RESPONSE OF MUNGBEAN GENOTYPES TO GIBBERELLIC ACID IN RABI SEASON

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CERTIFICATE

*This is to certify that the thesis entitled **"RESPONSE OF MUNGBEAN GENOTYPES TO GIBBERELLIC ACID IN RABI SEASON"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS) in AGRONOMY**, embodies the result of a piece of authentic research work carried out by **Md. Abdul Gaffer,** Registration No. **1809257** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated: December, 2020
Dhaka, Bangladesh

Prof. Dr. Md. Shahidul Islam
Supervisor

It is a fact that the remembrance of Allah brings peace in the heart. It is better to ponder over the verses to bring us even closer to Allah (swt).

DEDICATED TO-
MY BELOVED PARENTS

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- ***Author***

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ABSTRACT

A field experiment was accomplished in the Agronomy farm of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2019 to February 2020 to study the response of mungbean genotypes to Gibberellic acid in Rabi season. The experiment was comprised of two factors; factor A: Four varieties (4) viz. V_1 = Sonamug, V_2= BARI mung-4, V_3= BARI mung-5 and V_4= BARI mung-6 and factor B: Three levels of GA_3 (3) viz. G_0 = 0 ppm GA_3 (control), G_1 = 40 ppm GA_3 and G_2 = 80 ppm GA_3. The experiment was laid out in split plot design with three replications assigning variety in the main plot and GA_3 in the sub plot. Data on different growth and yield attributes were taken in which all the treatment showed significant variations. In the case of varieties, maximum plant height (31.16 cm), number of leaves (15.45), leaf dry weight (2.14 g), stem dry weight (1.90 g), pod length (6.62 cm), pods plant^{-1} (35.44), seeds pod^{-1} (10.77) and 1000 seeds weight (41.06 g) were recorded from V_4 (BARI mung-6) treatment. In the case of GA_3, maximum plant height (31.16 cm), number of leaves (15.58), leaf dry weight (1.99 g), stem dry weight (1.60 g), pod length (6.63 cm), pods plant^{-1} (29.41), seeds pod^{-1} (10.44) and 1000 seeds weight (36.83 g) were recorded from G_1 (40 ppm GA_3) treatment. The maximum seed yield (1188.10 kg ha^{-1}) was recorded from V_4 (BARI mung-6) and on the other hand, the lowest seed yield (638.10 kg ha^{-1}) obtained from V_1. Significantly higher seed yield (917.10 kg ha^{-1}) was recorded from G_1 (40 ppm GA_3) while the lowest seed yield (842.68 kg ha^{-1}) from G_0 treatment. In the case of the combination effects of treatments, the maximum yield (1276.80 kg ha^{-1}) was recorded from V_4G_1 while that of the lowest was found (500.60 kg ha^{-1}) recorded from V_1G_0 treatment. Thus, it was apparent from the above results that V_4G_1 combination of treatments was found best in the terms of seed yield of mungbeen under study.

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ABBREVIATIONS

AEZ	Agro-ecological Zone
IAA	Indole Acetic Acid
Agric.	Agricultural
BINA	Bangladesh Institute of Nuclear Agriculture
ANOVA	Analysis of Variance
BARI	Bangladesh Agricultural Research Institute
TSP	Triple Super Phosphate
MoP	Muriate of Potash
Biol.	Biology
CV	Coefficient of variation
DAS	Days After Sowing
et al.	And others
Ex.	Experiment
GA_3	Gibberellic Acid
g	Gram
Hort.	Horticulture
i.e.	That is
J.	Journal
Kg	Kilogram
LSD	Least Significance Difference
mm	Millimeter
SPD	Spit Plot Design
Res.	Research
SAU	Sher-e-Bangla Agricultural University
Sci.	Science
spp.	Species
Technol.	Technology
UNDP	United Nations Development Programme
viz.	Namely
%	Percent
NAA	Naphtalic Acetic Acid
PGR	Plant Growth Rate
Agron	Agronomy
MSTAT	Michigan State University Statistical Package for Data Analysis
etc.	Etcetera
ha	Hectare
SRDI	Soil Resource and Development Institute
Agril.	Agriculture

CHAPTER I
INTRODUCTION

Pulses are the primary source of vegetable protein for the people, particularly for poor section of the third world and named as the poor men's meat as it is the common source of protein. In Bangladesh, per capita consumption of pulses is only14.72 g per day (BBS, 2019) as against 45.0 g recommended by World Health Organization. Pulses are the emergent protein source for the majority of the people of Bangladesh. It comprises protein about twice as much as cereals. It also comprises amino acid, lysine, which is generally deficit in food grains (Elias, 1986). Mungbean (*Vigna radiata* L.) is one of the most essential pulse crops of Bangladesh. The present nutritional status of developing countries like Bangladesh is a matter of leading concern since the most of the people are patient from malnutrition (Mahbub *et al.*,2015).

Mungbean is regarding as the best of all pulses from the nutritional viewpoint, which comprised of 51% carbohydrate, 26% protein, 4% minerals and 3% vitamins (Kaul, 1982 and Uddin *et al.,* 2009). The young plantsare used as pasture and the residues as compost. Among the pulses, it is in third position according to area and production but first in market price. Improving physical, chemical and biological properties of soil by fixing nitrogen from atmosphere through symbiosis scheme is another important character of mungbean. The climatic state of Bangladesh is favorable for winter farming of mungbean but it can cultivate in both Kharif I and Kharif II (Bose, 1982 and Miah *et al.,* 2009). Production of mungbean can be increased by cultivation of winter mungbean along with summer mungbean through low temperature stress management for mungbean (Uddin *et al.*, 2009).

Improving physical, chemical and biological properties of soil by fixing nitrogen from atmosphere through symbiosis procedure is another important character of mungbean. The climatic condition of Bangladesh is friendly for winter farming of local mungbean but it can be cultivated in both kharif-I and kharif-II (Bose, 1982 and Miah *et al.,* 2009).It is a short duration crop and less water requisite as compared to summer crops.

Moreover, it is drought resistant that can endure adverse environmental conditions, and hence successfully be grown in rain fed areas (Anjum *et al.,* 2006). Mungbean cultivation is gaining vogue day by day among the farmers. There has been a continuous retrenchment in the production of pulses in the last decades. Mungbean had been cultivated in both rabi and kharif seasons in the past but now high yielding varieties of mungbean has been cultivated only in kharif seasons due to sensitivity to rabi season for low temperature stress. Mungbean is a extensively cultivated legume crop having wide conformation to different environmental conditions. Mungbean plant is raised in temperate regions and can be grown in all seasons throughout the year in tropical countries, whereas this plant may face low temperature (LT) or chilling stress in the winter (Chen *et al.,* 2005). Low temperature (LT) or chilling temperature often adversely attack plant growth and productivity. Every year, plants covering a vast area of the world suffer from LT stress, which conducts to substantial crop losses and thus LT stress is considered as one of the major abiotic stresses (Sanghera *et al.,* 2001). Low temperature stress causes physiological and metabolic disorder leading to curtailed growth and vigor.

Obstacles in plant–water relationships, curtailed stomatal conductance, photosynthetic efficiency, changes in protein structure and enzyme activities are some of the most common and primary LT injury symptoms within plants (Yadav, 2010). High yielding varieties of mungbean face low temperature stress when cultivated in rabi season of which cultivate effects are curtailed internode elongation, leaf area reduction, cell division and finally reduction in growth rate of drastically reduction in yield.

Application of gibberellic acid (GA_3) to plants, results in a variety of responses. The elongation of internodes has been indicated to be a result of cell division (Sachs, 1965; Greulach and Haesloop, 1958), cell elongation (Kato-Emori *et al.,*2001). Treated plants irradiated a change in leaf shape or size and a retardation of root growth (Kato-Emori *et al.,* 2001). Haqqani and Pandey (1994) stated that mungbean enduring from different stresses resulted in decreased seed yield, pod number, number of seeds pod^{-1} and 1000seeds weight. Flowers attendant earlier in plants irrigated every 5days than plants watered every 10 days. Plants watered every 15 days, flowered later and produced fewer flowers than mungbean watered every 10 days (Sheteawi and Tawfik, 2007).

Gibberellic acid (GA_3) is a phytohormone that is needed in small quantities at low concentration to accelerate plant growth and development. So, favorable condition may be incited by applying growth regulator exogenously in proper concentration at a proper time in a specific crop by GA_3. Gibberellic acid is such a plant growth regulator, which can manipulate a variety of growth and development phenomena in various crops. GA_3 promotes growth activities to plant, stimulates stem elongation and increases dry weight and yield (Deotale, 1998 and Abdel *et al.,1*996).Therefore, GA_3 may have effects on the amelioration of low temperature stress in mungbean when cultivated in rabi season.

Objective (s):

i. To observe the performance of variety regarding growth and yield of mungbean in rabi season

ii. To find out the effect of GA_3 on growth and yield of mungbean in rabi season

iii. To find out the suitable combination of GA_3 and mungbean variety for cultivating in rabi season.

CHAPTER II
REVIEW OF LITERATURE

This chapter includes research findings of different researchers in home and abroad regarding the effect of growth regulators and different varieties on the growth and yield of mungbean. Since the work on the influence of plant growth regulators on mungbean is scanty, an attempt has therefore been made to review the work on mungbean and other crops. The information have been reviewed and cited under the following headings.

2.1 Effect of varieties on growth and yield of mungbean

Quaderi *et al.* (2006) carried out an experiment in the Field Laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh during the period from October 2000 to February 2001 to evaluate the influence of seed treatment with Indole Acetic Acid (IAA) at a concentration of 50 ppm 100 ppm and 200 ppm on the growth yield and yield contributing characters of two modern mungbean (*Vigna radiata* L.) varieties viz. BARI mung-4 and BARI mung-5. The two-factor experiment was laid out in Randomized Complete Block Design (RCBD) (factorial) with 3 replications. Among the mungbean varieties BARI mung-5 performed better than that of BARI mung-4.

To study the nature of association between *Rhizohinin phascoli* and mungbean an experiment was conducted by Muhammad *et al.* (2006). 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. A control treatment was also included for comparison. 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 genotypes NCM-209 and

NM-98 compared with NM-92 and Chakwalmung-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 NCM209 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 (*Brady rhizobium*) and plant growth regulators (GA_3 and IAA) of) 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.

Mungbean cultivars Pusa 105 and Pusa Vishal were sown at 22.5 and 30 cm spacing and supplied with 36-46 and 58-46 kg NP/ha in a field experiment conducted in Delhi, India during the kharif season of 2000 by Tickoo *et al.* (2006). Cultivar PusaVishal recorded higher biological and grain yield (3.66 and 1.63 t/ha, respectively) compared to cv. Pusa 105.

To evaluate the effects of crop densities (10. 13. 20 and 40 plants/m^2) on yield and yield components of two cultivars (Partow and Gohar) and a line of mungbean (VC-1973A), a field experiment was conducted by Aghaalikhani *et al.* (2006) at the Seed and Plant Improvement Institute of Karaj, Iran, in the summer of 1998. The results indicated that VC-1973A had the highest grain yield. This line was superior to the other cultivars due to its early and uniform seed maturity and easy mechanized harvest.

Rahman *et al.* (2005) conducted an experiment with mungbean in Jamalpur, Bangladesh, from February to June 1999, involving two planting methods, i.e.

line sowing and broadcasting, five mungbean cultivars, namely Local, BARI mung-2; BARI mung-3; BINA moog-2 and BINA moog-5 and five sowing dates. Significantly the highest dry matter production ability was found in four modern 12 mungbean cultivars, and dry matter partitioning was found highest in seeds of BINA moog-2 and lowest in Local. However, the local cultivar produced the highest portion of dry matter in leaf and stern.

Studies were conducted by Bhati *et al.* (2005) from 2000 to 2003 to evaluate the effects of cultivars and nutrient management strategies of the productivity of different Kharif legumes (mungbean, mothbean and clusterbean) in the region of Rajasthan, India. The experiment with munghean showed that K-851 gave better yield than Asha and the local cultivar. In another experiment mungbean cv. PDM-54 showed 56.9% higher grain yield and 13.7% higher fodder yield than the local cultivar. The experiment with mothbean showed that RN40-40 gave 34.8- 35.2% higher grain yield and 30.2-33.4% higher fodder yield over the local cultivar as well as 11.8% higher grain yield and 9.2% higher fodder yield over RMO-257. The experiment with clusterbean showed that improved cultivars of RGC-936 gave 136.0 and 73.5% higher grain yield and 124.0 and 67.3% higher fodder yield over the local cultivar and Maru Guar, respectively.

A field experiment was conducted by Raj and Tripathi (2005) in Jodhpur, Rajasthan, India during the kharif seasons, to evaluate the effects of cultivar (K851 and MG-62) as well as nitrogen (0 and 20 kg ha^{-1}) and phosphorus levels (0, 20 and 40 kg ha^{-1}) on the productivity of mungbean. 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 six recommended cultivars (KPSI, KPS2, CN60, CN36, CN72 and PSUI) and five elite lines (C. F. F. G. II) under Kasetsart mungbean breeding project in Lopburi Province, Thailand, during the dry (February-May 2002), early rainy (June-September 2002) and late rainy season (October 2002-January 2003). Line C. KPSI, CN60, CN36 and CN72 gave high yields in the early rainy season, while line H, line G, line E, KPS1 and line C gave high yields in the late rainy session. Yield trial of the 6 recommended mungbean cultivars was also conducted in the farmer's field.

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). Data were recorded on days to first flowering, days to first leaf senescence, days to pod maturity, flower + pod abscission, root, stem+leaf, pod husk and seed dry matter content, pods plant^{-1}, seeds pod^{-1}, 100- seed weight, seed yield, biological yield and harvest index. 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.

An experiment was conducted by Abid *et al.* (2004) in Peshawar, Pakistan, during the 2002 summer season to study the effect of sowing dates on the agronomic traits and yield of mungbean cultivars NM-92 and M-I. Data were recorded for days to emergence. Emergence m^{-2}, days to 50% flowering, days to physiological maturity, plant height at maturity and grain yield. Sowing on 15 April took more number of days to emergence but showed maximum plant height. The highest emergence/rn2and higher mean grain yield was recorded in NM-92 than M-l.

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). Pusa 9531 showed higher yield components and grain yield than Pusa 105 and Pant mung.

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 moog-2 and BU moog-1. Among the cultivars, BARI mung-4 performed the best in all aspects showing the highest seed yield of 1135 kg/ha. Rhizobium strain TAL 169 did better than TAL44I in most of the studied parameters. It was concluded that BAR1 mung 4 in combination with TAL169 performed the best in terms of nodulation plant growth, seed and stover yields, and seed protein content.

The performance of 20 mungbean cultivars were evaluated by Madriz-Isturiz and Luciani-Marcano (2004) in a field experiment conducted in Venezuela. Data on plant height, clusters per plant, pods per plant, pod length, seeds per pod, grain yield by plant and yield/ha were recorded. Significant differences in the values of the parameters measured due to cultivar were recorded. The average yield was 1342.58 kg/ha, VC 1973C, Creole VC 1973A, VC 2768A, VC 1178B and Mililiter 267 were the most promising cultivars for cultivation in the area.

