PERFORMANCE OF GROUNDNUT VARIETIES UNDER SALT STRESS CONDITIONS

MD. TOUHIDUR RAHMAN TUHIN

DEPARTMENT OF AGRONOMY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

DHAKA-1207

JUNE, 2022

PERFORMANCE OF GROUNDNUT VARIETIES UNDER SALT STRESS CONDITIONS

By

MD. TOUHIDUR RAHMAN TUHIN

REGISTRATION NO. 15-06662

Mobile No. +8801644-930669

Email: touhidtuhin36@gmail.com

A Thesis

Submitted to the Faculty of Agriculture,

Sher-e-Bangla Agricultural University, Dhaka,

in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE

IN

AGRONOMY

SEMESTER: JANUARY-JUNE, 2022

Approved by:

Dr. Anisur Rahman **Professor** **Supervisor**	**Dr. Parimal Kanti Biswas** **Professor** **Co-Supervisor**

Prof. Dr. Md. Abdullahil Baque

Chairman

Examination Committee

DEPARTMENT OF AGRONOMY

Sher-e-Bangla Agricultural University

Sher-e-Bangla Nagar

Dhaka-1207

CERTIFICATE

*This is to certify that thesis entitled, "**PERFORMANCE OF GROUNDNUT VARIETIES UNDER SALT STRESS CONDITIONS**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) in AGRONOMY**, embodies the result of a piece of bona-fide research work carried out by **MD. TOUHIDUR RAHMAN TUHIN**, **REGISTRATION NO. 15-06662** 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 dully been acknowledged.

Date:

Place: Dhaka, Bangladesh

Dr. Anisur Rahman
Professor
Supervisor

DEDICATED TO

MY

BELOVED PARENTS

ACKNOWLEDGEMENTS

All praises are putting forward to God Who is the Supreme Planner and has blessed the author to complete this piece of study as required for the degree Master of Science.

It is a great pleasure for the author to make delighted his respected parents, who had been shouldering all kinds of hardship to establish a favourable platform thereby receiving proper education until today.

The author is happy to express his sincere appreciation and profound gratitude to his respected ***Supervisor, Prof. Dr. Anisur Rahman,*** *Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka for his dynamic guidance, constant encouragement, constructive criticism and valuable suggestions encompassed the research work and thesis writing times.*

It is a great pleasure for the author to express his deep sense of gratitude and sincere regards to his ***Co-Supervisor, Prof. Dr. Parimal Kanti Biswas****, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka for his adept guidance, supervision, kind cooperation, and valuable suggestions in preparation of the thesis.*

It is highly appreciating words for ***Prof. Dr. Md. Abdullahil Baque, Chairman****, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka along with faculties of the Department of Agronomy, Sher-e-Bangla Agricultural University for their rendered novel services towards me as their student.*

The author also expresses heartfelt thanks to the staff of Department of Agronomy and central farm, SAU, for their valuable suggestions, instructions cordial help and encouragement during the period of research work.

The author wish to extend his special thanks to his classmates and friends for their keen help as well as heartfelt co-operation and encouragement.

The author express his thanks to own brothers, sisters, uncles, aunts and other relatives who continuously prayed for his success and without whose love, affection, inspiration and sacrifice this work would not have been completed.

May God bless and protect them all.

The Author.

PERFORMANCE OF GROUNDNUT VARIETIES UNDER SALT STRESS CONDITIONS

ABSTRACT

A pot experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during February to July 2020 to study the performance of groundnut varieties under salt stress conditions. The study was conducted by following Randomized Complete Block Design with three replications and consisted of two factors i.e. variety (factor A) and salinity (factor B). Fourteen groundnut variety e.g. BINA Chinabadam-4 (V_1), BINA Chinabadam-5 (V_2), BINA Chinabadam-6 (V_3), BINA Chinabadam-8 (V_4), BINA Chinabadam-9 (V_5), BINA Chinabadam-10 (V_6), Dhaka-1 (V_7), BARI Chinabadam-5 (V_8), BARI Chinabadam-6 (V_9), BARI Chinabadam-8 (V_9), BARI Chinabadam-9 (V_{10}), BARI Chinabadam-10 (V_{11}), Zhingabadam (V_{13}) and Bashanti (V_{14}) were grown in three levels of salinity such as 0 mM NaCl (S_0), 50 mM NaCl (S_1) and 100 mM NaCl (S_2). Different levels of salinity were induced to the pots at 30, 40 and 45 DAP. Experimental result revealed that the BINA Chinabadam-9 produced the highest seed and pod yield compared with other groundnut varieties under controlled and saline conditions. However, exposure of salinity decreased yield of groundnut by decreasing growth, pod number, pod weight, seed number and seed yield. Compared with controlled conditions, the highest seed and stover yield reduction was observed in BINA Chinabadam-5 and BARI Chinabadam-10. Exposure of 50 mM NaCl decreased seed yield by 52% and stover yield by 28% of BINA Chinabadam-5 variety when compared with untreated control. Under 100 mM NaCl, the highest seed yield reduction was recorded in BINA Chinabadam-5 (80%). Bashanti showed lowest yield reduction under 50 mM and 100 mM NaCl-stressed conditions. Considering the yield and yield reduction performances under saline conditions, Bashanti is most salt tolerant variety and BINA Chinabadam-5 is most salt sensitive variety.

LIST OF CONTENTS

LIST OF CONTENTS

LIST OF CONTENTS (Cont'd)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF PLATES

LISTS OF ABBREVIATIONS

Full word	Abbreviations
Agriculture	Agr.
Agro-Ecological Zone	AEZ
Bangladesh Bureau of Statistics	BBS
Biology	Biol.
Biotechnology	Biotechnol.
Botany	Bot.
Cultivar	Cv.
Dry weight	DW
Editors	Eds.
Emulsifiable concentrate	EC
Environments	Environ.
Food and Agriculture Organization	FAO
Fresh weight	FW
International	Intl.
Journal	J.
Least Significant Difference	LSD
Liter	L
Triple super phosphate	TSP
Science	Sci.
Soil Resource Development Institute	SRDI
Technology	Technol.
Serial	Sl.

CHAPTER-I

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) or peanut is the sixth most important oilseed crop in the world cultivated throughout tropical and subtropical areas, followed by cereal crops. In Bangladesh, it is popularly known as "cheenabadam" and it is the second most oilseed crop and has played a pivotal role in meeting the growing oil requirements in recent years and ensuring nutritional security for a population of over 160 million (Shakil, 2022). Nutritionally, groundnut seeds contain about 48-50% edible oil, 22–29% protein, and 20% carbohydrate, with an average yield of 2.30-3.00 t ha^{-1} (Dun *et al.* 2019). Groundnut is cultivated on about 32,000 ha of land, and the total groundnut production is about 47,000 Mt in Bangladesh (Azad *et al.*, 2020).

Groundnut is a major crop in the char lands of Bangladesh, but because of poor yields, farmers derive a limited income from the crop. It is a photo insensitive crop and allows cultivation throughout the year. Despite its insensitivity, it is grown mainly in Rabi season in charlands due to high land scarcity in Rabi season (Qasim *et al*., 2016).

The productivity of groundnut depends on proper selection of variety, fertilizer management, environmental factors, metal contents in soil and other management practices (Mouri *et al*., 2018). Variation in any of the weather parameter causes reduction in the pod yield. Thus, it is necessary to improve the genotype, which can withstand weather aberrations. Raagavalli *et al*. (2019) revealed that improved genotypes contribute 25 to 28 % to the yield increase, while improved management practices contributed 30 to 32 %. However, different growth stages of this crop is often subjected to various types of abiotic stress like drought, salinity, high temperature etc which may cause yield loss.

Soil salinity, spread in about 1.06 m ha of coastal and saline areas in the major groundnut growing areas of Bangladesh, is one of the most important abiotic factors that significantly affect seedling, vegetative and reproductive growth, seed quality and productivity (Hasan *et al*., 2019). Groundnut yields have been reported to be severely affected with an increase in soil and water salinity (Gohari *et al.*, 2018).

The effect of salinity on the plant growth is a complex syndrome that involves osmotic stress, ion toxicity and mineral deficiencies (Shrivastava and Kumar, 2015). Salinity stress results in ionic and nutritional imbalance due to competition of salt ions with nutrients. Saline condition influences the different steps of nitrogen (N) metabolism, its uptake, reduction and protein synthesis which are responsible for the reduction in plant growth (Ma *et al*., 2020) and decreased dry matter production. A negative correlation between concentrations of nitrate (NO_3) and Cl^- was seen in the shoots and roots (Abdelgadir *et al.*, 2005). Salinity reduced potassium (K^+), and calcium (Ca^{2+}) contents, and increased Na^+ and Cl^- content in leaves and stems (Assaha *et al*., 2017). Saline environment is generally deficient in nitrogen (Ashraf *et al.,* 2017) as a result there is reduction in NO_3^- uptake due to high Cl^- in saline condition. Addition of N to salinity, improved the growth and yield of plant, and increased salt tolerance (Nazir *et al*., 2023).

Salinity reduces substrate water potential, thereby restricting water and nutrient uptake by plants. However, under such conditions some plant species thrive and yield better than other species by affectively adjusting or modifying their metabolism. Groundnut *(Arachis hypogaea* L.*)* is an oilseed crop rated moderately salt and drought tolerant but it is sensitive at germination and seedling stages (Pal and Pal, 2017).

Salinity affects the both vegetative and reproductive phase of plants. In the vegetative phase, it lead to reduction in growth and in reproductive phase, the main issue will be related to the decline in the yield (Shrivastava and Kumar, 2015). Salinity stress produced adverse effect on quality of plant and resultant reduction in leaf area and number of leaves, simultaneously increased leaf thickness and chloroplast per unit leaf area due to lower photosynthesis, thus photosynthesis is measured in terms of chlorophyll (Hnilickova *et al*., 2021). Therefore, biochemical traits like proline and chlorophyll as well as ratio of sodium, potassium and calcium are important criteria for screening of variety for their tolerancy against salinity stress (Bot *et al*., 2014).

One of the most effective ways to overcome salinity problems is the introduction of salt-tolerant crops. It has been reported that differences in salt tolerance exist, not only among different species, but also within certain species (Gupta and Huang, 2014). Success of selection depends upon the amount of genetic variation present in the population.

Evidence collected from various species suggests that salt tolerance is a developmentally regulated, stage-specific phenomenon, so that tolerance at one stage of development may not be correlated with tolerance at other developmental stages (Nongpiur *et al*., 2016).

Therefore, specific stages throughout the ontogeny of the plant, such as germination and emergence, seedling growth and its vigour, should be evaluated separately during the assessment of germplasm for salt tolerance. Such assessments may help in the development of cultivars with salt tolerance characteristics throughout the ontogeny of the plant (Azad *et al*. (2014). In Bangladesh information on salt tolerance of local high yielding groundnut varieties tolerant to salinity is scanty. Hence, selection and breeding of cultivars that can grow and provide economical yield under saline condition may be an efficient tool in resolving the cultivation of crop under saline soil condition.

Therefore, keeping all the points in view, the present study entitled, "Performance of groundnut varieties under salt stress conditions" was undertaken with the following objectives:

i. To screen the groundnut genotypes against salinity and discriminate salt tolerant and sensitive groups.
ii. To know the effect of salinity on the performance of groundnut plant.

CHAPTER II

REVIEW OF LITERATURE

In this section, an attempt was made to collect and study relevant information available regarding the performance of groundnut varieties under salt stress conditions, in order to gather knowledge useful in carrying out the current piece of work. Because the available literature on this crop is limited, literature on other related crops was gathered and reviewed under the following headings:

2.1 Effect of varieties

Among the major factors influencing the pod yields in groundnut, selection of a suitable high yielding variety, that produces more number of pods of uniform maturity and more pod weight, plays important role (Dash *et al*., 2021).

2.2 Effect of varieties on growth, yield attributes and yield

Ibrahim *et al.* (2022) carried out a experimental study to investigate the effect of different types of fertilizer on groundnut (*Arachis hypogaea* L.) varieties in Katsina State. Two field experiments were conducted during the 2020 and 2021 rainy seasons at Basic vocational Agricultural research farm Gidan Kwakwa Katsina 13.00530N, 7.58540E. Treatments consisted of two varieties of groundnut (SAMNUT 25 and SAMNUT 26) and four different types of fertilizer (zero fertilizer, organic manure, NPK fertilizer, and poultry manure) replicated three times. A combination of eight treatments was factorized and laid out in a randomized complete block design (RCBD). The study revealed that there was a significant ($P \leq 0.05$) effect of different types of fertilizer applications on the number of branches per plant, plant height, and canopy spread at 3, 6 and 9 WAS and SAMNUT 25 significantly ($P \leq 0.05$) performed better than SAMNUT 26 groundnuts. Poultry manure recorded a significant ($P \leq 0.05$) effect on plant height at 3, 6 and 9 WAS, canopy spread at 3, 6 and 9 WAS, and the number of branches per plant at the two growing seasons. However, the study revealed that SAMNUT 25 and poultry manure application on growth parameters proved to be most effective in the study area.

Dash *et al.* (2021) conducted an experiment during rabi season 2019-20 in Khairiput and Malkangiri blocks of Malkangiri district to study the performance and yield gap analysis of groundnut (*Arachis hypogaea* L.), Var Dharani through cluster front line demonstration in south eastern ghat zone of odisha and reported that ground nut variety Dharani recorded the higher yield (21.6 q ha^{-1}), followed by farmer‟s traditional variety Kadri -6 recorded an average yield of (17.9 q ha^{-1}). HYV groundnut variety Dharani with proper nutrient management and plant protection measures gave 17.13 % higher over farmer‟s practices.

Aliyu *et al.* (2020) carried out an experiment to evaluated the growth and yield of groundnut (*Arachis hypogaea* L.) as affected by varieties in dry land farm of Usmanu Danfodiyo University, Sokoto state during 2018 cropping season. The treatments comprised of six (6) varieties of groundnut. Four are improved varieties (Samnut23, Samnut24, Samnut25 and Samnut26) and two local varieties (Bahausa, and Yarmadani) and were laid out in a randomized complete block design (RCBD) replicated three times. Results of the analysis indicated that varieties differed significantly on growth and yield except for stand count at 3WAS. Samnut 24 recorded the highest mean stand count before harvest and highest mean pod yield while Samnut 25 recorded the highest canopy spread, least days to maturity and highest grain yield. Bahausa recorded the highest mean haulm yield and thus, the study concluded that Bahausa has the highest haulm yield per hectare with yield of 2166.7kg ha^{-1} and Samnut 25 possess highest grain yield of 117.80 kg ha^{-1}.

Nwokwu *et al.* (2020) conducted a field experiment at the research field of Faculty of Agriculture and Natural Resources Management, Ebonyi State University Abakaliki during the 2018 farming season to determine the effect of plant density on growth, yield and yield components of groundnut varieties. The results showed that groundnut varieties were significant in all growth and yield parameters assessed except number of days to 50% flowering, Relative Growth Rate, number of pod per plant, and hundred seed weight while planting density recorded significant effect on all the growth and yield parameters. There were also significant interaction effects of varieties and plant density on plant height, number of branches per plant, leaf area index, relative growth rate, pod weight per plant, number of seeds per plant, total yield, stover yield and biological per hectare. This result indicated that SAMNUT 26 and plant density of 160,000 plants ha^{-1} recorded the highest yield of groundnut and can be recommended for the farmers in the study area.

Uko *et al.* (2019) carried out an experiment to evaluated the growth and yield responses of two groundnut varieties to inoculation with two species of arbuscular mycorrhizal fungi (AMF) and reported that inoculation of the groundnut varieties with AMF significantly ($p \leq 0$) increased number of pods/plant, pod yield, seed yield and 100-seed weight. The highest enhancements in yield attributes were obtained when variety SAMNUT 21 was inoculated with *Glomus clarum* while *G. gigantea* inoculation enhanced the growth attributes of SAMNUT 22.

Shendage *et al*. (2018) conducted an experiment entitled, "Effect of sowing times and varieties on growth and yield of summer groundnut (*Arachis hypogaea* L.)" during summer 2015 at Post Graduate Research Farm, College of Agriculture, Kolhapur. The objective of experiment is to study the optimum sowing time and varieties of groundnut under summer condition. The experiment was laid out in split plot design viz. sowing dates (52nd MW, 2^{nd}MW, 4^{th} MW, 6^{th} MW) as main plot and four varieties (JL-501, JL-24, JL-286 and TAG-24) as sub plot with three replications. Experimental result showed that being a bunch type variety, the height of plant was significantly higher in JL-501 while number of functional leaves, leaf area $plant^{-1}$, number of branches, dry matter accumulation was higher in variety JL-501 followed by TAG-24. The yield attributing characters like number of pod $plant^{-1}$ was maximum in variety JL-501 while it was minimum in JL-24. The weight of 100 kernel was higher in JL-501 (57.55 g), shelling percentage, kernel yield was also higher in variety JL-501. The dry pod yield given by JL-501 (34.84 q ha^{-1}) was maximum among the varieties JL-24 (29.26 q ha-1) JL-286 (32.21 q ha-1) and TAG-24-(33.91 q ha^{-1}). The dry haulm yield was significantly higher in variety JL-501 (31.21 q ha^{-1}). Higher oil content (48.67%), protein content (24.57%) and oil yield (10.32 q ha^{-1}), protein yield (7.35 q ha^{-1}) was also recorded by JL-501 as compared to other varieties.

Asif *et al*. (2017) conducted a field experiment to evaluate groundnut varieties for the agro-ecological zone of Malak and Division at Agriculture Research Institute (North) Mingora, in 2014. Six groundnut varieties (6) were evaluated for different agronomic traits. Randomized complete block design with three replications was used in the experiment. Days to 50% flowering, plant height, seed pod^{-1}, 100 seed weight (gm), and seed yield kg ha^{-1} significantly differ among different genotypes. a genotype PG-1165 and SP-2000 took maximum days to flowering while the lowest days took by PG-1132 and PG-1058 maximum plant height was observed in PG-1165 and SP-2000 while the minimum height was observed in PG- 1132 and PG-1058.Maximum weight of 100 kernel were recorded by SP-2000 and PG-207and the early maturity were recorded by SP-2000 and PG-1058 while the late maturity were recorded by PG-1132 and PG1165 and highest pod length were recorded by PG-214,PG-1132 while the lowest pod length were recorded by PG-1165 and PG-1132 number of seed were maximum counted in PG-1165 pod while minimum in PG-1058,PG-1132,PG-214 and high shelling percentage were recorded by PG-1132 while low recorded by SP-2000 significant difference were recorded by SP-2000 and PG-214 which produce high yield while the lowest yield observed by PG-1058 and PG-1165.

Venkatachalapathi and Rao (2014) conducted field experiment at Agricultural Research Station, Anantapur under AICRP on Agrometerology during kharif seasons of 2009 and 2010 on red sandy loam soil to study the performance of groundnut varieties at different dates of sowing and irrigation regimes. Experimental result revealed that among different varieties of groundnut the variety K-6 realized significantly higher pod yield (1486 kg ha^{-1}) over K-134 (1308 kg ha^{-1}) and K-127 (1250 kg ha^{-1}).

Prathima *et al.* (2012) conducted a field experiment at Regional Agricultural Research Station, Tirupati, ANGR Agriculture University, Hydrabad (AP) and reported that the number of filled pods plant^{-1}, total pods, shelling percentage and pod yield ha^{-1} were recorded higher by Abhaya groundnut variety than other varieties. While 100 pod weight recorded higher by Narayani than other varieties.

Bala *et al.* (2011) were conducted field trails during the 2004 and 2005 cropping seasons at Samaru, Nigeria on groundnut varieties and reported that variety SAMNUT-23 produced significantly more pods plant^{-1} and higher pod, seed and haulm yield than SAMNUT-92.

Ravisankar *et al.* (2010) conducted an experiment during season of 2007-09 at Andman and Nicobar Islands on groundnut varieties and reported that the varieties SG-99 and ICGS-76 performed equally in term of yield.

