EFFECT OF ASCORBIC ACID TO MITIGATE SALT STRESS ON GROWTH AND YIELD OF BRINJAL

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*This is to certify that thesis entitled, **"EFFECT OF ASCORBIC ACID TO MITIGATE SALT STRESS ON GROWTH AND YIELD OF BRINJAL"** submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS) in HORTICULTURE**, embodies the result of a piece of bona-fide research work carried out by **RAJVEEN AKTER**, Registration No. **09-03348** 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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ABSTRACT

The pot experiment was carried out at the Horticulture Farm of Sher-e-bangla Agricultural University, Dhaka during the period from October 2013 to April 2014 to find out the mitigation of salt stress by using foliar application of ascorbic acid (AA) in brinjal. BARI Begun 8 variety was used as planting material. The two factors experiment was laid out in Randomized Completely Block Design with three replications. The factors was: Factor A: Four levels of salinity such as (i) S_0: 0 dS/m, (ii) S_1: 6 dS/m, (iii) S_2: 8 dS/m, (iv) S_3: 10 dS/m and Factor B: Three concentration of ascorbic acid (AA) (i) A_0: 0 mM AA, (ii) A_1: 0.5 mM AA, (iii) A_2: 1 mM AA. The total treatment combinations were 12 (3x4). The highest plant height (78.8 cm), number of fruit per plant (23.2), yield per pot (1.71 kg) and yield per hectare (34.2 ton) were recorded at control (0 dS/m salinity) and lowest value was measured at highest salinity level (10 dS/m). The present result also shows that soluble ascorbic acid significantly increased the growth contributing characters, fruit weight as well as yield of brinjal in both saline and non-saline conditions. The combined effect of control condition and 1 mM AA produced the tallest plant (80.9 cm), at harvest the highest number of fruits per plant (24.2), the highest yield per pot (1.82 kg) and yield per hectare (36.4) due to mitigation of saline which is close to control (S_0A_0) treatment whereas the lowest value was found from 10 dS/m salinity without AA. Finally, this result suggests that foliar application of ascorbic acid can effectively mitigate the deleterious effect of salt stress in brinjal upto certain limit.

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CHAPTER I

INTRODUCTION

Brinjal (*Solanum melongena* L.) has the early European name “eggplant” locally known as “Begun” is a self pollinated annual crop belongs to the family Solanaceae (Thompson, 1951). It is a major vegetable crop throughout the tropic and subtropics (Bose and Som, 1986). It is the second most important vegetable crop next to potato in Bangladesh in respect of acreage and production (BBS, 2005). It is thought to be originated in Indian sub-continent because of maximum genetic diversity and closely related species of *solanum* are grown in this region (Zeven and Zhukovesky, 1975). The eggplant is of much importance in the warm areas of Far East, being grown extensively in Bangladesh, India, Pakistan, Nepal, China, Japan and Philippines. It is also popular in France, Italy, USA, the Mediterranean and Balkan areas (Bose and Som, 1986). Brinjal is nutritious vegetable and has got multifarious use as a dish item (Bose and and Som, 1986 and Rashid, 1993). It has high calorie, iron, phosphorous and riboflavin contents than tomato (Shaha, 1989). It has potentiality as raw material in picking and in dehydration industries (Singh *et al*. 1963). Fried brinjal in till has some medicinal value to cure liver problem. It gives small, marginal and landless farmers a continuous source of income and provides employment facilities for rural people. For most of the time, except peak period, market price of brinjal compared to other vegetables remains high which is in favor of the farmer’s solvency.

Salinity is one of the major constraints in the development of irrigated agriculture in arid and semi-arid regions in the world. Salinity problem can be severe in arid and semi-arid regions since precipitation is not sufficient and water supplies are also scarce as compared to water needs for crop production (Lamsal *et al*., 1999). High salt levels in soil result in hyper-osmolarity, ion disequilibrium, nutrient imbalance and production of reactive oxygen species (ROS), leading to plant growth retardation through molecular damage. This can be achieved either through genetic modifications or chemical treatments. Alternatively, the exogenous application of plant growth regulating compounds is an efficient and technically simpler approach to cope with the deleterious effects of salinity on plants.

It has been reported that there are some plant that have their capability of developing adaptive mechanism to salinity (Flower *et al*., 1977; Greenway and Munns, 1980) which in turn induces the plant to have better growth and yield under saline conditions. Owing to population pressure, the cultivable area is decreasing day by day, and this problem will gradually but soon be acute. Food shortage and land scarcity are driving. Asian Countries need to make an attempt to grow food crops on land that has been unutilized because of soil problems. It is estimated that at least 20% of total irrigated lands in the world is salt-affected (Pitman and Läuchli, 2002). The problem of salinity is severe in the winter though during summer the salt concentration decreases dramatically due to monsoon rains. To feed the millions of people of Bangladesh food production must be increased in these areas. Now is the right time to be strategic: first by understanding the reasons – fundamental to complex – for yield reductions so that precise research planning can be brought about to cope with increasing salinity problems. With that view, plant scientists are now searching for ways to make the plants adaptive under saline conditions. Researchers are trying to understand the effects of salt stress on plants so that they can modify the plant‘s external growing condition as well as change the plant from within by applying different exogenous protectants .

Ascorbic acid (AA) is regarded as one of the most effective growth regulators against abiotic stresses. AA not only acts as an antioxidant but the cellular levels of AA are correlated with the activation of complex biological defense mechanisms. It has also used to counteract the adverse effects of salt stress in many crop plants (Beltagi MS, 2008; Salama, 2002 and Khan A, Iqbal I, Shah *et al*., 2010). Exogenous application of AA may reduce salt-induced adverse effects and results in a significant increment of growth and yield. The role of AA is intensively studied in plant responses to biotic stress. In recent years, the involvement of AA in the response to abiotic stresses has come into light. Several studies support a major role of AA in plant adaptation to the changing environment, and induce plant tolerance to various abiotic stresses including elevated NaCl (Stevens *et al*., 2006; Arfan *et al*., 2007; Gunes *et al*., 2007). It is a well observed fact that AA potentially generates a wide array of metabolic responses in plants and also affects plant water relations (Hayat *et al*., 2010).

This study was designed to understand the physiological mechanisms of four salt stress tolerance mediated by exogenous ascorbic acid on one variety which were grown in saline condition. Objectives of the present study was :

i. To study the effect of salinity on the growth and yield of brinjal

ii. To find out the effect of ascorbic acid (AA) on yield contributing characters and yield of brinjal

CHAPTER II

REVIEW OF LITERATURE

Eggplant (*Solanum melongena* L.) is a traditional vegetable crop in many tropical, subtropical and Mediterranean countries. It is one of the most widely consumed vegetable in the world. A wide number of varieties has been used for food and medicinal purposes. Brinjal fruits have a great nutritive potential, due to its high fiber content as well as its high phenolic concentration, which results in a high antioxidant capacity. Eggplant is classified as a moderately sensitive vegetable crop (Maas, 1984), whereas Bresler *et al.* (1982) classified it as salt sensitive vegetable. Conflicting literature exists on brinjal tolerance to soil salinity. Nowadays, one of the main goals of the brinjal breeding program is to obtain brinjal varieties with a high content of vitamin C, which apart from its antioxidant properties, can prevent fruit browning caused by the oxidation of phenolics.

2.1 Abiotic stress

World agriculture is facing a lot of challenges like producing 70% more food for an additional 9.7 billion people by 2050 while at the same time fighting with poverty and hunger, consuming scarce natural resources more efficiently and adapting to climate change (Wilmoth, 2015). However, the productivity of crops is not increasing in parallel with the food demand. The lower productivity in most of the cases is attributed to various abiotic stresses. Curtailing crop losses due to various environmental stressors is a major area of concern to cope with the increasing food requirements (Shanker and Venkateswarlu, 2011). The complex nature of the environment, along with its unpredictable conditions and global climate change, are increasing gradually, which is creating a more adverse situation (Mittler and Blumwald, 2010). Plants can experience abiotic stress resulting from the high concentrations of toxic or antagonistic substance. In some cases, such as the supply of water, too little (drought) or too much flood can both impose stress on plants. Abiotic stresses modify plant metabolism leading to harmful effects on growth, development and productivity. If the stress becomes very high and/or continues for an extended period it may lead to an intolerable metabolic load on cells, reducing growth, and in severe cases, result in plant death (Hasanuzzaman *et al*., 2012a, b).

According to Araus *et al*. (2002), abiotic stresses not only limits crop productivity, but also influence the distribution of plant species in different types of environment. Wang *et al*. (2003) quoted that temperatures could rise by another 3-9^0C by the end of the century with far-reaching effects. Increased drought and salinization of arable land are expected to have devastating global effects. There is also growing evidence that all of these stresses are inter connected, for instance during drought stress, plant also suffers nutrient deficiency as most of the nutrients in the soil are available to plant when dissolved in water. In case of heat stress drought stress occurred simultaneously.

Ahmad and Prasad (2012) reported that abiotic stress cause changes in soil-plant-atmosphere continuum which is responsible for reduced yield in several of the major crops in different parts of the world. Abiotic stresses like heavy metals, drought, salt, low temperature, etc. are the major factors that limit crop productivity and yield. These stresses are associated with production of certain deleterious chemical entities called reactive oxygen species (ROS), which include hydrogen peroxide (H_2O_2), superoxide radical (O2-), hydroxyl radical (OH-), etc. (Chowdhury *et al.*, 2013). In their review, Macedo (2012) concluded that plant abiotic stress has been a matter of concern for the maintenance of human life on earth and especially for the world economy. In their review, Keunen *et al*. (2013) concluded that plants suffering from abiotic stress are commonly facing an enhanced accumulation of reactive oxygen species (ROS) with damaging as well as signaling effects at organellar and cellular levels. The outcome of an environmental challenge highly depends on the delicate balance between ROS production and scavenging by both metabolic and enzymatic antioxidants. To meet these challenges, genes, transcripts, proteins, and metabolites that control the architecture and/or stress resistance of crop plants in a wide range of environments will need to be identified, in order to facilitate the biotechnological improvement of crop productivity.

The crop losses due to abiotic stress are estimated by many researchers. As per the report of Bray *et al*. (2000), abiotic stress is already the primary reason of crop loss worldwide, reducing average yields for most major crop plants by more than 50%. Some recent reports showed that the major abiotic stresses negatively influence the survival, biomass production and yields of staple food crops up to 70% (Thakur *et al*., 2010). However the loss due to abiotic stresses has been predicted to become even more severe as desertification will further increase and the current amount of annual loss of arable area may double by the end of the century because of global warming (Evans, 2005; Vinocur and Altman, 2005).

Salinity is one of the most brutal environmental factors limiting the productivity of crop plants because most of the crop plants are sensitive to salinity caused by high concentrations of salts in the soil. A considerable amount of land in the world is affected by salinity which is increasing day by day. More than 45 million hectares (M ha) of irrigated land which account to 20% of total land have been damaged by salt worldwide and 1.5 M ha are taken out of production each year due to high salinity levels in the soil (Pitman and Läuchli, 2002; Munns and Tester, 2008).

On the other hand, increased salinity of agricultural land is expected to have destructive global effects, resulting in up to 50% loss of cultivable lands by the middle of the twenty- first century (Mahajan and Tuteja, 2005). Cropping intensity in saline area of Bangladesh is relatively low, mostly 170% ranging from 62% in Chittagong coastal region to 114% in Patuakhali coastal region (FAO, 2007).

In most of the cases, the negative effects of salinity have been attributed to increase in Na+ and Cl- ions in different plants hence these ions produce the critical conditions for plant survival by intercepting different plant mechanisms. Although both Na+ and Cl- are the major ions produce many physiological disorders in plant, Cl- is the most dangerous (Tavakkoli *et al.*, 2010). Salinity at higher levels causes both hyperionic and hyperosmotic stress and can lead to plant demise. The outcome of these effects may cause membrane damage, nutrient imbalance, altered levels of growth regulators, enzymatic inhibition and metabolic dysfunction, including photosynthesis which ultimately leading to plant death (Mahajan and Tuteja, 2005; Hasanuzzaman *et al.*, 2012a).

2.2 Salt stress on brinjal plant

According to Tejera *et al*., (2006) salt stress affects many aspects of plant metabolism and as a result, growth and yields are reduced. Excess salt in the soil solution may adversely affect plant growth either through osmotic inhibition of water uptake by roots or specific ion effects. Salinity impacts plants in two main ways: osmotic stress and ion toxicity (Munns, 2005). Osmotic stress is caused by ions (mainly Na+ and Cl-) in the soil solution decreasing the availability of water to roots. Ion toxicity occurs when plant roots take up Na + and/or Cl ions and these ions are accumulated to detrimental levels in leaves. Ion imbalances and nutrient deficiency, particularly for K+ nutrition, can also occur

According to Parida and Das, 2005; Hajer *et al*., (2006) salinity stress results in a clear stunting of plant growth, which results in a considerable decrease in fresh and dry weights of leaves, stems and roots. Increasing salinity is also accompanied by significant reductions in shoot weight, plant height and root length. Exposure of plants to salt stress usually begins in the roots. This leads to changes in growth, morphology and physiology of the root that will in turn change water and ion uptake and the production of signals that sends information to shoot. The whole plant is then affected when roots are growing in a salty medium.

