EFFECTS OF SALINITY ON GERMINATION, INITIAL GROWTH STAGE AND NUTRIENT CONTENTS OF MUNGBEAN

A Thesis

by

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CERTIFICATE

This is to certify that the thesis entitled, "EFFECTS OF SALINITY ON GERMINATION,INITIAL GROWTH STAGE AND NUTRIENT CONTENTS OF MUNGBEAN" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfillment of the requirements for the degree of MASTER OF SCIENCE (M.S.) IN AGRICULTURAL CHEMISTRY, embodies the result of a piece of bona fide research work carried out by MONIRUL ISLAM , Registration No. 14-06259 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:

Place: Dhaka, Bangladesh

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Dedicated to

My

Beloved Parents

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ABSTRACT

The experiment was undertaken in February 2019 to June 2020 in the net house of Agricultural Chemistry Department, Sher-e-Bangla, Dhaka, Bangladesh effects of salinity on germination, initial growth stage and nutrient contents of mungbean. In this experiment, the treatment consisted of four mungbean varieties viz., V_1 = BARI Mung 5, V_2 = Binamung 5, V_3 = BARI Mung 6, V_4 =Binamung 7 and five salinity levels (0, 3, 6, 9 and 12 dSm^{-1}). The experiment was set in Completely Randomized Design (CRD) having two factors with three replications. Results showed that a significant variation was observed among the treatments in respect of majority of the observed parameters. The collected data were statistically analyzed for evaluation of the treatment effect.

Data were collected on germination percentage, population density, plant height, number of leaves per plant, length of root. A statistically significant variation was recorded in terms of all the characters related to growth and chemical analysis. The maximum plant height, number of leavess per plant, length of root was produced by Binamung 7. The maximum plant height, number of leave per plant, length of root was observed in levels of 0 dS^{-1}. Among the combined effects of varieties and salinity levels, plant height, number of leaves per plant, root length was found in Binamung 7 with 0 dSm^{-1} level and at 3, 6, 9 and 12 dSm^{-1} salinity levels. Among the four varieties, K content was highest in BARI Mung 6 among the other three varieties. In both varieties K content decreased significantly with the increasing salinity level. Na content was highest in BARI Mung 5 than Binamung 7. N and P content was highest in BARI Mung 6.

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LIST OF ABBREVIATION AND ACRONYMS

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

CHAPTER I

INTRODUCTION

Mungbean, grass pea, lentil, blackgram, chickpea, field pea and cowpea are the major pulse crops of Bangladesh. Among them mungbean (*Vigna radiata* L.) is one of the most important pulse crop of Bangladesh and belongs to the family Leguminosae and sub-family Papilionaceae. It holds the 3rd in protein content and 4th in both acreage and production in Bangladesh (Sarkar *et al*., 1982). The agro-ecological condition of Bangladesh is favourable for growing this crop. Pulses constitute the main source of protein for the people, particularly the poor sections of Bangladesh. These are also the best source of protein for domestic animals. Besides, the crops have the capability to enrich soils through nitrogen fixation. Mungbean contains 51% carbohydrates, 26% protein, 4% mineral and 3% vitamin. On the nutritional point of view, mungbean is one of the best among pulses (Khan, 1981). It is widely used as "Dal" in the country like other pulses. It contains almost double amount of protein as compared to cereals. It has a good digestibility and flavor. The green plants are used as animal feed and the residues as manure. Life cycle of mungbean is short; it is also drought tolerant and can grow with a minimum supply of nutrients. Mungbean also improves physical, chemical and biological properties of soil by fixing nitrogen from atmosphere through symbiosis process.

According to FAO (2013) recommendation, a minimum per capita uptake of pulse should be 80 g/day, whereas it is 7.92 g/day in Bangladesh. This is because of fact that national production of the pulses is not adequate to meet our national demand. The total production of mungbean in Bangladesh in 2019-2020 was 37054 metric tons from the area of 44,025 hectares (ha) with an average yield 0.84 t ha^{-1} (BBS, 2020).

Variety plays an important role in producing high yield of mungbean because different varieties perform differently for their genotypic characters also vary from genotype to genotype. Improved variety is the first and foremost requirement for initiation and accelerated crop production program. Recently, Bangladesh Agricultural Research Institute (BARI) and Bangladesh Institute of Nuclear Agriculture (BINA) have developed photo-insensitive high yielding cultivars mungbean, mostly known as climate smart options. There has been so far varieties released by BARI, BINA and Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU). During *kharif* season the crop fits well into the existing cropping system of many areas in Bangladesh. However, to my knowledge information are not enough to find the suitable variety/ies for *kharif-1* season.

Salinity is a common abiotic stress factor seriously affecting crop production in different regions, particularly in arid and semi–arid regions. It is estimated that over 800 million hectare of land in the world are affected by both salinity and sodicity (Munns, 2005). The arable land is continuously transforming into saline (1-3% per year) either due to natural salinity or due to human interference which accounts nearly 20% of the irrigated agricultural land. Due to natural salinity and human interferences, the arable land is continuously transforming into saline that is expected to have overwhelming global effects, resulting in up to 50% land loss by 2050 (Saha *et al*., 2010; Hasanuzzaman *et al*., 2013). Salt stress imposes substantial adverse effects on the performance and physiology of the crop plants, which eventually leads to plant death as a consequence of growth arrest and metabolic damage (Hasanuzzaman *et al*., 2012).

There are various detrimental effects of salt stress in crop plants, which are responsible for severe decrease in the growth and yield of plants. Osmotic stress (drought problem), ion imbalance, particularly with Ca, K, and the direct toxic effects of ions on the metabolic process are the most important and widely studied physiological impairments caused by salt stress (Zhu, 2001; Munns *et al*., 2006 and Eker et al., 2006). High salt concentration in root affects the growth and yield of many important crops (Alam *et al*., 2004; Taffouo *et al*., 2004). The salinity may reduce the crop yield by upsetting water and nutritional balance of plant (Khan *et al*., 2007 and Taffouo, *et al*., 2009). It is recognized as major constraint in the production of this crop where 50 mM NaCl can cause yield losses ≥70% (Hasanuzzaman et *al*., 2013). However, the intensity of adverse and injurious, effects of salinity stress depends upon the nature of plant species, concentration and duration of salt stress, plant developmental stage, and mode of salt application to the crop. Salinity is a polygenic trait which adversely affected the biometric, morpho-physiological, biochemical and biophysical characters of mungbean (Mahajan and Tuteja, 2005). The increased salinity of agronomically important land is expected to have overwhelming global effects by the middle of th e twenty-first century (Kandil, 2012; Karthikeyan *et al*., 2012).

Due to the complex nature of salinity stress and lack of appropriate techniques for introgression little progress has been made in developing salt tolerant mungbean varieties (Mahdavi and Sanavy, 2007). Worldwide, a total of 43,027 mungbean accessions are available at core collections or Gene Bank at different stations. To date, over 110 mungbean cultivars have been released by AVRDC in South and Southeast Asia and around the world. AVRDC has developed several mungbean with superior lines for production in the tropics and subtropics which are early and uniformly maturing (55-65 days), disease resistant, and high yielding. An improved variety is the first and foremost requirement for initiation and accelerated production program of any crop. Recently, Sehrawat *et al*. (2013) reviewed that mungbean also encounters the cumulative adverse effects of other environmental factors as insects, pests, high temperature, pod-shattering along with salinity causing high yield loss. Due to the complex nature of salinity stress and lack of suitable techniques for introgression of desirable agronomic traits or resistant genes, little progress has been made in developing salt tolerant mungbean varieties (Singh and Singh, 2011).

Considering the above factors the present experiment was conducted to effects of salinity on germination, initial growth stage and nutrient contents of mungbean with the following objectives:

i) To find out the effect of salinity on germination and initial growth stage of some mungbean cultivars.

ii) To determine the nutrient content of mungbean varieties.

CHAPTER II
REVIEW OF LITERATURE

A good number of research works on different aspects of mungbean production have been done by research workers in and outside of the country, especially in the South East Asia for the improvement of mungbean production. Recently Bangladesh Agricultural Research Institute (BARI) and Bangladesh Institute of Nuclear Agriculture (BINA) have started research on varietal development and improvement of this crop. Research work related to the study of reproductive behaviour of mungbean is reviewed and presented in this chapter.

2.1 Effect of variety of mungbean

Lema *et al*. (2018) conducted the experiment to investigate the performance of 3 different Mungbean varieties (Sunian, MH-97-6 and Gofa local) on response of different growth parameters to assess the performance of Mungbean cultivars in relation to growth parameters and to estimate the analysis of growth characteristics using the primary values generated from these cultivars. There is significant difference among cultivars observed for total dry biomass. The SLA (specific leaf area) and LAR (leaf area ratio) of all cultivars increment from first sample to second sample as crop development progressed. The highest SLA and LAR were attributed suniana variety. Gofa local cultivar is highest total dry biomass, since in this study genetic factor and environment are key factors for achieving optimum growth and dry matter production of Mungbean cultivars.

Singh and Sharma (2014) conducted the experiment at Simbhaoli and identify stable genotype of Mungbean under varying environment. Forty indigenous genotypes of Mungbean collected from different institute/organizations were evaluated under eight artificially created environments for stability analysis for seed yield and its components. On the basis of stability parameters, genotype KM 2194, KM 2224, KMU 41, KMU 42, and KMU 55 were identified as desirable for seed yield.

Singh *et al*. (2014) conducted the experiment at Simbhaoli and identify stable genotype of Mungbean under varying environment. Forty indigenous genotypes of Mungbean collected from different institute/organizations were evaluated under eight artificially created environments for stability analysis for seed yield and its components.

Bhowal and Bhowmick (2014) reported that variety and date of harvest had significant influences on various crop characters and seed yield. The variety Bina Mung 7 showed superiority in plant height, number of branches plant^{-1}, number of effective pods and total pods plant^{-1} and number of seeds pod^{-1} over other two varieties resulting in highest seed yield of 1856 kg ha^{-1}.

Ali *et al.* (2014) investigated the effect of sowing time on yield and yield components of different mungbean varieties; a field experiment was conducted during 2012 at agronomic research area, University of Agriculture, Faisalabad, Pakistan. The experiment was designed according to randomized complete block design under split plot arrangement in triplicate. Different sowing times (15th June, 25th June, 5th July and 15th July) were assigned to main plots and varieties (NM-2011, NM-2006, AZRI-2006 and NM-98) were allocated to subplots. Different mungbean varieties also responded significantly towards yield and yield components and NM-2011 variety outperformed in terms of maximum seed yield (1282.87 kg ha^{-1}) than rest of varieties.

Parvez *et al*. (2013) conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from October to January 2011 to study the performance of mungbean as affected by variety and level of phosphorus. The experiment comprised four varieties viz. BARI Mung-6, Binamoog-4, Binamoog-6 and Binamoog-8 and four levels of phosphorus viz. 0, 20, 40 and 60 kg P_2O_5 ha^{-1}, and laid out in a Randomized Complete Block Design with three replications. Results revealed that the longest plant, highest number of branches plant^{-1}, number of total pods plant^{-1}, seeds plant^{-1} and seed weight plant^{-1} were obtained from BARI mung 6. Binamung 6 produced the highest seed yield which was as good as Binamoog-8.

Rasul *et al*. (2012) conducted an experiment to establish the proper inter-row spacing and suitable variety evaluation in Faisalabad, Pakistan. Three mungbean varieties V_1, V_2, V_3 (NM-92, NM-98, and M-1) were grown at three inter-row spacing (S_1- 30 cm, S_2- 60 cm and S_3- 90 cm) respectively. Highest seed yield was obtained for variety V_2 at 30 cm spacing. Among varieties V_2 exhibited the highest yield 727.02 kg ha^{-1} while the lowest seed yield 484.79 kg ha^{-1} was obtained with V_3. The spacing 30 cm showed highest seed yield 675.84 kg ha^{-1} as compared to other spacing treatments. So it can be concluded that mung bean variety Nm-98 should be grown at inter row spacing of 30 cm under the agro-climatic conditions of Faisalabad.