The effect of sowing rates on the growth and yield of mungbean cultivars NM-92, NARC mung-1 and NM-98 was investigated in Faisalabad, Pakistan during 2002-03 by Riaz e*t al.* (2004). NM-98 produced the maximum pod number of 17.30, grain yield of 983.75 kg/ha and harvest index value of 24.91%. NM-92 also produced the highest seed protein content of 24.64%.

Seed treatment with biofertilizers in controlling root and root rot of mungbean cultivars BINA moog-3 and BINA moog-4 was investigated by Mohammad and Hossain (2003) under field conditions in Pakistan. Treatment of seeds of BINA moog-3 with biofertilizer showed a 5.67% increase in germination over the control, but in case of BINA moog-4 10.81% increase in germination over the control was achieved by treating seeds with biofertilizer. The biofertilizers caused 77. 79% reduction of foot and fool rot disease incidence over the control along with BINA moog-3 and 76.78% reduction of foot rot disease in BINA moog-4. Seed treatment with biofertilizer also produced up to 20.83% higher seed yield in BINA moog-3 and 12.79% higher seed yield BINA moog-4 over the control.

Three munghean cultivars (LGG 407, LGG 450 and LOG 460) and two bean [black gram] cultivars (LBG 20 and LBG 623) were sown on June 2001 in Lain, Guntur, Andhra Pradesh, India by Durga *et al.*(2003) and subjected to severe moisture stress during the first 38 days after sowing (DAS) and only a rainfall of 21.4 mm was received during this period. Mungbean registered higher root length (11.83%), root volume (37.50), root weight (31.43%), lateral roots (81.71%), shoot length (13.04%), shoot weight (84.62%), leaf number (25.75%), leaf weight (122.86%) and leaf area (108.60%) than the urd bean. Mungbean recorded better leaf characters than urd bean, but root and shoot characters were better in the latter. Among the mungbean cultivars LOG 407 recorded the highest yield. Between the urd bean cultivars, LBG 20 had a higher yield than LBG 623. Among the mungbean cultivars, LGG 407 was the most tolerant, while in urd bean LBG 20 was more efficient in avoiding early drought stress than LBG 623.

Taj *et al.* (2003) carried out an experiment to find out the effects of seed rates (10, 20, 30 and 40 kg seed/ha) on the performance of five mungbean cultivars (NM92, NM 19-19, NM 121-125, N/41 and a local cultivar) were studied in

Ahmadwala, Pakistan during the summer season of 1998. Among the cultivars, NM 121-125 recorded the highest average pods per plant (18.18), grains per pod (9.79), 1000-grain weight (28.09 g) and grain yield (1446.07 kg ha^{-1}).

Satish *et al.* (2003) conducted an experiment in Haryana, India in 1999 and 2000 to investigate the response of mungbean cultivars Asha, MH 97-2, MH 85-111 and K 851 to different P levels. Results revealed that the highest dry matter content in the leaves, stems and pods was obtained in Asha and MI 97-2. The total above-ground dry matter as well as the dry matter accumulation in leaves, stems and pods increased with increasing P level up to 60 kg P ha^{-1}. MH 97-2 and Asha produced significantly more number of pods and branches/plant compared to MH 85-111 and K 851.

The development phases and seed yield were evaluated by Infante *et al.* (2003) in mungbcan 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 pod 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.

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.

Hamed (1998) carried out two field experiments in Shalakan, Egypt to evaluate mungbean cultivars Giza I and Kawny I 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/feddan (N_2) and inoculation with R only ±5 (N_3) or 10 kg N/feddan (N_4) Kawny I surpassed Giza I in pod number per plant (24.3) and seed yield (0.970 t/feddan), while Giza 1 was superior in 100-seed weight (7.02 g), biological and straw yields (5.53 and 4.61 t./feddan. respectively). While Kawny I surpassed Giza I in oil yield (35.78 kg/feddan), the latter cultivar recorded higher values of protein percentage and yield (28.22°A and 264.6 kg/feddan). 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.

2.2 Effect of growth regulators

Khan (2017) conducted a field experiment at the research field of Sher-e-Bangla Agricultural University, Dhaka during the period from October 2017 to January 2018 to study the effect of growth regulators on growth and yield of mungbean under different late sowing conditions in Kharif-II season. The experiment was comprised of two factors; factor A: growth regulators (6) viz. G_0 = distilled water, G_1 = 20 ppm BAP (*Benzylaminopurine*), G_2 = 40 ppm BAP, G_3 = 20 ppm GA_3 (Gibberellic acid), G_4= 40 ppm GA_3, G5 = 60 ppm GA_3 and factor B: sowing date (2) viz. S_1 = sowing on 31^{st} October, 2017, S_2 = sowing on 14^{th} November, 2017. The experiment was laid out in randomized complete block design (RCBD) in factorial arrangements with three replications. Results revealed that in case of growth, plant height (38.35 cm), and dry weight (9.57g) $plant^{-1}$ were significantly higher in G_5 (60 ppm GA_3) treatment. In terms of yield and yield attributes, number of pods $plant^{-1}$ (6.56), number of seeds pod^{-1} (5.52), weight of 1000-seed (35.07 g), seed yield (0.26 t ha^{-1}), and harvest index (37.75 %) were higher in G_5 (60 ppm GA_3) treatment. Results from interaction effect between different levels of growth regulators and different sowing conditions revealed that the highest plant height (39.43 cm), number of pods plant^{-1} (8.80), number of seeds pod^{-1} (7.22), weight of 1000-seed (38.74 g), seed yield (0.45 t ha^{-1}) were observed in S_1G_5 (Sowing on 31st October with 60 ppm Gibberellic acid) interaction.

Das and Prasad (2003) conducted a study on sandy clay loam soil in New Delhi, India, during summer 1999. The treatments comprised of three summer mungbean cultivars and two levels of NAA (20 and 40 ppm). NAA sprayed at 30 days after sowing and at flowering stages. Both the concentrations of NAA significantly increased the total dry matter production, number of leaves, number of flowers and number of pods per plant, pod length, number of seeds per pod, 1000-grain weight and grain yield of summer mungbean.

Mahla*et al.* (1999) reported that spraying 20 ppm NAA on blackgram had greater effect in increasing the number of branches.

Arora *et al.* (1998) reported that NAA applied at 50% flowering stage to chickpea increased the number of flowers as compared with the untreated ones. Flowering and fruiting were also reported to be increased by foliar spraying with NAA on groundnut (Manikandan and Hakim, 1999).

Lakshmamma and Rao(1996a) conducted a field experiment during the rabi season at Rajendranagar, Andhra Pradesh. Blackgram was sprayed with 0, 5, 10 or 20 ppm NAA at 50% flowering stage. They found that application of NAA increased plant height of blackgram.

Lakshmamma and Rao(1996b) conducted a field experiment at Rajendranagar in Andhra Pradesh during Rabi season. They found that blackgram when sprayed with 20 ppm of NAA at 50% flowering stage decreased flower drop and increased seed yield.

Chaplot *et al.* (1992) reported that increases in seed yield of mungbean due to NAA application by 5.7-21%.

Kelaiya *et al.* (1991) conducted an experiment with four growth regulators, such as CCC (chlormequat), NAA, and triacontanol and sprayed at 25, 50 and 75 days after sowing (DAS) on groundnut. In that experiment, they observed that NAA was found to be most effective one in increasing the plant height. They also reported that groundnuts when sprayed with 40 ppm of NAA at 25 and 50 DAS increased plant dry weight.

Lee (1990) found that soaking of groundnut seeds in solutions of 0, 50, and 100 ppm of GA_3 before sowing produced plants with greater number of flowers than those of the control.

Kandagal *et al.* (1990) observed that a foliar application of 50 ppm of NAA at flowering stage of mungbean gave seed yields of 0.66 t ha^{-1} compared with 0.55 t ha^{-1} with the untreated control.

Jaiswal and Bhambil (1989) conducted a field experiment to determine the effect of growth regulators on mungbean. It was observed that GA_3 and NAA resulted in the reduction of yield and yield components.

Rahman *et al.* (1989) in a pot experiment on grasspea showed that foliar application of 50 mililiter of GA_3 increased seed yield.

Sharma *et al.* (1989) reported from the result of a field trial with foliar applications of NAA at anthesis and 10 days later on mungbean. It was found that the NAA treated plants gave higher seed yield of 795 - 849 kg ha^{-1}

compared with 611-694 kg ha^{-1} of without NAA. Results revealed that the NAA application increased the number of pods per plant, number of seeds per pod and 1000-seed weight.

Gurpreet*et al.* (1988) mentioned that grain yield was increased from 0.71 t ha^{-1} to 0.78 t ha^{-1} with applications of NAA in mungbean. Kalita and Shah (1989) reported that applying a foliar spray at the rate of 50 ppm of NAA mungbean increased seed yield from 0.64 to 0.88 t ha^{-1}.

Bai *et al.* (1987) investigated the effect of growth regulators (NAA and GA_3) on the yield performance of mungbean. They found that 25 ppm of NAA and 50 ppm of GA_3 increased the yield of mungbean when compared with control.

Venkaten *et al.* (1984) pointed out that both in rabi and in kharif seasons application of NAA at various concentrations sprayed at 30 and 50 days after sowing increased the number of pods per plant and 1000-seed weight in groundnut.

Subbian and Chamy (1984) carried out a field trial in summer with 2 foliar applications of 0, 20 or 40 ppm NAA to greengram. They found increased number of flowers and pods per plant with increasing NAA rate. They also reported that seed yield was increased from 0.8 to 1.2 t ha^{-1} with increasing NAA concentrations.

Reddy and Shah (1984) reported that application of planofix (NAA) at the rate of 50 ppm significantly produced the higher number of leaves in groundnut.

Subbian and Chamy (1982) mentioned that two foliar sprays of 40ppm planofix (NAA) when applied to summer mungbean at the flower initiation stage and 15 days later significantly increased the seed yield.

Singh *et al.* (1982) conducted an experiment on groundnut to determine the effect of NAA. They observed that two foliar spray of 100 ppm planofix (NAA) to groundnut at 40 and 50 days after sowing increased the number of leaves per plant.

A foliar application of 40 ppm NAA on groundnut increased the number of pods per plant and eventually the pod yield (Gupta and Singh, 1982).

Studies have showed that external application of planofix (NAA) reduced the premature abscissions of flowers, young pods and thus increased the number of pods and consequently the yield of groundnut (Mani and Raja, 1976).

Cytokinins have been shown to enhance pod set when applied directly to individual racemes in soybean and mungbean. However, the application of BAP increased both, total seed weight and pod number (Patil *et al.*, 2005).

Previously it was reported that there is a continual effect of gibberellic acid (GA_3) on *Catharanthus roseus* L. plant phenotype. Earlier studies have reported that GA_3 application (at 50, 100 and 500 gm) as foliar spray on transplanted cutting of *Catharanthus roseus* L. increased plant height. Gibberellins (GA_3) increased shoot 12 length by increasing their rate of elongation in majority of the plants (Shil *et al.*, 2007). Therefore, GA_3 and its use can be able to overcome to the adverse effects of stress imposed at variable extents.

Gibberellic acid (GA_3) delays senescence, improves growth and development of chloroplasts, and intensifies photosynthetic efficiency which could lead to increase yield (Yuan and Xu, 2001).

Gibberellic acid (GA_3) plays a significant role in seed germination, endosperm mobilisation, stem elongation, leaf expansion, reducing the maturation time and increasing flower and fruit set and their composition (Roy and Nasiruddin, 2011).

Gibberellic acid (GA_3) is an important PGR that affects plant growth and development by inducing metabolic activities and regulating nitrogen utilization (Sure *et al.*, 2012).

Also, application of another plant growth bio-regulator has increased the salt tolerance of many crop plants (Haroun *et al.*, 1991). GA_3 has also been shown alleviate the effects of salt stress on water use efficiency (Aldesuquy and Ibrahim, 2001).

Gibberellic acid (GA_3) is known to be importantly concerned in the regulation of plant responses to external environment (Chakrabarti and Mukherji, 2003).

CHAPTER III
MATERIALS AND METHODS

This chapter presents a brief description about experimental period, site description, climatic condition, crop or planting materials, treatments, experimental design and layout, crop growing procedure, fertilizer application, uprooting of seedlings, intercultural operations, data collection and statistical analysis.

3.1 Location

The experiment was conducted at the experimental shed of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka ($90^{0}77'$ E longitude and $23^{0}77'$ N latitude) during the period from 9^{th} November 2019 to 12^{th}February 2020. The location of the experimental site has been shown in Appendix I.

3.2 Soil

The soil of the experimental area belonged to the Modhupur tract (AEZ -28). It was a medium high land with non-calcarious dark grey soil. The pH value of the soil was 5.6. The physical and chemical properties of the experimental soil have been shown in Appendix II.

3.3 Climate

The experimental area was under the subtropical climate and was characterized by high temperature, high humidity and heavy precipitation with occasional gusty winds during the period from November to February, but scanty rainfall associated with moderately low temperature prevailed during the period from November to February. The detailed meteorological data in respect of air temperature, relative humidity, rainfall and sunshine 14 hour recorded by the meteorology center, Dhaka for the period of experimentation have been presented in Appendix III.

3.4 Materials

3.4.1 Plant materials

Four mungbean varieties, Sonamug, BARI mung-4, BARI mung-5 and BARI mung-6 were used in the experiment. The features of four varieties are presented below:

BARI mung-4: BARI mung variety is grown in Kharif season. It is a line crossed variety of mungbean released by BARI in 1996.Plant height 50-55 cm, seed color green, seed smooth, 1000-seed weight 28-32 g, day neutral, for this reason it is cultivated in Kharif-I and Kharif-II. It is more suitable for southern part of Bangladesh, cooking time 15-20 min. crop duration 60-65 days, This, variety is cultivated throughout the Bangladesh. The cultivar gives an average yield of 1.2-1.4 t/ha.

BARI mung-5: BARI mung-5 variety is grown in Kharif season. It is a line crossed variety of mungbean released by BARI in 1997. Seed colour is green. The cultivar matures at 50- 60 days of sowing. It attains a plant height 40-45 cm. The cultivar gives an average yield of 1.8 t/ha.

BARI mung-6: Plant height 40-45 cm, photo insensitive and can be grown in Kharif-I, Kharif-II and late Rabi. After flowering stage, plant growth become stunted, leaf and seed color deep green and leaf broad, seed large shaped with smooth seed coat, pods matured at a same stage. Grain large, 1000-seed weight 51-52 g, after wheat harvest sowing up to April first week, It is sowing also Kharif-II and late rabi season, crop duration 60-70 days. The cultivar gives an average yield of 2.0 t/ha.

