EFFECT OF SALICYLIC ACID AND $CaSO_4$ ON MORPHOLOGICAL CHARACTERS AND YIELD OF MUNGBEAN

A THESIS

BY

MOHAMMAD NURUL ISLAM

DEPARTMENT OF AGRICULTURAL BOTANY

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MOHAMMAD NURUL ISLAM

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Approved by:

Prof. Dr. Md. Ashabul Hoque **Supervisor**	**Prof. Dr. Mohammad Mahbub Islam** **Co-Supervisor**

Prof. Dr. Nasima Akhter
Chairman
Examination Committee

Prof. Dr. Md. Ashabul Hoque
Department of Agricultural Botany
Sher-e-Bangla Agricultural University
Dhaka, Bangladesh

Ref: Date:

CERTIFICATE

This is to certify that the thesis entitled, ***"EFFECT OF SALICYLIC ACID AND $CaSO_4$ ON MORPHOLOGICAL CHARACTERS AND YIELD OF MUNGBEAN"*** *submitted to the Department of Agricultural Botany, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE IN AGRICULTURAL BOTANY***, *embodies the results of a piece of bonafide research work carried out by* ***MOHAMMAD NURUL ISLAM*** *Registration No.* ***16-07577*** *under my supervision and my 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 :December, 2017

Place: Dhaka, Bangladesh

Prof. Dr. Md. Ashabul Hoque
Dept. of Agricultural Botany
SAU,Dhaka
Supervisor

DEDICATED TO
MY
BELOVED PARENTS
AND
ALL ULTRA POOR FARMARS

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ABSTRACT

The experiment was conducted at the research plot of the department of Agricultural Botany of Sher-e-Bangla Agricultural University, Dhaka during the period from February 2017 to June 2017 to effect of salicylic acid and $CaSO_4$ on morphophysiology growth and yield of mungbean. In this experiment, the treatment consisted of two mungbean varieties viz. V_1 = BARI mung 4, V_2 = = BARI mung 6 and four different concentration of Salicylic acid (SA) and $CaSO_4$ viz. T_0=control, T_1=5 mMole CaSO4, T_2=Salicylic acid 0.5 mMole, T_3=Salicylic acid 0.5mMole + 5 mMole CaSO4. The experiment was laid out in a two factors randomized complete block design (RCBD) design having 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. Variety and salicylic acid and $CaSO_4$ had significant influence on growth, yield and yield components of mungbean. The tallest plant (60.40 cm) was obtained from BARI Mung-6 with Salicylic acid 0.5milimole + 5 mMole CaSO4. The highest number of leaves plant^{-1} (14.33), pod length (9.52 cm), number of pods plant^{-1} (30.07), number of seeds pod^{-1} (13.53), thousand seed weight (73.17 g) was obtained from BARI Mung-6 with Salicylic acid 0.5milimole + 5 mMole CaSO4. The lowest number of leaves plant^{-1} (9.13), pod length (6.25 cm), number of pods plant^{-1} (22.60), number of seeds pod^{-1} (11.53), thousand seed weight (36.91 g) was obtained from BARI Mung-4 with control treatment. The highest seed yield ha^{-1} (1.93 ton) was obtained from BARI Mung-6 with Salicylic acid 0.5milimole + 5 mMole CaSO4 treatment combinations while the lowest seed yield (1.26 ton) was recorded from BARI Mung-4 with control treatment combination. The most of the parameters gave the best performance which was achieved from BARI Mung-6. Again, Salicylic acid 0.5milimole + 5 mMole CaSO4 showed the best performance regarding most of the yield and yield contributing parameters. In case of combined effect, BARI Mung-6 and Salicylic acid 0.5milimole + 5 mMole CaSO4 gave the best result considering yield and yield contributing parameters.

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LIST OF ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
LAI	=	Leaf area index
ppm	=	Parts per million
et al.	=	And others
N	=	Nitrogen
TSP	=	Triple Super Phosphate
MoP	=	Muriate of Potash
RCBD	=	Randomized complete block design
DAS	=	Days after sowing
ha^{-1}	=	Per hectare
G	=	gram (s)
Kg	=	Kilogram
µg	=	Micro gram
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
HI	=	Harvest Index
No.	=	Number
WUE	=	Water use efficiency
Wt.	=	Weight
LSD	=	Least Significant Difference
^{0}C	=	Degree Celsius
NS	=	Not significant
mm	=	millimeter
Max	=	Maximum
Min	=	Minimum
%	=	Per cent
cv.	=	Cultivar
NPK	=	Nitrogen, Phosphorus and Potassium
CV%	=	Percentage of coefficient of variance
Hr	=	Hour
T	=	Ton
viz.	=	Videlicet (namely)
RWC	=	Relative water content
NAA	=	Naphthalene acetic acid

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 crops of Bangladesh and belongs to the family Leguminosae and sub-family Papilionaceae. This commonly grown pulse crop belongs to the family leguminosae. 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^{-1}, whereas it is 7.92 g day^{-1} 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 2013-14 was 1.81 lac metric tons from the area of 1.73 lac hectares with an average yield 1.04 t ha^{-1} (MoA, 2014).

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) has developed six and Bangladesh Institute of Nuclear Agriculture (BINA) has developed seven 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.

In the integrated plant growing, growth regulators are widely applied for seed soaking. In case of vegetables, growth regulators are used mainly to improve seed germination power, increase yield, plants become resistant to diseases and unfavorable growth conditions (Kadiri *et al.*, 1997; Saglam *et al.*, 2002; Halter *et al.*, 2005; Jankauskienė and Survilienė 2009; Mukhtar, 2008; Turan *et al.*, 2009).

The effectiveness of plant growth regulators by reducing longitudinal shoot growth and improving functional and qualitative aspects of several plants is well known. The plant growth regulating properties of these compounds are mediated by their ability to alter the balance of important plant hormones including gibberellic acid, ascorbic acid (ABA), salicylic acid (SA) and cytokinins. They also inhibit gibberellin and ergosterol biosynthesis in plants and fungi, respectively (Cutler and Schneider, 1990; Rademacher, 2000; Mander, 2003; Boehme *et al*., 2005; Abdul Jaleel *et al*., 2007; Kishorekumar *et al*., 2007; Banon *et al*., 2009).

Salicylic acid (SA) is considered to be a hormone like substance that is important in the regulation of plant growth and development (Klessig and Malamy,1994), seed germination, fruit yield, glycolysis, flowering and heat production in thermogenic plants (Klessig and Malamy, 1994), ion uptake and transport (Harper and Balke, 1981), photosynthetic rate, stomatal conductance and transpiration (Khan *et al*., 2003). It is one of a suite of endogenous hormones that regulate the synthesis of antioxidant enzymes during abiotic and biotic stress (Fujita *et al*., 2006). Also, SA has been shown to be an essential signal molecule involved in both local defense reactions and induction of systemic resistance response of plants after pathogen attack (Loake and Grant, 2007). It has been shown that SA provides protection in maize (Janda *et al*, 1999) and winter wheat plants (Tasgin *et al.*, 2003) against low-temperature stress, induces termotolerence in mustard seedlings (Dat *et al.*, 1998) or modulates plant responses to salt and osmotic stresses (Borsani *et al.*, 2001), ozone or UV light (Sharma *et al.*, 1996), drought (Senaratna *et al*., 2000) and herbicides (Ananieva *et al*., 2004). Furthermore, SA is also known to be involved in plant protection to heavy metals. The SA as natural plant hormone has many effects on physiological processes and growth of plants. Foliar spray of SA increases pod plant^{-1}, number of seeds per pod^{-1}, seed weigh plant$^{-1,}$ seed yield hectare^{-1} and protein content. SA application @ 100 mgL^{-1} under saline conditions is effective in improving the growth and plant productivity of mungbean through improving the nitrogen metabolism by enhancing nitrogen uptake, protein and total amino acids (Akhtar *et al*., 2013). Not only in pulse have crops SA also stimulated other crop. It has been suggested that the growth-promoting effects of SA could be related to changes in the hormonal status by improvement of photosynthesis, transpiration and stomatal conductance (Abreu and Munne-Bosch, 2009).