Dodwadiya and Sharma (2012) reported that variety SML 668 gave the highest seed yield in both seasons, followed by Pusa Vishal and Pusa 9531. Zero tillage was more profitable in summer, while conventional tillage was the best practice in the rainy season. It is recommended to grow newly-released variety SML 668 during summer as well as rainy season for higher productivity and profitability.

Ahamed *et al*. (2011) conducted at the experimental field of Agricultural Botany Department, Sher-e- Bangla Agricultural University, Dhaka, Bangladesh from the period of August, 2009 to April, 2010 (Kharif –2 season). Five Mungbean varieties namely BARI mung 2 (M_2), BARI mung 3 (M_3), BARI mung 4 (M_4), BARI mung 5 (M_5) and BARI mung 6 (M_6) were used in the experiment to observe their morphophysiological attributes in different plant spacings viz. 20×10 cm (D_1), 30×10 cm (D_2) and 40×10 cm (D_3). The highest plant height of BARI mung 4 is 49.38 cm that is statistically with the height of BARI mung 3 (i.e. 48.38 cm). Leaf area of BARI mung 3 was the highest (147.57 cm^2). The variety BARI mung 3 produced the lowest leaf area of 110.00 cm^2. In the study

BARI mung 2 took 30.44 days for flowering that is statistically at per BARI mung 6 (30.11) and BARI mung 4 flower earliest (at 28.88 days after sowing) as compared to all other varieties.

Singh *et al*. (2011) found varietal performance in Mungbean on different yield parameters. Genotypes; Pusa Vishal, SML 668, Pusa 9531, UPM 98-1 and MH 96-1 were considered for varietal evaluation. Genotypes Pusa Vishal (selection from AVRDC material NM 92), SML 668 (selection from NM 94) and Pusa 9531 were on at par in the grain yield and were better than UPM 98-1 and MH 96-1. Pusa Vishal and SML 668 had significantly larger seed size compared to Pusa 9531 and MH 96-1. Genotypes NM 92 and VC 3890-A were superior to NM 94 and SML 134 in grain yield.

Verma *et al*. (2011) reported that Mungbean cv. HUM 12 gave significantly higher plant height, number of trifoliate leaves/plant, number of branches/plant, dry matter accumulation/plant, pod length, number of pods/plant, number of seed/pods, 1000 grain weight, grain yield, harvest index, protein content and protein yield (kg/ha) than K 851 and NDM 1.

Salah-Uddin *et al.* (2009) carried out in experimental field of the department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to investigate the interaction effect of variety and fertilizers on the growth and yield of summer Mungbean during the summer season of 2007. Five levels of fertilizer viz. control, N + P +K, Biofertilizer, Biofertilizer + N + P + K and Bio-fertilizer + P + K. and three varieties BARI mung 5, BARI mung 6 and Binamung 5 were also used as experimental variables. The experiment was laid out in Randomized Block Design with fifteen treatments where each treatment was replicated three times. BARI mung 6 obtained highest number of nodule plant^{-1} and higher dry weight of nodule. It also obtained highest number of pod plant^{-1}, seed plant^{-1}, 1000 seed weight and seed yield.

Rehman *et al.* (2009) conducted a field experiment to study the effect of five planting dates viz. 30th March, 15th April, 15th May, 15th June and 15th July on two mungbean varieties i.e. NM-92 and M-1 were evaluated at NWFP Agricultural University, Peshawar during summer 2004. Significant differences were observed among various planting dates for all the parameters except days to 50% flowering and grains pod^{-1}. Sowing date of 30th March took more days to emergence, flowering and physiological maturity. Maximum emergence m^{-2} was recorded for 15th April sowing. The crop attained maximum plant height under 15th May sowing. Highest grain yield was recorded for early planting of 30th March. Both mungbean varieties produced statistically similar grain yield.

Kabir and Sarkar (2008) carried out to study the effect of variety and planting density on the yield of mungbean in Kharif-I season (February to June) of 2003. The experiment comprised five varieties viz. BARI mung 2, BARI mung 3, BARI mung 4, BARI mung 5 and Binamung 2. The experiment was laid out in a randomized complete block design with three replications. It was observed that BARI mung 2 produced the highest seed yield and Binamung 2 did the lowest.

Bhuiyan *et al*. (2008) carried out an experiment with five mungbean varieties to observe the yield and yield attributes of mungbean. Five mungbean varieties viz. BARI mung 2, BARI mung 4, BARI mung 5, Binamung 2 and Barisal local, and the rhizobial inoculum (Bradyrhizobium strain BAUR-604) were used. The seeds and stover were dried and weighed adjusting at 14% moisture content and yields were converted to t/ha. The yield attributing data were recorded from 10 randomly selected plants. BARI mung 2 produced the highest seed yield (1.03 t/ha in 2001 and 0.78 t/ha in 2002) and stover yield (2.24 t/ha in 2001 and 2.01 t/ha in 2002). Higher number of pods/plant was also recorded in BARI mung 2, while BARI mung 5 produced the highest 1000-seed weight. Application of Bradyrhizobium inoculant produced significant effect on seed and stover yields in both trials conducted in two consecutive years. Seed inoculation significantly increased seed (0.98 t/ha in 2001, 27% increase over control and 0.75 t/ha in

2002, 29% increase over control) and stover (2.31 t/ha in 2001 and 2.04 t/ha in 2002) yields of mungbean.

An experiment was conducted by Muhammad *et al*. (2006) to study the nature of association between Rhizobium phaseoli and mungbean. Inocula of two Rhizobium strains, Tal-169 and Tal-420 were applied to four mungbean genotypes viz., NM-92, NMC-209, NM-98 and Chakwal Mung-97 with a control. The experiment was carried out at the University of Arid Agriculture, Rawalpindi, Pakistan, during kharif, 2003. Both the strains in association with NM-92 had higher nodule dry weight, which was 13% greater than other strains x mungbean genotypes combinations. Strain Tal-169 was specifically more effective on genotype NCM-209 and NM-98 compared with NM-92 and Chakwal Mung-97. Strain Tal-420 increased branches plant^{-1} of all the genotypes. Strain Tal-169 in association with NCM-209 produced the highest yield of 670 kg ha^{-1} which was similar (590 kg ha^{-1}) in case of NCM-209 either inoculated with strain Tal-420 or uninoculated. Variety NM-92 produced the lowest grain yield (330 kg ha^{-1}) either inoculated with strain Tal-420 or uninoculated.

Islam *et al*. (2006) carried out an experiment at the field laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh during the period from March 2002 to June 2002 to evaluate the effect of biofertilizer (Bradyrhizobium) and plant growth regulators (GA_3 and IAA) on growth of 3 cultivars of summer mungbean (*Vigna radiata* L.). Among the mungbean varieties, Bina moog 5 performed better than that of Bina moog 2 and Bina moog 4.

Studies were conducted by Bhati *et al*. (2005) from 2000 to 2003 to evaluate the effects of cultivars and nutrient management strategies on the productivity of different kharif legumes (mungbean, mothbean and clusterbean) in the arid region of Rajasthan, India. The experiment with mungbean variety K-851 gave better yield than Asha and the local cultivar. In another experiment, mungbean cv. PDM-54 showed 56.9% higher seed yield and 13.7% higher fodder yield than the local cultivar.

A field experiment was conducted by Raj and Tripathi (2005) in Jodhpur, Rajasthan, India, during the kharif seasons, to evaluate the effects of cultivar (K-851 and RMG-62) as well as nitrogen (0 and 20 kg/ha) and phosphorus levels (0, 20 and 40 kg ha^{-1}) on the productivity of mungbean. The cultivars K-851 produced significantly higher values for seed and straw yields as well as yield attributes (plant height, pods $plant^{-1}$, seeds pod^{-1} and 1000-seed weight) compared with RMG-62. Higher net return and benefit:cost (B:C) ratio were also obtained with K-851 (Rs. 6544 ha^{-1} and 1.02, respectively) than RMG-62 (Rs. 4833 ha^{-1} and 0.76, respectively).

Chaisri *et al*. (2005) conducted a yield trial involving 6 recommended cultivars (KPS 1, KPS 2, CN 60, CN 36, CN 72 and PSU 1) and 5 elite lines (C, E, F, G, H) in Lopburi Province, Thailand, during the dry (February-May 2002), early rainy (June-September 2002) and late rainy season (October 2002-January 2003). The Line C, KPS 1, CN 60, CN 36 and CN 72 gave high yields in the early rainy season, while line H, line G, line E, KPS 1 and line C gave high yields in the late rainy session.

Two summer mungbean cultivars, i.e. Binamoog 2 and Binamoog 5, were grown during the kharif-1 season (February-May) of 2001, in Mymensingh, Bangladesh, under no irrigation or with irrigation once at 30 days after sowing (DAS), twice at 30 and 50 DAS, and thrice at 20, 30 and 50 DAS by Shamsuzzaman *et al*. (2004). The two cultivars tested were synchronous in flowering, pod maturity and leaf senescence, which were significantly delayed under different irrigated frequencies. Binamung 2 performed slightly better than Binamung 5 for most of the growth and yield parameters studied.

The performance of 20 mungbean cultivars were evaluated by Madriz-Isturiz and Luciani-Marcano (2004) in a field experiment conducted in Venezuela during the rainy season of 1994-95 and dry season of 1995. Significant differences in the values of the parameters measured due to cultivar were recorded. The cultivars VC 1973C, Creole VC 1973A, VC 2768A, VC 1178B and Mililiter 267 were the most promising cultivars for cultivation in the area with the average yield was 1342.58 kg/ha.

A field experiment was conducted by Apurv and Tewari (2004) during kharif season of 2003 in Uttaranchal, India, to investigate the effect of Rhizobium inoculation and fertilizer on the yield and yield components of three mungbean cultivars (Pusa 105, Pusa 9531 and Pant mung 2). The variety Pusa 9531 showed higher yield components and grain yield than Pusa 105 and Pant mung 2.

To find out the effects of Rhizobium inoculation on the nodulation, plant growth, yield attributes, seed and stover yields, and seed protein content of six mung bean (*Vigna radiata*) cultivars were investigated by Hossain and Solaiman (2004). The mungbean cultivars were BARI mung 2, BARI mung 3, BARI mung 4, BARI mung 5, Binamung 2 and BU mung-1. Rhizobium strains TAL169 and TAL441 were used for inoculation of the seeds. Two-thirds of seeds of each cultivar were inoculated with Rhizobium inoculant and the remaining one-third of seeds was kept uninoculated. Among the cultivars, BARI mung 4 performed the best in all aspects showing the highest seed yield of 1135 kg/ha. Rhizobium strain TAL169 did better than TAL441 in most of the studied parameters. It was concluded that BARI mung 4 in combination with TAL169 performed the best in terms of nodulation, plant growth, seed and stover yields, and seed protein content.

Ali *et al*. (2004) carried out an experiment at BARI, Joydebpur, Gazipur to find out the response of inoculation with different plant genotypes of mungbean. Three varieties of mungbean viz. BARI mung 1, BARI mung 2, BARI mung 3 and Rhizobial inoculums (BARI Rvr 405) were use in this experiment. Each variety was tested with and without inoculation. Inoculated plants gave significantly higher number of nodules.

Sadi (2004) observed that plant height, 1000-seed weight and harvest index were significantly influenced by variety. In an experiment with 15 genotypes in mungbean, the highest seed yield was obtained in MB 45 (Hasan, 2004).

