EFFECT OF GA_3 AND NITROGEN ON GROWTH, YIELD AND PROTEIN CONTENT OF MUNGBEAN

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CERTIFICATE

This is to certify that the thesis entitled "EFFECT OF GA$_3$ AND NITROGEN ON GROWTH, YIELD AND PROTEIN CONTENT OF MUNGBEAN" submitted to the DEPARTMENT OF AGRICULTURAL CHEMISTRY, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in AGRICULTURAL CHEMISTRY, embodies the result of a piece of bona fide research work carried out by MD. MAHBUBUL ALAM, Registration No. 10-04072 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: June, 2016

Dhaka, Bangladesh

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Dedicated To

My Beloved Parents

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EFFECT OF GA_3 AND NITROGEN ON GROWTH, YIELD AND PROTEIN CONTENT OF MUNGBEAN

ABSTRACT

An experiment was conducted at research field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from March to June, 2016 to find out the effect of GA_3 and nitrogen (N) on growth, yield and protein content of mungbean. The experiment consisted of two factors: Factor A: Three levels of GA_3 viz.G_0: control (no GA_3); G_1: 50 ppm GA_3; G_2: 100 ppm GA_3 and Factor B: Four levels of nitrogen (N). viz.N_0: Control (no urea), N_1: 22 kg urea ha^{-1}, N_2: 44 kg urea ha^{-1}, N_3: 66 kg urea ha^{-1}. There were 12 treatment combinations. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth and yield contributing characters and yield were recorded to find out the optimum levels of GA_3 and nitrogen (N) on mungbean production. Due to GA_3 application maximum number of pods $plant^{-1}$ (107.52), seeds pod^{-1} (9.97), chlorophyll content (52.75 %), seed yield (2.16 t/ha), stover yield (1.05 t/ha), nitrogen content (4.11 %) and protein content (25.72 %) were recorded from G_1 (50 ppm GA_3) treatment while minimum from G_0 (control) treatment. Due to nitrogen application maximum number of pods $plant^{-1}$ (108.94), seeds pod^{-1} (10.14), 1000 seed weight (47.22 g), seed yield (2.16 t/ha), stover yield (1.08 t/ha), nitrogen content (4.16 %), protein content (26.00 %) were observed from N_2 (44 kg urea ha^{-1}) treatment while the minimum were observed from N_0 (control) treatment. In the case of interaction effect maximum number of pods $plant^{-1}$ (132.27), seeds pod^{-1} (11.30), 1000 seed weight (47.92 g), seed yield (2.38 t/ha), stover yield (1.28 t/ha), nitrogen content (4.20 %) and protein content (26.25 %) were recorded from G_1N_2 (50 ppm GA_3 with 44 kg urea ha^{-1}) treatment combination while the minimum from G_0N_0 (control) treatment combination. The overall results suggest that 50 ppm GA_3 along with 44 kg urea ha^{-1} can be applied to obtain optimum mungbean yield, nitrogen and protein contents under the agro-climatic condition of SAU.

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LIST OF ACRONYMS

ABBREVIATIONS	ELABORATIONS
AEZ	Agro-Ecological Zone
Anon.	Anonymous
ANOVA	Analysis of Variance
@	At the rate of
a.i	Active Ingredient
Adv.	Advanced
Agron .	Agronomy
Agric.	Agriculture Agricultural
Agril.	Agricultural
BRRI	Bangladesh Rice Research Institute
BARI	Bangladesh Agricultural Research Institute
SAU	Sher-e-Bangla Agricultural University
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
RCBD	Randomized Complete Block Design
CV	Coefficient of Variation
cv.	Cultivar
EC	Emulsifiable Concentrate
cm	Centimeter
df	Degrees of Freedom
DAS	Days After Sowing
LSD	Least Significance Difference
et al.	And others
etc.	Etcetera
FAO	Food and Agricultural Organization
Fig	Figure
ns	Non Significant

ABBREVIATIONS	ELABORATIONS
J.	Journal
PP.	Pages
g	Gram
ha^{-1}	Per Hectare
t	Ton
%	Percent
m^2	Square Meter
pod^{-1}	Per pod
J.	Journal
kg	Kilogram
No.	Number
NS	Non Significant
NOS	Number of Species
^0C	Degree Celsius
Res.	Research
RH	Relative Humidity
WCE	Weed Control Efficiency
SRDI	Soil Resource Development Institute
Sci.	Science's
HI	Harvest Index
Vol.	Volume

CHAPTER 1
INTRODUCTION

Mungbean (*Vigna radiata* L.) is an important legume and short duration pulse crop of Bangladesh and other South Asian Countries. Mungbean also known as green gram or golden gram which belongs to the family Leguminosae. It is native to the Indian subcontinent and mainly cultivated in India, China, Thailand, Philippines, Indonesia, Myanmar, Bangladesh, Laos and Cambodia but also in hot and dry regions of Europe and the United States.

Mungbean (*Vigna radiata* L.) has high nutritive value. Thus it plays an important role in human diet as well as the development of soil fertility by fixing the atmospheric nitrogen (Ather *et al.*, 2004). Its seed is more palatable, nutritive, digestible and non-flatulent than other pulses (Anjum *et al.*, 2006). Pulse is a popular crop in the daily diet of the people of Bangladesh. Pulses have been considered as “poor men's meat” since pulses contains more protein than meat and also more economical, they are the best source of protein for the underprivileged people. It is taken mostly in the form of soup which is commonly known as "dal". Generally, there is no complete dish without "dal" in Bangladesh. Green pulse seeds also can be consumed as fried peas or can be used in curry.

In Bangladesh, daily consumption of pulses is only 14.30g capita^{-1} (BBS, 2010), while The World Health Organization (WHO) suggested 45g capita^{-1} day^{-1} for a balanced diet. This is because of the fact that production of the pulses is not adequate to meet the national demand. Due to shortage of production 291 thousand metric tons pulses was imported in Bangladesh in 2006-07 fiscal years (BBS, 2010). Though total pulse production in Bangladesh is 231 thousand metric tons (BBS, 2011), but to provide the above mentioned requirement of 45g capita^{-1} day^{-1}, the production has to be increased even more than three folds.

Mungbean has good digestibility and flavor. It contains 24% protein, 1-3% fat, 50.4% carbohydrates, 3.5-4.5% fibers and 4.5-5.5% ash, while calcium and phosphorus are 132 and 367 mg per 100 grams of seed, respectively (Frauque *et al.,* 2000). Hence, on the nutritional point of view, mungbean is perhaps the best of all other pulses (Khan, 1981 and Kaul, 1982), contains almost triple amount of protein as compared to rice. It may play an important role to supplement protein in the cereal-based low-protein diet of the people of Bangladesh. It can also minimize the scarcity of fodder because the whole plant or its by product can be used as good animal feed. Cultivation of pulses also can improve the physical, chemical and biological properties of soil as well as increase soil fertility status through nitrogen fixation. As a whole, mungbean could be considered as an inevitable component of sustainable agriculture.

The major cropping pattern in Bangladesh consists of two major crops of rice (i.e. boro rice-fellow-aman rice). In Bangladesh, more than 75% of the total cropping area is occupied by rice where pulse crop covers only 2.8% of the total cropping area (BBS, 2005). Mungbean grows well in all over Bangladesh. The majority portion is being produced in southern part of the country. Among the pulse crops the largest area is covered by lentil (40.17%) and mungbean is grown in only 6.34% area (BBS, 2005). The cultivation of mungbean in Bangladesh is tends to increase and it covers 54, 57 and 68 thousand acres respectively in the 2008- 09, 2009-10 and 2010-11 fiscal years (BBS, 2011). At present the average yield of mungbean grain in our country is about 279 kg acre^{-1} (BBS, 2010). So mungbean can be a good source for the demand of plant protein of evergrowing population in Bangladesh

Among the pulse crops, mungbean has a special importance in intensive crop production system of the country for its short growing period (Ahmed *et al*., 1978). In Bangladesh it can be grown in late winter and summer season. Summer mungbean can tolerate high temperature exceeding 40^{0}C and grown well in the temperature range of 30-35^{0}C (Singh and Yadav, 1978). This pulse crop is reported to be drought tolerant and can also be cultivated in areas of low rainfall, but also grows well in the areas with 750-900 mm rainfall (Kay, 1979). So, cultivation of mungbean in the summer season could be an effective effort to increase pulse production in Bangladesh.

It is recognized that pulses offer the most practical means of solving protein malnutrition in Bangladesh but there is an acute shortage of grain legumes in relation to its requirements because the yield of legumes in farmer's field is usually less than 1 t ha^{-1} against the potential yield of 2 to 4 t ha^{-1} (Ram and Dixit, 2000). Low yields of grain legumes, including mungbean make the crop less competitive with cereals and high value crops. Therefore, to meet the situation it is necessary to boost up the production through varietal development and improved management practices with modern as well as summer mungbean cultivation.

Farmers have a wrong view that mungbean does not need fertilizers. The management of fertilizer and plant growth regulators can play an important role for the growth, development and yield of this crop. Application of small amount of nitrogen as a starter dose has a beneficial effect on crop yield and quality (Sandhu *et al.*, 1978).Pulses although fix nitrogen from the atmosphere, there is evident that application of nitrogenous fertilizers at flowering stage becomes helpful in increasing the yield (Patel *et al.*, 1984, Ardeshana *et al*., 1993). For the pulse crops, nitrogen is most useful because it is the main component of protein (BARC, 2005). Nitrogen is an essential nutrient that needed for plant growth and its deficiency is usually seen in the soil. Nitrogen deficiency reduces the number of branches per plant, plant height, stem diameter, pod length, number of nodes.

Again, Gibberellic acid (GA_3) is a phytohormone that is needed in small quantities at low concentration to accelerate plant growth and development by inducing metabolic activities and regulating nitrogen utilization (Sure *et* *al.*,2012). So, favorable condition may be induced by applying growth regulator exogenously in proper concentration at a proper time in a specific crop by GA_3. GA_3 is such a plant growth regulator, which can manipulate a variety of growth and development phenomena in various crops. It is the most important growth regulator, which breaks seed dormancy, promotes germination, inter nodal length, hypocotyls growth and cell division in cambial zone and increases the size of leaves. GA_3 stimulates hydrolytic enzymes that are needed for the degradation of the cells surrounding the radicle and thus speeds germination by promoting seedling elongation growth of cereal seeds (Rood *et al.,* 1990). Gibberellins (GAs) belong to a wide group of plant hormones and natural components called terpenoids, with huge application which GA_3 is the most popular (Hartmann *et al.*, 1999).

Therefore, in accordance with recent agricultural policy to increase yield vertically and to get early yield and better quality seed, an attempt was made to study the effects of different concentrations of GA_3 and nitrogen on plant growth and yield of mungbean with the following objectives:

- To study the effect of exogenous application of GA_3on growth, yield and protein content of mungbean
- To study the effect of exogenous application of nitrogen on growth, yield and protein content of mungbean
- To find out the combined effects of GA_3 and nitrogen on mungbean production.

CHAPTER II

REVIEW OF LITERATURE

An attempt was made in this section to collect and study relevant information available in the country and abroad regarding the effect of different levels of nitrogen and gibbrellic acid on the growth and yield of mungbean and other crops to gather knowledge helpful in conducting the present research work and sequently writing up the result and discussion.

2.1 Effect of GA_3 on the growth and yield of mungbean

Arpita Swarnakar (2017) observed that pretreatment of mungbean seeds with Phytohormone- GA_3 and Kinetin could ameliorate Arsenate induced toxicity to different extent in terms of growth and sucrose metabolism. Thus, the use of GA_3 and Kinetin may help to resist the arsenic toxicity in seedling stage, to some extent, in arsenic contaminated areas.

Keykha *et al.* (2014) found that the maximum of Plant height of treatments 50 ppm gibberellin was obtained The maximum of grain yield of treatments 50 ppm gibberellin was obtained

Abdel *et al.* (2011) investigated that 200 $mg.L^{-1}$ GA_3 treated plants irrigated every 2 days appeared the most potent dual interaction treatment. Since it exhibited the highest values in terms of plant height (52.33 cm), internodes length (6.19), inflorescence number per plant (13), pod length 5.83 cm), pod number per plant (29), seed number per pod (9.33), biomass (502.22 $g.m^{-2}$), yield (165.91 g. m^{-2}) and seed weights per plant (4.36g).