The beneficial Ca effects in ameliorating Al toxicity in different crops growing in acid soils are reported by Illera *et al*. (2004) and Mora *et al*. (2002). Meriño-Gergichevich *et al*. (2010) reviewed the Al^{3+}-Ca^{2+} interaction in plants growing in acid soils in com-parison to the Al-phytotoxicity response to calcareous amendments and pointed out the importance of gyp-sum amendments in the reduction of toxic Al without altering pH conditions (Franzen *et al*., 2006). This occurs due to the replacement of exchangeable Al^{3+} by Ca^{2+}particularly in the subsoil and the formation of Al^{-}hydroxyl-sulfate or aluminum sulfate complexes (Mora *et al*., 2002), which are less toxic to plants. Therefore, experimental evidences indicate that there are enough scopes to increase the productivity of mungbean under proper management. In this study, an attempt was made to effect of salicylic acid and $CaSO_4$ on morphophysiology growth and yield of Mungbean. Considering the above factors the present experiment was conducted with the following objectives:

1. To know the effect of SA and $CaSO_4$ on growth parameters are scanty and yield components of mungbean varieties.
2. To find out the appropriate combination of SA and $CaSO_4$ on mungbean.

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

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. Binamoog-6 produced the highest seed yield which was as good as Binamoog-8.

Rasul *et al*. (2012) conducted 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.

Kamal Uddin 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.

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 BINA mung 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. It is concluded from the experiment that mungbea.

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. BARIMung-2, BARIMung-3, BARIMung-4, BARIMung-5 and BINAMung-2. The experiment was laid out in a randomized complete block design with three replications. It was observed that BARIMung-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, BINA mung-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. Bina moog 2 and Bina moog 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. Bina moog 2 performed slightly better than Bina moog 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, Bina mung-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. BINA mung2, BINA mung5, BARI mung2 and BARI mung5. Result revealed that BINA mung5 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, BINA mung5 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 mung2, BARI mung3, BARI mung4, BARI mung5, BU mung1, BU mung2 and BINA mung5 and found that BARI mung2 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, BINA moog-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 BINA mung5 produced higher seed yield over BINA mung2. Field duration of BINA mung5 was about 78 days as against 82 days for BINA mung2. 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.

However, BARI (2006) and BINA (2007) released several mungbean varieties and instructed that seed rate depend on seed size of a variety. BARI (2005) and BINA (2005) further reported that optimum seed rate required 30-35 kg ha^{-1} for BARI mung2, BARI mung3, BARI mung4, BINA mung2, BINA mung3, BINA mung4 and BINA mung7 while optimum seed rate required 35-40 kg ha^{-1} for BARI mung5, BARI mung6, BINA mung5 and BINA mung6.

2.2 Effect of growth regulators on growth and yield of mungbean

Mohtashami *et al.* (2016) evaluated the effect of seed treatments with growth regulators on the yield and yield components of common bean (*Phaseolus vulgaris* L.) lines, a factorial experiment was carried out based on a randomized complete block design with three replications at two years. In this research, pre-treatment (priming) of two red bean (D81083 and KS31169) seeds with growth regulators including salicylic acid (SA) and naphthalene acetic acid (NAA) at four levels (P_0: control, distilled water; P_1: 0.5 m mol L^{-1} NAA; P_2: 0.7 m mol L^{-1} SA; P_3: combination of SA and NAA hormones at rates of 0.5 and 0.7 m mol

L^{-1}) were studied. The results showed that the effect of line in all of the characteristics and seed priming with growth regulators in all of the characteristics except to harvest index were significant. The highest number of grains per pod and biological yield (14602 kg ha^{-1}) due to growth regulator application was obtained from line D81083 in 0.5 m mol L^{-1} NAA. Generally, the use of growth regulators as a seed pre-treatment increased the yield and yield components of red beans.

Nezhad *et al*. (2014) was laid out in randomized complete block design with split plot design with three replications. Drought stress in three levels (I1: Regular watering 5 days, I_2:10 days, I_3:15 days) allocated to main plots and foliar application of salicylic acid in four levels (S_1: 0, S_2: 0.5, S_3:1, S_4:1.5 M mol) was allocated to sub plots. Drought stress and SA on plant height, Number of Branch, Number of Pod and Biological yield was significant.

Jasim and Muhsen (2014) conducted in a field Crop Science Department in Abu Gharaq/Hella/Babylon province during 2013 to study the effect of fours owing dates (15/5 , 15/6, 15/7 and 15/8) , five spraying treatment (SA 0.5 and 0.1mM, humic acid, high phosphorus fertilizer, in addition to control) and their interaction on yield of mung bean plants. Plants were sprayed twice (after 30 and 45 days of seeding) and there queried measurements were analyzed and the results showed that: Second time of seeding was superior in the number of pods.$plant^{-1}$,100 seeds weight, seed protein content and seed yield. Forth seeding time was superior in pod seed number and pod length. High phosphate fertilizer was superior in the number of pods plant^{-1}, pod seed number, pod length, protein percentage and seed yield. Humic acid was superior in 100 seeds weight. The interaction of high phosphate in second seeding was superior in the number of pods.plant^{-1}, 100 seeds weight and seed yield.

Abbastash *et al.* (2013) conducted to determine the effects of exogenous SA application on growth indices (dry weight, leaf area, number of leaves and plant height) of maize plants under salt stress in green house conditions. Maize plants were treated with SA at different concentrations (0, 1, 2, 3 mM). Salinity treatments were 6 levels of NaCl (10, 20, 30, 40, 50 meq/Kg soil). A factorial experiment based on a completely randomized design with four replicates. As a consequence of salinity stress the growth parameters of maize plants were negatively affected, however plants treated with SA, significantly had greater shoot dry weight, leaf area, number of leaves and stem length. Results of analysis of variance showed that salinity levels and SA concentrations affected growth parameters significantly ($P<0.01$). Means comparison indicated that the greatest values were obtained by the 2.00 mM SA application. Generally, these results suggest that SA could be used as a plant growth regulator to improve their resistance toward salinity stress.

Abbas and Abdullah (2012) studied that the effects of silicon (Si) and SA on the proline, lipid peroxidation (MDA), protein content, transpiration rate and lipoxygenase activity in mung bean (Phaseolus aureus Roxb.) cuttings under boron (B) toxicity were studied. In general, Boron toxicity at (250- 600 μg/ml) significantly reduced growth parameters and morphological symptoms represented by bleaching of primary leaves, in addition to chlorosis and necrosis. The physiological parameters of B toxicity were significantly declined for protein (25%) and transpiration rate (50%), but there was significant increase in malondialdehyde (52 %), lipoxygenase activity (68 %) and proline (90 %) compared with control .For alleviating B toxicity, SA and Si were supplied. That resulted in increasing in MDA content, whereas decrease proline and maintaining of lipoxygenase activty.

Shakeel and Mansoor (2012) conducted to investigate the effect of salicylic acid on biochemical response of plant to salt stress. In the present study two Mung bean genotypes (NM 19-19 and NM 20-21) were taken as experimental material and imbibed in distilled water and solution of SA (50, 100 and 1000 mM) for 13 h prior to salt stress. Then seedlings were treated with 0, 50 and 100 mM NaCl. It was observed that 50 mM NaCl treatment enhanced protein synthesis which was reduced in seedlings treated with 100 mM NaCl as compared to control. However the pretreatment of SA before NaCl treatment enhanced protein synthesis. Salt stress caused reduction in "-amylase activity with the promotion in the activity of Acid Phosphatase. The pretreatment of low concentrations of SA (50 and 100 mM) induced AMY activity as compared to salt treated samples with the reduction in AP activity. Highest concentration of SA (1000 mM) showed reduction in the activity of both enzymes. It was further observed that the overall biochemical performance of NM 19-19 was better than NM 20-21.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the research plot of the department of Agricultural Botany of Sher-e-Bangla Agricultural University, Dhaka during the period from February 2017 to June 2017 to Effect of Salicylic Acid and $Caso_4$ on Morphological Characters and Yield of Mungbean. Materials used and methodologies followed in the present investigation have been 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) (Appendix-I). The land topography was medium high and soil texture was silt clay with pH 5.6. The morphological, physical and chemical characteristics of the experimental soil have been presented in Appendix-II.

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

BARI Mung-4:

BARI Mung-4 was used as planting material. BARI Mung-4 was released and developed by BARI in 1996. Plant height of the cultivar ranges from 52 to 57 cm. Average yield of this cultivar is about 1200 kg ha^{-1}. The seeds of BARI Mung-4 for the experiment were collected from pulse research cenre, BARI, Joydepur, Gazipur.

