivars differing in salt tolerance to inoculation with mycorrhizal fungi under salt stress. *Mycorrhiza*. **11**: 43-47.

Al-Saady, N. A., Khan , A. J., Rajesh, L. and Esechie, H. A. 2012. Effect of salt stress on germination, proline metabolism and chlorophyll content of fenugreek (*Trigonella foenum gracium* L.). *J. Plant Sci.***7**: 176-185.

Al-Sobhi, O. A., Al-Zahrani, H. S. and. Al-Ahmadi, S. B(2006). Effect of salinity on chlorophyll and carbohydrate contents of Calotropis procera seedlings. *Sci. J. King Faisal Univ. Basic and Appl. Sci*. **7**: 105-115.

Amirjani, M. R. (2010). Effect of NaCl on some Physiological Parameters of Rice. *EJBS*. **3**(1): 06-16.

Anonymous. (1988 a). The Year Book of Production. FAO, Rome, Italy.

Anonymous. (1988 b). Land resources appraisal of Bangladesh for agricultural development. Report No.2. Agro-ecological regions of Bangladesh, UNDP and FAO. pp. 472–496.

Anonymous. (2004). Effect of seedling throwing on the grain yield of wart land rice compared to other planting methods. Crop Soil Water Management Program Agronomy Division, BRRI, Gazipur-1710.

Asaadi, A. M. (2009). Investigation of salinity stress on seed germination of *Trigonella foenum-graecum*. *Res. J. Biol. Sci*. **4**: 1152-1155.

Asfaw, Z. and Eshetu, D. (2015). Production and management of major vegetable crops in antioxidants as markers. *Biotech. Adv*. **27**: 84–93.

Ashraf, M. (1994). Breeding for salinity tolerance in plants. *Crit.Rev. Plant Sci.* **13**: 17-42. 3

Ashraf, M. (2009). Biotechnological approach of improving plant salt tolerance using

Ashraf, M. and O'leary, J. W. (1997). Response of a salt-tolerant and a salt-sensitive line of sunflower to varying sodium/calcium ratios in saline sand culture. *J. Plant. Nutr*. **20** (2-3): 361-377.

Auge, K. D., Assefa, T. M., Woldeyohannes W. H., and Asfaw. (2018). Potassium dynamics under enset (*Ensete ventricosom* cheesman) farming systems of B.T.Sidama zone, Southern Ethiopia. J. *Soil Sci. Environ. Manage*. **9**(4): 47-58.

Balibrea, M., Dell'Amico, J. and Bolarín, C. ((2000). Carbon partitioning and sucrose metabolism in tomato (*Lycopersicum esculentum*) plants growing under salinity. *Physiol plant*. **110**: 503.

BBS (Bangladesh Bureau of Statistics). (2015). Yearbook of Agricultural Statistics 2015. Ministry of Planning, Government of Bangladesh, Dhaka.

BBS. 2009. Hand book of Agricultural Statistics, December. Bangladesh Bureau of Statistics (BBS).Ministry of Planning, Govt. People's Repub. Bangladesh. pp. 14.

Blum, A. and Arkin, G. F. (1984) Sorghum root growth and water-use as affected by water supply and growth duration. *Field Crops Res.***9**: 131–142.

Bose, T. K. and Som, M. G. (1990). Vegetables Crops in India. B. MitraNayaProkash, Bidhan Sarani, Calcutta, India.

Bruria, H. (2005). Photosynthetic Carbon Metabolism of Crops under Salt Stress. Institute of Soils, Water and Environmental Sciences, Agricultural Research Organization, Volcani Center.

Campos, C. A. B., Fernandes, P. D., Gheyi, H. R., Blanco, F. F., Goncalves, C. B. and Campos, S. A. F. (2006). Yield & fruit quality of industrial tomato under saline irrigation. *Sci. Agric.* **63**: 146-152.

Chen, Z., Newman, I., Zhou, M., Mendham, N., Zhang, G. and Shabala, S. (2005). Screening plants for salt tolerance by measuring K+ flux: A case study for barley. *Plant Cell Env.* **28**: 1230-1264.