Makanda *et al.* (2009) conducted a field experiment on Bambara groundnut varieties for off season production at Harare Research Station, Zimbabwe during 2000-01 and reported that varieties BS-599, BS-537, VZ-17, BS-520 and variety-10 had higher relative yield.

On-farm experiments conducted by Bucheyeki *et al.* (2008) for adaptation and adoption of promising groundnut varieties in Tanzania revealed that farmers and 15 researchers ranked Pendo and Johari as the most preferred genotypes. The study also revealed that Pendo (1444 kg ha^{-1}) and Johari (1163 kg ha^{-1}) out yielded other varieties.

Dhadge *et al.* (2008) were conducted field experiment at Zonal Agriculture Research Station, Igatpuri (MS) on groundnut and reported that the groundnut variety ICGS-11 produced significantly higher dry pod, dry haulm and kernel yield than rest of the variety and higher shelling percentage was recorded by the variety T-26 while maximum 100 kernel weight and 100 pod weight was recorded by the variety B-95.

Ahmad *et al.* (2007) conducted an experiment at Agriculture Research Institute (N) Mingera, Swat (NWTP) Pakistan and reported that among different varieties of groundnut the highest pod yield of 2987 kg ha^{-1} was produced by SP-2002, while the lowest pod yield of 2314 kg ha^{-1} was recorded for variety SP-96.

Karanjikar *et al.* (2007) conducted a field experiment at MAU, Parbhani (MS) on groundnut and reported that dry pod yield, kernel yield and harvest index of TAG-24 and ICGS-11 genotype significantly higher than other genotype.

Sardana and Kandhola (2007) conducted a field experiment at PAU Ludhiana in 2006 to study the productivity of semi spreading and bunch type varieties of groundnut as influenced by sowing dates and reported that pod yield ha^{-1}, shelling percentage was significantly higher in SG-99 than other varieties however, pods plant^{-1}, 100 seed weight was significantly higher in M-522 than other varieties.

Bharud and Pawar (2005) conducted a field experiment during summer 1999 at Instructional Farm of Post Graduate Institute, MPKV, Rahuri to study the physiological Basis of yield variation in groundnut varieties under summer condition and reported that among the seven varieties *viz.*, SB-XI, ICGS-11, JL-286, TAG-24, TG-26, RHRG-95 and RHRG-100 the higher pod yield of 35.02 q ha-1 was recorded by variety ICGS-11 and pod yield of other variety i.e. SB-XI, JL-286, TAG-24, TG-26, RHRG-95 and RHRG-100 is 22.55, 26.42, 29.38, 30.25, 34.80 and 24.16 q ha^{-1} respectively.

Talwar *et al.* (2002) conducted a field experiment at the research farm of the Regional Research Station, Central Arid Zone Research Institute (CAZRI), Bikaner in Rajasthan and reported that among the ten varieties of groundnut the ICGV-92113 produced highest pod yield under both BBF (Bio based fertilizer) and BF (Bio fertilizer).

2.3 Plants and salinity stress

Plants are living organisms, affected from the various types of abiotic and biotic stresses such as salinity, drought, flooding, high or low temperature, UV-radiations, herbicides, metal toxicity and pathogen (Ahmad and Prasad, 2012a). Among them, salinity stress has been increasing day by day and reducing the agricultural productivity in large areas of the world. (Hasanuzzaman *et al.*, 2013).

2.4 Effects of salinity on crop growth and productivity

Usually, salinity produces dwarfed, stunted plants with dull colored leaves frequently covered with deposits of wax (Ambede *et al*., 2012). High salt levels in the root zone may induce: cell turgor loss followed by growth reduction or direct plant death through marginal burns, necrotic spots, defoliation depending on severity of salinity (Bawa, 2016). In pigeon pea, growth parameters reduced with salinity possibly through imbalances in nutrients, injurious ions and shortage of water (Ahmed and Ahmad, 2016). Also, soybean exposed to increasing salinity reduced or inhibited nodulation consequently plant growth. Productivity in crops is thus influenced by salinity (Parihar *et al*., 2015). High NaCl levels restrict water and air movement, and porosity of the soil (Egamberdiyeva *et al*., 2019). Additionally, it controls physio-chemical properties of soil decreasing soil health. Thus, poor growth in plants subjected to salinity results from decrease in circulation of nutrients, ROS generation, imbalances in hormones among others (Kumar *et al*., 2020).

The level of injury caused by salts and possible death varies from one species to another and even between varieties in the same species subject to factors like age, concentration of salt, species level of salt tolerance (Yu *et al*., 2016). However, bean plant height substantially increased (Egamberdieva, 2011) and Faba bean improved growth under saline conditions (Metwal *et al*., 2015) as a result of enhanced growth of roots promoting enormous surface area that improved absorption of nutrients. Similarly, under saline conditions productivity in crops and fertility of the soils increased (Grover *et al*., 2011). Although salinity adversely affects growth responses varying leaf morphology, root length and shoot to root ratio in plants (Ambede *et al*., 2012), symbiotic interactions may amend the effect of salinity and improve plant growth. They increase growth in plants through production and regulation of phtyto-hormones such as auxins and cytokinin (Qin *et al*., 2009). Higher auxins and cytokinins quantities are associated with enhanced plant growth, cytokinins maintain totipotency in cells within the growing regions and gibberellins promote growth and yield in plants under salinity (Howell *et al*., 2003). For instance, more gibberellins and auxins were produced in rice leading to greater crop productivity (Castro-Camba *et al*., 2022). This may assist to expound on crop salt tolerance when cultivated in possibly saline environments.

Growth is crucial in plants because survival and reproduction are dependent on plant size, and thus on the rate of growth. Salt interference on growth and productivity in plants is therefore a complicated process relating to water stress, toxicity of ions as well as nutritional effects (Negrão *et al*., 2017). Thus, sodium and chloride ions may cause considerable damage substantially decreasing growth and yield in crops (Lodeyro *et al*., 2016). Therefore, investigating the effects of osmotic, ionic stress, and nutritional imbalances in plants like Bambara groundnuts could enhance the understanding of the effects of NaCl salinity.

2.5 Effect of salinity on groundnut growth, yield attributes and yield

Shradhdha and Subbaiah (2020) carried out a field experiment during 2015 to study the influence of variable concentrations of irrigation water subjected to groundnut crop and its effect on assessed on crop yield response. Four different concentration of saline irrigation water mainly 2 dSm^{-1} (T_1), 4 dSm^{-1} (T_2), 8 dSm^{-1} (T_3) and 12 dSm^{-1} (T_4) applied to vegetative stage (S_1), flowering stage (S_2) and pod development stage (S_3), treatments were replicated four times. Threshold irrigation water salinity level was found to be 2 dSm^{-1} at each stage. FAO approach failed to predict concentration of irrigation water at which relative yield becomes zero accurately. The salinity of irrigation water at which yield become zero was estimated for different stages as per the procedure developed in the present study. Developed approach for yield response to differential salinity at different stages represented with a 3rd or 4th order polynomial equation. Based on different concentration of saline water, concluded that for each stage, yield decreases continuously while salinity increases above threshold level.

Chakraborty *et al*. (2019) examined the effect of salinity (50, 100 and 200 mM NaCl) on the germination of six peanut genotypes. They observed that seed germination and seedling vigour index decreased with increasing salinity concentration.

Satu *et al*. (2019) investigated the effects of salinity on the growth of groundnut (*Arachis hypogaea* L.), variety BARI Badam-8. The plants were grown in a series of plastic pots under controlled light and temperature conditions in the growth room. Salt (NaCl) solutions of different concentrations (0, 50, 100, 150, 200, and 250 mM) were added to the pots, with three replicates. Results showed that shoot height, number of plants, main root length and lateral root length significantly decreased with the increase of salt concentrations. Fresh weight as well as dry weight of shoots and roots also decreased with the increase of salt concentrations.

Meena and Yadav (2018) investigate the seed of two cultivars (TG 37A and GG 2) of groundnut were grown under three different irrigation-water salinity levels (2, 4 and 6 dS m^{-1}) and under normal soil conditions. All plant biometric parameters, including pod and haulm yield, decreased with increasing salinity levels for both seed types and both cultivars. However, biometric parameters were higher in Cultivar GG2 than in TG37A except days to 50% flowering, number of immature pods, 100-pod mass, and 100-seed mass.

An experiment was performed by Pandya and Subbaiah (2017) on groundnut to evaluate the effect of salinity (2, 4, 8 and 12 dS m^{-1}) on yield. Result showed that the haulm yield, pod yield and shelling per cent decreased with increasing soil salinity.

Anny *et al*. (2017) performed an experiment at AICRP on saline water Scheme, Bapatla, Andhra Pradesh to evaluate the performance of groundnut varieties under five salinity levels (0.6, 2, 4, 6 & 8 dS m^{-1}) and found that plant height, pod yield and dry matter production was the maximum with 0.6 dS m^{-1}.

Meena *et al.* (2017) conducted a field experiment at Directorate of Groundnut Research Farm, Junagadh, during 2012-2013 to assess the performance of groundnut-cluster bean cropping system in calcareous saline black clay soils under four different saline irrigation water of ECiw of 0.5, 2.0, 4.0 and 6.0 dS m^{-1} were used for irrigation in groundnut (*kharif*)-cluster bean (summer) rotation. The result revealed that with the increase in salinity levels of irrigation water, there was decrease in seedling emergence, plant height, root length and pod yield of groundnut at highest salinity ECiw 6.0 dS m^{-1}, whereas the same trend was noticed for plant height, dry weight of plant and final plant stand for cluster bean in the next season.

Bahrami *et al*. (2016) conducted pot experiment on sesame cultivars to study the effect of different six salt levels (control, 4.89, 8.61, 10.5, 14.5 and 17.7 dS m^{-1}). Results revealed that sesame respond to increasing salinity caused significantly reduction in plant height, root and shoot growth, yield components and seed yield also.

Meena *et al*. (2016) investigate the two different types of seed (seed harvested from crop grown under salinity and under normal soil condition) of two cultivars (TG 37A and GG 2) were grown under 0.5, 2, 4 and 6 dS m^{-1} levels of salinity. The result revealed that germination per cent, shoot and root length, no. of branches, root and pod weight per plant and pod and haulm yield were significantly reduced with increase in salinity levels for both cultivars and seed types. Relatively shoot length found to be more prone to the increased salinity levels as compared to root length. GG 2 performed better over TG 37A in respect to growth and other yield attributes.

Oliveria *et al.* (2016) examined the effect of salinity (0.5, 1.5, 2.5, 3.5, 4.5 and 5.5 dS m^{-1}) on physiological and morphological characteristics of groundnut. The result showed that increasing salinity, reduced the plant height, fresh and dry weight of shoot, stem diameter, fresh and dry weight of root, no. of branches $plant^{-1}$ and leaf area.

An experiment was carried out by Tayyab *et al.* (2016) in order to investigate the effect of sea salt concentrations (0.5, 1.6, 2.8, 3.5, 3.8 and 4.3 dS m^{-1}) on growth and yield of pigeon pea plant. They reported that salinity adversely affect the reproductive growth of pigeon pea plant where production of flower, pods, number of seeds and seed weight were significantly reduced with salinity.

Singh *et al*. (2016) carried out an experiment to identify salinity tolerant genotypes based on plant mortality, seed yield and nutrient absorption through field screening of 210 high yielding peanut germplasm. Result revealed that the salinity (4.5 dS m^{-1} at sowing and 3.5–3 dS m^{-1} 15–80 days after sowing), reduced plant stand, yield and yield attributes in peanuts with 0-70 % plant mortality and 9-78 percent plant stand (average 51 %) at maturity, and out of 210 genotypes, only 134 showed pods setting.

The effect of soil salinity level (6.3, 7.6, 8.8, 9.4, 10.6 and 11.8 dS m^{-1}) on groundnut growth and yield were studied by Abd EI-Rheemkh and Zaki (2015). They found that growth and yield attributes like plant height, no. of branches per plant, straw yield and grain yield reduced with salinity.

The research was carried out by Aydinsakir *et al.* (2015) in order to determine the effect of different salinity levels (control, 1, 2, 4, 8 and 16 dS m^{-1}) on the growth and development of peanut. Results showed that plant height and fresh weight decreased as much as 21.6 % and 21.4 %respectively after 4 dS m^{-1}, while root length decreased 30 % after 8 dS m^{-1} compared to control treatment.

Sareh *et al*. (2015) examined the effect of salinity (0, 50, 100 and 150 mM NaCl) on the morphological and physiological characteristics of three cultivar of peanut (local cultivar of Guilan, ICGV-96177 and ICGV-03060). The result showed that increasing salinity, reduced the size of morphological traits of seedlings in all cultivars. They also observed that under salinity stress, local cultivar Guilan was less sensitive to salinity compared to the other investigated cultivars.

Shrimali *et al.* (2015) studied on ten groundnut cultivars under different salinity levels (control, 40, 80, 120 and 160 mM NaCl). Results revealed that shoot length, root length, no. of secondary root, germination percentage and seed vigour index decreased with increasing salt concentration.

Kekere (2014a) carried out trials with groundnut on saline soil with different salinity levels. He observed that salinity significantly reduced the shoot length, collar diameter, leaf area, root length, relative growth rate and numbers of leaves, branches and root nodules per plant in groundnut at 150 to 200 mM NaCl saline levels.

A field experiment was conducted by Meena *et al.* (2014) to assess the possibilities for use of saline irrigation water (0.5, 2, 4 and 6 dS m^{-1}) in *kharif* groundnut and rabi mustard during 2005-06 and 2006-07. Result indicated that germination of groundnut was delayed by 3 to 4 days under saline water irrigation. The salinity affect the no. of pods and pod weight per plant in groundnut and initial plant growth stage like plant stand, plant height and days to flowering in mustard crop. It was clearly evident from the results that mustard crop was more resistance to salinity hazard as compare to groundnut crop.

Osuagwa and Udogy (2014) carried out experiment to study the effect of different level of salinity (0.02, 0.03, 0.07 and 0.1 mol L^{-1}) on growth and yield of groundnut. Result showed that Salt stress significantly affected the growth of groundnut. At higher salt (NaCl) concentration (0.07 and 0.1 mol L^{-1}) the length of shoot, numbers of leaves, number of branches, number of pods, length of pod, pod biomass, root biomass and shoot biomass were significantly reduced. However, at lower concentration (0.01 to 0.03 mol L^{-1}) the effect of salt stress on these parameters was not significant.

A greenhouse experiment was carried out by Ambede *et al.* (2012) on two bambara groundnut vatieties (Mumias and Kakamega) to study the effect of different salinity levels (control, 6.96, 12.93, 19.89 and 25.86 dS m^{-1}). Results showed that germination percentage, root length, root dry weight, shoot dry weight and leaf area decreased with increasing salinity in both varieties.

Agarwal *et al*. (2011) conducted experiment on effect of salinity (ECe 2.1 dS m^{-1} and ECe 7.5 dS m^{-1}) on morpho-physiological parameters, photosynthetic efficiency, water relation parameter in four *Brassica* genotype namely T-59, CS-52, YST-151 and NDYS-2. They concluded that salinity reduced the plant height, number of branches plant^{-1}, leaf area plant^{-1}, leaf area index, number of siliqua plant^{-1}, above ground phyto-mass productivity, seed yield, stover yield and harvest index.

Lakshman *et al.* (2011) carried out experiment at West Bengal on groundnut cultivar JL-24 with different level of soil salinity (1.63, 1.85, 2.06, 2.26, 2.37, 2.49, 2.58, 2.70 dS m-1). The result showed that germination per cent, plant height, days to 50 % flowering, no. of branch plant^{-1}, no. of pod plant^{-1}, leaf area, no. of seed pod^{-1} and weight of pod plant^{-1} decreased with increasing soil salinity. Other characters such as pod yield, haulm yield and shelling per cent also reduced with salinity.

Salama (2011) studied the influence of different levels of salinity on yield of groundnut. Four salinity levels were use; control, 2.4, 2.7, 3.3 and 4.4 dS m^{-1}. The result showed that the high salinity decreased the yield from 3.89 ton ha^{-1} to 1.54 ton ha^{-1} with the successive increase in salinity from control to 4.4 dS m^{-1}, respectively.

The laboratory experiment was conducted by Taffouo *et al.* (2010a) in three bambara groundnut cultivars under different NaCl levels (0, 50, 100 and 200 mM). Results indicated that growth and yield component decreased with increasing NaCl levels.

Vadez *et al.* (2005) reported that the ratio of biomass production and nodulation were decreased with increasing salinity levels. They also reported that tolerant plant are able to maintain leaf size to that of control even at high salinity level. Stem leaves ratio increase with increasing salinity.

2.6 Relative tolerance of groundnut varieties under salt stress conditions

Gohari *et al.* (2018) taken field experiment on effect of salinity (1, 3, 5 and 7 dS m^{-1}) on growth and yield attributes in four groundnut cultivar (Guil, Gorgani, Jonobi and Mesri). They concluded that plant height, no. of pod per plant, pod length, seed yield and 100 seed weight higher in Guil cultivar than other cultivars at salinity level 5 dS m^{-1}.

Shrivastava *et al*. (2018) carried out three year experiment to evaluate the seed yield potentials of 275 genotypes of groundnut. The result indicated that significant variation among the genotypes in respect of seed yield parameters. They also observed 14 tolerant and 17 sensitive groundnut genotypes based on pod-seed yield and pod-seed numbers under saline conditions in the seasons studied. Among all the genotypes, ICGV 87187 and ICGS 76 were the most tolerant lines and ICG 6993 and ICG 4746 were the most susceptible lines in 2006 and 2006-2007, respectively.

Singh *et al.* (2017) screened twenty groundnut cultivars in the field at two salinity levels (2 and 4 dS m^{-1}) during summer 2015. Result showed that soil salinity delayed the germination by 7-10 days followed by seedling mortality, reduction in germination rate, plant height, no. of pods per plant and pod and haulm yields. In general, this groundnut cultivars showed 15 % lesser germination and 34 % lesser pod yield at 4 dS m^{-1} than 2 dS m^{-1} salinity. Among these, cultivar VRI 16, LGN 1 and VRI 4 very sensitive to salinity while TLG 45, CO 3 and JGN 23 more tolerant to salinity compared to other cultivars.

A laboratory experiment was carried out by Pal and Pal (2017) on 26 groundnut genotypes under control and 200 mM NaCl treatment. Out of all the genotypes, KDG-197 was found to be most salinity tolerant based on their relative performance under stress in respect to dry weight followed by R 2001, VG 315, TCGS 1157 and TG 51.

Putri *et al.* (2017) displayed experiment on sixteen genotypes with concentration of NaCl were (0, 75 and 125 mM). The response of sixteen genotypes of soybean into salinity stress is clearly visible at sprout length and fresh weight variable. Ichiyou was sensitive based on all variable especially sprout length and fresh weight, while Baluran was salt tolerant up to 125 mM NaCl based on sprout length and fresh weight.

A field experiment was conducted by Agarwal *et al.* (2015) to test the salinity tolerance of two soybean genotypes (PK-416 & PS-1347) under six different levels of salt concentrations. Results revealed that among the yield components no. of pods, fresh and dry weight of pods per plant were significantly reduced with increasing salt concentration. In which, reduction being maximum in PS-1347. Thus, PK-416 proved tolerant under saline condition.

Kekere (2014b) examined the effect of salinity (0, 25, 50, 100, 150 and 200 mM NaCl) on the growth and yield attributing characters of ten genotypes of groundnut. He observed that ICG-IS-3584, ICGY-5M-4746 and ICG-IS-6646 genotypes recorded higher germination per cent, plant height, no.of leaves per plant, no. of branches, no. of nodes on primary stem, no. of pod plant^{-1}, no. of seed pod^{-1} and no. of seed plant^{-1} as compared to other genotypes.