3.5 Treatments under investigation

There were two factors in the experiment as mentioned below:

Factor A: Varieties (4)

V_1 = Sonamug

V_2 = BARI mung-4

V_3 = BARI mung-5

V_4 = BARI mung-6

Factor B: Levels of GA_3 (3)

G_0= 0 ppm GA_3 (control)

G_1= 40 ppm GA_3

G_2= 80 ppm GA_3

3.5.1 Treatment combinations

There are 12 treatment combinations of different mungbean varieties and different levels of GA_3 used in the experiment under as follows: V_1G_0, V_1G_1, V_1G_2, V_2G_0, V_2G_1, V_2G_2, V_3G_0, V_3G_1, V_3G_2, V_4G_0, V_4G_1 and V_4G_2

3.6 Experimental design and layout

The experiment was laid out in a split-plot design having three replications. Each replication had 4 main plots and each main plot consisting 3 sub-plots. Varieties were assigned randomly in the main plots and GA_3 in the sub-plots. The unit sub-plot size was $3m^2$ (1.5m ×2m). The replication plots and unit plots were separated by 1m and 0.75m spacing, respectively.

3.7 Crop management

3.7.1 Seed collection

Seeds of mungbean varieties were collected from Pulse Seed Section, BARI, Joydebpur, Gazipur, Bangladesh.

3.7.2 Seed sowing

The seeds of mungbean varieties having more than 80% germination were sown by hand in 30 cm apart lines continuously at about 3 cm depth at the rate of 12 g plot^{-1} on 21 November, 2019.

3.7.3 Collection and preparation of initial soil sample

The soil sample of the experimental field was collected before fertilizer application. The initial soil samples were collected before land preparation from 0-15 cm soil depth. The samples were collected by an auger from different location covering the whole experimental plot and mixed thoroughly to make a composite sample. After collection of soil samples, the plant roots, leaves etc. were removed. Then the samples were air-dried and sieved through a 10-mesh sieve and stored in a clean plastic container for physical and chemical analyses.

3.7.4 Preparation of experimental land

A pre sowing irrigation was given on 12 November, 2019. The land was open with the help of a tractor drawn disc harrow on 19 November, 2019, then ploughed with rotary plough twice followed by laddering to achieve a medium tilth required for the crop under consideration. All weeds and other plant residues of previous crop were removed from the field. Immediately after final land preparation, the field layout was made on November 21, 2019 according to experimental specification. Individual plots were cleaned and finally prepared the plot.

3.7.5 Fertilizer application

The specific plots were fertilized @ 45, 100, 60 and 1 kg ha^{-1} of Urea, TSP, M_OP, BA and 10 t ha^{-1} cowdung, respectively. The entire quantity of triple super phosphate (TSP), muriate of potash (M_OP), boric acid (BA) and cowdung along with half of urea were applied as basal dose at final land preparation. The rest urea was applied by spit application at 25 days after sowing.

3.7.6 Intercultural operations

3.7.6.1 Thinning

The plots were thinned out on 15 days after sowing to maintain a uniform plant stand.

3.7.6.2 Weeding

The crop was infested with some weeds during the early stage of crop establishment. Two hand weeding were done, first weeding was done at 15 days after sowing followed by second weeding at 15 days after first weeding.

3.7.6.3 Application of irrigation water

Irrigation water was added to each plot, first irrigation was done pre-sowing and other two were given 2-3 days before weeding.

3.7.6.4 Drainage

There was a heavy rainfall during the later stage of the crop growth (February to March, 2020). Drainage channel were properly prepared to easy and quick drained out of excess water.

3.7.6.5 Plant protection measures

The crops were infested by insects and diseases. The fungicide Bavistin 0.2% @25g/18L water was sprayed at 17 and 36 days after sowing and insecticide Ripcord 10 EC @50 ml/20L water was sprayed at 20 and 47 days after sowing to control insect.

3.8 Harvesting and post-harvest operation

Maturity of crop was determined when 80-90% of the pods became blackish in color. The harvesting of mungbean varieties were done up to 01March, 2020. Five pre-selected plants per plot from which different yield attributing data were collected and $3m^2$ areas from middle portion of each plot was separately harvested and bundled, properly tagged and then brought to the threshing floor for recording seed and straw yield. The seeds were cleaned and sun dried to a moisture content of 12%. Straw was also sun dried properly. Finally seed and straw yields plot^{-1} were determined and converted to kg ha^{-1}.

3.9 Recording of data

Emergence of plants were counted from starting to a constant number of plants m^{-2} area of each plot. Experimental data were determined from 15 days of growth duration and continued until harvest. Dry weights of plant were collected by harvesting respective number of plants at different specific dates from the inner rows leaving border rows and harvest area for seed. The following data were recorded during the experimentation.

A. Crop growth characters

i. Plant height (cm) at 15 days interval
ii. Leaves plant^{-1}(Number) at 15 days interval
iii. Leaf dry weight (g) at 15 days interval
iv. Stem dry weight plant^{-1}(g) at 15 days interval
v. Days to flowering (%)
vi. Days to maturity (%)

B. Yield and other crop characters

i. Number of pods plant^{-1}
ii. Length of pod (cm)
iii. Number of seeds pod^{-1}
iv. Weight of 1000 seeds (g)
v. Seed yield plant^{-1}(g)
vi. Stover yield plant^{-1} (g)
vii. Seed yield m^{-2}(g)
viii. Stover yield m^{-2} (g)
ix. Seed yield (kg ha^{-1})
x. Stover yield (kg ha^{-1})

xi. Biological yield (kg ha^{-1})

xii. Harvest index (%)

3.10 Detailed procedures of recording data

A brief outline of the data recording procedure followed during the study given below:

A. Crop growth characters

3.10.1 Plant height (cm)

Plant height of 5 selected plants from each plot was measured at15, 30, 45, 60 days after sowing (DAS) and at harvest. The height of the plant was determined by measuring the distance from the soil surface to the tip of the leaf of main shoot.

3.10.2 Number of leaves $plant^{-1}$

Leaves $plant^{-1}$ of 5 selected plants from each plot was measured at15, 30, 45, 60 days after sowing (DAS) and at harvest. The number of leaves $plant^{-1}$ was determined and averaged together.

3.10.3 Leaf dry weight $plant^{-1}$ (g)

Leaf dry weight $plant^{-1}$was recorded by weighing the total axillary leaves of an individual plant and was expressed in gram (g).

3.10.4 Stem dry weight $plant^{-1}$(g)

Stem dry weight $plant^{-1}$was recorded by weighing the total stems of an individual plant and was expressed in gram (g).

3.10.5 Days to flowering

Each plant of the experimental plot was kept under close observation from pod set to count days required for flowering. Total number of days from the date of sowing to the flower initiation was recorded for 1st and 2nd flask of flowering.

3.10.6 Days to maturity

Each plant of the experimental plot was kept under close observation from pod set to count days required for maturity of pods for 1st and 2nd flask. Total number of days from the date of sowing to respective pod maturity was recorded.

B. Yield and other crop characters

3.10.7 Pods plant^{-1}(no.)

Pods of ten selected plants were counted and the average pods for each plant was determined.

3.10.8 Pod length (cm)

The ten pods were selected to measure the pod length and then averaged together.

3.10.9 Seeds pod^{-1}(no.)

Pods from each of ten selected plants plot^{-1} were separated from which ten pods were selected randomly. The number of seeds pod^{-1} was counted and average number of seeds pod^{-1} was determined.

3.10.10 Weight of 1000-seed (g)

One thousand cleaned dried seeds were counted randomly from each sample and weighed by using a digital electric balance at the stage the seed retained 12% moisture and the mean weight were expressed in gram.

3.10.11 Seed yield plant^{-1} (g)

Seed yield plant^{-1}was determined from the ten randomly pre-selected plants of each plot and expressed as gplant^{-1} and adjusted with 12% moisture basis. Moisture content was measured by using a digital moisture tester.

3.10.12 Stover yield plant^{-1} (g)

The stover collected from plant pre-selected ten plants of each pot at harvest was sun dried properly. The weight of stover was taken and converted the stover yield in g plant^{-1}.

3.10.13 Seed yield m^{-2} (g)

Seed yield was determined from the central 1 m^2 area of each plot and expressed as g m^{-2} and adjusted with 12% moisture basis. Moisture content was measured by using a digital moisture tester.

3.10.14 Stover yield m^{-2} (g)

The stover collected from plant of central 1 m^2 of each plot was sun dried properly. The weight of stover was taken and converted the stover yield in g m^{-2}.

3.10.15 Seed yield (kg ha^{-1})

Seed yield was determined from the central1 m^2 area of each plot and expressed as kg ha^{-1} and adjusted with 12% moisture basis. Moisture content was measured by using a digital moisture tester. Pods were collected thrice to determine seed yield after 1st, 2nd and 3rd maturity.

3.10.16 Stover yield (kg ha^{-1})

The stover collected from plant of central part of each plot was 1 m^2 at harvest sun dried properly. The weight of stover was taken and converted the stover yield in kg ha^{-1}.

3.10.17 Biological yield (kg ha^{-1})

The summation of seed yield and above ground stover yield is called the biological yield. Biological yield was calculated following the formula:

Biological yield =Seed yield + Stover yield.

3.10.18 Harvest index

Harvest index denotes the ratio of economic yield (seed yield) to biological yield and was calculated with following formula (Gardner *et al.*, 1985).

$$\text{Harvest index (\%)} = \times \frac{\text{Seed yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}} \quad 100$$

3.4.11 Statistical analysis

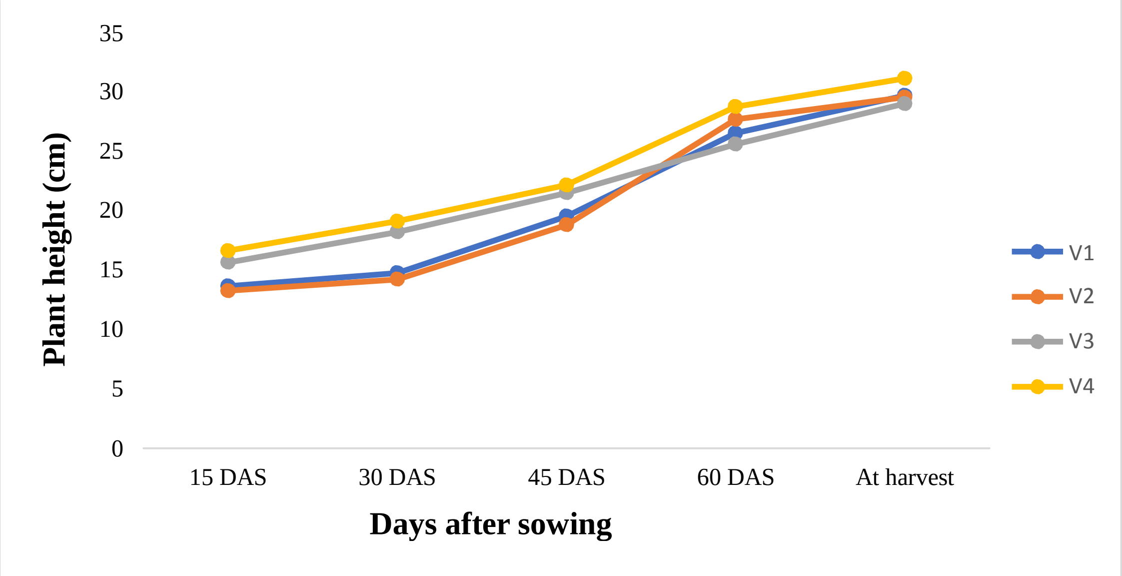
The data obtained for different parameters were statistically analyzed to find out the significant differences on yield and yield contributing characters of mungbean under the treatments designed. The mean values of all the characters were calculated and the analysis of variance (ANOVA) was performed by the 'F'(variance ratio) test. The significance of the difference among the treatment means was estimated by the Least Significant Difference (LSD) test at 5% level of probability.

CHAPTER IV
RESULT AND DISCUSSION

This chapter comprises the presentation and discussion of the results obtained from the experiment. The experiment was conducted to response of mungbean genotypes to gibberellic acid in Rabi season. The growth and yield components such as plant height, number of leaves plant^{-1}, leaf dry weight plant^{-1}, stem dry weight plant^{-1}, days to flowering, days to maturity, pod length (cm), pods plant^{-1}, seeds pod^{-1}, 1000-seed wt.(g), seed yield plant^{-1}(g) stover yield plant^{-1}(g), seed yield m^{-2} (g), stover yield m^{-2} (g),seed yield (kg ha^{-1}), stover yield (kg ha^{-1}), biological yield (kg ha^{-1}) and harvest index (%) of mungbean as influenced by gibberellic acid are presented in different table and figures. The analysis of variance of data in respect of all the parameters has been shown in Appendix IV-XI. The results of each parameter have been adequately discussed and possible interpretations whenever necessary have been given under the following headings:

4.1 Plant height (cm)

Plant height was significantly influenced by performance of varieties at different days after sowing (DAS) (Figure 1 and Appendix IV). The tallest (16.64 cm) plant was recorded from V_4 (BARI mung-6) variety, which was followed by (15.66 cm) V_3 and the shortest (13.28 cm) plant was recorded from V_2 at 15 DAS. The tallest (19.13 cm) plant was recorded from V_4 (BARI mung-6) variety which was followed by (18.22 cm) varietyV_3 and the shortest (14.23 cm) plant was recorded from V_2 at 30 DAS. AT 45 DAS, The tallest (22.17 cm) plant was recorded from V_4 (BARI mung-6) variety which was followed by (21.52 cm) variety V_3 and the shortest (18.82 cm) plant was recorded from V_2 at 45 DAS. The tallest (28.77 cm) plant was recorded from V_4 (BARI mung-6) variety which was followed by (27.71 cm) variety V_2 and the shortest (25.62 cm) plant was recorded from V_3 at 60 DAS. The tallest (31.16 cm) plant was recorded from V_4 (BARI mung-6) variety which was followed by (29.72 cm) variety V_1 and the shortest (29.03 cm) plant was recorded from V_3 at harvest.

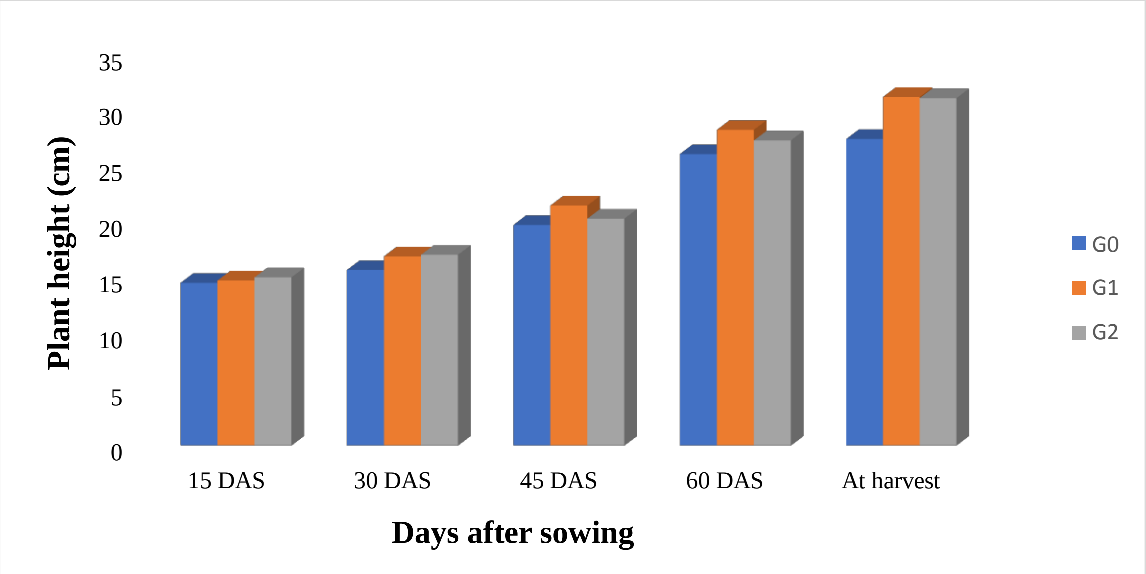


V_1=Sonamug, V_2=BARI mung-4, V_3=BARI mung-5 and V_4=BARI mung-6

Figure 1: Effect of variety on plant height of mungbean at different days after sowing (LSD $_{0.05}$ =0.81, 1.34, 2.00, 2.67 and 1.23 at 15, 30, 45, 60 DAS and harvest, respectively).