Cokkizgin, A. and **C**okkizgin, M. (2012). Germination responses of pea under NaCl induced salt stress. *Int. J. Agric. Sci. Bior. Eng. Res*. **1**(3): 71-77.

Cuartero, J. and Munoz, R. F. (1999). Tomato and salinity. *Scientia Hort.***78**: 83–125.

Dasgan, H.Y., Aktas, H., Abak, K. and Cakmak, I. (2002). Determination of screening techniques to salinity tolerance in tomatoes and investigation of genotype responses. *Plant Sci.***163**: 695-703.

Delachiave, M. E. A. and dc-Pinho, S. Z. (2003). Scarification, temperature and light in germination of Sennacccidentalis seed (*Caesal pinaceae*). *Seed Sci. Technol*. **31**: 225-230.

Edris A. M. A., Hemmat, M. I. A., Shaltout, F. A., Elshater M. A. B. and Eman, F. M. (2012). Study on incipient spoilage of chilled chicken cuts-up. *Benha Vet. Med. J.***23**:(1): 81-86.

Edris, K. M., Islam, A. M. T., Chowdhury, M. S. and Haque, A. K. M. M. (1979). Detailed Soil Survey of Bangladesh, Dept. Soil Survey, BAU and Govt. Peoples Republic of Bangladesh. p. 118.

El-Zanaty, A. A, El-Nour, A. and El-Fouly, M. M. (2006). Modern methods for counteracting salinity stress: A review. In The second International Conf. on Water Resources & Arid Environment. Ethiopia. Addis Ababa, Ethiopia.

FAO. (2014). United Nation Food and Agriculture Organization Statistics Division. Crop Production data. Rome, Italy.

FAO. 2007. FAO Agristat. Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO. Production Year Book of 2006. No. 67. 2010. Food and Agriculture Organization (FAO). Rome, Italy. 54p.

FAOSTAT (Food and Agriculture Organization of the United Nations). 2012. Production. Countries and commodity. Tomatoes.

Fariduddin, Q., Mir, B. A. and Ahmad, A. (2012). Physiological and biochemical traits as tools to screen sensitive and resistant varieties of tomatoes exposed to salt stress. *Brazilian soc. plant physiol.* **24**(4): 281-292.

Flowers, T. J. and Yeo, A. R. (1995). Breeding for salinity resistance in crop plants. Where next?. *Australian J. Plant Phy.***22**: 875-884.

Ghorbanpour, A., Mami, Y., Ashournezhad, M., Abri, F. and Amani, M. (2011). Effect of salinity and drought stress on germination of fenugreek. *Afr. J. Agric. Res*. **6**: 5529-5532.

Gomez, M. A. and Gomez, A. A. (1984). Statistical procedures for Agricultural Research. John Wiley and sons. New York, Chichester, Brisbane, Toronto. Pp. 97–129, 207–215.

Goudarzi, M., Pakniyat, H. (2008). Evaluation of wheat cultivars under salinity stress based on some agronomic and physiological traits. *J. Agric. Soc.***4**: 35-38.

Hajer A. S., Malibari A. A., Al-Zahrani H. S. and Almaghrabi O.A. (2006). Responses of three tomato (*Lycopersicum esculentum*) cultivars to sea water salinity 1. Effect of salinity on the seedling growth. *African J. Biotec.* **5** (10):855-861.

Hajer, A. S. Malibari, A. A. Al-Zahrani, H. S. and Almaghrabi, O. A. (2006). Responses of three tomato cultivars to seawater salinity, 1.Effect of salinity on the seedling growth. *African J. Biotech*. **5**(10): 855-861.

Hajer, A. S., Malibari, A. A., Al-Zahrani, H. S. and Almaghrabi, O.A. (2006). Responses of three tomato cultivars to sea water salinity 1. Effect of salinity on the seedling growth. African J. Biotech. 5(10): 855-861.

Hossain, M. M. (2001). Influence of planting time on the extension of picking period of four tomato varieties. M S Thesis, Dept. Crop Bot. Bangladesh Agric. Univ. Mymensingh, Bangladesh. pp. 37-39.