Faiza Khalid *et al*., (2012) conducted an experiment in Department of Botany, University of Gujrat (UOG), Gujrat, Pakistan. They state that soluble salts are present in all soils and irrigation water, which are essential and required for normal plant development and growth. The design used for the experiment is CRD with three replicates with three different treatments of Na_2SO_4, was conducted to check the effect of salinity on plant growth. After 14 days interval it was observed that different replicates showed different morphological growth parameters due to application of Na_2So_4. Results showed that replicates with maximum salt concentration i.e. that is 60 ppm Na_2So_4 gave best growth which showed that maximum salt stress for brinjal was good enough for growth and stress showed positive response on the plants with 60 ppm Na_2SO_4 normally salinity stress in excess is harmful for plant growth but our experimental observations showed that our brinjal specie was salt tolerant. Plants bore the salt stress upto 60 ppm Na_2SO_4. It was examined that this tolerance limit was not harmful and not acted as stress on brinjal spp. Infact it favored the plant growth. Discrepancies and in consistences can also exist there in some of information due to difference in environments, cultivars and experimental conditions.

Kadam, J. R., Bhingardeve, S. D. and Walke V. N. (2007) conducted a field experiment on brinjal Cv. Krishna at Inter Faculty Department of Irrigation Water Management, Post Graduate Institute, MPKV., Rahuri during summer season of 1999-2000. The concentration of N was highest in a canal water treatment of 1.60 % in SW0 + F1 treatment than saline water treatment of 1.20 % in SW1 + F1 treatment at harvest in plant and 2.81 and 2.08 % in case of fruit. The plant height was highest in canal water treatment of SW0 + F1 of 71.3 cm at 90 days after transplanting and in lowest height was observed in saline water treatment (SW1 + F1) of 54.7 cm at 90 days after transplanting. The highest dry matter accumulation in canal water was observed of 112.6 g/plant and lowest was observed of 86.3 g/plant in water treatment (SW1 + F3). The highest dry matter accumulation in fruit was recorded of 87.4 g/plant and lowest was recorded of 66.9 g/plant in SW1 + F1 treatment.

V. R. Naik *et al.* (2011) for studying the effect of saline water usage through drip in brinjal, one field experiment was conducted on Vertic Halaquepts of Coastal Soil Salinity Research Station, NAU, Danti during 2002-03, 2003-04 and 2004-05. The treatments consisted of 4 water salinity levels (2, 4 6 and 8 dS/m) and 3 moisture regimes (0.4, 0.6 and 0.8 PEF). The experimental soil was non saline-sodic (EC2.5 0.28 to 0.43 dS/m and pH 8.89 to 9.58). The differences in yield of brinjal due to salinity levels and moisture regimes were not conspicuous during individual years and in pooled data also except that of salinity effect in pooled analysis. The interaction effect of water salinity and PEF levels was not significant. Among the salinity levels, application of water having EC 8 dS/m gave significantly lower yield than 2, 4 and 6 dS/m waters. Effect of different treatments applied to brinjal was not significant on the grain yield of subsequent paddy. Though, the soil salinity tended to increase due to irrigation with saline water in brinjal, it decreased considerably after harvest of paddy crop due to heavy monsoonic conditions of this area.

An experiment was conducted by Siddique Alam. The screening of eggplant germplasms for salinity was carried out with a laboratory and greenhouse experiment. For this purpose 20 eggplant germplasms were tested with electrical conductivities of 4, 8, 12 dS/m and tap water as a control treatment. The observation was performed in three stages of plant growth as germination, seedling, and vegetative with fruiting stage. Eggplant was not found to be tolerant to high salinity of 12 EC at vegetative and fruiting stage though some germplasms gave better performance in germination and seedling stage at same salinity level but at vegetative and fruiting stage their performance was not satisfactory in respect of growth and yield. Only the variety Senrho No 2 showed the consistent result in all stages and found to be more tolerant to salinity than other varieties up to 8 EC with minimum reduction of germination (5%) and yield (24%). The variety Kurosuke found to be the most susceptible variety from the results of all growth stages.

John Wiley & Sons, Ltd. (2008) conducted an experiment on the effect of irrigation water salinity on eggplant growth, yield, water consumption and mineral matter accumulation in leaves and fruits were investigated with a greenhouse experiment. For this purpose, five saline irrigation waters with conductivities of 1.5, 2.5, 3.5, 5.0, 7.0 dS/m and tap water as a control treatment were utilized. Throughout the experiment, the amounts of irrigation water to be applied were determined based on the weight changes of each pot. After irrigation the amount of drainage water volume was measured in drain pans placed underneath each pot. We calculated the plant water consumption from the water budget information. Threshold soil salinity and slope values of the yield response to soil salinity level were determined as <1.5 dS m^{-1} and 4.4 respectively for fruit yield and 6.7 dS /m and 3.7 for the vegetative dry weight. The fruit yield results revealed that eggplant was moderately sensitive to salinity. Plant water consumption and water use efficiency decreased with increasing salinity. The crop yield coefficient (Ky) was 2.3. Salinity caused a decrease in K content, and increased Cl content of leaves. Although mineral concentration of the leaves did respond to increased mineral concentration of irrigation water, mineral concentration of fruits did not.

M. N. Islam *et al.* (2010) conducted an experiment on screening of eggplant genotype against water logging salinity at the HRC /BARI during February to

April 2010. Eleven eggplant genotype viz. SM-11, SM-12, SM-18, SM-19., SM-20, BARI Begun-1, BARI Begun-4, BARI Begun-6, BARI Begun-7, BARI Begun-8, Tarapuri were used in the experiment. Twenty five day old seeding were subjected to flooding treatment of 1-day and 3-day. A significant decrease in photosynthesis occurred for 1-day flooding and continued to decrease up to 3-day flooding. The loss of photosynthesis productivity was found to depend on the genotype too. Reduction of photosynthesis was highly significant in genotype BARI Begun-4, out of 11 genotype SM-20 showed tolerant to flooding. Drastic reduction is PS of other genotype was noticed due to flooding durations of different levels. Reduction stomatal conductance was higher in BARI Begun-4 and BARI Begun-6 only in 1-day flooding. There had been significant differences in sub-stomatal carbon concentration among the genotypes and flooding treatments was also noticed. The extent of reduction of sub-stomatal carbon concentration was much higher in control than the flooded plant.

2.3 Effects of ascorbic acid on brinjal

Ascorbate is an important antioxidant in plant tissues which is synthesized in the cytosol of higher plants primarily from the conversion of D-glucose to AA. It reacts with a range of ROS such as H_2O_2, O_2.-, and OH. at diffusion-controlled rates (Smirnoff, 2005). AA is also responsible for keeping prosthetic metal ions in a reduced form, thereby maintaining the activity of various antioxidant enzymes (De Tullio, 2004). AA plays an important role in plant stress tolerance (Hossain *et al*., 2010, 2011; Hasanuzzaman *et al*.,2011a). Exogenous application of AA influences the activity of many enzymes and minimizes the damage caused by oxidative processes through synergic function with other antioxidants (Shalata and Neuman, 2001).

Nahed *et al.,* (2006) also conducted an experiment to study the effect of foliar spraying of ascorbic acid (0, 200, 400 ppm) on growth and chemical constituents under three level of salinity (1000,2000 and 3000 ppm) and tap water served as control. Salinity effect have a depressing effect on various growth parameters (i.e. stem length, stem diameter, root length, leaves number/plant, leaf area and fresh and dry weight of all plant organs. The same tendency was observed regarding total sugar, chlorophyll a, b, carotenoids content as well as percentage and uptake of N, P and K. such depressive effect was increasingly prominent with increasing Salinity level. While proline content and the percentage and uptake of Na increased by increasing salinity level. On the contrary, all previous growth parameters and chemical constituents, except the percentage and uptake of Na, tended to increase by increasing the concentration of ascorbic acid up to 400 ppm as compared to the untreated ones. It could be recommended to spray plants, grown in regions irrigated with saline water, with ascorbic acid to overcome destructive effect of salinity.

E-Tohamy *et al*., conducted an experiment under sandy soil conditions in the experimental farm of the National Research Center in Nubaria region. The objective of the experiments was to investigate the physiological responses, growth and yield of eggplant to the foliar application of putrescine, yeast and vitamin C under such sandy soil conditions. Vegetative growth measurements, yield, hormonal changes in leaves (Cytokinins) and N, P and K contents of leaves were recorded to study the effects of these treatments. Foliar application of putrescine, yeast and vitamin C resulted in a significant increment of vegetative growth (including plant height, number of leaves, number of branches and fresh weight of plants) and yield of eggplant compared to control plants. Yeast treatments had the best results concerning plant growth and yield. All treatments increased cytokinine content especially at the high level of yeast. The treatments resulted in a significant increase of N, P and K contents of leaves. The possible roles of the treatments on growth, yield and physiological responses of eggplant are discussed.

R San Jose *et al.*, conducted an experiment to evaluate the difference on vitamin C composition of modern hybrids (Cristal F1,Ecavi F1 and Bandera F1) and traditional (ALM1, CS16 and IVIA371) eggplant varieties cultivated both on open air and greenhouses. Plants of each one of these varieties were cultivated in COMAV facilities. Samples were analyzed for pH, titratable acidity, dry matter and vitamin C (both ascorbic acid, AA; and dehydroascorbic acid, DHA fractions) (Sanchez et al., 2000; San Jose Rodriguez et al., 2006). The results of physiochemical parameters on the six varieties analyzed in both growing condition were quite similar. Main difference were found in eggplants grown in greenhouses, with four times higher vitamin C levels (up to 25mg/100g fresh fruit) than in the open air ones (with a maximum of 6 mg/100g fresh fruit), maintaining in all of them the same proportions between AA and DHA. Results from samples grown in open air in agreement with previous studies (San Jose Rodriguez *et al.*, 2006). In the samples analyzed, the DHA form is the predominant, possibly due to the activity of ascorbate-oxydase at pH levels of AA which were found in the samples. The results show that conversely to what occurs for phenolic compounds, good sources of variation for high vitamin C content might be found in modern varieties.

An study was undertaken by Batool *et al.*, (2012) to examine the effects of exogenous application of ascorbic acid (AA) through different modes on growth and associated biochemical parameters in Lycopersicum spp. hybrid cv. HSF-240, under salt stress. In a pot experiment, AA was applied through irrigation or foliar-spray at the concentrations of 0.1, 0.5, and 1 mM with or without 100 mM NaCl concentration. Vegetative growth measurements, antioxidant enzyme activities (POD and SOD), and protein and proline contents of plants were recorded to study the effects of these treatments. The presence of salt reduced the growth of sugarcane plants. The AA application not only mitigated the inhibitory effects of salt stress but also induced a stimulatory effect on all the studied growth parameters. The activities of antioxidant enzymes (POD and SOD) as well as proline contents of plants were increased, although the protein contents were decreased after AA application. The exogenous application of AA through either way significantly alleviated the adverse effects of salinity on growth and biochemical parameters of sugarcane plants. However, in this study, the AA application through irrigation proved to be a better option in mitigating the adverse effects of salinity.

Another study was conducted by Lila *et al.*, (2006) on the effects of ascorbic acid on salt induced alfalfa (*Medicago sativa* L.) in *in vitro* culture. Ascorbic acid as an antioxidant agent has already been used for increasing of stress tolerance. Callus was produced from stem segments of alfalfa (*Medicago sativa* L.) on MS medium supplemented with 2,4 dichlorophenoxy acetic acid, naphthalene acetic acid and kinetin (2 mg/l each). Calli were then transferred to the same medium containing 0, 30, 60, 90, 120 mM NaCl and 0, 0.5, 1.0, 2.0 mM ascorbic acid. Addition of ascorbic acid to the medium improved seed germination and also increased the activity of acid phosphates, chlorophyll content, and dry mass. The Na+ and K+ content of stem-leaf and root was relatively increased with some variations. The fresh weight of calli was also increased by ascorbic acid under salt stress condition.

The transition from reversible to permanent wilting, in whole tomato seedlings (*Lycopersicon esculentum* Mill. Cv. M82) following severe salt stress by root exposure to 300 mM NaCl was investigated by Abed Shalata and Peter. M. Neumann, (2001). Salinized seedlings wilted rapidly but recovered if return to non-saline nutrient solution within 6 h. However, after 9 h of salt treatment 100% of the seedlings remain wilted and die. Remarkably an addition of an antioxidant (0.5 mM ascorbic acid) to the root medium, prior to and during salt treatment of 9 h facilitated the subsequent recovery and long term survival of c. 50% of the wilted seedlings. Other organic solution with known antioxidant activity were not effective. Salt stress increase the accumulation of root, stems and leaves, of lipid per oxidation products produced by interaction with damaging active oxygen species. Additional Ascorbic Acid partially inhibited this response but did not significantly reduced Na uptake or plasma membrane leakiness.