Azad *et al*. (2014) carried out an experiment to evaluated three varieties of groundnut for their morphological and yield attributes under different level of salinity (control, 2.5, 5, 7.5, 10 and 12.5 dS m^{-1}). Based on relative performance of yield contributing characters (plant height, no. of leaf per plant, leaf weight per plant and root and shoot biomass) Binachinabadam-3 emerged to be a tolerant variety and Dacca-1 appeared as tolerant while Zhingabadam always performed as sensitive variety.

A pot experiment was conducted by Nithila *et al.* (2013) subjected to three concentration of NaCl solution (50 mM, 100 mM, 125 mM) on ten groundnut cultivars. They revealed that Leaf area and photosynthetic surface of the plant was drastically reduced under salinity stress. High level of salinity stress caused a mean leaf area reduction of 8.3 % in CO-4 cultivar whereas 15 % reduction in ALR 3 cultivar. Overall, groundnut variety CO-4 was identified as the most tolerant variety to salt stress and ALR 3, the most sensitive one.

Meena *et al.* (2012) conducted a field experiment at Directorate of Groundnut Research, Junagadh (Gujarat) during 2007-08 and 2008-09 to evaluate the performance of groundnut-pearl-millet cropping system using water varying in salinity levels (control, 2, 4 and 6 dS m^{-1}). Among the tested genotypes, ICGS 76 and GG 20 were found more tolerant to salinity than other genotypes. The other genotypes performed well at germination stage, but did not perform well at the later stages of crop growth. With an increase in the salinity of the irrigation water, the soil salinity in the root zone increased both in groundnut and pearl millet crops but the buildup in salinity was more in pearl millet than in *kharif* groundnut plots mainly owing to availability of sufficient rain water to leach down the salt below the root zone in case of groundnut.

An experiment was carried out by Gajera *et al.* (2010) on six genotype of groundnut under sulphate and chloride dominant salinity (0, 20, 40 and 80 meq L^{-1}). They observed that sulphate dominant salinity was more detrimental to germination and seedling growth than chloride dominant salinity. Germination percentage, root and shoot length, fresh and dry weight of seedling and vigour index recorded higher in JL-24 followed by GG-2 and GAUG-10.

Salwa *et al.* (2010) conducted experiment on two peanut cultivars namely Gregory and Giza 6 with three soil salinity levels (7.55, 9.20 and 12.5 dS m^{-1}). They resulted that all studied characters of growth showed significant decrease with increasing salinity levels. Gregory variety had best growth and yield as compared to Giza 6. Gregory variety had the best growth and yield and also it was more stable in its physiological and chemical component under salt stress conditions compared to variety Giza 6.

Singh *et al.* (2007) directed experiment on twenty seven groundnut cultiivars with five levels of salinity (control, 10, 18, 25 and 31 dS m^{-1}). They resulted that cultivar Kopergaon 3, MH 2, Gangapuri, Tirupati 4, ICGV 86590 and GG 4 showed more than 70 per cent germination in 31 dS m^{-1} but, cultivars TMV 12, ICGS 44 and VRI 4 showed about 44 per cent reduction in germination. Though germination percentage decreased with increasing salinity levels, genetic variations in the sensitivity to salinity was wide in 25 and 31 dS m^{-1}. Apart from germination, average root length also decreased with increasing salinity levels.

Mensah *et al.* (2006) conducted experiment at Nigeria on groundnut varieties (Ex-Dakar, RRB 12, RMP 12, RMP 91 and Esan Local) with different level of salinity (0.015, 1.50, 2.60, 4.68, 8.90 and 17.0 dS m^{-1}). The result get that seedling edmergence, radicle elongation, plant height and dry matter weight also tended to decrease with increasing salinity. Other characters such as leaves per plant and number of branches per plant were significantly reduced with salinities higher than 2.60 dS m^{-1}. Esan Local, Ex-Dakar and RRB 12 as being more salt tolerant than the other genotypes under saline irrigation condition.

CHAPTER III

MATERIALS AND METHODS

The materials and methods used in the experiment were organized in this chapter, which includes a brief overview of the experimental location, groundnut variety, soil, climate, land preparation, experimental design, treatments, soil and plant sample collection cultural operations, and analytical methods. Here were the specifics of the research method.

3.1 Description of the experimental site

3.1.1 Location

The experiment was conducted at the Agronomy Field, Sher-e-Bangla Agricultural University, Dhaka-1207, during the period of February to July 2020 to observe the performance of different groundnut variety as influenced by different levels of salinity. The experimental filed is located at 23°41' N latitude and 90°22' E longitude at a height of 8.6 m above the sea level belonging to the Agro-ecological Zone “AEZ-28” of Madhupur Tract (BBS, 2020).

3.1.2 Soil

The soil of the research is slightly acidic in reaction with low organic matter content. Soil sample from 0-15 cm depth were collected and filled in the experimental pot after sun dried and crushed. The physical properties and nutritional status of soil of the experimental pot are given in Appendix I.

3.1.3 Climate

The experimental location was suited under the sub-tropical climate, usually the rainfall is heavy during Kharif season, (April to September) and scanty in Rabi season (October to March). In Rabi season temperature is generally low and there is plenty of sunshine. The temperature tends to increase from February as the season proceed towards Kharif and temperature was so high during April to July in spite of having sometimes rainfall. Rainfall was scanty during March to April 2020, but increase from May to July. The monthly total rainfall, average temperature during the study period (March to July) has been presented in Appendix II.

3.2 Planting materials

Fourteen (14) varieties of groundnut were used in this experiment to studies the performance of these varieties under salt stress conditions. Seeds were collected from Bangladesh Agricultural Research Institute (BARI), Gazipur and Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. Average plant height of these varieties ranged from 30-42 cm. Average yield in Kharif season 1.6-1.8 t ha^{-1} to 2.5 t ha^{-1}. Selected verities require about 120-142 days for completing its life cycle in Kharif season. The sources of these genotypes were shown in Table 1.

Table 1. The list and sources of the genotypes used in the experiments

SL. No.	Variety	Genotypes	Source
1	V_1	BINA Chinabadam-4	BINA
2	V_2	BINA Chinabadam-5	BINA
3	V_3	BINA Chinabadam-6	BINA
4	V_4	BINA Chinabadam-8	BINA
5	V_5	BINA Chinabadam-9	BINA
6	V_6	BINA Chinabadam-10	BINA
7	V_7	Dhaka-1	BARI
8	V_8	BARI Chinabadam-5	BARI
9	V_9	BARI Chinabadam-6	BARI
10	V_{10}	BARI Chinabadam-8	BARI
11	V_{12}	BARI Chinabadam-9	BARI
12	V_{12}	BARI Chinabadam-10	BARI
13	V_{13}	Zhingabadam	BARI
14	V_{14}	Bashanti	BARI

3.3 Soil preparation

The initial soil were collected before experimental pot preparation. Soil was collected from agronomy field of Sher-e-Bangla Agricultural University, Dhaka-1207. After collection of soil, the plant roots, leaves etc. were picked up and removed. The collected soil was sun dried, crushed and sieved properly.

3.4 Fertilizer application

The following doses of manure and fertilizer were used. The soil and fertilizers were mixed well before placing the soils into the pots. Fertilizers were applied to the experimental pot considering the recommended doses of BARI (2019).

Manures/fertilizers	Doses ha^{-1}
Urea	25 kg
TSP	160 kg
MoP	85 kg
Gypsum	170 kg
$ZnSO_4$	4 kg
Boric acid	10 kg

(BARI, 2019).

Half dose of urea and all others fertilizer were applied during final soil preparation and incorporated in each pot. The rest half urea was applied at 45 days after sowing (DAS) when flowers were initiated by side dressing.

3.5 Preparation of pot

The size of the pot was 35 cm height and 30 cm diameter. The pots were filled with about 10 kg soil that were collected from field and exposed to sun for 12 hours. Required amount of organic manures and chemical fertilizers were added to each pot.

3.6 Experimental treatment

The experiment consisted of 2 factors:

Factors A: Groundnut varieties

There were 14 varieties under study and they were-

V_1 = BINA Chinabadam-4,

V_2 = BINA Chinabadam-5,

V_3 = BINA Chinabadam-6,

V_4 = BINA Chinabadam-8,

V_5 = BINA Chinabadam-9,

V_6= BINA Chinabadam-10,

V_7= Dhaka-1,

V_8 = BARI Chinabadam-5,

V_9 = BARI Chinabadam-6,

V_{10} = BARI Chinabadam-8,

V_{11} = BARI Chinabadam-9,

V_{12} = BARI Chinabadam-10,

V_{13} = Zhingabadam,

V_{14}= Bashanti

Factors B: Levels of salinity

There were three level of salinity. There were-

S_0 = 0 mM NaCl (Control),
S_1 = 50 mM NaCl and
S_2 = 100 mM NaCl

3.7 Experimental design

The experiment was laid out in a RCBD pot experiment design with three replications. Each experimental unit was divided into three blocks each of which representing a replication which content 42 units plot. There were altogether 126 units of pots, each pot was measuring $15cm^2$.

3.8 Sowing of seeds

The seeds were sown on 15 February 2020 to the experimental pot. Before sowing, seeds were treated with Provax-200 Ec @ 2.5 g powder kg^{-1} seed. After providing slight water in each pot, 5 seeds were sown in each pot.

3.9 Application of NaCl

The salinity treatments were induced after establishment of seedlings. Three levels of NaCl were added on pot as per treatments in three equal instalments at 30, 40 and 45

DAP. 50 mM NaCl concentration, 100 mM NaCl concentration were prepared by 0.731 g NaCl and 1.463 g NaCl were dissolved in 250 ml water respectively.

3.10 Intercultural operations

3.10.1 Gap filling and thinning

Continuous observation was done after seed sowing. It was observed that some seeds germinated early and some were later. Keen observation was made for thinning to maintain uniform seedlings. Thinning was done to maintain spacing of the plants.

3.10.2 Weeding and Irrigation

Sometimes there were some weeds observed in pots which were uprooted manually. Irrigation was done one day after one day to maintain moisture level with a hand sprayer in a certain amount so that salinity levels were not changed.

3.10.3 Plant protection measure

As the pots were in net house, Birds did not harm. There was not seen any other insect pests except rat. For this reason, rodenticides were used to control rat.

3.11 General observations of the experimental field

Regular observations were made to see the growth and visual differences of the crops. Incidence of white fly, ants were observed during vegetative growth stage and there were also some mites were present in the experimental pot. The flowering was not uniform.

3.12 Harvesting and post-harvest operation

There is a thumb rule that the crop should be harvested when about 75% of the pods became mature. After observing some maturity indices such as leaf became yellow, spots on the leaf, pod became hard and tough and dark tannin discoloration inside the shell crops were harvested. The Samples were collected from of each pot. During harvest the pod contained 35% moisture. The harvested crops were tied into bundles and carried to the threshing floor. Then the pods were separated from the plants. The separated pod and the stover were sun dried by spreading those on the threshing floor. The seeds were separated from the pod and dried in the sun for 3 to 5 consecutive days for achieving safe moisture (8%) of seed.

3.13 Collection of data

The yield and yield contributing parameters were measured at harvest. Growth, and physiological parameters were recorded on specific date. Data were collected on the following parameters:

a. Growth parameters

i. Plant height (cm)
ii. Number of leaf
iii. Number of branch

b. Yield and yield contributing parameters

iv. Number of pods pot^{-1}
v. Number of true pods pot^{-1}
vi. Number of seed pod^{-1}
vii. Pod weight plant^{-1} (g)
viii. Seed weight pot^{-1}
ix. Stover yield pot^{-1}

3.14 Procedures of data collection

i. Plant height

Plant height was measured from the ground level to top of the plant at 40, 65 and 90 DAP, and during harvesting. Mean plant height of groundnut plant were calculated and expressed in cm.

ii. Number of leaf plant^{-1}

Number of leaf was measured at 40, 65 and 90 DAP, and at harvest from each plant. The average was calculated and expressed as number of leaves plant^{-1}.

iii. Number of branch plant^{-1}

Number of branch was measured from each plant and the average was calculated and expressed as number of branch plant^{-1}

iv. Number of pods pot^{-1}

Number of pods pot^{-1} was counted from all plants of each pot to find out the average pods number pot^{-1}.

v. Number of true pods pot^{-1}

Number of true pods pot^{-1} was counted from the all plants of each pot to find out the average true pods number pot^{-1}.

vi. Number of seeds pot^{-1}

Number of seeds pot^{-1} was counted from the from the all plants of each pot to find out the average number of seeds pot^{-1}.

vii. Pod weight pot^{-1}

The pod weight was calculated from each pot and expressed as pod weight pot^{-1} in g.

viii. Seed weight pot^{-1}

Seed yield was calculated from shelled, cleaned and well dried pod collected from each pot and expressed as g pot^{-1} on 8 % moisture basis.

ix. Stover yield pot^{-1}

Stover yield was calculated from each pot and expressed as g pot^{-1} after sun drying.

3.15 Data analysis technique

The collected data were compiled and analysed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program Statistix-10 and then mean difference were adjusted by Least Significant Difference (LSD) at 5% levels of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

Results obtained from the present study have been presented and discussed in this chapter with a view to study the performance of groundnut varieties under salt stress conditions. The data are given in different tables and figures. The results have been discussed, and possible interpretations are given under the following headings.

4.1 Growth characters

4.1.1 Plant height (cm)

Effect of variety

Plant height is an essential character of the vegetative stage of the crop plant and indirectly impacts on yield (Dash *et al.*, 2021). Different variety significantly influenced on plant height of groundnut at different days after planting (DAP). It was seen that height increased gradually with the age of the crop up to harvest (Table 2). Experimental result revealed that the plant height of groundnut significantly varied at 40, 65, 90 DAP and at harvest respectively, due to cultivation of different varieties of groundnut. At harvesting stage, BARI Chinabadam-5 showed the highest plant height (44.94 cm) which was statistically similar with Dhaka-1 (42.71 cm) and Zhingabadam (42.62 cm) groundnut variety, while the lowest plant height (31.91 cm) was found from BINA Chinabadam-8 variety. The variation of plant height is probably due to the genetic make-up of the varieties. Ibrahim *et al.* (2022) reported that plant height in groundnut varieties is determined by genetic character, and under a given set of environmental conditions, different varieties will acquire their height based on their genetic makeup.

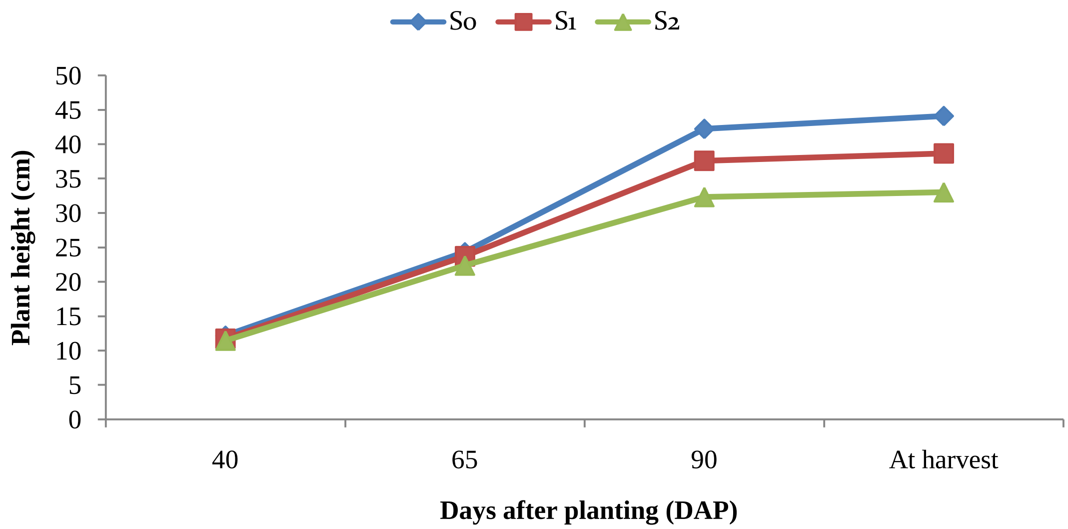
Table 2. Effect of variety on the plant height of groundnut at different days after planting.

Treatments	Plant height (cm) at			
	40 DAP	65 DAP	90 DAP	At harvest
V_1	11.08 cd	21.74 f	38.06 c-e	38.27 cd
V_2	13.03 ab	21.36 fg	34.02 h	34.96 ef
V_3	11.57 b-d	23.69 e	34.80 f-h	37.32 de
V_4	11.43 b-d	19.76 gh	30.27 i	31.91 g
V_5	11.13 cd	19.67 gh	38.56 cd	38.44 cd
V_6	10.06 de	18.58 h	34.64 gh	34.53 f
V_7	12.01bc	28.18 a	37.18 d-f	42.71 ab
V_8	11.29 b-d	25.62 cd	42.42 ab	44.94 a
V_9	9.84 de	20.27 f-h	35.84 e-h	36.50 d-f
V_{10}	14.20 a	26.31 bc	37.00 d-g	38.13 d
V_{11}	14.33 a	25.69 c	38.56 cd	41.07 b
V_{12}	13.97 a	26.24 bc	40.40 bc	40.73 bc
V_{13}	12.06 bc	27.42 ab	43.29 a	42.62 ab
V_{14}	9.02 e	23.96 de	38.56 cd	38.31 cd
$LSD_{0.05}$	1.75	1.69	2.43	2.53
CV (%)	9.13	4.43	3.99	4.02

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, V_1 = BINA Chinabadam-4, V_2 = BINA Chinabadam-5, V_3 = BINA Chinabadam-6, V_4 = BINA Chinabadam-8,V_5 = BINA Chinabadam-9, V_6= BINA Chinabadam-10, V_7= Dhaka-1, V_8 = BARI Chinabadam-5, V_9 = BARI Chinabadam-6, V_{10} = BARI Chinabadam-8, V_{11} = BARI Chinabadam-9, V_{12} = BARI Chinabadam-10, V_{13} = Zhingabadam, V_{14}= Bashanti.

Effect of salt stress

Exposure of salinity had significant impact on plant height of groundnut at 40, 65 DAP and at harvest (Figure 1). At 40, 65, 90 DAP and at harvest the highest plant height (12.17, 24.30, 42.24 and 44.11 cm, respectively) was observed in S_0 treatment and the lowest plant height (11.45, 22.37, 32.34 and 33.03 cm, respectively) was observed in S_2 (100 mM NaCl) treatment. Salinity decreased plant height throughout life cycle of groundnut The decreasing rate of plant height increased with the increment of salinity level. Exposure of 100 mM NaCl decreased plant height by 6, 8, 23 and 25% at 40, 65 and 90 DAP and at harvest, respectively, compared with control. Gradual decrease in plant height might be due to the nutrient unavailability caused by increased salinity or the inhibition of cell division or cell enlargement. The result obtained from the present study was similar with the findings of Anny *et al*. (2017) who reported that plant height of groundnut decreased with the increment of salinity levels.



Note: Here, S_0 = 0 mM NaCl, S_1 = 50 mM NaCl and S_2 = 100 mM NaCl.

Figure 1. Effect of salt stress on the plant height of groundnut at different days after planting.

Combined effect of variety and salt stress

Combined effect of variety and salt stress significantly affected plant height of groundnut at 40, 65, 90 DAP and at harvest (Table 3). Experimental result revealed that at harvesting time exposure of 50 and 100 mM NaCl decreased plant height in BINA Groundnut -4 by 20 and 33%, respectively. In BINA Chinabadam-5, plant height reduction by 50 and 100 mM NaCl was 17 and 43%, respectively, compared with control. Whereas, it was only 2 and 13 % in BARI Chinabadam-10. The results were quite similar to the findings of Gohari *et al.* (2018), who reported that the Guil groundnut cultivar had the smallest reduction in plant height at salinity level 5 dS m^{-1} due to its tolerance of salt stress conditions than other cultivars.

Table 3. Combined effect of variety and salt stress on the plant height of groundnut at different days after planting.