Mondal (2004) conducted an experiment at farmer's field of Rangpur zone during kharif-1 season to evaluate the performance of four mungbean varieties viz. Binamung 2, Binamung 5, BARI mung 2 and BARI mung 5. Result revealed that Binamung 5 had the highest seed yield (1091 kg ha^{-1}) than the other tested varieties because it produced the greater number of pods $plant^{-1}$ and 1000 seed weight. Moreover, Binamoog 5 matured 5 days earlier than the others.

It was reported in Bangladesh condition that BARI mung2 contributed higher seed yield than BARI mung5 due to production of higher number of pods $plant^{-1}$ (Sarkar *et al*., 2013). Ahmad *et al*. (2003) conducted a pot experiment in Bangladesh on the growth and yield of mungbean cultivars viz., BARI mung 2, BARI mung 3, BARI mung 4, BARI mung 5, BU mung 1, BU mung 2 and Binamung 5 and found that BARI mung 2 produced the highest seed yield while BARI mung3 produced the lowest.

The development phases and seed yield were evaluated by Infante *et al*. (2003) in mungbean cultivars ML 267, Acriollado and VC 1973C under the agroecological conditions of Maracay, Venezuela, during May-July 1997. The differentiation of the development phases and stages, and the morphological changes of plants were studied. The variable totals of pod clusters, pods per plant, seeds per pods and pod length were also studied. The earliest cultivar was ML 267 with 34.87 days to flowering and 61.83 to maturity. There were significant differences for total pod clusters per plant and pods per plant, where ML 267 and Acriollado had the highest values. The total seeds per pod of VC 1973C and Acriollado were significantly greater than ML 267. Acriollado showed the highest yield with 1438.33 kg/ha.

Solaiman *et al*. (2003) studied on the response of mungbean cultivars BARI mung 2, BARI mung 3, BARI mung 4, BARI mung 5, Binamung 2 and BU mung-1 to Rhizobium sp. Strains TAL 169 and TAL441. It was observed that inoculation of the seeds increased nodulation.

Bhuiyan *et al*. (2003) conducted a field Experiment at Regional Agricultural Research Station (RARS), Rahmatpur, Barisal, to study the response of inoculation with different plant genotypes. Four varieties of mungbean viz. BARI mung 2, BARI mung 3, BARI mung 4, BARI mung 5, and Rhizobial inoculum (Bradyrhizobium strain RVr-441) were used in this experiment. Each variety was tasted with/without inoculation. Inoculated plants gave significantly higher nodule number.

Vieiera *et al*. (2003) conducted an experiment to evaluate 25 mungbean genotypes during the summer season in Vicosa and Prudente de morais, Minas Gerais, Brazil. The yield varied from 1200 to 2000 kg ha^{-1} in Prudente de morais.

Seeds of mungbean cultivars BM-4, S-8 and BM-86 were inoculated with Rhizobium strains M-11-85, M-6-84, GR-4 and M-6-65 before sowing in a field experiment conducted by Navgire *et al*. (2001) in Maharashtra, India during the kharif season of 1993-94 and 1995-96. S-8, BM-4 and BM-86 recorded the highest mean nodulation (16.66), plant biomass (8.29 q/ha) and grain yield (4.79 q/ha) during the experimental years. S-8, BM-4 and BM-86 recorded the highest nodulation, plant biomass and grain yield when their seeds were inoculated with Rhizobium strains M-6-84, M-6-65 and M-11-85, respectively.

Hamed (1998) carried out two field experiments during 1995 and 1996 in Shalakan, Egypt, to evaluate mung bean cultivars Giza 1 and Kawny 1 under 3 irrigation intervals after flowering (15, 22 and 30 days) and 4 fertilizer treatments: inoculation with Rhizobium (R) + Azotobacter (A) + 5 (N_1) or 10 kg N/ha (N_2), and inoculation with R only +5 (N_3) or 10 kg N/ha (N_4). Kawny 1 surpassed Giza 1 in pod number per plant (24.3) and seed yield (0.970 t/ha), while Giza 1 was superior in 100-seed weight (7.02 g), biological and straw yields (5.53 and 4.61 t/ha, respectively). While Kawny 1 surpassed Giza 1 in oil yield (35.78 kg/ha), the latter cultivar recorded higher values of protein percentage and yield (28.22% and 264.6 kg/ha). The seed yield of both cultivars was positively and highly significantly correlated with all involved characters, except for 100-seed weight of Giza 1 and branch number per plant of Kawny 1. BINA (1998) reported that MC-18 Binamung 5 produced higher seed yield over Binamung 2. Field duration of Binamung 5 was about 78 days as against 82 days for Binamung 2. BINA (1998) observed that among nine summer mungbean (*Vigna radiata* L.) cultivars, kalamung was the best performing cultivar with a potential grain yield of 793.65 kg ha^{-1} and the highest number of pods $plant^{-1}$(18.66) and high number of seeds pod^{-1}.

BARI (1980) conducted a field trial with three mungbean strains to know the optimum seed rate and observed that optimum seed rate depend on seed size of a genotype and said that bold seeded plants required more seed rate than the small seeded ones. BARI (2005) found that small seeded entries had greater germination percentage than bold seeded ones which required less seed rate compared to bold seeded plants and even with same seed rate, small seeded entries accommodated more plants per unit area which contributed towards higher yield than the bold seeded ones.

Thakuria and Shaharia (1990) reported that different varieties of mungbean differed significantly in seed yield and other yield related traits. Rana and Singh (1992) in Kanpur, Uttar Pradesh of India reported that the yield was generally higher in Vigna radiata than Vigna mango and was the highest in cultivar PDM-11 than Sona.

Chaudhury *et al*. (1989) reported that mungbean cultivars had significant variation in dry matter accumulation in stem, leaf, seed and husk.

2.2. Effects of salinity on mungbean

Podder, *et al.* (2019) conducted to investigate the effect of salinity on germination and seedling growth of mungbean genotypes. The experiment comprised two factors viz. genotypes (BARI mung 6, Binamung 5, Binamung 8 and Tila Mung) and salinity levels (0 mM/L, 40 mM/L, 80 mM/L, 120 mM/L and 160 mM/L). Among the seed germination parameters, no significant genotypic difference observed at 0 mM /L and 40 mM/L. At 120 mM/L, the highest germination capacity (93%) and germination percentage (94%) was found in Binamoog-8 followed by BARI mung 6 (91% and 92% respectively) and the lowest value was in Tila Mung (73% and 76% respectively). At 160 mM/L, BARI Mung-6 showed the highest germination capacity (95%) and germination percentage (95%) and Tila Mung showed the lowest value (51% and 52% respectively). At 160 mM/L, the highest shoot length (2.8 cm), seedling vigor index (488.26), seedling dry weight (45.9 mg) found in BARI mung 6 while the lowest in Tila Mung (1.56 cm, 180.93 and 32.52 mg respectively). Regarding all the germination and seedling growth parameters, BARI mung 6 was found superior to other genotypes. Study should be conducted in the field for better understanding the effects of salinity stress on growth and yield performance of mungbean.

The effect of salt stress on two popular mungbean varieties (Pusa vishal and Pusa ratna) has been compared by Sehrawat *et al*. (2015) during summer and spring seasons. The experiment was carried out at two salinity stress levels (50 mM and 75 mM NaCl). Significant variations and adaptability among stressed and non-stressed plants were observed in both varieties. The plants in early vegetative stage were found more resistant to salinity as compared to plants in late vegetative and reproductive stage. Salt stress, high temperature and salinity induced osmotic stress severely limited the plant growth, morphology, physiology and yield characteristics during summer. Measured parameters were less affected during spring season. The tolerant variety ‘Pusa vishal’ exhibited less reduction in plant height, total chlorophyll and carotenoid contents, plant length, leaf area, rate of photosynthesis, number of pods per plant and grain yield at high salinity level. However, the susceptible variety 'Pusa ratna' showed higher reduction for the measured parameters under salinity stress. A delay in pod ripening during spring season resulted in less pod-shattering. The present study may help to execute further research on screening of large mungbean germplasm for salt tolerance during spring season. The germplasm screening may help to identify resistant genotypes for genetic improvement of mungbean for growing in saline soil.

Ghosh *et al*. (2014) evaluated the physiological and biochemical responses to increasing NaCl concentrations, along with low concentrations of gibberellic acid or spermine, either alone or in their combination, were studied in mungbean seedlings. Similarly, oxidative stress markers such as proline, malondialdehyde (MDA), and hydrogen peroxide (H_2O_2) contents also increased as a result of progressive increase in salt stress. Combined application of NaCl along with low concentrations of either gibberellic acid (5 μM) or spermine (50 μM) in the test seedlings showed significant alterations, that is, drastic increase in seedling elongation, increased biomass production, increased chlorophyll content, and significant lowering in all the antioxidant enzyme activities as well as oxidative stress marker contents in comparison to salt treated test seedlings, leading to better growth and metabolism. The study shows that low concentrations of either gibberellic acid or spermine will be able to overcome the toxic effects of NaCl stress in mungbean seedlings.

Kandil *et al*. (2012) conducted an a laboratory experiment to study the performance of mungbean to salinity stress with salinity tolerance of two mungbean varieties (Kawmy-1 and IV 2010) to eight salinity levels i.e. 0, 2, 4, 6, 8, 10, 12 and 14 dS/m of NaCl concentrations. Mungbean (*Vigna radiata* L.) Wilczek) varieties were compared for germination efficiency and seedling characters. The obtained results suggested that the two varieties registered a decrease in the percentage of germination and seedlings growth at higher NaCl concentrations. Results clearly indicated that mungbean Kawme-1 variety appeared to be more tolerant to salt stress than IV 2010 variety recording higher germination parameters and seedling characters. Increasing salinity concentrations significantly reduced germination percentage, seedling vigor index, coefficient of velocity, mean germination time, shoot and root length, shoot and root fresh and dry weight. It could be concluded that germination efficiency i.e. final germination percentage, germination index, energy of germination, mean germination time, abnormal seed percentage, root and shoot length, seedling total fresh and dry weight, dry weight reduction and shoot length reduction were gradually decreased significantly when salinity increased.

The salinity sensitivity of mungbean was studied by Amira and Abdul (2010) to determine the effect of salinity on vegetative growth (plant dry weight and plant height), yield components (plant height, pods number, pods weight, seeds number/pod, seeds weight/plant and biological yield/plant), nutritional value of produced seeds (N, P, K, Ca, Mg, Na, Cl, soluble carbohydrate, polysaccharides, total carbohydrate, proline, total amino acids and protein contents) and mineral contents in green shoot at harvest (N, P, K, and Na) and also, the role of arginine in alleviating the effect of salinity stress was studied. Munbean seeds were planted in soils of different salinity levels. The concentration of the irrigation water used in this experiment were (0, 15000, 3000, 4500 and 6000 ppm). All growth parameters were significantly reduced with high salinity levels (4500 and 6000 ppm) while 1500 and 3000 ppm induced slight increase. Salinity stress also, induced significant increases in Na, Cl, Ca and Mg and decreased significantly N,P, and K contents. Salinity stress reduced most yield components and nutritional value of produced seeds. However, spraying plants with arginine could alleviate the harmful effect of salinity at all studied parameters.

A pot experiment was conducted by Hossain *et al*. (2008) at the Bangladesh Institute of Nuclear Agriculture (BINA) experimental farm, Mymensingh, to observe the response of three mungbean genotypes (Binamoog-4 and two-advanced line BMX 92007-3 and BMX 94010-11) under different salt stress (control, 3.89 dSm^{-1} and 7.82 dSm^{-1}). All morpho-physiological characters such as plant height, number of leaf, leaf area, yield contributing characters such as number of pods $plant^{-1}$, number of seeds pod^{-1}, 1000 seed weight, harvest index were reduced with the increase of salinity levels as compared to control. Plant height and yield attributes like number of pods $plant^{-1}$, number of seeds pod^{-1}, 1000 seed weight, harvest index were the highest in advanced line BMX 94010-11 compared to those in Binamoog-4 and advanced line BMX 92007-3. Going through the above reviews, it is concluded that the variety and salt stress is an important factor in consideration of growth and yield of mungbean.