Similar investigation was conducted by Hamed *et al*., (2014) on effect of salinity and ascorbic acid on growth, water status and anti-oxidant in a perinnial halophyte. The study showed that salinity causes oxidative stress in plants by enhancing production of reactive oxygen species, so that an efficient antioxidant system, of which ascorbic acid (AA) is a key component, is an essential requirement of tolerance. However, antioxidant responses of plants to salinity vary considerably among species. *Limonium stocksii* is a sub-tropical halophyte found in the coastal marshes from Gujarat (India) to Karachi (Pakistan) but little information exists on its salt resistance. In order to investigate the role of AA in tolerance, 2-month-old plants were treated with 0 (control), 300 (moderate) and 600 (high) mM NaCl for 30 days with or without exogenous application of AA (20 mM) or distilled water. Shoot growth of unsprayed plants at moderate salinity was similar to that of controls while at high salinity growth was inhibited substantially. Sap osmolarity, AA concentrations and activities of AA dependant antioxidant enzymes increased with increasing salinity. Water spray resulted in some improvement in growth, indicating that the growth promotion by exogenous treatments could partly be attributed to water. However, exogenous application of AA on plants grown under saline conditions improved growth and AA dependent antioxidant enzymes more than the water control treatment. Our data show that AA-dependent antioxidant enzymes play an important role in salinity tolerance of *L. stocksii*.

Exogenous application of AA helps the *L. esculentum* seedling to recover from salt stress (Shalata and Neumann 2001). They observed that the addition of exogenous AA to the root medium remarkably increased seedling survival and decreases lipid per oxidation. Hamada and Al-Hakimi (2009) found that exogenously applied AA were generally effective partially or completely countering the inhibitory effects of salt stress on net photosynthetic rate, pigments biosynthesis and membrane integrity by exerting a stimulatory action on these parameters, especially in plants subjected to moderate and low salinity levels. The leakage of K + was also reduced by the application of AA.

2.4 Use of substances for mitigation of salt stress

Numerous research results have indicated that exogenous application of osmo-protectants, plant hormones, antioxidants, signaling molecules, polyamines and trace elements provided significant protection against salt-induced damages in plants. These protectants enhanced salt stress tolerance by enhancing their germination, growth, development, photosynthesis, anti oxidative capacities and yield.

Tropism represent fascinating examples how plants respond to environmental signals by adapting their growth and development was investigated by Ampudia *et al.*, (2013) and reported that salt induced phospholipase D activity stimulates clathrin-mediated endocytosis of PIN2 at the side of the root facing the higher salt concentration. The intracellular relocalization of PIN2 allow for auxin redistribution and for the directional bending of the root way for the higher salt concentration. Their results thus identify a cellular pathway essential for the integration of the environmental cues with auxin regulated root growth that likely plays a key role in adaptive responses to salt stress.

Leo *et al*., (2013) conducted a study with different methods, including seed soaking, root drenching, anthrone colorimetry, and Mo anti-antimony colorimetry were used to study the effects and the corresponding mechanisms of Bacillus megaterium CJLC2 on the salt tolerance of tomato and reported that when tomato seedlings were treated with 100 mM/L NaCl, CJLC2 could reduce the content of the Na by 11.25%. B. megaterium CJLC2 could improve the salt tolerance of tomato and promote the growth by enhancing the salt-tolerance related physiological and biochemical characters.

Tomato plants hybrid Astona and Gloria growing on pots by Posada and Rodrogueze (2009) with soil were exposed to 20, 40, 60 and 80 mmol NaCl under greenhouse conditions and the electrical conductivity values of treated soil were 2.95, 4.90, 6.56 and 7.70 ds m^{-1}. To soil of some salt stressed palnt, Humitron 60S (23.6% humic acid and 1.1% fulvic acid, from leonardite) was added 1.6 g per plant (40 kg ha^{-1}, proportionally) at transplanting time to reduce the negative effect of salinity on plants. The study was carried out in greenhouse in Tunja, Colombia. Result shows statistical difference between hybrids. Salinity, in general, reduced the values of evaluated growth and yield parameters, however, Leonardite ameliorate the negative effect of salinity on plant. The fruits of salt stressed plants had higher specific leaf area, total soluble solid and titratable acidity in comparison with those of control plants, while total dry matter, yield and leaf area were reduced. For most evaluated parameters, Leonardite had poor effect on alleviation of salt stressed in plants of 20 mmol NaCl treatment, but in soils subjected to 40 to 80 mmol NaCl an increase of yield and dry matter production per plant as well as reduction of total soluble solids and titratable acidity of fruits was observed. Results showed a possibility to reduce the negative effect of salinity on tomato plants growing under greenhouse condition by adding Leonardite salinized soils.

In a recent study, Azzedine *et al*. (2011) reported that the application of vitamin C was effective to mitigate the adverse effect of salt stress on plant growth due to increased leaf area, improved Chlorophyl and Car contents, enhanced Pro accumulation and decreased H_2O_2 content.

Einset *et al*., (2007) reported that exogenous application of compatible solutions has been suggested as an alternative/additional approach genetic engineering to improve crop productivity under stressed conditions. Although the application of exogenous GB to salt-stressed plants was described several decades ago and its function has been relatively well characterized, its effect on protein responsiveness has not yet been completely defined and a detailed understanding of many of its cellular functions has proved elusive. DNA microarray analysis was used to identify genes whose expression was enhanced by GB included genes for transcription factors, for membrane trafficking components, for reactive oxygen species (ROS)-scavenging enzymes, and for NADP-dependent ferric reductase that is located in plasma membrane.

Glutathione (GSH) is a strong antioxidant which prevents damage to important cellular components caused by ROS (Pompella *et al.* 2003). It also plays an indirect role in protecting membranes by maintaining a-tocopherol and zeaxanthin in the reduced state. It can also function directly as a free radical scavenger by reacting with $1O_2$, $O^{2\bullet-}$ and HO•. GSH protects proteins from denaturation caused by oxidation of protein thiol groups under stress. In addition, GSH is a substrate for glutathione peroxidase (GPX) and glutathione-S-transferases (GST), which are also involved in the removal of ROS (Noctor *et al*. 2002).

The effect of salt stress and adaption of salicylic acid (SA) content and on antioxidant and lipoxygenase (LOX) enzyme activity was studied by Molina *et al.* (2002) in tomato (*Lycopersicon esculentum*cv.Pera) cells. Application of 200 micro M SA+100 mMNaCl inhibited APX activity in both unadapted and adapted cells, induced the Mn-SOD in adapted cells and increase lipid peroxide in unadapted cells. The findings also indicated that adaption of tomato cells to NaCl-induced oxidative stress and suggest a role of SA in this response.

Kishitani *et al*., (1994) reported that accumulation of concentration of either in organic ions or low molecular weight organic solutes. Although they play a crucial role in higher plants grown in the saline conditions, their relative contribution varies among species, among cultivars and even between different compartments within the same plants. There is strong evidence that glycinbetanine (GB) and proline play an adaptive role in mediating osmotic adjustment and protecting the subcellular structures in stressed plants, stablizing photosynthetic reactions, the structure of extrinsic proteins of the phoyosystem II (PSII) complex, and ATP synthesis and activation of enzymes.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted during the period from October 2013 to April 2014 to study the mitigation of salt stress in brinjal by using exogenous ascorbic acid. The materials and methods that were used for conducting the experiment has been presented in this chapter. It includes a short description of the location of experimental site, soil and climate condition of the experimental area, materials used for the experiment, data collection and data analysis procedure.

3.1 Location

The experiment was conducted at the farm of the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka (90.06^0 E longitudes and 24.09^0N latitude) during the period from October 2013 to April 2014.The altitude of the locations was 8 m from the sea level as per the Bangladesh Metrological Department, Agargaon, Dhaka-1207 (Anon., 1989).

3.2 Soil

Experimental site belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28 and the soil of the pot was medium in nature with adequate irrigation facilities. The soil texture of the experiment was sandy loam. The nutrient status of the farm soil under the experimental pot were collected and analyzed in the Soil Research and Development Institute Dhaka, and result has been presented in Appendix I.

3.3 Climate

The experimental area was under the subtropical climate and was characterized by high temperature, high humidity and heavy precipitation with occasional gusty winds during the period from April to September, but scanty rainfall associated with moderately low temperature prevailed during the period from October to

March. The detailed meteorological data in respect of air temperature, relative humidity, rainfall and sunshine hour recorded by the meteorology center, Dhaka for the period of experimentation have been presented in Appendix II.

3.4. Planting materials

30 days seedlings of BARI Begun 8 were used as planting material. The seedling of brinjal were grown at the seedbed of Sher-e-Bangla Agricultural University Horticulture Farm.

3.5 Treatments

The experiment consisted of two factors as mentioned below:

a) Factor A: Different levels of Salinity

i. S_o : 0 dS/m

ii. S_1: 6 dS/m

iii. S_2: 8 dS/m

iv. S_3: 10 dS/m

b) Factor B: Different levels of Ascorbic acid (AA)

i. A_0: 0 mM AA

ii. A_1: 0.5 mM AA

iii. A_2: 1 mM AA

There were 12 (4x3) treatments combination such as S_0A_0, S_0A_1, S_0A_2, S_1A_0, S_1A_1, S_1A_2, S_2A_0, S_2A_1, S_2A_2, S_3A_0, S_3A_1 and S_3A_2.

3.6 Design and layout of the experiment

The experiment was laid out in a Randomized Completely Block Design (RCBD) with three replications. There were 36 pots all together replication with the given factors. The experiment area was divided into three equal blocks. Each block was covered by 12 pots where 12 treatments combination were allotted. The distance between two blocks and two pots were 1.0 m and 0.5 m respectively.

3.7 Pot preparation

The collected soil was sun dried, crushed and sieved. The soil and fertilizers were mixed well before placing the soils in the pots. The experimental pots were filled at 26 November. Pots were placed at the germplasm of Sher-e bangla Agricultural University. The pots were pre-labeled for each treatment. The soil was treated with insecticides (cinocarb 3G @ 4 kg/ha) at the time of final pot preparation to protect young plants from the attack of soil inhibiting insects.

3.8 Fertilizer application

The sources of N, P_2O_5, K_2O as urea, TSP and MP were applied, respectively. The entire amounts of TSP and MP were applied during the final pot preparation. Urea was applied in three equal installments at 15, 30 and 45 days after seedling transplanting. Well-rotten cowdung 5 t/ha also applied during final pot preparation. The following amount of manures and fertilizers were used which shown as tabular form recommended by BARI (2011).

Table 1: Fertilizer and Manure Applied for the experimental field

Manures and Fertilizers	Rate (kg/ha)	Rate (g/pot)
Cowdung	5000	227
Nitrogen (N_2)	160	7
P_2O_5 (as TSP)	48	2
K_2O (as MP)	120	5

3.9 Raising of seedlings

Brinjal seedlings were raised in one seedbed of 3m × 1m size area. The soil was well prepared and converted into loose friable and dried mass by spading. All weeds and stubbles were removed and 5 kg well rotten cow dung was mixed with soil in seedbed. 3g seeds were sown on each seedbed on 26 October, 2013. After sowing, seeds are covered with light soil. Heptachlor 40 WP was applied @ 4kg/ha, around each seedbed as precautionary measure against ant and worm. The emergence of seedlings took place with 5 to 6 days after sowing. When the seed completely germinated, shade by bamboo mat was provided to protect the young seeding from scorching heat and rain. No chemical fertilizer was applied for raising the seedlings. Seedlings were not attacked by any kind of insect or diseases.

3.10 Transplanting of seedlings

Healthy and uniform 30 days old seedlings were transplanted in the experimental pots in the afternoon of 26 November, 2013. The seedlings were watered after transplanting. Shading was provided for three days to protect the seedling from hot sun and removed after seeding was established. They were kept open at night to allow them receiving dew. Each pot allowed two seedlings and one seedling is removed from pot after establishment of seedlings.

3.11 Preparation of different levels of salinity and application of ascorbic acid

As per treatment the required amount of saline solution was applied in the pot as application of water. The tray was used in the bottom of each pot to collect the water. Ascorbic acid also was applied by foliar spraying with irrigation in the pot according to treatment combination. First application of solution and ascorbic acid applied in the pot soil at 25 days after transplanting.

3.12 Intercultural operation

After transplantation of seedling, various intercultural operation such as weeding, irrigation pest and disease control etc. were accomplished for better growth and development of the brinjal plant.

3.12.1 Weeding

The hand weeding was done as when necessary to keep the pots free from weeds. Weeding was done every 15 days interval from planting to the peak flowering stage. Spading was done from time to time specially to break the soil crust and keep the pot free after each irrigation.

3.12.2 Irrigation

Light watering was given by a watering cane in each pot with equal amount as necessary at afternoon.

3.12.3 Pest and disease control

As prevention measure against the insect pest like cutworm, shoot and fruit borer, leafhooper etc. Malathion 60 EC @ 2 ml per litre was applied to reduce the attack in the pot. Many cleaning practices were also done to reduce the insect attack. Ripcord was also applied to control the insect pest @ 85 ml/ha.

Precautionary measure against various diseases of brinjal were taken. Neem powder mixed with water @ 5.0% and ash spraying were done to control the bacterial and fungal disease of brinjal.

