EFFECTS OF SALINITY ON GROWTH, YIELD AND NUTRIENTS CONTENT OF TWO ONION CULTIVERS

A Thesis

by

MD. MAHAMUDUL HASAN

DEPARTMENT OF AGRICULTURAL CHEMISTRY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
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by

MD. MAHAMUDUL HASAN
Registration No.: 14-06101

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Approved By:

....

(Dr. Md. Abdur Razzaque)
Professor
Department of Agricultural chemistry
Sher-e-Bangla Agricultural University
Dhaka-1207
Supervisor

....

(Dr. Sheikh Shawkat Zamil)
Professor
Department of Agricultural chemistry
Sher-e-Bangla Agricultural University
Dhaka-1207
Co-Supervisor

…………………………….…………

(Prof. Dr. Sheikh Shawkat Zamil)
Chairman
Examination Committee

Department of Agricultural chemistry

Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

Memo No: SAU/ Agricultural Chemistry/ **Date:**

CERTIFICATE

This is to certify that the thesis entitled, "EFFECTS OF SALINITY ON GROWTH, YIELD AND NUTRIENTS CONTENT OF TWO ONION CULTIVERS" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfillment of the requirements for the degree of MASTER OF SCIENCE (M.S.) IN AGRICULTURAL CHEMISTRY, embodies the result of a piece of bona fide research work carried out by ***MD. MAHAMUDUL HASAN*** *Registration No. 14-06101 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated:

Place: Dhaka, Bangladesh

(Prof. Dr. Md. Abdur Razzaque)

Professor
Department of Agricultural chemistry
Sher-e-Bangla Agricultural University
Dhaka-1207
Supervisor

Dedicated to

My

Beloved Parents

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The Author

EFFECTS OF SALINITY ON GROWTH, YIELD AND NUTRIENT CONTENT OF TWO ONION CULTIVAR

ABSTRACT

A pot experiment was conducted at the net house of Agro-Environmental Chemistry Laboratory, Department of Agricultural Chemistry, Sher-e-Bangla Agricultural University, Dhaka-1207 from November, 2020 to April, 2021 to observe the effects of salinity on growth, yield, and nutrient content of two onion cultivars. The experiment was conducted using two varieties (BARI Piaz-1 and BARI Piaz-6) and five salinity levels (0, 3, 6, 9 and 12 dSm^{-1}). The experiment was set in Completely Randomized Design **(**CRD) having two factors with three replications. Results of the experiment showed that plant height, number of leaves per plant, length of leaf, fresh weight of leaf per plant, length of bulb, diameter of bulb, individual bulb weight of onion were influenced by varieties. The tallest plant (40.90 cm) was found in BARI Piaz-1 that statistically not significant. BARI Piaz-6 achieved the maximum length of leaf (34.65 cm), number of leaves per plant (5.39), fresh weight of leaf per plant (1.73 g), length of bulb (30.33 mm). Among the two cultivars, the higher individual bulb weight (30.56 g) was found in BARI Piaz-6. Among different salinity levels the maximum plant height (43.99 cm), length of leaf (37.29 cm), fresh weight of leaf per plant (2.07 g), length of bulb (30.33 mm), diameter of bulb (31.5 cm) of onion was obtained at 0 dSm^{-1}. The highest individual bulb weight (34.26 g) was also recorded at control treatment. Among the combined effects of varieties and salinity levels, individual bulb weight (36.70 g) was found in BARI Piaz-6 with 0 dSm^{-1} level and at 3, 6, 9 and 12 dSm^{-1} salinity levels BARI Piaz-6 should better result than BARI Piaz-1. Among the two varieties, K content was maximum in BARI Piaz-6 than BARI Piaz-1. In both varieties K content decreased significantly with the increasing salinity level. Na content was higher in BARI Piaz-1 than BARI Piaz-6. In both varieties it increased significantly with the increasing salinity level. N content was higher in BARI Piaz-6 than BARI Piaz-1. P and S content was higher in BARI Piaz-1 than BARI Piaz-6. The cultivar BARI Piaz-6 had better expression of morphological, yield and yield contributing characters than those of BARI Piaz-1 under salinity stress.

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LIST OF ABBREVIATION AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
FAO	=	Food and Agricultural Organization
N	=	Nitrogen
B	=	Boron
GA_3	=	Gibberellic acid
et al.	=	And others
TSP	=	Triple Super Phosphate
MoP	=	Muirate of Potash
RCBD	=	Randomized Complete Block Design
DAT	=	Days after Transplanting
ha^{-1}	=	Per hectare
µg	=	microgram
g	=	gram (s)
kg	=	Kilogram
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
wt	=	Weight
LSD	=	Least Significant Difference
^0C	=	Degree Celsius
NS	=	Not significant
Max	=	Maximum
Min	=	Minimum
%	=	Percent
NPK	=	Nitrogen, Phosphorus and Potassium
CV%	=	Percentage of Coefficient of Variance

CHAPTER-I

INTRODUCTION

Onion (*Allium cepa* L.) is one of the most important bulb crops and popular vegetable grown for its pungent bulbs and flavorful leaves. It is a member of *Alliaceae* family belonging to the genus *Allium*. It is commonly known as "queen of the kitchen, "due to its highly valued flavor, aroma, and unique taste, and the medicinal properties of its flavor compounds (Selvaraj, 1976; Griffiths *et al*., 2002). Onion contains vitamin B and trace of vitamin C and also traces of iron and calcium. The outstanding characteristic of onion is its pungency, which is due to a volatile oil known as allyl-propyl-disulphide (Yawalkar, 1985). The great physician "Hippocrates" suggested onion as a diuretic, laxative, and emmenagogue. He also used onion for the treatment of pneumonia, and, externally, for healing putrid wounds (Koch and Lawson, 1996). Ascorbic acid is the most abundant vitamin found in the onion bulb, with a concentration of 1 mg/g dry weight (Breu, 1996). Onion contains steroidal saponins (Carotenuto *et al.*, 1999), which prevent absorption of cholesterol in the intestine. The plant has shallow adventitious fibrous roots (Ranjitkar, 2003). The onion bulb ranges in shape from flat to globular to oblong. There are three colors of onion such as red, white, and yellow (Fritsch, 2005).

There are more than 500 species within the genus *Allium*, of these most are bulbous plants. It is one of the most important spice as well as promising vegetable for Bangladesh. Central Asia is the primary center of its origin and the Mediterranean is the secondary center for large type of onion (Mc. Cullum, 1976). Onion cultivation in commercial scale is found to be concentrated in the greater districts of Faridpur, Dhaka, Rajshahi, Comilla, Mymensingh, Rangpur and Pabna (BBS, 2013). During the year 2019-2020, onion occupied an area of 4,57,809 acres of land of Bangladesh with a total production of 19,53,800 metric ton (BBS, 2020). But this production of onion is not sufficient to meet up the demand of our huge population (Rahim and Siddique, 1991). Due to limitation of land in Bangladesh, it is very hard to expand the cultivable land area under onion cultivation.

It is grown by farmers in both for home use and source of income. Therefore, the introduction of new varieties represents an important axe to enhance production by increasing the number of cultivars available for growers, which is not only an advantage for the farming community but also for markets and processing industries. The farmers choose onion variety for planting depending on a number of factors which include production potential, market demand, regional adaptability and availability of seeds and their prices. The availability of seeds and the cost of seeds affect the adoption of the varieties by the farmers. If the seeds are expensive and difficult to obtain, the farmers find other available cheaper varieties in the local market which usually are low productive. Therefore, the perception of farmers is also important while selection and evaluating the varieties.

In fact, successful onion production depends mainly on the selection of varieties that are adapted to different conditions imposed by specific environment. Onion crop requires cool weather during the early development of bulbs. Environmental factors influence development, growth and biological yield of plants primarily by affecting their physiology. A cultivar crop performs differently under different agro-climatic conditions and various cultivars of the same species grown even in the same environment give different yields as the performance of a cultivar mainly depends on the interaction of genetic makeup and environment (Boukary *et al.*, 2012).

Salinity is a major environmental constraint to crop productivity throughout the arid and semi-arid regions of the world (Foolad and Lin, 1997). About 20% of the net cultivable land of Bangladesh coastal region is affected by different degrees of salinity (Karim *et al.*, 1990). Bangladesh is a deltaic country with total area of 1,47,570 km^2. The major part (80%) of the country consists of alluvial sediments deposited by the rivers Padma, Brahmaputra, Tista, Jamuna, Meghna and their tributaries. All these rivers are either directly or indirectly connected with the Bay of Bengal. In the recent years, the sea level of our country is gradually increasing and thus, salinity is being increased in the soil of southern part of our country. A one meter sea level rise will affect the vast costal area and flood plain zone of Bangladesh (Sarwar, 2005). If the rising of the sea level is continued, some districts of our country like Rajbari, Faridpur, Madaripur, Jessore, Khulna, Barisal etc. which are the major onion producing areas may also be affected by salinity and in that condition the production of spices especially onion will be hampered. 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. 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). 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 which produce many physiological disorders in plants, Cl^- is the most dangerous (Tavakkoli *et al.*, 2010). Salinity at higher levels causes both hyperionic and hyperosmotic stress and can lead to plant damage. 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 leads to plant death (Mahajan and Tuteja, 2005; Hasanuzzaman *et al.*, 2012).