BARI Mung-6:

BARI Mung-6 was used as planting material. BARI Mung-6 was released and developed by BARI in 2003. Plant height of the cultivar ranges from 40 to 45 cm. Average yield of this cultivar is about 1600 kg ha^{-1}. The seeds of BARI Mung-6 for the experiment were collected from pulse research cenre, BARI, Joydepur, 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-4

V_2 = BARI Mung-6

Factor V: Salicylic acid level and $CaSO_4$

T_0=control

T_1=5 mMole CaSO4

T_2=Salicylic acid 0.5 mMole

T_3=Salicylic acid 0.5 mMole + 5 mMole CaSO4

3.3.1Treatment combinations

There are 8 treatment combinations of different varieties and different concentration of salicylic acid used in the experiment under as following:

1. V_1T_0	5. V_2T_0
2. V_1T_1	6. V_2T_1
3. V_1T_2	7. V_2T_2
4. V_1T_3	8. V_2T_3

3.4 Experimental design and layout

The experiment was laid out in a two factor randomized complete block design (RCBD) design having three replications. Each replication had 8 unit plots to which the treatment combinations were assigned randomly. The unit plot size was 6.0 m^2 (2 m ×3m). The blocks and unit plots were separated by 0.5 m and 0.50 m spacing respectively. The layout of the experiment is presented in Appendix III.

3.5 Land preparation

The experimental land was opened with a power tiller on March 08, 2017. Ploughing and cross ploughing were done with country plough followed by laddering. Land preparation was completed on March, 2017 and was ready for sowing of seeds.

3.6 Fertilizer application

The fertilizers were applied as basal dose at final land preparation where N, K_2O, P_2O_5 ,Ca and S were applied @ 20.27 $kgha^{-1}$, 33 kg ha^{-1}, 48 kg ha^{-1}, 3.3 kg ha^{-1} and

1.8 kg ha^{-1} respectively in all plots. All fertilizers were applied by broadcasting and mixed thoroughly with soil.

3.7 Sowing of seeds

Seeds were sown at the rate of 25 kg ha^{-1} in the furrow on March 29, 2017 and the furrows were covered with the soils soon after seeding.

3.8 Intercultural operations

3.8.1 Weed control

Weeding was done once in all the unit plots with care so as to maintain a uniform plant population as per treatment in each plot at 15 DAS.

3.8.2 Thinning

Thinning was done at 20 DAS and 35 DAS. Plant to plant distance was maintained at 10 cm.

3.8.3 Irrigation and drainage

Pre sowing irrigation was given to ensure the maximum germination percentage. During the whole experimental period, there was a shortage of rainfall in earlier part; however, it was heavier in later one. So it was essential to remove the excess water from the field at later period.

3.8.4 Insect and pest control

Malathion 57 EC @ 1.5 L ha^{-1} was sprayed when required.

3.9 Determination of maturity

At the time when 80% of the pods turned brown color, the crop was considered to attain maturity.

3.10 Harvesting and sampling

The crop was harvested at 70 DAS from prefixed 1.0 m^2 areas. Before harvesting ten plants were selected randomly from each plot and were uprooted for data recording. The rest of the plants of prefixed 1 m^2 area were harvested plot wise and were bundled separately, tagged and brought to the threshing floor.

3.11 Threshing

The crop was sun dried for three days by placing them on the open threshing floor. Seeds were separated from the plants by beating the bundles with bamboo sticks.

3.12 Drying, cleaning and weighing

The seeds thus collected were dried in the sun for reducing the moisture in the seeds to a constant level. The dried seeds and straw were cleaned and weighed.

3.13 Detailed Procedures of Recording Data

I. Plant height (cm)

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

II. Number of leaves plant^{-1}

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

III. Number of pods plant^{-1}

Number of pods per plant was counted from each selected plant sample.

IV. Pod length (cm)

Pod length was measured in centimeter (cm) scale from randomly selected ten pods. Mean value of them was recorded as treatment wise.

V. Number of seeds pod^{-1}

Average number of seedpod^{-1} was calculated by counting the number of seed pod^{-1} of 10 pod plant^{-1}.

VI. 1000 seed weight (g)

A composite sample was taken from the yield of ten plants. The 1000-seeds of each plot were counted and weighed with a digital electric balance. The 1000-seed weight was recorded in g.

VII. Seed yield (t ha^{-1})

Seed yield was recorded on the basis of total harvested seeds per 1m^2 and was expressed in terms of yield (t ha^{-1}). Seed yield was adjusted to 12% moisture content.

VIII. Stover yield

Stover yield was determined from the central 1 m^2 area of each plot. After threshing, the plant parts were sun-dried and weight was taken and finally converted to ton per hectare.

IX. Biological yield

The biological yield was calculated with the following formula-

Biological yield= Grain yield + Stover yield

X. Harvest index (%)

Harvest index was calculated on dry basis with the help of following formula.

Harvest index (HI %) = (Seed yield/ Biological yield) × 100

3.14 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 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 Plant height

The plant height was varied with the different varieties at harvest (Fig. 1). The tallest plant (56.91 cm) was obtained from BARI Mung-6 (V_2) and the shortest plant (43.26 cm) was obtained in BARI Mung-4 (V_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 concentration of salicylic acid with $CaSO_4$. The tallest plant (54.84 cm) was obtained from T_3 (Salicylic acid 0.5mMole + 5 mMole $CaSO_4$) treatment and the shortest plant height (44.28 cm) from T_0, control condition. Data revealed that with the application of salicylic acid plant height showed an increasing trend. Muhal *et al.* (2014) reported that foliar application of salicylic acid produced significantly longest plant at different days after sowing compared to water spray plays a significant role in photosynthesis and growth of plant that leads to the production of longest plant as well as vegetative growth. Sharma *et al*. (2013) reported that foliar application of SA improved growth parameters as well as plant height of mustard compared to the application of water.

Interaction effect of varieties and salicylic acid and $CaSO_4$ had a significant variation on plant height of mungbean (Table 1). The tallest plant (60.40 cm) was obtained from V_2T_3 (BARI Mung-6 with Salicylic acid 0.5mMole + 5 mMole $CaSO_4$) treatment combination, which was statistically similar with V_2T_1. The shortest plant height (36.43 cm) was observed from V_1T_0 (BARI Mung-4 with control) treatment combination.

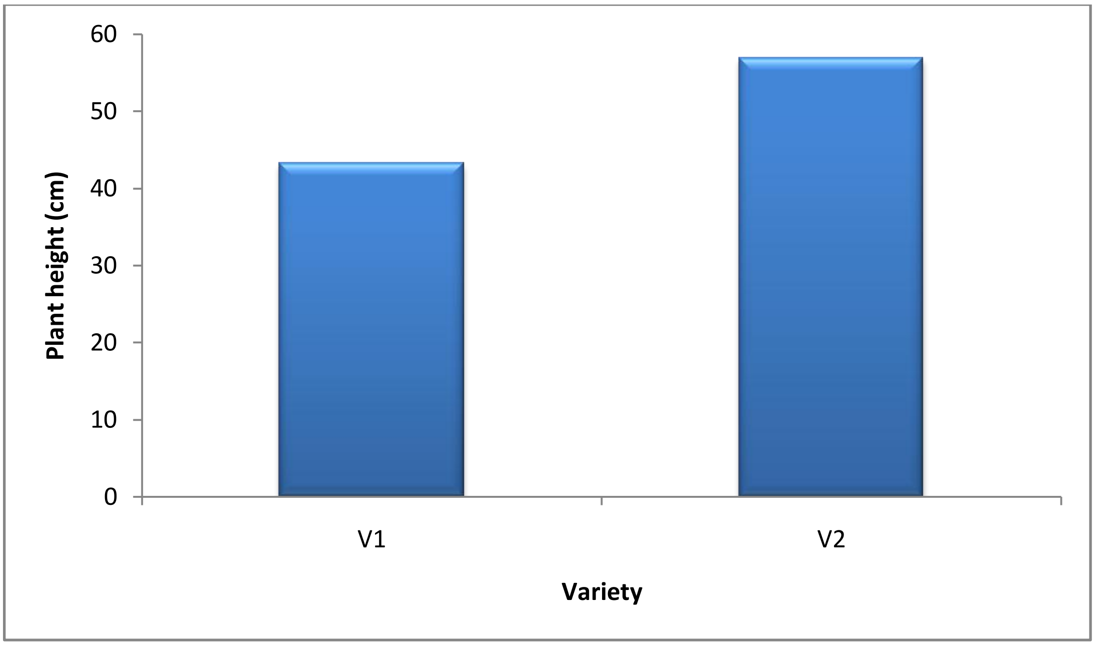

Fig.1: Effect of varieties on the plant height of Mungbean

(V_1 = BARI Mung-4, V_2 = BARI Mung-6)