Nasser Akbari *et al.* (2010) found that irrigation with saline water adversely affects growth and productivity of plants and application of gibberellic acid hormone overcome the effects of salt stress and improved the growth parameters.

El-Shabasi *et al.* (2008) presented 100 ppm GA_3 increased flower production.

Mohammed (2007) observed that pre-soaking the seeds in GA_3(200 mg L^{-1}) was shown to a meliorate the deleterious effects of salinity in the majority of cases.

Foliar application of GA_3 (1.00 mg L^{-1}) increased plant growth and seed yield of mungbean (Rahman, 2004).

Hoque and hoque (2002) indicated that a high potentiality to increase the yield of mungbean in Bangladesh by the application on GA_3.Seed treatment with GA_3 at 50 ppm increased the leaf area index, total dry matter, crop growth rate, while at 200 ppm increased relative growth rate and net assimilation rate. Foliar application of GA_3 at 200 ppm had higher relative growth rate, while that at 100 ppm had greater leaf area index, total dry matter, crop growth rate and net assimilation rate.

Rajan *et al.* (2000) investigated that GA_3 treatment overcame the effect of salt stress and improved the percentage of germination.

Patel and Saxena (1994) reported that presoaking of seed of gram in varying concentrations of GA_3 (10^{-5} M) showed the best results on seed germination, seedling growth, fresh and dry weights.

Bai*et al.* (1987) reported that application of GA_3 at 50,100 and 150 ppm as foliar spray has significantly increased the plant height, vegatative growth and this accelerated vegetative growth resulted in an extensive photosynthetic apparatus and relative increases in LAI and LAD in mungbean. Finally, mungbean gave seed yields of 1166 kg ha^{-1} respectively as against 761.00 kg ha^{-1} of the control showing that GA_3 favours the grain filling process also. Increased seed protein content in mungbean inflorescence number per plant and podnumber per inflorescence there by increasing the grainyield significantly. GA_3 at 100 ppm recorded the highest per plant inflorescence number (5.40) when compared to control (4.67) in mungbean.

Vidhu and Murty (1985) reported that pretreatment of GA_3 to stimulate total chlorophyll content in mungbean plants.

Tilden (1985) observed that slow hydration of seeds with PGR solutions followed by the dehydration produced vigorous seedlings and increased germination as compared to the untreated seeds.

Yadireddy (1984) recorded increase in the number of branches with NAA at (10,50 ppm) and GA_3 at (10,50 ppm) sprayed at 18 and 30 DAS in mungbean.

Castro and Bergemann (1973) recorded increase in the number of flowers per plant by application of GA in *Phaseolus vulgaris*.

Khan and Rao (1969) reported that application of NAA or GA_3, both as seed treatment and foliar spray in mungbean had recorded an increase of 30 percent in plant height and gave higher yields in mungbean over control.

GA stimulates both vegetative and subsequent reproductive growth. Various workers have reported the pronounced effect of GA on seedling growth of crops like *Phaseolus munge* (Mohan *et al*., 1962)

2.2 Effect of nitrogen on the growth and yield of mungbean

Razzaque *et al*. (2017) observed that increasing nitrogen level in nutrient stress soil increased growth and dry matter production up to 60 kg N ha^{-1} irrespective of genotype and thereafter decreased. Among the mungbean genotype IPSA 12 showed maximum leaf area, dry matter production and seed yield (14.22 g plant^{-1}) in nutrient stress soil. The lowest seed yield (7.33 g plant $^{-1}$) was recorded in ACC12890053 under control condition.

Hossen *et al.* (2015) stated that longest pod (7.96 cm), maximum pods plant$^{–1}$ (10.45), maximum seeds pod$^{–1}$ (9.70), higher weight of 100–seed (4.52 g), higher weight of seed (5.73 g plant$^{–1}$) and greater seed yield (1.85 t ha$^{–1}$) were also obtained in 45 kg N ha$^{–1}$ compare other N levels. The BARI mung–6 × 45 kg N ha$^{–1}$ for seed yield was found under the regional condition of Patuakhali (AEZ-13).

Amin *et al.* (2015) investigated that root dry weight increased with combined application of N and K fertilizers. Flooded plants treated with 14 kg N ha^{-1} + 25 kg K ha^{-1} produced the highest TDM and seed yield, though the yield was statistically similar to that obtained when the levels of N and K were applied separately, as well as with that of 1% urea + 25 kg K ha^{-1}.

Mainul *et al.* (2014) observed maximum plant height (40.52 cm), number of leaves (19.14), number of branches (10.09), average dry weight/plant (7.35 g), number of pods/plant (15.90),number of seeds/pod (4.49), 1000-seed weight (42.56 g), seed yield (1.06 t/ha), stover yield (2.08 t/ha), N content in seed (3.60), P content in seed (0.48) and K content in seed (1.26) were found in N3 which was statistically similar with N2 whereas minimum from N0.

Hossain *et al*. (2014) found that Mungbean variety namely BARI Mung-6 performed better in respect to growth and yield (seed and stover) as compared to BARI Mung-5 with the application of nitrogen (50 kg ha^{-1}) and inoculums Bradyrhizobium (1.5 kg ha^{-1}).

Kumar and Tomar (2013) investigated that the growth and yield attributes increased with the decrease in plant density and with the increase in the levels of nitrogen and phosphorus while plant height was positively increased with the increase in plant density and levels of nitrogen and phosphorus. Interaction effect revealed that decreasing plant density and increasing levels of nitrogen and phosphorus increased dry matter accumulation and grain yield significantly. The maximum dry matter (34.4 g/plant) and grain yield (2.07 t ha^{-1}) were recorded in 333 × 103 plants ha^{-1} plant density with 20 kg N and 60 kg P_2O_5 ha^{-1}. Nigamananda and Elamathi (2007) conducted an experiment during 2005-06 to evaluate the effect of N application time as basal and as DAP (diammonium phosphate) or urea spray and plant growth regulator (NAA at 40 ppm) on the yield and yield components of greengram. Results showed that 2% foliar spray as DAP and NAA, applied at 35 DAS resulted in the highest values for number of pods plant^{-1} (38.3), seeds pod^{-1}, test weight, flower number, fertility coefficient, grain yield (9.66 q ha^{-1}).

Azadi *et al.* (2013) observed that different nitrogen levels influenced different growth and yield attributes of mungbean such as plant height, seed yield, stem diameter, number of node and 75 kg N ha^{-1} showed higher values than the other N doses (50, 100 and 150 kg N ha^{-1}).

Achakzai *et al. (*2012) found that different Nitrogen levels influenced most of the growth attributes of the mungbean. Maximum days to flowering, number of branches plant^{-1}, number of leaves plant^{-1}, plant height, number of branches plant^{-1}, leaf area and grain yield recorded for plants subjected to highest dose of applied N fertilizer at 100 kg ha^{-1}.

Sultana *et al.* (2009) reported that application of 20 kg N ha^{-1} as basal dose and 20 kg N ha^{-1} with one weeding at vegetative stage showed significantly higher values of all growth parameters like leaf area, shoot dry weight, number of branches, pods plant^{-1} and seed yield.

Asaduzzaman *et al.* (2008) Application of 30 kg N ha^{-1} as basal with one irrigation at flower initiation stage (35 DAS) significantly improved dry matter accumulation. This greater dry matter production eventually partitioned to pods per plant, seeds per plant and 1000-seed weight which is get her resulted with maximum seed yield per plant (5.53 g) or per hectare (1.65 t). A functional positive relationship was observed in with pods per plant and seeds per plant.

Sultana *et al.* (2008) reported that the highest grain yield was obtained in 30 kg N ha^{-1} due to improvement of yield components. The lowest grain yield was obtained in the no nitrogen i.e. control treatment.

Asaduzzaman (2006) found that plant height and number of leaves per plant of mungbean was significantly increased by the application of nitrogen fertilizer at 30 kg ha^{-1}.

Sultana (2006) noticed that plant height of mungbean showed superiority at 30 kg N ha^{-1} followed by 40 kg N ha^{-1}. Nitrogen fertilizer significantly influenced plant height at all growth stages of mungbean. At 20, 35, 50, 65 DAS and harvest the maximum heights were observed in the plants treated with 30 kg N ha^{-1}.

Mungbean genotypes require additional N for better pod development although it is capable to fix atmospheric N through rhizobium species living in root nodules (Anjum*et al.*, 2006).

Oad and Buriro (2005) conducted a field experiment to determine the effect of different NPK levels (0-0-0, 10-20-20, 10-30-30, 10-30-40 and 10-40-40 kg/ha) on the growth and yield of mungbean cv. AEM 96 in Tandojam, Pakistan, during the spring season of 2004. The different NPK levels significantly affected the crop parameters. The 10-30-30 kg NPK/ha was the best treatment, recording plant height of 56.3. germination of 90.5%. satisfactory plant population of 162.0. prolonged days taken to maturity of 55.5. long pods of 5.02 crn, seed weight of 10.5 g, seed index of 3.5 g and the highest seed yield of 1205.2 kg/ha. There was no significant change in the crop parameters beyond this level.

Ghosh (2004) used different levels of nitrogen and indicated that number of branches $plant^{-1}$ of mungbean was gradually increased with increasing N level at 25 kg N ha^{-1}.

Nadeem *et al.* (2004) studied the response of mungbean cv. NM-98 to seed inoculation and different levels of fertilizer (0-0, 15-30, 30-60 and 45-90 kg NP_2O_5 ha^{-1}) under field conditions. Application of fertilizer significantly increased the yield and the maximum seed yield was obtained when 30 kg N ha^{-1} was applied along with 60 kg P_2O_5 ha^{-1}.

Masud (2003) observed that highest plant height of mungbean with the application of 30 kg N ha^{-1} while Ghosh (2004) at 25 kg N ha^{-1}.

Mozumder *et al.* (2003) also stated that application of 40 kg N ha^{-1} gave the highest seed yield of mungbean.

Malik *et al.* (2003) conducted an experiment to determine the effect of varying levels of nitrogen (0, 25 and 50 kg ha^{-1}) and phosphorus (0, 50, 75, and 100 kg ha^{-1}) on the yield and quality of mungbean cv. NM-98. Growth and yield components were significantly affected by varying levels of nitrogen and phosphorus. A fertilizer combination of 25 kg N + 75 kg ha^{-1} resulted with maximum seed yield (1112.96 kg ha^{-1}).

Rajander *et al.* (2003) investigated the effects of N (0, 10, 20 and 30 kg ha^{-1}) and P (0, 20, 40 and 60 kg ha^{-1}) fertilizer rates on mungbean genotypes MH 85-111 and T44. They observed grain yield increased with increasing N rates up to 20 kg ha^{-1}.

Mahboob and Asghar (2002) studied the effect of seed inoculation at different nitrogen levels on the yield and yield components of mungbean at the agronomic research station, Farooqabad in Pakistan during the year of 2000 and 2001. They revealed that with the application of NPK at the rate of 50-50-0 kg ha^{-1} significantly affected the 1000 grain weight.

Rudreshhappa and Halikatti (2002) explained the effect of N levels (0, 12.5 and 25 kg) on growth, yield and nutrient uptake of green gram in paddy fallows. Application of 12.5 kg N ha^{-1} was recorded to produce significantly higher seed yield. Further increase in N doses (25 kg ha $^{-1}$) did not significantly increase the yield.

Srinivas *et al.* (2002) examined the effect of nitrogen (0, 20, 40 and 60 kg ha^{-1}) and P (0, 25, 50 and 75 kg ha^{-1}) on the growth and seed yield of mungbean. They observed that the number of pods per plant was increased with the increasing rates of N up to 40 kg ha^{-1} followed by a decrease with further increase in N.

Pathak *et al.* (2001) evaluated the effect of N levels (0, 10, 20 and 30 kg ha^{-1}) on growth and yield of mungbean under rainfed condition during the summer of 1999 and found that application of 20 kg N ha^{-1} yielded poorer than 30 kg N ha^{-1}.

Ashraf (2001) found that number of pods per plant, seeds per pod, 1000-seed weight were significantly affected by the application of nitrogen from 20 to 50 kg ha^{-1}.

Tariq *et al.* (2001) found that application of 30: 30.8: 58.10 kg ha^{-1} N-P-K enhanced production of pods $plant^{-1}$, 1000-seed weight and gain the highest grain yield (876.32 kg ha^{-1}) of mungbean.

Hamid (1999) revealed the effects of foliar application of nitrogen on mungbean cv. Mubarik. In both pot and field trials he showed 10 kg N ha^{-1} increased the number of pods $plant^{-1}$.