Therefore, keeping the above points in view, the present work was undertaken with the following objectives:

I. To study the growth parameters of BARI Piaz-1 and BARI Piaz-6 under different saline conditions.

II. To observe yield and yield contributing characters of two onion cultivars under different saline conditions.

III. To observe nutrient contents of two onion cultivars under different saline condition.

CHAPTER II
REVIEW OF LITERATURE

Salinity impairs in the growth and yield and causes oxidative stress. Through a number of physiological and biochemical process has been associated with the adaptive responses, the underlying tress tolerant mechanism is still not clear. Therefore, I discussed the following reviews to make a foundation of my study.

Sharma and Jarial (2017) conducted to assess the effect of varieties and planting time on kharif onion production under low hill conditions of Himachal Pradesh at Research Farm of the Institute of Biotechnology and Environmental Science, Neri, Hamirpur for two consecutive seasons (2011 & 2012). Four cultivars of onion viz. N-53, Nasik Red, Agrifound Dark Red (AFDR) and Agrifound Light Red (AFLR) were transplanted on six dates at ten days interval starting from 5th July to 25th August. All the observations pertaining to traits viz. plant height (cm), neck thickness (cm), bulb diameter (cm), bulb weight (g), days for harvesting, and yield (q/ha) were taken by randomly selecting twenty healthy plants from each plot. Standard package and practices were followed for raising the crop as per the recommendations of the University. The maximum bulb diameter was 5.50 cm where showed that all the variables had significant effect on bulb diameter. There was a significant effect of both by varieties and transplanting dates. The highest average yield (229.03 q/ha) was observed in cultivar AFDR. The highest bulb yield (197.54 q/ha) among transplanting dates was noted on third transplanting date i.e. 25th July. Therefore it can be summarized that cultivar Agrifound Dark Red (AFDR) is the best suited cultivar for kharif onion production in lower Shivalik hills of Himachal Pradesh and it should be transplanted around 25th July for maximization of bulb yield.

Bystricka *et al*., (2015) carried out in Slovak Republic, was aimed at assessment of quality of onion based on the contents of heavy metals (Zn, Cu, Ni, Pb, Cd) as well as the possible correlations among selected heavy metals in soil and onions (*Allium cepa* L.). Seven different varieties were analyzed (Sherpa, Boston, Bingo, Shakespeare, Lusy, Všetana, Radar). Gained results showed that in some sampling sites the measured values were exceeded in comparison with limit values given by the law no. 220/2004 (valid in the Slovak Republic - SR) as well as threshold values proposed by European Commission (EC) (2006). Among the varieties statistically significant differences ($P < 0.05$) in intake of heavy metals were found (Multiple Range Tests for heavy metal by variety, Method: 95.0 percent LSD).

A cultivar crop performs differently under different agro-climatic conditions and various cultivars of the same species grown even in the same environment give different yields as the performance of a cultivar mainly depends on the interaction of genetic makeup and environment (Jilani and Ghafoor, 2003; Kimani *et al*., 1993). Ijoyah *et al*., (2008) conducted a field experiment to evaluate the yield performance of four onion varieties and found that some other varieties performed better than the commonly grown onion varieties by the farmers. Shah *et al*., (2012) conducted an evaluation trial of three onion cultivars in Randomized Complete Block Design having three replications and concluded that onion cultivar performed differently and Parachinar local variety resulted in higher yield.

Successful bulb production is depend upon selecting cultivars that will grow and bulb satisfactorily under the conditions imposed by a specific environment (Jones and Mann, 1963). Wide variations in bulb characteristics were observed among the cultivated genotypes by several workers. In a study of 43 onion varieties Padda *et al*., (1973) observed a wide variation for bulb size (25.00-71.80 g), total solids (7.4-17.5%) and yield (241.5-597.60 q/ha).

Randhawa *et al.,* (1974) reported that variation for bulb yield (120.2-297.6 q/ha), bulb weight (38.4-56.0 g), plant height (38.5-50.5 cm) and number of scales leaves (5.3-7.3) in onion.

Azoom *et al.*, (2014) were conducted a field experiment from September 2010 to July 2011 in Tunisia in order to evaluate the performance of seven onion varieties grown under field conditions. Results obtained showed that onion varieties were significantly different when it comes to the plant and bulb morphological characteristics. Variety 'Morada de Amposta' recorded the highest leaf length (68.06 cm), pseudo stem diameter (8.63 cm), number of leaves (8.71), plant height (76.95 cm), in addition to the greatest yields (32.88t/ha) which were significantly ($p \leq 0.05$) increased by respectively 66.2, 88.8,2.1, 61.2, 63, 27.9 and 28.4% compared to those obtained from the regular variety 'Blanc Hâtif de Paris'. Variety 'Blanc Hâtif de Paris' was the earliest to maturity and recorded the most preferment bulb weight (155.02 g) and diameter (8.21 cm). 'Keep Red' variety had the highest height of the bulb (7.19cm). Variety 'Z6' recorded the minimum data in all measured parameters.

Mohamed and Gamie, (1999), revealed that Giza 20 cultivars was the best in plant height, number of leaves per plant, bulb weight and total yield as compared to Shandaweel 1 and Giza 6, while, Shandaweel 1 cultivar was the best for the early bulb development.

Onion (*Allium cepa* L.) is one of the most important vegetable in Turkey, and often cultivated in arid and semiarid regions with salinity problems. In the first year of the study, three onion varieties were evaluated at various levels of salinity to identify susceptibility and tolerance levels. At the end of the experiment, "Akgun" determined more tolerant than the other varieties. At 9.6 dSm^{-1} condition, the survived individuals of this variety were selected as "candidate line". Selected individuals were grown to maturity and self-pollinated to produce next generations. In the third year of the study, the plants have been grown in vermiculite by substrate culture technique. The early plant stage at the 250 mM NaCl was used for the second selection studies. The same selection procedures were repeated once more on the next season. At each selection stage, the individuals were selected based on plant mortality. At the last year of study, the selected line was evaluated for both seed germination and seedlings growth at three treatment levels of 0 (non stress), 250 mM and 350 mM NaCl and were compared with the unselected population. The results indicated that selections were effective at all two salt-stress levels (Hanci and Cebeci, 2018).

El-Sharkawy *et al*., (2017) conducted an experiment to explore the effect of various rates of potassium sulfate (K_2SO_4) nano particles on alfalfa (*Medicago sativa* L.) growth and physiological response under salt stress. One salt-tolerant genotype (Mesa-Sirsa) and one salt-sensitive genotype (Bulldog 505) were selected based on germination under salt and were planted in pots containing 2 kg of sand. The two genotypes were subjected to 0 and 6 dSm^{-1} salt levels using $CaCl_2 \cdot 2H_2O$: NaCl (2:1) mixed with Hoagland solution. Three K_2SO_4 nanoparticle treatments consisting of, 1/4, 1/8, and 1/10 of the potassium (K) level in full strength Hoagland solution (235 mgL^{-1}) were applied. Adding K_2SO_4 nanoparticles at the 1/8 level resulted in the highest shoot dry weight, relative yield, root length and root dry weight in both genotypes. The different rates of K_2SO_4 nanoparticles affected significantly Na/K ratio and the concentrations of Calcium (Ca), Phosphorus (P), Copper (Cu), Manganese (Mn), and Zinc (Zn) in plant tissue. The application of K_2SO_4 nanoparticles at the 1/8 rate enhanced the plant's physiological response to salt stress by reducing electrolyte leakage, increasing catalase and proline content, and increasing antioxidant enzymes, activity. These results suggest that the application of K nanoparticles may have better efficiency than conventional K fertilizers in providing adequate plant nutrition and overcoming the negative effects of salt stress in alfalfa.

Hanci *et al.,* (2016) conducted an experiment to investigate the effects of salt stress on proline, chlorophyll-a, chlorophyll-b, total chlorophyll, carotenoids, sodium, calcium, potassium, chloride contents of some onion (*Allium cepa* L.) cultivars. Seeds of 'Akgun-12', 'Besirli-77', 'BeyazBilek', 'ImraliKirmasi', 'Kantartopu-3', 'Metan-88' and 'Texas Early Grano' were germinated in peat material and transferred to plastic pots after 21 days of sowing. The plants have been grown in vermiculite by substrate culture technique. The early plant stage (63 days old plant) was used for screening studies. Three different salinity levels (0-control, 50 mM and 125 mM NaCl) were tested under greenhouse conditions. After six weeks of transferring, leaf parts were isolated and studied for physiological and mineral analyses. Cultivars showed different responses to NaCl. Increased salinity levels resulted in decreased chlorophyll-and carotenoids, increased proline. The sodium (Na^+), potassium (K^+) and chloride (Cl^-) contents of plants were significantly affected by salinity in all cultivars.

Agami, (2014) carried out a study to examine the effects of seed soaking in 1 mM ascorbic acid (AA) or 1 mM proline on the growth, content of photosynthetic pigments and proline, relative water content, electrolyte leakage, antioxidant enzymes and leaf anatomy of *Hordeum vulgare* L. Giza 124 seedlings grown in greenhouse under 100 or 200 mM NaCl. The plants exposed to the NaCl stress exhibited a significant reduction in growth, relative water content, leaf photosynthetic pigments, soluble sugars, as well as alterations in leaf anatomy. However, the treatment with AA or proline ameliorated the stress generated by NaCl and improved the above mention parameters. NaCl increased electrolyte leakage, proline content, and activities of antioxidant enzymes (SOD, CAT, and POX). The antioxidant enzymes and leaf anatomy exhibited considerable changes in response to AA or proline application in the absence or presence of NaCl.