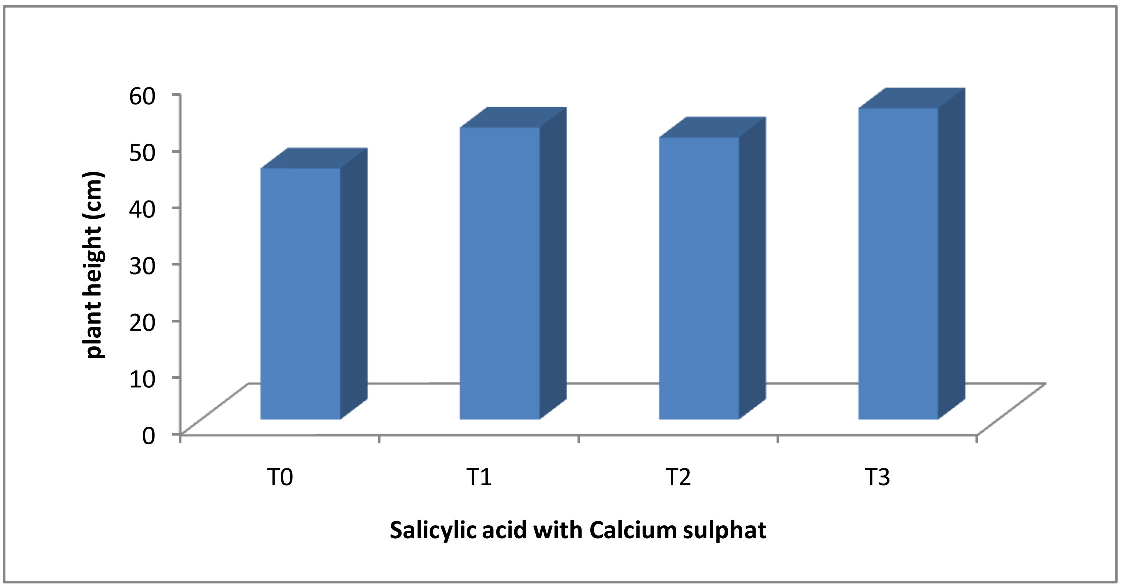

Fig.2: Effect of salicylic acid with calcium sulphate on the plant height of Mungbean

(T_0=control, T_1=5 mMole $CaSO_4$, T_2=Salicylic acid 0.5 mMole, T_3=Salicylic acid 0.5mMole + 5 mMole $CaSO_4$)

Table 1. Interaction effect of varieties and salicylic acid on the plant height of mungbean

Treatment	Plant height (cm)	Number of leaf per plant	Number of pod per plant
V_1T_0	36.43 d	9.13 b	22.60 c
V_1T_1	43.28 cd	11.67 ab	26.73 ab
V_1T_3	44.00 cd	10.93 ab	25.60 bc
V_1T_2	49.33 bc	14.33 a	29.20 ab
V_2T_0	52.13 ab	8.80 b	27.13 ab
V_2T_1	59.63 a	9.33 b	29.13 ab
V_2T_3	55.47 ab	10.27 b	29.07 ab
V_2T_2	60.40 a	11.00 ab	30.07 a
$LSD_{(0.05)}$	7.76	3.38	3.36
CV(%)	8.85	8.06	5.47

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.

V_1 = BARI Mung-4, V_2 = BARI Mung-6
T_0=control, T_1=5 mMole $CaSO_4$, T_2=Salicylic acid 0.5 mMole, T_3=Salicylic acid 0.5mMole + 5 mMole $CaSO_4$

4.2 Number of leaves plant^{-1}

The number of leaves plant^{-1} was influenced by varieties (Fig. 3).The BARI Mung-4 produced maximum number of leaves (11.52) and the minimum number of leaves (9.85) 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 concentration of salicylic acid with calcium sulphate (Fig. 4). The maximum number of leaves plant^{-1} (12.67) was obtained from T_3 (Salicylic acid 0.5mMole + 5 mMole CaSO4) treatment. The minimum number of leaves plant^{-1} (8.97) from T_0 control condition. The number of leaves was increased with increasing in salicylic acid at certain level. Farahbakhsh and Saiid (2011) who reported that high concentration of SA (200 ppm) caused an increase of 74.94% in leaf area and number of leaf. Zhou *et al.* (1999) also indicate that SA increases the leaf area in sugarcane plants, which is consistent with our results.

Interaction effect of varieties and salicylic acid with calcium sulphate had significant variation on number of leaves plant^{-1} of mungbean. The highest number of leaves plant^{-1} (14.33) was obtained from V_1T_2 (BARI Mung-6 with Salicylic acid 0.5mMole) treatment while the lowest number of leaves plant^{-1} (9.13) from V_2T_0 (BARI Mung-6 with control) treatment, which was statistically similar with. $V_1T_{0,}$ V_2T_1 and V_2T_2 (Table 1).

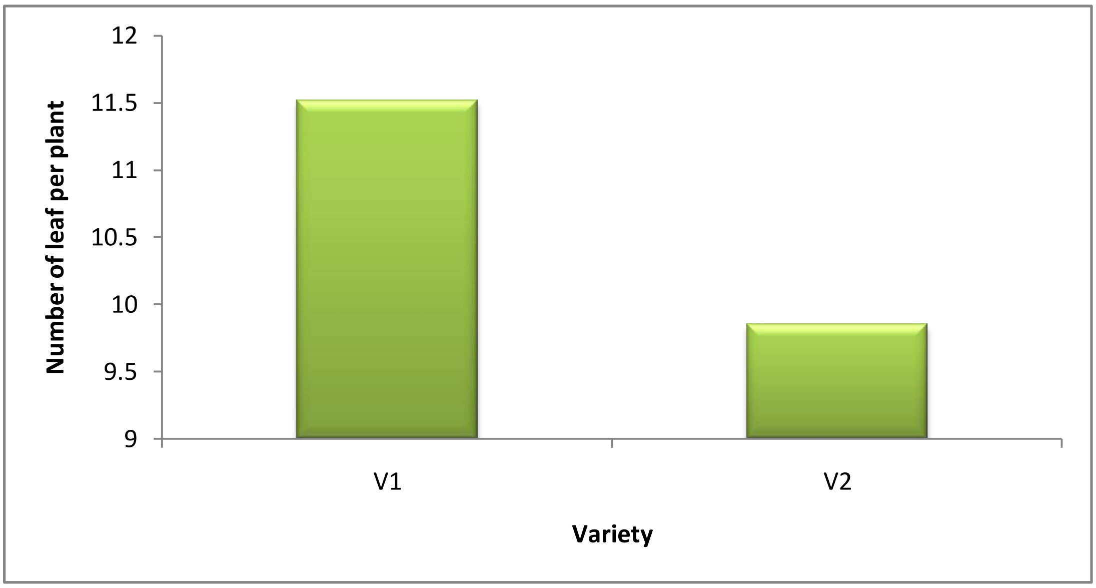

Fig.3: Effect of varieties on the number of leaf plant^{-1} of mungbean

(V_1 = BARI Mung-4, V_2 = BARI Mung-6)

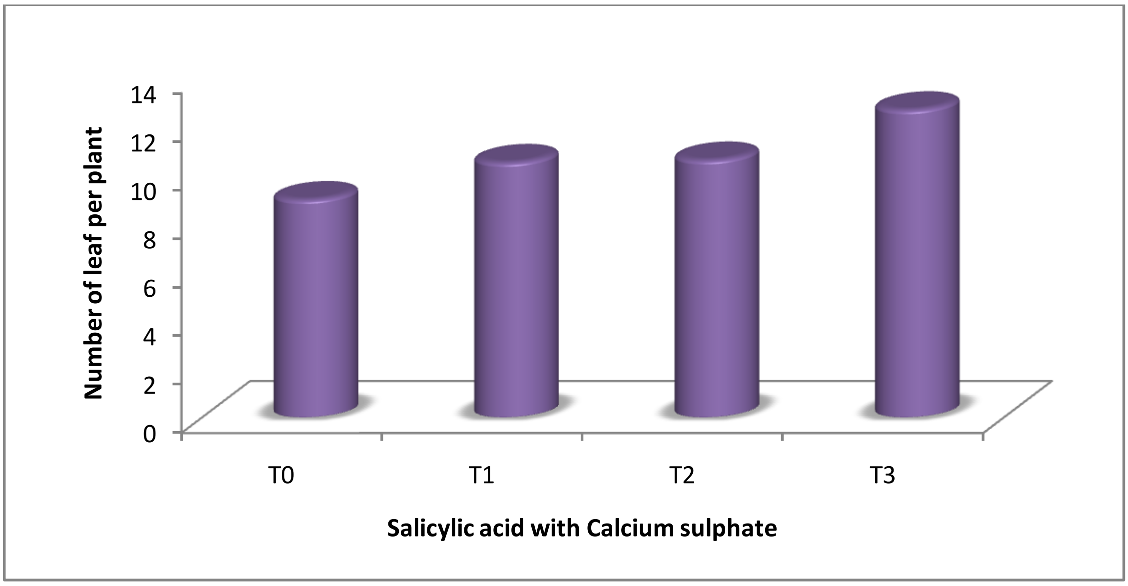

Fig.4: Effect of salicylic acid with Calcium sulphate on the number of leaf plant^{-1} of Mungbean