The application of different levels of GA_3 markedly influenced the height of plants (Figure 2 and Appendix IV). An increasing trend in plant height was observed due to increase of GA_3 levels. The maximum plant height (15.07 cm) was recorded from the treatment G_2 (80 ppm GA_3)which was followed by (14.79 cm) G_1 treatment and minimum plant height (14.58 cm) was recorded from the control G_0 treatment at 15 DAS. The plant height increased with the progress of time. The maximum plant height (17.08 cm) was recorded from the treatment G_2 (80 ppm GA_3) which was followed by G_1 treatment (16.95 cm) and minimum plant height (15.73 cm) was recorded from the control G_0 treatment at 30 DAS. The maximum plant height (21.48 cm) was recorded from the treatment G_1(40 ppm GA_3) which was followed by (20.31 cm) G_2 treatment and minimum plant height (19.75 cm) was recorded from the control G_0 treatment at 45 DAS. The maximum plant height (28.23 cm) was recorded from the treatment G_1 (40 ppm GA_3) which was followed by G_2 treatment

(27.28 cm) and minimum plant height (26.07 cm) was recorded from the control G_0 treatment at 60 DAS. The maximum plant height (31.16 cm) was recorded from the treatment G_1 (40 ppm GA_3) which was followed by G_2 treatment (31.05 cm) and minimum plant height (27.41 cm) was recorded from the control G_0 treatment plants at harvest.



G_0= 0 ppm GA_3, G_1=40 ppm GA_3 and G_2= 80 ppm GA_3

Figure 2: Effect of GA_3 on plant height of mungbean at different days after sowing (LSD $_{0.05}$ =0.71, 0.89, 0.99, 0.96 and 0.89 at 15, 30, 45, 60 DAS and harvest, respectively).

The plant height was significantly influenced by the interaction effect of varieties and GA_3 at 15, 30, 45, 60 DAS and at harvest (Table 1 and Appendix IV). At 15 DAS, the highest plant height (16.93 cm) was measured from V_4G_2 (BARI mung-6 with 80 ppm GA_3), which was statistically similar with V_4G_0 (16.60 cm) and V_4G_1 (16.40 cm), respectively and the lowest plant height (12.70 cm) was recorded from V_2G_0 (BARI mung-4 and 0 ppm GA_3), which was statistically similar with V_2G_1 (13.16 cm). At 30 DAS, the highest plant height (19.96cm) was measured from V_4G_2 (BARI mung-6 with 80 ppm GA_3), which was statistically similar with V_4G_1 (19.04 cm) and V_3G_2 (18.74 cm). On the other hand, the lowest plant height (13.32 cm) was observed from V_2G_0 (BARI mung-4 and 0 ppm GA_3), which was statistically similar with V_1G_0

(13.60 cm). At 45 DAS, the highest plant height (23.52 cm) was measured from V_4G_2 (BARI mung-6 with 40 ppm GA_3) treatment combination which was statistically similar with V_3G_2 (22.32 cm) and V_4G_2 (21.78 cm). On the other hand, the lowest plant height (17.48 cm) was observed from V_2G_0 (BARI mung-4 and 0 ppm GA_3), which was statistically similar with V_1G_2 (18.06 cm). At 60 DAS, the highest plant height (31.44 cm) was measured from V_4G_2 (BARI mung-6 with 40 ppm GA_3) treatment combination which was statistically similar with V_3G_2 (29.72 cm). On the other hand, the lowest plant height (22.07 cm) was observed from V_2G_0 (BARI mung-2 and 0 ppm GA_3), which was statistically similar with V_1G_2 (18.06 cm). At harvest, the highest plant height (34.71 cm) was measured from V_4G_2 (BARI mung-6 with 40 ppm GA_3), which was statistically similar with V_4G_1 (33.52 cm) and V_1G_1 (32.55 cm). On the other hand, the lowest plant height (25.70 cm) was observed from V_2G_0 (BARI mung-4 and 0 ppm GA_3) treatment combination which was statistically similar with V_3G_1 (26.43 cm).

Table 1. Interaction effect of variety and gibberellic acid on plant height of mungbean at different days after sowing and at harvest

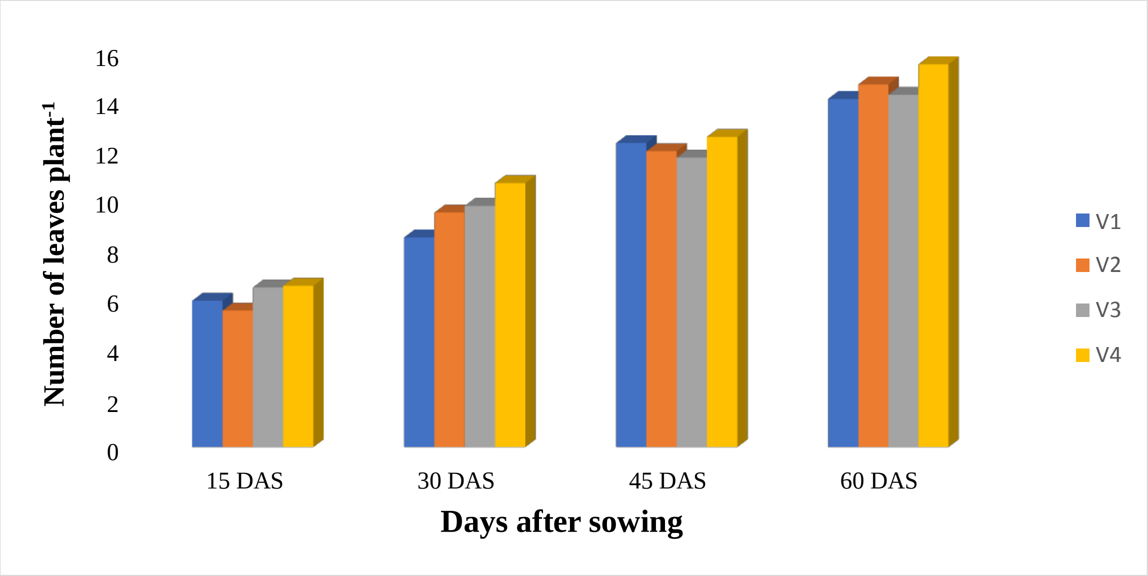
Interaction	Plant height (cm)				
	15 DAS	**30 DAS**	**45 DAS**	**60 DAS**	**At harvest**
V_1G_0	13.72 a-d	13.60 e	19.63 c-f	26.40 a-c	28.90 b-d
V_1G_1	13.86 a-d	15.65 b-e	20.92 b-d	27.94 a-c	32.55 a
V_1G_2	13.43 b-d	15.05 c-e	18.06ef	25.32bc	27.70 cd
V_2G_0	12.70 d	13.32 e	17.48 f	22.07 d	25.90 d
V_2G_1	13.16 cd	14.82 c-e	19.92 b-e	28.56 a-c	31.57 ab
V_2G_2	13.99 a-d	14.54 de	19.07 def	29.72 ab	31.25 a-c
V_3G_0	15.33 a-d	17.63 a-d	20.68 b-d	23.78 c	27.13 d
V_3G_1	15.73 a-d	18.28 a-c	21.57 a-d	24.96bc	26.43 d
V_3G_2	15.93 a-d	18.74 ab	22.32 ab	28.13 a-c	33.52 a
V_4G_0	16.60 ab	18.39 a-c	21.20 b-d	25.79bc	27.69 cd
V_4G_1	16.40 a-c	19.04 ab	23.52 a	31.44 a	34.07 a
V_4G_2	16.93 a	19.96 a	21.78 a-c	25.95bc	27.71 ab
LSD $_{(0.05)}$	**3.42**	**3.33**	**1.99**	**4.46**	**2.65**
CV $_{(\%)}$	**13.35**	**11.63**	**5.63**	**9.50**	**13.34**

V_1=Sonamug, V_2=BARI mung-4, V_3=BARI mung-5, V_4=BARI mung-6

G_0= 0 ppm GA_3, G_1=40 ppm GA_3 and G_2= 80 ppm GA_3

4.2 Number of leaves plant^{-1}

The effect of different varieties on number of leaves plant^{-1} of mungbean was observed at 15, 30, 45 and 60 DAS. Among these, statistically significant variation was recorded at 30, 45 and 60 DAS (Appendix V and Figure 3). At 30 DAS, the highest number of leaves (10.67) was produced from V_4 (BARI mung-6). On the other hand, the lowest number of leaves (8.48) was observed in V_1. At 45 DAS, the highest number of leaves (12.53) was produced from V_4 (BARI mung-6). On the other hand, the lowest number of leaves (11.69) was observed in V_3. At 60 DAS, the highest number of leaves (15.45) was produced from V_4 (BARI mung-6). On the other hand, the lowest number of leaves (14.06) was observed in V_1. Number of leaves plant^{-1} recorded for other sampling date (15 DAS) showed non-significant difference due to varietal performance.

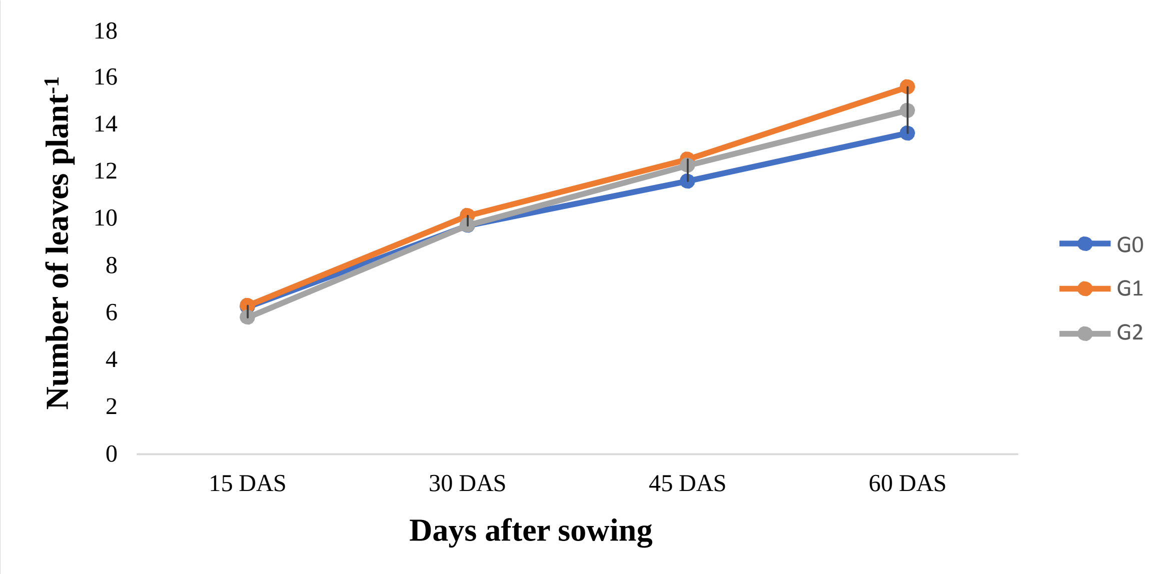


V_1=Sonamug, V_2=BARI mung-4, V_3=BARI mung-5, V_4=BARI mung-6

Figure 3: Effect of variety on number of leaves plant^{-1} of mungbean at different days after sowing (LSD $_{0.05}$ =NS, 0.48, 0.04 and 0.67 at 15, 30, 45, and 60 DAS, respectively).

GA_3 had a significant influence on number of leaves plant^{-1} of mungbean at 30, 45, and 60 DAS. At 30 DAS, G_1 produced the maximum number of leaves plant^{-1} (10.12) whereas $G_0$0 ppm produced the minimum number of leaves plant^{-1}(9.70). At 45 DAS, G_1 produced the maximum number of leaves plant^{-1}

(12.51) whereas G_0 ppm produced the minimum number of leaves plant^{-1} (11.58). At 60 DAS, the maximum number of leaves plant^{-1}(15.58) was recorded from G_1 and the minimum number of leaves plant^{-1}(13.62) was measured in G_0. Number of leaves plant^{-1} recorded for other sampling date (15 DAS) showed non-significant difference due to varietal performance (Figure 4 and appendix V). It was observed that number of leaves per plant increased gradually with the increase of GA_3 doses.



G_0= 0 ppm GA_3, G_1=40 ppm GA_3 and G_2= 80 ppm GA_3

Figure 4: Effect of GA_3 on number of leaves plant^{-1} of mungbean at different days after sowing (LSD $_{0.05}$ =NS, 0.07, 0.91 and 0.93 at 15, 30, 45, and 60 DAS, respectively).

The number of leaves plant^{-1} of mungbean was significantly influenced by the interaction effect of varieties and GA_3 at 30, 45 and 60 DAS (Table 2 and Appendix V). At 30 DAS, the maximum number of leaves plant^{-1}(11.53) was measured from V_4G_1 which was statistically similar to that of V_4G_0 while the minimum number of leaves plant^{-1}(8.67) was recorded from V_2G_0. At 45 DAS, the maximum number of leaves plant^{-1}(13.26) was recorded from V_4G_1 which was statistically similar to that of V_2G_1 and V_2G_2 while the minimum number of leaves plant^{-1}(9.80) was recorded from V_2G_0. At 60 DAS, the maximum number of leaves plant^{-1}(16.26) was measured from V_4G_1 while the minimum number of leaves plant^{-1}(12.73) was recorded from V_1G_0. Number of leaves plant^{-1} recorded for other sampling date (15 DAS) showed non-significant difference due to varietal performance.