3.13 Harvesting

Fruits were harvested at mature stage. Harvesting was started from 10 March, 2014 and was continued upto 28 April, 2014.

3.14 Data collection

The following data were collected from plant of each unit pot.

3.14.1 Plant height

The height of the brinjal plants was recorded from 20 days after transplanting (DAT) at 20 days interval up to 80 DAT, beginning from the ground level up to tip of the leaf was counted as height of the plant.

3.14.2 Number of leaf pair per plant

The total number of leaf pair per plant was counted from plant of each unit pot. Data was calculated as 20 days interval starting from 20 days of planting upto 80 days.

3.14.3 Days required from transplanting to 1st flowering

Days required for transplanting to initiation of flowering was counted from the date of transplanting to the initiation of flowering and was calculated.

3.14.4 Number of flowers per plant

Number of flowers per plant was counted from the plant of each unit pot and the number of flowers was calculated.

3.14.5 Number of fruits per plant

Number of fruits per plant was counted from the plant of each unit pot and the number of fruits was calculated.

3.14.6 Length of the fruit

The length of the fruit was measured with a scale from the neck of the fruit to the bottom of 5 selected marketable fruits from each pot and there average was taken and expressed in cm.

3.14.7 Diameter of fruit

Diameter of fruit was measured at middle portion of 5 selected marketable fruit from each pot with a slide calipers and there average was taken and expressed in cm.

3.14.8 Dry weight of individual plant

After harvesting, individual plant sample previously sliced into thin pieces were put into envelop and placed in oven maintained at 70^0 C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The final weight of the sample was taken. The dry weight of individual plant was recorded.

3.14.9 Dry weight of individual fruit

After harvesting, randomly selected fruit sample previously sliced into very thin pieces were put into envelop and placed in oven maintained at 60^0C for 72 hours. The sample was then transferred into desiccators and all allowed to cool down at room temperature. The final weight of the sample was taken. The dry weight of fruit was recorded.

3.14.10 Weight of individual fruit

Among the total number of fruits during the period from first to final harvest the fruits, except the first and final harvest, was considered for determining the individual fruit weight.

3.14.11 Yield per pot

Yield of brinjal per plant was calculated as the whole fruit per plant and was expressed in kilogram.

3.14.12 Yield (t/ha)

According to field condition number of plant per hectare was calculated considering plant to plant distance 75 cm x 60 cm. The experimental pot was arranged according to that distance and thus yield per pot was converted to yield per hectare in ton.

3.15 Statistical analysis

The data obtained for different characters were statistically analyzed by using MSTAT-C computer package program to find out the significance of the difference for salt stress and ascorbic acid on yield and yield contributing characters of brinjal. The mean value of all the recorded characters was evaluated and analysis of variance was performed by the “F” (variance ratio) test. The significance of the difference among the treatment combination of means was estimated by Duncan’s Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULT AND DISCUSSION

The experiment was conducted to study the effect of salinity and ascorbic acid on growth and yield of brinjal. The analysis of variance (ANOVA) of the data are presented in Appendix III-VI. The result has been presented by using table and graphs and discussed with possible interpretations under the following headings:

4.1 Plant height

Plant height of brinjal varied significantly due to different levels of salinity at different days after transplanting (DAT) (Figure 1 and Appendix III). At 20, 40, 60 and 80 DAT, the longest plant (27.3 cm, 55.5 cm, 68.3 cm and 78.7 cm) was recorded from S_0 (0 dS/m salinity) which was closely followed (25.7 cm, 52.8 cm. 66.7 cm and 76.8 cm) with S_1 (6 dS/m salinity) and then (22.6 cm, 50.1 cm, 62.7 cm and 68.8 cm) by S_2 (8 dS/m salinity), while the shortest plant (20.2 cm, 46.1 cm, 56..8 cm and 63.8 cm) from S_3 (10 dS/m salinity) respectively (Figure 1). Leo *et al*., (2013) reported that under the salt stress of NaCl, the increase of NaCl concentration had stronger inhibitor effect on tomato growth. Agong *et al*., (2003) reported that significant genotype and/or salt treatment effect registered on plant height.

Plant height of brinjal do not varied so much significantly due to different levels of ascorbic acid at different days after transplanting (DAT) (Figure 2 and Appendix III). At 20, 40, 60 and 80 DAT, the longest plant (21.7 cm, 48.7 cm, 60.8 and 69.9 cm) was recorded from A_2 (0 mM AA) which was closely followed (24.1 cm, 50.9 cm. 63.4 cm and 71.7 cm) with A_1 (0.5 mM AA), while the shortest plant (26.2 cm, 53.7 cm, 66.4 cm and 74.5 cm) from A_0 (1 mM AA) respectively (Figure 2).

Interaction effect of saline water and ascorbic acid showed statistically significant variation for plant height at 20, 40, 60 and 80 DAT (appendix III). At 20 DAT the longest plant (29.1 cm) was recorded from S_0A_2 (0 dS/m salinity + 1 mM AA) which is very close to S_0A_0 (25.1 cm) and the shortest plant (17.8 cm) was recorded from S_3A_0 (10 dS/m salinity + No ascorbic acid). At 40 and 60 DAT the similar trend of interaction effect between saline water and ascorbic acid showed on the plant height of brinjal. At 80 DAT, the longest plant (80.9 cm) was recorded from S_0A_2 (0 dS/m salinity + 1 mM ascorbic acid) and the shortest plant (61.8 cm) was recorded from S_3A_0 (10 dS/m salinity + 0 mM AA) (Table 2).

4.2 Number of leaf pair per plant

Due to different level of saline water number of leaf pair per plant of brinjal varied significantly at 20, 40, 60 and 80 DAT (Appendix IV). At 20 days, the maximum number of leaf pair per plant (5.8) was recorded from S_0 (0 dS/m salinity) which was statistically identical (4.4) with S_1 and S_2, while the minimum number of leaf pair per plant (3.2) from S_3 (Figure 3). At 40 DAT, the maximum number of leaf pair per plant (9.2) was recorded from S_0 which was statistically identical (8.8, 8.3) with S_1 and S_2 and the minimum number of leaf pair per plant (7.5) from S_3. At 60 DAT, the maximum number of leaf pair per plant (16.4) was recorded from S_0 which was statistically identical (15.5, 15.1) with S_1 and S_2 respectively and the minimum number of leaf pair per plant (14.3) from S_3. At 80 DAT, the maximum number of leaf pair per plant (23.3) was recorded from S_0 which was statistically followed (22.2, 21.7) by S_1 and S_2 respectively while the minimum number of leaf pair per plant (20.8) from S_3 treatment (Table 3).

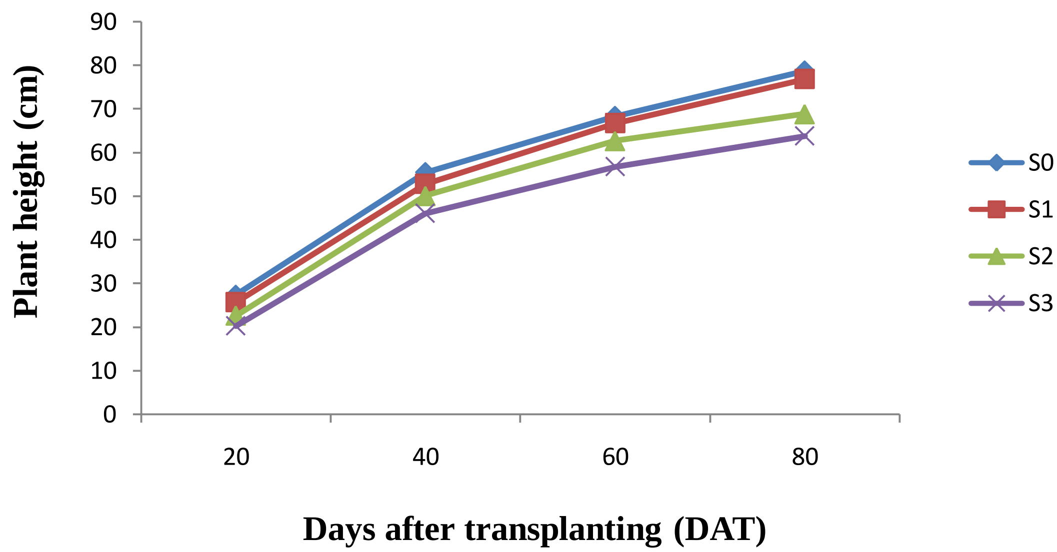

Figure 1. Effect of salinity on plant height of brinjal at different days after transplanting

S_0= 0 dS/m, S_1= 6 dS/m, S_2= 8 dS/m, S_3= 10 dS/m

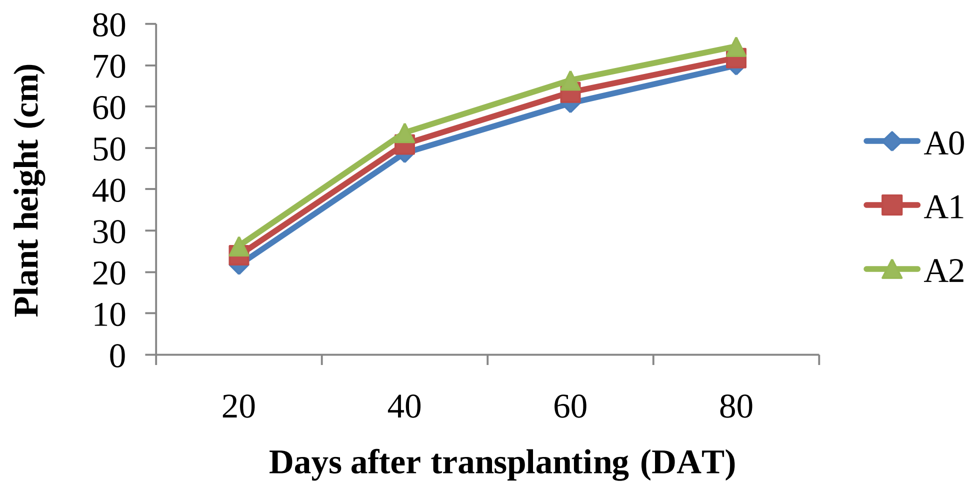

Figure 2. Effect of ascorbic acid doses on plant height of brinjal at different days after transplant

A_0= 0 mM AA, A_1= 0.5 mM AA, A_2= 1 mM AA

Table 2. Interaction effects of salinity levels and ascorbic acid doses on plant height of brinjal at different days after transplanting(DAT)

Salinity level x ascorbic acid	Plant height (cm) at different DAT			
	20	40	60	80
S_0A_0	25.1	53.5	66.1	76.8
S_0A_1	27.8	55.3	68.3	78.6
S_0A_2	29.1	57.6	70.6	80.9
S_1A_0	23.1	50.8	64.0	74.5
S_1A_1	26.5	52.5	66.5	76.6
S_1A_2	27.5	55.1	69.8	79.5
S_2A_0	20.6	47.8	59.6	66.8
S_2A_1	22.1	49.8	62.8	68.1
S_2A_2	25.1	52.6	65.6	71.6
S_3A_0	17.8	43.0	53.6	61.8
S_3A_1	19.6	46.0	56.3	63.6
S_3A_2	23.3	49.4	59.5	66.1
$LSD_{0.05}$	1.38	1.41	1.82	1.73
Level of significance	**	*	*	**
CV (%)	2.76	1.28	1.31	1.14

S_0 = 0 dS/m , S_1 = 6 dS/m, S_2 = 8 dS/m, S_3 = 10 dS/m, A_0 =0 mM AA, A_1 =0.5 mM AA, A_2 = 1 mM AA

**=Significant at 1% level of probability, *=Significant at 5% level of probability, Number of leaf pair per plant of brinjal did not show significant difference for different level of ascorbic acid at 20, 40, 60 and 80 DAT (Appendix IV). At 20 days, the maximum number of leaf pair per plant (5) was recorded from A_2 which was statistically identical (4.4, 4) with A_1 and A_0 (Figure 4). At 40 DAT, the maximum number of leaf pair per plant was recorded (9.5) from A_2 which was identical (8.7, 7.2) with A_1 and A_0 respectively. At 60 DAT, the maximum number of leaf pair per plant was recorded (17.5) from A_2 which was identical (15.1, 13.3) with A_1 and A_0 respectively. At 80 DAT, the maximum number of leaf pair per plant was recorded (24.4) from A_2 which was followed (22.6) by A_1, while the minimum number of leaf pair per plant (19) from A_0 treatment (Table 4).

Interaction effect of saline water and ascorbic acid showed statistically significant variation for number of leaf pair per plant at 20, 40, 60 and 80 DAT (appendix IV). At 20 DAT the maximum number of leaf pair per plant (5.3) was recorded from S_oA_2 and S_0A_0 and the minimum number of leaf pair per plant (3.0) was recorded from S_3A_o (10 dS/m salinity + 0 mM AA). At 40 and 60 DAT the similar trend of interaction effect between saline water and ascorbic acid showed on the plant height of brinjal. At 80 DAT, the maximum number of leaf pair per plant was recorded (25.6) from S_oA_2 (0 dS/m salinity + 1 mM ascorbic acid) which was close to S_0A_0 and the minimum number of leaf pair per plant (17.3) was recorded from S_3A_o (10 dS/m salinity + 0 mM AA) (Table 5).