Hussein, M., Nadia. G., and Desuki, E. L.(2006) Role of Puterscine in Resistance to Salinity of Pea Plants (*Pisum sativum* L.) *J. App. Sci. Res*. **2**(9): 598-604.

Islam, A. K. M. M., Hasan, M., Musha, M. M. H., Uddin, M. K., . Juraimi A. S and Anwar, M. P. (2018). Exploring 55 tropical medicinal plant species available in Bangladesh for their possible allelopathic potentiality. *Ann. Agric. Sci.***63**: 99-107.

Jamil, M., Lee, C. C., Rehman, S. U., Lee, D. B., Ashraf, M. and Rha, E. S. (2005). Salinity (NaCI) tolerance of brassica species at germination and early seedling growth. *Electro. J. Environ. Agric. Food Chem.***7**: 116-121.

Jamil, M., Lee, C. C., Rehman, S. U., Lee, D. B., Ashraf, M. and Rha, E. S. (2005). Salinity (NaCl) tolerance of brassica species at germination and early seedling growth. *Electronic J.Environ. Agric. Food Chem*. **7**: 116-121.

Jogendra. S., Divakar, S. E. V. and Vijayata, S. (2011). Effect of salinity on tomato (*Lycopersicon esculentum* Mill.) during seed germination stage. *Physiol. Mol. Biol. Plants.***18**(1):45–50.

Kahlaoui, B., Hachicha, M., Rejeb, S., Rejeb, M. N., Hanchi, B. and Misle, E. (2011). Effects of saline water on tomato under subsurface drip irrigation: nutritional and foliar aspects. J. Soil Sci. Plant Nut. **11**:69-86.

Kalaji, M. H. and Pietkiewica, S. (1993). Salinity effects on plant growth and other physiological processes. *Acta Physiol. Plant*. **15**: 89-124.

Kapoor, N., Arif , M. and Pande, V. (2013). Antioxidative defense to salt stress in *Trigonella foenum graecum. L. Curr. Discovery*. **2**: 123-127.

Karim, Z., Ibrahim, A.M., Iqbal, A. and Ahmed, M. (1990). Drought in Bangladesh Agriculture and Irrigation Schedules for Major Crops, Bangladesh Agricultural Research Council (BARC), Soils Public, No. 34. pp. 11.

Kavandi, S. and Shokoohfar, A. (2014).The effect of salinity stress on germination parameters in sunflower cultivars. *Indian J. Fund. App. Life Sci.* **4** (S4): 116-123.

Kaveh, H., Nemati, H., Farsi, M. and Jartoodeh, S. V. (2011). How salinity affect germination and emergence of tomato lines. *J. Bio. Environ. Sci*. **5**: 159-163.

Kaveh, H., Nemati, H., Farsi, M. and Jartoodeh, S.V. (2011). How Salinity Affect Germination and Emergence of Tomato Lines. *J. Biol. Environ. Sci.*, **5**(15): 159-163.

Kazemi, E. M., Jonoubi, P., Pazhouhandeh, M., Majd, A. and Aliasgharpour, M. (2014). Response of variable tomato (*Solanum lycopersicum* mill.) genotypes to salinity at germination & early seedling growth stages. *Int. J. Plant, Animal and Environ. Sci*. **4**: 605-612.

Kazemi, M. A, Jonoubi, P., Pazhouhandeh, M., Majd, A. and Aliasgharpour, M. (2014). Response of variable tomato (*Solanum lycopersicum* Mill.) genotypes to salinity at germination and early seedling growth stages. *Int. J. Plant, Animal and Environ. Sci.***4**(2): 605-612.

Keshavarzi, B. M. H., Rafsanjani, M.S.O., Moussavinik, S. M. and Lak, A. P. (2011). Effect of salt (NaCl) stress on germination and early seedling growth of Spinach (*Spinacia oleracea* L.). *Ann. Bio. Res.* **2**(4): 490-497.

Ketema, S. and Dessalegne, L. (2006). Evaluation Tomato Genotypes for Salt Tolerance at Seed Germination. In. Addis Abeba, Ethiopia: *Ethiopian Hort. Sci. Soci.***1**: 1-2.