Mandal and Sikdar (1999) laid out a greenhouse pot experiment where mungbean (BARI Mung-5) grown on saline soil and given 0, 50 or 100 kg N ha^{-1} and 0, 75 or 150 kg P ha^{-1}. Growth and yield increased significantly with N application while P significantly increased the setting of pods and seeds. Root growth was significantly improved by both individual and combined application of these two fertilizers.

Mozumder (1998) studied the effect of five N levels (0, 20, 40, 60 and 80 kg N ha^{-1}) and two varieties of summer mungbean, BINA Mung-2 and Kanti, found that N exerted negative effect on the harvest index. In an experiment with the foliar application of nutrients on the growth and yield of mungbean cv. Kowmy-1.

Abd-El-Latif *et al.* (1998) revealed that application of urea increase the number of branches $plant^{-1}$ on mungbean plant.

Akhtaruzzaman (1998) conducted a field experiment on mungbean where plant height increased almost linearly up to 40 kg N ha^{-1} although response of 30 and 40 kg N ha^{-1} was identical.

Karle and Power (1998) examined the effect of varying levels of N and P fertilizers on summer mungbean. They reported that mungbean produced higher seed yield with the application of 15 kg N ha^{-1} and 40 kg P_2O_5 ha^{-1}.

Provorov *et al.* (1998) observed the effect of seed inoculation of mungbean with strain CIAMI 901 of Bradyrhizobium and found that the seed yield was increased by 39.2% and 1000 seed weight 16%. These results were equivalent to applying 120 kg N ha^{-1}. Best results obtained with inoculations + 60 kg N ha^{-1}.

Patra and Bhattacharyya (1997) observed that the highest seed yield and yield components were obtained by applied urea at the rate of 25 kg N ha^{-1}.

In a field experiment conducted by Satyanarayanamma*et al.* (1996), five mungbean cultivars were sprayed with 2% urea at pre-flowering, flowering, pod development or at all the combinations or at combination of two of three growth stages. They reported that spraying urea at flowering and pod development stages produced the highest seed yield.

Kaneria and Patel (1995) conducted a field experiment on mungbean cv. K 581 using 0 or 20 kg N ha^{-1} levels. They found that application of 20 kg N ha^{-1} significantly increased the seed yield.

Bachchhav*et al.* (1994) who found that application of 30 kg N ha^{-1} resulted in highest seed yield of mungbean.

Quah and Jafar (1994) noted that 1000 seed weight of mungbean increased significantly with 40 kg N ha^{-1}.

Santos (1993) carried out an experiment on mungbean cv. Berken grown in pots in podzolic soil with 7 levls of N (0,25,50,100,200,400,500 kgha^{-1}),applied as NH_4NO_3 and noted that application of N up to 200kg ha^{-1} increased the total dry matter,higher rates decreased it.

Patel *et al.* (1993) studied that, in summer season on clayey soil application of 0, 10, 20 and 30 kg N ha^{-1} significantly increased the number of pods plant^{-1}.

Ardeshana *et al.* (1993) conducted a field experiment on response of mungbean to nitrogen. Seed yield increased with the application of nitrogen fertilizer up to 20 kg N ha^{-1} in combination with phosphorus fertilizer up to 40 kg P_2O_5 ha^{-1}.

Gopala *et al.* (1993) found that the response of mungbean cultivars (PusaBaishakhi, LGG 407, LGG 410 and MS 267) to a uniform dose of 20 kg N $ha^{-1}$and found that plant height, net assimilation rate (NAR), crop growth rate (CGR), relative growth rate (RGR) were increased at 20 kg N ha^{-1}.

Chowdhury and Rosario (1992) studied the effect of 0, 30, 60 or 90 kg N ha^{-1} levels on the rate of growth and yield performance of mungbean at los Banos, Philippines in 1988. They observed that N above the rate of 30 kg N ha^{-1} reduced the dry matter yield.

Tank *et al.* (1992) reported that mungbean fertilized with 20 kg N ha^{-1} along with 75 kg P_2O_5 ha^{-1} significantly increased the number of pods per plant.

Agbenin*et al.* (1991) carried out a field experiment under glass house condition and found that nitrogen application significantly increased the dry matter yield of mungbean.

Suhartatik (1991) also reported that NPK fertilizers significantly increased the plant height of mungbean.

Sarkar and Banik (1991) conducted a field experiment to evaluate the effect of varying rates of N on mungbean. Results revealed that application of 10 kg N ha^{-1} resulted in the appreciable improvement in different yield attributes along with number of pods per plant and 1000 seed weight over control. Result also showed that application of N along with P significantly increased the seed yield of mungbean. The maximum seed yield was obtained with the combination of 20 kg N and 60 kg P_2O_5 ha^{-1}.

Leelavathi *et al.* (1991) reported that different levels of N showed significant difference in seed yield of mungbean up to a certain level.

Different varieties of mungbean differed significantly with respect to plant height was reported by Thakuria and Shaharia (1990).

Increase in plant height of mungbean at higher nitrogen levels may be ascribed to increase of N in chlorophyll which increased photosynthesis and enhanced meristematic activity of plant (Sawwar*et al.*, 1989).

Hamid (1988) conducted a field experiment to investigate the effect of nitrogen and carbon on the growth and yield performance of mungbean (Vigna radiate L. wilczek). He found that the plant height of mungbean cv. to be increased with nitrogen at 40 kg ha^{-1}.

Pongkao and Inthong (1988) applied N at the rate of 0-60 kg ha^{-1} on mungbean and reported that application of 15 kg N ha^{-1} was found to be superior giving 23% higher seed yield over the control.

Mahmoud and Gad (1988) observed that application of N increased the stover yield up to a certain level under different row spacing of mungbean.

Samiullah *et al*. (1987) recorded that number of seeds pod^{-1} were the highest with 10 kg N + 75 kg P_2O_5 + 60 kg K_2O in summer mungbean.

Patel and Parmer (1986) observed that increasing N application to rainfed mungbean (*Vigna radiata* cv. Gujrat-1) from 0-45 kg ha^{-1} increase average seed yield from 0.83 to 0.94 t ha^{-1} and also increased protein content, plant height, number of branches plant^{-1}, pods plant^{-1}, seeds plant^{-1} and 1000 seed weight.

Patel *et al.* (1984) showed that increased in the dose of nitrogen from 20 to 40 kg ha^{-1} at flowering improved grain yield from 39 to 89 percent over control. It is interesting to note that half dose of 20 kg ha^{-1} of nitrogen applied at sowing and remaining at the time of flowering gave higher yield than the application of 40 kg N ha^{-1} as basal in mungbean. It was also found that application of 30 kg N ha^{-1} along with 40 kg P_2O_5 ha^{-1} significantly increased the number of pods per plant.

Raju and Verma (1984) conducted a field experiment on response of mungbean var. Pusabaishaki to varying levels of nitrogen (15, 30, 45 and 60 kg N ha^{-1}) in the presence and absence of seed inoculation with Rhizobium. They found that maximum dry matter weight per plant was obtained by the application of 60 kg N ha^{-1} inoculated with Rhizobium.They also reported that application of 15-60 kg N ha^{-1} significantly increased seed yields of mungbean.

Trung and Yoshida (1983) conducted a field trial on mungbean in nutrient-rich soil, involving 0-100 ppm N as treatments. They observed that maximum plant height at all the stages of plant growth were obtained by the application of 25 ppm N.

In an experiment, Yein *et al.* (1981) applied nitrogen and phosphorus fertilizers to mungbean and reported that combined application of nitrogen and phosphorus fertilizers increased the number of pods per plant. The rate of nitrogen and phosphorus was 50 kg and 75 kg per hectare, respectively.

CHAPTER III

MATERIALS AND METHODS

This chapter deals with the materials and methods that were used in carrying out the experiment.

3.1 Location of the experimental field

The experiment was conducted at Research field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from March to June, 2016. The location of the experimental site was at $23^0 46^,$ N latitude and $90^0 22^,$ E longitudes with an elevation of 8.24 meter from sea level (Anon., 1989).

3.2 Climate of the experimental area

The experimental area is characterized by subtropical rainfall during the month of March to September and scattered rainfall during the rest of the year (Anon., 1988). Information regarding average monthly temperature as recorded by Bangladesh Meteorological Department (climate division) during the period of study has been presented in Appendix I.

3.3. Soil of the experimental field

Soil of the study site was silty clay loam in texture belonging to series. The area represents the Agro-Ecological Zone of Madhupur tract (AEZ No. 28) with pH 5.8-6.5, ECE-25.28 (Haider, 1991). The analytical data of the soil sample collected from the experimental area were determined in the Soil Resources Development Institute (SRDI), Soil Testing Laboratory, Khamarbari, Dhaka and have been presented in Appendix II.

3.4 Plant materials collection

The variety used in the experiment was "BARI Mung-6". This is a high yielding type variety. The seeds were collected from from the Pulse Research

Centre of Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.5 Characteristics of test variety

BARI Mung-6, a high yielding variety of mungbean was released by Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur in 2003. It is photo insensitive, short lifespan, 55 to 58 days require to mature and bold seeded crop. The special characteristic of this variety is it is a crop of almost synchronized maturity crop. It was developed from the NM-92 line introduced by AVRDC in 1992. Its yield potentiality is about 1.5 to 2 t ha^{-1}. This variety is resistant to yellow mosaic virus diseases, insects and pest attack (BARI, 2008).

3.6 Treatments of the experiment

The experiment consisted of two factors as follows:

Factor A: Three levels of GA_3 (Gibberellic acid)

G_0 = 0 ppm GA_3

G_1 = 50 ppm GA_3

G_2 = 100 ppm GA_3

Factor B: Four levels of Nitrogen

N_0 = Control (no urea)

N_1 = 22 kg urea ha^{-1} (10.12 kg N ha^{-1})

N_2 = 44 kg urea ha^{-1} (20.24 kg N ha^{-1})

N_3 = 66 kg urea ha^{-1} (30.36 kg N ha^{-1})

There were altogether 12 treatment combinations used in each block which were as follows:

G_0N_0, G_0N_1, G_0N_2, G_0N_3, G_1N_0, G_1N_1, G_1N_2, G_1N_3, G_2N_0, G_2N_1, G_2N_2, G_2N_3.

3.7 Design and layout of the experiment

The experiment was laid out in Randomized Complete Block Design (RCBD) having two factors with three replications. An area of 19.5 m x 10 m was divided into three equal blocks. Each block were consisted of 12 plots where 12 treatments were allotted randomly. There were 36 unit plots in the experiment. The size of each plot was 2 m x 1 m. The distance between two blocks and two plots were kept 1 m and 0.5 m respectively.

3.8 Cultivation procedure

3.8.1 Land preparation

The soil was well prepared and good tilth that was ensured for commercial crop production. The land of the experimental field was ploughed with a power tiller on First week of March, 2016. Later on the land was ploughed three times followed by laddering to obtain desirable tilth. The corners of the land were spaded and larger clods were broken into smaller pieces. After ploughing and laddering, all the stubbles and uprooted weeds were removed and then the land was made ready. The field layout and design was followed after land preparation.

3.8.2 Fertilizers application

Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MoP) were used as a source of nitrogen, phosphorous and potassium respectively. The recommended dose of urea at the rate of 50 kg ha^{-1}. Urea was applied as per treatment in three split doses. MoP was applied as basal at the rate of 35 kg per hectare, during the final land preparation. TSP was applied during the final land preparation at the rate of 80 kg ha^{-1} . The fertilizers were then mixed well with the soil by spading and individual unit plots were leveled.

3.8.3 Application and preparation of GA_3

The stock solution of 1000 ppm of GA_3 was made by mixing of 1 g of GA_3 with small amount of ethanol to dilute and then mixed in 1 litre of distilled water. Then as per requirement of 50 ppm and 100 ppm solution of GA_3, 50 and 100 ml of stock solution were mixed with 1 litre of distilled water respectively. Application of GA_3 were done at 15 days interval and were applied at 24 and 39 days after sowing.

3.8.4 Sowing of seeds in the field

Seeds were sown on the furrow on 16 March, 2016 and the furrows were covered by soils soon after seeding. Seeds were treated with Bavistin before sowing the seeds to control the seed borne disease. The seeds were sown continuously in line to line distance of 30 cm and plant to plant distance of 10 cm at about 2-3 cm depth in afternoon and covered with soil.