Table 3. Effect of salinity levels on leaf pair of brinjal at different days after transplanting (DAT)

Salinity levels	Leaf pair at different DAT			
	20	40	60	80
S_0	5.8	9.2	16.4	23.3
S_1	4.4	8.8	15.5	22.2
S_2	4.4	8.3	15.1	21.7
S_3	3.2	7.5	14.3	20.8
$LSD_{0.05}$	0.14	0.25	0.32	0.52
Level of significance	**	**	**	**
CV (%)	3.37	3.10	2.14	2.45

S_0 = 0 dS/m, S_1 = 6 dS/m, S_2 = 8 dS/m, S_3 = 10 dS/m

**=Significant at 1% level of probability, *=Significant at 5% level of probability

Table 4. Effect of ascorbic acid doses on leaf pair of brinjal at different days after transplanting (DAT)

Ascorbic acid doses	Leaf pair at different DAT			
	20	40	60	80
A_0	4.0	7.2	13.3	19.0
A_1	4.4	8.7	15.1	22.6
A_2	5.0	9.5	17.5	24.4
$LSD_{0.05}$	0.12	0.22	0.27	0.45
Level of significance	**	**	**	**
CV (%)	3.37	3.10	2.14	2.45

A_0 = 0 mM AA, A_1 =0.5 mM AA, A_2 = 1 mM AA

**=Significant at 1% level of probability, *=Significant at 5% level of probability

Table 5. Interaction effects of salinity levels and ascorbic acid doses on leaf pair of brinjal at different days after transplanting (DAT)

Salinity level x ascorbic acid	Leaf pair at different DAT			
	20	40	60	80
S_0A_0	4.3	8.3	14.6	21.0
S_0A_1	5.0	9.3	16	23.3
S_0A_2	5.3	10	18.6	25.6
S_1A_0	4.0	7.3	13.3	19.3
S_1A_1	4.3	9.3	15.6	23
S_1A_2	5.0	10	17.6	24.3
S_2A_0	4.0	7	13.3	18.6
S_2A_1	4.3	8.6	14.6	22.3
S_2A_2	5.0	9.3	17.3	24.3
S_3A_0	4.0	6.3	12.0	17.3
S_3A_1	4.0	7.6	14.3	22
S_3A_2	4.6	8.6	16.6	23.3
$LSD_{0.05}$	0.25	0.44	0.55	0.91
Level of significance	*	*	*	*
CV (%)	3.37	3.10	2.14	2.45

S_0 = 0 dS/m, S_1 = 6 dS/m, S_2 = 8 dS/m, S_3 = 10 dS/m, A_0 = 0 mM AA, A_1 =0.5 mM AA, A_2 = 1 mM AA

**=Significant at 1% level of probability, *=Significant at 5% level of probability

4.3 Days required from transplanting to 1^{st} flower initiation

Days from transplanting to 1^{st} flower initiation showed statistically significant variation due to different level of saline water (Appendix V). The maximum days (48.7) from transplanting to 1^{st} visible flower was recorded from S_3 (10 dS/m salinity), whereas the minimum days (45.4) from transplanting to 1^{st} visible flower was recorded S_0 (0 dS/m) which was statistically identical (47.5, 46.4) with S_2 and S_3 respectively (Table 6).

Statistically significant variation due to different level of ascorbic acid was recorded from transplanting to 1^{st} flower initiation (Appendix V). The maximum days (48.4) from transplanting to 1^{st} visible flower was recorded from A_0 (0 mM AA), whereas the minimum days (45.8) from transplanting to 1^{st} visible flower was recorded A_2 (1 mM AA) which was statistically identical (46.9) with A_1 (0.5 mM AA) (Table 7).

Interaction effect of saline water and ascorbic acid showed statistically significant variation for days from transplanting 1^{st} flower initiation (appendix V). The maximum days from transplanting to 1^{st} flower initiation (50.3) was recorded from S_3A_o (10 dS/m salinity + no AA) and the minimum days from transplanting to 1^{st} flower initiation (44.3) was recorded from S_oA_2 (0 dS/m + 1mM AA) (Table 8).

4.4 Number of flowers per plant

Number of flowers per plant showed statistically significant variation due to different level of saline water (Appendix V). The highest number of flowers per plant (24.4) was recorded from S_0 (0 dS/m salinity) which was identical (21.8) with S_1 (6 dS/m salinity) and followed (19.2) by S_2 (8 dS/m salinity), while the lowest number of flowers per plant (14.5) was recorded from S_3 (10 dS/m salinity) (Table 6).

Significance difference was recorded due to different levels of ascorbic acid for number of flowers per plant (Appendix V). The maximum number of flowers per plant (21.2) was recorded from A_2 (1 mM AA) which was closely followed (20.2) by A_1 (0.5 mM AA), while the minimum number of flowers per plant (18.4) was recorded from A_0 (0 mM AA) (Table 7).

Interaction effect of saline water and ascorbic acid showed statistically significant variation for number of flowers per plant (Appendix V). The maximum number of flowers per plant (25.9) was recorded from S_0A_2 (0 dS/m salinity + 1 mM AA), while the minimum number of flowers per plant (13.7) was recorded from S_3A_0 (10 dS/m salinity + 0 mM AA) (Table 8).

Table 6. Effect of salinity levels on first flowering and number of flowers/plant of brinjal at days after transplanting (DAT)

Salinity levels	1st flowering (DAT)	Number of flowers/plant
S_0	45.4	24.4
S_1	46.4	21.8
S_2	47.5	19.2
S_3	48.7	14.5
$LSD_{0.05}$	0.16	0.19
Level of significance	**	**
CV (%)	0.35	1.38

S_0 = 0 dS/m, S_1 = 6 dS/m, S_2 = 8 dS/m, S_3 = 10 dS/m

**=Significant at 1% level of probability, *=Significant at 5% level of probability

Table 7. Effect of ascorbic acid doses on first flowering and number of flowers/plant of brinjal at days after transplanting (DAT)

Ascorbic acid doses	1st flowering (DAT)	Number of flowers/plant
A_0	48.4	18.4
A_1	46.9	20.2
A_2	45.8	21.2
$LSD_{0.05}$	0.13	0.16
Level of significance	**	**
CV (%)	0.35	1.38

A_0= 0 mM AA, A_1= 0.5 mM AA, A_2= 1 mM AA

**=Significant at 1% level of probability, *=Significant at 5% level of probability

Table 8. Interaction effects of salinity and ascorbic acid levels on first flowering and number of flowers/plant of brinjal at days after transplanting

Salinity level x ascorbic acid	1^{st} flowering (DAT)	Number of flowers/plant
S_0A_0	46.6	22.6
S_0A_1	45.3	24.7
S_0A_2	44.3	25.9
S_1A_0	47.6	20.1
S_1A_1	46.3	22.4
S_1A_2	45.3	23
S_2A_0	49	17.3
S_2A_1	47.3	19.6
S_2A_2	46.3	20.7
S_3A_0	50.3	13.6
S_3A_1	48.6	14.3
S_3A_2	47.3	15.4
$LSD_{0.05}$	0.27	0.33
Level of significance	*	*
CV (%)	0.35	1.38

S_0 = 0 dS/m, S_1 = 6 dS/m, S_2 = 8 dS/m, S_3 = 10 dS/m, A_0 = 0 mM AA, A_1 =0.5 mM AA, A_2 = 1 mM AA

**=Significant at 1% level of probability, *=Significant at 5% level of probability

4.5 Number of fruits per plant

Number of fruits per plant showed statistically significant variation due to different level of saline water (Appendix VI). The highest number of fruits per plant (23.2) was recorded from S_0 (0 dS/m salinity) which was identical (20.4) with S_1 (6 dS/m salinity) and followed (17) by S_2 (8 dS/m salinity), while the lowest number of fruits per plant (12.5) was recorded from S_3 (10 dS/m saliniy) (Figure 3).

A statistically significant difference from was recorded due to different levels of ascorbic acid for number of fruits per plant (Appendix VI). The maximum number of fruits per plant (20.2) was recorded from A_2 (1mM AA) which was closely followed (18.5) by A_1 (0.5 mM AA), while the minimum number of fruits per plant (16.19) was recorded from A_0 (0 mM AA) (Figure 4).

Interaction effect of saline water and ascorbic acid showed statistically significant variation for number of fruits per plant (Appendix VI). The maximum number of fruits per plant (24.2) was recorded from S_0A_2 (0 dS/m salinity + 1 mM AA), while the minimum number of fruits per plant (10.4) was recorded from S_3A_0 (10 dS/m salinity + 0 mM AA) (Figure 5).