Treatment combinations	Plant height (cm) at			
	40 DAP	65 DAP	90 DAP	At harvest
V_1S_0	11.07 d-j	22.49 h-n	45.00 ab	46.60 b-d
V_1S_1	10.63 e-j	21.93 i-o	38.73 d-k	37.13 i-m
V_1S_2	11.53 c-j	20.80 k-p	30.05 r-u	31.07 o-q
V_2S_0	12.83 a-h	22.73 g-m	40.93 b-h	43.67 b-f
V_2S_1	13.63 a-e	21.13 k-p	35.87 i-p	36.40 j-n
V_2S_2	12.63 a-i	20.20 l-q	25.27 u	24.80 r
V_3S_0	12.27 a-i	24.63 c-j	41.47 b-f	42.77 c-h
V_3S_1	10.72 e-j	24.18 c-k	35.20 k-q	37.47 i-m
V_3S_2	11.73 c-j	22.27 h-n	27.73 t-u	31.73 n-q
V_4S_0	10.77 e-j	20.20 l-q	33.73 l-r	36.20 j-o
V_4S_1	12.30 a-i	20.27 l-q	29.60 r-u	31.33 n-q
V_4S_2	11.23 c-j	18.80 o-q	27.47 tu	28.20 p-r
V_5S_0	11.33 c-j	21.40 j-p	44.20 bc	44.80 b-e
V_5S_1	11.40 c-j	19.53 m-q	38.13 d-m	37.40 i-m
V_5S_2	10.67 e-j	18.07 pq	33.33 m-s	33.13 l-p
V_6S_0	10.07 f-j	19.27 n-q	41.07 b-g	43.20 c-g
V_6S_1	10.20 e-j	19.27 n-q	34.20 k-r	33.27 l-p
V_6S_2	9.90 g-j	17.20 q	28.67 s-u	27.13 qr
V_7S_0	12.03 b-j	28.60 ab	44.27 bc	47.47 bc
V_7S_1	12.37 a-i	28.60 ab	36.00 h-p	42.07 d-i
V_7S_2	11.62 c-j	27.33 a-d	31.27 p-t	38.60 f-k
V_8S_0	11.07 d-j	26.80 a-e	50.00 a	53.27 a
V_8S_1	11.53 c-j	26.67 a-e	45.20 a-c	48.73 ab
V_8S_2	11.27 c-j	23.40 e-l	32.07 o-t	32.83 m-p
V_9S_0	9.57 h-j	21.53 j-o	40.53 b-i	41.03 e-j
V_9S_1	10.03 g-j	20.53 l-q	36.40 g-o	36.97 i-m
V_9S_2	9.93 g-j	18.73 o-q	30.60 q-t	31.50 n-q
$V_{10}S_0$	14.43 a-d	27.20 a-d	40.47 b-i	41.87 d-i
$V_{10}S_1$	14.57 a-d	26.27 a-f	37.80 e-m	38.20 g-l
$V_{10}S_2$	13.60 a-f	25.47 b-h	32.73 n-s	34.33 k-o
$V_{11}S_0$	15.70 a	26.00 b-g	41.87 b-f	45.13 b-e
$V_{11}S_1$	14.47 a-d	25.40 b-h	38.33 d-l	41.13 e-j
$V_{11}S_2$	12.83 a-h	25.67 b-h	35.47 j-q	36.93 i-m
$V_{12}S_0$	15.30 ab	26.53 a-f	42.47 b-e	42.87 c-h
$V_{12}S_1$	13.30 a-g	26.80 a-e	40.26 c-j	42.07 d-i
$V_{12}S_2$	13.30 a-g	25.40 b-h	38.47 d-l	37.27 i-m
$V_{13}S_0$	14.67 a-c	29.67 a	44.47 bc	47.33 bc
$V_{13}S_1$	10.73 e-j	27.47 a-c	43.07 b-d	41.33 e-j
$V_{13}S_2$	10.77 e-j	25.13 c-i	42.36 b-e	39.20 f-k
$V_{14}S_0$	9.30 h-j	23.20 f-l	40.47 b-i	41.33 e-j
$V_{14}S_1$	8.50 j	24.00 d-k	37.87 e-m	37.87 h-m
$V_{14}S_2$	9.27 ij	24.67 c-j	37.33 f-n	35.73 k-o
$LSD_{0.05}$	3.57	3.45	4.95	5.14
CV (%)	9.13	4.43	3.99	4.02

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, S_0 =0 mM NaCl, S_1 = 50 mM NaCl and S_2 = 100 mM NaCl; V_1 = BINA Chinabadam-4, V_2 = BINA Chinabadam-5, V_3 = BINA Chinabadam-6, V_4 = BINA Chinabadam-8,V_5 = BINA Chinabadam-9, V_6= BINA Chinabadam-10, V_7= Dhaka-1, V_8 = BARI Chinabadam-5, V_9 = BARI Chinabadam-6, V_{10} = BARI Chinabadam-8, V_{11} = BARI Chinabadam-9, V_{12} = BARI Chinabadam-10, V_{13} = Zhingabadam, V_{14}= Bashanti.

4.1.2 Number of leaves plant^{-1}

Effect of variety

Depending on the variety, number of leaves plant^{-1} of groundnut varied significantly at 40, 65, 90 DAP and at harvest (Table 4). According to the experimental results, at harvesting stage, the highest number of leaves plant^{-1} of groundnut (48.69) was observed from Bashanti variety, while the lowest number of leaves plant^{-1} of groundnut (27.72) was observed from BINA Chinabadam-5 variety which was statistically similar with BINA Chinabadam-4 (29.07), BINA Chinabadam-8 (29.09) and BINA Chinabadam-10 (28.82) variety. The reason of difference in number of leaves among varieties are the genetic makeup of the varieties, which is primarily influenced by heredity. Aliyu *et al.* (2020) found a significant difference in the number of leaves plant^{-1} between different groundnut varieties.

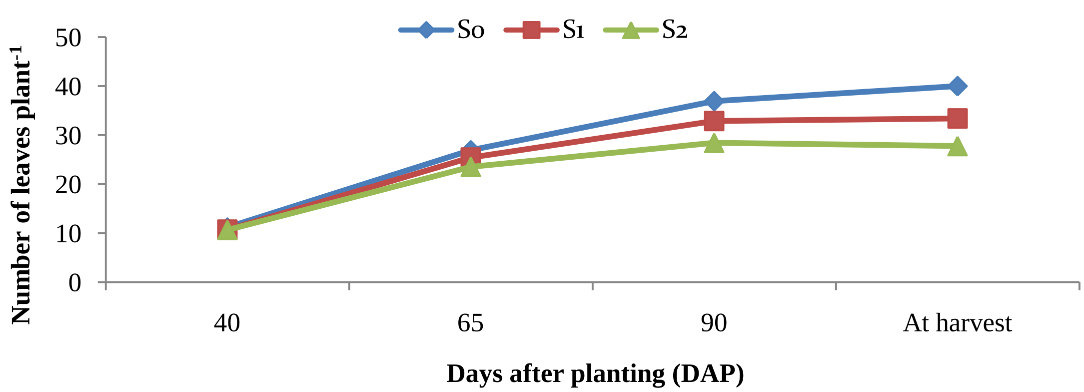
Table 4. Effect of variety on the number of leaves plant^{-1} of groundnut at different days after planting.

Treatments	Number of leaves plant^{-1} at			
	40 DAP	**65 DAP**	**90 DAP**	**At harvest**
V_1	6.58 h	20.16 de	30.08 d-f	29.07 gh
V_2	7.62 gh	19.67 de	28.20 fg	27.72 h
V_3	10.71 de	21.89 d	32.49 d	33.96 de
V_4	10.93 cd	20.27 de	28.31 e-g	29.09 gh
V_5	10.29 d-f	16.73 f	31.42 d	32.64 d-f
V_6	8.96 fg	18.33 ef	26.60 g	28.82 gh
V_7	9.13 e-g	27.64 bc	30.20 d-f	32.38 d-f
V_8	10.56 de	26.13 c	30.42 d-f	29.47 gh
V_9	16.98 a	38.16 a	49.36 a	44.93 b
V_{10}	14.16 b	25.56 c	32.16 d	34.76 d
V_{11}	12.47 c	27.04 bc	31.04 d-e	31.09 fg
V_{12}	10.58 de	28.56 b	35.82 c	37.53 c
V_{13}	10.91 cd	26.38 bc	31.19 d	32.02ef
V_{14}	11.71 cd	37.64 a	41.27 b	48.69 a
$LSD_{0.05}$	1.58	2.23	2.75	2.55
CV (%)	8.95	5.43	5.15	4.64

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, V_1 = BINA Chinabadam-4, V_2 = BINA Chinabadam-5, V_3 = BINA Chinabadam-6, V_4 = BINA Chinabadam-8,V_5 = BINA Chinabadam-9, V_6= BINA Chinabadam-10, V_7= Dhaka-1, V_8 = BARI Chinabadam-5, V_9 = BARI Chinabadam-6, V_{10} = BARI Chinabadam-8, V_{11} = BARI Chinabadam-9, V_{12} = BARI Chinabadam-10, V_{13} = Zhingabadam, V_{14}= Bashanti.

Effect of salt stress

Number of leaves plant^{-1} of groundnut was significantly affected by different salinity levels at 65, 90 DAP and at harvest (Figure 2). At 40, 65, 90 DAP and at harvest, the highest number of leaves plant^{-1} (11.14, 26.90, 36.94 and 40.01) was observed in control treatment (S_0) and the lowest number of leaves plant^{-1} (10.64, 23.54, 28.42 and 27.77) was observed in S_2 treatment. Application of 100 mM NaCl decreased the number of leaves plant^{-1} of groundnut by 4, 12, 23 and 30% at 40, 65, 90 DAP and at harvest compared to control treatment. Our results were similar with the findings of Kekere (2014a) who reported that the agronomic characteristics of groundnut such as number of leaves plant^{-1} and number of branches plant^{-1} were significantly reduced at 150 to 200 mM NaCl saline levels.



Note: Here, S_0 = 0 mM NaCl, S_1 = 50 mM NaCl and S_2 = 100 mM NaCl.

Figure 2. Effect of salt stress on the number of leaves plant^{-1} of groundnut at different days after planting.

Combined effect of variety and salt stress

Combined effect of variety and salt stress significantly affected the number of leaves plant^{-1} of groundnut at 40, 65, 90 DAP and at harvest (Table 5). The experimental results showed that at harvesting time, 50 and 100 mM NaCl exposure reduced leaves number in BINA Chinabadam-5 by 34 and 61%, respectively. Number of leaves plant^{-1} was reduced by 27 and 55% in BINA Chinabadam-4 by exposure of 50 and 100 mM NaCl, respectively, when compared to the control. While in BARI Chinabadam-10, exposure of 50 and 100 mM NaCl reduced leaves number plant^{-1} only by 3 and 10%.

Table 5. Combined effect of variety and salt stress on the number of leaves plnat^{-1} of groundnut at different days after planting.

Treatment combinations	Number of leaf (No.) at			
	40 DAP	65 DAP	90 DAP	At harvest
V_1S_0	6.67 jk	21.47 h-o	37.20 d-f	40.07 e-i
V_1S_1	6.27 k	20.80 j-p	31.47 g-o	29.27 n-q
V_1S_2	6.80 jk	18.20 n-q	21.58 st	17.87 st
V_2S_0	7.60 i-k	22.67 g-n	36.27 d-h	40.67 e-h
V_2S_1	7.67 i-k	19.40 l-q	29.67 k-q	26.87 q
V_2S_2	7.60 i-k	16.93 o-q	18.67 t	15.63 t
V_3S_0	10.73 e-i	24.53 d-k	36.53 d-g	39.40 e-j
V_3S_1	10.47 f-i	21.72 h-n	31.53 g-o	33.33 k-o
V_3S_2	10.93 e-h	19.27 l-q	29.40 k-q	29.13 n-q
V_4S_0	11.07 d-h	21.13 i-p	32.67 e-m	33.80 k-n
V_4S_1	11.20 c-h	20.53 j-p	27.93 l-r	28.07 pq
V_4S_2	10.53 f-i	19.13 m-q	24.33 q-s	25.40 qr
V_5S_0	10.47 f-i	18.27 n-q	36.33 d-h	39.07 e-j
V_5S_1	10.13 f-i	16.93 o-q	31.53 g-o	32.33 l-p
V_5S_2	10.27 f-i	15.00 q	26.40 n-s	26.53 qr
V_6S_0	9.13 h-k	20.07 k-p	30.87 h-p	36.13 g-l
V_6S_1	8.87 h-k	18.20 n-q	26.00 o-s	28.80 n-q
V_6S_2	8.87 h-k	16.73 pq	22.93 r-t	21.53 rs
V_7S_0	9.27 g-k	28.27 b-e	31.60 g-n	35.93 h-l
V_7S_1	9.47 g-k	27.60 b-e	30.40 j-p	32.80 l-p
V_7S_2	8.67 h-k	27.07 b-g	28.60 l-q	28.40 o-q
V_8S_0	10.47 f-i	28.07 b-e	33.40 e-l	36.00 h-l
V_8S_1	10.60 f-i	27.40 b-f	32.00 e-m	33.53 k-o
V_8S_2	10.60 f-i	22.93 f-m	25.87 p-s	18.87 st
V_9S_0	17.47 a	38.93 a	54.00 a	50.40 ab
V_9S_1	17.13 a	39.07 a	49.00 ab	43.20 c-e
V_9S_2	16.33 ab	36.47 a	45.07 bc	41.20 d-g
$V_{10}S_0$	14.27 a-d	26.73 b-g	36.07 d-i	41.93 d-f
$V_{10}S_1$	14.33 a-c	25.07 c-j	31.80 e-n	34.47 j-m
$V_{10}S_2$	13.87 b-e	24.87 c-j	28.60 l-q	27.87 pq
$V_{11}S_0$	13.33 b-f	28.33 b-d	34.60 e-k	35.73 h-l
$V_{11}S_1$	11.67 c-h	27.13 b-g	30.67 i-p	29.67 m-q
$V_{11}S_2$	12.40 c-g	25.67 b-i	27.87 l-r	27.87 pq
$V_{12}S_0$	11.53 c-h	29.20 bc	37.33 de	39.20 e-j
$V_{12}S_1$	10.33 f-i	28.87 b-d	35.53 e-j	38.00 f-k
$V_{12}S_2$	9.87 g-j	27.60 b-e	34.60 e-k	35.40 i-l
$V_{13}S_0$	11.53 c-h	29.68 b	34.33 e-k	39.51 e-j
$V_{13}S_1$	10.40 f-i	25.73 b-h	31.62 f-n	29.87 m-q
$V_{13}S_2$	10.80 e-i	23.73 e-l	27.60 m-r	26.70 qr
$V_{14}S_0$	12.40 c-g	39.20 a	45.93 bc	52.27 a
$V_{14}S_1$	11.27 c-h	37.80 a	41.40 cd	47.47 a-c
$V_{14}S_2$	11.47 c-h	35.93 a	36.47 d-g	46.33 b-d
$LSD_{0.05}$	3.21	4.55	5.59	5.19
CV (%)	8.95	5.43	5.15	4.64

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, S_0 = 0 mM NaCl, S_1 = 50 mM NaCl and S_2 = 100 mM NaCl; V_1 = BINA Chinabadam-4, V_2 = BINA Chinabadam-5, V_3 = BINA Chinabadam-6, V_4 = BINA Chinabadam-8,V_5 = BINA Chinabadam-9, V_6= BINA Chinabadam-10, V_7= Dhaka-1, V_8 = BARI Chinabadam-5, V_9 = BARI Chinabadam-6, V_{10} = BARI Chinabadam-8, V_{11} = BARI Chinabadam-9, V_{12} = BARI Chinabadam-10, V_{13} = Zhingabadam, V_{14}= Bashanti.

4.1.3 Number of branches plant^{-1}

Effect of variety

The result of the experiment revealed that different varieties had shown significant effect on the number of branches plant^{-1}of groundnut at 40, 65, 90 DAP and at harvest (Table 6). According to the experimental results, at the harvesting stage, the BARI Chinabadam-6 variety had the highest number of branches plant^{-1} of groundnut (7.93) which was statistically similar with Bashanti (7.31) groundnut variety, while the BINA Chinabadam-5 variety had the lowest number of branches plant^{-1} of groundnut (4.64), which was statistically similar to all other varieties except BARI Chinabadam-6 Bashanti groundnut variety.

Table 6. Effect of variety on the number of branches plant^{-1} of groundnut at different days after planting.

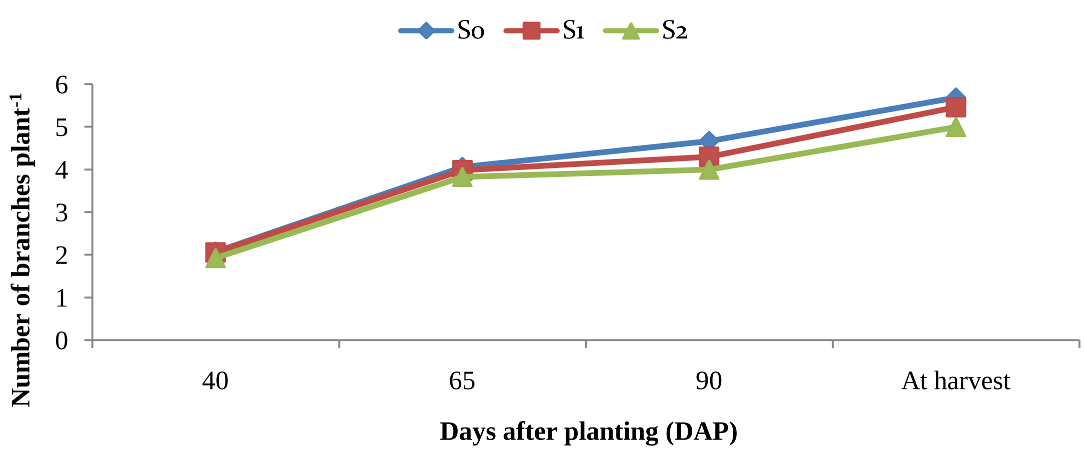
Treatments	Number of branches plant^{-1} at			
	40 DAP	**65 DAP**	**90 DAP**	**At harvest**
V_1	1.62 bc	3.62 cd	4.16 c-e	4.69 c
V_2	1.56 c	4.18 c	4.24 c-e	4.64 c
V_3	1.91 bc	4.06 cd	4.41 b-d	4.96 bc
V_4	1.84 bc	3.27 d	3.47 e	4.93 bc
V_5	1.67 bc	2.18 e	3.67 de	5.04 bc
V_6	1.58 c	3.40 cd	3.60 de	4.78 bc
V_7	1.49 c	3.84 cd	4.31 b-e	5.11 bc
V_8	2.24 bc	4.00 cd	4.11 c-e	4.82 bc
V_9	3.80 a	6.49 a	6.53 a	7.93 a
V_{10}	2.40 b	4.04 cd	4.69 bc	5.73 b
V_{11}	2.13 bc	3.73 cd	4.16 c-e	5.00 bc
V_{12}	1.93 bc	4.00 cd	3.96 c-e	5.22 bc
V_{13}	1.93 bc	3.29 cd	4.12 c-e	5.22 bc
V_{14}	2.18 bc	5.31 b	5.13 b	7.31 a
$LSD_{0.05}$	0.78	0.90	0.86	0.99
CV (%)	23.67	13.89	12.18	11.32

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, V_1 = BINA Chinabadam-4, V_2 = BINA Chinabadam-5, V_3 = BINA Chinabadam-6, V_4 = BINA Chinabadam-8,V_5 = BINA Chinabadam-9, V_6= BINA Chinabadam-10, V_7= Dhaka-1, V_8 = BARI Chinabadam-5, V_9 = BARI Chinabadam-6, V_{10} = BARI Chinabadam-8, V_{11} = BARI Chinabadam-9, V_{12} = BARI Chinabadam-10, V_{13} = Zhingabadam, V_{14}= Bashanti.