Khajeh-Hosseini, M., Powell, A. A. and Bingham, I. (2003). The interaction between salinity stress & seed vigour during germination of soyabean seeds. *Seed Sci. Technol*. **31**: 715-725.

Khavari, N, Ramazan. R., Mostofi, Y. (1998). Effects of NaCl on photosynthetic pigments, saccharides, and chloroplast ultrastructure in leaves of tomato cultivars. *Photosynthetica*. **35**: 151-154.

Kirst, G.O. (1989). Salinity tolerance of eu-karyotic marine algae: Annual Review PlantPhysiology. *Plant Molecular Biol*. **40**: 21-53.

Kumar, K., Kumar, M., Kim, S. R., Ryu, H. and Cho, Y. G. (2013). Insights in to genomics of salt stress response in rice. *Rice*. **6**(1): 27.

Li, Y. (2009). Physiological Responses of Tomato Seedlings (*Lycopersicon esculentum*) to Salt Stress. *Morden App. Sci.* **3**(3): 171-176.

Maas, E. V. (1986). Salt tolerance of plants. *AppiedAgril. Res*. **1**: 12-26.

Maas, E. V. and Hoffman, G. J. (1977). Crop salt tolerance: Current assessment. *J. Irrigation and Drainage Division*. **103**: 115-34.

Mostafavi, K. (2012). Effect of salt stress on germination and early seedling growth stage of sugar beet cultivars. *American-Eurasian J. Sust. Agric.* **6**(2): 120-125.

Mozafariyan, M., Saghafi, K., Bayat, A. E. and Bakhtiari, S. (2013). The effects of different sodium Chloride concentrations on the growth and photosynthesis parameters of tomato (*Lycopersicum esculentum*cv. Foria). *International J. Agric. Crop Sci.* **6**(4): 203-207.

Muhammad, Z. and Hussain, F**.** (2010)**.** Effect of Nacl salinity on the germination and seedling growth of some medicinal plants. *Pak. J. Bot*. **42**(2): 889-897.

Munns, R. and Termaat, A. (1986). Whole plant responses to salinity. *Australian J. Plant Physio*. **13**: 143-160.

Munns, R. and Tester, M.. (2008). Mechanisms of salinity tolerance. *Annu. Rev. Plant Biol*. **59**: 651-681.

Murumkar, C.V. and Chavan, P. O. (1986). Influence of salt stress on biochemical processes in chickpea (*Cicer arietinum* L.). *Plant Soil.***96**: 439-443.

Nasrin, S. and Mannan, M. A. (2019). Impact of salinity on seed germination & seedling growth of tomato. *J. Biosci. Agric. Res.* **21**: 1737-1748.

Neumann, P. M. (1993). Wall extensibility and the growth of salt stressed leaves. In: Jackson MB, Black CR (eds), Nato ASI series, Vol **16**. Interacting Stress on Plants in a Changing Climate, pp. 13-19. Springer Verlag, Berlin, Germany.

Ozcoban, M. and Demir, L. (2006). Germination performance of sequentially harvested tomato (*Lycopersicon esculentum* Mill.) seed lots during seed development under salt & osmotic stress. *J. Cen. Europ. Agric*. **7**: 141-178.

Pak ,V. A., Nabipour, M. and Meskarbashee, M. (2009). Effect of Salt Stress on Chlorophyll Content, Fluorescence, Na+ and K+ Ions Content in Rape Plants (*Brassica napus*L.). *Asian J. Agric. Res*. **3**: 28-37.

Pour, A. P., Farahbakhsh, H. Saffari, M. and Keramat, B. 2013. Response of Fenugreek plants to short-term salinity stress in relation to photosynthetic pigments and antioxidant activity. *Int. J. Agric.: Res. Rev*. **3**: 80-86.

Rahman, M. J. and Inden. H. (2012). Effect of nutrient solution and temperature on capsaicin content and yield contributing characters in six sweet pepper (*Capsicum annuum* L.) cultivars. *J. Food, Agric. Environ*. **10**: 524-529.