Table 2. Interaction effect of variety and gibberellic acid on number of leaves plant^{-1} of mungbean at different days after sowing

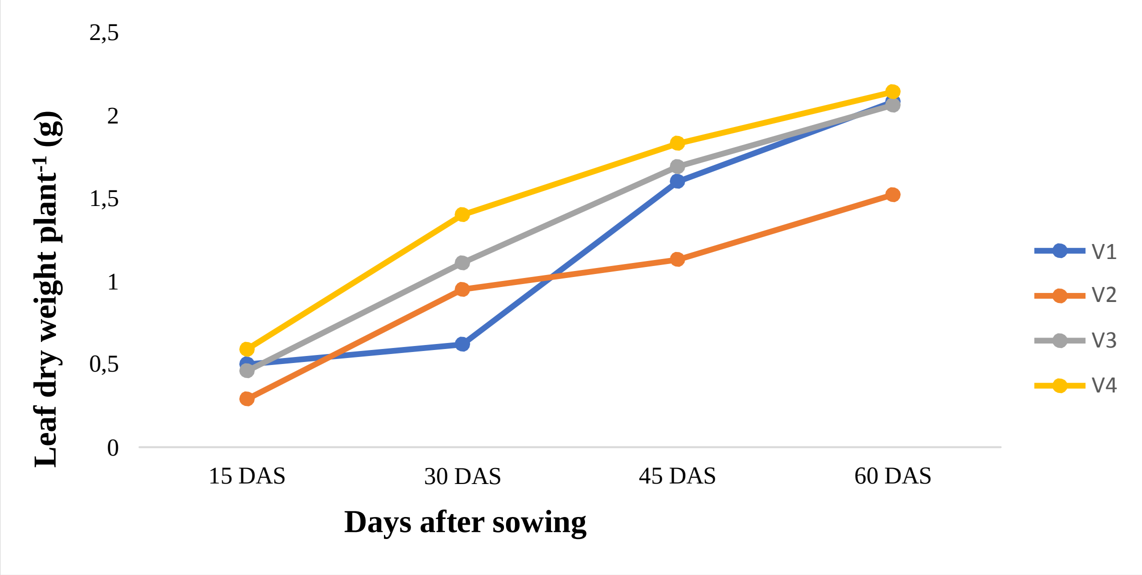
Interaction	Number of leaves plant^{-1}			
	15 DAS	**30 DAS**	**45 DAS**	**60 DAS**
V_1G_0	6.00	9.80 b-d	12.46 ab	15.28 ab
V_1G_1	6.20	9.73 b-d	11.80 ab	16.00 a
V_1G_2	5.60	8.93 cd	12.60 ab	15.06 a-c
V_2G_0	5.80	8.67 d	9.80 b	12.73 d
V_2G_1	5.60	9.46 b-d	13.06 a	15.40 ab
V_2G_2	5.20	10.33 ab	13.00 a	15.80 ab
V_3G_0	6.80	9.93bc	11.46 ab	13.46 b-d
V_3G_1	6.60	9.80 b-d	11.93 ab	14.66 a-d
V_3G_2	6.00	9.53 b-d	11.66 ab	14.53 a-d
V_4G_0	6.40	10.40 ab	12.60 ab	13.00 cd
V_4G_1	6.80	11.53 a	13.26 a	16.26 a
V_4G_2	6.40	10.06bc	11.73 ab	12.93 cd
LSD (0.05)	**1.03**	**1.15**	**1.82**	**1.87**
CV (%)	**9.74**	**6.80**	**8.70**	**7.43**

V_1=Sonamug, V_2=BARI mung-4, V_3=BARI mung-5, V_4=BARI mung-6

G_0= 0 ppm GA_3, G_1=40 ppm GA_3 and G_2= 80 ppm GA_3

4.3 Leaf dry weight

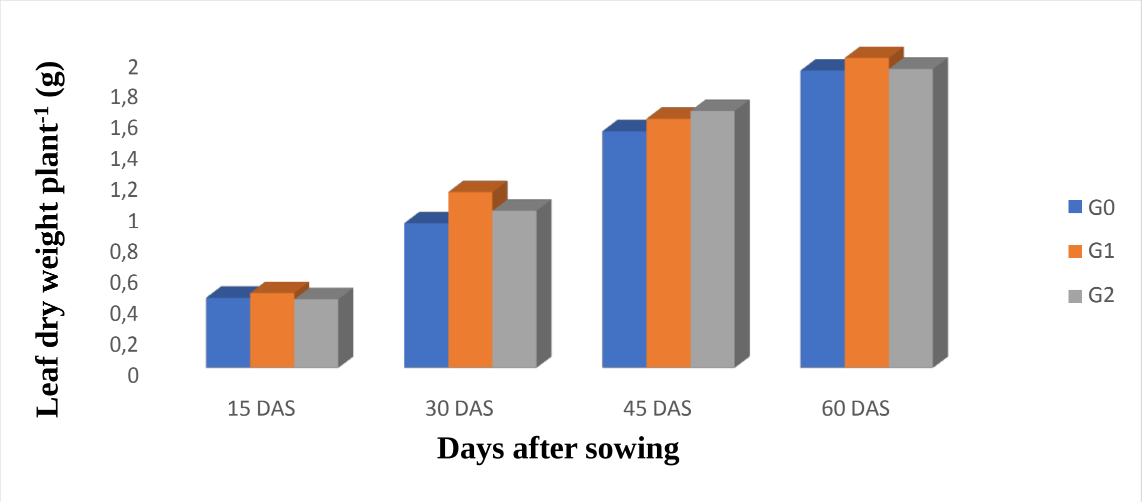
Different varieties of mungbean on leaf dry weight per plant varied significantly at 30, 45 and 60 DAS (Figure 5 and Appendix VI). At 30 DAS, the highest leaf dry weight per plant (1.40 g) was recorded from V_4(BARI mung-6) which was statistically similar (1.11 g) with that of V_3 (BARI mug-5), while the lowest leaf dry weight per plant (0.62 g) was recorded from V_1 (Sonamug). At 45 DAS, the highest leaf dry weight per plant (1.83 g) was recorded from V_4 (BARI mung-6); which was statistically similar (1.69 g) and (1.60 g) with V_3 and V_1 and the lowest leaf dry weight per plant (1.13 g) was recorded from V_2. At 60 DAS, the highest leaf dry weight per plant (2.14 g) was recorded from V_4 (BARI mung-6) which was statistically identical (2.08 g) to that of V_1, which was closely followed (2.06 g) by that of V_3 while the lowest leaf dry weight per plant (1.52 g) was recorded from V_2.



V_1=Sonamug, V_2=BARI mung-4, V_3=BARI mung-5, V_4=BARI mung-6

Figure 5: Effect of variety on leaf dry weight plant^{-1} of mungbean at different days after sowing (LSD $_{0.05}$ =NS, 0.35, 0.36 and 0.26 at 15, 30, 45, and 60 DAS, respectively).

Leaf dry weight at 30, 45 and 60 DAS varied significantly when GA_3 was applied (Figure 6 and Appendix VI). Among the different levels, G_1 (40 ppm GA_3) treatment showed the highest leaf dry weight (1.13, 1.65 and 1.99 g at 30and 60 DAS, respectively) but at 45 DAS, the highest leaf dry weight (1.65 g) was found in G_2 treatment (80 ppm GA_3). On the contrary, the lowest leaf dry weight (0.93, 1.52 and 1.91 g at 30, 45 and 60 DAS, respectively) was observed with G_0 where no growth regulators were applied. This result is supported with the findings of Foysal (2014) who stated that leaf dry weight varied significantly with different levels of plant growth regulators, the maximum leaf dry weight was produced from40 ppm (GA_3) treatment while, the minimum was found from 0 ppm (GA_3)treatment.



G_0= 0 ppm GA_3, G_1=40 ppm GA_3 and G_2= 80 ppm GA_3

Figure 6: Effect of GA_3 on leaf dry weight plant^{-1} of mungbean at different days after sowing (LSD $_{0.05}$ =NS, 0.14, 0.05 and 0.06 at 15, 30, 45, and 60 DAS, respectively).

Interaction effect of varieties and GA_3 showed statistically significant effect leaf dry weight per plant at 30, 45 and 60 DAS (Table 3 and Appendix VI).At 30 DAS, the highest leaf dry weight per plant (1.70 g) was recorded from V_4G_1 (BARI mung-6 with 40 ppm GA_3) and the lowest leaf dry weight per plant (0.49 g) was recorded from V_1G_0 (Sonamug with 0 GA_3). At 45 DAS, the highest leaf dry weight per plant (2.10 g) was recorded from V_4G_1 and the lowest leaf dry weight per plant (1.07 g) was recorded from V_2G_0. at 30 DAS. At 60 DAS, the highest leaf dry weight per plant (2.32 g) was recorded from V_4G_1 and the lowest leaf dry weight per plant (1.46 g) was recorded from V_2G_0 (Table 4).

Table 3. Interaction effect of variety and gibberellic acid on leaf dry weight plant^{-1} of mungbean at different days after sowing

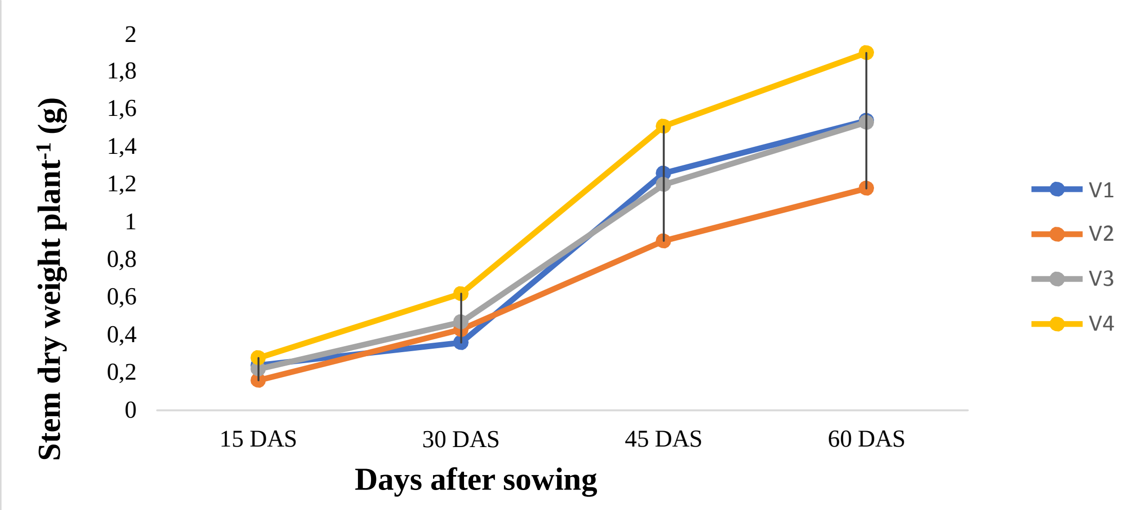
Interaction	Leaf dry wt. (g plant^{-1})			
	15 DAS	**30 DAS**	**45 DAS**	**60 DAS**
V_1G_0	0.49	0.49 e	1.59 b	2.25 ab
V_1G_1	0.50	0.67 de	1.59 b	2.05 ab
V_1G_2	0.51	0.71 c-e	1.63 b	2.10 ab
V_2G_0	0.30	0.99 b-d	1.07 c	1.46 d
V_2G_1	0.30	1.01 b-d	1.16 c	1.52 d
V_2G_2	0.28	0.92 b-d	1.15 c	1.57 cd
V_3G_0	0.44	1.08 b-d	1.76 ab	2.03bc
V_3G_1	0.49	1.15 b	1.56 b	2.08 ab
V_3G_2	0.46	1.11bc	1.74 ab	2.03 ab
V_4G_0	0.59	1.24 b	1.66 b	2.08 ab
V_4G_1	0.65	1.70 a	2.10 a	2.32 a
V_4G_2	0.53	1.26 b	1.72 b	2.03 ab
LSD $_{(0.05)}$	**0.13**	**0.28**	**0.21**	**0.33**
CV $_{(\%)}$	**16.81**	**16.15**	**7.68**	**9.89**

V_1=Sonamug, V_2=BARI mung-4, V_3=BARI mung-5, V_4=BARI mung-6
G_0= 0 ppm GA_3, G_1=40 ppm GA_3 and G_2= 80 ppm GA_3

4.4 Stem dry weight

Different varieties of mungbean on stem dry weight per plant varied significantly at 15, 30, 45 and 60 DAS (Figure 7 and Appendix VII). At 15 DAS, the highest stem dry weight per plant (0.28 g) was recorded from V_4 (BARI mung-6) which was statistically similar (0.24 g) with that of V_1 (Sonamug), while the lowest stem dry weight per plant (0.16 g) was recorded from V_2 (BARI mug-4). At 30 DAS, the highest stem dry weight per plant (0.62 g) was recorded from V_4 (BARI mung-6) which was statistically similar (0.47 g) with that of V_3 (BARI mung-5), while the lowest stem dry weight per plant (0.36 g) was recorded from V_1 (Sonamug). At 45 DAS, the highest stem dry weight per plant (1.51 g) was recorded from V_4 (BARI mung-6); which was statistically similar (1.26 g) and (1.20 g) with V_1 and V_3 and the lowest stem dry weight per plant (0.90 g) was recorded from V_2. At 60 DAS, the highest stem dry weight per plant (1.90 g) was recorded from V_4 (BARI mung-6) which was statistically identical (1.53 g) to that of V_1, which was closely followed (1.53 g) by that of V_3 while the lowest stem dry weight per plant

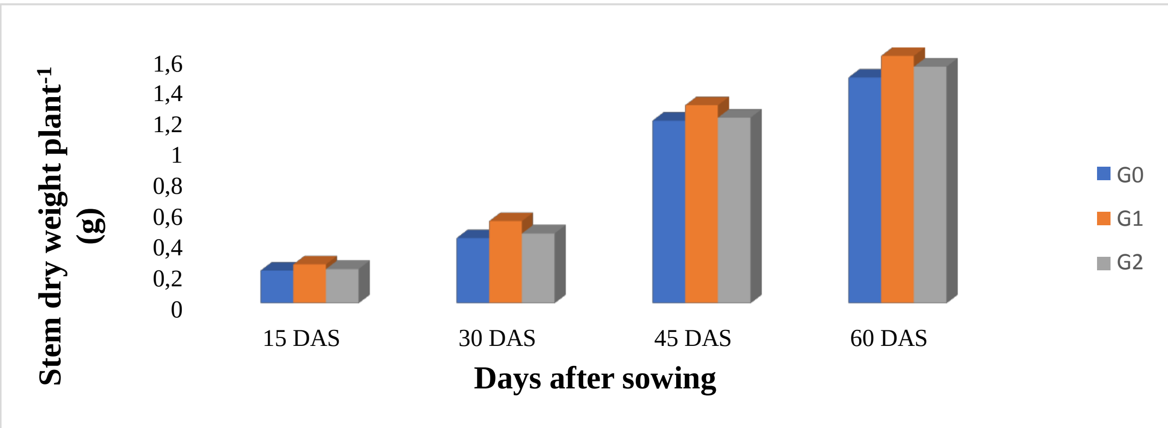
(1.18 g) was recorded from V_2.



V_1=Sonamug, V_2=BARI mung-4, V_3=BARI mung-5, V_4=BARI mung-6

Figure 7: Effect of variety on stem dry weight plant^{-1} of mungbean at different days after sowing (LSD $_{0.05}$ = 0.05, 0.09, 0.17 and 0.21 at 15, 30, 45, and 60 DAS, respectively).