(T_0=control, T_1=5 mMole CaSO4, T_2=Salicylic acid 0.5 mMole, T_3=Salicylic acid 0.5mMole + 5 mMole CaSO4)

4.3 Number of pod plant^{-1}

The number of pod plant^{-1} was varied with to the different varieties (Fig. 5). The highest number of pod plant^{-1} (28.85) was recorded in V_2 (BARI Mung-6). The lowest number of pods plant^{-1} (26.03) was recorded in BARI Mung-4. Genotypic variations in effective pods plant was observed by Mondal *et al.,* (2004) in mungbean. Similar results were found by Aslam *et al*. (2004) and he observed significant differences between mungbean varieties for number of number of pods plant^{-1}. Similar results were also found by Parvez *et al*. (2013), Kumar *et al*. (2009), Raj and Tripathi (2005), Shamsuzzaman *et al*. (2004), Madriz-Isturiz and Luciani-Marcano (2004) and Brar *et al*. (2004). They found that variety had also significant effect on number of pods plant^{-1} of mungbean.

There was significant variation in the number of pods plant^{-1} due to the salicylic acid with $CaSO_4$ (Fig 6). The maximum number of pods plant^{-1} (29.63) was observed from T_3 and the minimum number of pods plant^{-1} (24.87) was obtained in T_0 control condition. Muhal and Solanki (2015) reported that 100 ppm SA foliar spray registered significantly higher number of pod plant^{-1} compared to water spray.

Interaction effect of different varieties and different salicylic acid with $CaSO_4$ had a significant variation on number of pods plant^{-1}. The highest number of pods plant^{-1} (30.07) was obtained from V_2T_3 (BARI Mung-6 with Salicylic acid 0.5mMole + 5 mMole CaSO4) treatment, whiles the lowest number of pod plant^{-1} (22.6) from V_1T_0 (BARI Mung-4 with control) treatment combination (Table 1).

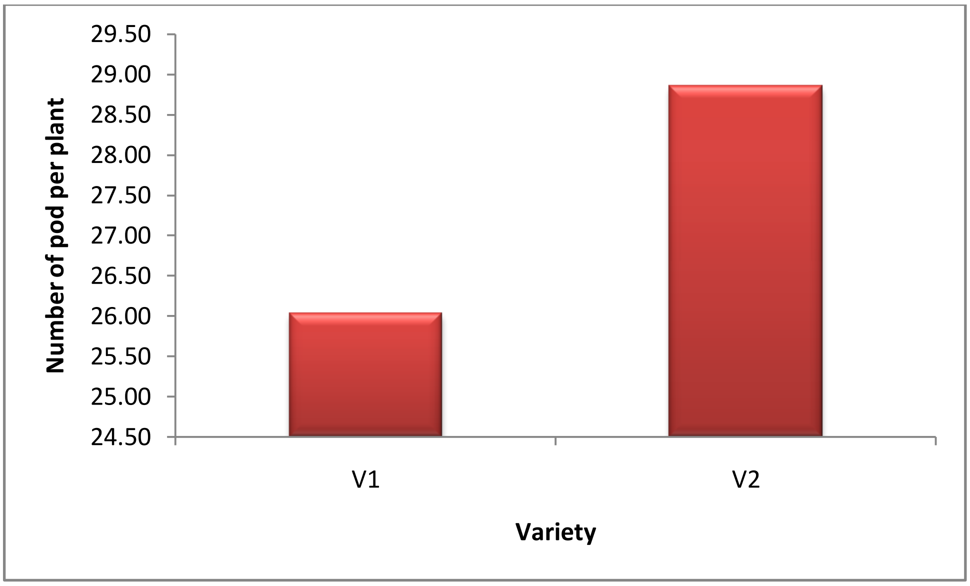

Fig.5: Effect of varieties on the number of pod plant^{-1}of mungbean

(V_1 = BARI Mung-4, V_2 = BARI Mung-6)

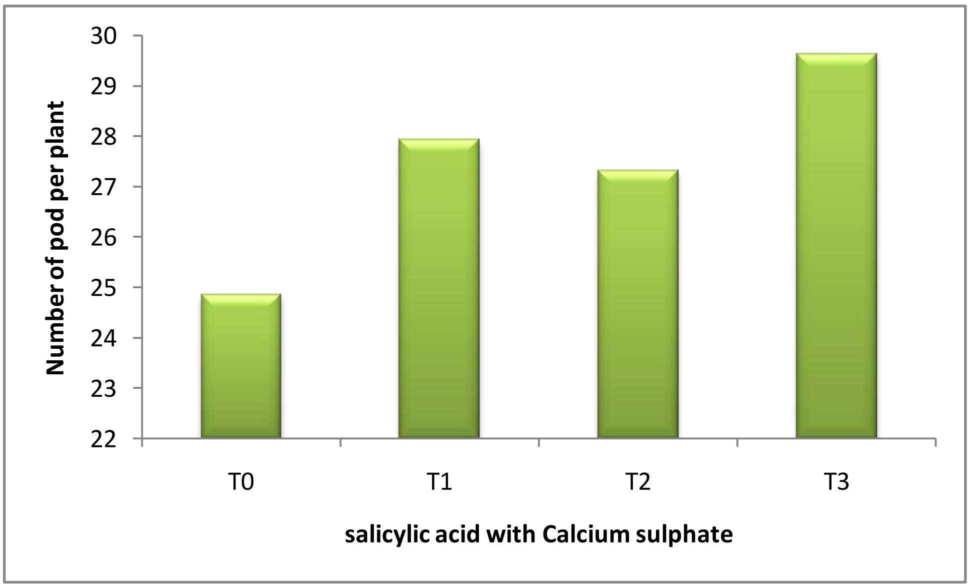

Fig.6: Effect of salicylic acid with Calcium sulphate on the number of pods plant^{-1}of Mungbean

(T_0=control, T_1=5 mMole CaSO4, T_2=Salicylic acid 0.5 mMole, T_3=Salicylic acid 0.5mMole + 5 mMole CaSO4)

4.4 Pod Length

Pod length is one of the most important yield contributing characters of mungbean. Varieties showed variation in pod length (Table 2). The longest pod length (9.19 cm) was observed in V_2 (BARI Mung- 6). The shortest pod length (6.12 cm) was obtained in $V_{1,}$ (BARI Mung-4). These results have the agreement with the results of Sarkar *et al.* (2004) who reported that pod length differed from varieties to varieties. The probable reason of this difference could be the genetic make-up of the varieties. Similar results were found by Aslam *et al*. (2004) and he observed significant differences between mungbean varieties for pod length.

Pod length of mungbean was significantly influenced by variation with the different concentration of salicylic acid with calcium sulphate (Table 2). The longest pod length (8.56 cm) was recorded from T_3 treatment, which was statistically different from all other treatment. The shortest pod length (7.48 cm) was observed in T_0 (control condition) treatment.

Interaction effect of different varieties and salicylic acid with $CaSO_4$ had a significant variation on pod length of mungbean (Table 2). The highest pod length (9.52 cm) was obtained from V_2T_3 (BARI Mung-6 with Salicylic acid 0.5mMole + 5 mMole $CaSO_4$) treatment, which was statistically similar with V_2T_2 whiles the lowest (6.25 cm) from V_1T_0 treatment.