Rahman, M., Mobarok, H., Kaniz, H., Sikder, M., Mashura, S., Mohammad, H., Alam, A. K. M. and Khabir, U. (2018). Effects of NaCl-salinity on tomato (*Lycopersiconesculentum* Mill.) plants in a pot experiment. Open Agric. **3**: 578-585.

Ramezani, S. and Shekafandeh, A. (2011). Influence of Zn and K Sprays on Fruit and Pulp Growth in Olive (Oleaeuropaea L. cv. 'Amygdalifolia'). *Iran Agric. Res.* **30**(1): 1-3.

Rashed, M. R. U., Roy, M., Paul, S. K. and Haque, M. M. (2016). In vitro Screening of SaltTolerent Genotypes in Tomato (*Solanumlycopersicum* L.). *J. Hort.* **3**: 186.

Ratnakar, A. and Rai, A. (2013). Effect of sodium chloride salinity on seed germination & early seedling growth of Triginellafoenum-graecum L. Var. *Peb*. *Octa J. Environ. Res.* **1**: 304-309.

Rubio, J. S., Garcia, F., Rubio, F. and Martinez, V. (2009). Yield, blossom end rot incidence and fruit quality in pepper plants under moderate salinity area affected by K+ and Ca^2+ fertilization. *Scientia Hort*. **1**: 79-87.

Rupali, S. (2018). Assessment of salinity tolerance in tomato cultivars grown in Maharashtra, India. *Ann. Plant Sci.***7**(5): 2259-2261.

Sardoei, A. S. Zad, M. N., Fazel, M. S., Gerdeh, B. A. and Shahvardi, M. (2013). Effect of Salinity Stress on Germination in *Lycopersiconesculentum*L. var Cal-ji. *Int. J. Adv. Bio. Biomedical Res.***1**(12): 1543-1550.

Shabala, S. (2013). Learning from halophytes: physiological basis and strategies to improve abiotic stress tolerance in crops. *Ann. Botany*. **112**: 1209-1221.

Shaheen, S., Naseer, S., Ashraf, M. and Akram, N. A. (2013). Salt stress affects water relations, photosynthesis, and oxidative defense mechanisms in *Solanummelongena*L. *J. Plant Inter.* **8**(1): 85-96.

Shahid, M. A., Pervez, M. A., Balal, R. M., Ahmad, R., Ayyub, C. M., Abbas, T. and Akhta, N. (2011). Salt stress effects on some morphological and physiological characteristics of okra (*Abelmoschusesculentus*L.). *Soil Environ.* **30**(1): 66-73.

Shitole, M. S. and Dhumal, N. K. (2012). Effect of water stress by polyethylene glycol 6000 and sodium chloride on seed germination and seedling growth of *Cassia angustifolia*, *Int. J. pharma. Sci. Res***3**(2): 528-531.

Shiyab, S. M., Shatnawi, M. A., Shibli, R. A., Al Smeirat, N. G., Ayad, J. and Akash, M. W.(2013). Growth, nutrient acquisition, and physiological responses of hydroponic grown tomato to sodium chloride salt induced stress. *J. Plant Nut.* **36**: 665–676.

Siddiky, M. A. Sardar, P. K., Hossain, M. M., Khan, M. S. and Khabir, U. M. (2012). Screening of different tomato varieties In saline areas of Bangladesh. *Int. J. Agril. Res. Innov. Tech.***2**(1): 13-18.

Siddiky, M. A., Khan, M. S., Rahman, M. M. and Uddin, M. K. (2014). Performance of tomato (*Lysopersiconesculentum*) germplasms grown in Bangladesh for salinity tolerance. *Agrivita*. **36**: 128-133.

Siddiky, M. A., Sardar, P. K., Hossain, M. M., Khan, M. S. and Khabir, U. (2012). Screening of Different Tomato Varietiesin Saline Areas of Bangladesh. *Int. J. Agric. Res.Inn. Technol.***2**(1): 13-18.

Singh, J., Sastry, E. V. D. and Singh, V. (2012). Effect of salinity on tomato (*Lycopersicon esculentum* Mill.) during seed germination stage. *Physiol. Mol. Bio. Plants.* **18**(1):45–50.