Stem dry weight at 15, 30, 45 and 60 DAS varied significantly when GA_3 was applied (Figure 8 and Appendix VII). Among the different levels, G_1 (40 ppm GA_3) treatment showed the highest stem dry weight (0.25, 0.53, 1.28 and 1.60 g at 15, 30, 45 and 60 DAS, respectively). On the contrary, the lowest stem dry weight (0.21, 0.42, 1.18 and 1.46 g at 15, 30, 45 and 60 DAS, respectively) was observed with G_0 where no growth regulators were applied.



G_0= 0 ppm GA_3, G_1=40 ppm GA_3 and G_2= 80 ppm GA_3

Figure 8: Effect of GA_3 on stem dry weight plant^{-1} of mungbean at different days after sowing (LSD $_{0.05}$ = 0.03, 0.04, 0.05 and 0.05 at 15, 30, 45 and 60 DAS, respectively).

Interaction effect of varieties and GA_3 showed statistically significant effect stem dry weight per plant at 15, 30, 45 and 60 DAS (Table 4 and Appendix VII). At 15 DAS, the highest stem dry weight per plant (0.32 g) was recorded from V_4G_1 (BARI mung-6 with 40 ppm GA_3) and the lowest stem dry weight per plant (0.15 g) was recorded from V_2G_0 (BARI mung-4 with 0 GA_3). At 30 DAS, the highest stem dry weight per plant (0.75 g) was recorded from V_4G_1 (BARI mung-6 with 40 ppm GA_3) and the lowest stem dry weight per plant (0.31 g) was recorded from V_2G_0 (BARI mung-4 with 0 GA_3). At 45 DAS, the highest stem dry weight per plant (1.68 g) was recorded from V_4G_1 and the lowest stem dry weight per plant (0.84 g) was recorded from V_2G_0. At 60 DAS, the highest stem dry weight per plant (2.11 g) was recorded from V_4G_1 and the lowest stem dry weight per plant (1.08 g) was recorded from V_2G_0.

Table 4. Interaction effect of variety and gibberellic acid on stem dry weight $plant^{-1}$ of mungbean at different days after sowing

Interaction	Stem dry wt. (g $plant^{-1}$)			
	15 DAS	**30 DAS**	**45 DAS**	**60 DAS**
V_1G_0	0.23 b-d	0.35fg	1.20 b-d	1.47 c-e
V_1G_1	0.26 a-c	0.34fg	1.31bc	1.51 c-e
V_1G_2	0.24bc	0.38 e-g	1.27bc	1.60bc
V_2G_0	0.15 e	0.31 g	0.84 f	1.08 f
V_2G_1	0.16 e	0.55 bc	0.88ef	1.27 d-f
V_2G_2	0.17 de	0.45 def	0.98 def	1.19ef
V_3G_0	0.21 b-e	0.46 c-f	1.25 bc	1.53 b-d
V_3G_1	0.24bc	0.48 b-e	1.24 b-d	1.50 c-e
V_3G_2	0.20 c-e	0.47 b-e	1.11 c-e	1.57 b-d
V_4G_0	0.27 ab	0.58 b	1.44 ab	1.78bc
V_4G_1	0.32 a	0.75 a	1.68 a	2.11 a
V_4G_2	0.27 a-c	0.51 b-d	1.41 b	1.83 ab
LSD $_{(0.05)}$	**0.06**	**0.08**	**0.24**	**0.28**
CV $_{(\%)}$	**15.34**	**10.63**	**11.77**	**10.85**

V_1=Sonamug, V_2=BARI mung-4, V_3=BARI mung-5, V_4=BARI mung-6
G_0= 0 ppm GA_3, G_1=40 ppm GA_3 and G_2= 80 ppm GA_3

Table 5. Effect of variety and gibberellic acid on days to flowering and maturity of mungbean

Varieties	Days to flowering	Days to maturity
V_1	43.00 ab	53.11 b
V_2	41.77 bc	52.33 b
V_3	40.00 c	50.11 c
V_4	43.77 a	54.77 a
LSD $_{(0.05)}$	**1.56**	**1.58**
CV $_{(\%)}$	**15.21**	**17.61**
Levels of GA_3		
G_0	41.58 b	50.91 b
G_1	42.25 b	53.00 a
G_2	43.25 a	53.83 a
LSD $_{(0.05)}$	**0.79**	**1.55**
CV $_{(\%)}$	**9.15**	**10.41**

V_1=Sonamug, V_2=BARI mung-4, V_3=BARI mung-5, V_4=BARI mung-6
G_0= 0 ppm GA_3, G_1=40 ppm GA_3 and G_2= 80 ppm GA_3

4.5 Days to flowering

Different varieties of mungbean showed significant effect on days to flowering of mungbean (Table 5 and Appendix VIII). The maximum day to flowering (43.77) was recorded from V_4 (BARI mung-6).While, the minimum days to flowering (40.00) was observed in V_3.

Significant variation was found for different levels of GA_3 on days to flowering of mungbean (Table 5 and Appendix VIII). The maximum days to flowering (43.25) was found from G_2 whereas the minimum days to flowering (41.58) from G_0.

Varieties and GA_3 showed significant differences on days to flowering of mungbean due to their combined effect (Table 6 and Appendix VIII). The maximum days to flowering (47.33) was attained from V_4G_1 treatment combination and the minimum days to flowering (38.67) was found from V_2G_0 treatment combination.

Table 6. Interaction effect of variety and gibberellic acid on days flowering and maturity of mungbean

Interaction	Days to flowering	Days to maturity
V_1G_0	44.33 b	54.00 b
V_1G_1	42.00 cd	52.00 b-d
V_1G_2	42.67 c	53.33cd
V_2G_0	38.67 e	46.33 f
V_2G_1	40.00 de	52.00 b-d
V_2G_2	46.66 a	58.67 a
V_3G_0	41.33 cd	51.00 c-e
V_3G_1	39.67 e	49.00ef
V_3G_2	41.67 cd	50.33 de
V_4G_0	42.00 cd	52.00 b-d
V_4G_1	47.33 a	59.00 a
V_4G_2	42.00 cd	53.00 b-d
LSD $_{(0.05)}$	**1.58**	**3.10**
CV $_{(\%)}$	**9.15**	**10.41**

V_1=Sonamug, V_2=BARI mung-4, V_3=BARI mung-5, V_4=BARI mung-6
G_0= 0 ppm GA_3, G_1=40 ppm GA_3 and G_2= 80 ppm GA_3

4.6 Days to maturity

Days to maturity varied significantly among 15e varieties (Table 5 and Appendix VIII). The maximum days tomaturity (54.77) was recorded from V_4 (BARI mung-6). In comparison, the minimum daysto maturity (50.11) was observed in V_3.

Significant variation was found for different levels of GA_3 on days to maturity of mungbean (Table 5 and Appendix VIII). The maximum days to maturity (53.83) was found from G_2 whereas the minimum days to maturity (50.91) from G_0.

Varieties and GA_3 showed significant differences on days to maturity of mungbean due to their combined effect (Table 6 and Appendix VIII).The maximum days to maturity (59.00) was attained from V_4G_1 treatment combination and the minimum days to maturity (46.33) was found from V_2G_0 treatment combination.

4.7 Pod length

Statistically significant variation was recorded for pod length among mungbean varieties (Table 7 and Appendix IX). The longer pod (6.62 cm) was found from V_4 and the shorter pod (5.65 cm) from V_1.

Different levels of GA_3 varied significantly for pod length under the present trial (Table 7 and Appendix IX). The longest pod (6.63 cm) was attained from G_1 which was statistically identical (5.68 cm) with G_2, while the shotest pod (5.93 cm) was observed from G_0.

Pod length showed significant differences due to the interaction effect of mungbean varieties and levels of GA_3 (Table 8 and Appendix IX). The longest pod (7.76 cm) was recorded from V_4G_1, which was statistically identical (6.52 cm) with V_3G_1, whereas the shortest pod (4.91 cm) from V_1G_0, which was statistically identical (5.33 cm) with V_2G_0.

Table 7. Effect of variety and gibberellic acid on pod length, pods plant^{-1}, seeds pod^{-1} and 1000-seed weight of mungbean

Variety	Pod length (cm)	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	1000-seed wt.(g)
V_1	5.65 b	23.00 c	9.66 b	28.38 c
V_2	5.76 b	23.55 c	9.74 b	34.67 b
V_3	6.29 ab	31.22 b	9.75 b	39.38 a
V_4	6.62 a	35.44 a	10.77 a	41.06 a
LSD $_{(0.05)}$	**0.65**	**1.48**	**0.87**	**2.37**
CV $_{(\%)}$	**9.27**	**11.55**	**9.96**	**15.73**
Levels of GA_3				
G_0	5.68 b	27.33 b	9.26 b	33.25 b
G_1	6.63 a	29.41 a	10.44 a	36.83 a
G_2	5.93 b	28.16 b	10.25 a	36.16 a
LSD $_{(0.05)}$	**0.43**	**1.17**	**0.66**	**0.93**
CV $_{(\%)}$	**8.24**	**9.78**	**7.71**	**11.64**

V_1=Sonamug, V_2=BARI mung-4, V_3=BARI mung-5, V_4=BARI mung-6

G_0= 0 ppm GA_3, G_1=40 ppm GA_3 and G_2= 80 ppm GA_3

4.8 Number of pods plant^{-1}

Number of pods plant^{-1}ofmungbean differed significantly due to the different varieties of mungbean (Table 7 and Appendix IX). The maximum number of pods plant^{-1}(35.44) was recorded from V_4 (BARI mung-6), which was statistically similar (31.22) with V_3 (BARI mung-5), while the minimum number of pods per plant (23.00) was recorded from V_1 (Sonamug).

Statistically significant variation was recorded for number of pods plant^{-1}due to different levels of GA_3 (Table 7 and Appendix IX). The highest number of pods plant^{-1}(29.41 g) was found from G_1, which was statistically identical (28.16 g) with G_2 whereas the lowest number of pods plant^{-1}(27.33 g) from G_0. Srinivas *et al.* (2002) observed that the number of pods plant^{-1}ant was increased with the increasing rates of GA_3 to 40 ppm.

Interaction effect of varieties and GA_3 showed statistically significant differences on number of pods per plant (Table 8 and Appendix IX). The maximum number of pods per plant (36.67) was recorded from V_4G_1 (BARI mung-6 with 40 ppm GA_3) which was statistically similar with V_4G_2 (36.00) and the minimum number of pods per plant (20.67) was observed in V_1G_0 (Sonamug with 0 GA_3).

Table 8. Interaction effect of variety and gibberellic acid on pod length, pods plant^{-1}, seeds pod^{-1} and 1000-seed weight of mungbean

Interaction	Pod length (cm)	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	1000-seed wt. (g)
V_1G_0	4.91 d	20.67 g	7.77 d	27.50 i
V_1G_1	6.06 bc	25.00 e	10.44 ab	33.33 g
V_1G_2	5.57 b-d	22.33fg	9.89 a-c	35.83 ef
V_2G_0	5.33 cd	23.33 ef	8.89 cd	34.33 fg
V_2G_1	6.16 bc	24.00ef	10.44 a-c	28.00 hi
V_2G_2	6.20bc	24.33 ef	10.77 ab	29.67 h
V_3G_0	6.25 bc	31.67 cd	10.05 a-c	37.83 de
V_3G_1	6.52 b	32.00 cd	9.44bc	40.00 bc
V_3G_2	6.11bc	30.00 d	9.78bc	40.33 a-c
V_4G_0	6.24bc	33.67 bc	10.33 a-c	38.83 cd
V_4G_1	7.76 a	36.67 a	11.44 a	42.83 a
V_4G_2	5.85bcd	36.00 ab	10.55 ab	41.50 ab
LSD $_{(0.05)}$	**0.86**	**2.34**	**1.33**	**1.87**
CV (%)	**8.24**	**9.78**	**7.71**	**11.64**

V_1=Sonamug, V_2=BARI mung-4, V_3=BARI mung-5, V_4=BARI mung-6

G_0= 0 ppm GA_3, G_1=40 ppm GA_3 and G_2= 80 ppm GA_3

4.9 Number of seeds pod^{-1}

Number of seeds pod^{-1} of mungbean differed significantly due to the different varieties of mugbean (Table 7 and Appendix IX). The maximum number of seeds pod^{-1} (10.77) was recorded from V_4 (BARI mung-6) while the minimum number of seeds per pod (9.66) was recorded from V_1 (Sonamug).

Statistically significant variation was recorded for number of seeds pod^{-1}due to different levels of GA_3 (Table 7 and Appendix IX). The highest number of seeds pod^{-1}(10.44 g) was found from G_1, which was statistically identical (10.25 g) with G_2 whereas the lowest number of seeds per pod (9.26 g) from G_0.

Interaction effect of varieties and levels of GA_3 showed statistically significant differences on number of seeds pod^{-1} (Table 8 and Appendix IX). The maximum number of seeds pod^{-1} (11.44) was recorded from V_4G_1 (BARI mung-6 with 40 ppm GA_3) which was statistically similar with V_4G_2 (10.55) and the minimum number of seeds pod^{-1} (7.77) was observed in V_1G_0 (Sonamug with 0 ppm GA_3).

4.10 Weight of 1000-seed

Weight of 1000 seed of mungbean showed statistically significant variation under the present trial (Table 7 and Appendix IX). The highest weight of 1000 seeds (41.06 g) was recorded from V_4, while the lowest weight (28.38 g) from V_1.

Statistically significant variation was recorded for weight of 1000 seeds due to different levels of GA_3 (Table 7 and Appendix IX). The highest weight of 1000 seeds (36.83 g) was found from G_1, which was statistically identical (36.16 g) with G_2 whereas the lowest weight (37.98 g) from G_0.

Mungbean varieties and levels of GA_3 showed significant differences on weight of 1000 seed due to their interaction effect (Table 8 and Appendix IX). The highest weight of 1000 seeds (42.83 g) were recorded from V_4G_1 and the lowest weight (27.50 g) from V_1G_0.

4.11 Seed yield plant^{-1}

Statistically significant variation was recorded for seed yield of BARI mungbean (Table 9 and Appendix X). The highest seed yield plant^{-1} (15.58g) was recorded from V_4, whereas the lowest seed yield (7.92 g) from V_1. Varieties plays an important role in producing high yield of munghean and yield varied for different varieties might be due to genetical and environmental influences as well as management practices.

Seed yield per hectare showed significant variation for different levels of GA_3 (Table 9 and Appendix X). The highest seed yield (11.02g) was observed from G_1, which was statistically identical (10.99 g) with G_2, again the lowest seed yield (10.04 g) was recorded from G_0.

Interaction effect of mungbean varieties and levels of GA_3 showed significant differences on seed yield per plant (Table 10 and Appendix X). The highest seed yield (18.16g) was observed from V_4G_1, while the lowest (6.48g) from V_1G_0.