Table 2. Interaction effect of varieties and salicylic acid on yield contributing characters of mungbean

Treatment	Pod length (cm)		Number of seed per pod		Thousand seed weight (g)	
Effect of Variety						
V1	7.12b		12.26a		42.86b	
V2	9.19a		12.8a		68.77a	
CV(%)	4.82		5.28		5.73	
Effect of salicylic acid with Calcium sulphate						
T_0	7.48	b	11.8	c	49.39	c
T_1	8.18	ab	13	a	57.16	ab
T_3	8.4	ab	12.1	b	55.87	b
T_2	8.56	a	13.21	a	60.84	a
$LSD_{(0.05)}$	1		0.97		4.1	
CV(%)	4.82		5.28		5.73	
Interaction effect of variety and salicylic acid with Calcium sulphate						
V_1T_0	6.25	d	11.53	c	36.91	f
V_1T_1	7.33	c	13.00	ab	43.52	e
V_1T_3	7.31	c	11.60	c	42.51	e
V_1T_2	7.60	c	12.90	ab	48.51	d
V_2T_0	8.71	b	12.07	bc	61.87	c
V_2T_1	9.03	ab	13.00	ab	70.79	ab
V_2T_2	9.48	a	12.60	abc	69.23	b
V_2T_3	9.52	a	13.53	a	73.17	a
$LSD_{(0.05)}$	0.69		1.16		3.65	
CV(%)	4.82		5.28		5.73	

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.

(V_1 = BARI Mung-4, V_2 = BARI Mung-6
T_0=control, T_1=5 mMole $CaSO_4$, T_2=Salicylic acid 0.5 mMole, T_3=Salicylic acid 0.5mMole + 5 mMole $CaSO_4$)

4.5 Number of seeds pod^{-1}

The number of seeds pod^{-1}of mungbean was varied with varieties (Table 2). The highest number of seeds pod^{-1} (12.80) was observed in V_2 treatment. The lowest number of seeds pod^{-1} (12.26) was obtained from V_1. A result was found by Infante *et al.* (2003) which was not similar with this study. They found significant difference on number of seeds pod^{-1} among the varieties. Genotypic variations in seeds pod^{-1} was also observed by Thakuria and Saharia (1990) in mungbean.

The number of seeds pod^{-1} was significantly influenced by different concentration of SA with $CaSO_4$ (Table 2). The maximum number of seeds pod^{-1} (13.00) was obtained from T_3 which was followed by T_1. The minimum number of seeds pod^{-1} (11.8) was recorded from T_0 (control condition). Sharma *et al.* (2013) reported that SA improved yield attributes and total number of seeds per pod improved by 3.2% over the unsprayed control.

Interaction effect of different varieties and SA with $CaSO_4$ was a significant effect on number of seeds pod^{-1} (Table 2). The highest number of seeds pod^{-1} (13.53) was obtained from V_2T_3 (BARI Mung-6 with Salicylic acid 0.5mMole + 5 mMole $CaSO_4$) while the lowest 11.53 from $V_1S_{0,}$ BARI Mung-4 with control treatment combination.

4.6 1000 seed weight

Variety had been variation in 1000-seed weight and it was also observed in studied varieties of mungbean (Table 2). The highest 1000-seed weight (68.77g) was recorded in V_2 (BARI Mung-6). In contrast, the lowest 1000-seed weight (42.86 g) was recorded inV_1, (BARI Mung-4). Genotypic variation in 1000-seed weight was also observed in mungbean that also supported the present experimental results. Similar results were found by Ali *et al*. (2004) and they observed significant differences between mungbean genotypes for 1000 seeds weight.

There was significant variation in the thousand seed weight due to the salicylic acid with $CaSO_4$. The maximum thousand seed weight (60.84g) was obtained from T_3, which was followed by T_1 and the minimum thousand seed weight (49.39) g from T_0 (Table 2).

Interaction effect of different varieties and salicylic acid with $CaSO_4$ was significant variation on thousand seed weight. The highest thousand seed weight (73.17 g) was obtained from V_2T_3 (BARI Mung-6 with Salicylic acid 0.5mMole + 5 mMole $CaSO_4$) treatment while the lowest (36.91 g) from V_1T_0 treatment (Table 2).

4.7 Seed yield

The yield of mungbean was varied with different varieties. Yield is a function of various yield components such as number of pod plant^{-1}, seed pod^{-1} and 1000-grain weight. The highest seed yield (1.69 tha^{-1}) was recorded in V_2 (BARI Mung-6). In contrast, the lowest seed yield (1.42 tha^{-1}) was obtained from V_1 (BARI Mung-4) (Table 3). The probable reason of this difference might be due to higher number of pod length, number of seeds pod^{-1}. Genotypic variation in seed yield was also observed by Hague (1995) and Borah (1994). Aslam *et al*. (2004) observed significant differences between mungbean genotypes for seed yield kg ha$^{-1.}$ Khan *et al.* (2001), Reddy *et al.*, (1990) also reported significant differences between mungbean genotypes for yield (kg ha^{-1}).

There was significant variation in the seed yield hectare^{-1} due to the salicylic acid with $CaSO_4$. The maximum seed yield hectare^{-1} 1.75 ton was obtained from T_3, and the minimum (1.40 ton) was obtained in T_0, control condition (Table 3). Muhal *et al*. (2014) reported that that foliar application of salicylic acid produced significantly higher seed yield compared to water spray.

Interaction effect of different varieties and salicylic acid with $CaSO_4$ had a significant variation on seed yield ha^{-1}. The highest seed yield ha^{-1} (1.93 ton) was obtained from V_2T_3 (BARI Mung-6 with Salicylic acid 0.5mMole + 5 mMole CaSO4) treatment combination while the lowest (1.26 ton) from V_1T_0 (BARI Mung-4 with control) treatment combination (Table 3)

Table 3. Interaction effect of varieties and salicylic acid on yield and yield contributing characters of mungbean

Treatment	Seed yield (t/ha)	Stover yield (t/ha)	Biological yield (t/ha)	Harvest Index (%)
Effect of Variety				
V1	1.42	1.53	2.95	47.90
V2	1.69	1.83	3.52	48.02
CV(%)	5.58	7.82	5.93	6.41
Effect of salicylic acid with Calcium sulphate				
T_0	1.40 c	1.497 b	2.894 b	48.05 ab
T_1	1.54 b	1.708 a	3.251 ab	47.47 ab
T_2	1.54 b	1.718 a	3.253 ab	46.93 b
T_3	1.75 a	1.777 a	3.527 a	49.38 a
$LSD_{(0.05)}$	0.12	0.14	0.40	2.39
CV(%)	5.58	7.82	5.93	6.41
Interaction effect of variety and salicylic acid with Calcium sulphate				
V_1T_0	1.26 e	1.31 e	2.58 e	48.60 ab
V_1T_1	1.40 de	1.46 de	2.85 de	48.50 ab
V_1T_3	1.46 cd	1.70 bcd	3.15 cd	45.93 b
V_1T_2	1.57 bc	1.63 cd	3.20 cd	48.57 ab
V_2T_0	1.53 bcd	1.68 bcd	3.21 cd	47.50 ab
V_2T_1	1.69 b	1.96 a	3.65 ab	46.43 b
V_2T_2	1.61 bc	1.74 abc	3.35 bc	47.93 ab
V_2T_3	1.93 a	1.92 ab	3.85 a	50.20 a
$LSD_{(0.05)}$	0.16	0.23	0.34	2.86
CV(%)	5.58	7.82	5.93	6.41

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.

(V_1 = BARI Mung-4, V_2 = BARI Mung-6
T_0=control, T_1=5 mMole $CaSO_4$, T_2=Salicylic acid 0.5 mMole, T_3=Salicylic acid 0.5mMole + 5 mMole $CaSO_4$)

4.8 Stover yield

Varieties on stover yield in mungbean genotypes had a significant variation (Table 3). Results revealed that the highest stover yield 1.83 t ha^{-1} was recorded from BARI Mung-6. Whereas, the lowest stover yield 1.53 t ha^{-1} was achieved from BARI Mung-4. Varietal performance showed significant variation on stover yield which was supported by the findings of Parvez *et al*. (2013) and Hossain and Solaiman (2004).

The experimental result varied with growth and yield of Mungbean by salicylic acid with $CaSO_4$ on stover yield (t ha^{-1}) of Mungbean (Table 3). Results showed that the maximum stover yield 1.78 t/ha was recorded from T_3, which was statistically similar with T_1 and T_3, whereas the lowest stover yield 1.49 t/ha was achieved from control.