Smolik, M., Kram, P., Krupa-Małkiewicz, M., Smolik, B. and Malinowska, K. (2011). Response of tomato genotypes to salinity stress assessed at the seedlings stage. *Elec.J. Polish Agric. Univ.***14**(4):17.

Sozharajan, R. and Natarajan, S. (2014). Germination and seedling growth of *Zea mays* L. under different levels of sodium chloride stress. *Int. Lett. Nat. Sci.* **12**: 5-15.

SRDI. (2001). Soil Salinity in Bangladesh-2000. Soil Resource Development Institute, Dhaka, Bangladesh. pp. 113.

SRDI. (2010). Saline soils of Bangladesh. SRMAF project, Ministry of Agriculture, Govt. Peoples Repiublic of Bangladesh. pp. 35.

Sultana, N., Ikeda, T. and Itoh, R. (1999). Effect of NaCl salinity on photosynthesis and dry matter accumulation in developing rice grains. *Environ. Exp. Bot.* **42**: 211-220.

Suzuki, K., Yamaji, N., Costa, A., Okuma, E., Kobayashi, N. I. and Kashiwagi, T. (2016). OsHKT1; 4-mediated Na+ transport in stems contributes to Na+ exclusion from leaf blades of rice at the reproductive growth stage upon salt stress. *BMC Plant Bio*. **16**: 22.

Szabolcs, I. (1994). Soil Salinization. In: M. Pessarakli, Ed. Handbook of Plant Crop Stress. Marcel Dekker, New York, USA. pp: 3-11.

Takagi, M., Hany, A., El-Shemy, B., Sasaki, A., Toyama, A. and Kanai A. (2009). Elevated CO_2 concentration alleviates salinity stress in tomato plant. *ActaHorti*. **59**: 87-96.

Talukdar, D. (2012). Modulation of plant growth and leaf biochemical parameters in grass pra (*Lathyrus sativus*L.) and fenugreek (*Trigonellafoenum-graecum*L.) exposed to NaCl treatments. *Indian J. Fund. Applied Life Sci*. **2**: 20-28.

Tuncturk, R. (2011). Salinity exposure modifies nutrient concentrations in fenugreek (*Trigonellafoenumgraecum*L.). *Afr. J. Agric. Res.***6**: 3685-3690.

Turhan, A.,Vedat , E. and Hayrettin, K. (2009). Effect of NaCl in tomato cultivars. *African J. Biotec*. **8**(6): 1062-1068.

Xu, Z., Zhou, G. and Shimizu, H. 2010. Plant responses to drought and dewatering. *PlantSignal. Behav*. **5**: 649-654.