3.9 Intercultural operations

3.9.1 Thinning and weeding

Thinning and weeding were done at 20 days after sowing (DAS) when the plant attained at a height of about 10 cm. Plant to plant distance was maintained at 6-7 cm. Second weeding was done at 35 DAS when the plants attained about 15-20 cm height.

3.9.2 Irrigation

The field was irrigated twice- one at 15 days and the other one at 30 days after sowing.

3.9.3 Protection against insect and pest

At early stage of growth few worms (*Agrotisipsilon)* and virus vectors (jassid) attacked the young plants and at latter stage of growth pod borer (*Marucatestulalis*) attacked the plant. Dimecron 50 EC was sprayed at the rate of 1litre ha^{-1} to control these insects.

3.10 Harvest and post harvest operations

Harvesting was done when 90% of the pods became brown to black in color. The matured pods were collected by hand picking from a pre-demarcated area of 1 m^2 at the center of each plot.

3.11 Crop sampling and data collection

Ten (10) plants were selected randomly from each plot and were uprooted for data recording. The data of plant height, number of branches, number of flowers, and leaves per plant were recorded from sampled plants at an interval of ten days which was started from 20 DAS.

3.11.1 Plant height

The plant height was measured from the ground level to the top. Height of 10 plants randomly from each plot were measured. It was done at the ripening stage of the crop.

3.11.2 Number of leaves

The number of leaves per plant was manually counted at 20, 30, 40, 50 and 60 days after sowing from randomly selected tagged plants. The average of ten plants were computed and expressed in average number of leaves per plant.

3.11.3 Number of branches

The number of branches per plant was manually counted at 50 and 60 days after sowing from randomly selected tagged plants. The average of ten plants were computed and expressed in average number of branch per plant.

3.11.4 Number of inflorescences

The number of inflorescences per plant was manually counted at 50 and 60 days after sowing from randomly selected tagged plants. The average of ten plants were computed and expressed in average number of branch per plant.

3.11.5 Number of flowers

The number of flowers inflorescences^{-1} was manually counted at 50 and 60 days after sowing from randomly selected tagged plants. The average of ten plants were computed and expressed in average number of branch per plant.

3.11.6 Number of pods

Pods were counted at the ripening stage. Pods of 10 plants randomly from each plot were counted and averaged.

3.11.7 Pod length

Length of 10 pods from each plot were measured randomly and averaged after harvesting.

3.11.8 Number of seeds

It was done after harvesting. At first, number of seeds pod^{-1} was counted. Seeds of 10 pods randomly from each plot were counted and averaged.

3.11.9 Thousand seeds weight

Thousand seeds of mungbean were counted randomly and then weighed plot wise.

3.11.10 Number of nodule

It was done after harvesting. At first, number of nodule plant^{-1} was counted. Nodule of 5 plants randomly from each plot were counted and averaged.

3.11.11 Dry matter content of plant

After harvesting, randomly selected 100 gram of plant sample previously sliced into very thin pieces. The plant were then dried in the sun for one day and placed in oven maintained at 80.2 ^{0}C for 48 hrs. The sample was then transferred into desiccators and allowed to cool down to the room temperature. The final weight of the sample was taken. The dry matter was calculation by the following formula:

$$\text{Dry matter of plant (\%)} = \frac{\text{Dry weight of plant}}{\text{Fresh weight of fruit}} \times 100$$

3.11.12 Chlorophyll content of leaf

The Chlorophyll percentage of leaf of the plant was measured by a SPAD meter, a product of Konica Minolta Sensing Ltd, Singapore (Appendix XVI), at 60 days after sowing from randomly selected ten tagged plants. This machine gives the direct calculated value of the chlorophyll percentage of leaf of the plant. The Chlorophyll percentage of ten tagged leaves of each plant was measured and calculated the average Chlorophyll percentage of leaf of each plant of ten sample plants.

3.11.13 Seed yield

Seeds obtained from 1m^2 area from the center of each unit plot was dried, weighted carefully and then converted into t ha^{-1}.

3.11.14 Stover yield

Stover obtained from each individual plot was dried, weighed carefully and the yield expressed in t ha^{-1}.

3.11.15 Nitrogen content

The N concentration was determined by Semi–micro Kjeldahl method as described as: One gram of oven dry plant soil sample was taken into micro kjeldahl flask to which 1.1 g catalyst mixture (K_2SO_4: $CuSO_4.5H_2O$: Se=100: 10: 1), 2 mL 30% H_2O_2 and 5 mL H_2SO_4 were added. The flasks were swirled and allowed to stand for about 10 minutes. Then heating was continued until the digest was clear and colorless. After cooling, the content was taken into 100 mL volumetric flask and the volume was made up to the mark with distilled water. A reagent blank was prepared in a similar manner. These digest was used for nitrogen determination. After completion of digestion, 40% NaOH was added with the digest for distillation. The evolved ammonia was trapped into 4% H_3BO_3 solution and 5 drops of mixed indicator of bromocressol green ($C_{21}H_{14}O_5Br_4S$) and methyl red ($C_{10}H_{10}N_3O_3$) solution. Finally the distillate was titrated with standard 0.01 NH_2SO_4 until the color changed from green to pink (Tecator, 1982). The amount of N was calculated using the following formula:

$$\% \text{ N} = \frac{(\text{T}-\text{B})\times\text{N}\times0.014\times100}{\text{S}}$$

Where, T= Sample titration value (mL) of standard H_2SO_4

B= Blank titration value (mL) of standard H_2SO_4

N = Strength of H_2SO_4

S= Sample weight in gram

3.11.16 Protein content

The amount of protein content (%) was calculated using the following formula:

Protein content (%) = Nitrogen content (%) X 6.25

Where,

6.25= Convertion factor

3.12 Statistical analysis

The recorded data on various parameters were statistically analyzed using MSTAT-C statistical package program. The mean for all the treatments was calculated and analysis of variance for all the characters were performed by F-Difference between treatment means were determined by LSD method according to Gomez and Gomez, (1984) at 5% level of significance.

CHAPTER IV

RESULTS AND DISCUSSION

The present study was conducted to find out the effect of GA_3 and nitrogen on growth yield and protein content of mungbean. Data on different growth and yield contributing characters were recorded. The analysis of variance (ANOVA) of the data on different growth and yield parameters are given in Appendix (III-VIII). The results have been presented and discussed with the help of tables and graphs and possible interpretations were given under the following headings:

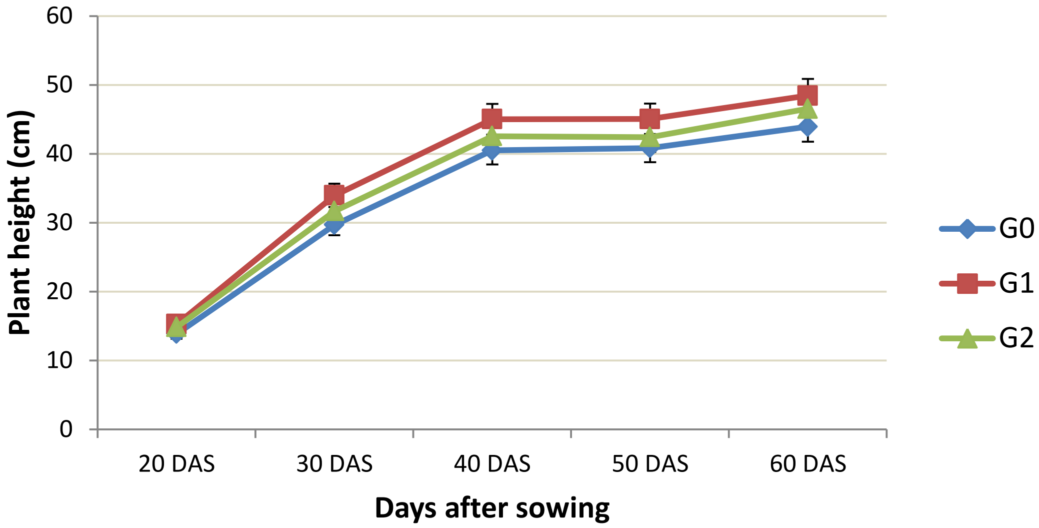
4.1 Plant height

The significant difference in plant height of BARI Mung-6 was observed due to the application of GA_3 at 30, 40, 50 and 60 DAS except 20 DAS (Appendix III). At 20, 30, 40, 50 and 60 DAS the maximum plant height (15.26 cm, 33.95 cm, 45.01 cm, 45.04 cm and 48.43 cm) was recorded from G_1 (50 ppm GA_3) treatment. On the other hand, at 20, 30, 40, 50 and 60 DAS minimum plant height (13.88 cm, 29.68 cm, 40.48 cm, 40.84 cm and 43.94 cm) was recorded from G_0(control) treatment (Fig 1). Azadi *et al* (2013) and Mainul *et al.* (2014) observed the similar results.

In case of nitrogen application significant difference was observedat 30, 40, 50 and 60 DAS except 20 DAS (Appendix III). At 20, 30, 40, 50 and 60 DAS the maximum plant height (15.21 cm, 34.30 cm, 45.07 cm, 45.14 cm and 48.09 cm) was obtained from N_2 (44 kg urea ha^{-1}) treatment. On the other hand, at 20, 30, 40, 50 and 60 DAS minimum plant height (13.23 cm, 27.99 cm, 38.08 cm,38.69 cm and 41.92 cm) was recorded from N_0 (control) treatment (Fig 2).

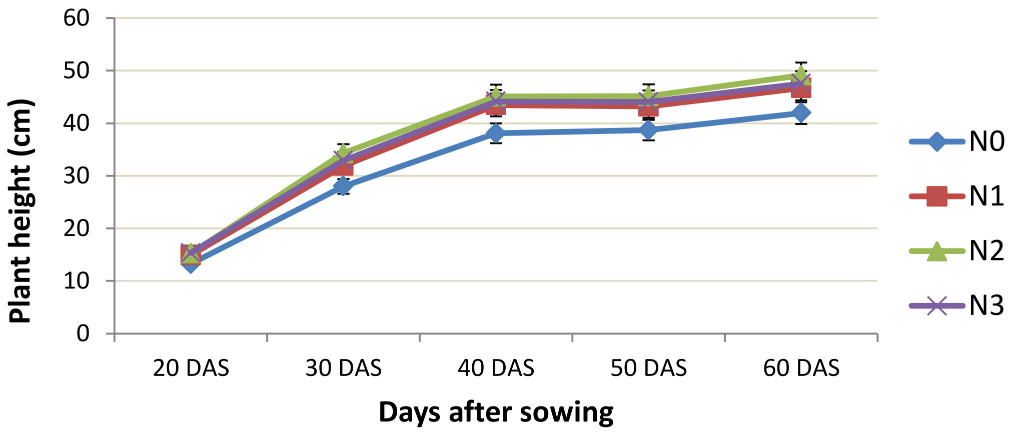
The significant difference was observed due to the interaction effect of different GA_3 and nitrogen application at 30, 40, 50 and 60 DAS except 20 DAS (Appendix III). At 20, 30, 40, 50 and 60 DAS the maximum plant height

(16.74 cm, 38.17 cm, 48.25 cm, 49.02 cm and 52.80 cm) was recorded from G_1N_2(50 ppm GA_3 and 44 kg urea ha^{-1}) treatment combination. On the other hand, at 20, 30, 40, 50 and 60 DAS minimum plant height (12.96 cm, 27.08 cm, 37.11 cm, 38.42 cm and 41.27 cm) was recorded from G_0N_0 (control) treatment combination (Table 1).