The difference in the number of branches plant^{-1} of groundnut among different varieties is due to the fact that each variety has a distinct growth stage and uses resources from its surroundings differently, allowing them to grow according to their own genetically traits. Similar result also observed by Nwokwu *et al.* (2020) who found a significant difference in the number of branches plant^{-1} among groundnut varieties.

Effect of salt stress

Number of branches plant^{-1} of groundnut was significantly affected by salinity at 90 DAP (Figure 3). At 40, 65, 90 DAP and at harvest, the highest number of branches plant^{-1} (2.07, 4.06, 4.67 and 5.69) was observed in control treatment (S_0) and the lowest number of branches plant^{-1} (1.93, 3.83, 4.00 and 5.00) was observed in S_2 (100 mM NaCl) treatment. Application of 100 mM NaCl decreased the number of branches plant^{-1} of groundnut by 6, 5 and 14 and 12 % at 40, 65, 90 DAP and at harvest compared to control treatment. Oliveria *et al.* (2016) reported a decrease in number of branches by increasing salinity. High salinity concentration which hindered photosynthetic activity of the plant and hampered the growth of branch on the individual plant and as result the plant exposed to deficiency of important mineral and food to survive. These results are also in concordance with most similar previous studies of Abd EI-Rheemkh and Zaki (2015) in respect of branches per plant of groundnut under saline irrigation water.



Note: Here, S_0 = 0 mM NaCl, S_1 = 50 mM NaCl and S_2 = 100 mM NaCl.

Figure 3. Effect of salt stress on the number of branches plant^{-1} of groundnut at different days after planting.

Combined effect of variety and salt stress

Combined effect of variety and salt stress had shown non significant effect on the number of branches plant^{-1} of groundnut at 40, 65, 90 DAP and at harvest (Table 7). The experimental results showed that at harvesting stage, 50 and 100 mM NaCl exposure reduced branches of BINA Chinabadam-6 by 6 and 32%, respectively. Number of branches plant^{-1} was reduced by 11 and 27% in BINA Chinabadam-5 and by 4 and 22% in BINA Chinabadam-4 due to exposure of 50 and 100 mM NaCl, respectively, when compared to the control. While in BARI Chinabadam-9, BARI Chinabadam-10 and Zhingabadam exposure of 50 and 100 mM NaCl reduced number of branches plant^{-1} only by 1 and 3%, 0 and 6% and 2 and 4 % respectively. The result was similar with the findings of Pal and Pal (2017) who found that out of all 26 groundnut genotypes, the genotypes, KDG-197 was found to be most salinity tolerant based on their relative performance under stress in respect to dry weight followed by R 2001, VG 315, TCGS 1157 and TG 51.

Table 7. Combined effect of variety and salt stress on the number of branches plnat^{-1} of groundnut at different days after planting.

Treatment combinations	Number of branch plant^{-1} at			
	40 DAP	**65 DAP**	**90 DAP**	**At harvest**
V_1S_0	2.00	3.93	4.40	5.13
V_1S_1	1.20	3.80	4.13	4.93
V_1S_2	1.67	3.13	3.95	4.00
V_2S_0	1.47	4.33	4.47	5.33
V_2S_1	1.67	4.20	4.27	4.73
V_2S_2	1.53	4.00	4.00	3.87
V_3S_0	2.07	4.27	4.70	5.67
V_3S_1	1.53	4.12	4.40	5.33
V_3S_2	2.13	3.80	4.13	3.87
V_4S_0	1.93	3.20	3.73	5.13
V_4S_1	1.40	3.20	3.60	5.07
V_4S_2	2.20	3.40	3.07	4.60
V_5S_0	1.60	2.07	4.13	5.40
V_5S_1	1.67	2.33	3.53	5.13
V_5S_2	1.73	2.13	3.33	4.60
V_6S_0	1.47	3.47	3.87	5.00
V_6S_1	1.73	3.33	3.53	4.73
V_6S_2	1.53	3.40	3.40	4.60
V_7S_0	1.33	3.87	4.67	5.33
V_7S_1	1.73	3.73	4.27	5.07
V_7S_2	1.40	3.93	4.00	4.93
V_8S_0	2.00	3.93	4.33	5.00
V_8S_1	2.60	4.07	4.20	4.93
V_8S_2	2.13	4.00	3.80	4.53
V_9S_0	3.67	6.07	6.87	8.13
V_9S_1	4.07	7.27	6.40	7.93
V_9S_2	3.67	6.13	6.33	7.73
$V_{10}S_0$	2.40	3.93	4.93	5.93
$V_{10}S_1$	2.33	4.07	4.67	5.80
$V_{10}S_2$	2.47	4.13	4.47	5.47
$V_{11}S_0$	2.40	3.27	4.40	5.07
$V_{11}S_1$	1.93	3.80	4.07	5.00
$V_{11}S_2$	2.07	4.13	4.00	4.93
$V_{12}S_0$	1.80	4.53	4.20	5.33
$V_{12}S_1$	1.73	3.87	4.13	5.33
$V_{12}S_2$	2.27	3.60	3.53	5.00
$V_{13}S_0$	2.07	3.75	4.67	5.33
$V_{13}S_1$	1.87	3.07	4.13	5.20
$V_{13}S_2$	1.87	3.07	3.56	5.13
$V_{14}S_0$	2.80	6.27	6.07	7.87
$V_{14}S_1$	1.533	4.93	4.93	7.27
$V_{14}S_2$	2.20	4.73	4.40	6.80
$LSD_{0.05}$	NS	NS	NS	NS
CV (%)	23.67	13.89	12.18	11.32

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, S_0 = 0 mM NaCl, S_1 = 50 mM NaCl and S_2 = 100 mM NaCl; V_1 = BINA Chinabadam-4, V_2 = BINA Chinabadam-5, V_3 = BINA Chinabadam-6, V_4 = BINA Chinabadam-8,V_5 = BINA Chinabadam-9, V_6= BINA Chinabadam-10, V_7= Dhaka-1, V_8 = BARI Chinabadam-5, V_9 = BARI Chinabadam-6, V_{10} = BARI Chinabadam-8, V_{11} = BARI Chinabadam-9, V_{12} = BARI Chinabadam-10, V_{13} = Zhingabadam, V_{14}= Bashanti.

4.2 Yield and yield contributing characters

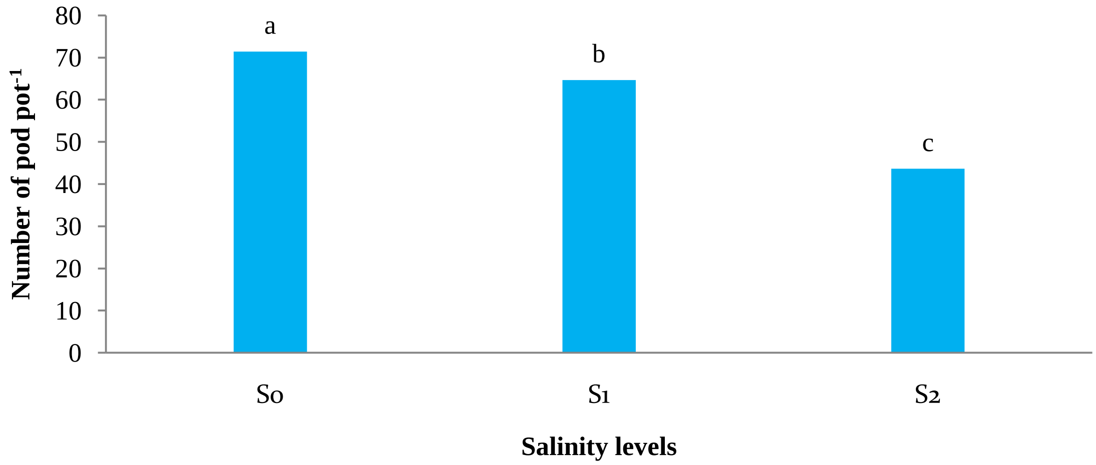
4.2.1 Number of pods pot^{-1}

Effect of variety

The number of pod pot^{-1} was significantly influenced by various groundnut varieties (Table 8). According to the experimental findings, the highest number of pod pot^{-1} (83.00) was produced by BINA Chinabadam-9 variety while the lowest number of pod pot^{-1} (43.33) was produced by Zhingabadam groundnut variety. The genetic makeup of the varieties might be the possible reasons for these variations. Nwokwu *et al.* (2020) reported that number of pod plant^{-1} were differed significantly by the groundnut varieties.

Effect of salt stress

Exposure to various salinity levels had shown significant impact on the number of pods pot^{-1} of groundnut. (Figure 4). The result showed that the highest pods number pot^{-1}of groundnut (71.45) was observed in control treatment (S_0) while the lowest pods number pot^{-1}of groundnut (43.62) was observed in S_2 (100 mM NaCl) treatment. Application of 100 mM NaCl decreased number of pods pot^{-1} of groundnut by 38 % compared to control treatment. Since salinity stress on one hand leads reduction in flowering period and on the other hand brings about less vegetative growth and consequently less photosynthetic production, so under the given condition the plant ensures its survival at the expense of reducing the number of pods. Reduction in pod yield as a result of salt stress has been by reported Satu *et al*. (2019) for groundnut. The reduction in the number of pods affected by salinity stress is consistent with the findings of (Meena and Yadav, 2018) in groundnut.



Note: Here, S_0 = 0 mM NaCl, S_1 = 50 mM NaCl and S_2 = 100 mM NaCl.

Figure 4. Effect of salt stress on the number of pods pot^{-1} of groundnut.

Combined effect of variety and salt stress

Cultivation of different groundnut varieties in combination with various salinity levels, significantly influenced the number of groundnut pods pot^{-1} (Table 9). Experimental result revealed that exposure of 50 and 100 mM NaCl treatment decreased the number of pods pot^{-1} of BINA Chinabadam-4 by 5 and 52%. While exposed to 50 and 100 mM NaCl, respectively, the number of pods pot^{-1} was decreased by 22 and 56% in BINA Chinabadam-5; 10 and 44% in BINA Chinabadam-6; 5 and 52% in Dhaka-1 and 17 and 52% in BARI Chinabadam-5 variety. However, the number of pods pot^{-1} reduced only by 2 and 1% in the Bashanti groundnut variety when exposed to 50 and 100 mM NaCl, respectively.

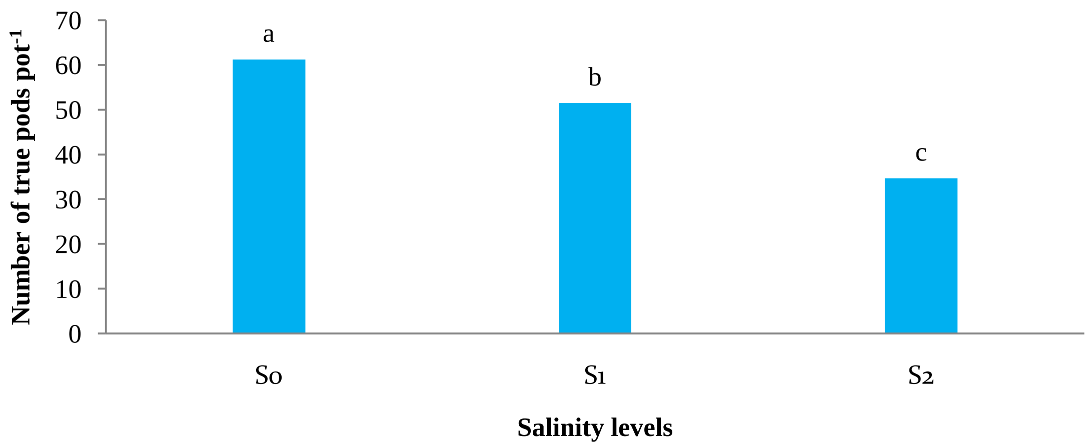
4.2.2 Number of true pods pot^{-1}

Effect of variety

The number of true pods pot^{-1} was significantly influenced by different groundnut varieties (Table 8). According to the experimental result BINA Chinabadam-9 produced the highest number of true pods pot^{-1} which was statistically similar with BINA Chinabadam-6 (65.33) and Bashanti (62.56) groundnut varieties. Whereas the lowest number of true pods pot^{-1} was produced by Zhingabadam (35.11) which was statistically similar with BARI Chinabadam-5 (38.56) variety.

Effect of salt stress

Exposure of different salinity levels significantly influenced the number of true pods pot^{-1} (Figure 5). The results of the experiment revealed that the highest number of true pods pot^{-1} (61.24) was found in the control treatment (S_0), whereas the lowest pods number pot^{-1}of groundnut (34.71) was found in the S_2 (100 mM NaCl) treatment. Application of 100 mM NaCl decreased number of true pods pot^{-1} of groundnut by 43% compared to control treatment.



Note: Here, S_0 = 0 mM NaCl, S_1 = 50 mM NaCl and S_2 = 100 mM NaCl.

Figure 5. Effect of salt stress on the number of true pods pot^{-1} of groundnut.

Combined effect of variety and salt stress

The number of groundnut true pods pot^{-1} was significantly influenced by the cultivation of different groundnut varieties in combination with varying saline levels (Table 9). The experimental results showed that exposure of 50 and 100 mM NaCl treatments reduced the number of true pods pot^{-1} of BINA Chinabadam-4 by 10 and 59%, respectively. When exposed to 50 and 100 mM NaCl, the number of true pods pot^{-1} was reduced by 27 and 73% in BINA Chinabadam-5; 13 and 46% in BINA Chinabadam-6; 21 and 42% in Dhaka-1, and 26 and 60% in BARI Chinabadam-5, respectively. However, when exposed to 50 and 100 mM NaCl, the number of true pods pot^{-1} was decreased only by 5 and 10%, respectively in Bashanti groundnut variety.

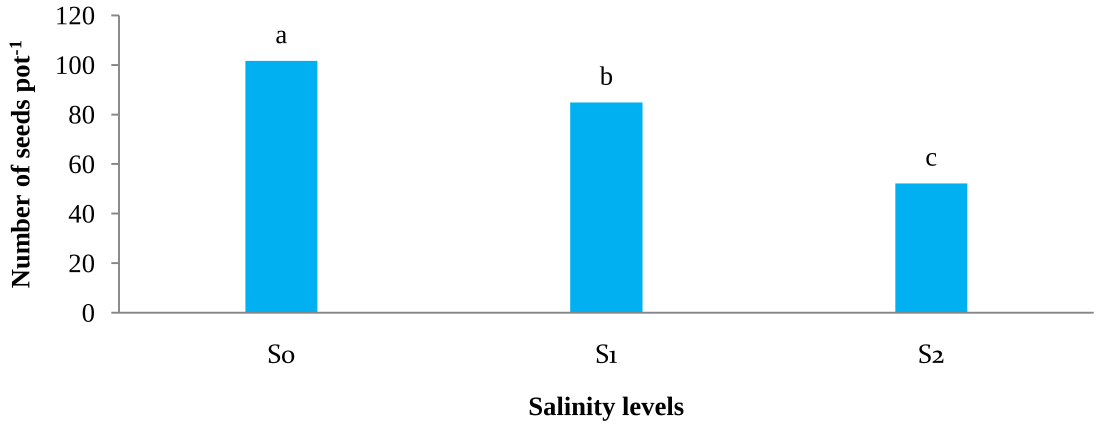
4.2.3 Number of seeds pot^{-1}

Effect of variety

The effect of varietal difference on the number of seeds pot^{-1} of groundnut was found to be significant (Table 8). The result of the experiment revealed that the highest number of seeds pot^{-1} of groundnut (120.44) was produced by BINA Chinabadam-9 variety. While the lowest number of seeds pot^{-1} of groundnut (58.89 g) was produced by Zhingabadam which was statistically similar with BARI Chinabadam-9 (64.89). The difference in number of seeds pot^{-1} between varieties is due to the fact that each variety has a unique growth stage and use resources from its environment differently. The findings were similar to those of Uko *et al.* (2019), who reported that variation in the quantity of seeds pod^{-1} was due to groundnut varietal differences.

Effect of salt stress

Groundnut seed pot^{-1} was significantly influenced by exposure to various salinity levels (Figure 6). The experimental findings revealed that the highest seeds pot^{-1}of groundnut (101.64) was found in the control treatment (S_0), while the lowest seeds pot^{-1}of groundnut (52.24) was found in the S_2 (100 mM NaCl) treatment. Increased salinity level gradually decreased seeds pot^{-1}of groundnut. When compared to the control, exposure to 100 mM NaCl reduced the number of seed pot^{-1} of groundnut by 48%. These results agree with those of Pandya and Subbaiah (2017) who reported that the reduction of flowers, pods and seeds pod^{-1} were increased with increasing salinity stress condition. As NaCl levels restrict water and air movement, as well as soil porosity, a gradual increase in salinity levels not only linearly reduced the number of pods but also the number of seeds pod^{-1} (Egamberdiyeva *et al*., 2019). Furthermore, it regulates soil physio-chemical properties, lowering soil health. Thus, poor growth in plants exposed to salinity is caused by a decrease in nutrient circulation, ROS generation, and hormonal imbalances, among other things (Kumar *et al*., 2020).



Note: Here, S_0 = 0 mM NaCl, S_1 = 50 mM NaCl and S_2 = 100 mM NaCl.

Figure 6. Effect of salt stress on the number of seeds pot^{-1} of groundnut.

Combined effect of variety and salt stress

Combined effect of variety and salt stress significantly influenced the number of seeds pot^{-1} of groundnut (Table 9). The experimental results showed that exposure to 50 and 100 mM NaCl treatments reduced the number of seeds pot^{-1} of BINA Chinabadam-4 by 10% and 62%, respectively. When subjected to 50 and 100 mM NaCl, the number of seeds pot^{-1} was reduced by 25 and 61% in BINA Chinabadam-5; 16 and 55% in BINA Chinabadam-6; 21 and 54% in BINA Chinabadam-10; 22 and 50% in Dhaka-1 and 16 and 60% in BARI Chinabadam-5 variety, respectively. Whereas, when exposed to 50 and 100 mM NaCl, the number of seeds pot^{-1} was reduced only by 7 and 37%, respectively, in the BINA Chinabadam-9 variety; 7 and 26% in the BINA Chinabadam-10 variety and 17 and 26%, in the Bashanti groundnut variety.

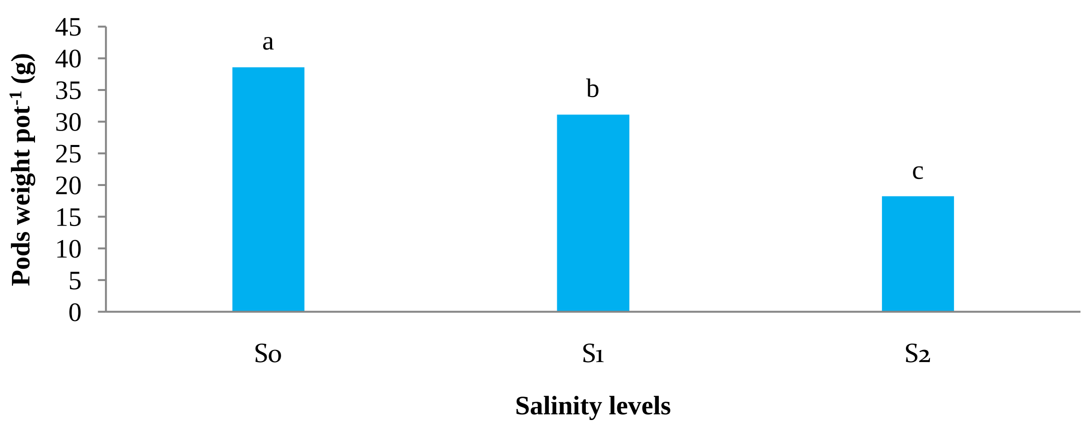
4.2.4 Pods weight pot^{-1} (g)

Effect of variety

Groundnut pods weight pot^{-1} was significantly influenced by different varieties (Table 8). In this experiment result revealed that the highest pods weight pot^{-1} (45.01 g) was observed from BINA Chinabadam-9 variety. While the lowest pods weight pot^{-1} (22.04 g) was observed from Zhingabadam variety which was statistically similar with BARI Chinabadam-6 (23.93 g). Different groundnut varieties had different genetic makeup which affects the growth and yield among varieties. The result obtained from the present study was similar with the findings of Venkatachalapathi and Rao (2014) who reported that different varieties of groundnut showed wide differences in their agronomic characteristics and seed yield, depending on their genotypes and environmental conditions.