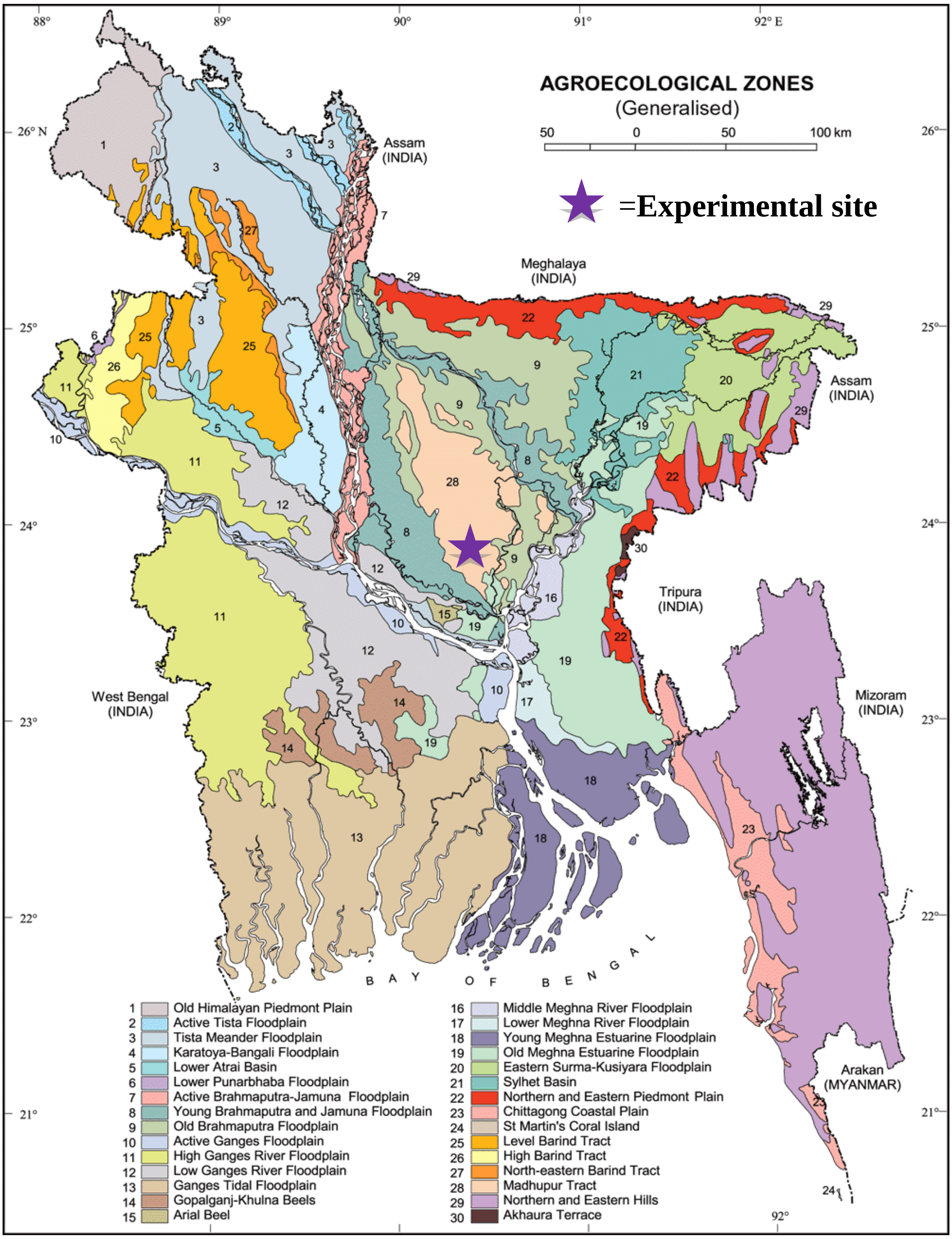
Zahed, H. M. and Naeini, M. B. (2007). Effects of salinity stress on the morphology and yield of two cultivars of Canola (*Brassica napus*L.). *J.Agron*. **6**(3): 409-414.

Zhang, H., Louis, J. I., Craig, M., Cory, M., Daowei, Z. and Peter, K. (2010). The effects of salinity & osmotic stress on barley germination rate: sodium as an osmotic regulator. *Ann. Bot.* **106**: 1027-1035.

Zhani, K., Elouer, M. A., Aloui, H. and Hannachi, C. (2012). Selection of a salt tolerant Tunisian cultivar of chilli pepper (*Capsicum frutescens*). *EurAsian J. Bio Sci.* **6**: 47-59.

APPENDICES

Appendix I. Map showing the experimental site under study



Appendix II. Characteristics of soil of experimental pot

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Sher-e-Bangla Agricultural University Agronomy research field, Dhaka
AEZ	AEZ-28, Modhupur Tract
General Soil Type	Shallow Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. The initial physical and chemical characteristics of soil of the experimental site (0 - 15 cm depth)

Physical characteristics	
Constituents	**Percent**
Sand	26
Silt	45
Clay	29
Textural class	Silty clay

Chemical characteristics	
Soil characteristics	**Value**
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.03
Available P (ppm)	20.54
Exchangeable K (mg/100 g soil)	0.10

Appendix III. Monthly meteorological information during the period from January to February 2020.