Camilia *et al*., (2013) conducted an experiment to investigate the effects of foliar application of mono potassium phosphate (MKP) in 3 levels; Blank (0), 100 and 200 ppm on onion plants grown under saline irrigation water containing two salt concentrations (2000 and 4000 ppm) as compared to tap water (300 ppm). The results showed that irrigation of onion crop with saline water decreases plant growth and biomass production compared to those irrigated by tap water. The most serious effect was observed for the plants under higher salinity of irrigation water (4000 ppm) as compared to that of the plants under moderate salinity level (2000 ppm). In addition, increasing the salinity of irrigation water from 2000 to 4000 ppm caused a reduction, with different magnitudes, in the contents of N, P, K, Ca and Mg nutrients as a result of competition between Na^+, Cl^- from high saline water and these nutrients. Whereas, the sodium contents in onion plants were increased by increasing the salinity of irrigation water. Irrigation with tap water combined with foliar application of mono potassium phosphate (MKP) at either 100 or 200 ppm increased the plant growth. This positive effect of MKP was minimized by using higher concentration of saline irrigation water. Irrespective to the salinity of irrigation water, the concentration of potassium and phosphorus in onion plant tissues increased significantly with foliar application of (MKP) in the two levels, while the sodium content was decreased. Foliar application of MKP in two levels has different positive effect on the other nutrients under investigation. This study demonstrated that foliar application of (MKP) mitigated to some extent the negative effects of salts in irrigation water on onion plant growth and quality.

Adsul *et al.*, (2009) highlighted the importance of onions as vegetable and has shown its taxonomic position among 750 species of genus *Allium*. It has compared merits of Random Amplified Polymorphic DNA (RAPD) markers vs Restriction Fragment Length Polymorphism (RFLP) and established the superiority of RAPD over RFLP. Further , significance of RAPD markers in onion breeding program is indicated and subsequently validated by its multi-faceted applications to (i) assess in-bred integrity , (ii) establish genetic relationship in conjunction with morphological markers, (iii) prove hybrid status in conjunction with genomic in-situ hybridization (GISH), (iv) established origin and relationship between two taxa, (v) establish phylogenetic relationship, (vi) confirm inter-specific hybrids, (vii) assess genetic diversity among the onion cultivars and (viii) prepare genetic map of onion cultivars.

Jamil *et al.*, (2011) indicated that soil salinity is among the leading environmental stresses affecting global agriculture, causing billions of dollars in crop damages every year. Regardless of the cause, ion toxicity, water deficit, or nutritional imbalance, high salinity in the root zone severely impedes normal plant growth and development, resulting in reduced crop productivity or crop failure. Development of salt-tolerant cultivars is an attractive and economical approach to solving this problem. Although several salt-tolerant plant genotypes have been developed through transgenic approaches, often they have failed or exhibited limited success under field saline conditions. This is due to several reasons, including the fact that plant growth and development under saline conditions in the field is often influenced by cumulative effects of multiple environmental stresses and genetic factors, which may not have been considered during the development of salt-tolerant transgenic plants. Adoption of inappropriate screening techniques or selection criteria may also lead to selection of genotypes that may not be stress tolerant in a real sense. In most plant species, salt tolerance is a genetically complex trait, often modulated by multiple biosynthetic and signaling pathways. Cross-talks among various stress-controlling pathways have been observed under salt stress, many of which are regulated by transcription factors. Thus, a comprehensive knowledge of the up and down regulating genes under salt-stress is necessary, which would provide a better understanding of the interactions among pathways in response to salt stress. Attaining such knowledge is a good step toward successful development of salt-tolerant crop cultivars. To the end, DNA microarray technology has been employed to study expression profiles in different plant species and at varying developmental stages in response to salt stress. As a result, large-scale gene expression profiles under salt stress are now available for many plant species, including Arabidopsis, rice, barley, and ice plant. Examinations of such gene expression profiles will help understand the complex regulatory pathways affecting plant salt tolerance and potentially functional characterization of unknown genes, which may be good candidates for developing plants with field salt tolerance. In this article, we review and discuss the current knowledge of plant salt tolerance and the extent to which expression profiling has helped, or will help, a better understanding of the genetic basis of plant salt tolerance. We also discuss possible approaches to improving plant salt tolerance using various tools of biotechnology.

Soil salinity is a major environmental constraint to crop productivity worldwide. The “biological” approach to this problem focuses on the management, exploitation, or development of plants able to thrive on salt-affected soils. This chapter reviews strategies by which plants can be enabled to grow on saline soils. The first strategy is to prime seeds before planting by treating them with inorganic or organic chemicals and/or with high or low temperatures. The second strategy involves exogenous application of organic chemicals, such as glycine betaine, proline, or plant growth regulators, or inorganic chemicals to plants under salinity stress. Considerable improvements in growth and yield have been reported in a number of crops using these approaches. The third strategy is to employ selection and breeding. Major efforts have been made to develop salt-tolerant lines or cultivars of crops using conventional plant breeding. However, the complexity of the tolerance mechanisms, lack of selection criteria, and variation in responses of plants at different developmental stages have resulted in only limited success. The emphases for developing salt-tolerant lines/cultivars are now on marker-assisted breeding and genetic transformation. The development of salt-tolerant transgenic plants is still at an early stage but may become increasingly more effective as better knowledge of the complex mechanisms involved in plant salt tolerance is acquired. Furthermore, the rapid expansion in knowledge on genomics and proteomics will undoubtedly accelerate the transgenic and molecular breeding approaches However, to date, there are few conclusive reports indicating successful performance of transgenic cultivars under natural stressful environments (Ashraf, *et al*. 2008).

Csiszár *et al.*, (2007) investigated the enzymatic antioxidative defence mechanisms of some regional subspecies of Allium (*A. cepa* L., A. ascalonicumauct. hort., *A. sativum* L.) cultivated mainly in the western regions of Romania, and two modern Hungarian climate resistant F1 hybrids were reported by Csiszár *et al*., (2007). Thevari ability in the activities of antioxidant enzymes superoxide dismutase (SOD), catalase (CAT), peroxidase (POD), glutathione reductase (GR) and glutathione S-transferase (GST) and their changes under soil moisture stress were investigated. 1-week-long water stress revealed that among three Allium species, relative water content decreased only in *Allium ascalonicum* leaves (up to 16%). Unlike root enzymes, the activities of the shoot enzymes, especially POD, GR and GST showed a stronger correlation with the water content of the leaves after one week of water withdrawal; regression coefficients (R^2) were 0.359, 0.518 and 0.279, respectively. The ancient populations with elevated (or highly inducible) antioxidant enzyme activities were suggested for further research and for breeding of new *Allium* varieties.

Zhu, (2001) conducted to soil salinity is a major abiotic stress in plant agriculture worldwide. This has led to research into salt tolerance with the aim of improving crop plants. However, salt tolerance might have much wider implications because transgenic salt-tolerant plants often also tolerate other stresses including chilling, freezing, heat and drought. Unfortunately, suitable genetic model systems have been hard to find. A recently discovered halophytic plant species, the llungiellah alophile, now promises to help in the detection of new tolerance determinants and operating pathways in a model system that is not limited to Arabidopsis traits or ecotype variations.

CHAPTERIII

MATERIALS AND METHODS

The experiment was undertaken in November, 2020 to April, 2021 in the net house of Agro-Environmental Chemistry laboratory of Agricultural Chemistry Department, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to study the effect of salinity on growth, yield and nutrient content of two onion cultivars. The materials and methods followed during entire period of the experiment are described in this chapter.

3.1 Site of the experiment

Geographically the experimental field was located at 23^0 77´ latitude and 90^0 33´ E longitudes at an altitude of 9 m above the mean sea level. The soil belonged to the Agro-ecological Zone – Modhupur Tract (AEZ 28). The land topography was medium high and soil texture was silt clay with pH 8.0. The morphological, physical and chemical characteristics of the experimental soil have been presented in Appendix-1.

3.2 Materials

3.2.1 Seed

The high yielding varieties of onion are BARI Piaz-1 and BARI Piaz-6 developed Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, respectively and were used as an experimental planting material. The seeds were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.2.2 Fertilizers

The recommended doses of urea as a source of Nitrogen (N), Triple super phosphate (TSP) as a source of phosphorus (P), Muriate of Potash (MoP) as a source of Potash (K) and Gypsum as a source of Sulphur (S) were added to the soil of experimental pots.

3.3 Experimental design

The experiment was set in Completely Randomized Design (CRD) having two factors with three replications.

Factor A: variety

V_1 = BARI Piaz-1

V_2 = BARI Piaz-6

Factor B: Salinity

S_0 = 0 dSm^{-1}

S_1 = 3 dSm^{-1}

S_2 = 6 dSm^{-1}

S_3 = 9 dSm^{-1}

S_4 = 12 dSm^{-1}

The two cultivars in combination with five salinity levels were randomly assigned to 30 (2×5×3) experimental pots.

3.4 Salinity treatments

The five salinity treatments were 0 (control), 3, 6, 9 and 12 dSm^{-1}. The different salinity levels were obtained by dissolving commercial salt (NaCl) at the rate of 640 mg per liter distilled water for 1 dSm^{-1} salinity level. The control treatment was maintained using distilled water only.

3.5 Collection and preparation of soil

The soils of the experiment were collected from Sher-e-Bangla Agricultural University (SAU) farm. The soil was non-calcareous Red Brown Terrace soil with loamy texture belonging to the AEZ 28 (Modhupur Tract). The collected soil was pulverized and inert materials, visible insect pest and plant propagules were removed. The soil was dried in the sun, crushed carefully and thoroughly mixed.