Effect of salt stress

Groundnut pods weight pot^{-1} was significantly influenced by exposure to various salinity levels (Figure 7). According to the experimental findings, the control treatment (S_0) had the highest pods weight pot^{-1} of groundnut (38.60 g), while the S_2 treatment had the lowest pods weight pot^{-1} of groundnut (18.21 g). When subjected to 100 mM NaCl to the experimental pot the pod weight pot^{-1} of groundnut was decreased by 53% compared to control treatment. The variation of pods weight pot^{-1} among different treatment due to reason that, the salt availability in soil can disturb normal functioning of plant metabolism, consequently leading to stunted growth and low crop productivity. Similar result also observed by Pandya and Subbaiah (2017) who reported that the haulm yield, pod yield and shelling per cent decreased with increasing soil salinity.



Note: Here, S_0 = 0 mM NaCl, S_1 = 50 mM NaCl and S_2 = 100 mM NaCl.

Figure 7. Effect of salt stress on the pods weight pot^{-1} of groundnut.

Combined effect of variety and salt stress

Combined effect of variety and salt stress significantly influenced the pods weight pot^{-1} of groundnut (Table 9). The experimental results showed that exposure to 50 and 100 mM NaCl treatments reduced the pods weight pot^{-1} of BINA Chinabadam-4 by 10% and 60%, respectively. When subjected to 50 and 100 mM NaCl, the pods weight pot^{-1} was reduced by 23 and 68% in BINA Chinabadam-5; 29 and 58% in BINA Chinabadam-6; 34and 52% in BINA Chinabadam-8; 17 and 59% in BINA Chinabadam-10; 23 and 53% in Dhaka-1 and 24 and 64% in BARI Chinabadam-5 variety, respectively. Whereas, when exposed to 50 and 100 mM NaCl, the pods weight pot^{-1} was reduced only by 7 and 53%, respectively, in the BARI Chinabadam-6 variety; 13 and 38% in the BARI Chinabadam-10 variety; 8 and 53%, in the Zhingabadam groundnut variety and 8 and 18%, in the Bashanti groundnut variety.

4.2.5 Seed yield pot^{-1} (g)

Effect of variety

Different groundnut varieties had shown significant effect on the seed yield pot^{-1} at (Table 8). According to the experimental findings, the highest seed yield pot^{-1} of groundnut (23.64 g) was observed from BINA Chinabadam-9 variety, while the lowest seed yield pot^{-1} of groundnut (10.74 g) was observed from BINA Chinabadam-10 variety which was statistically similar with BINA Chinabadam-4 (11.37 g) and BARI Chinabadam-6 (11.41 g) variety. Different groundnut varieties have different genetic makeup, which affects growth and yield. Asif *et al*. (2017) reported similar results as varieties differed significantly in seed yield of groundnut.

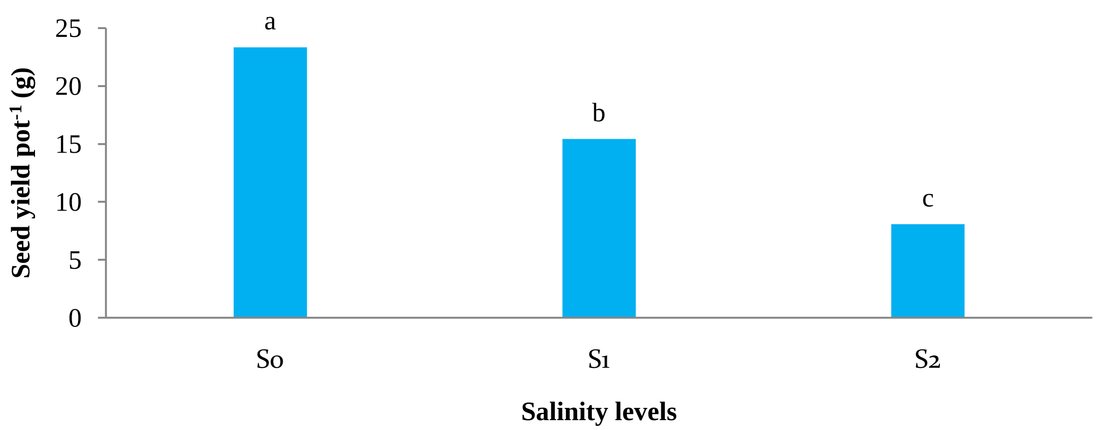
Table 8. Effect of variety and salt stress on yield and yield contributing characteristics of groundnut

Treatments	Number of pods pot^{-1}	Number of true pods pot^{-1}	Number of seeds pot^{-1}	Pod weight pot^{-1} (g)	Seed yield pot^{-1} (g)	Stover yield pot^{-1} (g)
V_1	57.33 de	48.33 c	77.33 ef	24.22 gh	14.23 de	118.34 ef
V_2	63.33 c	51.22 bc	86.44 cd	34.82c	15.80 de	76.28 i
V_3	75.22 b	65.33 a	106.67 b	39.78 b	18.37 bc	84.04 h
V_4	66.22 c	53.89 b	91.00 c	27.15 de	11.37 f	99.98 g
V_5	83.00 a	66.89 a	120.44 a	45.01 a	23.64 a	113.52 f
V_6	52.33 ef	42.78 d	69.44 gh	24.58 f-h	10.74 f	93.22 g
V_7	62.89 c	51.11 bc	80.11 de	28.69 d	15.97 ce	136.96 c
V_8	51.78 f	38.56 de	70.00 f-h	26.23 ef	16.35 ce	152.75 b
V_9	49.22 f	40.00 d	68.33 gh	23.93 hi	11.41 f	198.25 a
V_{10}	53.33 ef	43.11 d	69.56 gh	26.05 e-g	16.12 c-e	128.63 d
V_{11}	49.11 f	40.00 d	64.89 hi	26.84 de	14.0 e	122.55 de
V_{12}	59.67 d	49.11 bc	77.89 e	26.57 ef	16.56 cd	125.06 de
V_{13}	43.33 g	35.11 e	58.89 i	22.04 i	14.10 de	128.10 d
V_{14}	72.00 b	62.56 a	73.11 e-g	34.48 c	19.92 b	148.80 b
$LSD_{0.05}$	5.11	4.87	7.60	1.99	2.49	7.40
CV (%)	5.25	6.08	5.86	4.17	9.78	3.68

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, V_1 = BINA Chinabadam-4, V_2 = BINA Chinabadam-5, V_3 = BINA Chinabadam-6, V_4 = BINA Chinabadam-8,V_5 = BINA Chinabadam-9, V_6= BINA Chinabadam-10, V_7= Dhaka-1, V_8 = BARI Chinabadam-5, V_9 = BARI Chinabadam-6, V_{10} = BARI Chinabadam-8, V_{11} = BARI Chinabadam-9, V_{12} = BARI Chinabadam-10, V_{13} = Zhingabadam, V_{14}= Bashanti.

Effect of salt stress

Groundnut seed yield pot^{-1} was significantly influenced by exposure to various salinity levels (Figure 8). The results showed that the highest seed yield pot^{-1} of groundnut (23.35 g) was found in the S_0 treatment. However, the lowest seed yield pot^{-1} of groundnut (8.07 g) was found in the S_2 treatment. Application of 100 mM NaCl decreased seed yield $pot^{-1}$of groundnut by 65% compared to control treatment. Increasing salinity of irrigation water decrease in seed yield may be due to accumulation of salts in root zone affects plant performance through the development of water deficit and the disruption of ion homeostasis (Bawa, 2016). These stresses change hormonal status and impair basic metabolic processes (Kumar *et al*., 2020) resulting in growth inhibition and reduction in yield. Lodeyro *et al*. (2016) reported that salinity can severely limit crop production, because high salinity lowers water potential and induces ionic stress and results in a secondary oxidative stress. This can potentially reduce photosynthesis and consequently grain yield of groundnut accessions. Sareh *et al*. (2015) also concerned that restricted water uptake by salinity due to the high osmatic potential in the soil and high concentration of specific ions that may cause physiological disorders in the plant tissues and reduce yields of peanut. These results are also in agreement with those reported earlier by Shrimali *et al.* (2015), Meena *et al.* (2014) and Osuagwa and Udogy (2014).



Note: Here, S_0 = 0 mM NaCl, S_1 = 50 mM NaCl and S_2 = 100 mM NaCl.

Figure 8. Effect of salt stress on the seed weight pot^{-1} of groundnut

Combined effect of variety and salt stress

Groundnut seed yield pot^{-1} had been significantly influenced by the combined effects of variety and salt stress (Table 9). According to the experimental findings exposure to 50 and 100 mM NaCl treatments reduced the seeds yield pot^{-1} of BINA Chinabadam-4 by 18% and 74%, respectively. When subjected to 50 and 100 mM NaCl, the seeds yield pot^{-1} was reduced by 52 and 80% in BINA Chinabadam-5; 45 and 73% in BINA Chinabadam-6; 35 and 49% in BINA Chinabadam-8; 30 and 64% in BINA Chinabadam-10; 37 and 67% in Dhaka-1 and 42 and 74% in BARI Chinabadam-5 variety, respectively. Whereas, when exposed to 50 and 100 mM NaCl, the seeds yield pot^{-1} was reduced only by 17 and 41%, respectively, in the BARI Chinabadam-10 variety; 19 and 76% in the Zhingabadam variety; 20 and 39 %, in the Bashanti groundnut variety.

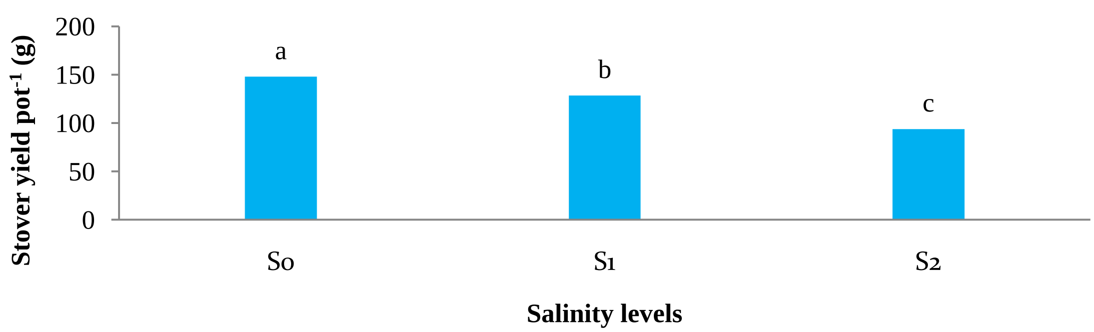
4.2.6 Stover yield pot^{-1} (g)

Effect of variety

The groundnut stover yield pot^{-1} was significantly affected by different varieties (Table 8). According to the experimental results, the BARI Chinabadam-6 variety had the highest stover yield pot^{-1} (198.25 g) of groundnut. Whereas the BINA Chinabadam-5 variety had the lowest stover yield pot^{-1} (76.28 g) of groundnut. Different groundnut varieties have different genetic makeup, which affects growth and yield. Nwokwu *et al.* (2020) reported similar results as varieties differed significantly in stover yield of groundnut.

Effect of salt stress

Groundnut stover yield pot^{-1} was significantly influenced by exposure to various salinity levels (Figure 9). According to experimental results, the S_0 treatment produced the highest groundnut stover yield pot^{-1} (147.87 g). However, the S_2 treatment produced the lowest groundnut stover yield pot^{-1} (93.74 g). Application of 100 mM NaCl decreased stover yield pot^{-1}of groundnut by 36% compared to control treatment. Reduction in yield under elevated salinity may be the result of various factors acting simultaneously like the decline in leaf area and the subsequent reduction in the photosynthesis and stomatal conductance, which would result in a reduction in the accumulated biomass thereby reduced groundnut stover yield pot^{-1}. Agarwal *et al.* (2011) reported that increasing level of soil salinity decreased stover yield of mustard.



Note: Here, S_0 = 0 mM NaCl, S_1 = 50 mM NaCl and S_2 = 100 mM NaCl.

Figure 9. Effect of salt stress on the stover yield pot^{-1} of groundnut.

Combined effect of variety and salt stress

Groundnut stover yield pot^{-1} had been significantly influenced by the combined effects of variety and salt stress (Table 9). According to the experimental findings exposure to 50 and 100 mM NaCl treatments reduced the stover yield pot^{-1} of BINA Chinabadam-4 by 22% and 85%, respectively. When subjected to 50 and 100 mM NaCl, the stover yield pot^{-1} was reduced by 28 and 76% in BINA Chinabadam-5; 19 and 32% in BINA Chinabadam-9; 23 and 48% in BINA Chinabadam-10 and 5 and 60% in BARI Chinabadam-5. Whereas, when exposed to 50 and 100 mM NaCl, the stover yield pot^{-1} was reduced only by 6 and 11%, respectively, in the BARI Chinabadam-10 variety; 18 and 39% in the Zhingabadam variety and 5 and 10 %, in the Bashanti groundnut variety. The findings were similar to those of Azad *et al.* (2014), who reported that among three varieties of groundnut cultivation grown under different levels of salinity, Binachinabadam-3 emerged as a tolerant variety, Dacca-1 as tolerant, and Zhingabadam as sensitive. Salwa *et al.* (2010) reported that that all studied characters of growth of peanut were showed significant decrease with increasing salinity levels. Gregory variety had best growth and yield as compared to Giza 6. Gregory variety had the best growth and yield and also it was more stable in its physiological and chemical component under salt stress conditions compared to variety Giza 6.

Table 9. Combined effect of variety and salt stress on the yield and yield contributing characteristics of groundnut.

Treatment combinations	Number of pods pot^{-1}	Number of true pods pot^{-1}	Number of seeds pot^{-1}	Pod weight pot^{-1} (g)	Seed yield pot^{-1} (g)	Stover yield pot^{-1} (g)
V_1S_0	71.00 fg	63.00 d-h	102.00 c-e	31.56 f-j	20.52 e-h	184.29 c
V_1S_1	67.33 gh	56.33 f-k	91.33 d-g	28.50 i-l	16.85 g-j	143.96 e-h
V_1S_2	33.67 q-s	25.67 wx	38.67 q-s	12.60 r	5.33 op	26.75 v
V_2S_0	86.00 b-d	76.67 ab	122.00 b	50.07 b	28.40 a-c	117.29 k-n
V_2S_1	66.667 gh	56.00 g-k	90.33 d-h	38.64 cd	13.55 j-l	84.27 st
V_2S_2	37.33 q-s	21.00 x	47.00 qr	15.76 o-r	5.44 op	27.28 v
V_3S_0	92.00 a-c	81.33 a	140.33 a	56.25 a	30.38 ab	100.33 o-r
V_3S_1	82.00 c-e	70.67 b-d	117.00 bc	39.90 c	16.67 g-j	85.52 r-t
V_3S_2	51.67 m-o	44.00 n-t	62.67 n-p	23.20 mn	8.08 m-p	66.27 u
V_4S_0	80.33 d-f	68.00 b-e	116.67 bc	38.12 cd	15.78 g-k	112.28 l-o
V_4S_1	65.00 g-i	53.67 h-n	89.00 e-i	25.00 lm	10.26 l-o	102.83 n-q
V_4S_2	53.33 k-o	40.00 q-u	67.33 l-o	18.33 o	8.06 m-p	84.83 st
V_5S_0	94.00 ab	81.00 a	141.33 a	58.79 a	32.19 a	136.78 f-j
V_5S_1	96.67 a	73.00 a-c	131.67 ab	49.15 b	25.45 b-e	110.50 m-p
V_5S_2	58.33 h-m	46.67 k-r	88.33 e-j	27.10 k-m	13.27 j-l	93.28 q-t
V_6S_0	64.00 g-j	55.33 g-l	93.00 d-g	33.12 e-g	15.65 h-k	122.60 j-m
V_6S_1	59.33 h-m	47.67 k-o	73.33 j-n	27.26 kl	10.96 k-n	93.55 q-s
V_6S_2	33.67 q-s	25.33 wx	42.00 q-s	13.37 qr	5.61 op	63.50 u
V_7S_0	80.00 d-f	65.00 c-g	105.67 cd	38.49 cd	24.45 c-f	149.37 d-f
V_7S_1	64.67 g-i	51.00 j-o	81.67 f-l	29.59 g-k	15.39 i-k	134.58 f-j
V_7S_2	44.00 n-q	37.33 r-v	53.00 o-q	17.98 op	8.08 m-p	126.94 i-l
V_8S_0	67.67 gh	54.00 h-m	94.33 d-f	37.18 cd	26.72 b-d	194.90 bc
V_8S_1	55.67 i-m	40.00 q-u	78.67 g-m	28.13 i-l	15.41 i-k	185.09 c
V_8S_2	32.00 rs	21.67 x	37.00 rs	13.38 qr	6.93 n-p	78.26 tu
V_9S_0	58.00 h-m	49.00 k-q	89.00 e-i	30.01 g-k	16.98 g-j	227.16 a
V_9S_1	56.00 i-m	42.33 o-u	75.00 h-n	27.83 j-l	11.49 k-n	203.94 b
V_9S_2	33.66 q-s	28.67 v-x	41.00 q-s	13.95 p-r	5.75 op	163.66 d
$V_{10}S_0$	62.67 g-l	52.67 i-n	88.67 e-j	36.19 c-e	26.23 b-d	140.44 f-i
$V_{10}S_1$	54.00 j-n	41.00 p-u	74.33 i-n	25.00 lm	15.26 i-l	128.68 i-k
$V_{10}S_2$	43.33 o-q	35.67 t-v	45.67 q-s	16.95 o-q	6.86 n-p	116.78 k-n
$V_{11}S_0$	53.67 j-o	46.00 l-s	77.67 g-n	32.82 e-h	23.30 d-f	136.31 f-j
$V_{11}S_1$	53.00 k-o	40.00 q-u	67.00 l-o	28.96 h-l	11.11 k-n	121.94 j-m
$V_{11}S_2$	40.67 p-r	34.00 u-w	50.00 p-r	18.75 o	7.58 m-p	109.40 m-p
$V_{12}S_0$	65.67 g-i	54.33 h-m	87.67 e-j	32.16 e-i	20.64 e-h	133.23 g-j
$V_{12}S_1$	63.33 g-k	50.33 j-p	81.33 f-l	27.82 j-l	16.99 g-j	124.22 j-m
$V_{12}S_2$	50.00 m-p	42.67 o-u	64.67 m-p	19.73 no	12.033 j-m	117.74 k-n
$V_{13}S_0$	52.67 l-o	45.00 m-t	79.00 f-m	27.70 j-l	20.74 e-g	158.24 de
$V_{13}S_1$	50.33 m-p	36.33 s-v	66.67 l-o	25.46 lm	16.70 g-j	129.73 h-k
$V_{13}S_2$	27.00 s	24.00 x	31.00 s	12.97 qr	4.85 p	96.33 p-s
$V_{14}S_0$	72.67 e-g	66.00 c-f	85.67 f-k	37.91 cd	24.93 c-e	157.00 de
$V_{14}S_1$	71.33 fg	62.33 d-i	70.67 k-n	34.64 d-f	19.78 f-i	148.07 e-g
$V_{14}S_2$	72.00 e-g	59.33 e-j	63.00 n-p	30.90 f-k	15.05 i-l	141.34 f-i
$LSD_{0.05}$	10.42	1.26	15.47	4.05	0.78	15.05
CV (%)	5.25	7.20	5.86	4.17	6.30	3.68

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, S_0 = 0 mM NaCl, S_1 = 50 mM NaCl and S_2 = 100 mM NaCl; V_1 = BINA Chinabadam-4, V_2 = BINA Chinabadam-5, V_3 = BINA Chinabadam-6, V_4 = BINA Chinabadam-8,V_5 = BINA Chinabadam-9, V_6= BINA Chinabadam-10, V_7= Dhaka-1, V_8 = BARI Chinabadam-5, V_9 = BARI Chinabadam-6, V_{10} = BARI Chinabadam-8, V_{11} = BARI Chinabadam-9, V_{12} = BARI Chinabadam-10, V_{13} = Zhingabadam, V_{14}= Bashanti.