Table 9. Effect of variety and gibberellic acid on seed yield plant^{-1}, stover yield plant^{-1}, seed yield m^{-2} and stover yield m^{-2} of mungbean

Variety	Seed yield (g plant^{-1})	Stover yield (g plant^{-1})	Seed yield m^{-2}(g)	Stover yield m^{-2} (g)
V_1	7.92 c	0.31 bc	63.81 d	7.89 c
V_2	8.26 c	0.33 c	70.20 c	8.29 bc
V_3	12.04 b	0.38 b	96.86 b	8.96 b
V_4	15.58 a	0.51 a	113. 37 a	11.32 a
LSD $_{(0.05)}$	**1.2617**	**0.0603**	**3.4014**	**0.9297**
CV $_{(\%)}$	**8.75**	**14.60**	**12.13**	**8.84**
Levels of GA_3				
G_0	10.04 b	0.36 b	82.10 b	8.39 b
G_1	11.02 a	0.42 a	91.71 a	9.62 a
G_2	10.99 a	0.37 b	84.36 b	9.33 ab
LSD $_{(0.05)}$	**0.7601**	**0.0381**	**4.2272**	**0.9696**
CV (%)	**8.02**	**11.03**	**11.43**	**12.60**

V_1=Sonamug, V_2=BARI mung-4, V_3=BARI mung-5, V_4=BARI mung-6

G_0= 0 ppm GA_3, G_1=40 ppm GA_3 and G_2= 80 ppm GA_3

4.12 Stover yield plant^{-1}

Stover yield per plant^{-1} of mungbean showed statistically significant differences (Table 9 and Appendix X). The highest stover yield (0.51g) was found from V_4, while the lowest (0.31g) from V_1.

Different levels of GA_3 showed significant differences in terms of stover yield plant^{-1} (Table 9 and Appendix X). The highest stover yield plant^{-1}(0.42g) was attained from G_1, whereas the lowest stover yield (0.37g) was observed from G_2, which was identical with G_0.

Statistically significant variation was found due to the interaction effect of mungbean varieties and levels of GA_3 on stover yield plant^{-1} (Table 10 and

Appendix X). The highest stover yield (0.55 g) was recorded from V_4G_1 which was statistically similar with V_4G_0 (0.51 g) and the lowest yield (0.27g) from V_1G_0.

Table10.Interaction effect of variety and gibberellic acid on seed yield plant^{-1}, stover yield plant^{-1}, seed yield m^{-2} and stover yield m^{-2} of mungbean

Interaction	Seed yield (g plant^{-1})	Stover yield (g plant^{-1})	Seed yield m^{-2}(g)	Stover yield m^{-2} (g)
V_1G_0	6.48 e	0.27 f	50.05 g	6.93 e
V_1G_1	8.89 c	0.36 cd	76.35 e	9.04 bc
V_1G_2	8.38 cd	0.31 de	65.02 f	7.70 cd
V_2G_0	8.25 cd	0.33 ef	81.87 e	6.97 d
V_2G_1	7.03 de	0.33 de	62.38 f	8.13 cd
V_2G_2	9.37 c	0.32 de	66.36 f	8.50 cd
V_3G_0	12.28 b	0.32 de	92.85 d	6.97 d
V_3G_1	11.78 b	0.42bc	100.44bc	9.42 bc
V_3G_2	11.96 b	0.39 cd	97.29 cd	10.50 ab
V_4G_0	15.22 a	0.51 ab	103.64bc	11.42 a
V_4G_1	18.16 a	0.55 a	127.68 a	11.89 a
V_4G_2	15.35 a	0.45 bc	108.79 b	10.64 ab
LSD $_{(0.05)}$	**1.41**	**0.07**	**8.45**	**1.93**
CV $_{(\%)}$	**8.02**	**11.03**	**11.43**	**12.60**

V_1=Sonamug, V_2=BARI mung-4, V_3=BARI mung-5, V_4=BARI mung-6

G_0= 0 ppm GA_3, G_1=40 ppm GA_3 and G_2= 80 ppm GA_3

4.13 Seed yield m^{-2}

Statistically significant variation was recorded for seed yield m^{-2} of BARI mungbean (Table 9 and Appendix X). The highest seed yield (113.37g) was recorded from V_4, whereas the lowest seed yield (63.81 g) from V_1. Varieties plays an important role in producing high yield of munghean and yield varied for different varieties might be due to genetical and environmental influences as well as management practices.

Seed yield per hectare showed significant variation for different levels of GA_3 (Table 9 and Appendix X). The highest seed yield m^{-2} (91.71g) was observed from G_1, which was statistically not identical (84.36 g) with G_2, again the lowest seed yield (82.10 g) was recorded from G_0.

Interaction effect of mungbean varieties and levels of GA_3 showed significant differences on seed yield m^{-2} (Table 10 and Appendix X). The highest seed yield (127.68g) was observed from V_4G_1, while the lowest (50.05g) from V_1G_0.

4.14 Stover yield m^{-2}

Stover yield m^{-2} of mungbean showed statistically significant differences (Table 9 and Appendix X). The highest stover yield (11.32g) was found from V_4, while the lowest stover yield (7.89g) from V_1.

Different levels of GA_3 showed significant differences in terms of stover yield m^{-2} (Table 9 and Appendix X). The highest stover yield m^{-2} (9.62g) was attained from G_1, whereas the lowest stover yield (8.39g) was observed from G_0.

Statistically significant variation was found due to the interaction effect of mungbean varieties and levels of GA_3 on stover yield m^{-2} (Table 10 and Appendix X). The highest stover yield (11.89 g) was recorded from V_4G_1 which was statistically similar with V_4G_0 (11.42 g) and the lowest yield (6.93g) from V_1G_0.

4.15 Seed yield kg ha^{-1}

Statistically significant variation was recorded for seed yield kg $ha^{-1}$of BARI mungbean (Table 11 and Appendix XI). The highest seed yield (1188.10kg ha^{-1}) was recorded from V_4, whereas the lowest seed yield (638.10 kg ha^{-1}) from V_1.

Seed yield kg ha^{-1}showed significant variation for different levels of GA_3 (Table 11 and Appendix XI). The highest seed yield (917.10 kg ha^{-1}) was observed from G_1, again the lowest seed yield (842.68 kg ha^{-1}) was recorded from G_0.

Interaction effect of mungbean varieties and levels of GA_3 showed significant differences on seed yield (Table 12 and Appendix XI). The highest seed yield (1276.80 kg ha^{-1}) was observed from V_4G_1, while the lowest (500.60 kg ha^{-1}) from V_1G_0.

Table11. Effect of variety and gibberellic acid on seed yield, stover yield, biological yield kg ha^{-1} and harvest index of mungbean

Varieties	**Seed yield (kg ha^{-1})**	**Stover yield (kg ha^{-1})**	**Biological yield (kg ha^{-1})**	**Harvest index (%)**
V_1	638.10 c	75.72 c	713.80 c	88.33 c
V_2	688.50 c	81.68 bc	866.70 b	89.60 b
V_3	968.70 b	92.30 b	964.40 b	90.66 ab
V_4	1188.10 a	117.01 a	1281.10 a	91.09 a
LSD $_{(0.05)}$	**125.36**	**12.12**	**112.00**	**1.47**
CV $_{(\%)}$	**18.69**	**13.05**	**9.78**	**10.42**
Levels of GA_3				
G_0	842.68 b	82.40 b	994.60 b	89.14 b
G_1	917.10 a	107.41 a	1046.10 a	90.11 a
G_2	852.69 b	85.23 b	824.80 b	89.76 b
LSD $_{(0.05)}$	**77.93**	**8.48**	**69.43**	**0.81**
CV $_{(\%)}$	**11.67**	**10.69**	**8.55**	**9.54**

V_1=Sonamug, V_2=BARI mung-4, V_3=BARI mung-5, V_4=BARI mung-6
G_0= 0 ppm GA_3, G_1=40 ppm GA_3 and G_2= 80 ppm GA_3

4.16 Stover yield kg ha^{-1}

Stover yield of mungbean showed statistically significant differences (Table 11 and Appendix XI). The highest stover yield (117.01 kg ha^{-1}) was found from V_4, while the lowest stover yield (75.72 kg ha^{-1}) from V_1.

Different levels of GA_3 showed significant differences in terms of stover yield kg ha^{-1} (Table 11 and Appendix XI). The highest stover yield kg ha^{-1}(107.41 kg ha^{-1}) was attained from G_1, whereas the lowest stover yield (82.24 kg ha^{-1}) was observed from G_0.

Statistically significant variation was found due to the interaction effect of mungbean varieties and levels of GA_3 on stover yield kg ha^{-1} (Table 12and Appendix XI). The highest stover yield (136.70 kg ha^{-1}) was recorded from V_4G_1 which was statistically similar with V_4G_0 (118.36 kg ha^{-1}) and the lowest yield (61.43 kg ha^{-1}) from V_1G_0.

4.17 Biological yield (kg ha^{-1})

Biological yield of mungbean exerted significant variation due to different varieties of mungbean (Table 11 and Appendix XI). The highest biological yield (1281.10 kg ha^{-1}) was found from V_4 (BARI mung-6) which was statistically similar with V_3 (BARI mung-5). The lowest biological yield (713.80 kg ha^{-1}) was observed from V_1 (Sonamug).

Remarkable variation was identified on biological yield due to the effect of GA_3 application in mungbean (Table 11 and Appendix XI). The highest biological yield (1020.10 kg ha^{-1}) was found from the treatment G_1 (40 ppm GA_3). The lowest biological yield (854.80 kg ha^{-1}) was achieved from the treatment of G_2 (80 ppm GA_3).

Significant variation on biological yield was noted due to combined effect of varieties and levels of GA_3 (Table 12 and Appendix XI). However, the highest biological yield (1395.70 kg ha^{-1}) was obtained from the treatment combination of V_4G_1 and the lowest biological yield (562.20 kg ha^{-1}) was observed from the treatment combination of V_1G_0.

4.18 Harvest index

Harvest index of mungbean varieties exerted significant variation due to different varieties effect of mungbean (Table 11 and Appendix XII). The highest harvest index (91.09%) was found from V_4 (BARI mung-6) which was statistically similar with V_3 (BARI mung-5). The lowest harvest index (88.33%) was observed from V_1 (Sonamug).

Remarkable variation was identified on harvest index due to the effect of GA_3 application in mungbean (Table 11 and Appendix XI). The highest harvest index (90.11%) was found from the treatment G_1 (40 ppm GA_3). The lowest harvest index (89.14%) was achieved from the treatment of G_0 (0 ppm GA_3).

Significant variation on harvest index was noted due to combined effect of varieties and levels of GA_3 (Table 12 and Appendix XI). However, the highest harvest index (92.28%) was obtained from the treatment combination of V_4G_1 and the lowest harvest index (86.29%) was observed from the treatment combination of V_1G_0.

Table12.Interaction effect of variety and gibberellic acid on seed yield, stover yield, biological yield kg ha^{-1} and harvest index of mungbean

Interaction	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
V_1G_0	500.60 g	61.43 g	562.20 g	86.29 e
V_1G_1	763.50 d-f	95.00 cd	858.50 ef	89.12 b-d
V_1G_2	650.20 fg	70.73fg	720.90 f	89.74 bc
V_2G_0	742.00 ef	75.13 e-g	780.50 f	89.94 a-c
V_2G_1	623.80 fg	89.00 d-f	817.10 f	87.08 de
V_2G_2	699.60 fg	80.90 d-f	1002.60 de	88.62 c-e
V_3G_0	928.50 c-e	74.13fg	712.80 fg	90.47 a-c
V_3G_1	1004.40 bc	108.93bc	1113.30 b-d	90.58 a-c
V_3G_2	973.10 cd	93.83 c-e	1067.00 cd	90.93 a-c
V_4G_0	1199.70 ab	118.90 b	1259.70 ab	89.84 a-c
V_4G_1	1276.80 a	136.70 a	1395.70 a	92.28 a
V_4G_2	1087.90 a-c	95.43 cd	1188.00 bc	91.15 ab
LSD $_{(0.05)}$	**217.76**	**16.96**	**138.87**	**2.47**
CV $_{(\%)}$	**11.67**	**10.69**	**8.55**	**9.54**

V_1=Sonamug, V_2=BARI mung-4, V_3=BARI mung-5, V_4=BARI mung-6
G_0= 0 ppm GA_3, G_1=40 ppm GA_3 and G_2= 80 ppm GA_3

CHAPTER V
SUMMARY AND CONCLUSION

The experiment was conducted at the research field laboratory of Sher-e-Bangla Agricultural University, Dhaka, during the period of November, 2019 to February, 2020to study the response of mungbean varieties to GA_3 in Rabi season. The experiment was comprised of two factors; factor A: Varieties (4) viz. V_1 = Sonamug, V_2= BARI mung-4, V_3= BARI mung-5 and V_4= BARI mung-6 and factor B: levels of GA_3 (3) viz. G_0 = 0 ppm GA_3 (control), G_1 = 40 ppm GA_3 and G_2 = 80 ppm GA_3. The experiment was laid out in Split Plot Design in factorial arrangements with three replications. The data on crop growth parameters like plant height (cm), number of leaves, leaf dry weight (g) and stem dry weight (g) were recorded at different days after sowing (DAS). Five plants were randomly selected from each unit plot for taking observations on number of leaves, leaf dry weight (g) and stem dry weight (g) with 15 days interval at 15, 30, 45 and 60 days after sowing (DAS). Yield and other crop characters like number of pods plant^{-1}, pod length (cm), number of seeds pod^{-1}, 1000-seed weight (g), seed yield (kg ha^{-1}), stover yield (kg ha^{-1}), biological yield (kg ha^{-1}) and harvest index (%) were recorded after harvest. Thousand seeds weight was measured from the sampled seed.

The plant height was varied significantly among different varieties at all stages of growth. At 15, 30, 45 and 60 DAS, the highest plant height (16.64, 19.13, 22.17 and 31.16 cm, respectively) was recorded in V_4 (BARI mung-6) whereas the lowest was measured at 15, 30 and 45 DAS (13.28, 14.23 and 18.82 cm, respectively) in V_2 (BARI mung-4) treatment while lowest was measured at 60 DAS and at harvest (25.62 and 29.03 cm, respectively) in V_3 (BARI mung-5) treatment. Leaf dry weight was significantly influenced by different varieties at all stages of growth except 15 DAS. At 30, 45 and 60 DAS the maximum leaf dry weight (1.40, 1.83 and 2.14 g, respectively) was recorded in V_4 (BARI mung-6). The lowest leaf dry weight (0.62) was found from V_1, the lowest leaf dry weight (1.13 and 1.52 g at 45 and 60 DAS, respectively) was achieved with V_2 (BARI mung-4). The findings showed that varieties also significantly influenced yield attributes. The highest pods plant^{-1} (35.44), pod length (6.62 cm), number of seeds pod^{-1} (10.77), 1000-seed wt. (41.06 g), seed yield (1188.10 kg ha^{-1}), stover yield (117.01 kg ha^{-1}) and biological yield (1281.10 kg ha^{-1}) were obtained from the V_4 (BARI mung-6) and the lowest number of pods plant^{-1} (23.00), pod length (5.65 cm), number of seeds pod^{-1} (9.66), 1000-seed wt. (28.38 g), seed yield (638.10 kg ha^{-1}) and stover yield (75.72 kg ha^{-1}) were obtained from the V_1 (Sonamug) and biological yield (798.80 kg ha^{-1}) were found from V_1 (Sonamug). The highest harvest index (91.09%) was found from the V_4 (BARI mung-6) treatment and the lowest (88.33%) was from the V_1 (Sonamug).