G_0: 0 ppm GA_3, G_1: 50 ppm GA_3, G_2: 100 ppm GA_3

Fig 1. Effect of GA_3 on plant height of mungbean at different days after sowing (DAS)



N_0: Control, N_1: 22 kg urea ha^{-1}, N_2: 44 kg urea ha^{-1}, N_3: 66 kg urea ha^{-1}

Fig 2. Effect of nitrogen on plant height of mungbean at different days after sowing (DAS)

Table 1. Combined effect of GA_3 and nitrogen on plant height of mungbean at different days after sowing (DAS)

Treatment	Plant Height (cm)				
	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS
G_0N_0	12.96 e	27.08 i	37.11 g	38.42 g	41.27 e
G_0N_1	13.86cde	29.61fgh	40.95 ef	40.96 efg	43.27 de
G_0N_2	14.75bcd	31.36def	42.41cde	42.36 de	46.40bcd
G_0N_3	13.97cde	30.68efg	41.45 de	41.62def	44.83cde
G_1N_0	13.18 e	28.02 hi	38.35 g	38.76fg	42.06 e
G_1N_1	15.83 ab	34.21bc	46.25 ab	45.62bc	49.13ab
G_1N_2	16.74 a	38.17 a	48.25 a	49.02 a	52.80 a
G_1N_3	15.29bc	35.41 b	47.21 a	46.76 ab	49.72 ab
G_2N_0	13.55 de	28.88ghi	38.78fg	38.89fg	42.43 de
G_2N_1	15.06bc	31.87cdef	43.21cde	42.96 cde	47.63 bc
G_2N_2	15.59ab	33.38bcd	44.55 bc	44.06 bcd	48.06bc
G_2N_3	15.21bc	32.64cde	43.71 cd	43.76 bcde	48.06bc
LSD $_{(0.05)}$	**0.69**	**1.15**	**2.40**	**3.07**	**4.04**
CV %	**5.77**	**4.66**	**5.33**	**4.25**	**5.16**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

G_0: 0 ppm GA_3, G_1: 50 ppm GA_3, G_2: 100 ppm GA_3, N_0: Control (no urea), N_1: 22 kg urea ha^{-1}, N_2: 44 kg urea ha^{-1}, N_3: 66 kg urea ha^{-1}

4.2Number of leaves

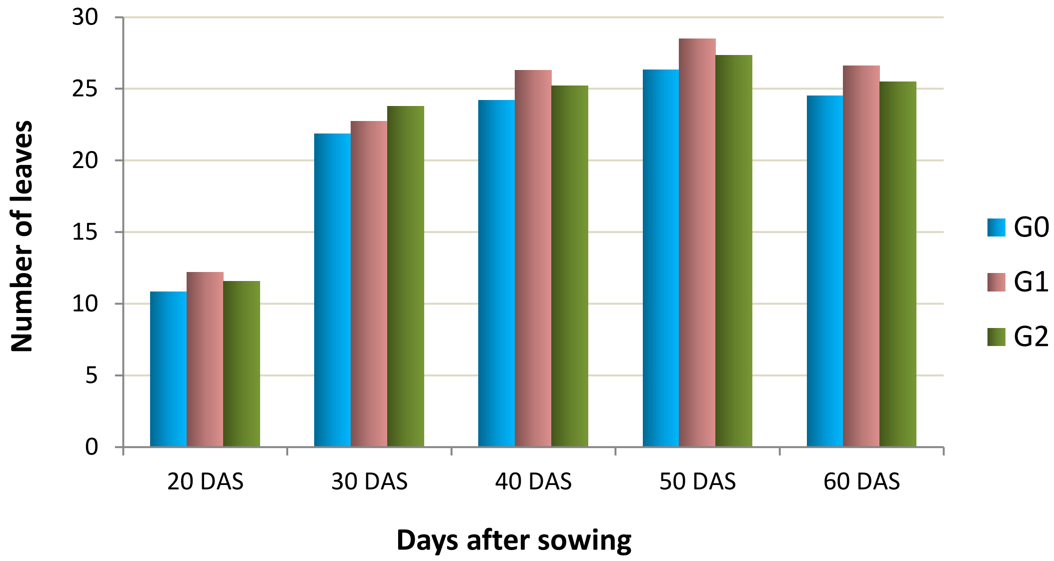
The significant difference was observed in number of leaves $plant^{-1}$due to the application of GA_3 at 30, 40, 50 and 60 DAS except 20 DAS (Appendix IV). At 30 DAS the maximum number of leaves per plant (23.77) was obtained from G_2 (100 ppmGA_3) treatment and at 20, 40, 50 and 60 DAS, the highest number of leaves per plant (12.20, 26.29, 28.48 and 26.60) was recorded from G_1 (50 ppmGA_3) treatment. On the other hand, at 20, 30, 40, 50 and 60 DAS minimum number of leaves per plant (10.85, 21.86,24.20,26.33 and 24.50) was recorded from G_0(control) treatment (Fig 3). Mainul *et al.* (2014) supported the results.

In case of nitrogen application significant difference was observedat 30, 40, 50 and 60 DAS except 20 DAS(Appendix IV). At 20 and 30 DAS the maximum number of leaves per plant (12.48 and 23.83) was obtained from N_3 (66 kg urea ha^{-1}) treatment and at 40, 50 and 60 DAS the maximum number of leaves per plant (26.60, 28.94 and 27.11) was obtained from N_2 (44 kg urea ha^{-1}) treatment. On the other hand, at 20, 30, 40, 50 and 60 DAS minimum number of leaves per plant (10.21, 21.36, 23.40, 25.18 and 23.37) was recorded from N_0 (control) treatment (Fig 4).

The significant difference was observed due to the interaction effect of different GA_3 and nitrogen application at 30, 40, 50 and 60 DAS except 20 DAS (Appendix IV). At 20 and 30 DAS the maximum number of leaves per plant (13.740 and 25.84) was obtained from G_1N_3 (50 ppm GA_3 and 66 kg urea ha^{-1}) treatment combination and at 40, 50 and 60 DAS, the highest number of leaves per plant (28.77, 31.06 and 29.12) was recorded from G_1N_2 (50 ppm GA_3 and 44 kg urea ha^{-1}) treatment combination. On the other hand at 20 DAS, 30, 40, 50 and 60 DAS minimum number of leaves per plant (9.79, 2.51, 23.00, 24.49 and 22.96) was recorded from G_0N_0 (control) treatment combination (Table 2).

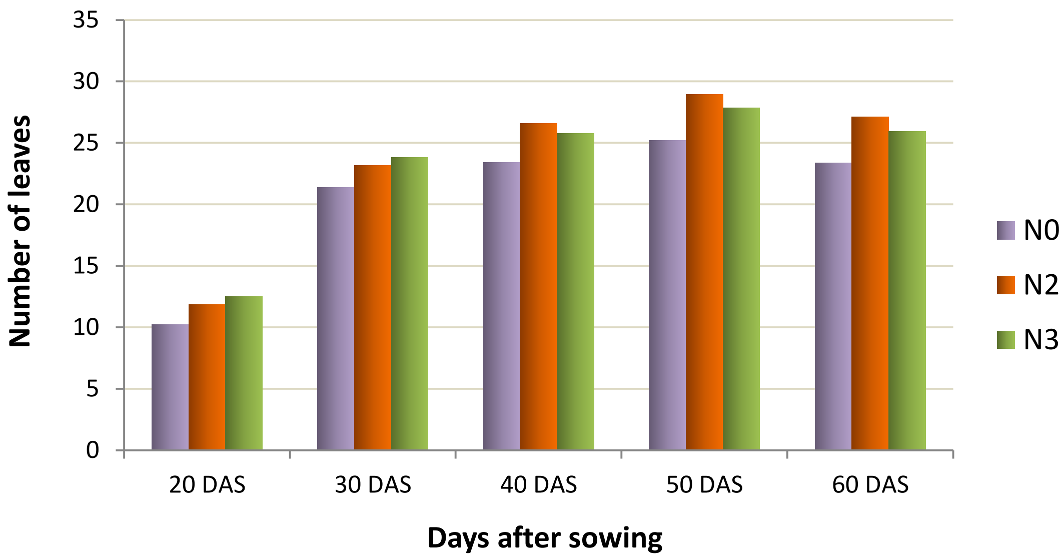
4.3 Number of branches

The number of branches $plant^{-1}$ varied significantly due to the application of GA_3 (Appendix V). The maximum number of branches per plant (2.75) was obtained from G_2 (100 ppm GA_3) treatment which is statistically identical to G_1 treatment and followed by (2.70) G_1 treatment. On the other hand, the minimum number of branches per plant (2.31) was recorded from G_0 (control) treatment (Table 3).These results are similar to that of Mainul *et al.* (2014)



G_0: 0 ppm GA_3, G_1: 50 ppm GA_3, G_2: 100 ppm GA_3

Fig 3. Effect of GA_3 on number of leaves per plant of mungbean at different days after sowing (DAS)



N_0: Control, N_1: 22 kg urea ha^{-1}, N_2: 44 kg urea ha^{-1}, N_3: 66 kg urea ha^{-1}

Fig 4. Effect of nitrogen on number of leaves per plant of mungbean at different days after sowing (DAS)

Table 2. Combined effect of GA_3 and nitrogen on number of leaves per plant of mungbean at different days after sowing (DAS)

Treatment	Number of leaves per plant				
	20 DAS	**30 DAS**	**40 DAS**	**50 DAS**	**60 DAS**
G_0N_0	9.79 h	20.51 h	23.00 h	24.49 g	22.96 g
G_0N_1	10.83 f	22.11 efg	24.23ef	26.56 e	24.66 e
G_0N_2	11.63 de	22.51def	25.10 d	27.56 d	25.69 d
G_0N_3	11.16ef	22.34efg	24.47 e	26.69 e	24.69 e
G_1N_0	10.23 gh	21.64 g	23.43gh	25.33 f	23.39fg
G_1N_1	12.23 bc	23.51 bc	26.03 c	28.53 bc	26.81 b
G_1N_2	12.59 b	24.11 b	28.77 a	31.06 a	29.12 a
G_1N_3	13.74 a	25.84 a	26.93 b	29.03 b	27.09 b
G_2N_0	10.63fg	21.94fg	23.77fg	25.73 f	23.77 f
G_2N_1	11.83 cd	22.77 de	25.23 d	27.63 d	25.72 d
G_2N_2	12.06bcd	23.14 cd	25.93 c	28.19 cd	26.52bc
G_2N_3	11.83 cd	23.11 cd	25.90 c	27.81 cd	25.99 cd
LSD $_{(0.05)}$	**0.58**	**0.72**	**0.54**	**0.73**	**0.64**
CV %	**5.00**	**6.18**	**7.29**	**6.59**	**7.48**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

G_0: 0 ppm GA_3, G_1: 50 ppm GA_3, G_2: 100 ppm GA_3, N_0: Control (no urea), N_1: 22 kg urea ha^{-1}, N_2: 44 kg urea ha^{-1}, N_3: 66 kg urea ha^{-1}

In case of nitrogen application significant difference was found (Appendix V). The maximum number of branches per plant (2.81) was obtained from N_2 (44 kg urea ha^{-1}) treatment which is statistically identical to N_1 and N_3 treatment. On the other hand the minimum number of branches per plant (2.11) was recorded from N_0 (control) treatment (Table 4).

The significant difference was observed due to the interaction effect of different GA_3 and nitrogen application (Appendix V). The maximum number of branches per plant (3.02) was obtained from G_1N_2 (50 ppm GA_3 and 44 kg urea ha^{-1}) treatment combination which is statistically identical to G_1N_3 treatment combination. On the other hand, the minimum number of branches per plant (1.88) was recorded from G_0N_0 (control) treatment combination (Table 5).

4.4 Number of inflorescence

The significant difference was observed in no. of inflorescences $plant^{-1}$due to the application of GA_3 (Appendix V). The maximum number of inflorescences $plant^{-1}$(8.63) was obtained from G_1 (50 ppm GA_3) treatment and followed by (7.75) G_2 treatment. On the other hand, the minimum number of inflorescences $plant^{-1}$ (7.02) was recorded from G_0 (control) treatment (Table 3).

In case of nitrogen application significant difference was found (Appendix V). The maximum number of inflorescences $plant^{-1}$ (8.48) was obtained from N_2 (44 kg urea ha^{-1}) treatment and followed by (8.19) N_3 treatment. On the other hand the minimum number of inflorescences $plant^{-1}$ (6.62) was recorded from N_0 (control) treatment (Table 4).

The significant difference was observed due to the interaction effect of different GA_3 and nitrogen application (Appendix V). The maximum number of inflorescences $plant^{-1}$ (9.59) was obtained from G_1N_2 (50 ppm GA_3 and 44 kg urea ha^{-1}) treatment combination. On the other hand, the minimum number of inflorescences $plant^{-1}$(6.09) was recorded from G_0N_0 (control) treatment combination (Table 5).

4.5 Number of flowers

Number of flowers $inflorescences^{-1}$ showed significant variation due to the application of GA_3 (Appendix V). The maximum number of flowers $inflorescences^{-1}$ (9.02) was obtained from G_1 (50 ppm GA_3) treatment and followed by (7.44) G_2 treatment. On the other hand, the minimum number of flowers inflorescences^{-1} (5.85) was recorded from G_0(control) treatment (Table 3).