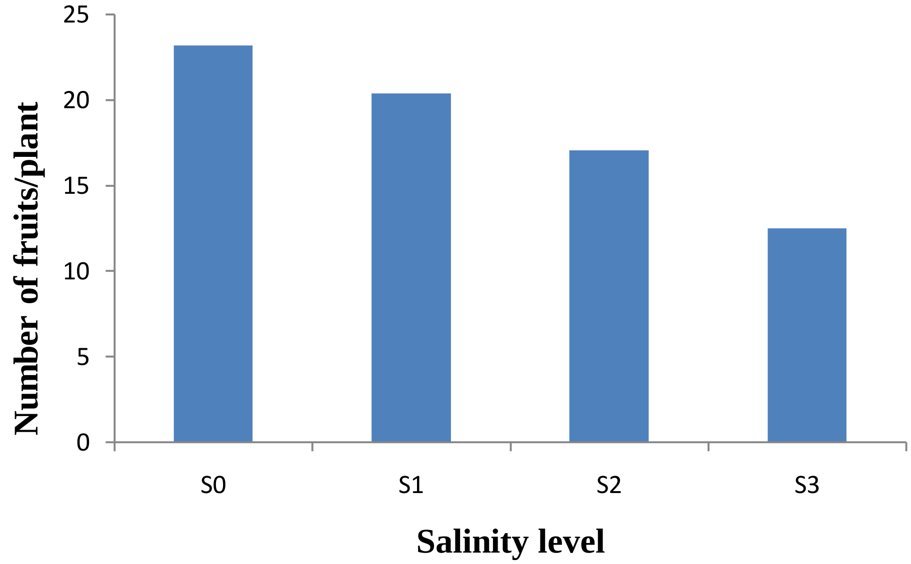

Figure 3. Effect of salinity on number of fruits /plant in brinjal

S_0= 0 dS/m, S_1= 6 dS/m, S_2= 8 dS/m, S_3= 10 dS/m

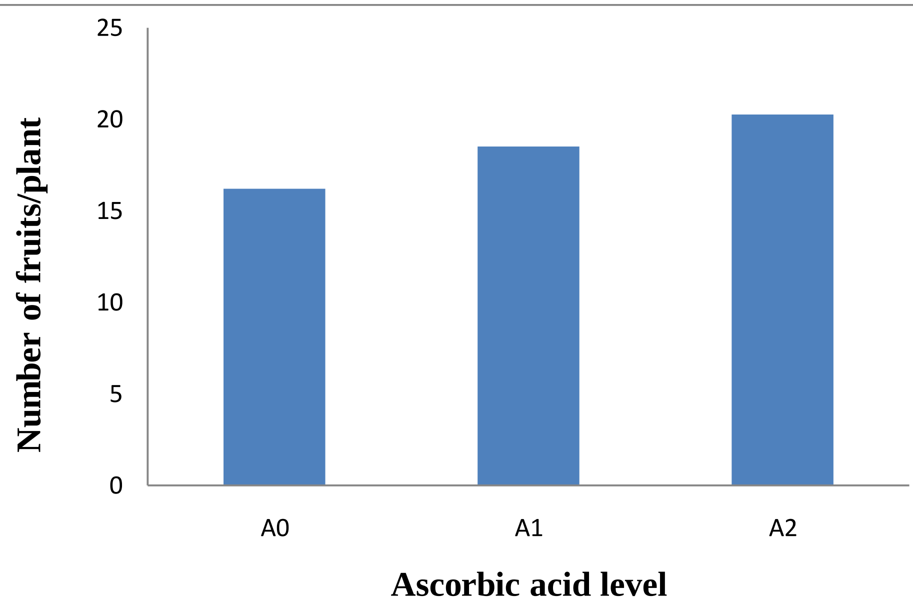

Figure 4. Effect of ascorbic acid on number of fruits /plant of brinjal

A_0= 0 mM AA, A_1= 0.5 mM AA, A_2= 1mM AA

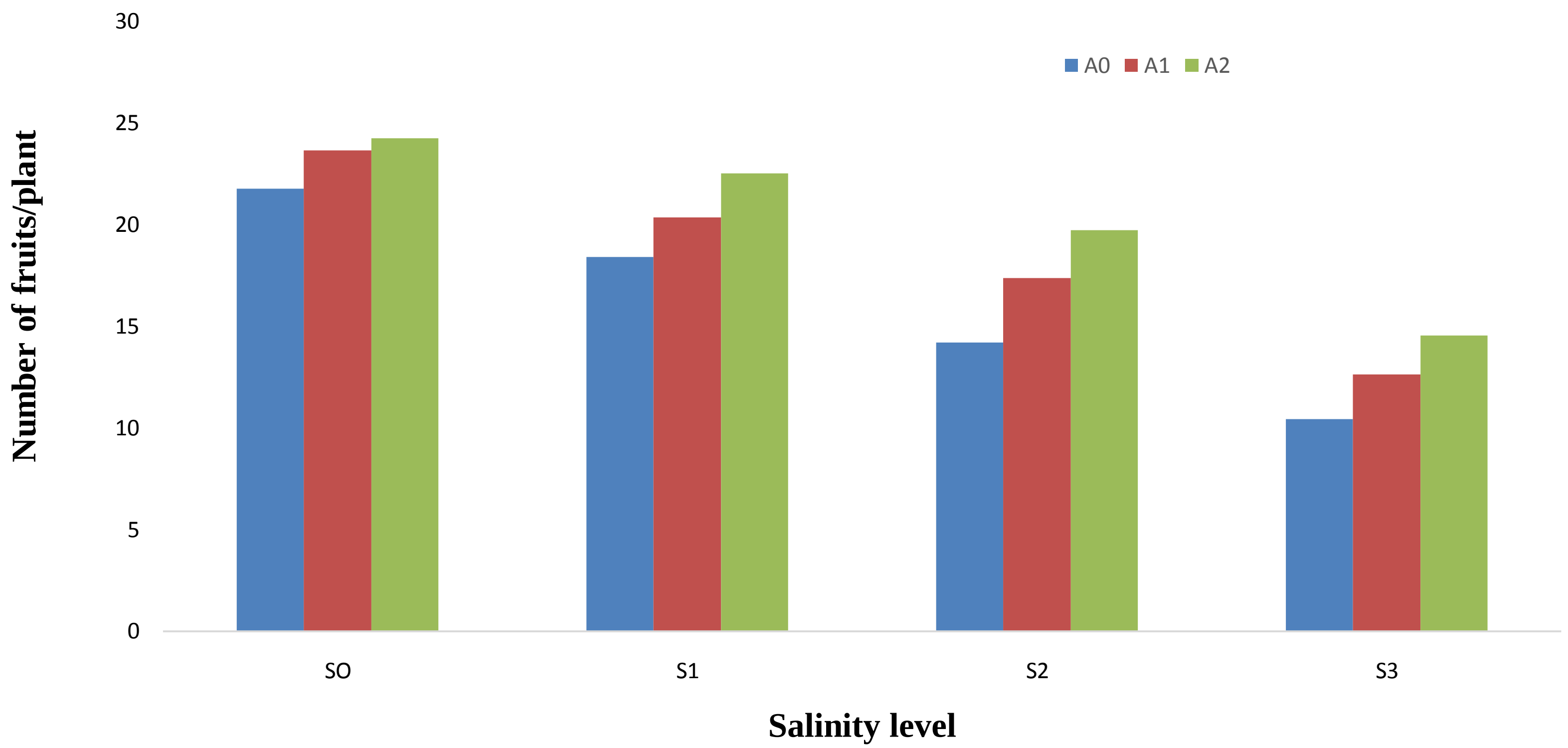

Figure 5. Combined effect of salinity and ascorbic acid on number of fruits/plant of brinjal

S_0= 0 dS/m, S_1= 6 dS/m, S_2= 8 dS/m, S_3= 10 dS/m, A_0= 0 mM AA, A_1= 0.5 mM AA, A_2= 1 mM AA

4.6 Dry weight of individual plant

Dry weight of individual plant statistically varied significantly due to different level of saline water (Appendix VI). The highest dry weight of individual plant (19.5 g) was recorded from S_0 (0 dS/m salinity) which was statistically identical (17 g) with S_2 (6 dS/m salinity) and followed (12.8 g) by S_2 (8 dS/m salinity).On the other hand, the lowest dry weight of individual plant (10.3 g) was recorded from S_3 (10 dS/m salinity) (Figure 6).

A statistically significant difference was recorded due to different levels of ascorbic acid for dry weight of individual plant (Appendix VI). The highest dry weight of individual plant (16.1 g) was recorded from A_2 (1mM AA) which was closely followed (14.9 g) by A_1 (0.5 mM AA), while the lowest dry weight of individual plant (13.7 g) was recorded from A_0 (0 mM AA) (Figure 7).

Interaction effect of saline water and ascorbic acid showed statistically significant variation for dry matter content in plants (Appendix VI). The highest dry weight of individual plant (21.1 g) was recorded from S_0A_2 (0 dS/m salinity + 1 mM AA), while the lowest dry weight of individual plant (8.8 g) was recorded from S_3A_0 (10 dS/m salinity + 0 mM AA) (Figure 8).

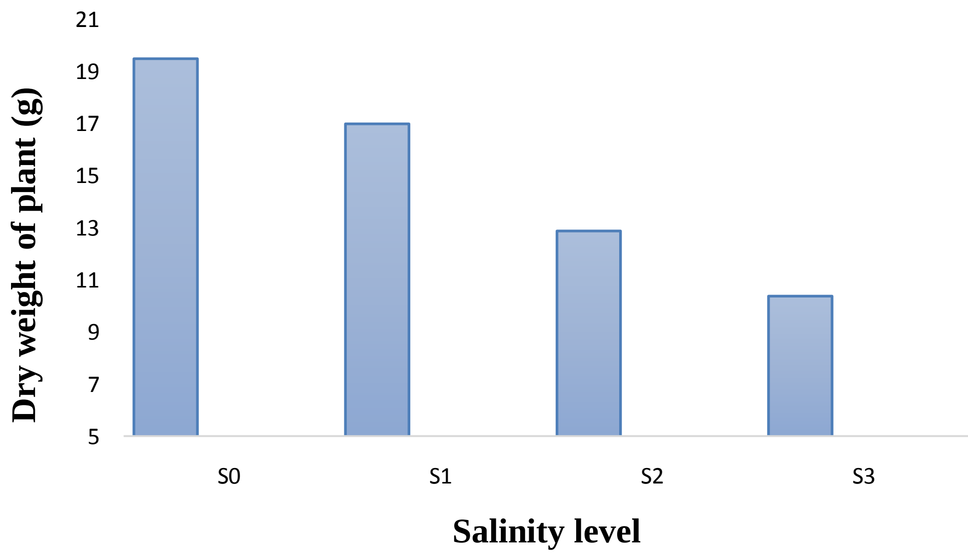

Figure 6. Effect of salinity on dry weight of individual plant

S_0= 0 dS/m, S_1= 6 dS/m, S_2= 8 dS/m, S_3= 10 dS/m

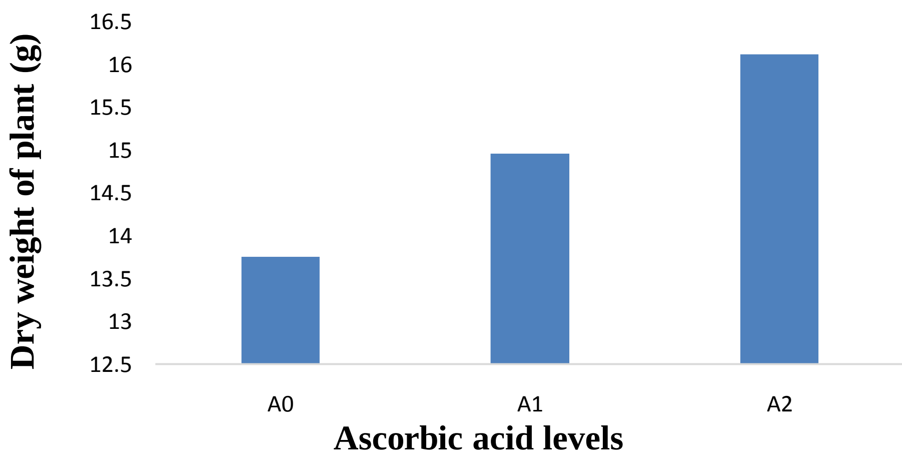

Figure 7. Effect of ascorbic acid on dry weight of individual plant

A_0= 0 mM AA, A_1= 0.5 mM, AA, A_2= 1 mM AA

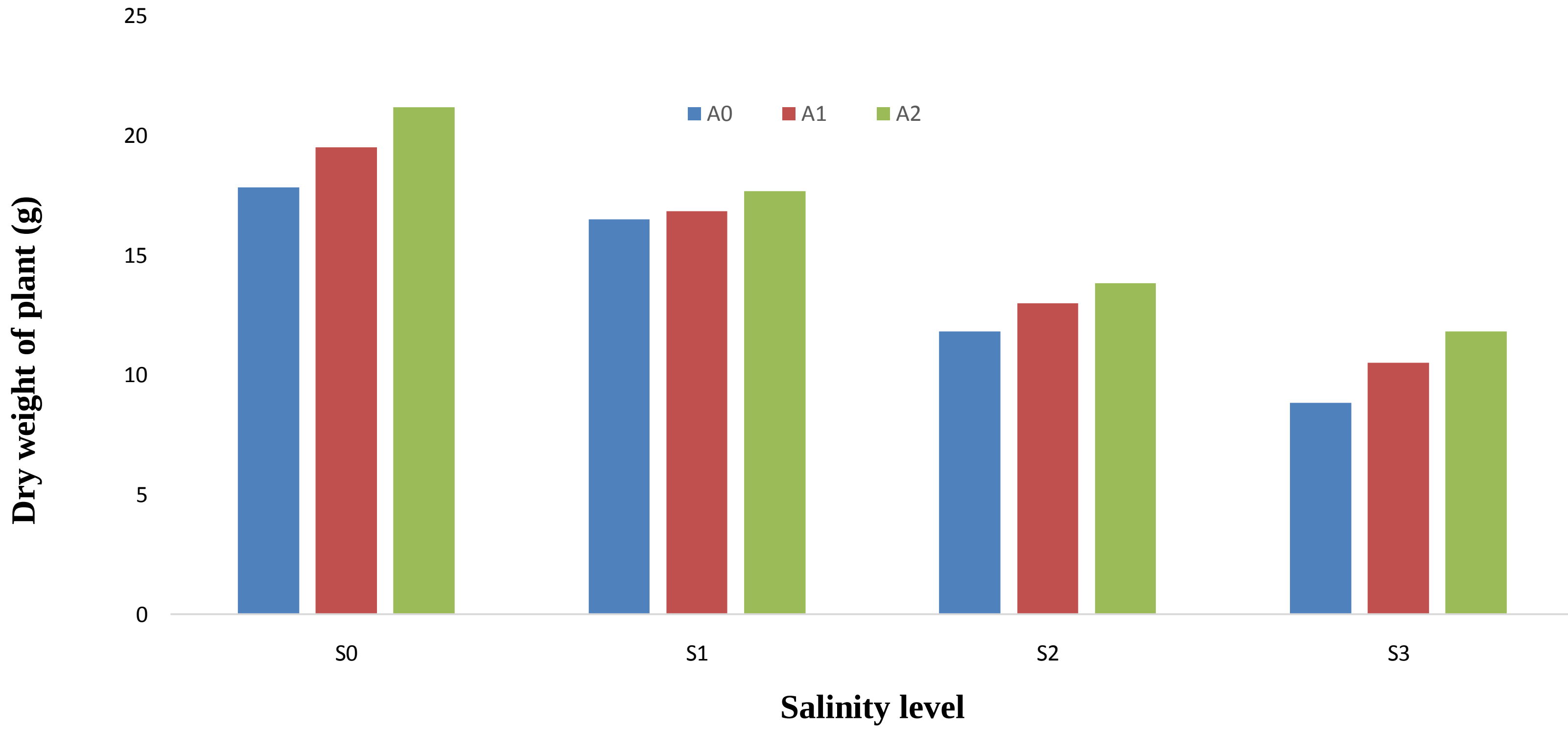

Figure 8. Combined effect of salinity and ascorbic acid on dry weight of individual plant

S_0= 0 dS/m, S_1= 6 dS/m, S_2= 8 dS/m, S_3= 10 dS/m, A_0= 0 mM AA, A_1= 0.5 mM AA, A_2= 1 mM AA

4.7 Weight of individual fruit

Due to different level of saline water statistically significant variation was recorded for weight of individual fruit (Appendix VI). The highest weight of individual fruit (73.9 g) was recorded from S_0 (0 dS/m salinity) which was statistically similar (67.6 g) with S_1 (6 dS/m salinity) and closely followed (63.6 g) by S_2 (8 dS/m salinity), while the lowest weight of individual fruit (60.5 g) was recorded from S_3 (10 dS/m salinity) (Figure 9).

A significant difference from was recorded due to different levels of ascorbic acid for weight of individual fruit per plant (Appendix VI). The maximum weight of fruit (67.4 g) was recorded from A_2 (1mM AA) which was closely followed (66.3 g) by A_1 (0.5 mM AA), while the minimum weight of individual fruit (65.5 g) was recorded from A_0 (0 mM AA) (Figure 10).