3.6 Pot preparation

An amount of 8 kg soil was taken in a series of pots. The required number of plastic pots having 24 cm top, 18 cm bottom diameter and 22 cm depth were collected from the local market and cleaned before use. There were altogether 30 pots comprising 5 salinity levels to two onion cultivars with 3 replications. Water was added to the pot to bring the soil up to saturation.

3.7 Raising of seedlings

The onion seedlings were raised in two seed beds, which were high, well drained and sunny. The land was spaded and left for drying for 10-15 days. Bigger clods broken into small pieces and finally the soil was made loose, friable and brought into fine tilth. All weeds and stubbles were removed and the soil was mixed thoroughly. Onion seeds were soaked in water for 15 hours before sowing and then kept in a piece of cloth for sprouting. After sprouting the seeds were sown in the seed bed on November 01, 2020. The seeds were then covered with light soil and compacted carefully. Shades were provided to protect the seedlings from strong sunshine. The germination was completed within 3-5 DAS days after sowing. Light irrigation, mulching and weeding was done whenever necessary.

3.8 Transplanting of seedlings

Healthy and disease free 35 days old seedlings were uprooted from the seedbeds and transplanted in the pot. Three plants were transplanted in each pot. The seedbed was watered before uprooting the seedlings and watered immediately after transplanting.

3.9 Harvesting

The crops were harvested on 5 April, 2021 when maximum number of plant showed the sign of maturity by yellowing out most of the leaves drying of pseudo stem, thin and dried outer scale. The tops were removed by cutting off the pseudo stem keeping 2.5 cm with the bulb.

3.10 Crop sampling and data collection

Three plants of each pot were marked with tag for recording plant characters. .

3.11 Collection of data

Data were recorded on the following parameters from the sample plants during the course of experimentation.

1. Plant height (cm)
2. Number of leaves per plant
3. Leaf length (cm)
4. Fresh leaf weight (g)
5. Diameter of bulb (mm)
6. Length of bulb (mm)
7. Individual bulb weight (g)

3.11.1 Plant height (cm)

The height of the selected plants in each pot was measured at harvest. The height was measured in centimeters (cm) from the neck of the bulb to the tip of the longest leaf.

3.11.2 Number of leaves plant^{-1}

Number of leaves per plant was counted from each selected plant sample and then averaged.

3.11.3 Leaf length (cm)

The length of leaf was measured with a centimeter scale from pseudo stem to the tip of the leaf from three selected plants from each plot at harvest and their average was recorded.

3.11.4 Fresh weight of leaf

Fresh weight of leaf per plant at harvest was calculated in gram.

3.11.5 Diameter of bulb (mm)

The diameter of bulb was measured at the middle portion of bulb with a slide calipers at harvest and their average was recorded.

3.11.6 Length of bulb (mm)

The Length of bulb was measured with a slide calipers from the neck to the bottom of the bulb and their average was taken.

3.11.7 Individual bulb weight (g)

The Individual bulb weight per pot was converted in gram.

3.12 Chemical analysis of onion bulb samples

a. **Digestion of samples with sulphuric acid for N**

For the determination of nitrogen an amount of 1 g raw onion bulb sample were taken in a micro Kjeldahl flask. 1.1 g catalyst mixture (K_2SO_4: $CuSO_4$ $5H_2O$: Se in the ratio of 100: 10: 1), and 10 mL conc. H_2SO_4 were added. The flasks were heated at 160^0 C and added 2 mL H_2O_2 then heating was continued at 360^0 C until the digests become clear and colorless. After cooling, the content was taken into a 100 mL volumetric flask and the volume was made up to the mark with de-ionized water. A reagent blank was prepared in a similar manner. Nitrogen in the digest was estimated by distilling the digest with 10 N NaOH followed by titration of the distillate trapped in H_3BO_3 indicator solution with 0.01N H_2SO_4.

The amount of N was calculated using the following formula:

$$\% N = (T-B) \times N \times 0.014 \times 100 / S$$

Where,

T = Sample titration (ml) value of standard H_2SO_4

B = Blank titration (ml) value of standard H_2SO_4

N = Strength of H_2SO_4

S = Sample weight in gram

b) Digestion of plant samples

An amount of 0.5 g of sample was taken into a dry clean 100 mL Kjeldahl flask, 10 mL of di-acid mixture (HNO_3, $HClO_4$ in the ratio of 2:1) was added and kept for few minutes (Jackson, 1973).Then, the flask was heated at a temperature rising slowly to 200^0C. Heating was instantly stopped as soon as the dense white fumes of $HClO_4$ occurred and after cooling digested sample was filtered in a volumetric flask and add distilled water upto 100 mL. This digest was used for determining P, K and S and Na.

c) Determination of elements in the digest

Phosphorus contents in the digests were determined by method as described in onion analysis. In the digest Potassium and sodium concentrations were determined directly by flame photometer. In the digest Sulphur and phosphorus concentrations were estimated by a spectrophotometer.

3.13 Statistical analysis

The collected data were analyzed statistically following CRD design by MSTAT-C computer package programme developed by Russel (1986).The treatment means were compared by Duncan's Multiple Range Test (DMRT) and regression analysis were performed as and where necessary.

CHAPTER IV

RESULTS AND DISCUSSION

Two onion varieties (BARI Piaz-1 and BARI Piaz-6) have been selected for present experiment in order to effects of salinity on growth, yield and nutrient content of two onion cultivars. The levels of salinity 0, 3, 6, 9 and 12 dSm^{-1}were chosen in order to get more frequency for having a precise effect of salinity levels.

4.1 Plant height (cm)

Plant height of the onion varieties was measured at maturity. It was evident from Figure 1 that the height of the plant was influenced by variety but not significantly affected. The tallest plant (40.90 cm) was found in BARI Piaz-1 and the shortest plant height (40.39 cm) was in BARI Piaz-6 (Appendix-II). Probably the genetic makeup of varieties was responsible for the variation in plant height. This confirms the reports of BINA (1992), Shamsuddin *et al.*, (1988) that plant height differed due to varietal variation.

The height of the plant was significantly influenced by different levels salinity. The highest plant height (43.99 cm) was observed at 0 dSm^{-1} and it gradually decreased until salinity level at 12 dSm^{-1} (Figure 2). The shortest plant (37.38) was found in 12 dSm^{-1}(Appendix- II). Salinity might be lead to osmotic inhibition, toxic effect of ions and nutritional imbalance of elements by lowering down the uptake of essential nutrient elements and finally culminates in decreased growth. The results are in also in confirmation with the findings of Strogonov (1964).