CHAPTER V

SUMMARY AND CONCLUSION

5.1 Summary

A pot experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during February to July 2020 to study the performance of groundnut varieties under salt stress conditions. The study was conducted by following Randomized Complete Block Design with three replications and consisted of two factors i.e. variety (factor A) and salinity (factor B). Fourteen groundnut variety e.g. BINA Chinabadam-4 (V_1), BINA Chinabadam-5 (V_2), BINA Chinabadam-6 (V_3), BINA Chinabadam-8 (V_4), BINA Chinabadam-9 (V_5), BINA Chinabadam-10 (V_6), Dhaka-1 (V_7), BARI Chinabadam-5 (V_8), BARI Chinabadam-6 (V_9), BARI Chinabadam-8 (V_9), BARI Chinabadam-9 (V_{10}), BARI Chinabadam-10 (V_{11}), Zhingabadam (V_{13}) and Bashanti (V_{14}) were grown in three levels of salinity such as 0 mM NaCl (S_0), 50 mM NaCl (S_1) and 100 mM NaCl (S_2). Data on different parameters were collected for assessing results for this experiment and showed significant variation in respect of growth, yield and yield contributing characteristics of groundnut due to the effect of variety, salt stress and their combinations.

Cultivation of different varieties of groundnut significantly influenced growth, yield and yield contributing characteristics of groundnut. The highest number of pods pot^{-1} (83.00), true pods pot^{-1} (66.89), seeds pot^{-1} (120.44), pod weight pot^{-1} (45.01 g), seed yield pot^{-1} (23.64 g) were observed from BINA Chinabadam-9 variety. Whereas the lowest number of pods pot^{-1} (43.33), true pods pot^{-1} (35.11), seeds pot^{-1} (58.89) and pod weight pot^{-1} (22.04 g) were observed from Zhingabadam variety. However in case of seed yield the lowest seed yield pot^{-1} (10.74 g) and stover yield pot^{-1} (93.22 g) were observed from BINA Chinabadam-10 variety.

In case of different salt stress condition, plant growth deceasing with increasing salt level. The minimum plant height, number of branch plant^{-1}, number of leaves plant^{-1} were observed by the S_2 (100 mM NaCl) treatment. Exposure of salt greatly reduced the yield and yield contributing parameters of groundnut. The lowest number of pods pot^{-1} (43.62), true pods pot^{-1} (34.71), seeds pot^{-1} (52.24), pod weight pot^{-1} (18.21 g), seed yield pot^{-1} (8.07 g) and stover yield pot^{-1} of groundnut (93.74 g) were recorded in S_2 treatment. Application of 100 mM NaCl decreased number of pods pot^{-1} of groundnut by 38 %, true pods pot^{-1} by 43%, seed pot^{-1} by 48%, pod weight pot^{-1} by 53%, seed yield pot^{-1} by 65% and stover yield pot^{-1} by 36% when compared to control treatment.

In case of combined effect plant growth, yield contributing characteristics and yield of groundnut significantly varied among different treatment combination. Experimental result revealed that compared with controlled conditions, the highest seed and stover yield reduction were observed in BINA Chinabadam-5 and BARI Chinabadam-10 variety. Exposure of 50 mM NaCl decreased seed yield by 52% and stover yield by 28% of BINA Chinabadam-5 variety when compared with untreated control. Under 100 mM NaCl, the highest seed yield reduction was recorded in BINA Chinabadam-5 (80%). Exposure of 50 and 100 mM NaCl, the seeds yield pot^{-1} was reduced only by 17 and 41%, respectively, in the BARI Chinabadam-10 variety; 19 and 76% in the Zhingabadam variety and 20 and 39 %, in the Bashanti groundnut variety when compared with untreated control.

5.2 Conclusion

Salinity inhibits groundnut development throughout its life cycle, resulting in lower yields. The soil salinity problem can be solved by utilizing plants' varietal potential for adaptability to adverse environmental stress conditions. So, taking into account the above facts, the following conclusions can be drawn:

- ❖ In terms of yield contributing characteristics and yield, the highest number of pods pot^{-1} (83.00), true pods pot^{-1} (66.89), seeds pot^{-1} (120.44), pod weight pot^{-1} (45.01 g), seed yield pot^{-1} (23.64 g) were observed from BINA Chinabadam-9 variety.
- ❖ Exposure of salt decreased plant growth and yield of groundnut.
- ❖ On the basis of salinity indices, the Bashanti groundnut variety performed comparatively better in terms of different salinity tolerance criteria such as lowest seed yield reduction under different salinity levels, while the highest seed yield

reduction under different salinity levels was observed from the BINA Chinabadam-5 variety when compared to the control treatment.

Therefore, considering the yield and yield reduction performances under saline conditions, Bashanti groundnut variety is most salt tolerant genotypes and BINA Chinabadam-5 is most salt sensitive genotypes.

Recommendations

Among the fourteen groundnut varieties studied in this experiment, the Bashanti groundnut variety can be considered salt tolerant to some extent. However, an on-farm verification trial is suggested for further evaluation before making a final recommendation.

REFERENCES

Abd EI-Rheemkh, M. and Zaki, S.S. (2015). Effect of salinity on growth, yield and nutrient balance of peanut plants. *Int. J. Chem. Tech Res.* **8**(12): 564-568.

Abdelgadir, E., Ka, M.A. and Fujiyama, H. (2005). Nitrogen nutrition of rice plants under salinity. *Biochem. Plant*. **49**: 99-104.

Agarwal, N., Kumar, A., Agarwal, S. and Singh, A. (2015). Evaluation of soybean (*Glycine max* L.) cultivars under salinity stress during early vegetative growth. *Int. J. Cur. Microb. App. Sci.* **4**(2): 123-134.

Agarwal, V.P., Kakralya, B.L. and Gupta, S. (2011). Effect of salinity on morpho-physiological and seed quality attributes of *brassicas*. *Ann. Arid Zone.* **50**(2): 127-130.

Ahmad, N., Mohammad, R. and Khan, U. (2007). Evaluation of various sowing dates for groundnut varieties under agro ecological condition of Malakand division. *Gomal Univ. J. Res.* **23**(2): 1-4.

Ahmad, P. and Prasad, M.N.V. (2012a). Environmental adaptations and stress tolerance in plants in the era of climate change. Springer, New York. pp. 1-3.

Ahmed, N. and Ahmad, R. (2016). Salt stress responses of pigeon pea (*Cajanus cajan*) on growth, yield and some biochemical attributes. *Pakistan J. Bot.* **48**(4): 1353-1360.

Aliyu, M., Moshood, H.A. and Gwaggo, Z.D. (2020). Performance of groundnut (*Arachis hypogaea* L.) varieties in Sokoto State, Nigeria." *Int. J. Sci. Global Sust.* **6**(3): 81-82.

Ambede J.G., Netondo G.W., Mwai G.N. and Musyimi D.M. (2012). NaCl salinity affects germination, growth, physiology, and biochemistry of bambara groundnut. *Brazillian J. Plant Phy.* **24**: 151–160.

Anny, M.K., Sambaiah, A., Sudharani, Y. and Lakshmi, G.V. (2017). Performance of groundnut under saline water using drip irrigation system. 5th National Seminar-Climate Resilient Saline Agriculture: Sustaining Livelihood Security. 21-23 January 2017, Indian Society of Soil Salinity and Water Quality. pp: 57.

Ashraf, M., Shahzad, S., Imtiaz, M., Rizwan, M., Arif, M. and Kausar, R. (2018). Nitrogen nutrition and adaptation of glycophytes to saline environment: a review. *Arch. Agron. Soil Sci.* **1**: 1-26.

Asif, R., Zafar, H.K., Kamran, K., Anjum, M.M., Ali, N., Iqbal, M.O. and Usman, H. (2017). Evaluation of Groundnut Varieties for the Agro-Ecological Zone of Malak and Division. *Int. J. Environ. Sci. Nat. Res.* **5**(5): 555671.

Assaha, D.V.M., Ueda, A., Saneoka, H., Al-Yahyai, R. and Yaish, M.W. (2017). The role of Na^+ and K^+ transporters in salt stress adaptation in glycophytes. *Front. Physio. **8***: 509.

Aydinsakir, K., Buyuktas, D., Dinc, N. and Karaca, C. (2015). Impact of salinity stress on growing, seeding development and water consumption of peanut (*Arachis hypogaea* L.). *Akdeniz Uni. Zir. Fak. Der*. **28**(2): 77-84.

Azad, A.K., Miaruddin, M., Wohab, M.A., Sheikh, M.H.R., Nag, B. and Rahman, M.H.H. (2020.) Krishi Projukti Hatboi (Handbook on Agro-Technology), 9th edn. Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh. pp. 60-78.

Azad, M.A., Alam, M.S., Hamid, M.A. and Rafil, M.A. (2014). Combining ability of pod yield and related traits of groundnut (*Arachis hypogaea* L.) under salinity stress. *Legume Res.* **35**(4): 271-278.

Bahrami, H., Jafari, A.O. and Razmjoo, J. (2016). Effect of salinity levels on yield, yield components and quality content of sesame (*Sesamum indicum* L.) cultivars. *Environ. Manage. Sust. Dev.* **5**(2): 104-117.

Bala, H.M.B., Ogunlela, V.B., Kuchind, N.C. and Taimu, B. (2011). Response of two groundnut (*Arachis hypogaea*) varieties to sowing date and NPK fertilizer rate in a semi-arid environment. A*sia J. Crop Sci.* **3**(1): 130-140.

BARI (Bangladesh Agricultural Research Institute). (2019). 'Krishi Projukti Hathboi'. Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. pp. 370-372.

Bawa, A.L.H. (2016). Screening and evaluation of some genotypes of maize (*Zea mays* L.) and their f1 hybrids for tolerance to drought and *Striga hermonthica* (Del.) Benth (Doctoral dissertation). MS thesis. Department of Agronomy. University of Ahamadu Bello, Samaru Zaria, Nigeria. pp. 1-2.

BBS. (2020). Year Book of Agricultural Statistics of Bangladesh. Bangladesh Bureau of Statistics, Ministry of Planning. Government of the People's of Republic of Bangladesh, Dhaka, Bangladesh. pp. 1-2.

Bharud, R.W. and Pawar, M.R. (2005). Physiological Basis of yield variation in groundnut varieties under summer condition. *J. Maharashtra Agric. Univ.* **30**(1): 100-102.

Bot, P., Khan, A., Shirazi, M., Khan, M., Mujtaba, S., Islam, E., Mumtaz, S., Shereen, A., Ansari, R. and Ashraf, M. (2014). Role of proline, k/na ratio and chlorophyll content in salt tolerance of wheat (*Triticum Aestivum* L.). *Pakistan J. Bot.* **41**(2): 633-638.

Bucheyeki, T.L., Shenkalwa, M.E., Mapunda, T. and Matata, W.L. (2008). On-farm evaluation of promising groundnuts varieties for adaptation and adoption in Tanzania. *African J. Agric. Res.* **3**(8): 531–536.

Castro-Camba, R., Sánchez, C., Vidal, N. and Vielba, J.M. (2022). Plant development and crop yield: the role of gibberellins. *Plants.* **11**(19): 2650.

Chakraborty, K., Bhaduri, D., Meena, H.N. and Kalariya, K. (2019). External potassium application improves salinity tolerance by promoting Na+ exclusion, K+ accumulation and osmotic adjustment in contrasting peanut cultivars. *Plant Phys. Biochem.* **103**: 143-153.

Dash, S.R., Sangramsingh, S.P., Routray, B.K., Rai, A.K. and Das, H. (2021). Performance and yield gap analysis of groundnut (*Arachis hypogaea* L.), Var Dharani through cluster front line demonstration in south eastern ghat zone of odisha. *Int. J. Curr. Microbiol. App. Sci.* **10**(12): 43-53.

Dhadge, S.M., Shinde, J.B., Patil, H.M. and Wandnekar, N.U. (2008). Performance of groundnut (*Arachis hypogaea*) varieties to different dates of sowing in *rabi* season. *Int. J. Agric. Sci.* **4**(2): 551-553.

Egamberdieva, D. (2011). Survival of *Pseudomonas extremorientalis* TSAU20 and *P.* c*hlororaphis* TSAU13 in the rhizosphere of common bean (*Phaseolus vulgaris*) under saline conditions. *Plant Soil Environ.* **57**: 122-127.

Egamberdieva, D., Stephan, W., Sonoko, D., Bellingrath,K., Jitendra, M. and Naveen, K.A. (2019). Salt-tolerant plant growth promoting rhizobacteria to enhancing crop productivity of saline soils. *Front. Microb.* **10**: 2791.

Gajera, H.P., Patel, S.V., Kanani, J.K. and Golakiya, B.A. (2010). Evaluation of sulphate and chloride dominant salt tolerance of groundnut genotypes based on physiological traits. *Int. J. Agric. Sci.* **6**(2): 439-448.

Gohari, A.A., Babazadeh, H., Amiri, E. and Sedghi, H. (2018). Estimate of peanut production function under irrigated condition and salinity. *Polish J. Environ. Stud.* **27**(4): 1503-1512.

Gomez, K.A. and Gomez, A.A. (1984). Statistical procedure for agricultural research. Second Edition. A Willey Inte-Science Publication, John Wiley and Sons, New York. p. 680.

Grover M., Ali S.Z., Sandhya V., Rasul A., Venkateswarlu, B. (2011). Role of microorganisms in adaptation of agriculture crops to abiotic stresses. *World J. Microb. Biotech.* **27**: 1231-1240.

Gupta, B. and Huang, B. (2014). Mechanism of salinity tolerance in plants: physiological, biochemical, and molecular characterization. *Int. J. Gen*. **1**: 701596.

Hasan, M., Rahman, M., Haque, A. and Hossain, T. (2019). Soil salinity hazard assessment in Bangladesh coastal zone. Conference: International conference on disaster risk management (ICDRM), 2019At: BUET-JIDPUS Academic Building, West Palashi Campus, Dhakeshwari Road, BUET, Dhaka, Bangladesh-1000. pp. 1-2.

Hasanuzzaman, M., Nahar, K. and Fujita, M. (2013). Plant response to salt stress and role of exogenous protectants to mitigate salt-induced damages, in Ecophysiology and Responses of Plants Under Salt Stress, eds Ahmed P., Azooz M. M., Prasad M. N. V., editors. (New York, NY: Springer). pp. 25–87.

Hnilickova, H., Kraus, K., Vachova, P., Hnilicka, F. (2021). Salinity stress affects photosynthesis, malondialdehyde formation, and proline content in *Portulaca oleracea* L. *Plants*. **10**(5): 845.

Howell, S.H., Lall, S. and Che, P. (2003). Cytokinins and shoot development. *Trend. Plant Sci.* **8**: 453-459.

Ibrahim, A.M., Kerau, M.I., Saleh, M.H., Sanusi, J. and Adesoji, A.G. (2022). The effect of different types of fertilizer on groundnut (*Arachis hypogaea* L.) varieties". Acta Sci. Agric. **6**(11): 42-47.

Karanjikar, P.N., Jadhav, G.S., Walke, P.K. and Pawar, S.B. (2005). Effect of sowing dates and genotype on dry matter partitioning in groundnut during post monsoon season. *J. Maharashtra Agric. Univ.* **30**(1): 083-084.

Kekere, O. (2014a). Growth, yield and seed nutritional composition of groundnut (*Arachis hypogea* L.) under elevated level of soil salinity. *Mole. Soil Bio.* **5**(6): 31-38.

Kekere, O. (2014b). Sustainable production of groundnut (*Arachis hypogaea* L.) through screening and selection of soil salinity tolerant genotypes. *American J. Exp. Agric.* **4**(12): 1842-182.

Kumar, V., Kumar, P. and Khan, A. (2020). Optimization of PGPR and silicon fertilization using response surface methodology for enhanced growth, yield and biochemical parameters of French bean (*Phaseolus vulgaris* L.) under saline stress. *Bio. Agric. Biotech.* **23**: 101463.

Lakshman, S.S., Rahaman, S. and Jana, A.K. (2011). Effect of salinity on growth, yield and yield attributes of summer groundnut (*Arachis hypogaea* L.*)* in coastal saline belts of West Bengal. *Adv. Res. J. Crop Imp.* **2**(2): 178-184.

Lodeyro, A.F., Giró, M., Poli, H.O., Bettucci, G., Cortadi, A., Ferri, A.M. and Carrillo, N. (2016). Suppression of reactive oxygen species accumulation in chloroplasts prevents leaf damage but not growth arrest in salt-stressed tobacco plants. *PloS one*. 11(7): 1-7.

Ma, Y., Dias, M.C. and Freitas, H. (2020). Drought and salinity stress responses and microbe-induced tolerance in plants. *Front. Plant Sci.* **11**: 591911.

Makanda, I., Tongoona, P., Madamba, R., Icishahaya and Derera J.A. (2009). Evaluation of bambara groundnut varieties for off season production in Zimbabwe. *African Crop Sci. J.* **16(**3): 178-183.

Meena, H.N. and Yadav, R.S. (2018). Effect of reusing peanut seeds grown in saline irrigation water on yield attributes and quality traits. *J. Irrigation Drainage Eng.* **144**(3): 1281.

Meena, H.N., Bhaduri, D., Yadav, R.S., Jain, N.K. and Meena, M.D. (2017). Agronomic performance and nutrient accumulation behaviour in groundnut-cluster bean cropping system as influenced by irrigation water salinity. *Biol. Sci.* **87**(1): 31-37.

Meena, H.N., Bhalodia, P.K., Jat, R.S. and Vekaria, L.C. (2012). Prospects of using saline water for irrigation in groundnut (*Arachis hypogaea* L.)- pearl millet (*Pennisetum glaucum*) cropping system in saline black soil of Saurashtra. *Indian J. Agron.* **57**(2): 9-13.

Meena, H.N., Girdhar, I.K., Bhalodia, P.K., Yadav, R.S. and Misra, J.B. (2014). Possibilities for use of saline irrigation water for higherland productivity under groundnut-mustard rotation in salt affected *vertisols* of Saurashtra in Gujarat. *Legume Res.* **37**(1): 79-86.

Meena, H.N., Meena, M. and Yadav, R.S. (2016). Comparative performance of seed types on yields potential of peanut (*Arachis hypogaea* L.*)* under saline irrigation. *Field Crops Res.* **196**: 305-310.

Mensah, J.K., Akomeah, P.A., Ikhajiagbe, B. and Ekpekurede, E.O. (2006). Effects of salinity on germination, growth and yield of five groundnut genotypes. *African J. Biotech.* **5(**20): 1973-1979.

Metwali, E.M.R., Abdelmoneim, T.S., Bakheit, M.A. and Kadasa, N.M.S. (2015). Alleviation of salinity stress in faba bean (*Vicia faba* L.) plants by inoculation with plant growth promoting rhizobacteria (PGPR). *Plant Omics*. **8**: 449-460.

Mouri, S.J. Sarkar, M.A.R. Uddin, M.R. Sarker, U., Kaysar, M. and Hoque, M.M.I. (2018). Effect of variety and phosphorus on the yield components and yield of groundnut. *Prog. Agric.* **29**: 117.

Nazir, F., Mahajan, M., Khatoon, S., Albaqami, M., Ashfaque, F., Chhillar, H., Chopra, P. and Khan, M.I.R. (2023). Sustaining nitrogen dynamics: A critical aspect for improving salt tolerance in plants. *Front. Plant Sci.* **14**: 1087946.