Interaction effect of saline water and ascorbic acid showed statistically significant variation for weight of individual fruit (Appendix VI). The maximum weight of individual fruit (75.2 g) was recorded from S_0A_2 (0 dS/m salinity + 1 mM AA), while the minimum weight of individual fruit (59.8 g) was recorded from S_3A_0 (10 dS/m salinity + 0 mM AA) (Figure 11).

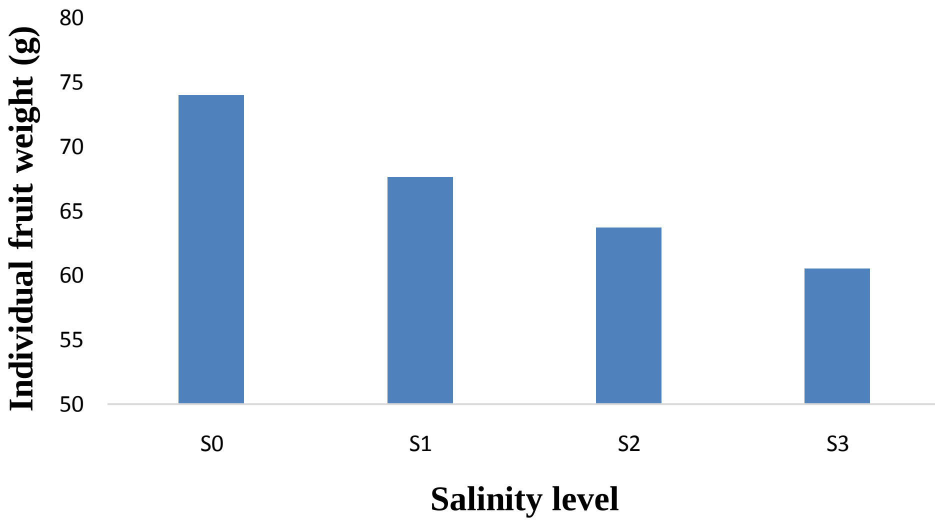

Figure 9. Effect of salinity on individual weight of fruit

S_0= 0 dS/m, S_1= 6 dS/m, S_2= 8 dS/m, S_3= 10 dS/m

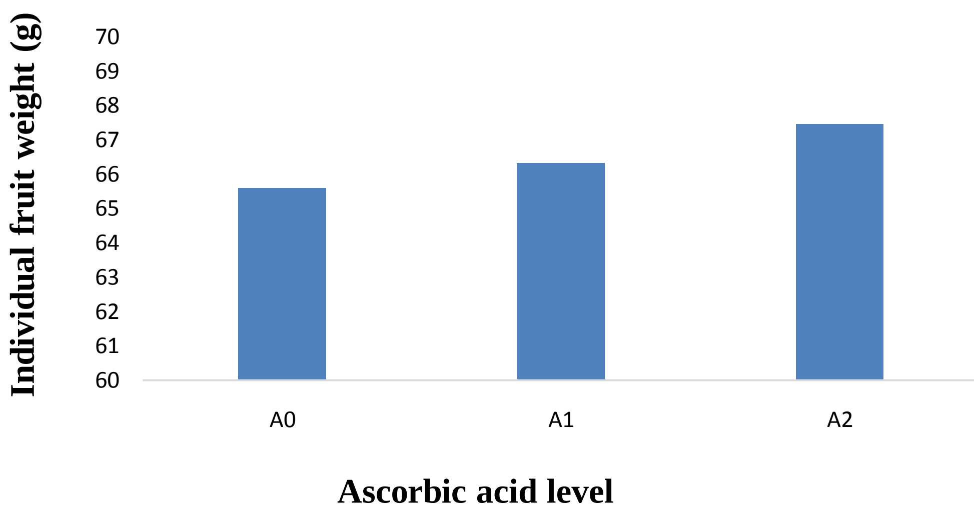

Figure 10. Effect of ascorbic acid on individual weight of fruit

A_0= 0 mM AA, A_1= 0.5 mM AA, A_2= 1 mM AA

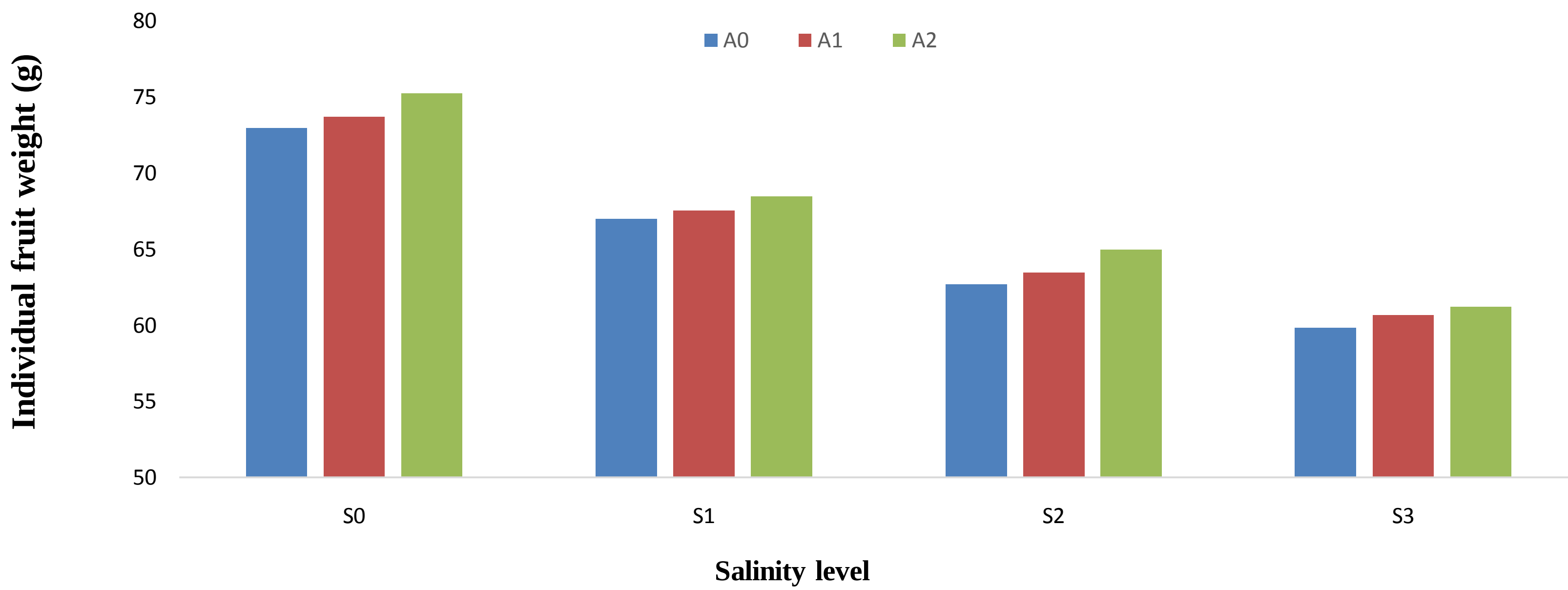

Figure 11. Combined effect of salinity and ascorbic acid on individual weight of fruit

S_0= 0 dS/m, S_1= 6 dS/m, S_2= 8 dS/m, S_3= 10 dS/m, A_0= 0 mM AA, A_1= 0.5 mM AA, A_2= 1 mM AA

4.8 Length of fruit

Length of fruits showed statistically significant variation due to different level of saline water (Appendix VI). The maximum length of fruits (21.5 cm) was recorded from S_0 (0 dS/m salinity) which was statistically identical (19.0 cm) with S_1 (6 dS/m salinity) and followed (14.8 cm) by S_2 (8 dS/m salinity), while the minimum of fruits per plant (12.6 cm) was recorded from S_3 (10 dS/m salinity) (Table 9).

A significant difference from was recorded due to different levels of ascorbic acid for length of fruits (Appendix VI). The maximum length of fruit (18.2 cm) was recorded from A_2 (1mM AA) which was closely followed (17.1 cm) by A_1 (0.5 mM AA), while the minimum length of fruit (15.7 cm) was recorded from A_0 (0 mM AA) (Table 10).

Interaction effect of saline water and ascorbic acid showed statistically significant variation for length of fruits (Appendix VI). The maximum length of fruit (22.5 cm) was recorded from S_0A_2 (0 dS/m salinity + 1 mM AA), while the minimum length of fruit (10.6 cm) per plant was recorded from S_3A_0 (10 dS/m salinity + 0 mM AA) (Table 11).

4.9 Diameter of fruit

Diameter of fruits varied significantly due to different level of saline water (Appendix VI). The maximum diameter of fruit (3.61) was recorded from S_0 (0 dS/m salinity) which was statistically identical (3.40) with S_1 (6 dS/m salinity) and followed (3.02) by S_2 (8 dS/m salinity), while the minimum diameter of fruit (2.50) was recorded from S_3 (10 dS/m salinity) (Table 9).

Very little significant difference was recorded due to different levels of ascorbic acid for diameter of fruits (Appendix VI). The maximum diameter of fruit (3.16 cm) was recorded from A_2 (1mM AA) which was closely followed (3.13 cm) by A_1 (0.5 Mm AA), while the minimum diameter of fruit (3.11 cm) was recorded from A_0 (0 mM AA) (Table 10).

Interaction effect of saline water and ascorbic acid showed statistically significant variation for diameter of fruits (Appendix VI). The maximum diameter of fruit (3.65 cm) was recorded from S_0A_2 (0 dS/m salinity + 1 mM AA), while the minimum diameter of fruit (2.38 cm) was recorded from S_3A_0 (10 dS/m salinity + 0 mM AA) (Table 11).

4.10 Dry weight of individual fruit

Dry weight of individual fruit varied significantly due to different level of saline water (Appendix VI). The highest dry weight of fruit (10.13 g) was recorded from S_o (0 dS/m salinity) which was identical (8.56 g) with S_2 (6 dS/m salinity) and followed (6.78 g) by S_2 (8 dS/m salinity). On the other hand, the lowest dry weight of individual fruit (5.42 g) was recorded from S_3 (10 dS/m salinity) (Table 9).

A statistically significant difference was recorded due to different levels of ascorbic acid for dry weight of fruit (Appendix VI). The highest dry weight of individual fruit (7.95 g) was recorded from A_2 (1mM AA) which was closely followed (7.73 g) by A_1 (0.5 mM AA), while the lowest dry weight of fruit (7.54 g) was recorded from A_0 (0 mM AA) (Table 10).

Interaction effect of saline water and ascorbic acid showed statistically significant variation for dry weight of fruits (Appendix VI). The highest dry weight of fruit (10.40 g) was recorded from S_0A_2 (0 dS/m salinity + 1 mM AA), while the lowest dry weight of fruit (4.22 g) was recorded from S_3A_0 (10 dS/m NaCl + 0 mM AA) (Table 11).

4.11 Yield per pot

Yield per pot in brinjal showed statistically significant variation due to different level of saline water (Appendix VI). The highest yield per pot (1.71 kg) was recorded from S_0 (0 dS/m salinity) which was identical (1.38 kg) with S_1 (6 dS/m salinity) and closely followed (1.09 kg) by S_2 (8 dS/m salinity), while the lowest yield per pot (0.76 kg) was recorded from S_3 (10 dS/m salinity) (Table 9).

A statistically significant difference from was recorded due to different levels of ascorbic acid for yield per pot (Appendix VI). The highest yield per pot was (1.37 kg) recorded from A_2 (1mM AA) which was closely followed (1.24 kg) by A_1 (0.5 mM AA) (Table 4), while the lowest yield per pot (1.08 kg) was recorded from A_0 (0 mM AA) (Table 10). Application of AA increase cell growth and elongation and leads to bigger plants with longer shoots, leaves and maximum canopy in many plants with bigger yields.

Interaction effect of saline water and ascorbic acid showed statistically significant variation for yield per pot (Appendix VI). The highest yield per pot (1.82 kg) was recorded from S_0A_2 (0 dS/m salinity + 1 mM AA) which is very close to S_0A_0, while the lowest yield per pot (0.62 kg) was recorded from S_3A_0 (10 dS/m salinity + 0 mM AA) (Table 11).

4.11 Yield per hectare

Yield per hectare in brinjal showed statistically significant variation due to different level of saline water (Appendix VI). The highest yield per hectare (34.2 ton) was recorded from control (0 dS/m salinity) which was identical (27.6 ton) with S_1 (6 dS/m salinity) and closely followed (21.8 ton) by S_2 (8 dS/m salinity), while the lowest yield per hectare (15.2 ton) was recorded from S_3 (10 dS/m salinity) (Table 9).

A statistically significant difference from was recorded due to different levels of ascorbic acid for yield per hectare (Appendix VI). The highest yield per hectare was (27.4 ton) recorded from A_2 (1mM AA) which was closely followed (24.8 ton) by A_1 (0.5 mM AA), while the lowest yield per hectare (21.6 ton) was recorded from A_0 (0 mM AA) (Table 10).

Interaction effect of saline water and ascorbic acid showed statistically significant variation for yield per hectare (Appendix VI). The highest yield per hectare (36.4 ton) was recorded from S_0A_2 (0 dS/m salinity + 1 mM AA) which is very close to S_0A_0, while the lowest yield per hectare (12.4 ton) was recorded from S_3A_0 (10 dS/m salinity + 0 mM AA) (Table 11).