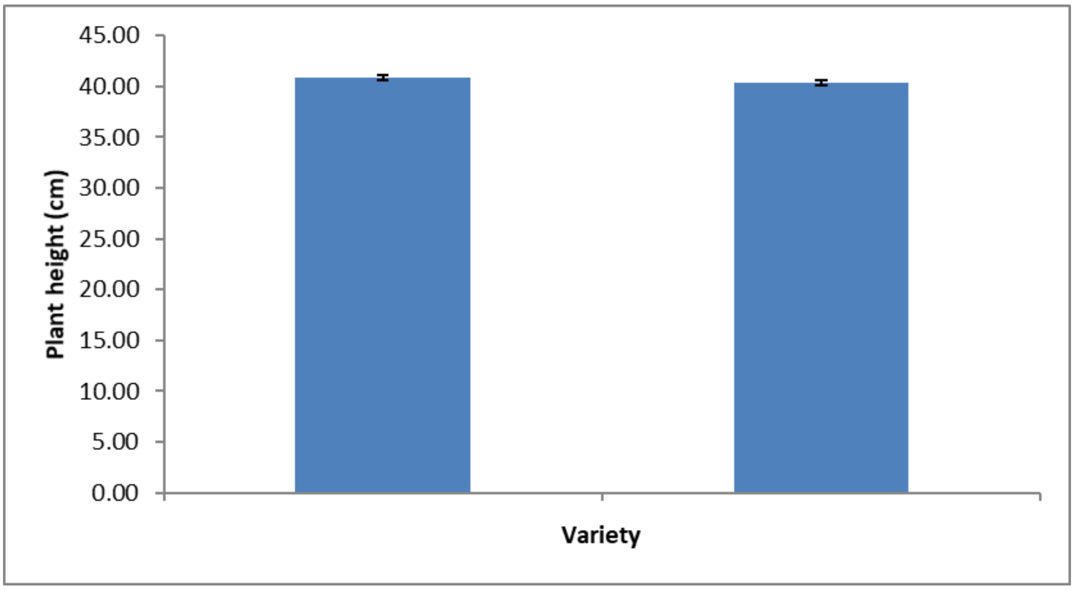

Figure 1. Effect of onion varieties on the plant height of onion

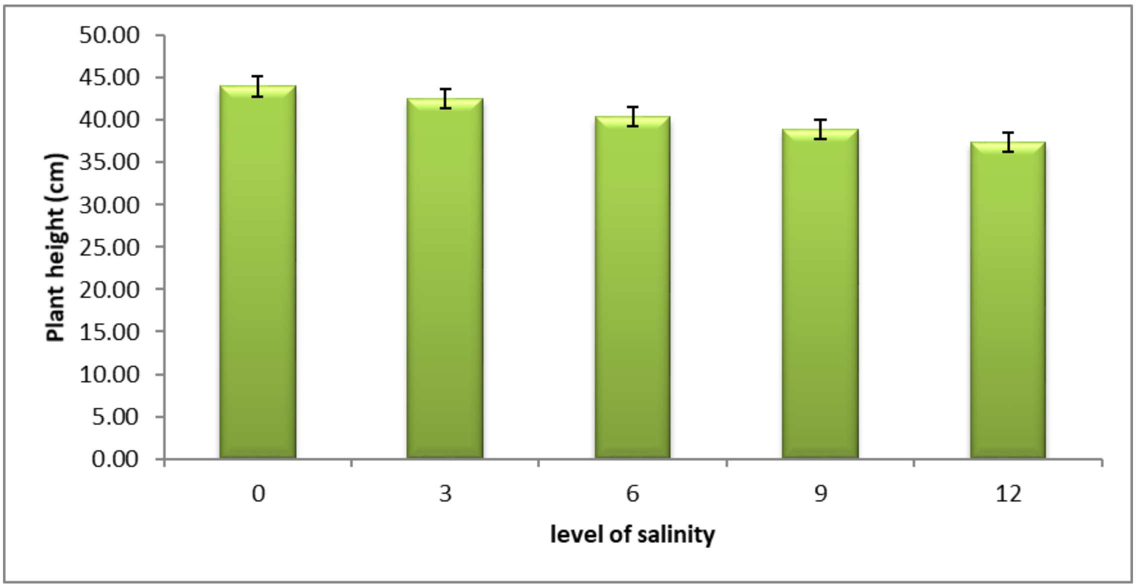

Figure 2. Effect of different salinity levels on the plant height of onion

In combined effect of varieties and salinity levels was significantly influenced on plant height. The plant height of different onion varieties significantly decreased with increase in different salinity levels (Table 1). The highest plant height (44.73cm) was found in BARI Piaz-1 with 0 dSm^{-1} and the lowest plant height (37.5 cm) was found in BARI Piaz-1 with 12 dSm^{-1} level of salinity, which was statistically similar with BARI Piaz-6 with 12 dSm^{-1} levels of salinity. Reduced plant height under salinity might be due to inhibited cell division and cell enlargement. Choi *et al.,* (2003) observed that the plant height decreased in the 0.5% saline water in the soil. During vegetative period, the most common salinity effect was stunting of plant growth, whereas leaf withering was less apparent (Alam *et al.*, 2001).

4.2 Number of leaf per plant

There was a non-significant difference among the variety in the number of leaf per plant (Figure 3). The maximum number of leaves per plant (5.39) was produced in BARI Piaz-6. The minimum number of leaves per plant (4.40) was produced in BARI Piaz-1 (Appendix- II).

The level of salinity was showed significant variation in the number of leaf per plant (Figure 4). The maximum number of leaves per plant (6.82) was produced by 0 dSm^{-1} level of soil salinity, whereas 12 dSm^{-1} level of soil salinity produced the minimum number of leaf per plant (3.21) (Appendix- II).

Number of leaf per plant indicated a significant variation among the treatment combinations of variety and level of salinity (Table 1). The maximum number of leaf per plant (7.53) was found in BARI Piaz-6 with 0 dSm^{-1} level of soil salinity. The minimum number of leaf per plant (2.75) was found BARI Piaz-1 with 12 dSm^{-1} level of soil salinity.

Table 1. Interaction effect of onion varieties and different salinity levels on Plant height (cm), Number of leaves per plant leaf length and fresh leaf weight of onion

Interaction effect of variety and salinity		Plant height (cm)		Number of leaf per plant		Leaf length (cm)		Fresh leaf weight (g)	
V_1	**0**	44.73	a	6.10	b	37.03	a	1.99	ab
	3	43.08	ab	5.53	bc	35.11	bc	1.75	bc
	6	40.10	cde	4.24	c	31.10	ef	1.61	cd
	9	39.35	def	3.34	d	30.14	fg	1.43	cd
	12	37.25	f	2.75	e	28.77	g	1.38	d
V_2	**0**	43.26	ab	7.53	a	37.55	a	2.14	a
	3	41.99	bc	6.00	b	36.21	ab	1.74	bc
	6	40.72	cd	5.25	bc	34.34	cd	1.47	cd
	9	38.45	ef	4.50	c	33.41	d	1.63	cd
	12	37.52	f	3.67	cd	31.72	e	1.68	bcd
Level of significant		*		*		*		*	
	LSD0.05	1.99		1.589		1.40		0.30	
	CV (%)	5.87		10.49		5.46		8.67	

In a column, means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

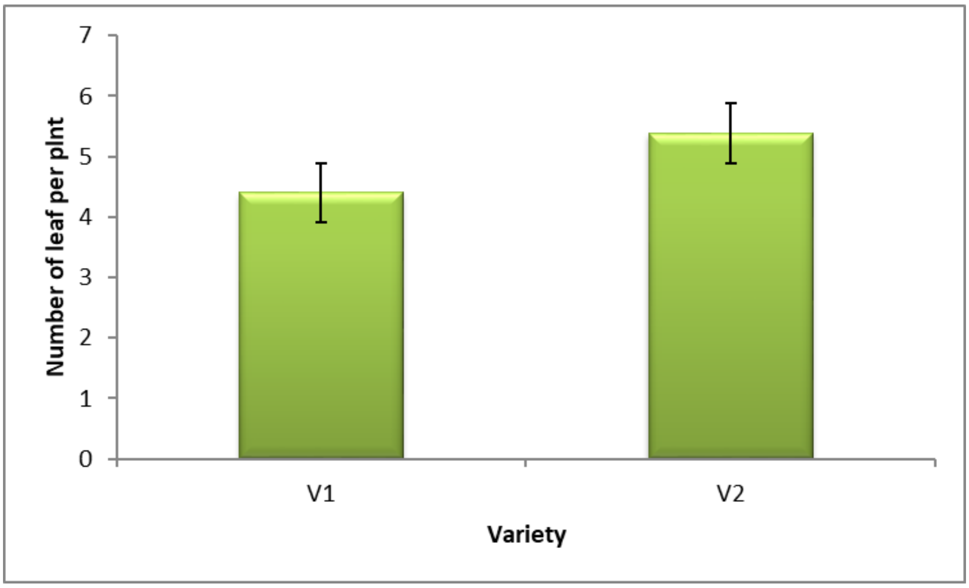

Figure 3. **Effect of onion varieties on the number of leaf per plant of onion**

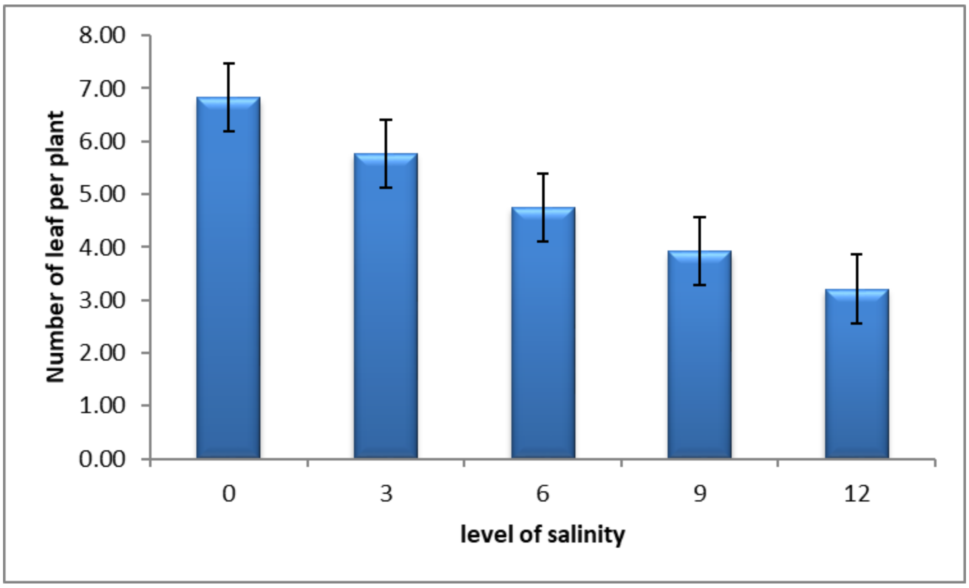

Figure 4. **Effect of different salinity levels on number of leaf per plant of onion**

4.3 Length of leaf

There was a significant difference among the variety in the length of leaf (Figure 5). The maximum length of leaf (34.65 cm) was produced in BARI Piaz-6. The minimum length of leaf (32.43 cm) was produced in BARI Piaz-1 (Appendix- II).

The level of salinity was showed significant variation in the length of leaf (Figure 6). The maximum length of leaf (37.29 cm) was produced by 0 dSm^{-1} level of soil salinity, whereas 12 dSm^{-1} level of soil salinity produced the minimum length of leaf (30.24 cm), which was statistically similar with 9 dSm^{-1} level of soil salinity. (Appendix- II).

Length of leaf indicated a significant variation among the treatment combinations of variety and level of salinity (Table 1). The maximum length of leaf (37.55 cm) was found in BARI Piaz-6 with 0 dSm^{-1} level of soil salinity, which was statistically similar with BARI Piaz-1 with 0 dSm^{-1} level of soil salinity. The minimum length of leaf (28.77 cm) was found BARI Piaz-1 with 12 dSm^{-1} level of soil salinity.

4.4 Fresh leaf weight

Fresh leaf weight production was not significantly influenced by variety throughout the lifecycle (Fig. 7). The maximum fresh leaf weight (1.73 g) was gained at BARI Piaz6and minimum fresh leaf weight (1.63 g) was recorded at BARI Piaz-1 (Appendix- II).