Legume production is affected by hostile environments, especially soil salinity and high temperatures (HTs). Among legumes, mungbean has acceptable intrinsic tolerance mechanisms, but many agro-physiological characteristics of the *Vigna* species remain to be explored. Mungbean has a distinct advantage of being short-duration and can grow in wide range of soils and environments (as mono or relay legume). This review focuses on salinity and HT stresses on mungbean grown as a fallow crop (mungbean-rice-wheat to replace fallow-rice-wheat) and/or a relay crop in cereal cropping systems. Salinity tolerance comprises multifaceted responses at the molecular, physiological and plant canopy levels. In HTs, adaptation of physiological and biochemical processes gradually may lead to improvement of heat tolerance in plants. At the field level, managing or manipulating cultural practices can mitigate adverse effects of salinity and HT. Greater understanding of physiological and biochemical mechanisms regulating these two stresses will contribute to an evolving profile of the genes, proteins, and metabolites responsible for mungbean survival. We focus on abiotic stresses in legumes in general and mungbean in particular, and highlight gaps that need to be bridged through future mungbean research. Recent findings largely from physiological and biochemical fronts are examined, along with a few agronomic and farm-based management strategies to mitigate stress under field conditions (Rao, *et al*. 2016).

CHAPTER III

MATERIALS AND METHODS

The experiment was undertaken in February 2019 to June 2020 in the net house of Agricultural Chemistry Department, Sher-e-Bangla, Dhaka, Bangladesh effects of salinity on germination, initial growth stage and nutrient contents of mungbean. The materials and methods followed during entire period of the experiment are described in this chapter

3.1 Description of the experimental site

3.1.1 Site and soil

Geographically the experimental field was located at 23^0 77´ latitude and 90^0 35´ E longitudes at an altitude of 9 m above the mean sea level. The soil is belonged to the Agro-ecological Zone – Modhupur Tract (AEZ 28) . The land topography was medium high and soil texture was silt clay with pH 5.6.

3.1.2 Climate and weather

The climate of the locality is subtropical which is characterized by high temperature and heavy rainfall during *Kharif* season (April-September) and scanty rainfall during *Rabi* season (October-March) associated with moderately low temperature. The experiment was conducted during *Kharif* season.

3.2 Plant materials

The high yielding varieties of mungbean are Binamung 5, Binamung 7, BARI mung 5 and BARI mung 6 developed by Bangladesh Institute Nuclear Agriculture, Mymensigh and the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, respectively and were used as a experimental planting materials. The seeds were collected from Bangladesh Institute Nuclear Agriculture (BINA), Mymensigh and Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.3 Treatments under investigation

There were two factors in the experiment namely variety of mungbean as mentioned below:

Factor-A: Varieties

V_1 = BARI mung 5

V_2 = Binamung 5

V_3 = BARI mung 6

V_4= Binamung 7

Factor B: Salinity levels - 5

S_0= 0 dS m^{-1}

S_1= 3 dS m^{-1}

S_2= 6 dS m^{-1}

S_3=9 dS m^{-1}

S_4= 12 dS m^{-1}

3.4 Experimental design

It was a factorial experiment. The experiment was laid out in a Complete Randomized Design (CRD) with three replications.

3.5 Salinity treatments

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

3.6 Collection and preparation of soil

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

3.7 Pot preparation

An amount of 8 kg soil was taken in a series of pots. The required number of plastic pots having 24 cm top, 18 cm bottom diameter and 22 cm depth were collected from the local market and cleaned before use. There were altogether 60 pots comprising 5 salinity levels to four mungbean cultivars with 3 replications. Water was added to the pot to bring the soil up to saturation.

3.8. Fertilizer application

Urea, Triple super phosphate (TSP), Muriate of potash (MoP) and gypsum were used as a source of nitrogen, phosphorous, potassium and sulphur, respectively. Urea, TSP, MP and gypsum were applied @ 50, 35, 85 and 10 kg ha-1 respectively following Bangladesh Agricultural Research Institute (BARI) recommendation. All of the fertilizers were applied during final pot soil preparation.

3.9. Sowing of seeds in the pot

The seeds of mungbean were sown on February 04, 2019 in having a depth of 60 seeds were sown in each pot. Before sowing seeds were treated with Bavistin to control the seed borne disease.

3.10 Intercultural operations

3.10.1 Weed control

Weeding was done once in all the unit pots with care so as to maintain a uniform plant population as per treatment in each pot .

3.10.2 Thinning

Seeds started germination from two days after sowing (DAS). Thinning was done in each pot by keeping 20 healthy seedlings as to maintain optimum plant population in each pot.

3.10.3 Irrigation and drainage

Irrigation was done as per requirements with saline water based on treatment

3.11 Detailed Procedures of Recording Data

3.11.1 Germination percentage

Germination percentage was determined by the following formula (Li 2008):

Germination percentage (G%) = n/ N ×100,

where n is the number of germinated seed at the three/fourth day;

N is the number of total seeds

3.11.2 Population density

The data on population density were collected from each pot. The number was counted population of mungbean.

3.11.3 Plant height (cm)

The height of the selected plant was measured from the ground level to the tip of the plant.

3.11.4 Number of leaves plant^{-1}

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

3.11.5 Root length

Root length (cm) was measured from the root base to the tip of root and was at the time of uprooting of seedling.

3.12 Analysis of different chemical constituents of mungbean plant samples

i) Grinding: Oven-dried of plant samples were ground in a Wiley Hammer Mill, passed through 40 mesh screens, mixed well and stored in plastic vials.

ii. Digestion of plant samples with sulphuric acid for N

For the determination of nitrogen an amount of 0.5 g oven dry, ground sample were taken in a micro kjeldahl flask. 1.1 g catalyst mixture (K_2SO_4: $CuSO_4$ $5H_2O$: Se in the ratio of 100: 10: 1), and 10 mL conc. H_2SO_4 were added. The flasks were heated at 160^0 C and added 2 ml H_2O_2 then heating was continued at 360^0 C until the digests become clear and colorless. After cooling, the content was taken into a 100 mL volumetric flask and the volume was made up to the mark with de-ionized water. A reagent blank was prepared in a similar manner. Nitrogen in the digest was estimated by distilling the digest with 10 N NaOH followed by titration of the distillate trapped in H_3BO_3 indicator solution with 0.01N H_2SO_4.

The amount of N was calculated using the following formula:

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

Where,

T = Sample titration (ml) value of standard H_2SO_4

B = Blank titration (ml) value of standard H_2SO_4

N = Strength of H_2SO_4

S = Sample weight in gram

iii) Determination of Na and K

Mungbean plant samples were analyzed to determine the amount of Na and K content therein. Na and K content analyses were conducted on acid digested material through micro-Kjeldahl digestion system (Thomas *et al*., 1967). The content of Na and K was measured by Flame Photometer.

iv) Determination of P

Mungbean plant amples were analyzed to determine the amount of P content therein. P content analysis was conducted on acid digested material through micro-Kjeldahl digestion system (Thomas *et al*., 1967). The content of P was measured by spectrophotometer.

3.13 Data analysis technique

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program MSTAT-C (Russel,1986) and the mean differences were adjusted by Least Significance Difference (LSD) test (Gomez and Gomez, 1984).

CHAPTER IV
RESULTS AND DISCUSSION

Results obtained from the present study have been presented and discussed in this chapter. The data have been presented in different tables and figures. The results have been discussed, and possible interpretations are given under the following headings**.**

4.1 Germination percentage of seeds

There was significant difference among the varieties of mungbean in the germination percentage of seeds. The maximum germination percentage of seeds (72.00%) was found in cultivars of mungbean BARI mung 5 (V_1), which was statistically similar with V_4 (Binamung 7) and the minimum germination percentage of seedling (65.07%) was found in cultivars of Binamung 5 (V_2) (Table 1).

There was significant variation in germination percentage of seeds due to different levels of salinity. The maximum germination percentage of seedlings (76.83%) was recorded from 0 dSm^{-1} (control). The minimum germination percentage of seedlings (62.33%) was recorded 12 dSm^{-1} (Table 1). Seed germination begins with water intake. Salinity prevents water imbibition, thereby inhibiting the initial process of seed germination (Othman 2005).

The combined effect of different varieties and levels of salinity on germination percentage of seedlings was found to be significant. Data in Table 2 shows that, the germination percentage of seeds was maximum (81.00) in BARI Mung 5 with 0 dSm^{-1}, and BARI Mung 6 with 0 dSm^{-1}, while it was minimum (56.33%) in Binamung 5with 12 dSm^{-1} levels of salinity, which was statistically similar with Binamung 7 with 12 dSm^{-1} .

Table 1. Effect of mungbean varieties and different salinity levels on Germination percentage and plant population of Mungbean

Treatments	Germination percentage of seeds	Population density
Effect of variety		
BARI mung-5 (V_1)	72.00 a	17.00 b
Binamung 5 (V_2)	65.07 b	41.40 a
BARI mung-6 (V_3)	65.67 b	19.87 b
Binamung 7 (V_4)	71.80 a	40.40 a
Level of significant	*	*
LSD (0.05)	2.52	6.78
CV (%)	9.33	5.95
Effect of salinity		
S_0 (0 dSm^{-1})	76.83 a	37.25 a
S_1 (3 dSm^{-1})	71.00 b	32.42 ab
S_2 (6 dSm^{-1})	68.08 bc	29.75 b
S_3 (9 dSm^{-1})	64.92 cd	26.83 bc
S_4 (12 dSm^{-1})	62.33 d	22.08 c
Level of significant	*	*
LSD (0.05)	5.05	6.95
CV (%)	9.33	5.95

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

* 5 % level of Significance

Table 2. Interaction effect of mungbean varieties and different salinity levels on Germination percentage and plant population of Mungbean

Variety	Salinity levels (dSm^{-1})	Germination percentage of seeds	Population density
BARI mung-5	0	81.00 a	30.33 g
	3	77.67 ab	17.33 i
	6	67.67 abcd	15.33 ij
	9	65.33 bcd	13.67 j
	12	68.33 abcd	8.33 k
Binamung-5	0	72.33 abc	49.67 a
	3	64.00 bcd	47.33 b
	6	71.00 abcd	42.33 cd
	9	61.67 cd	37.67 e
	12	56.33 d	30.00 g
BARI mung-6	0	73.00 abc	22.67 h
	3	64.67 bcd	21.67 h
	6	69.33 abcd	20.67 h
	9	65.00 bcd	17.67 i
	12	56.67 d	16.67 i
Binamung-7	0	81.00 a	46.33 b
	3	77.67 ab	43.33 c
	6	64.33 bcd	40.67 d
	9	67.67 abcd	38.33 e
	12	68.33 abcd	33.33 f
Level of significant		*	*
LSD (0.05)		12.83	2.22
CV (%)		9.33	5.95

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

* 5 % level of Significance

4.2 Population density

Significant variation was observed on population density throughout the growing period for different varietal treatments (Table 1). The highest plant population (41.40) was observed in Binamung 5(V_2), which was statistically similar with V_4 (Binamung 7). The lowest number of plant population (17.00) was observed in BARI Mung 5 (V_1).

There was significant variation observed on population density per pot due to salinity levels (Table 1). The highest plant population (37.25) was recorded at 0 dSm^{-1} and it gradually decreased until salinity level at 12 dSm^{-1} and lowest plant population (22.08) recorded from 12 dSm^{-1}.

The interaction effect of variety and salinity on number of plant population was statistically significant (Table 2). The maximum plant population (49.67) was found from Binamung 5 with 0 dSm^{-1} levels of salinity and minimum number of plant population (8.33) from BARI Mung 5 with 12 dSm^{-1} levels of salinity.