Table 9. Effect of salinity levels on fruit length, fruit diameter, fruit dry weight, yield/pot, yield/hcetare in brinjal

Salinity levels	Fruit length (cm)	Fruit diameter (cm)	Fruit dry weight (g)	Yield/pot (kg)	Yield (t/ha)
S_0	21.5	3.61	10.13	1.71	34.2
S_1	19.0	3.40	8.56	1.38	27.6
S_2	14.8	3.02	6.78	1.09	21.8
S_3	12.6	2.50	5.42	0.76	15.2
$LSD_{0.05}$	0.46	0.04	0.13	0.14	0.81
Level of significance	**	**	**	**	**
CV (%)	2.83	1.47	2.01	6.15	5.99

S_0 = 0 dS/m, S_1 = 6 dS/m, S_2 = 8 dS/m, S_3 = 10 dS/m

**=Significant at 1% level of probability, *=Significant at 5% level of probability

Table 10. Effect of ascorbic acid doses on fruit length, fruit diameter, fruit dry weight, yield/pot, yield/hectare in brinjal

Ascorbic acid doses	Fruit length (cm)	Fruit diameter (cm)	Fruit dry weight (g)	Yield/pot (kg)	Yield (t/ha)
A_0	15.7	3.13	7.54	1.08	21.6
A_1	17.1	3.11	7.74	1.24	24.8
A_2	18.2	3.16	7.95	1.37	27.4
$LSD_{0.05}$	0.40	0.03	0.11	0.12	0.62
Level of significance	**	*	**	**	**
CV (%)	2.83	1.47	2.01	6.15	5.99

A_0 = 0 mM AA, A_1 =0.5 mM AA, A_2 = 1 mM AA

**=Significant at 1% level of probability, *=Significant at 5% level of probability

Table 11. Interaction effect of saline levels and ascorbic acid doses on fruit length, fruit diameter, individual fruit dry weight, yield/pot, yield/hectare in brinjal

Salinity level x ascorbic acid	Fruit length (cm)	Fruit diameter (cm)	Fruit dry weight (g)	Yield/pot (kg)	Yield (t/ha)
S_0A_0	20.5	3.58	9.81	1.58	31.6
S_0A_1	21.5	3.62	10.20	1.74	34.8
S_0A_2	22.5	3.65	10.40	1.82	36.4
S_1A_0	18.1	3.35	8.50	1.23	24.6
S_1A_1	19	3.41	8.56	1.37	27.4
S_1A_2	20	3.44	8.64	1.54	30.8
S_2A_0	13.5	2.93	6.64	0.90	18.0
S_2A_1	14.8	3.04	6.77	1.10	22.0
S_2A_2	16.1	3.10	6.93	1.28	25.6
S_3A_0	10.6	2.38	5.22	0.62	12.4
S_3A_1	13.1	2.45	5.42	0.76	15.2
S_3A_2	14.1	2.50	5.83	0.90	18.0
$LSD_{0.05}$	0.81	0.075	0.23	0.24	1.48
Level of significance	*	**	**	**	**
CV (%)	2.83	1.47	2.01	6.15	5.99

S_0 = 0 dS/m, S_1 = 6 dS/m, S_2 = 8 dS/m, S_3 = 10 dS/m, A_0 = 0 mM AA, A_1 =0.5 mM AA, A_2 = 1 mM AA

**=Significant at 1% level of probability, *=Significant at 5% level of probability

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the Horticulture Farm of Sher-e-bangla Agricultural University (SAU), Dhaka during the period from October 2013 to April 2014 to study the effects of salt stress in brinjal and to mitigate salt stress by ascorbic acid. Seedlings of 30 days of BARI begun-8 were used as test crop. The experiment consisted of two factors: Factor A: Four levels of salinity as So: 0 dS/m, S_1: 6 dS/m, S_2 : 8 dS/m, S_3 : 10 dS/m ; Factor B: Ascorbic acid (AA) (three levels) as A_0: Control (0 Mm AA), A_1: 0.5 mM AA, A_2: 1 mM AA. The two factor experiment was laid out in randomized completely block design (RCBD) with three replications. Data on different growth and yield parameter were recorded and statistically significant variation was found for different level of salt stress and ascorbic acid and their combined effect.

At 20, 40, 60 and 80 DAT the tallest plant (27.3 cm, 55.5 cm, 68.3 cm and 78.7 cm) was recorded from S_0 (0 dS/m salinity), whereas the shortest plant (20.7 cm, 46.1 cm, 56.8 cm and 63.8 cm) from S_3 (10 dS/m salinity). At 20, 40, 60 and 80 DAT the maximum number of leaf pair (5.8, 9.2, 16.4 and 23.3) was found from $S_{0,}$ whereas the minimum number (3.2, 7.5, 14.3 and 20.8) from S_3. The minimum days from transplanting to 1^{st} flowering (45.4) were recorded from S_0 and the maximum days (48.7) from S_3. The highest number of flower per plant (24.4) was found from S_0, while the lowest number (14.5) from S_3. The highest number of fruits per plant (23.2) was recorded from S_0 and the lowest number (12.5) from S_3. The highest length of fruit (21.5 cm) was found from S_0, whereas the lowest length (12.6 cm) from S_3. The highest diameter of fruit (3.61) was recorded from S_0 whereas the lowest diameter (2.50 cm) from S_3. The highest dry weight of plant (19.5 g) was recorded from S_0, whereas the lowest (10.3 g) from S_3. The highest dry weight of individual fruit (10.1 g) was recorded from S_0 while the lowest (5.42

g) from S_3. The highest weight of individual fruit (73.9 g) was found from S_0 and the lowest (60.5 g) from S_3. The highest yield per pot (1.71 kg) was recorded from S_0 while the lowest yield (0.76 kg) from S_3 and the highest yield per hectare (34.2 ton) was found from S_0 while the lowest yield (15.2 ton) from S_3.

At 20, 40, 60 and 80 DAT the tallest plant (26.2 cm, 53.7cm, 66.4 cm and 74.5 cm) was recorded from A_2 (1 mM AA), whereas the shortest plant (21.7 cm, 48.7 cm, 60.8 cm and 69.9 cm) from A_0 (0 mM AA). At 20, 40, 60 and 80 DAT the maximum number of leaf pair (5, 9.5, 17.5 and 24.4) was found from A_2 whereas the minimum number (4.08, 7.24, 13.3 and 19) from A_0. The maximum days from transplanting to 1st flowering (48.4) were recorded from A_0 and the minimum days (45.8) from A_2. The highest number of flowers per plant (21.2) was found from A_2 while the lowest number (18.4) from A_0. The highest number of fruits per plant (20.2) was recorded from A_2 and the lowest number (16.1) from A_0. The highest length of fruit (18.21 cm) was attained from A_2 whereas the lowest length (15.71 cm) from A_0. The highest diameter of fruit (3.16 cm) was recorded from A_2 whereas the lowest diameter (3.13 cm) from A_0. The highest dry weight of individual plant (16.1 g) was recorded from A_2 whereas the lowest (13.7 g) from A_0. The highest dry weight of individual fruit (7.95 g) was recorded from A_2 while the lowest (7.54 g) from A_0. The highest weight of individual fruit (67.4 g) was found from S_0 and the lowest (65.5 g) from A_0. The highest yield per pot (1.37 kg) was recorded from A_2 while the lowest yield (1.08 kg) from A_0 and the highest yield per hectare (27.4 ton) was found from A_2 while the lowest yield (21.6 ton) from A_0. There was not so much significance difference than control.

At 20, 40, 60 and 80 DAT the tallest plant (29.1 cm, 57.6 cm, 70.6 cm and 80.9 cm) was recorded from S_0A_2 (0 dS/m salinity and 1 mM AA) whereas the shortest plant (17.8 cm, 43 cm, 53.6 cm and 61.8cm) from S_3A_0 (10 dS/m and 0 mM AA). At 20, 40, 60 and 80 DAT the maximum number of leaf pair (5.33, 10, 8.67 and 25.6) was found from S_0A_2whereas the minimum number (3, 6.33, 12 and 17.33) from S_3A_0. The maximum days from transplanting to 1st flowering (50.3) were recorded from S_3A_0 and the minimum days (44.3) from S_0A_2. The highest number of flower per plant (25.9) was found from S_0A_2 while the lowest number (13.7) from A_0. The highest number of fruits per plant (24.2) was recorded from S_0A_2 and the lowest number (10.4) from S_3A_0. The highest length of fruit (22.5 cm) was attained from S_0A_2 whereas the lowest length (10.6cm) from S_3A_0. The highest diameter of fruit (3.65 cm) was recorded from S_0A_2 whereas the lowest diameter (2.68 cm) from S_3A_0. The highest dry weight of individual plant (21.1g) was recorded from S_0A_2 whereas the lowest (8.83 g) from S_3A_0. The highest dry weight of fruit (10.4 g) was recorded from S_0A_2, while the lowest (5.2 g) from S_3A_0. The highest weight of individual fruit (75.2 g) was found from S_0A_2 and the lowest (59.8 g) from S_3A_0. The highest yield per pot (1.82 kg) was recorded from S_0A_2 while the lowest yield (0.62 kg) from S_3A_0 and the highest yield per hectare (36.4 ton) was found from S_0A_2 while the lowest yield (12.4 ton) from S_3A_0

Above findings revealed that 1 mM concentration of ascorbic acid was suitable in consideration of yield contributing characters and yield of brinjal plant which can mitigate salt stress more or less upto certain limit.

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APPENDICES

Appendix I. Soil characteristics of experimental field

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Horticulture farm field, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. Physical and chemical properties of the initial soil

Characteristics	**Value**
% Sand	27
% Silt	43
% Clay	30
Textural class	Silty-clay
pH	5.6
Organic matter (%)	0.78
Total N (%)	0.03
Available p (ppm)	20.00
Exchangeable k (me/100 g soil)	0.10
Available S (ppm)	45

Source: Soil Resources Development Institute (SRDI), Dhaka-1207

Appendix II. Monthly record of air temperature, relative humidity, rainfall and sunshine hour of the experimental site during the period from October 2013 to April 2014 (*Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka)

Month	*Air temperature (^{0}C)		*Relative humidity	Total rainfall (mm)	*Sunshine (hr)
	Maximum	Minimum			
October, 2013	26.5	19.4	81	22	6.9
November, 2013	25.8	16.0	78	00	6.8
December, 2013	22.4	13.5	74	00	6.3
January, 2014	24.5	12.4	68	00	5.7
February, 2014	27.1	16.7	67	30	6.7
March, 2014	31.4	19.6	54	11	8.2
April, 2014	34.4	23.1	64	119	8.2

Appendix III. Analysis of variance (mean square) of the data for plant height of brinjal at different days after transplanting (DAT)

Source of variation	df	Plant height (cm) at DAT			
		20	40	60	80
Salinity levels (A)	3	22.910**	56.619**	68.735**	20.590**
Ascorbic acid (B)	2	5.374**	5.374**	3.818**	23.556**
A x B	6	0.381**	0.202*	0.961*	1.141**
Error	24	0.107	0.074	0.337	0.295

* = Significant at 5% level of probability, ** = Significant at 1% level of probability

Appendix IV. Analysis of variance (mean square) of the data for leaf pair of brinjal at different days after transplanting (DAT)

Source of variation	df	Leaf pair at DAT			
		20	40	60	80
Salinity levels (A)	3	0.697**	4.757**	7.008**	9.311**
Ascorbic acid (B)	2	2.589**	5.788**	9.591**	12.665**
A x B	6	0.065*	0.194*	0.269*	0.772*
Error	24	0.023	0.069	0.108	0.292

* = Significant at 5% level of probability, ** = Significant at 1% level of probability

Appendix V. Analysis of variance (mean square) of the data for first flowering and number of flowers of brinjal

Source of variation	df	1st flowering	Number of flowers
Salinity levels (A)	3	18.552**	26.618**
Ascorbic acid (B)	2	20.260**	12.112**
A x B	6	0.082*	0.111*
Error	24	0.027	0.040

* = Significant at 5% level of probability, ** = Significant at 1% level of probability

Appendix VI. Analysis of variance (mean square) of the data for no. of fruit, fruit length, diameter, dry weight and yield of brinjal

Source of variation	df	Fruits/plant	Fruit length (cm)	Fruit diameter (cm)	Dry weight (plant)	Fruit dry weight (g)	Individual weight (g)	Yield/pot (kg)	Yield (t/ha)
Salinity levels (A)	3	24.477**	13.855**	2.149**	14.928**	37.138**	63.78**	1.5748**	22.91**
Ascorbic acid (B)	2	14.062**	18.860**	0.007*	16.912**	0.505**	20.37**	.72861**	5.374**
A x B	6	0.045*	0.584*	0.033**	0.766*	0.046**	35.20**	.06854**	0.381*
Error	24	0.017	0.231	0.002	0.285	0.018	6.73	0.02164	0.107

* = Significant at 5% level of probability, ** = Significant at 1% level of probability