Table 3. Effect of GA_3 on number of branches plant^{-1}, number of inflorescence plant^{-1} and number of flowers inflorescence^{-1} of mungbean

Treatment	**Number of branches plant^{-1}**	**Number of inflorescence plant^{-1}**	**Number of flowers inflorescence^{-1}**
G_0	2.31 b	7.02 c	5.85 c
G_1	2.70 a	8.63 a	9.02 a
G_2	2.75 a	7.75 b	7.44 b
LSD $_{(0.05)}$	**0.20**	**0.22**	**0.59**
CV %	**9.54**	**6.44**	**9.43**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

G_0: 0 ppm GA_3, G_1: 50 ppm GA_3, G_2: 100 ppm GA_3

Table 4. Effect of nitrogen on number of branches plant^{-1}, number of inflorescence plant^{-1} and number of flowers inflorescence^{-1} of mungbean

Treatment	**Number of branches plant^{-1}**	**Number of inflorescence plant^{-1}**	**Number of flowers inflorescence^{-1}**
N_0	2.11 b	6.62 d	5.19 c
N_1	2.67 a	7.91 c	7.52 b
N_2	2.81 a	8.48 a	9.19 a
N_3	2.68 a	8.19 b	7.85 b
LSD $_{(0.05)}$	**0.23**	**0.26**	**0.68**
CV %	**9.54**	**6.44**	**9.43**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

N_0: Control (no urea), N_1: 22 kg urea ha^{-1}, N_2: 44 kg urea ha^{-1}, N_3: 66 kg urea ha^{-1}

Table 5. Combined effect of GA_3 and nitrogen on number of branches plant^{-1}, number of inflorescence plant^{-1} and number of flowers inflorescence^{-1} of mungbean

Treatment	Number of branches plant^{-1}	Number of inflorescence plant^{-1}	Number of flowers inflorescence^{-1}
G_0N_0	1.88 f	6.09 h	4.52 f
G_0N_1	2.38 cde	7.09fg	5.85 de
G_0N_2	2.63 a-d	7.56 e	6.85 cd
G_0N_3	2.363 de	7.36 ef	6.19 de
G_1N_0	2.01 ef	6.82 g	5.52 ef
G_1N_1	2.81ab	8.96 b	9.19 b
G_1N_2	3.02 a	9.59 a	11.52 a
G_1N_3	2.99 a	9.16 ab	9.85 b
G_2N_0	2.45bcd	6.96fg	5.52ef
G_2N_1	2.83 ab	7.69 de	7.52 c
G_2N_2	2.78 abc	8.29 c	9.19 b
G_2N_3	2.70 a-d	8.06 cd	7.52 c
LSD $_{(0.05)}$	**0.41**	**0.45**	**1.18**
CV %	**9.54**	**6.44**	**9.43**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

G_0: 0 ppm GA_3, G_1: 50 ppm GA_3, G_2: 100 ppm GA_3, N_0: Control (no urea), N_1: 22 kg urea ha^{-1}, N_2: 44 kg urea ha^{-1}, N_3: 66 kg urea ha^{-1}

In case of nitrogen application significant difference was found for the parameter number of flowers inflorescence^{-1}(Appendix V). The maximum number of flowers inflorescence^{-1} (9.19) was obtained from N_2 (44 kg urea ha^{-1}) treatment and followed by (7.85) N_3 treatment which is statistically identical to N_1 treatment. On the other hand the minimum number of flowers inflorescence^{-1} (5.19) was recorded from N_0 (control) treatment (Table 4).

The significant difference was observed due to the interaction effect of different GA_3 and nitrogen application (Appendix V). The maximum number of flowers inflorescences^{-1} (11.52) was obtained from G_1N_2 (50 ppm GA_3 and 44 kg urea ha^{-1}) treatment combination. On the other hand, the minimum number of flowers inflorescences^{-1} (4.52) was recorded from G_0N_0 (control) treatment combination (Table 5).

4.6 Number of pods

Number of pods plant^{-1}varied significantly due to the application of GA_3 (Appendix VI). The maximum number of pods plant^{-1} (107.52) was obtained from G_1 (50 ppm GA_3) treatment and followed by (93.27) G_2 treatment. On the other hand, the minimum number of pods plant^{-1} (77.02) was recorded from G_0(control) treatment (Table 6). These results followed the findings of Hossen *et al.* (2015)

In case of nitrogen application significant difference was found (Appendix VI). The maximum number of pods plant^{-1} (108.94) was obtained from N_2 (44 kg urea ha^{-1}) treatment which is statistically identical to N_3 treatment and followed by (92.38) N_1 treatment. On the other hand the minimum number of pods plant^{-1} (65.49) was recorded from N_0 (control) treatment (Table 7).

The significant difference was observed due to the interaction effect of different GA_3 and nitrogen application (Appendix VI). The maximum number of pods plant^{-1} (132.27) was obtained from G_1N_2 (50 ppm GA_3 and 44 kg urea ha^{-1}) treatment combination which is statistically identical to G_1N_3 treatment combination. On the other hand, the minimum number of pods plant^{-1} (56.27) was recorded from G_0N_0 (control) treatment combination (Table 8).

4.7 Number of seeds

Due to the application of GA_3 the number of pods plant^{-1} varied significantly (Appendix VI). The maximum number of number of seeds pod^{-1}(9.97) was found from G_1 (50 ppm GA_3) treatment and followed by (9.42) G_2 treatment. On the other hand, the minimum number of number of seeds pod^{-1}(9.07) was recorded from G_0 (control) treatment (Table 6).Hossen *et al.* (2015) and Mainul *et al.* (2014) found similar results in their experiments.

In case of nitrogen application significant difference was found (Appendix VI). The maximum number of number of seeds pod^{-1}(10.14) was obtained from N_2 (44 kg urea ha^{-1}) treatment and followed by (9.75) N_3 treatment which is statistically identical to N_1 treatment. On the other hand the minimum number of number of seeds pod^{-1}(8.50) was found from N_0 (control) treatment (Table 7).

The significant difference was observed due to the interaction effect of different GA_3 and nitrogen application (Appendix VI). The maximum number of number of seeds pod^{-1}(11.30) was obtained from G_1N_2 (50 ppm GA_3 and 44 kg urea ha^{-1}) treatment combination. On the other hand, the minimum number of number of seeds pod^{-1}(8.27) was recorded from G_0N_0 (control) treatment combination (Table 8).

4.8 Pod length

Pod length varied significantly due to the application of GA_3 (Appendix VI). The longest pod length (8.24 cm) was found from G_2 (100 ppm GA_3) treatment and followed by (8.09 cm) G_1 treatment. On the other hand, the shortest pod length (7.87 cm) was recorded from G_0 (control) treatment (Table 6).Hossen *et al.* (2015) and Mainul *et al.*(2014) found similar findings in their researches.

In case of nitrogen application significant difference was found (Appendix VI). The maximum pod length (68.33 cm) was obtained from N_3 (66 kg urea ha^{-1}) treatment and followed by (8.21 cm) N_2 treatment which is statistically identical to N_1 treatment. On the other hand the minimum pod length (7.58 cm) was found from N_0 (control) treatment (Table 7).

The significant difference was observed due to the interaction effect of different GA_3 and nitrogen application (Appendix VI). The maximum pod length (8.58 cm) was obtained from G_2N_3 (100 ppm GA_3 and 66 kg urea ha^{-1}) treatment combination. On the other hand, the minimum pod length (7.48 cm) was recorded from G_0N_0 (control) treatment combination (Table 8).

Table 6. Effect of GA_3 on number pods plant^{-1}, number of seeds pod^{-1} and pod length of mungbean

Treatment	Number pods plant^{-1}	Number of seeds pod^{-1}	Pod length (cm)
G_0	77.02 c	9.07 c	7.87 c
G_1	107.52 a	9.97 a	8.09 b
G_2	93.27 b	9.42 b	8.24 a
LSD $_{(0.05)}$	**7.38**	**0.25**	**0.08**
CV %	**9.42**	**6.23**	**7.20**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

G_0: 0 ppm GA_3, G_1: 50 ppm GA_3, G_2: 100 ppm GA_3

Table 7. Effect of nitrogen on number pods plant^{-1}, number of seeds pod^{-1} and pod length of mungbean

Treatment	Number pods plant^{-1}	Number of seeds pod^{-1}	Pod length (cm)
N_0	65.49 c	8.50 c	7.58 c
N_1	92.38 b	9.54 b	8.14 b
N_2	108.94 a	10.14 a	8.21 b
N_3	103.60 a	9.75 b	8.33 a
LSD $_{(0.05)}$	**8.53**	**0.29**	**0.09**
CV %	**9.42**	**6.23**	**7.20**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

N_0: Control (no urea), N_1: 22 kg urea ha^{-1}, N_2: 44 kg urea ha^{-1}, N_3: 66 kg urea ha^{-1}

Table 8. Combined effect of GA_3 and nitrogen on number pods plant^{-1}, number of seeds pod^{-1} and pod length of mungbean

Treatment	Number pods plant^{-1}	Number of seeds pod^{-1}	Pod length (cm)
G_0N_0	56.27 g	8.27 g	7.48 h
G_0N_1	75.60ef	9.23 de	7.87 f
G_0N_2	90.60 cd	9.43 cd	8.16 de
G_0N_3	85.60 de	9.33 de	7.99ef
G_1N_0	66.60fg	8.40fg	7.60gh
G_1N_1	107.60 b	9.90bc	8.38bc
G_1N_2	132.27 a	11.30 a	8.23 cd
G_1N_3	123.60 a	10.30 b	8.42 ab
G_2N_0	73.60ef	8.83ef	7.67 g
G_2N_1	93.94 bcd	9.50 cd	8.18 d
G_2N_2	103.94 bc	9.70 cd	8.27bcd
G_2N_3	101.60bc	9.63 cd	8.58 a
LSD $_{(0.05)}$	**14.77**	**0.51**	**0.16**
CV %	**9.42**	**6.23**	**7.20**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

G_0: 0 ppm GA_3, G_1: 50 ppm GA_3, G_2: 100 ppm GA_3, N_0: Control (no urea), N_1: 22 kg urea ha^{-1}, N_2: 44 kg urea ha^{-1}, N_3: 66 kg urea ha^{-1}

4.9 1000-seed weight

The significant difference was observed in 1000-seed weight(g) due to the application of GA_3 (Appendix VII). The maximum 1000-seed weight (47.04g) was found from G_2 (100 ppm GA_3) treatment which is statistically identical to G_1. On the other hand, the minimum 1000-seed weight (45.37g) was recorded from G_0 (control) treatment (Table 9).The findings are in agreement with the findings of Hossen *et al.* (2015) and Mainul *et al.* (2014).

In case of nitrogen application significant difference was found (Appendix VII). The maximum 1000-seed weight (47.22g) was obtained from N_2 (44 kg urea ha^{-1}) treatment which is statistically identical to N_3. On the other hand the minimum 1000-seed weight (44.34g) was found from N_0 (control) treatment which is statistically identical to N_1 treatment (Table 10).

The significant difference was observed due to the interaction effect of different GA_3 and nitrogen application (Appendix VII). The maximum 1000-seed weight (47.92g) was obtained from G_1N_2(50 ppm GA_3 and 44 kg urea ha^{-1}) treatment combination which is statistically similar to G_0N_2, G_0N_3,G_1N_1, G_1N_3, G_2N_1, G_2N_2 andG_2N_3treatment combination. On the other hand, the minimum 1000-seed weight (43.25 g) was recorded from G_0N_0(control) treatment combination (Table 11).

4.10 Number of nodule

There was significant difference in number of nodule $plant^{-1}$ due to the application of GA_3 (Appendix VII). The maximum number of number of nodule $plant^{-1}$(6.17) was found from G_2 (100 ppm GA_3) treatment and followed by (5.67) G_1 treatment. On the other hand, the minimum number of number of nodule $plant^{-1}$(5.17) was recorded from G_0 (control) treatment (Table 9).Amin *et al.* (2015) supported the results.

In case of nitrogen application significant difference was found (Appendix VII). The maximum number of nodule $plant^{-1}$ (6.22) was obtained from N_2 (44 kg urea ha^{-1}) treatment which is statistically identical to N_1 and N_3 treatment. On the other hand the minimum number of nodule $plant^{-1}$(4.89) was found from N_0 (control) treatment (Table 10).