Year	Month	Air temperature (^0C)		Relative humidity (%)	Total rainfall (mm)
		Maximum	Minimum		
2020	January	25.5	13.1	41	00
	February	25.9	14	34	7.7
	March	31.9	20.1	38	71
	April	33.7	23.9	74	168

(Source: Metrological Centre, Agargaon, Dhaka (Climate Division)

Appendix IV. Analysis of variance of the data of reduction of shoot length (%) of tomato genotype at different salinity level

Source	DF	SS	MS	F	P
Rep	2	1.3	0.6		
Genotype	13	18397.4	1415.2	6025.55	0.0000**
Treatment	2	27608.4	13804.2	58775.17	0.0000**
Genotype × Treatment	26	8951.2	344.3	1465.86	0.0000**
Error	82	19.3	0.2		

**: Significant at 0.01 level of probability

Appendix V. Analysis of variance of the data of reduction of root length (%) of tomato genotype at different salinity level

Source	DF	SS	MS	F	P
Rep	2	1.6	0.8		
Genotype	13	19252.7	1481.0	2145.61	0.0000**
Treatment	2	31398.8	15699.4	22744.89	0.0000**
Genotype × Treatment	26	8696.6	334.5	484.59	0.0000**
Error	82	56.6	0.7		

**: Significant at 0.01 level of probability

Appendix VI. Analysis of variance of the data of reduction of shoot fresh weight (%) of tomato genotype at different salinity level

Source	DF	SS	MS	F	P
Rep	2	5.3	2.6		
Genotype	13	20709.8	1593.1	1100.38	0.0000**
Treatment	2	37061.9	18530.9	12799.94	0.0000**
Genotype × Treatment	26	12913.8	496.7	343.08	0.0000**
Error	82	118.7	1.4		

**: Significant at 0.01 level of probability

Appendix VII. Analysis of variance of the data of reduction of root fresh weight (%) of tomato genotype at different salinity level

Source	DF	SS	MS	F	P
Rep	2	1.5	0.8		
Genotype	13	36866.9	2835.9	4780.71	0.0000**
Treatment	2	25029.3	12514.6	21096.84	0.0000**
Genotype × Treatment	26	10351.5	398.1	671.16	0.0000**
Error	82	48.6	0.6		

**: Significant at 0.01 level of probability

Appendix VIII. Analysis of variance of the data of reduction of leaf area (%) of tomato genotype at different salinity level

Source	DF	SS	MS	F	P
Rep	2	5.3	2.6		
Genotype	13	11348.1	872.9	481.33	0.0000**
Treatment	2	33637.2	16818.6	9273.65	0.0000**
Genotype × Treatment	26	9578.3	368.4	203.13	0.0000**
Error	82	148.7	1.8		

**: Significant at 0.01 level of probability

Appendix IX. Analysis of variance of the data of reduction of chlorophyll content (%) of tomato genotype at different salinity level

Source	DF	SS	MS	F	P
Rep	2	0.7	0.4		
Genotype	13	3607.7	277.5	887.66	0.0000**
Treatment	2	24289.0	12144.5	38844.67	0.0000**
Genotype × Treatment	26	2918.4	112.2	359.02	0.0000**
Error	82	25.6	0.3		

**: Significant at 0.01 level of probability

Appendix X. Analysis of variance of the data of reduction of relative water content (%) of tomato genotype at different salinity level

Source	DF	SS	MS	F	P
Rep	2	1.2	0.60		
Genotype	13	7383.6	567.97	1200.05	0.0000**
Treatment	2	2842.3	1421.15	3002.72	0.0000**
Genotype × Treatment	26	1682.6	64.72	136.74	0.0000**
Error	82	38.8	0.47		

**: Significant at 0.01 level of probability

Appendix XI. Analysis of variance of the data of Salinity tolerance index of tomato genotype at different salinity level

Source	DF	SS	MS	F	P
Rep	2	0.00053	0.00026		
Genotype	13	1.13481	0.08729	481.33	0.0000**
Treatment	2	3.36372	1.68186	9273.65	0.0000**
Genotype × Treatment	26	0.95783	0.03684	203.13	0.0000**
Error	82				

**: Significant at 0.01 level of probability

Plate 2. Picture showing tomato seedling treated with different salinity level

Plate 3. Picture showing effect of different salinity level on tomato seedlings

Plate 4. Picture showing application of different levels of salinity to the plant

Plate 5. Picture showing survey of the experimental shade by supervisor and co-supervisor

Plate 6. Picture showing data recording of different parameters

Plate 7. Picture showing data recording of different physiological parameters