The result presented in figure 8 shows that fresh leaf weight significantly decreased with increasing the salinity levels. The fresh leaf weight was significantly influenced by the salinity levels. The fresh leaf weight was highest (2.07 g $plant^{-1}$) at 0 dSm^{-1} and it was lowest (1.53 g $plant^{-1}$) at 9, 12 dSm^{-1} level of soil salinity, which was statistically similar with 6 dSm^{-1} level of soil salinity (Appendix- II).

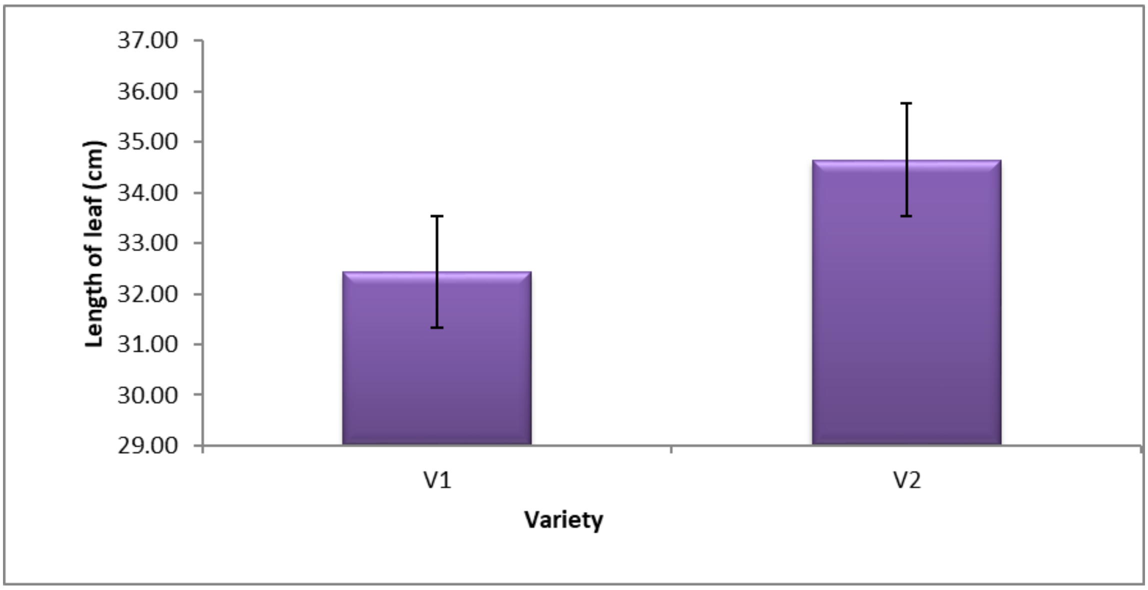

Figure 5. **Effect of onion varieties on the length of leaf of onion**

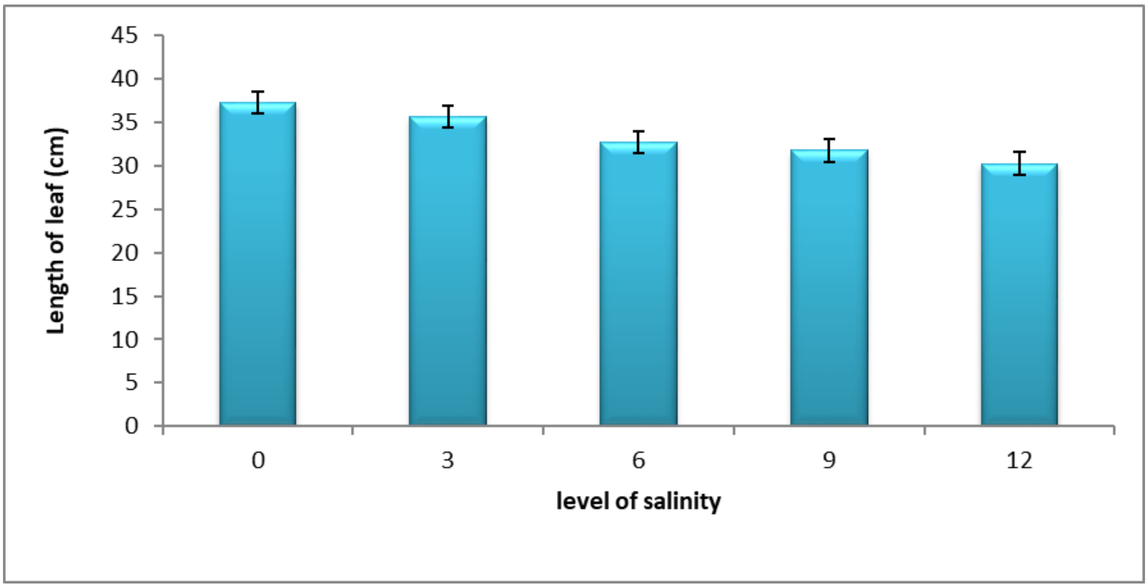

Figure 6. **Effect of different salinity levels on the length of leaf of onion**

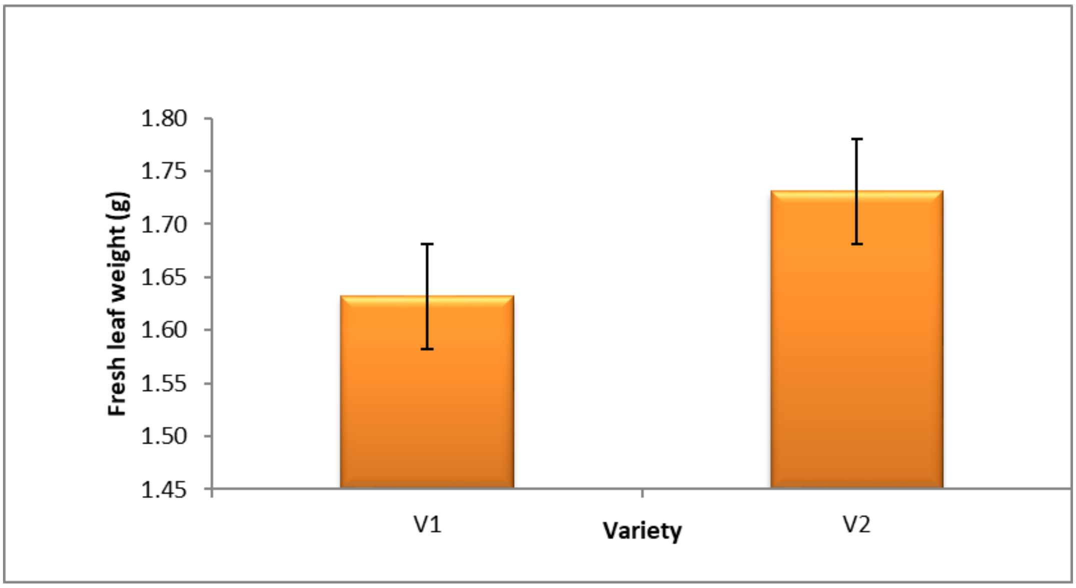

Figure 7. Effect of onion varieties on the fresh weight of leaf of onion

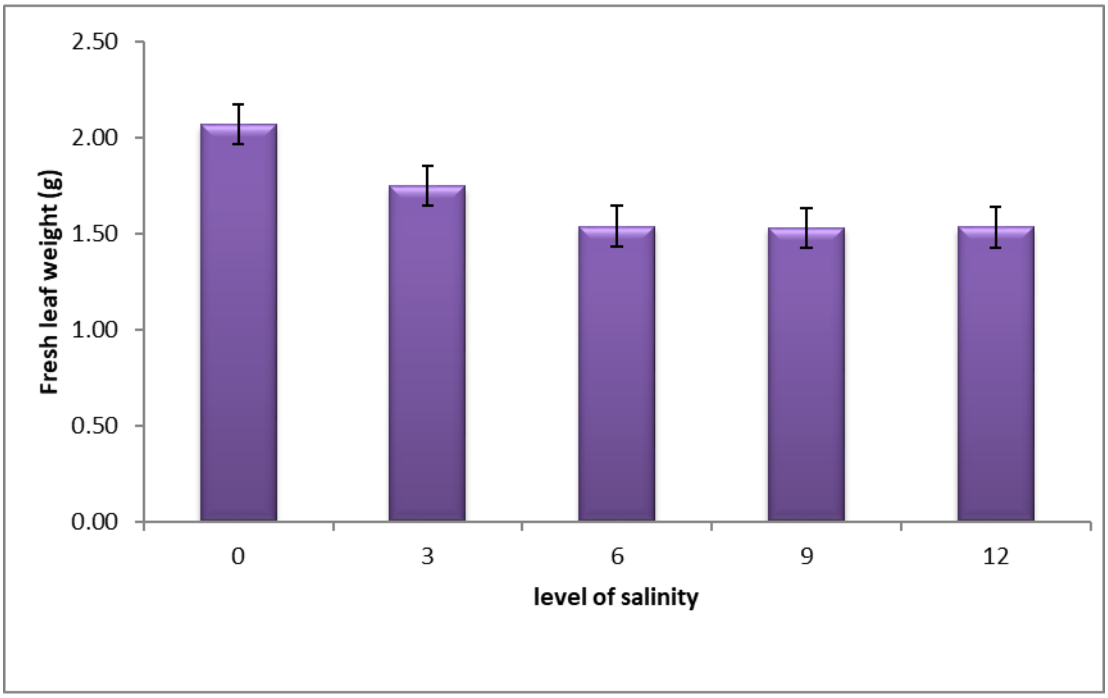

Figure 8. **Effect of different salinity levels on the fresh weight of leaf of onion**

Fresh leaf weight (g) was significantly influenced by the interaction of variety and salinity levels (Table 1). The maximum fresh leaf weight (2.14 g) accumulation was recorded at the combination of BARI Piaz-6 with 0 dSm^{-1} level of soil salinity and minimum fresh leaf weight (1.38 g) accumulation was observed at the combination of BARI Piaz-1 with 12 dSm^{-1} level of soil salinity. Chang and Randle (2004) observed that the fresh leaf weight of onion plants decreased to increasing NaCl concentrations in nutrient solutions and they also stated that onion plants react to salinity by reducing growth.