Significant variation was observed in the interaction effect of different types of varieties and different concentration of salicylic acid on stover yield (Table 3). The highest stover yield 1.96 t/ha was recorded fromV_2T_1 (BARI Mung-6 with 5 mMole $CaSO_4$), which statistically different from all other treatments, whereas the stover yield 1.31 t/ha was recorded from V_1T_0 treatment combination.

4.9 Biological yield

Biological yield of mungbean was significantly influenced by variety (Table 3). The maximum biological yield 3.52 t ha^{-1} was found in V_2 (BARI Mung-6). The lowest yield 2.95 t ha^{-1} was observed from V_1, BARI Mung-4. Varietal performance showed significant variation on biological yield which was supported by the findings of Parvez *et al*. (2013) and Hossain and Solaiman (2004).

There was a significant influence in the biological yield of mungbean due to SA and $CaSO_4$ (Table 3). The maximum biological yield 3.53 t ha^{-1} was found from T_3 and the minimum biological yield 2.89 t/ha from T_0, control condition.

Interaction of variety and SA had a significant influence on biological yield of mungbean (Table 3). The highest biological yield 3.85 t/ha was obtained from V_2T_3 (BARI Mung-6 with Salicylic acid 0.5mMole + 5 mMole CaSO4) while the lowest 2.58 t/ha from V_1T_0, BARI Mung-4 with contro).

4.10 Harvest index

Harvest index was influenced by variety (Table 3). The maximum harvest index (48.02%) was found in V_2 (BARI Mung-6). The lowest yield (47.90%) was observed from V_1 (BARI Mung-4).

There was a significant influence in the harvest index due to SA and $CaSO_4$ (Table 3). The maximum harvest index 49.38% was found from T_3 and the minimum harvest index 46.93% from T_0, control condition.

Interaction of variety and SA with $CaSO_4$ had a significant influence on harvest index (Table 3). The highest harvest index 50.20% was obtained from V_2T_3 (BARI Mung-6 with Salicylic acid 0.5mMole + 5 mMole CaSO4), while the lowest 45.93 % from V_1T_3.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the research plot of the department of Agricultural Botany of Sher-e-Bangla Agricultural University, Dhaka during the period from February 2017 to June 2017 to effect of salicylic acid with $CaSO_4$ on morphophysiological attributes, growth and yield of Mungbean. In this experiment, the treatment consisted of two mungbean varieties viz. V_1 = BARI mung 4, V_2 = = BARI mung 6 and four different concentration of Salicylic acid (SA) and $CaSO_4$ viz. T_0=control, T_1=5 mMole $CaSO_4$, T_2=Salicylic acid 0.5 mMole, T_3=Salicylic acid 0.5mMole + 5 mMole $CaSO_4$. The experiment was laid out in a two factors randomized complete block design (RCBD) design having 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 plant height was varied due to the different varieties. The tallest plant height (56.91 cm) was obtained from V_2 (BARI mung 6). The number of leaves plant^{-1} was influenced by varieties.The BARI Mung-4 produced maximum number of leaves (11.52). Pod length is one of the most important yield contributing characters of mungbean. Varieties showed variation in pod length. The longest pod length (9.19 cm) was observed in V_2 (BARI Mung- 6). The number of pod plant^{-1}, number of seeds pod^{-1} and 1000-seed weight was varied with to the different varieties. The highest number of pod plant^{-1} (28.85), number of seeds pod^{-1} (12.80) and 1000-seed weight (68.77g) was recorded in V_2 (BARI Mung-6). The yield of mungbean was varied with different varieties. Yield is a function of various yield components such as number of pod plant^{-1}, seed pod^{-1} and 1000-grain weight. The highest seed yield (1.69 tha^{-1}) was recorded in V_2 (BARI Mung-6). In contrast, the lowest seed yield (1.42 tha^{-1}) was obtained from V_1 (BARI Mung-4). Varieties on stover yield in mungbean genotypes had a significant variation. Results revealed that the highest stover yield 1.83 t ha^{-1} was recorded from BARI Mung-6. Biological yield of mungbean was significantly influenced by variety. The maximum biological yield 3.52 t ha^{-1} was found in $V_{2,}$ BARI Mung-6. Harvest index was influenced by variety. The maximum harvest index (48.02%) was found in $V_{2,}$ BARI Mung-6.

Plant height was significantly influenced by salicylic acid and $CaSO_4$. The tallest plant (54.84 cm) was obtained from T_3 (Salicylic acid 0.5milimole + 5 mMole $CaSO_4$) treatment. There was a significant variation in the number of leaves plant^{-1} due to the difference concentration of salicylic acid with calcium sulphet. The maximum number of leaves plant^{-1} (12.67) was obtained from T_3 (Salicylic acid 0.5milimole + 5 mMole $CaSO_4$) treatment. Pod length of mungbean was significantly influenced by variation with the different concentration of salicylic acid with calcium sulphet. The longest pod length (8.56 cm) was recorded from T_3 treatment. There was significant variation in the number of pods plant^{-1}, number of seeds pod^{-1} and thousand seed weight (60.84g) due to the salicylic acid with $CaSO_4$. The maximum number of pods plant^{-1} (29.63), number of seeds pod^{-1} (13.00) and thousand seed weight (60.84g) was observed from T_3. There was significant variation in the seed yield hectare^{-1} due to the salicylic acid with $CaSO_4$. The maximum seed yield hectare^{-1} 1.75 ton was obtained from T_3, and the minimum (1.40 ton) was obtained in T_0, control condition. The experimental result varied with growth and yield of Mungbean by salicylic acid with $CaSO_4$ on stover yield (t ha^{-1}), biological yield of Mungbean. Results showed that the maximum stover yield (1.18 t/ha), biological yield (3.53 t ha^{-1}) and harvest index (49.38%) was recorded from T_3 (Salicylic acid 0.5milimole + 5 mMole $CaSO_4$).

Interaction effect of varieties and salicylic acid with $CaSO_4$ had a significant variation on all parameter. The tallest plant (60.40 cm) was obtained from V_2T_3 (BARI Mung-6 with Salicylic acid 0.5milimole + 5 mMole $CaSO_4$) treatment combination. The highest number of leaves plant^{-1} (14.33) was obtained from V_2T_3 (BARI Mung-6 with Salicylic acid 0.5milimole + 5 mMole $CaSO_4$) treatment. The highest pod length (9.52 cm) was obtained from V_2T_3 (BARI Mung-6 with Salicylic acid 0.5milimole + 5 mMole $CaSO_4$) treatment. The highest number of pods plant^{-1} (30.07) was obtained from V_2T_3 (BARI Mung-6 with Salicylic acid 0.5milimole + 5 mMole $CaSO_4$) treatment. The highest number of seeds pod^{-1} (13.53) was obtained from V_2T_3 (BARI Mung-6 with Salicylic acid 0.5milimole + 5 mMole $CaSO_4$). The highest thousand seed weight (73.17 g) was obtained from V_2T_3 (BARI Mung-6 with Salicylic acid 0.5milimole + 5 mMole $CaSO_4$) treatment. The highest seed yield ha^{-1} (1.93 ton) was obtained from V_2T_3 (BARI Mung-6 with Salicylic acid 0.5milimole + 5 mMole $CaSO_4$) treatment combination while the lowest (1.26 ton) from V_1T_0 (BARI Mung-4 with control) treatment combination. The highest stover yield 1.96 t/ha was recorded fromV_2T_3. The highest biological yield 3.85 t/ha was obtained from V_2T_3

From the above findings it can be concluded that most of the parameters gave the best performance which was achieved from V_2, BARI Mung-6. Again, application of salicylic acid 0.5milimole + 5 mMole $CaSO_4$ showed the best performance regarding most of the yield and yield contributing parameters. In case of combined effect, BARI Mung-6 and salicylic acid 0.5milimole + 5 mMole $CaSO_4$ gave the best result considering yield and yield contributing parameters. The highest seed yield 1.93 t ha^{-1} was obtained from BARI Mung-6 and Salicylic acid 0.5milimole + 5 mMole $CaSO_4$. So, this treatment combination can be treated as the best treatment combination under the present study. With the increasing demand of protein and to meet the challenge of 21st century mungbean are needed with higher yield.