Negrão, S., Schmöckel, S.M., and Tester, M. (2017). Evaluating physiological responses of plants to salinity stress. *Ann. Bot.* **119**(1): 1-11.

Nithila, S., Devi, D.D., Velu, G., Amutha, R. and Rangaraju, G. (2013). Physiological evaluation of groundnut (*Arachis hypogaea* L.) varieties for salt tolerance and amelioration for salt stress. *Research J. Agric. For. Sci.* **1**(11): 1-8.

Nongpiur, R.C., Singla-Pareek, S.L. and Pareek, A. (2016). Genomics approaches for improving salinity stress tolerance in crop plants. *Curr. Gen.* **17**(4): 343-357.

Nwokwu, G., Odoh, I. and Ngozi, E. (2020). Growth and yield response of groundnut (*Arachis hypogaea* L.) varieties to plant density. *J. Agric. Stud.* **8(3)**: 633-650.

Oliveria, D.S, Dias, T.L., Oliveria, E.P., Santos, H.C., Magalhaes, W., Matos, B.E., Sousa, L. and Melofliho, J.S. (2016). Growth and physiology of Peanut (*Arachis hypogaea* L.) irrigated with saline water and biofertilizer application times. *African J. Agric. Res.* **11**(44): 4517-4524.

Osuagwa, G.G.E. and Udogy, O.F. (2014). Effect of salt stress on the growth and nitrogen assimilation of groundnut *(Arachis hypogaea* L.*). J. Pharm. Biol. Sci.* **9**(5): 51-54.

Pal, A. and Pal, A.K. (2017). Physiological basis of salt tolerance in groundnut (*Arachis hypogaea* L.). *Int. J. Cur. Microb. App. Sci.* **6**(9): 2157-2171.

Pandya S.M. and Subbaiah R. (2017). Groundnut (*Arachis hypogaea* L.) influenced by poor (saline) irrigation water for coastal region. *Int. J. Agric. Sci.* **9**(47): 4733-4736.

Parihar, P., Singh, S., Singh, R., Singh, V.P. and Prasad, S.M. (2015). Effect of salinity stress on plants and its tolerance strategies: A review. *Environ. Sci. Poll. Res.* **22**(6): 4056-4075.

Prathima, P., Reddy Y.T., Murthy, D.K.M., Krishna, M.T., Devaki, K., Nagamadhuri, K.V. and Parmeshwari, P. (2012). Influence of sowing date and crop variety on phenology growth and yield of rainfed groundnut (*Arachis hypogea*). In southern zone of Andhra Pradesh (India). *Int. J. Bus. Anal. Tech*. **3**(1): 1-4.

Putri, P.H., Susanto, G.W.A. and Artari, R. (2017). Response of soybean genotypes to salinity in germination stage. *Nus. Biosci.* **9**(2): 133-137.

Qasim, M., Bakhsh, K., Tariq, S.A., Nasir, M., Saeed, R. and Mahmood, M.A. (2016). Factors affecting groundnut yield in pothwar region of punjab, Pakistan. Pakistan J. Agric. Res. 29(1): 76-77.

Qin, J., Dong, W., He, K.N., Chen, J. and Wang, Z.L. (2009). Short-term responses to salinity of Seabuckthorn (*Hippophae rhamnoides* L.) seedlings in the extremely cold and saline Qinghai region of China. *Forest Stud. China*. **11**(4): 231-237.

Raagavalli, K., Soumya, T.M., Veeranna, H.K., Nataraju, S.P. and Narayanswamy, H. (2019). Effect of sowing windows on growth and yield of groundnut (*Arachis hypogaea* L.) genotypes. *Int. J. Curr. Microbiol. Appl. Sci*. **8**(3): 59-67.

Ravisankar, N., Balakrishanan, M., Chaudhari, G.S., Ambast, S.K., Srivastava, R.C., Subraman, T. and Bommayasamy, N. (2010). Evaluation of time method of sowing and varieties for table purpose groundnut (*Arachis hypogea*) under Island ecosystem. *Indian J. Agric. Sci.* **80**(4): 293.

Salama, M.A.A. 2011. Estimating water consumptive use for some crops under stress condition using neutron scattering method. Ph.D. Thesis, Ain Shams University, Cario. pp. 1-3.

Salwa, A.R., Hammad, K.A. and Tantaway, F. (2010). Studies on salinity tolerance of two peanut cultivars in relation to growth, leaf water content, some chemical aspects and yield. *J. App. Sci. Res.* **6**(10): 1517-1526.

Sardana, V. and Kandhola, S.S. (2007). Productivity of semi spreading and bunch type varieties of groundnut as influenced by sowing dates. *J. SAT. Agric. Res.* **5**(1): 1-4.

Sareh, E.N., Mansour, A.M., Damsi, B. and Masumeh, J. (2015). The effect of salinity on some morphological characteristics of three varieties of *Arachis hypogaea* L. *Int. J. Adv. Biotech. Res.* **6**(4): 498-507.

Satu, S.I., Mansora, A. and Ahmad, S. (2019). Effects of salinity on the growth and development of groundnut plant (*Arachis hypogaea* L.). *J. Bangaladesh Acad. Sci.* **43**(1): 25-30.

Shakil, M. (2022). Peanut cultivation: Peanut Emerging as a Major Cash Crop. In: Dly. Star. https://www.thedailystar.net/business/economy/news/peanut-emerging-major-cash-crop 2988416. Accessed 29 Jun 2022.

Shendage, R.C., Mohite, A.B. and Sathe, R.K. (2018). Effect of sowing times and varieties on growth and yield of summer groundnut (*Arachis hypogaea* L.). *J. Pharma. Phytochem*. **7**(1): 720-722.

Shradhdha, P. and Subbaiah R. (2020). Salinity response function on groundnut crop yield for Coastal region in Gujarat. *J. Soil Water Conserv*. **19**(3): 328-334.

Shrimali, G., Patel, I. and Trivedi, D. (2015). Studies on sensitivity of groundnut cultivars to NaCl stress. *Indian J. Res.* **4**(1): 4-6.

Shrivastava, N., Vadez, V., Shyam, N. N.,Upadhyaya, H.M. and Lakhsmi, N. (2018). Screening groundnut (*Arachis hypogaea* L.) germplasm for salinity tolerance. *J. Gen. Res.* **4**(2): 30-40.

Shrivastava, P. and Kumar, R. (2015). Soil salinity: A serious environmental issue and plant growth promoting bacteria as one of the tools for its alleviation. *Saudi J. Biol. Sci.* ***22***(2): 123-131.

Singh, A.L., Hariprasanna, L. and Chaudhari, V. (2016). Differential nutrients absorption an important tool for screening and identification of soil salinity tolerant peanut genotypes. *Indian J. Plant Phys.* **21**(1): 83-92.

Singh, P., Choudhary, O.P. and Singh, P. (2017). Performance of some groundnut cultivars under saline irrigation water in field condition. *Com. Soil Sci. Plant Anal.* **49**(1): 1-10.

Singh, R., Issar, D., Zale, P.V. and Nautiyal, P.C. (2007). Variation in sensitivity to salinity in groundnut cultivars during seed germination and early seedling growth. *J. SAT Agric. Res.* **5**(1): 1-7.

Sosnowski, J., Truba, M., Vasileva, V. (2023). The Impact of Auxin and Cytokinin on the Growth and Development of Selected Crops. Agriculture. 2023; 13(3):724.

Taffouo. V.D., Wamba, O.F., Youmbi, E., Nano, G.V. and Akoa, A. (2010a). Growth, yield, water status and ionic distribution response of three Bambara groundnut (*Vigna subterranean* L. *verdc.)* landraces grown under saline conditions. *Int. J. Bot.* **6**(1): 53-58.

Talwar, H., Soni, M., Beniwal, R., Tomar, R. and Nigam, S. (2002). Evaluation of short-duration groundnut genotypes for the arid zone of northwest Rajasthan, India. *Int. Arach. News*. **22**: 15-18.

Tayyab, A., Muhammad, A., Muhammad, Q., Naeem, A. and Rafiq, A. (2016). Salt stress responses of pigeon pea (*Cajanus cajan*) on growth, yield and some biochemical attributes. *Pakistan J. Bot.* **48**(4): 1353-1360.

Uko, A.E., Udo, I.A. and Effa, E.B. (2019). Growth and yield responses of groundnut (*Arachis hypogaea* L.) to arbuscular mycorrhizal fungi inoculation in calabar, Nigeria. *Asian J. Crop Sci.* **11**: 8-16.

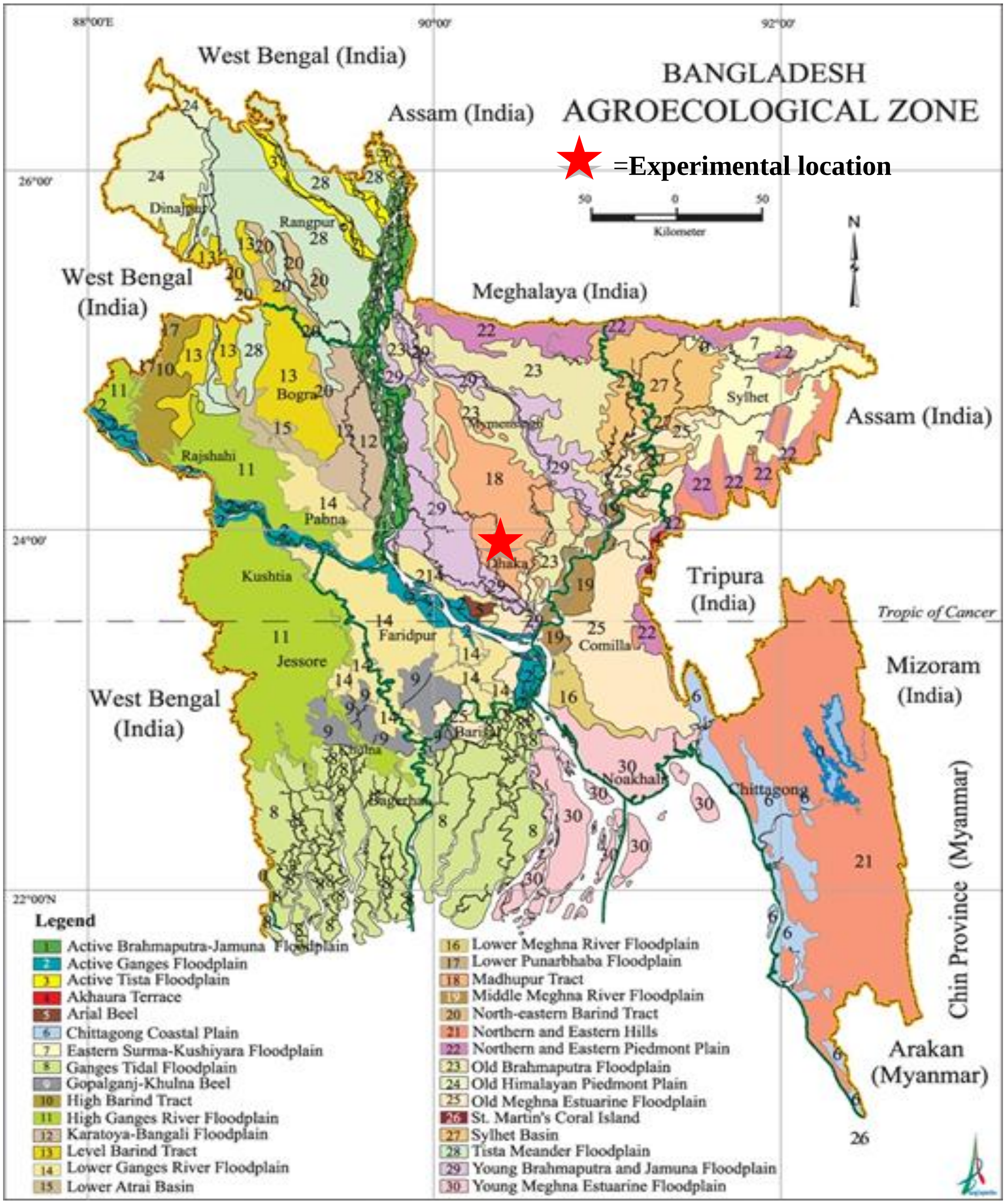
Vadez, V., Srivastava, S., Krishnamurthy, L., Aruna, R. and Nigam, S.N. (2005). Standerdization of a protocol to screen for salinity tolerance in groundnut. *Int. Ara. News.* **25**: 140-142.

Venkatachalapathi, V. and Rao, S.B.S.N. (2014). Performance of groundnut varieties under different dates of sowing and irrigation regimes. *Crop Res*. **48**(1, 2 & 3): 57-60.

Yu, L.H., Wu, S.J., Peng, Y.S., Liu, R.N., Chen, X., Zhao, P. and Xiang, C.B. (2016). *Arabidopsis* EDT 1/HDG 11 improves drought and salt tolerance in cotton and poplar and increases cotton yield in the field. *Plant Biotech. J.* **14**(1): 72-84.

APPENDICES

Appendix I. Map showing the experimental location under study



Appendix II. Soil characteristics of the experimental field

A. Morphological features of the experimental field

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

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

Physical characteristics	
Constituents	**Percent**
Clay	29 %
Sand	26 %
Silt	45 %
Textural class	Silty clay
Chemical characteristics	
Soil characteristics	**Value**
Available P (ppm)	20.54
Exchangeable K (mg/100 g soil)	0.10
Organic carbon (%)	0.45
Organic matter (%)	0.78
pH	5.6
Total nitrogen (%)	0.03

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

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

Year	Month	Air temperature (^{0}C)		Relative humidity (%)	Average rainfall (mm)
		Maximum	Minimum		
2020	February	25.9 ^{0}C	14 ^{0}C	34%	7.7 mm
	March	32.9°C	20.1°C	61%	54 mm
	April	34.1°C	23.6°C	67%	138 mm
	May	33.4°C	24.7°C	76%	269 mm
	June	34°C	27.3°C	76%	134 mm
	July	32.6°C	25.5°C	80%	106 mm

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

Appendix IV. Mean sum square values of the data for plant height at different days after planting of groundnut

Source of Variation	DF	Mean sum square values of plant height at			
		40 DAP	65 DAP	90 DAP	At harvest
Replication	2	1.046	0.71	3.73	0.78
Variety (V)	13	23.88 **	92.28 **	105.720**	114.24 **
Salinity (S)	2	5.54 **	41.46 **	1029.54 **	1288.29 **
V×S	26	2.15 *	1.932 *	21.62 **	21.61 **
Error	82	1.16	1.08	2.23	2.41

Ns: Non significant
** : Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

Appendix V. Mean sum square values of the data for number of leaves at different days after planting of groundnut

Source of Variation	DF	Mean sum square values of leaf number at			
		40 DAP	65 DAP	90 DAP	At harvest
Replication	2	0.64	0.31	0.01	0.15
Variety (V)	13	3.07 **	8.917**	5.29 **	8.88 **
Salinity (S)	2	0.26^{NS}	0.59^{NS}	4.81 **	5.12 **
V×S	26	0.26^{NS}	0.42^{NS}	0.11^{NS}	0.21^{NS}
Error	82	0.23	0.30	0.28	0.37

Ns: Non significant
** : Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

Appendix VI. Mean sum square values of the data for number of branches at different days after planting of groundnut

Source of Variation	DF	Mean sum square values of branch number at			
		40 DAP	65 DAP	90 DAP	At harvest
Replication	2	0.644	0.31	0.01	0.15
Variety (V)	13	3.07**	8.91 **	5.29 **	8.87**
Salinity (S)	2	0.26 ^{NS}	0.59 ^{NS}	4.80 **	5.12 **
V×S	26	0.26 ^{NS}	0.42^{NS}	0.11 ^{NS}	0.21 ^{NS}
Error	82	0.23	0.30	0.27	0.37

Ns: Non significant
** : Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

Appendix VII. Mean sum square values of the data for yield contributing characteristics of groundnut

Source of Variation	DF	Number of pods Pot^{-1}	Number of true pods pot^{-1}	Number of seeds pot^{-1}
Replication	2	8.39	3.52	14.40
Variety (V)	13	1144.62 **	928.66 **	2559.20 **
Salinity (S)	2	8846.20 **	7558.38 **	26506.20 **
V×S	26	157.73 **	145.67 **	263.60 **
Error	82	9.88	8.92	21.80

Ns: Non significant
** : Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

Appendix VIII. Mean sum square values of the data for yield characters of groundnut

Source of Variation	DF	Pod weight pot^{-1}	Seed yield pot^{-1}	Stover yield pot^{-1}
Replication	2	0.14	0.65	1201431
Variety (V)	13	403.04 **	109.89 **	1210515 *
Salinity (S)	2	4467.66 **	2453.88 **	1296663 *
V×S	26	57.27 **	25.59 **	1199418 *
Error	82	1.49	2.33	1203975

Ns: Non significant
** : Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

PLATES

Plate 1: Experimental view

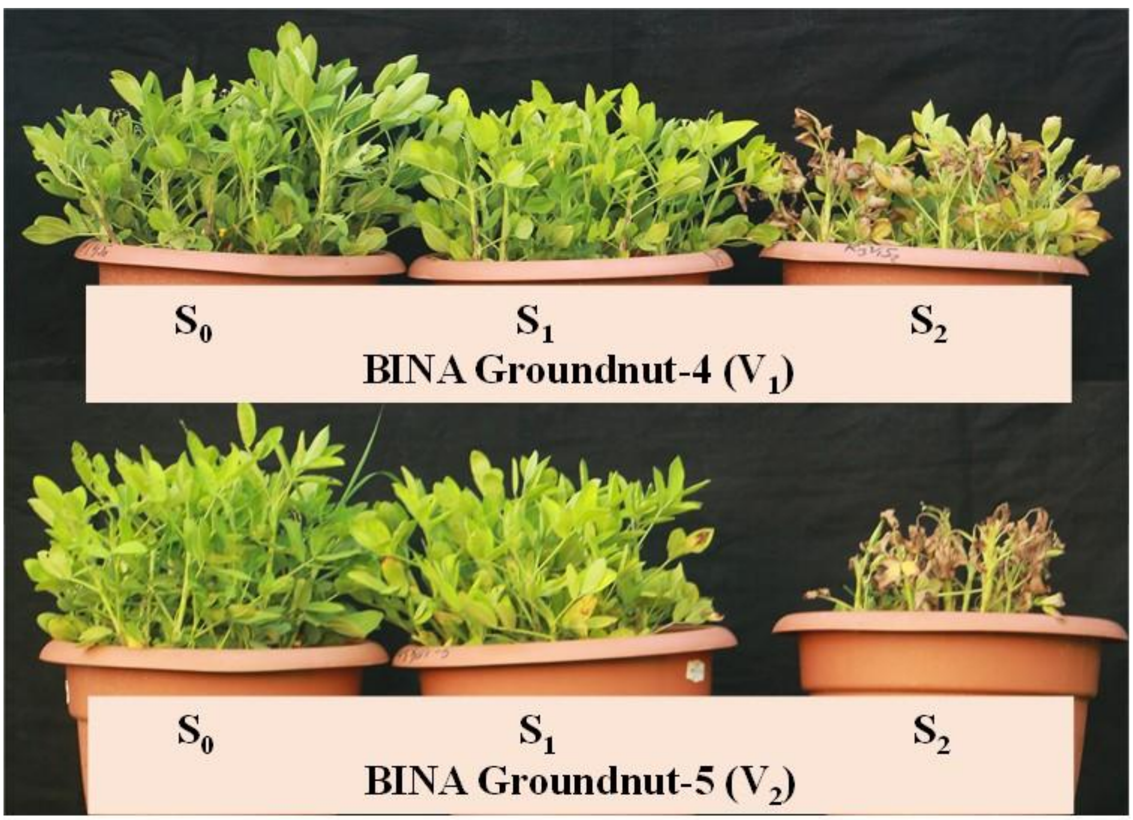


Plate 2: Phenotypic appearances of salt sensitive groundnut varieties

Plate 3: Phenotypic appearances of salt tolerant groundnut varieties