4.3 plant height (cm)

The plant height was varied with the different varieties (Fig. 1). The tallest plant (9.36.00 cm) was obtained from BINA Mung-7 (V_4), which was statistically similar with V_2 and V_3 and the shortest plant height (6.15 cm) was obtained in BARI Mung-5 (V_1) (appendix-1). This variation in plant height might be attributed to the genetic characters. These results recognized Farghali and Hossein (1995) who find out that plant height varied with different varieties of mungbean. Different varieties showed different plant height on the basis of their varietal characters and an improved variety is the first and foremost requirement for initiation and accelerated production program of any crop. Brar *et al*. (2004) reported that SML 668 has an average plant height of 44.6 cm as an early maturing cultivar.

There was a significant variation in plant height due to the difference level of salinity (Fig. 2). The tallest plant (9.54 cm) was obtained from S_0 treatment, which was statistically similar with S_1 treatment and the shortest plant height

(6.01 cm) from S_4 treatment (appendix-1). The plant height decreased with increasing salinity level. Salinity might be lead to osmotic inhibition, toxic effect of ions and nutritional imbalance of elements by lowering down the uptake of essential nutrient elements and finally culminates in decreased growth (Levitt, 1972). The results are in also in confirmation with the findings of Strogonov (1964), Poljakoff- Mayber and Gale (1975), Ashraf and Rasul (1988).

Interaction effect of varieties and level of salinity had a significant variation on plant height of mungbean (Table 3). The longest plant (11.00 cm) was obtained from V_4S_0 treatment combination, which was statistically similar with V_4S_1. The shortest plant height (4.90 cm) was observed from V_1S_4 (BARI Mung-5 with 12 dS^{-1}) treatment combination.

4.4 Number of leaves plant^{-1}

The number of leaves plant^{-1} was influenced by varieties (Fig. 3).The Binamung 7 produced maximum number of leaves (9.32) and the minimum number of leaves (7.96) was recorded in BARI Mung-6. Rahman (2002) observed leaf was significantly greater in BARI Mung-2 and BARI Mung-5 than in the BINA Mung-l with the magnitude being intermediate in the BINA Mung-2.

There was a significant variation in the number of leaves plant^{-1} due to the difference level of salinity (Fig. 4). The maximum number of leaves plant^{-1} (12.67) was obtained from S_0 (0 dS^{-1}) treatment. The minimum number of leaves plant^{-1} (7.14) from S_4 condition. The number of leaves was decreased with increasing in salinity level.

Interaction effect of varieties and level of salinity had significant variation on number of leaves plant^{-1} of mungbean. The highest number of leaves plant^{-1} (11.33) was obtained from V_4S_0 treatment while the lowest number of leaves plant^{-1} (6.83) from V_1S_4 treatment, which was statistically similar with. $V_3S_{4,}$ (Table 3).

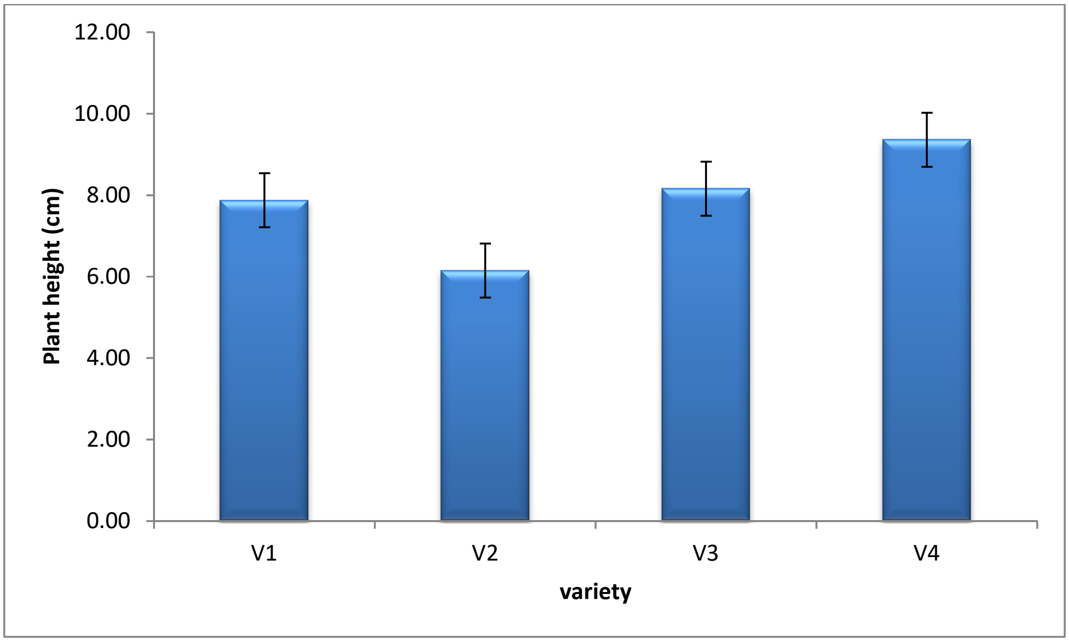
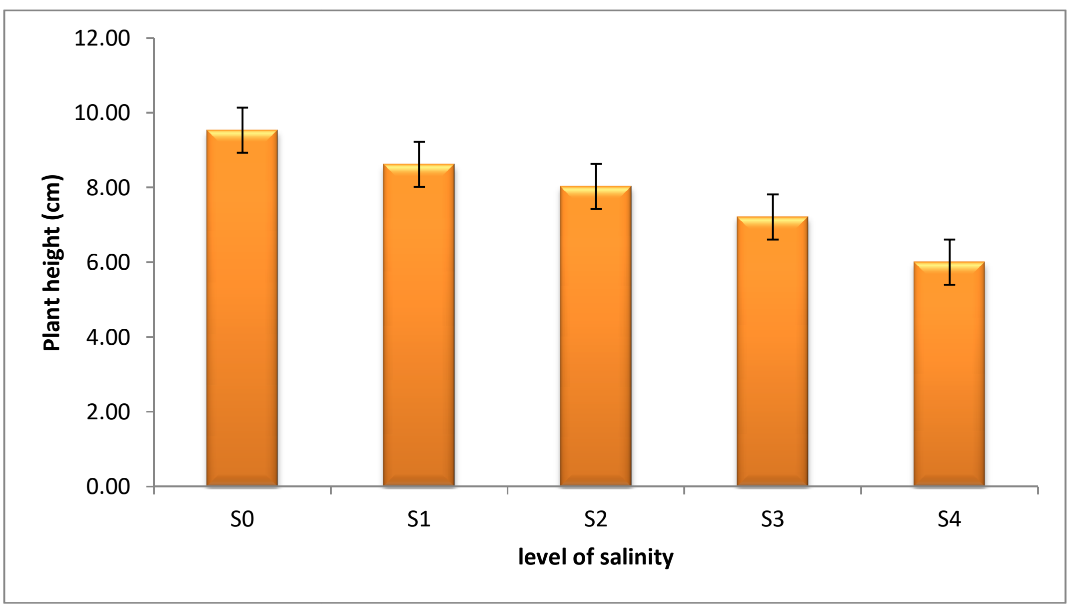


Fig.1: Effect of varieties on the plant height of Mungbean

(V_1 = BINA Moog-5, V_2 = BARI Mung-5, V_3 = BARI Mung-6, V_4 = BINA Moog-5)



(S_0= 0 dS m^{-1}, S_1= 3 dS m^{-1}, S_2= 6 dS m^{-1},S_3=9 dS m^{-1},S_4= 12 dS m^{-1})

Fig.2: Effect of level of salinity on the plant height of Mungbean

Table 3. Interaction effect of varieties and levels of salinity on the plant height, length of root and number of leaf per plant of mungbean

Variety	Salinity levels (dSm^{-1})	Plant height (cm)		Number of leaf per plant		Length of root (cm)	
BARI Mung 5	0	7.33	efgh	10.11	abc	1.77	def
	3	7.00	fgh	10.00	abcd	1.50	efgh
	6	6.17	hij	7.33	cd	1.20	hij
	9	5.33	ij	7.61	bcd	1.00	ij
	12	4.90	j	6.83	d	0.90	j
Binamung 5	0	10.33	ab	10.67	ab	2.83	b
	3	7.97	cdefg	8.89	abcd	1.73	def
	6	7.57	defgh	8.50	abcd	1.43	fgh
	9	7.13	fgh	8.50	abcd	1.33	ghi
	12	6.37	ghij	7.50	bcd	0.90	j
BARI Mung 6	0	9.50	abc	8.83	abcd	1.83	de
	3	8.90	bcde	8.67	abcd	1.60	efg
	6	8.33	cdef	8.28	abcd	1.47	fgh
	9	7.40	efgh	7.11	cd	1.20	hij
	12	6.67	ghi	6.89	d	1.00	ij
Binamung 7	0	11.00	a	11.33	a	3.17	a
	3	10.63	a	9.78	abcd	2.43	c
	6	10.07	ab	9.17	abcd	1.97	d
	9	9.00	bcd	9.00	abcd	1.60	efg
	12	6.10	hij	7.33	cd	0.93	j
Level of significant		*		*		*	
LSD (0.05)		1.41		2.66		0.32	
CV (%)		10.85		8.69		7.15	

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

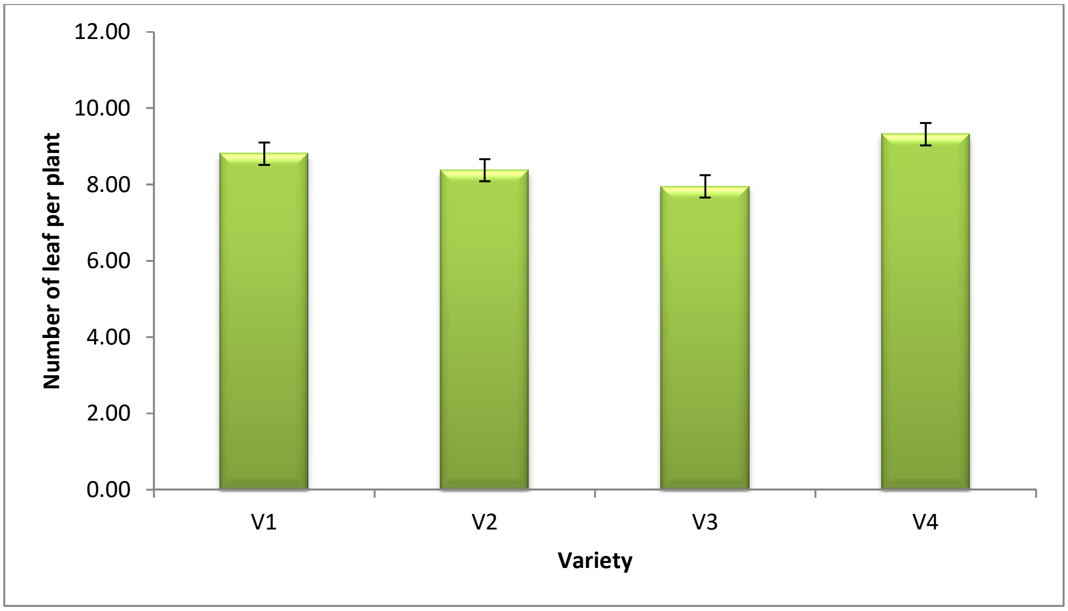
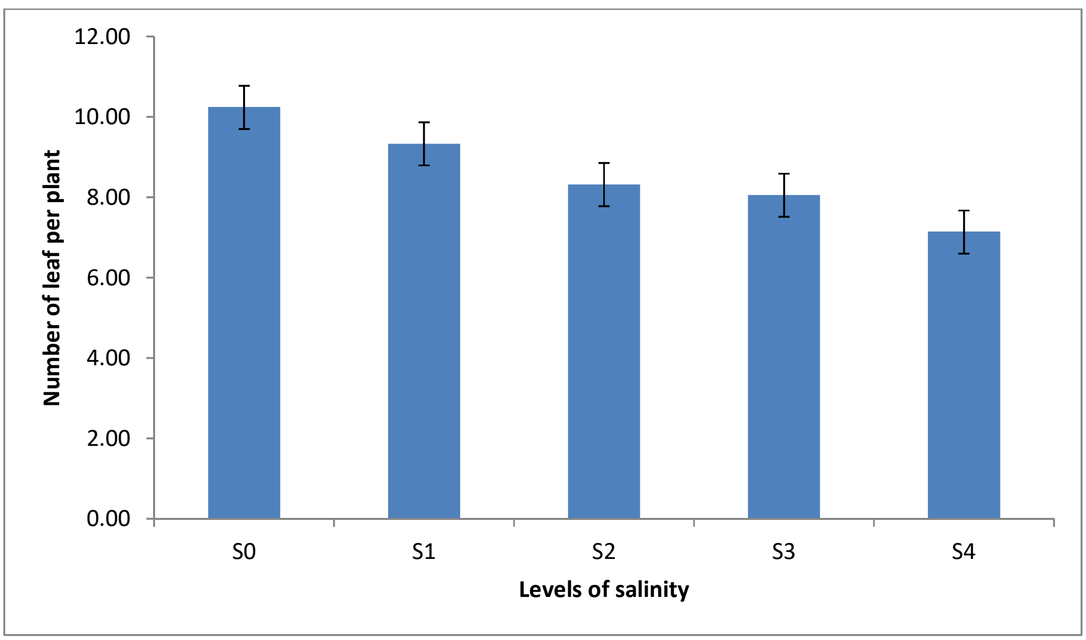