Results showed that growth regulators had significant effect on crop growth characters. The maximum plant height, number of leaves, leaf dry weight (g) and stem dry weight (g) was observed from the G_1 (40 ppm GA_3) compared to the other growth regulators. The study also revealed that growth regulators had significant influence on yield and other crop characters. The highest number of pods per plant (29.41) was obtained from the G_1 (40 ppm GA_3) treatment and the lowest number (27.33) was found when the plants were raised without growth regulators (G_0). G_1 (40 ppm GA_3) treatment showed the highest pod length (6.63 cm). The lowest pod length (5.68 cm) was obtained by G_0 treatment (No growth regulators). G_1 (40 ppm GA_3) treatment showed the highest number of seeds per pod (10.44). The lowest number of seeds per pod (9.26) was recorded with G_0 treatment where no growth regulators were applied. G_1 (40 ppm GA_3) treatment showed the highest thousand seed weight (36.83 g). The lowest thousand seed weight (33.25 g) was recorded with G_0 treatment. The higher seed yield (917.10 kg ha^{-1})and higher harvest index (90.11%) was found from the G_1 (40 ppm GA_3) and the lowest seed yield (842.68 kg ha^{-1}) and lower harvest index (89.14%) was obtained from the G_0. The G_1 produced higher stover yield (107.10kg ha^{-1}) and biological yield

(1020.10 kg ha^{-1}) where the G_0 produced lower stover yield (82.40kg ha^{-1}) and G_2 produced, the lower biological yield (854.80 kg ha^{-1}).

Interaction effect between varieties and different levels of growth regulators significantly affected growth as well as yield and yield contributing characters. The tallest plant (16.93, and 19.96cm at 15 and 30 DAS, respectively) was observed from V_4G_2 treatment (BARI mung-6 with 80 ppm GA_3) But the tallest plant (23.52, 31.44 and 34.07 cm at 45, 60 DAS and at harvest, respectively) was observed from V_4G_1 treatment (BARI mung-6 with 40 ppm GA_3) and the shortest plant (12.70, 13.32, 17.48, 22.07 and 25.90 cm at 15, 30, 45, 60 DAS and at harvest, respectively) was obtained from V_2G_0 treatment (BARI mung-4 with no growth regulators). The highest number of leaves (11.53, 13.26 and 16.26 at 30, 45 and 60 DAS, respectively) was observed in the BARI mung-6 with 40 ppm GA_3 ($V_4 \times G_1$). The lowest number of leaves (8.67, 9.80 and 12.73 cm at 30, 45 and 60 DAS, respectively) was observed from the BARI mung-4 with no growth regulators (V_2xG_0). The highest leaf dry weight (1.70, 2.10 and 2.32g at 30, 45 and 60 DAS, respectively) was observed in the BARI mung-6 with 40 ppm GA_3 ($V_4 \times G_1$). The lowest leaf dry weight (1.07 and 1.46g at 45 and 60 DAS, respectively) was observed from the BARI mung-4 with no growth regulators (V_2xG_0). The highest stem dry weight (0.32, 0.75, 1.68 and 2.11 g at 15, 30, 45 and 60 DAS, respectively) was observed in the BARI mung-6 with 40 ppm GA_3 ($V_4 \times G_1$). The lowest leaf dry weight (0.15, 0.31, 0.84 and 1.08 g at 15, 30, 45 and 60 DAS, respectively) was observed from the BARI mung-4 with no growth regulators (V_2xG_0). The highest number of pods $plant^{-1}$ (36.67), pods length (7.76 cm), number of seeds pod^{-1} (11.44), 1000-seed wt. (42.83 g), seeds yield (1276.80kg ha^{-1}), stover yield (136.70 kg ha^{-1}), biological yield (1395.70 kg ha^{-1}), and harvest index (92.28%) were obtained from the interaction of V_4G_1 treatment (BARI mug-6 with 40 ppm GA_3) and the lowest number of pods $plant^{-1}$ (20.67), pod length (4.91 cm), number of seeds pod^{-1} (7.77), 1000-seed wt. (27.50 g), seed yield (500.60 kg ha^{-1}), stover yield (61.43 kg ha^{-1}), biological yield (562.20 kg ha^{-1})

and harvest index (86.29%) were obtained from the interaction of V_1G_0 treatment (Sonamug with no growth regulators).

Based on the results of the present study, the following conclusions may be drawn-

¬Varieties (V_4) showed highest seed yield (1188.10 kg ha^{-1}) compared to the other varieties.

¬ Gibberellic acid @ 40 ppm showed highest seed yield (917.10kg ha^{-1}) than others.

¬ The highest seed yield (1276.80kg ha^{-1}) was recorded from the interaction of BARI mung-6 with 40 ppm Gibberellic acid.

¬ Growth regulators remarkably increased yield over control at BARI mung-4 compared to that of BARI mung-5.

However, to reach a specific conclusion and recommendation, the same experiment need to be repeated and more research work should be done over different agroecological zones with different growth regulators and with varieties.

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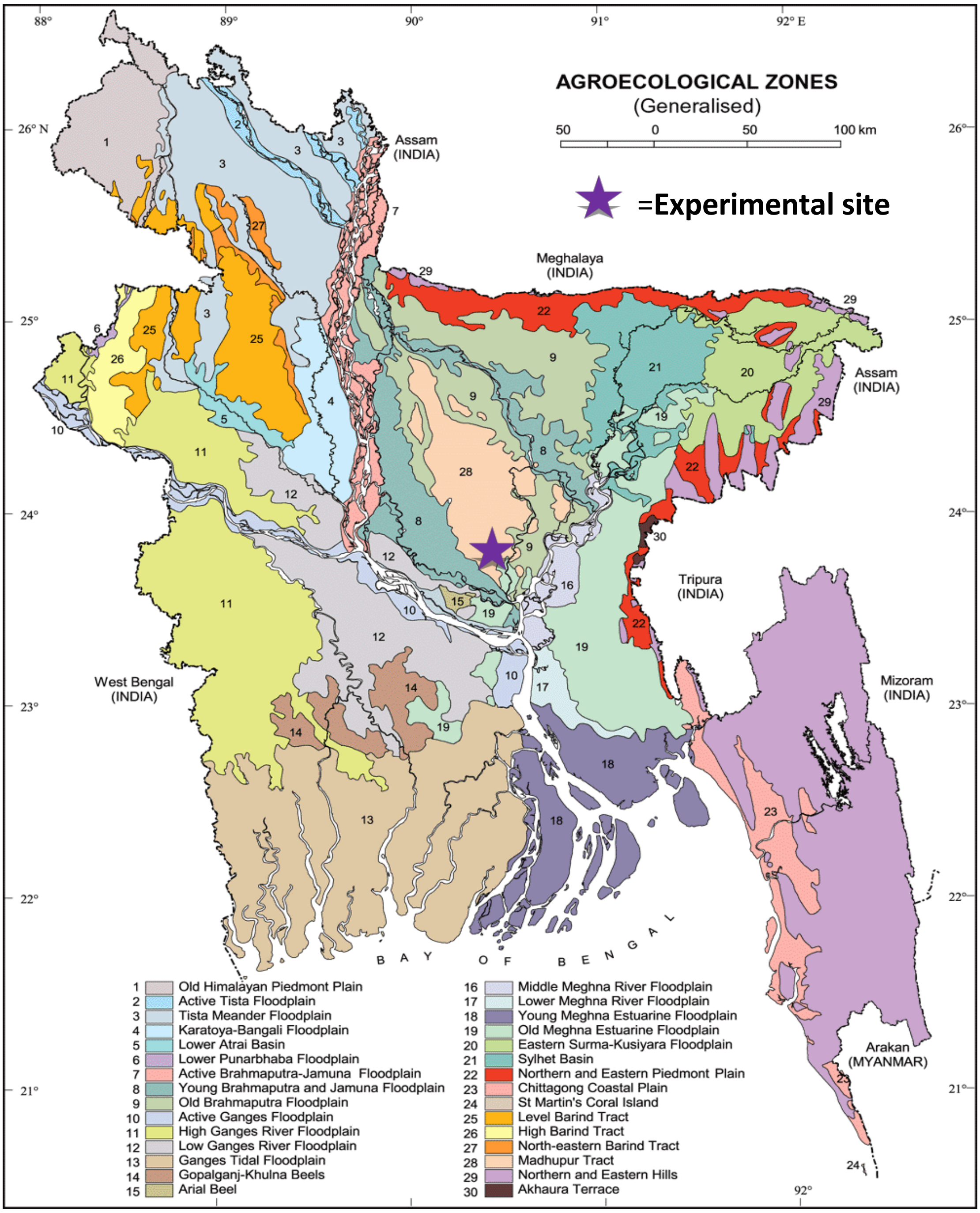
APPENDICES

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



Appendix II. Characteristics of soil of experimental field

A. Morphological characteristics of the experimental field

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

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

Physical characteristics	
Constituents	**Percent**
Sand	26
Silt	45
Clay	29
Textural class	Silty clay
Chemical characteristics	
Soil characters	**Value**
pH	6.8
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.071
Available P (ppm)	7.42
Exchangeable K (me/100 g soil)	0.08

Source: Soil Resource and Development Institute (SRDI), Farmgate, Dhaka

Appendix III. Monthly average of air temperature, relative humidity and total rainfall of the experimental site during the period from November, 2019 to March,2020

Month	*Air temperature (^{o}C)		*Relative humidity (%)	* Total rainfall (mm)
	Maximum	Minimum		
November, 2019	25.8	16.0	78	00
December, 2019	22.4	13.5	74	00
January, 2020	25.2	12.8	69	00
February, 2020	27.3	16.9	66	39
March, 2020	31.7	19.2	57	23

* Monthly average,

* Source: Bangladesh Meteorological Department (Climate &Weather Division) Agargoan, Dhaka - 1212

Appendix IV. Analysis of variance of plant height of mungbean at different days after sowing

Sources of variation	Degrees of freedom	Mean squares values				
		15 DAS	30 DAS	45 DAS	60 DAS	Harvest
Replication	2	61.13	38.06	121.40	169.42	289.16
Factor A	3	23.13*	54.02*	22.68*	16.96	7.44
Error I	6	14.83	24.79	18.12	75.97	39.07
Factor B	2	0.71	6.56	9.42*	14.93*	54.82*
AxB	6	0.40	0.49	2.58	12.92	23.98*
Error II	16	3.91	3.72	1.33	6.65	2.35

* = Significant at 5% level of Probability

Appendix V. Analysis of variance of number of leaves plant^{-1} of mungbean at different days after sowing

Sources of variation	Degrees of freedom	Mean squares values			
		15 DAS	30 DAS	45 DAS	60 DAS
Replication	2	1.03	72.13	59.21	83.98
Factor A	3	2.01	2.81*	1.23	3.46*
Error I	6	24.18	2.80	30.64	11.78
Factor B	2	0.91	0.72	2.77	11.54*
AxB	6	0.11	1.31*	3.39*	3.23*
Error II	16	0.35	0.44	1.11	1.17

* = Significant at 5% level of Probability

Appendix VI. Analysis of variance of leaves dry weight of mungbean at different days after sowing

Sources of variation	Degrees of freedom	Mean squares values			
		15 DAS	30 DAS	45 DAS	60 DAS
Replication	2	0.03	1.68	2.86	5.68
Factor A	3	0.13	0.95*	0.82*	0.73*
Error I	6	0.55	0.56	0.58	0.32
Factor B	2	0.004	0.11*	0.02	0.02
AxB	6	0.002	0.04*	0.06*	0.05
Error II	16	0.006	0.02	0.01	0.03

* = Significant at 5% level of Probability

Appendix VII. Analysis of variance of stem dry weight of mungbean at different days after sowing

Sources of variation	Degrees of freedom	Mean squares values			
		15 DAS	30 DAS	45 DAS	60 DAS
Replication	2	0.06	0.29	0.74	1.64
Factor A	3	0.02*	0.10*	0.56*	0.80*
Error I	6	0.01	0.04	0.02	0.03
Factor B	2	0.003	0.03*	0.03*	0.05*
AxB	6	0.0005	0.017*	0.02	0.03
Error II	16	0.001	0.002	0.02	0.02

* = Significant at 5% level of Probability

Appendix VIII. Analysis of variance of days to days to flowering and days to maturity of mungbean

Sources ofvariation	Degrees offreedom	Mean squares values	
		Flowering	Maturity
Replication	2	300.44	460.33
Factor A	3	14.76*	33.81*
Error I	6	1.85	1.88
Factor B	2	8.44*	27.08*
AxB	6	27.63*	44.63*
Error II	16	0.83	3.21

* = Significant at 5% level of Probability

Appendix IX. Analysis of variance of number of pods, pod length, seed per pod and 1000-seed weight of mungbean

Sources of variation	Degrees of freedom	Mean squares values			
		Number of pods	Pod length	Seeds per pod	1000-seed weight
Replication	2	144.69	43.47	44.81	397.31
Factor A	3	330.54*	1.87	2.52	290.06*
Error I	6	1.65	0.31	0.99	4.23
Factor B	2	13.19*	2.87	4.82*	15.39*
AxB	6	5.15*	0.78	2.15*	3.22*
Error II	16	1.83	0.25	0.59	1.17

* = Significant at 5% level of Probability

Appendix X. Analysis of variance of seed yield plant^{-1}, stover yield plant^{-1}, seed yield m^{-2} and stover yield m^{-2} of mungbean

Sources of variation	Degrees of freedom	Mean squares values			
		Seed yield plant^{-1}	Stover yield plant^{-1}	Seed yield m^{-2}	Stover yield m^{-2}
Replication	2	39.98	0.08	1451.61	84.34
Factor A	3	117.24*	0.06*	4826.81*	21.14*
Error I	6	1.19	0.002	27.85	0.82
Factor B	2	0.11	0.01*	302.78*	4.93*
AxB	6	3.125*	0.003	353.69*	3.20
Error II	16	0.67	0.001	23.86	1.25

* = Significant at 5% level of Probability

Appendix XI. Analysis of variance of seed yield ha^{-1}, stover yield ha^{-1}, biological yield ha^{-1} and harvest index of mungbean

Sources of variation	Degrees of freedom	Mean squares values			
		Seed yield ha^{-1}	Stover yield ha^{-1}	Biological yield ha^{-1}	(%) Harvest index
Replication	2	183685	3718.80	262168	244.30
Factor A	3	593014*	2952.18*	517208*	17.90*
Error I	6	11812	110.44	9428	1.68
Factor B	2	19572	2251.00*	154835*	14.41*
AxB	6	24923	331.47*	43700*	2.08
Error II	16	15828	108.33	6437	2.02

* = Significant at 5% level of Probability