4.5 Bulb Diameter

There was an on significant difference among the variety in the bulb diameter (Table 2). The maximum bulb diameter (29.00 mm) was produced in BARI Piaz-1. The minimum bulb diameter (28.93 mm) was produced in BARI Piaz-6.

The level of salinity showed significant variation in the bulb diameter (Table 2). The maximum bulb diameter (31.50 mm) was produced by 0 dSm^{-1} level of soil salinity, which was statistical similar with 3 dSm^{-1} level of soil salinity, whereas 12 dSm^{-1} level of soil salinity produced the minimum bulb diameter (26.67 mm).

Diameter of bulb indicated a significant variation among the treatment combinations of variety and level of salinity (Table 2). The maximum diameter of bulb (33.00 mm) was found in BARI Piaz-1 with 0 dSm^{-1} level of soil salinity treatment combination, whereas the minimum diameter of bulb (25.67 mm) was found in BARI Piaz-1 with 12 dSm^{-1} level of soil salinity.

4.6 Length of bulb

There was a significant difference among the variety in the length of bulb (Table 2).The maximum length of bulb (30.33 mm) was produced in BARI Piaz-6. The minimum length of bulb (23.13 mm) was produced in BARI Piaz-1.

The level of salinity showed significant variation in the length of bulb (Table 2). The maximum length of bulb (30.33 mm) was produced by 0 dSm^{-1} level of soil salinity, which was statistical similar with 3 dSm^{-1} level of soil salinity, whereas 12 dSm^{-1} level of soil salinity produced the minimum length of bulb (24.00 mm).

Length of bulb indicated a significant variation among the treatment combinations of variety and level of salinity (Table 2). The maximum length of bulb (36.00 mm) was found in BARI Piaz-6 with 0 dSm^{-1} level of soil salinity treatment combination, whereas the minimum length of bulb (21.67 mm) was found in BARI Piaz-1 with 12 dSm^{-1} level of soil salinity, which was statistically similar with BARI Piaz-1 with 3 dSm^{-1} level of soil salinity and BARI Piaz-1 with 6 dSm^{-1} level of soil salinity.

4.7 Individual bulb weight

The seed yield $plant^{-1}$ of two selected onion varieties differed significantly (Table 2). The highest individual bulb weight (30.56 g) was found in cultivar BARI Piaz-6 and the lowest individual bulb weight (25.21 g) was recorded in BARI Piaz-1.

A highly significant variation in individual bulb weight of onion varieties was observed due to the different salinity levels (Table 2**).** The highest individual bulb weight (34.26g) was recorded at control treatment, which was statistically similar with 3 dSm^{-1} level of salinity and it was lowest (20.51 g) at 12 dSm^{-1} level of salinity (Table 2).

It was evident from the table 2 that interaction of variety and different salinity levels significantly affected the individual bulb weight. The highest individual bulb weight (36.70 g) was found in BARI Piaz-6 with 0 dSm^{-1} level of soil salinity which is statistically similar BARI Piaz-6 at salinity levels 3 $dSm^{-1}$and the lowest yield (17.29g) was obtained in BARI Piaz-1 at 12 dSm^{-1} level of salinity. Chang and Randle (2004) also observed that the bulb weight of onion plants decreased to increasing NaCl concentrations in nutrient solutions and they also stated that onion plants react to salinity by reducing growth.

Table 2. Effect of onion varieties and different salinity levels with interaction on bulb diameter, length of bulb and Individual bulb weight of onion

Variety	Salinity levels (dSm^{-1})	Bulb Diameter (mm)		Length of bulb (mm)		Individual bulb weight	
Effect of variety							
V_1		29.00		23.13		25.21	
V_2		28.93		30.33		30.56	
Level of significant		NS		*		*	
LSD0.05		1.78		2.36		2.83	
CV (%)		8.05		11.57		7.37	
Effect of salinity							
	0	31.50	a	30.33	a	34.26	a
	3	30.33	a	26.83	ab	33.33	a
	6	28.33	ab	26.33	ab	26.69	b
	9	28.00	ab	26.17	ab	24.64	b
	12	26.67	b	24.00	b	20.51	c
Level of significant		*		*		*	
LSD0.05		3.46		5.34		2.36	
CV (%)		8.05		11.57		7.37	
Interaction effect of variety and salinity							
V_1	0	33.00	a	24.67	cd	31.83	ab
	3	29.67	abc	22.33	d	30.46	abc
	6	27.67	bc	22.67	d	24.59	cd
	9	29.00	abc	24.33	cd	21.89	de
	12	25.67	c	21.67	d	17.29	e
	0	30.00	abc	36.00	a	36.70	a
	3	31.00	ab	25.67	bcd	36.20	a
V_2	6	29.00	abc	31.00	ab	28.79	bcd
	9	27.00	bc	29.33	bc	27.40	bcd
	12	27.67	bc	29.67	bc	23.73	cde
Level of significant		*		*		*	
LSD0.05		3.97		5.27		6.33	
CV (%)		8.05		11.57		7.37	

In a column, means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

4.8 Nitrogen content in onion bulb

The effect of variety showed a statistically insignificant variation in the N concentration in onion plant (Table 3). The highest N content (0.025 %) was observed in onion cultivar of BARI Piaz-6. The lowest value of N (0.023 %) was observed under BARI Piaz-1.

The effect of different levels of salinity showed a statistically significant variation in the N concentration in onion plant (Table 3). The N content of the onion plant varied from 0.020 % to 0.029 %. Among the different levels of salinity, 0 dSm^{-1} showed the highest N concentration (0.029 %) in plant. The lowest value was (0.20 %) under control treatment 12 dSm^{-1} salinity level.

Interaction effect of different levels of salinity and variety on the N concentration was observed significant in onion plant (Table 3). The highest concentration of N in onion plant (0.029 %) was recorded in BARI Piaz-6 at 0 dSm^{-1} salinity level. On the other hand, the lowest N concentration (0.019 %) was found in BARI Piaz1 with 12 dSm^{-1} level of salinity. Increasing the levels of irrigation salinity decreased contents of N in onion bulb (Kuscu *et al.*, 2020).

4.9 Phosphorus content in onion bulb

The effect of variety showed a statistically insignificant variation in the P concentration in onion plant (Table 3). The highest P content (0.09 %) was observed in onion cultivar of BARI Piaz-1. The lowest value of N (0.07 %) was observed under BARI Piaz-6.

The effect of different levels of salinity showed a statistically significant variation in the P concentration in onion plant (Table 3). The P content of the onion plant varied from 0.05% to 0.1%. Among the different levels of salinity, 9 dSm^{-1} showed the highest P concentration (0.1 %) in plant. The lowest value was 0.05% under control treatment 3 dSm^{-1} salinity level.

Table 3. Effect of onion varieties and different salinity levels with interaction on N, P, K, S and Na content on bulb of onion

Variety	**Salinity levels (dSm^{-1})**	**N (%)**		P (%)		K (%)		S (%)		Na (%)	
Effect of variety											
V_1		0.024		0.09		1.03		0.15		1.13	
V_2		0.025		0.07		1.06		0.13		1.13	
Level of significant		NS		NS		NS		NS		NS	
LSD0.05		0.07		0.09		0.21		0.12		0.24	
CV (%)		5.08		6.08		6.11		9.6		7.54	
Effect of salinity											
	0	0.029	a	0.09	ab	1.23	a	0.1	b	0.73	b
	3	0.028	ab	0.05	b	1.15	ab	0.12	ab	0.85	b
	6	0.025	ab	0.08	ab	1.04	ab	0.13	ab	0.91	b
	9	0.021	b	0.1	a	1.0	b	0.14	ab	1.52	a
	12	0.020	b	0.08	ab	0.85	b	0.17	a	1.64	a
Level of significant		*		*		*		*		*	
LSD0.05		0.0080		0.04		0.29		0.06		0.41	
CV (%)		5.08		6.08		6.11		9.6		7.54	
Interaction effect of variety and salinity											
	0	0.028	a	0.08	ab	1.11	ab	0.09	b	0.68	b
	3	0.027	a	0.06	b	1.1	ab	0.13	ab	0.79	b
	6	0.023	ab	0.1	a	1.05	ab	0.13	ab	0.91	b
	9	0.021	b	0.1	a	1	ab	0.15	ab	1.52	a
V_1	12	0.019	b	0.09	a	0.81	ab	0.18	a	1.76	a
	0	0.029	a	0.1	a	1.35	a	0.1	ab	0.79	b
	3	0.028	a	0.05	b	1.21	ab	0.11	ab	0.91	b
	6	0.026	ab	0.06	b	1.04	ab	0.12	ab	0.91	b
	9	0.021	b	0.1	a	0.92	ab	0.12	ab	1.52	a
V_2	12	0.020	b	0.06	b	0.89	b	0.16	ab	1.52	a
Level of significant		*		*		*		*		*	
LSD0.05		0.007		0.04		0.47		0.07		0.53	
CV (%)		5.08		6.08		6.11		9.6		7.54	

In a column, means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

Interaction effect of different levels of salinity and variety on the P concentration was observed significant in onion plant (Table 3). The highest concentration of P in onion plant (0.1 %) was recorded in BARI Piaz-6 at 9 dSm^{-1} salinity level, which was statistically similar with BARI Piaz-6 with 0 dSm^{-1} level of salinity and BARI Piaz-1 with 6 and 9 dSm^{-1} level of salinity. On the other hand, the lowest P concentration (0.05 %) was found in BARI Piaz-6 with 3 dSm^{-1} level of salinity.(Kuscu *et al.*, 2020) observed that increasing the levels of irrigation salinity decreased contents of P in onion bulb.