Fig.3: Effect of varieties on the number of leaf plant^{-1}of mungbean

(V_1 = Binamung-5, V_2 = BARI Mung-5, V_3 = BARI Mung-6, V_4 = Binamung-5)



(S_0= 0 dS m^{-1}, S_1= 3 dS m^{-1}, S_2= 6 dS m^{-1},S_3=9 dS m^{-1},S_4= 12 dS m^{-1})

Fig.4: Effect of levels of salinity on the number of leaf plant^{-1}of Mungbean

4.4 Root Length

Length of root was significantly influenced by variation with varieties of mungbean. (Fig. 5). The longest root length (2.02 cm) was observed in V_4 (BINA moog- 7). The shortest root length (1.27cm) was obtained in $V_{2,}$ (BARI Mung-5).

Root length of mungbean was significantly influenced by variation with the different level of salinity (Fig. 6). The longest root length (2.40 cm) was recorded from S_0 treatment, which was statistically different from all other treatment. The shortest root length (7.14 cm) was observed in S_4 treatment.

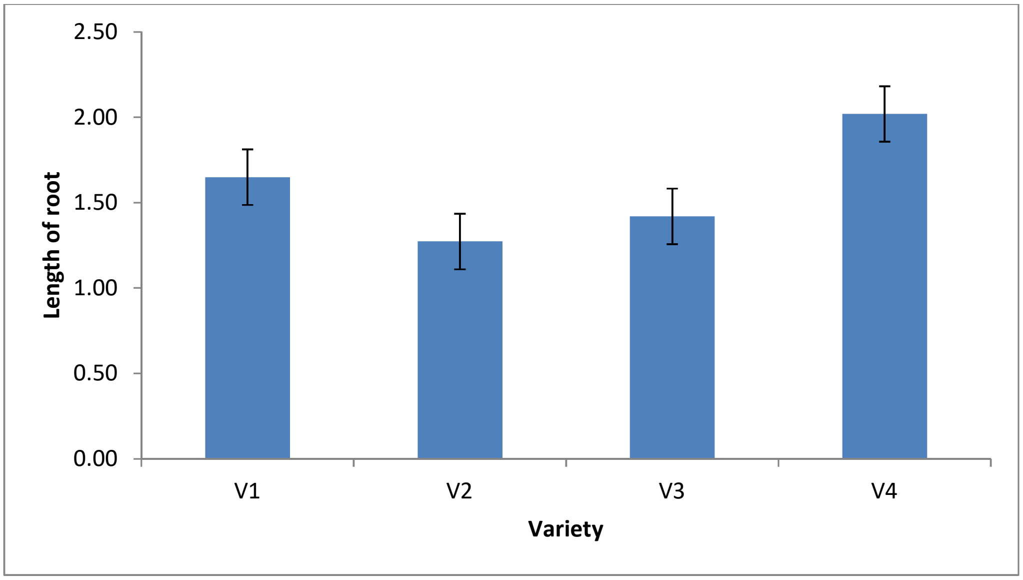
Interaction effect of different varieties and level of salinity had a significant variation on root length of mungbean (Table 2). The highest root length (3.17 cm) was obtained from V_4S_0 treatment, whiles the lowest (0.90 cm) from V_1S_4 and V_2S_4 treatment.

4.6 Nitrogen concentration in mungbean plant

The effect of variety showed variation in the N concentration in mungbean plant (Table 4). The total N content of mungbean plant varied from 1.60% to 1.66%. The highest total N content (1.66%) was observed in mungbean cultivar of Binamung-5. The lowest value of N (1.60%) was observed under Binamung-7.

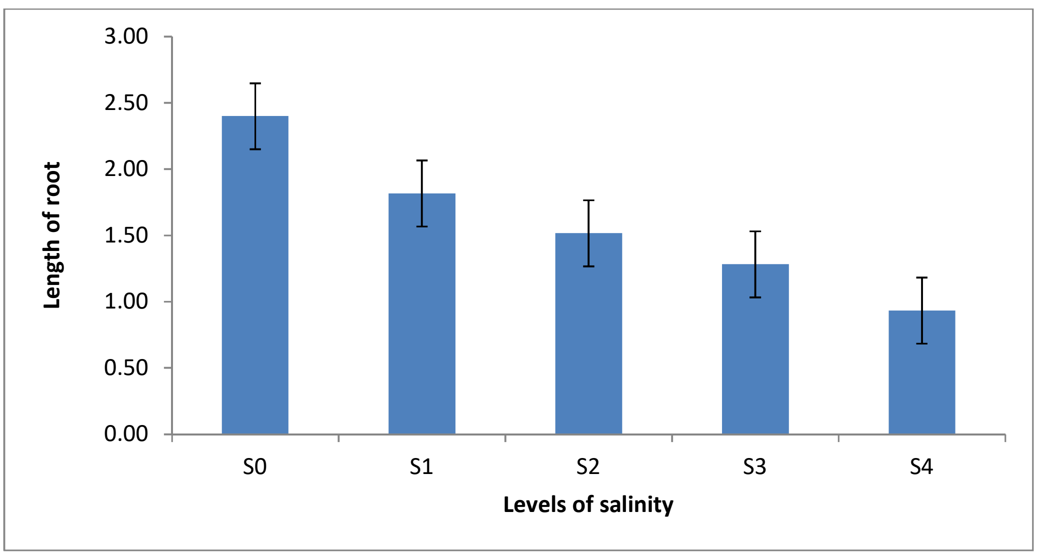
The effect of different levels of salinity showed a statistically significant variation in the N concentration in mungbean plant (Table 4). The total N content of the mungbean plant varied from 1.50 to 1.75. Among the different levels of salinity, 0 dSm^{-1} showed the highest N concentration (1.75%) in plant. The lowest value (1.50%) was under control treatment 12 dSm^{-1} salinity level.

Interaction effect of different levels of salinity and variety on the N concentration was observed significant in mungbean plant (Table 5). The highest concentration of N in mungbean plant (1.76%) was recorded in V_2S_0 treatment. On the other hand, the lowest N concentration (1.49%) was found in V_4S_{12} treatment.



(V_1 = Binamung-5, V_2 = BARI Mung-5, V_3 = BARI Mung-6, V_4 = Binamung-5)

Fig.5: Effect of varieties on the length of root of mungbean



(S_0= 0 dS m^{-1}, S_1= 3 dS m^{-1}, S_2= 6 dS m^{-1},S_3=9 dS m^{-1},S_4= 12 dS m^{-1})

Fig.6: Effect of levels of salinity on the length of root of Mungbean

Table 4. Effect of varieties and different salinity levels on content of N P K Na on plant of mungbean

Treatments	N (%)	P(%)	K(%)	Na (%)
Effect of variety				
BARI mung-5 (V_1)	1.63	0.50	1.34	0.51 B
Binamung-5 (V_2)	1.66	0.52	1.13	0.52 B
BARI mung-6 (V_3)	1.63	0.54	1.08	0.64 B
Binamung-7 (V_4)	1.60	0.50	1.05	0.80 A
Level of significant	NS	NS	NS	*
LSD (0.05)	0.26	0.20	0.43	0.14
CV (%)	8.14	5.06	7.923	7.96
Effect of salinity				
S_0 (0 dSm^{-1})	1.75 a	0.50	1.32 a	0.29 d
S_1 (3 dSm^{-1})	1.70 ab	0.51	1.28 a	0.44 c
S_2 (6 dSm^{-1})	1.63 bc	0.52	1.18 ab	0.63 b
S_3 (9 dSm^{-1})	1.56 cd	0.54	1.07 ab	0.78 b
S_4 (12 dSm^{-1})	1.50 d	0.51	0.90 b	0.95 a
Level of significant	*	NS	*	*
LSD (0.05)	0.10	0.12	0.36	0.14
CV (%)	8.14	5.06	7.923	7.96

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

* 5 % level of Significance

Table 5. Interaction effect of mungbean varieties and different salinity levels on content of N K Na on plant of mungbean

Variety	Salinity levels (dSm^{-1})	N (%)		P (%)		K (%)		Na (%)	
	0	1.76	a	0.51	abc	1.40	a	0.18	j
	3	1.71	a-c	0.55	abc	1.36	b	0.32	hij
	6	1.61	a-e	0.46	bc	1.28	bc	0.55	efg
BARI Mung	9	1.56	bcde	0.53	abc	1.20	b-e	0.68	de
5	12	1.51	de	0.45	c	1.04	b-e	0.84	bcd
	0	1.79	a	0.45	c	1.23	bcd	0.23	ij
	3	1.73	ab	0.51	abc	1.28	bc	0.36	hi
	6	1.66	a-d	0.51	abc	1.17	b-e	0.47	fgh
	9	1.58	b-e	0.57	abc	1.07	b-e	0.62	ef
Binamung 5	12	1.53	cde	0.58	ab	0.92	cde	0.89	bc
	0	1.74	ab	0.51	abc	1.16	b-e	0.31	hij
	3	1.68	a-d	0.50	abc	1.25	bc	0.46	fgh
	6	1.64	a-e	0.56	abc	1.14	b-e	0.69	de
BARI Mung	9	1.56	b-e	0.59	a	1.02	b-e	0.81	cd
6	12	1.50	de	0.55	abc	0.83	de	0.95	bc
	0	1.70	abc	0.54	abc	1.10	b-e	0.45	gh
	3	1.66	a-d	0.46	bc	1.22	b-e	0.61	efg
	6	1.62	a-e	0.56	abc	1.12	b-e	0.82	cd
	9	1.53	cde	0.47	abc	1.00	b-e	0.99	ab
Binamung 7	12	1.47	e	0.47	abc	0.80	e	1.12	a
Level of significant		NS		*		*		*	
LSD (0.05)		0.19		0.1		0.27		0.02	
CV (%)		6.1		5.06		5.95		6.96	

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

* 5 % level of Significance

4.7 Phosphorus (%)

It appears from the results presented in table 4 that there was a variation in phosphorus (%) content in four selected mungbean cultivars under mean effect of different salinity levels. The highest P content (0.59%) in plant was found in BARI mung 6 ds and that was lowest (0.50%) in BARI mung 5.