Number of nodule $plant^{-1}$ also varied significantly due to the interaction effect of different GA_3 and nitrogen application (Appendix VII). The maximum number of number of nodule $plant^{-1}$(6.67) was obtained from G_1N_2 (50 ppm GA_3 and 44 kg urea ha^{-1}) treatment combination which is statistically identical to G_1N_1 and G_1N_3 treatment combination. On the other hand, the minimum number of number of nodule $plant^{-1}$(4.67) was recorded from G_0N_0 (control) treatment combination (Table 11).

Table 9. Effect of GA_3 on 1000-seed weight, number of nodule plant^{-1}, dry matter content of plant and chlorophyll content of mungbean

Treatment	1000-seed weight (g)	Number of nodule plant^{-1}	Dry matter content of plant (%)	Chlorophyll content (%)
G_0	45.37 b	5.17 c	11.90 a	48.73 c
G_1	46.66 a	5.67 b	9.31 c	52.75 a
G_2	47.04 a	6.17 a	10.51 b	51.57 b
LSD $_{(0.05)}$	**0.94**	**0.41**	**0.41**	**0.61**
CV %	**7.41**	**8.68**	**4.60**	**9.41**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

G_0: 0 ppm GA_3, G_1: 50 ppm GA_3, G_2: 100 ppm GA_3

Table 10. Effect of nitrogen on 1000-seed weight, number of nodule plant^{-1}, dry matter content of plant and chlorophyll content of mungbean

Treatment	1000-seed weight (g)	Number of nodule plant^{-1}	Dry matter content of plant (%)	Chlorophyll content (%)
N_0	44.34 b	4.89 b	8.61 c	46.74 d
N_1	45.87 b	5.78 a	10.54 b	51.53 c
N_2	47.22 a	6.22 a	10.91 b	52.32 b
N_3	47.00 a	5.78 a	12.24 a	53.47 a
LSD $_{(0.05)}$	**1.09**	**0.48**	**0.47**	**0.70**
CV %	**7.41**	**8.68**	**4.60**	**9.41**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

N_0: Control (no urea), N_1: 22 kg urea ha^{-1}, N_2: 44 kg urea ha^{-1}, N_3: 66 kg urea ha^{-1}

Table 11. Combined effect of GA_3 and nitrogen on 1000-seed weight, number of nodule plant^{-1}, dry matter content of plant and chlorophyll content of mungbean

Treatment	1000-seed weight (g)	Number of nodule plant^{-1}	Dry matter content of plant (%)	Chlorophyll content (%)
G_0N_0	43.25 c	4.67 d	8.17 g	44.46 i
G_0N_1	45.80 b	5.00 cd	9.34 f	49.14 fg
G_0N_2	46.29 ab	5.67 bc	10.30 e	51.27 e
G_0N_3	46.17 ab	5.33 cd	14.94 a	50.05 f
G_1N_0	43.81 c	4.67 d	8.71fg	46.99 h
G_1N_1	47.49 ab	6.67 a	11.84bc	53.63bc
G_1N_2	47.92 a	6.67 a	11.49 bc	54.24 b
G_1N_3	47.42 ab	6.67 a	12.13 b	56.13 a
G_2N_0	45.96 b	5.33 cd	8.95fg	48.76 g
G_2N_1	47.33ab	5.67 bc	10.44 de	51.83 de
G_2N_2	47.45 ab	6.33ab	9.42 f	53.01 cd
G_2N_3	47.41 ab	5.33 cd	11.18 cd	52.69 cd
LSD $_{(0.05)}$	**1.89**	**0.83**	**0.82**	**1.22**
CV %	**7.41**	**8.68**	**4.60**	**9.41**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

G_0: 0 ppm GA_3, G_1: 50 ppm GA_3, G_2: 100 ppm GA_3, N_0: Control (no urea), N_1: 22 kg urea ha^{-1}, N_2: 44 kg urea ha^{-1}, N_3: 66 kg urea ha^{-1}

4.11 Dry matter content of plant

Dry matter content (%) varied significantly due to the application of GA_3 (Appendix VII). The maximum dry matter content of plant (11.90 %) was found from G_0 (0 ppm GA_3) treatment and followed by (10.51 %) G_2 treatment. On the other hand, the minimum dry matter content of plant (9.31 %) was recorded from G_1 (control) treatment (Table 9). Razzaque *et al*. (2017) supported the results.

In case of nitrogen application significant difference was found (Appendix VII). The maximum dry matter content of plant (12.24 %) was obtained from N_3 (66 kg urea ha^{-1}) treatment and followed by (10.91 %) N_2 treatment which is statistically identical to N_1 treatment. On the other hand the minimum dry matter content of plant (8.61 %) was found from N_0 (control) treatment (Table 10).

The significant difference was observed due to the interaction effect of different GA_3 and nitrogen application (Appendix VII). The maximum dry matter content of plant (14.94 %) was obtained from G_0N_3 (0 ppm GA_3 and 66 kg urea ha^{-1}) treatment combination. On the other hand, the minimum dry matter content of plant (8.17 %) was recorded from G_0N_0 (control) treatment combination (Table 11).

4.12 Chlorophyll content

Due to the application of GA_3 the chlorophyll content varied significantly (Appendix VII). The maximum chlorophyll content(52.75 %) was found from G_1 (50 ppm GA_3) treatment and followed by (51.57 %) G_2 treatment. On the other hand, the minimum chlorophyll content (48.73 %) was recorded from G_0 (control) treatment (Table 9).

In case of nitrogen application significant difference was found (Appendix VII). The maximum chlorophyll content(53.47 %) was obtained from N_3 (66 kg urea ha^{-1}) treatment and followed by (52.32 %) N_2 treatment. On the other hand the minimum chlorophyll content (46.74 %) was found from N_0 (control) treatment (Table 10).

The significant difference was observed due to the interaction effect of different GA_3 and nitrogen application (Appendix VII). The maximum chlorophyll content (56.13 %) was obtained from G_1N_3 (50 ppm GA_3 and 66 kg urea ha^{-1}) treatment combination. On the other hand, the minimum chlorophyll content (44.46 %) was recorded from G_0N_0 (control) treatment combination (Table 11).

4.13 Seed yield

The significant difference was observed in seed yield (t/ha) due to the application of GA_3 (Appendix VIII). The maximum seed yield (2.16 t ha^{-1}) was found from G_1 (50 ppm GA_3) treatment and followed by (2.02 t ha^{-1}) G_2 treatment. On the other hand, the minimum seed yield (1.92 t ha^{-1}) was recorded from G_0 (control) treatment (Table 12). Hossain *et al*. (2014) found the similar results.

In case of nitrogen application significant difference was found (Appendix VIII). The maximum seed yield (2.16 t ha^{-1}) was obtained from N_2 (44 kg urea ha^{-1}) treatment and followed by (2.08t ha^{-1}) N_3. On the other hand the minimum seed yield (1.86 t ha^{-1}) was found from N_0 (control) treatment (Table 13).

The significant difference was observed due to the interaction effect of different GA_3 and nitrogen application (Appendix VIII). The maximum seed yield (2.38 t ha^{-1}) was obtained from G_1N_2 (50 ppm GA_3 and 44 kg urea ha^{-1}) treatment combination. On the other hand, the minimum seed yield (1.83 t ha^{-1}) was recorded from G_0N_0 (control) treatment combination (Table 14).

4.14 Stover yield

Stover yield also varied significantly due to the application of GA_3 (Appendix VIII). The maximum stover yield(1.05 t ha^{-1}) was found from G_1 (50 ppm GA_3) treatment and followed by (0.94 t ha^{-1}) G_2 treatment. On the other hand, the minimum stover yield (0.85 t ha^{-1}) was recorded from G_0 (control) treatment (Table 12).Hossain *et al*. (2014) found the similar results.

In case of nitrogen application significant difference was found (Appendix VIII). The maximum stover yield (1.08 t ha^{-1}) was obtained from N_2 (44 kg urea ha^{-1}) treatment and followed by (0.97 t ha^{-1}) N_3 treatment which is statistically identical toN_1 treatment. On the other hand the minimum stover yield (0.78 t ha^{-1}) was found from N_0 (control) treatment (Table 13).

The significant difference was observed due to the interaction effect of different GA_3 and nitrogen application (Appendix VIII). The maximum stover yield (1.28 t ha^{-1}) was obtained from G_1N_2 (50 ppm GA_3 and 44 kg urea ha^{-1}) treatment combination. On the other hand, the minimum stover yield (0.71 t ha^{-1}) was recorded from G_0N_0 (control) treatment combination (Table 14).

4.15 Nitrogen content

The significant difference was observed in Nitrogen content (%) due to the application of GA_3 (Appendix VIII). The maximum nitrogen content (4.11 %) was found from G_1 (50 ppm GA_3) treatment. On the other hand, the minimum nitrogen content (4.04 %) was recorded from G_0 (control) treatment which is statistically similar with G_2 (Table 12). Kumar and Tomar (2013) investigated and supported the results.

In case of nitrogen application significant difference was found (Appendix VIII). The maximum nitrogen content (4.16 %) was obtained from N_2 (44 kg urea ha^{-1}) treatment. On the other hand the minimum nitrogen content (4.01 %) was found from N_0 (control) treatment (Table 13).

The significant difference was observed due to the interaction effect of different GA_3 and nitrogen application (Appendix VIII). The maximum nitrogen content (4.20 %) was obtained from G_1N_2 (50 ppm GA_3 and 44 kg urea ha^{-1}) treatment combination. On the other hand, the minimum nitrogen content (3.90 %) was recorded from G_0N_0 (control) treatment combination (Table 14).

4.16 Protein content

The significant difference was observed in protein content (%) due to the application of GA_3 (Appendix VIII). The maximum protein content (25.72 %) was found from G_1 (50 ppm GA_3) treatment. On the other hand, the minimum protein content (25.26 %) was recorded from G_0 (control) treatment (Table 12). Kumar and Tomar (2013) investigated and agreed with the results.

Table 12. Effect of GA_3 on seed yield, stover yield, nitrogen content and protein content of mungbean

Treatment	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Nitrogen content (%)	Protein content (%)
G_0	1.92 c	0.85 c	4.04 b	25.26 c
G_1	2.16 a	1.05 a	4.11 a	25.72 a
G_2	2.02 b	0.94 b	4.06 b	25.37 b
LSD $_{(0.05)}$	**0.011**	**0.031**	**0.001**	**0.009**
CV %	**10.31**	**7.03**	**7.23**	**6.25**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

G_0: 0 ppm GA_3, G_1: 50 ppm GA_3, G_2: 100 ppm GA_3

Table 13. Effect of nitrogen on seed yield, stover yield, nitrogen contentand protein content of mungbean

Treatment	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Nitrogen content (%)	Protein content (%)
N_0	1.86 d	0.78 c	4.01 c	25.06 c
N_1	2.04 c	0.96 b	4.06 b	25.37 b
N_2	2.16 a	1.08 a	4.16 a	26.00 a
N_3	2.08 b	0.97 b	4.06 b	25.37 b
LSD $_{(0.05)}$	**0.013**	**0.023**	**0.002**	**0.011**
CV %	**10.31**	**7.03**	**7.23**	**6.25**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

N_0: Control (no urea), N_1: 22 kg urea ha^{-1}, N_2: 44 kg urea ha^{-1}, N_3: 66 kg urea ha^{-1}

Table 14. Combined effect of GA_3 and nitrogen on seed yield, stover yield, nitrogen content and protein content of mungbean

Treatment	Seed yield ($t\ ha^{-1}$)	Stover yield ($t\ ha^{-1}$)	Nitrogen content (%)	Protein content (%)
G_0N_0	1.83 j	0.71 h	3.90 f	24.37 j
G_0N_1	1.93 h	0.88 f	4.00 e	25.00 i
G_0N_2	1.97 g	0.94 e	4.13 bc	25.81 d
G_0N_3	1.97 g	0.89 f	4.02 e	25.12 h
G_1N_0	1.88 i	0.81 g	4.15 ab	26.00 c
G_1N_1	2.18 c	1.04 c	4.00 e	25.00 i
G_1N_2	2.38 a	1.28 a	4.20 a	26.25 a
G_1N_3	2.22 b	1.08 b	4.19 a	26.18 b
G_2N_0	1.89 i	0.82 g	4.09 cd	25.56 f
G_2N_1	2.03 f	0.97 d	4.05 de	25.31 g
G_2N_2	2.13 d	1.04 c	4.11 bc	25.68 e
G_2N_3	2.06 e	0.96 de	4.02 e	25.12 h
LSD $_{(0.05)}$	**0.022**	**0.025**	**0.002**	**0.019**
CV %	**10.31**	**7.03**	**7.23**	**6.25**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

G_0: 0 ppm GA_3, G_1: 50 ppm GA_3, G_2: 100 ppm GA_3, N_0: Control (no urea), N_1: 22 kg urea ha^{-1}, N_2: 44 kg urea ha^{-1}, N_3: 66 kg urea ha^{-1}

In protein content due to various Nitrogen application significant difference was found (Appendix VIII). The maximum protein content (26.00 %) was obtained from N_2 (44 kg urea ha^{-1}) treatment. On the other hand the minimum protein content (25.06 %) was found from N_0 (control) treatment (Table 13). Azadi *et al.* (2013) observed the similar results.