4.10 Potassium content in onion bulb

It appears from the results presented in table 3 that there was a statistically insignificant variation in potassium (%) content in two selected onion varieties. The highest K content (1.06 %) in onion plant was found in BARI Piaz-6 and that was lowest (1.03 %) in BARI Piaz-1.

The Potassium (K) contents in plant of onion also significantly varied due to the effect of different salinity levels; where the K content decreased with the increasing level of salinity in plant (table 3).The highest K content in plant (1.23 %) was recorded in 0 dSm^{-1} and it was lowest (0.85 %) in 12 dSm^{-1} salinity level, which was statistically similar with 9 dSm^{-1} salinity level.

The combined effects of salinity and variety on content of K (%) in plant were differed significantly. The content of K in plant of two selected varieties progressively decreased with increasing the salinity levels. The highest K content (1.35%) in plant was found in BARI Piaz-6 with 0 dSm^{-1} level of soil salinity and it was lowest (0.81 %) for BARI Piaz-1 at 12 dSm^{-1} (Table 3). (Kuscu *et al.*, 2020) also found that increasing the levels of irrigation salinity decreased contents of K in onion bulb, increased contents of Na, Cl and Mn.

4.11 Sulphur content in onion bulb

The percent content of S in plant of the entire two selected onion varieties varied insignificantly. Its content in plant was highest (0.15%) in BARI Piaz-1 and lowest (0.13%) in BARI Piaz-6 (Table 3).

The S content in plant of onion significantly varied due to the effect of different salinity levels; where the S content in plant increased with the increasing level of salinity in plant. The highest S content (0.17%) in plant was recorded in 12 dSm^{-1} level of salinity and then was lowest (0.10%) in 0 dSm^{-1} (Table 3).

The combined effect of salinity and varieties on content of Sin plant was found significant. The S content increased with the increasing levels of salinity in both plant of all Varieties (table 3). The highest S content (0.18 %) in plant was found in BARI Piaz-1 with 12 dSm^{-1} level of soil salinity and it was lowest (0.09 %) in the cultivar BARI Piaz-1 at 0 dSm^{-1} salinity levels. Chang and Randle (2004), stated that increasing bulb $SO_4^{=}$ content indicating less S was entering the S metabolic stream.

4.12 Sodium content in onion bulb

The percent content of sodium (Na) in plant of the entire two selected onion varieties varied insignificantly. Its content similar percentage Na (1.13%) in BARI Piaz-1 and BARI Piaz-6 (Table3).

The sodium (Na) content in plant of onion significantly varied due to the effect of different salinity levels; where the Na content in plant increased with the increasing level of salinity in plant. The highest Na content (1.64%) in plant was recorded in 12 dSm^{-1} level of salinity and then was lowest (0.73%) in 0 dSm^{-1} (Table 3).

The combined effect of salinity and cultivar on content of Na in plant was found significant. The Na content increased with the increasing levels of salinity in both plant of all cultivars (table 3). The highest Na content (1.76 %) in plant was found in BARI Piaz-1 with 12 dSm^{-1} level of soil salinity and it was lowest (0.68 %) in the cultivar BARI Piaz-1 at 0 dSm^{-1} salinity level. Chang and Randle (2004) observed that the bulb Na^+ and Cl^- content increased in response to increasing NaCl concentrations in nutrient solutions.

CHAPTER V

SUMMARY AND CONCLUSIONS

The results on the effect of characters indicated that plant height, number of leaves per plant, length of leaf, fresh weight of leaf per plant, length of bulb, diameter of bulb, individual bulb weight was influenced by the variety. The tallest plant (40.90 cm) was found in cultivar BARI Piaz-1. BARI Piaz-6 achieved length of leaf (34.65 cm). The maximum fresh leaf weight (1.73 g) was gained at BARI Piaz-6. The maximum diameter of bulb (29.00) was produced in BARI Piaz-1. The maximum length of bulb (30.33 cm) was produced in BARI Piaz-6. The highest individual bulb weight plant^{-1} (30.56 g) was found in cultivar BARI Piaz-6 and the lowest yield (25.21 g pot^{-1}) was recorded in BARI Piaz-1.

There was a significant variation in P, K, S and Na content in two selected onion cultivars under different salinity levels. The highest N content (0.025 %) was observed in Onion cultivar of BARI Piaz-6. The highest P content (0.09 %) was observed in Onion cultivar of BARI Piaz-1. The highest K content (1.06 %) in plant was found in BARI Piaz-6. Its S content in plant was highest (0.15%) in BARI Piaz-1. Its Na content in plant was highest (1.13 %) in BARI Piaz-1.

All parameters were statistically influenced by different salinity levels of onion plant the highest plant height (43.99 cm) were observed in 0 dSm^{-1}. The maximum leaf number 6.82. The maximum leaf length (37.29 cm), fresh leaf weight was highest (2.07 g plant^{-1}), diameter of bulb (31.50 mm) and length of bulb (30.33 mm) was produced from 0 dSm^{-1}. The highest individual bulb weight (34.26 g) was recorded at control treatment and it was lowest (20.51 g plant^{-1}) at 12 dSm^{-1} level of salinity. In control treatment showed the highest N content (0.029 %) in bulb. In 9 dSm^{-1} level of salinity showed the highest P content (0.1 %) in bulb. The highest K content in bulb (1.23%) was recorded in 0 dSm^{-1}. The highest S content in bulb (0.17 %) was recorded in 12 dSm^{-1}. The highest Na content in bulb (1.64 %) was recorded in 12 dSm^{-1}.

In combined effect of cultivars and salinity levels all parameter were significantly influenced. The highest plant height (44.73 cm) was found in BARI Piaz-1 with 0 dSm^{-1}. The maximum leaf number (7.53). The maximum leaf length (37.55 cm), fresh leaf weight was highest (2.14 g $plant^{-1}$), and length of bulb (36.00 mm) was produced from BARI Piaz-6 with 0 dSm^{-1}. The highest diameter of bulb (33.00 mm) was found in BARI Piaz-1 with 0 dSm^{-1}. The highest individual bulb weight (36.70 g) was recorded at from BARI Piaz-6 with 0 dSm^{-1} and it was lowest (17.29 g) at from BARI Piaz-1 with 12 dSm^{-1}. BARI Piaz-6 with 9 dSm^{-1} showed the highest P concentration (0.1%) in plant. The highest K content in plant (1.35%) was recorded in BARI Piaz-6 with 0 dSm^{-1}. The highest S content in plant (0.18%) was recorded in BARI Piaz-1 with 12 dSm^{-1}. The highest Na content in plant (1.76 %) was recorded in BARI Piaz-1 with 12 dSm^{-1}

Based on the above results following conclusions and recommendations could be made -

- The BARI Piaz-6 had better expression of morphological, yield and yield contributing characters than of BARI Piaz-1 in all cases except plant height.
- Salinity increased the content of Na^+ and decreased K^+ content in bulb of the cultivars.
- Generaly the tolerant cultivar showed lower Na^+ concentration reflecting the dilutlion effect, the tolerance mechanism.
- Based on the above conclusions plant breeder may adapt the technique of selection or screening the genotypes and develop salt tolerant Onion cultivars.

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APPENDICES

Appendix I. The mechanical and chemical characteristics of soil of the experimental site as observed prior to experimentation (0- 15 cm depth).

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

Chemical composition:

Soil characters	Value
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.07
Phosphorus	22.08 µg/g soil
Sulphur	25.98 µg/g soil
Magnesium	1.00 µg /100 g soil
Boron	0.48 µg/g soil
Copper	3.54 µg/g soil
Zinc	3.32 µg/g soil
Potassium	0.30 µg/g soil

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

Appendix II. Effect of onion varieties and different salinity levels on plant height, Leaf length and Fresh leaf weight of onion

Variety	Salinity levels (dSm^{-1})	Plant height (cm)		Number of leaf per plant		Leaf length (cm)		Fresh leaf weight (g)	
Effect of variety									
V_1		40.90		4.4		32.43		1.63	
V_2		40.39		5.39		34.65		1.73	
Level of significant		NS		NS		*		NS	
LSD0.05		0.89		1.29		0.63		0.41	
CV (%)		5.87		0.00		5.46		8.67	
Effect of salinity									
	0	43.99	a	6.82	a	37.29	a	2.07	a
	3	42.53	ab	5.77	b	35.66	ab	1.75	ab
	6	40.41	bc	4.75	c	32.72	bc	1.54	b
	9	38.90	cd	3.92	cd	31.77	c	1.53	b
	12	37.38	d	3.21	d	30.24	c	1.53	b
Level of significant		*		*		*		*	
LSD0.05		2.53		0.90		3.63		0.49	
CV (%)		5.87		10.49		5.46		8.67	