The P contents in plant of mungbean also insignificantly varied due to the effect of different salinity levels (table 4). The highest P content in plant (0.54%) was recorded in 9 dSm^{-1} and it was lowest (0.50) in 0dSm^{-1} salinity level.

The combined effects of salinity and cultivar on content of P (%) in plant were differed significantly. The highest P content (0.59 %) in plant was found in V_3S_3 treatment and it was lowest (0.45%) for V_2S_4 treatment [1] (Table 5).

4.8 Potassium (%)

It appears from the results presented in table 4 that there was a variation in potassium (%) content in four selected mungbean cultivars under mean effect of different salinity levels. The highest K content (1.40%) in plant was found in BARI mung 5 and that was lowest (0.80%) in Binamung-7.

The Potassium (K) contents in plant of mungbean also significantly varied due to the effect of different salinity levels; where the K content decreased with the increasing level of salinity in plant (table 4). The highest K content in plant (1.40%) was recorded in 0 dSm^{-1} and it was lowest (0.80) in 12 dSm^{-1} salinity level.

The combined effects of salinity and cultivar on content of K (%) in plant were differed significantly. The content of K in plant of four selected cultivars progressively decreased with increasing the salinity levels. The highest K content (1.40%) in plant was found in BARI mung-5 with 0 dSm^{-1} level of salinity and it was lowest (0.80%) for V_4S_5 (Table 5).

4.9 Sodium (%)

The percent content of sodium (Na) in plant of the entire four selected mungbean cultivars varied grown at different levels of salinity. Its content in plant was highest (1.12%) in Binamung 7 and lowest (0.18%) in BARI mung 5 (Table 4).

The sodium (Na) content in plant of mungbean significantly varied due to the effect of different salinity levels; where the Na content in plant increased with the increasing level of salinity in plant. The highest Na content (1.12%) in plant was recorded in 12 dSm^{-1} level of salinity and then was lowest (0.18%) in 0 dSm^{-1} (Table 4).

The combined effect of salinity and cultivar on content of Na (%) in plant was found significant. The Na content increased with the increasing levels of salinity in both plant of all cultivars (table 4). The highest Na content (1.12%) in plant was found in Binamung 7 with 12 dSm^{-1} level of salinity and it was lowest (0.18%) in the cultivar BARI mung 5 at 0 dSm^{-1} salinity level.

CHAPTER IV

SUMMARY AND CONCLUSION

The experiment was undertaken in February 2019 to June 2020 in the net house of Agricultural Chemistry Department, Sher-e-Bangla, Dhaka, Bangladesh effects of salinity on germination, initial growth stage and nutrient contents of mungbean. In this experiment, the treatment consisted of four mungbean varieties viz., V_1 = BARI Mung 5, V_2 = Binamung 5, V_3 = BARI Mung 6, V_4 =Bina mung 7 and five salinity levels (0, 3, 6, 9 and 12 dSm^{-1}). The experiment was set in Completely Randomized Design **(**CRD) having two factors with three replications.

Results showed that a significant variation was observed among the treatments in respect of majority of the observed parameters. The collected data were statistically analyzed for evaluation of the treatment effect.

The maximum germination percentage of seeds (72.00%) was found in cultivars of mungbean BARI Mung 5. The highest plant population (41.40) was observed in Binamung 5. The tallest plant (9.36.00 cm) was obtained from Binamung 7. The Binamung 7 produced maximum number of leaves (9.32). The longest root length (2.02 cm) was observed in V_4 (Binamung 7). The highest total N content (0.72%) was observed in mungbean cultivar of BARI Mung 6. The highest P content (0.54%) in plant was found in BARI Mung 6. The highest K content (1.14%) in plant was found in BARI Mung 6. Na content in plant was highest (0.047%) in BARI Mung 5.

The maximum germination percentage of seedlings (76.83%) was recorded from 0 dSm^{-1}. The highest plant population (37.25) was recorded at 0 dSm^{-1}. The tallest plant (9.54 cm) was obtained from S_0 treatment. The maximum number of leaves plant^{-1} (12.67) was obtained from S_0 (0 dS^{-1}) treatment. The longest root length (2.40 cm) was recorded from S_0 treatment. the different levels of salinity, 9 dSm^{-1} showed the highest N concentration (0.720) in plant. The highest P content in plant (0.54%) was recorded in 9 dSm^{-1}. The highest K content in plant (1.39 %) was recorded in 0 dSm^{-1}. The highest Na content (0.055%) in plant was recorded in 12 dSm^{-1} level of salinity.

The combined effect of different varieties and levels of salinity on germination percentage of seedlings was found to be significant. The germination percentage of seeds was maximum (81.00) in BARI Mung 5 with 0 dSm^{-1}, and BARI Mung 6 with 0 dSm^{-1}. The maximum plant population (49.67) was found from Binamung 5 with 0 dSm^{-1} levels of salinity. The longest plant (11.00 cm) was obtained from V_4S_0 treatment combination. The highest number of leaves plant^{-1} (11.33) was obtained from V_4S_0 treatment. The highest root length (3.17 cm) was obtained from V_4S_0 treatment. The highest concentration of N in mungbean plant (0.75%) was recorded in V_3S_3 treatment. The highest P content (0.59 %) in plant was found in V_3S_3 treatment. The highest K content (1.44%) in plant was found in BINA moog 7 with 0 dSm^{-1} level of soil salinity. The highest Na content (0.059%) in plant was found in BARI Mung 5 with 12 dSm^{-1} level of soil salinity.

From the above findings it can be concluded that most of the parameters gave the best performance which was achieved from Binamung 7. Salinity decreased the rate of germination, plant height, number of leaf and root length.

Considering the results obtained from the present experiment, further studies in the following areas may be suggested:

- ❖ We got clear information about the reproductive pattern of different varieties of mungbean.
- ❖ The performance of mungbean variety named Binamung 7 was best in respect of growth components during the whole life cycle of the plant.
- ❖ Other growth regulators with different management practices may be included in future study for more accurate results,
- ❖ Future study may be carried out with more varieties/genotypes, and

REFERENCES

Alam, M., Stuchbury, Z. T., Naylor, R.E.L. and Rashid, M. A. R. (2004). Effect of salinity on growth of some modern rice cultivar. J. Agron., 3: 1-10.

Ali, M. E., Khanam, D., Bhuiyan M. A. H., and Khan, M. S. (2004). Effect of *Rhizobium* inoculation to different varieties of mungbean (*Vigna radiata L.*). BARI annual report, (2005).

Ali, S., Khaliq,T., Ahmad, A., Rehman, M., Hussain, S., Rehman, K. and perve, A.W. (2014**).** Genotypic Variations in Mungbean Yield and its Attributes in Response to Different Sowing Times. *Res. J. Agric. Environ. Manage.* **3**(5), pp. 255-258.

Amira, M. S. and Abdul, Q. (2010). Effect of arginine on growth, nutrient composition, yield and nutritional value of mungbean plants grown under salinity stress. Nature & Sci., 8(7): 30-42.

Apurv, P. and Tewari, S. K. (2004). Yield dynamics of mungbean (*Vigna radiata L*. Wilczek). varieties in poplar based agroforestry system. *Indian J. Agroforestry*. **6**(2): 89-91.

Ashraf, M. and Rasul, E. 1988. Salt tolerance of mung bean (*Vigna radiate* L.) at lower growth stages. Pl. Soil., **110**: 63-67.

BARI (Bangladesh Agricultural Research Institute). (1980). Annual Report of 1979-80. Bangladesh Agric. Res. Inst., Gazipur-1701. p. 83.

BARI (Bangladesh Agricultural Research Institute). (2005). A Booklet on Technology released by BARI. Bangladesh Agric. Res. Inst., Gazipur-1701. P. 56.

BARI (Bangladesh Agricultural Research Institute). (2006). A Booklet of mungbean production technology. Pulse Res. Center, Bangladesh Agric. Res. Inst., Gazipur-1701. P. 64.

Bhati, T. K., Rathore, S. S. and Gaur, N. K. (2005). Effect of improved varieties and nutrient management in kharif legumes under arid ecosystem in Institution Village Linkage Programme. *J. Arid Leg.* **2**(2): 227-229.

Bhowal, M.K. and Bhowmick, S.K. 2014. Performance of Summer Mungbean as affected by Variety and Date of Harvest Trends in Biosciences. **7** (13): 1534-2014.

Bhuiyan, M. A. H. Akhtar, M. I. and Farid, A. T. M., (2003). Influence of variety/cultivars and site on the response of mungbean to inoculation with elite strains of *Bradyrhizobnium*. BARI annual report, 2004.

Bhuiyan, M.A.H., Mian› M.H. and Islam, M.S. (2008). Studies on the effects of *bradyrhizobium inoculation* on yield and yield attributes of mungbean. *Bangladesh J. Agril. Res*. **33**(3): 449-457.

BINA (Bangladesh Institute of Nuclear Agriculture). (1998). Annual Report of 1997-98. Bangladesh Inst. Nuclear Agric., Mymensingh. p. 23.

BINA (Bangladesh Institute of Nuclear Agriculture). (2005). A Booklet on Technology released by BINA. Bangladesh Inst. Nuclear Agric., Mymensingh.

BINA (Bangladesh Institute of Nuclear Agriculture). (2007). A leaflet of BINA mung2, BINA mung5, BINA mung6 and BINA mung7. Bangladesh Inst. Nuclear Agric., Mymensingh.

Chaisri, P., Kaveeta, L., Chaisri, S. and Kaveeta, R. (2005). Mungbean yield trial for cropping system in Lopburi area. *Proceedings of 43rd Kasetsart Univ. Ann. Conf.*, Thailand, 1-4 February, 2005: 214-222.

Dodwadiya, K.S. and Sharma, A.R. (2012). Effect of tillage and method of sowing on performance of greengram (Vigna radiata) varieties during summer and rainy seasons. *Indian J. Agric. Sci.***82**(5): 462–5.

FAO (Food and Agriculture Organization) (2013). FAOSTAT: http://faostat. fao.org.

Ghosh, S., Mitra, S. and Paul, A. ().Physiochemical Studies of Sodium Chloride on Mungbean (Vigna radiata L. Wilczek) and Its Possible Recovery with Spermine and Gibberellic Acid. *The Scientific World J.*, 2015: 1-8.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedures for Agricultural Research (2nd Edn.). John Willey and Sons, Singapore, pp. 28-92.

Hamed, M. F. (1998). Response of two mungbean varieties under irrigation intervals and certain fertilization treatments. *Ann. Agril. Sci.* **36**(1): 31-42.

Hasanuzzaman, M., Hossain, M. A., Silva, J. A. T. and Fujita, M. (2012). Plant responses and tolerance to abiotic oxidative stress: antioxidant defenses is a key factors. In: Bandi, V., Shanker, A. K., Shanker, C., Mandapaka, M. (Eds.), Crop stress and its management: perspectives and strategies. Springer, Berlin, pp. 261-316.

Hasanuzzaman, M., Nathan, K. and Fujita, M. (2013). Plant response to salt stress and role of exogenous protectants to mitigate salt-induced damages. In: Ahmad, P., Azooz, M. M., Prasad, M. N. V. (Eds.), Ecophysiology and responses of plants under salt stress. Springer, New York, pp. 25-87.

Hossain, D. and Solaiman, A. R. M. (2004). Performances of mungbean varieties as affected by Rhizobium inoculants. *Bulletin Inst. Tropic. Agric.* **27**: 35-43

Hossain, M. M., Miah, M. N. A., Rahman, M. A., Islam, M. A. and Islam, M.T. (2008). Effect of salt stress on growth and yield attributes of Mungbean. *Bangladesh Res. Pub. J.* 1(4): 324-336.

Infante, N., Madriz, P. and Gonzalez, T. (2003). Phases of development and yield components of three mungbean cultivars (*Vigna radiata L.* Wilczek). in Maracay, Aragua state, Venezuela. *Revista Faculty of Agronomy*. **20**(4): 417-429.