Protein content varied significantly due to the interaction effect of different GA_3 and nitrogen application (Appendix VIII). The maximum protein content (26.25 %) was obtained from G_1N_2 (50 ppm GA_3 and 44 kg urea ha^{-1}) treatment combination. On the other hand, the minimum protein content (24.37 %) was recorded from G_0N_0 (control) treatment combination (Table 14).

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at research field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from March to June, 2016 to find out the effect of GA_3 and nitrogen on growth, yield and protein content of mungbean. BARI Mung-6 was used as a variety of mungbean. The experiment consisted of two factors: Factor A: Three levels of GA_3 viz.G_0: control (no GA_3); G_1: 50 ppm GA_3; G_2: 100 ppm GA_3 and Factor B: Four levels nitrogen. viz.N_0: Control (no urea), N_1: 22 kg urea ha^{-1}, N_2: 44 kg urea ha^{-1}, N_3: 66 kg urea ha^{-1}. There were 12 treatment combinations. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth and yield contributing characters and yield were recorded to find out the optimum levels of GA_3 and nitrogen on mungbean production.

Due to GA_3 application, the maximum plant height (48.43 cm) and maximum number of leaves (26.60) at 60 DAS, maximum number of inflorescence per plant (8.63), number of flower per inflorescence (9.02), number of pod per plant (107.52), number of seeds per pod (9.97), chlorophyll content (52.75 %) in leaf, seed yield (2.16 t/ha), stover yield (1.05 t/ha), nitrogen content (4.11 %), protein content (25.72 %) were recorded from G_1 (50 ppm GA_3) treatment. The maximum number of branches per plant (2.75), pod length (8.24 cm), 1000-seed weight (47.04 g), number of nodule per plant (6.17) were recorded from G_2 (100 ppm GA_3) treatment. The highest dry matter content of plant (11.90) was recorded from G_0 (control) treatment. On the other hand, the minimum plant height (43.94 cm) and minimum number of leaves (24.50) at 60 DAS, minimum number of inflorescence per plant (7.02), number of flower per inflorescence (5.85), number of pod per plant (77.02), number of seeds per pod (9.07), chlorophyll content (48.73 %) in leaf, minimum seed yield (1.92 t/ha), stover yield (0.85 t/ha), nitrogen content (4.04 %), protein content (25.26 %), number of branches per plant (2.31), pod length (7.87 cm), 1000-seed weight (45.37 g), number of nodule per plant (5.17) were recorded from G_0 (control) treatment. The minimum dry matter content of plant (9.31) was recorded from G_1 (50 ppm GA_3) treatment.

Due to nitrogen application, the highest plant height (49.09 cm) and maximum number of leaves (27.11) at 60 DAS, maximum number of inflorescence per plant (4.48), number of flower per inflorescence (9.19), number of pod per plant (108.94), number of seeds per pod (10.14), seed yield (2.16 t/ha), stover yield (1.08 t/ha), number of branches per plant (2.81), 1000-seed weight (47.22 g), number of nodule per plant (6.22), nitrogen content (4.16 %), protein content (26.00 %) were recorded from N_2 (44 kg urea ha^{-1}) treatment. Maximum chlorophyll content (53.47 %) in leaf, pod length (8.33 cm), dry matter content of plant (12.24 %) were recorded from N_3 (66 kg urea ha^{-1}) treatment. On the other hand, the minimum plant height (41.92 cm) and number of leaves (23.37) at 60 DAS, minimum number of inflorescence per plant (6.62), number of flower per inflorescence (5.19), number of pod per plant (65.49), number of seeds per pod (8.50), seed yield (1.86 t/ha), stover yield (0.78 t/ha), number of branches per plant (2.11), 1000-seed weight (44.34 g), number of nodule per plant (4.89), chlorophyll content (46.74 %) in leaf, nitrogen content (4.01 %), minimum protein content (25.04 %), pod length (7.58 cm) and the minimum dry matter content of plant (8.61 %) were recorded from N_0 (control) treatment.

Due to combined application of GA_3 and nitrogen application, the maximum plant height (52.80 cm) and maximum number of leaves (29.12) at 60 DAS, maximum number of inflorescence per plant (9.59), number of flower per inflorescence (11.52), number of pod per plant (132.27), number of seeds per pod (11.30), seed yield (2.38 t/ha), stover yield (1.28 t/ha), number of branches per plant (3.02), 1000-seed weight (47.92 g), number of nodule per plant (6.67), nitrogen content (4.20 %) and protein content (26.25 %) were recorded from G_1N_2 (50 ppm GA_3 with 44 kg urea ha^{-1}) treatment combination.

Maximum pod length (8.58 cm) was recorded from G_2N_3 (100 ppm GA_3 with 66 kg urea ha^{-1}) treatment combination and dry matter content of plant (14.94 %) were recorded from G_0N_3 (0 ppm GA_3 with 66 kg urea ha^{-1}) treatment combination. On the contrary, the lowest plant height (41.27 cm) and minimum number of leaves (22.96) at 60 DAS, minimum number of inflorescence per plant (6.09), number of flower per inflorescence (4.52), number of pod per plant (56.27), number of seeds per pod (8.27), seed yield (1.83 t/ha), stover yield (0.71 t/ha), number of branches per plant (1.88), 1000-seed weight (43.25 g), number of nodule per plant (4.67), chlorophyll content (44.46 %) in leaf, nitrogen content (3.90 %), protein content (24.37 %) pod length (7.48 cm) and dry matter content of plant (8.17 %) were recorded from G_0N_0 (0 ppm GA_3 with 0 kg urea ha^{-1}) treatment combination.

Conclusion

Based on the result of the present study it was found that application of 50 ppm GA_3 and 44 kg urea ha^{-1} treatment combination performed the best for seed yield (2.38 t ha^{-1}),nitrogen content (4.20 %) and protein content (26.25 %) of mungbean.

Further research should be conducted by setting more treatments on GA_3 and nitrogen (N) to study the maximum growth, yield and protein contents of mungbean at different places of Bangladesh.

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APPENDICES

Appendix I. Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from February to June, 2016

Month	Air temperature (^{0}C)		R. H. (%)	Total rainfall (mm)
	Maximum	Minimum		
February,16	27.1	16.7	67	3
March,16	31.4	19.6	54	11
April, 16	35.3	22.4	51	15
May, 16	37.2	23.2	62	17
June, 16	38.2	25.2	69	23

Source: Bangladesh Metrological Department (Climate and weather division) Agargaon, Dhaka

Appendix II. Results of morphological, mechanical and chemical analysis of soil of the experimental plot

A. Morphological Characteristics

Morphological features	**Characteristics**
Location	Field Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow redbrown terrace soil
Land Type	Medium high land
Soil Series	Tejgaon
Topography	Fairly leveled
Flood Level	Above flood level
Drainage	Well drained

Source: (SAU Farm, Dhaka)

B. Mechanical analysis

Constituents	Percentage (%)
Sand	28.78
Silt	42.12
Clay	29.1

Source: (SAU Farm, Dhaka)

C. Chemical analysis

Soil properties	Amount
Soil pH	5.8
Organic carbon (%)	0.95
Organic matter (%)	0.77
Total nitrogen (%)	0.075
Available P (ppm)	15.07
Exchangeable K (%)	0.32
Available S (ppm)	16.17

Source: Soil Resource Development Institute (SRDI)

Appendix-III. Analysis of variance of data on plant height (cm) at different days after sowing of mungbean

Source of variation	Degrees of freedom (df)	Mean square of plant height at				
		20 DAS	30 DAS	40 DAS	50 DAS	60 DAS
Replication	2	1.592	18.446	62.078	33.030	73.390
Factor A (GA_3)	2	5.969	54.848*	61.787*	54.022*	60.887*
Factor B (Nitrogen)	3	8.498	65.973*	88.722*	72.251**	85.860*
Interaction(A X B)	6	1.184*	5.730*	4.375*	6.182*	6.539**
Error	22	0.717	2.010	2.018	3.296	5.719
** : Significant at 1% level of probability; * : Significant at 5% level of probability						

Appendix-IV. Analysis of variance of data on number of leaves at different days after sowing of mungbean

Source of variation	Degrees of freedom (df)	Mean square of number of leaves at				
		20 DAS	30 DAS	40 DAS	50 DAS	60 DAS
Replication	2	0.354	6.298	4.252	4.862	5.175
Factor A (GA_3)	2	5.448	10.950*	13.130*	13.990*	13.291*
Factor B (Nitrogen)	3	8.223	9.820*	16.553*	22.524**	22.046*
Interaction(A X B)	6	0.642	1.330*	1.813**	1.540*	1.542*
Error	22	0.120	0.182	0.105	0.189	0.143
** : Significant at 1% level of probability; * : Significant at 5% level of probability						

Appendix-V. Analysis of variance of data on number of branches plant^{-1}, number of inflorescence plant^{-1} and number of flowers inflorescence^{-1} of mungbean

Source of variation	Degrees of freedom (df)	Mean square of		
		Number of branches plant^{-1}	Number of inflorescence plant^{-1}	Number of flowers inflorescence^{-1}
Replication	2	3.04E^{-31}	0.085	14.588
Factor A (GA_3)	2	0.597*	7.785*	30.083*
Factor B (Nitrogen)	3	0.867*	6.030*	24.910*
Interaction(A X B)	6	0.093*	0.414**	1.972**
Error	22	0.060	0.072	0.492
** : Significant at 1% level of probability; * : Significant at 5% level of probability				

Appendix-VI. Analysis of variance of data on number pods plant^{-1}, number of seeds pod^{-1} and pod length of mungbean

Source of variation	Degrees of freedom (df)	Mean square of		
		Number pods plant^{-1}	Number of seeds pod^{-1}	Pod length (cm)
Replication	2	1255.58	0.605	0.347
Factor A (GA_3)	2	2794.75*	2.518*	0.416*
Factor B (Nitrogen)	3	3368.52*	4.445*	1.000*
Interaction(A X B)	6	219.05**	0.624*	0.030*
Error	22	76.16	0.093	0.009
** : Significant at 1% level of probability; * : Significant at 5% level of probability				

Appendix-VII. Analysis of variance of data on 1000-seed weight, number of nodule plant^{-1}, dry matter content of plant and chlorophyll content of mungbean

Source of variation	Degrees of freedom (df)	Mean square of			
		1000-seed weight (g)	Number of nodule plant^{-1}	Dry matter content of plant (%)	Chlorophyll content (%)
Replication	2	1.90E^{-28}	2.44E^{-30}	12.222	0.75
Factor A (GA_3)	2	9.106*	3.000*	20.273*	51.202*
Factor B (Nitrogen)	3	16.450*	2.814*	20.255*	78.898*
Interaction(A X B)	6	1.114*	0.703*	2.670**	3.259*
Error	22	1.250	0.242	0.237	0.520
** : Significant at 1% level of probability; * : Significant at 5% level of probability					

Appendix-VIII. Analysis of variance of data on seed yield, stover yield, nitrogen content and protein content of mungbean

Source of variation	Degrees of freedom (df)	Mean square of			
		Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Nitrogen content (%)	Protein content (%)
Replication	2	0.0011	0.0011	2.78E^{-06}	0.00014
Factor A (GA_3)	2	0.171*	0.117*	0.058*	2.288*
Factor B (Nitrogen)	3	0.139**	0.145*	0.046*	1.812*
Interaction(A X B)	6	0.017**	0.010**	0.0011*	0.045*
Error	22	0.001	0.0018	2.78E^{-06}	0.0011
** : Significant at 1% level of probability; * : Significant at 5% level of probability					

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