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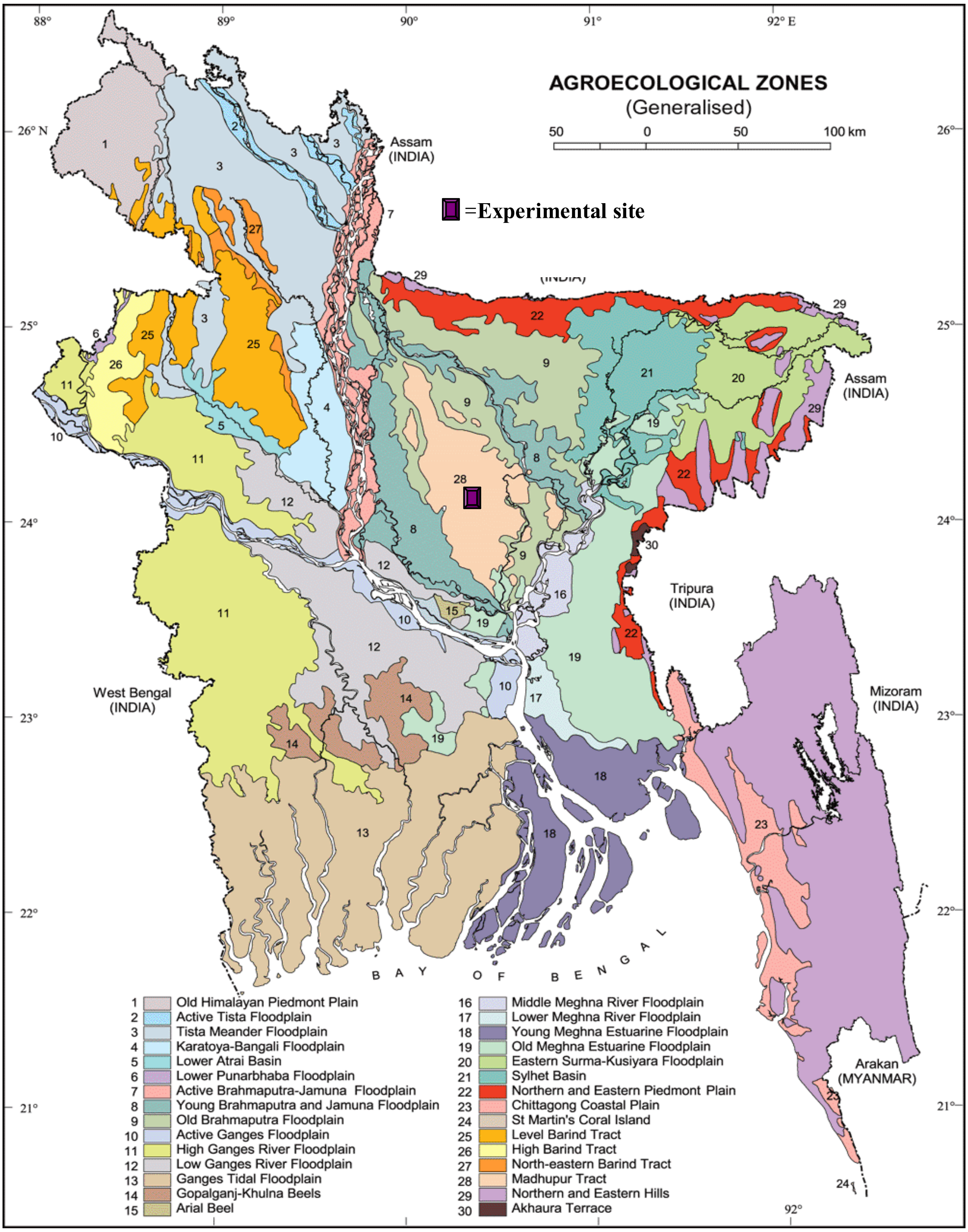
APPENDICES

Appendix I. Experimental location on the map of Agro-ecological Zones of Bangladesh



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

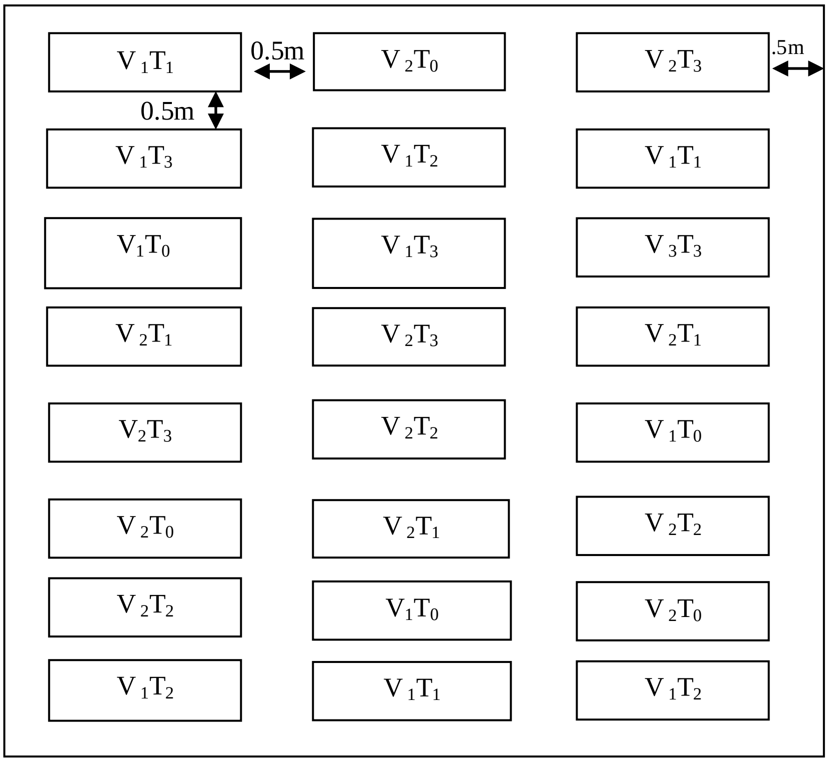
Constituents	Percent
Sand	26
Silt	45
Clay	29
Textural class	Silty clay

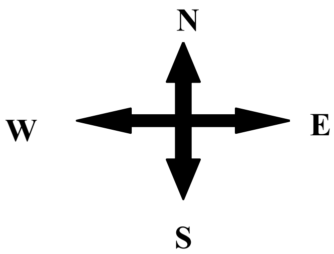
Chemical composition:

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

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

Appendix III. Layout and design of the experimental plot





Unit plot size:
2m x 3m

Factor-A: Varieties

V_1 = BARI Mung-4
V_2 = BARI Mung-6

Factor-B: Salicylic acid level and $CaSO_4$

T_0=control
T_1=5 mMole CaSO4
T_2=Salicylic acid 0.5 milimole
T_3=Salicylic acid 0.5milimole + 5 mMole CaSO4

Appendix IV: Analysis of variance of the data on plant height, number of leaf per plant, number of pod per plant of mungbean as influenced by varieties and salicylic acid level and $CaSO_4$

Source	Degrees of Freedom	Means square		
		Plant height (cm)	Number of leaf per plant	Number of pod per plant
Replication	2	125.33	4.432	11.812
Factor A	1	1117.4	16.667	47.602
Factor B	3	47.747*	5.144*	23.375*
AB	3	80.787*	11.698*	3.673*
Error	14	19.652	3.721	18.019

*significant at 5% level of probability

Appendix V: Analysis of variance of the data on pod length, number of seed per pod and Thousand seed weight of mungbean as influenced by varieties and salicylic acid level and $CaSO_4$

Source	Degrees of Freedom	Means square		
		Pod length (cm)	Number of seed per pod	Thousand seed weight (g)
Replication	2	0.143	2.445	28.757
Factor A	1	1.76	25.585	4025.6
Factor B	3	1.607*	1.349*	136.59*
AB	3	1.469*	0.158*	2.488*
Error	14	0.438	0.155	4.344

*significant at 5% level of probability

Appendix VI: Analysis of variance of the data on yield contributing characters and yield of mungbean as influenced by varieties and salicylic acid level and $CaSO_4$

Source	Degrees of Freedom	Means square			
		Seed yield (t/ha)	Stover yield (t/ha)	Biological yield (t/ha)	Harvest Index (%)
Replication	2	0.796	0.381	2.174	45.972
Factor A	1	0.446	0.54	1.967	0.082
Factor B	3	0.127*	0.09*	0.404*	6.663*
AB	3	0.011*	0.056*	0.1*	6.047*
Error	14	0.008	0.017	0.037	2.669

*significant at 5% level of probability