Islam, M. K., Islam, S. M. A., Harun-or-Rashid, M., Hossain, A. F. M. G. F., and Alom, M. M. (2006). Effect of biofertilizer and plant growth regulators on growth of summer mungbean. *Intl. J. Bot.* **2**(1): 36-41.

Kabir, M. H. and Sarkar, M.A.R. (2008). Seed yield of mungbean as affected by variety and plant spacing in *Kharif*-I season. *J. Bangladesh Agril. Univ.* **6**(2): 239–244.

Kamal Uddin Ahamed, Kamrun Nahar, Mirza Hasanuzzaman, Golam F aruq and Momena Khandaker, (2011). Morphophysiological Attributes of Mungbean (*Vigna radiata L.*). Varieties under Different Plant Spacing. *World J. Agril. Sci*. **7** (2): 234-245.

Kandil, A. A., Arafa, A.A., Sharief, A.E. and Ramadan, A.N. (2010). Genetic transformation of Vigna species: Current status and future prospect. (2012). Genotypic Differences between Two Mungbean Varieties in Response to Salt Stress at Seedling Stage. Intl. J. Agric. Sci., 4(7): 278-283.

Kandil, A. A., Arafa, A.A., Sharief, A.E. and Ramadan, A.N. (2010). Genetic transformation of Vigna species: Current status and future prospect. (2012). Genotypic Differences between Two Mungbean Varieties in Response to Salt Stress at Seedling Stage. Intl. J. Agric. Sci., 4(7): 278-283.

Karthikeyan, A., Valarmathi, R., Nandini, S., Nandhakumar, M. R. (2012). Genetically Modified Crops: Insect Resistance. Biotech., 11: 119-126.

Khan, A. R., Bhuiyan, Z. H. and Islam, M. R. (1981). Effectivity test of different strains of Rhizobium on black gram (Vigna Mungo L.). Fourth Ann.Con. Bangladesh Soc. Macrobiol. Feb. 7-8. Dhaka. Abst. No. 26. p. 15.

Khan, M. A., Qayym, A. and Noor, E. (2007): Assessment of wheat genotypes for salinity tolerance proceedings of 8th. African Crop Sci. Conf. October 27-31., El Minia, Egypt, p. 75-78.

Lema, M., Mekonnen , B. and Gudero, G. (2018). Performance and Growth Analysis of Three Mungbean (*Vigna Radiate* (L.) Wilczek) Genotypes at Hawassa, Ethiopia. *Int J Hort Agric*. **3**(2): 1-4.

Levitt, Y. 1992. Responses of plants to environmental stresses. Vol. 11. Aca. Press, New York, p. 491-505.

Madriz-Isturiz, P. M. and Luciani-Marcano, J. F. (2004). Agronomic characterization of 20 cultivars of mungbean, (*Vigna radiata* L.). during three seasons, in Maracay, Aragua state, Venezuela. *Revista Faculty Agron*. **21**(1): 19-35.

Mahajan, S. and Tuteja, N. (2005). Cold, salinity and drought stresses: An overview. Arch. Biochem. Biophys. 444: 139–158.

Mahdavi, B. and Sanavy, S. A. (2007). Techniques for introgression in developing salt tolerant mungbean varieties. *Pakistan J. Biol. Sci*., **10**(2): 273-279.

Mondal, M. M. A., Dutta, R. K. and Islam, M. A. (2004). Yield performance of some mungbean mutants in the northern region of Bangladesh. *Bangladesh J. Nuclear Agric*., **19**: 32-35.

Muhammad, A., Abdul, R., Muhammad, A. and Zafar, M. I. (2006). Association among Rhizobium phaseoli strains and mungbean genotypes under rainfed conditions. *Sarhad J. Agric.* **22**(3): 453-457.

Munns, R. (2005). Genes and salt tplerance bringing them together. New Phytol., 167: 645-663.

Munns, R., James, R. A. and Lauchli, A. (2006). Approaches to increasing the salt tolerance of wheat and other cereals. J. Exp. Bot., 57: 1025-1043.

Navgire, K. D., Datar, V. V., Asewar, B. V. and Dahiwal, A. L. (2001). Response of mungbean cultivars to different Rhizobium strains under rainfed conditions. *Ann. Plant Physio*. **15**(2): 134-137

Othman, Y. (2005). Evaluation of Barely Cultivars Grown in Jordan for Salt tolerance. Ph .D Thesis, Jordan University of Science and Technology, Jordan.

Parvez, M.T., Paul, S.K. and Sarkar, M. A. R., (2013). Yield and yield contributing characters of mungbean as affected by variety and level of phosphorus. *J. Agrofor. Environ*. **7** (1): 115-118.

Podder, S., Ray, J., Das, D. and Sarker, B. C. (2020). Effect of salinity (NaCl) on germination and seedling growth of mungbean (Vigna radiata L.). Journal of Bioscience andAgriculture Research, 24(02), 2012-2019.

Poljakoff-mayber, A. and Gale, J. Ed. 1975. Plants in saline environments. Springer Verlag, Berlin.

Raj, S. and Tripathi, K. P. (2005). Productivity and economics of mungbean (*Vigna radiata* L.). as influenced by varieties and nutrient management. *J. Arid Legum*. **2**(2): 223-226.

Rao, B.H., Nair, R.M. and Nayyar. (2016). Salinity and High Temperature Tolerance in Mungbean [*Vigna radiata* (L.) Wilczek] from a Physiological Perspective. Frontiers in Plant Science. 7: 957.

Rasul, F., Cheema, M. A. Sattar, A., Saleem, M. F. and Wahid, M.A. (2012). Evaluating the performance of three mungbean varieties grown under varying inter-row spacing. The *Journal of Animal & Plant Sciences*, **22**(4): 1030-1035.

Rehman, A. Khalil, S.K., Nigar, S., Rehman, S., Haq, I., Akhtar, S., Khan, A. Z. and Shah, S. R. (2009). Phenology, plant height and yield of mungbean varieties in response to planting date. *Sarhad J. Agric*. **25**(2): 148-152.

Sadi, S. M. (2004). Effect of variety and seed rate on the yield and quality of mungbean. M. S. Thesis, Dept. Agron., Bangladesh Agric. Univ., Mymensingh. p. 42.

Saha, P., Chatterjee, P. and Biswas, A. K. (2010): NaCl pretreatment alleviates salt stress by enhancement of antioxidant defense and osmolyte accumulation in mungbean (*Vigna radiata L*. Wilczek). Indian J. Exp. Biol., 48: 593-600.

Salah Uddin, M. Ruhul Amin, A. K. M., Jafar Ullah, M. and Asaduzzman, M. (2009). Interaction Effect of Variety and Different Fertilizerson the Growth and Yield of Summer Mungbean. *American-Eurasian Journal of Agronomy*. **2** (3): 180-184.

Sarkar, M. A. S., Parvez M. T. and Paul, S. K. (2013).Yield and yield contributing characters of mungbean as affected by variety and level of phosphorus. *J. Agrofor. Environ*. **7**(1): 115- 118.

Sehrawat, N., Jaiwal, P. K., Yadav, M., Bhat, K. V., Sairam, R. K. (2013). Salinity stress restraining mungbean (*Vigna radiata L*. Wilczek) production: gateway for genetic improvement. *Int. J. Agri. Crop Sci*., **6**: 505-509.

Sehrawat, N., Yadav, M., Bhat, K. V., Sairam, R. K., and Jaiwal, P. K. (2015). Effect of Salinity Stress on Mungbean [Vigna radiata (L.) wilczek] during consecutive summer and spring seasons. J. Agric. Sci., 60(1): 23-32.

Shamsuzzaman, A. M. M., Alam, M. S., Mondal, G. and Ahamed, K. U. (2004). Growth and yield response of summer mungbean to irrigation frequency. *J. Agric. Rural Dev*. **2**(1): 95-100.

Singh Guriqbal, Sekhon HS, Gurdip, Singh Brar JS, Bains TS and Shanmugasundaram, S. 2011. Effect of plant density on the growth and yield of Mungbean(Vigna radiata(L) Wilczek) genotypes under different environments in India and Taiwan. *Intel. J. Agril. Res.* **6**(7): 573-583.

Singh, D. P. and Singh, B. B. (2011). Breeding for tolerance to abiotic stresses in mungbean. *J. Food Legumes*, 24: 83-90.

Singh, T. and Sharma, A. (2014). Identification of stable genotypes under varying environments in Mungbean. Legume Research - *An Intel. J.*. **37**(2): 253-258.

Singh, T., Jagrup, Bohra, A. and Sekhon.(2014). Identification of stable genotypes under varying environments in Mungbean. Legume Res. *an Intel. J.* 37(3): 253-258.

Solaiman, A. R. M., Hossain, D. and Haque M. M. (2003). Response of mungbean varieties to Rhizobium inoculation in respect of nodulation, nitrogenase activity, dry matter yield, and nitrogen uptake. Department of soil science, Bangabandhu Sheikh Mujibur Rahman Agricultual university. Gazipur, Bangladesh. *Korean J. crop sci.* **48**(5): 355-360.

Strogonov, B.P. (1964). Physiological basis of salt tolerance of plants as affected by various types of salinity. Israel Prog. Sci. Trans. Jerusalem, Subraha.

Taffouo, V. D., Kouamou J. K., Ngalangue L.M.T., Ndjeudji B.A.N. and Akoa A. (2009). Effects of salinity stress on growth, Ion partitioning and yield of some cowpea (*Vigna unguiculata* L. Walp.) cultivars. Inter. J. Bot., 5(2): 135-143.

Taffouo, V. D., Kenne, M., Fokam, Tasse, R., Fotsoe, W. O., Fonkou, T., Vondo, Z. and Amougou, A. (2004). Salt stress variation response in five leguminous plants. Agron. Africa, 16: 33-44.

Thakuria, K. and Saharia, P. (1990). Response of greengram genotypes to plant density and phosphorus levels in summer. *Indian J. Agron*. 35: 431-432.

Verma, C.K., Yadav, D. and Singh, V. (2011). Effect of yield and quality of green gram varieties by foliar spray of urea and seed rate. Plant Archives. **11**(1): 289-291.

Vieiera, R. F., Oliveira, V. R. and Vieira, C. (2003). Mungbean cultivation in summer in Vicosa and Prudente de Morais. *Horticultural Brasileira* . **21**(1 &30): 43- 44.

Zhu, J. K. (2001). Plant salt tolerance. Trends Plant Sci., 6: 66-71.

APPENDICES

Appendix I: effect of variety and levels of salinity on plant height, number of leaf per plant, length of root of mungbean

Treatment	Plant height		Root length		Number of leaf	
BARI Mung 5 (V_1)	7.87	a	1.65	a	8.81	ab
Binamung 5 (V_2)	6.15	b	1.27	a	8.38	b
BARI Mung 6 (V_3)	8.16	a	1.42	a	7.96	b
Binamung 7 (V_4)	9.36	a	2.02	a	9.32	a
Level of significant	*		NS		*	
LSD (0.05)	1.57		1.61		0.56	
CV (%)	10.85		7.15		8.69	
Effect of salinity						
S_0 (0 dSm^{-1})	9.54	a	2.40	a	10.24	a
S_1 (3 dSm^{-1})	8.63	a	1.82	ab	9.33	ab
S_2 (6 dSm^{-1})	8.03	ab	1.52	ab	8.32	ab
S_3 (9 dSm^{-1})	7.22	ab	1.28	ab	8.06	ab
S_4 (12 dSm^{-1})	6.01	b	0.93	b	7.14	b
Level of significant	*		*		*	
LSD (0.05)	2.52		1.22		2.33	
CV (%)	10.85		7.15		8.69	

*significant at 5% level of probability