STUDY ON THE FEASIBILITY OF REDUCING NITROGENOUS FERTILIZER THROUGH BIO-FERTILIZER ON MUNGBEAN

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CERTIFICATE

This is to certify that the thesis entitled **STUDY ON THE FEASIBILITY OF REDUCING NITROGENOUS FERTILIZER THROUGH BIO-FERTILIZER ON MUNGBEAN** 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** in **Agronomy**, embodies the result of a piece of *bona fide* research work carried out by **NAJNIN JAHAN SUSMITA** Registration number: **09-03480** 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 duly been acknowledged.

Dated:
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DEDICATED

TO

MY BELOVED PARENTS

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The Author

STUDY ON THE MINIMIZATION OF NITROGENOUS FERTILIZER (UREA) THROUGH BIO-FERTILIZER USE IN MUNGBEAN

ABSTRACT

A field experiment was conducted at the research farm of Sher-e-Bangla Agricultural University, during Kharif-1 (March to June), 2014 to study on the feasibility of reducing nitrogenous fertilizer use through bio-fertilizer on Mungbean. The experiment comprised with 2 factors viz. A) Variety-3: V_1 = BARI mung 5, V_2 = BARI mung 6, V_3 = BINA mung 8; B) Bio-fertilizer and nitrogenius fertilizer combination-5: T_1 = Recommended nitrogenous fertilizer, T_2 = Bio-fertilizer (120g) + 25% nitrogenous fertilizer (urea) of the recommended dose, T_3 = Bio-fertilizer (120g) + 50% nitrogenous fertilizer (urea) of the recommended dose, T_4 = Bio-fertilizer (120g) + 75% nitrogenous fertilizer (urea) of the recommended dose, T_5 = Bio-fertilizer (120g) + 100% nitrogenous fertilizer (urea) of the recommended dose. The experiment was laid out in split plot design with three replications. Results revealed that, among all varieties BARI mung 6 gave the highest seed yield (1.58t ha^{-1}) which may be attributed to higher number of pods $plant^{-1}$ ((24.54),seeds pod^{-1} (11.06) and 1000 seed weight (44.09g). Among bio-fertilizer doses, the treatment T_5 gave highest seed yield (1.651 t ha^{-1}) as this treatment gave highest number of pods $plant^{-1}$ (24.90), seeds pod^{-1} (10.84) and 1000 seed weight (42.33g). It is also evident that T_4, T_3 and T_1 treatment also similar with T_5 treatment. And interaction of V_2T_5 gave higher number of number of pods $plant^{-1}$ (27.62), seeds pod^{-1} (12.38), 1000 seed weight (46.50g), seed yield (1.84 t ha^{-1}) and harvest index (32.73 %). As treatment T_5 (1.651 tha^{-1}), T_4 (1.623 t ha^{-1}) and T_3 (1.591 t ha^{-1}) showed statistically similar seed yield. So, 50% urea can be reduced by adding bio-fertilizer with urea without sacrificing seed yield of mungbean. This is the result of single year experiment. So, for higher acceptibility of the result this experiment may be conducted in different agro-ecological zone of Bangladesh by using different types of Bio-fertilizer and varieties.

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CHAPTER 1

INTRODUCTION

Pulses are well-known as the meat of the poor. The people of our country has been taking pulse as a supplement of animal proteins. Though the animal proteins are enhanced to vegetable proteins, the protein high animal products are relatively costly and beyond the reach of many of the general people of Bangladesh.

Pulses occupy a unique position in agriculture due to its rich protein content in seed and capacity of fixing atmospheric nitrogen. Legumes have been adding and conserving soil fertility status since the opening of agriculture. Mungbean (*Vigna radiata L.)* is one of the major pulse crops grown in Bangladesh. It belongs to the family Leguminose and sub-family Papilionaceae. It ranks the 1^{st} position in price, 3^{rd} in protein content and 4^{th} in both acreages and production in Bangladesh (Sarkar *et al,*1982). Pulses cover an area of about 5,60,036 hectares, where mungbean occupies 26,129 hectares (BBS, 2013). The production per unit is very low (867 kg ha^{-1}). Only 8-10% of protein intake from animal sources in Bangladesh as diet, the rest can be met from plant sources by increasing the consumption of pulses. It contains 51% carbohydrates, 26% protein, 4% mineral and 3% vitamin. On nutritional point of view, mungbean is one of the best among pulses.

In developing countries like Bangladesh, pulse can enrich the overall nutritional value of cereal-based diet. Unfortunately, there is an acute shortage of grain legumes production in our country. According to world Health Organization (WHO), per capita per day requirement of pulses is 45g. But in Bangladesh, only 12g pulse is available per capita per day. About 6.01 million tons of pulse is required to meet the present per capita requirement of our country. Increase of pulse production is directly needed to meet up the demand. So, it is also important to increase pulse crop production to minimize the scarcity of fodder because the whole plant or its by-products can also be used as good source of animal feed. Besides, cultivation of pulse can enrich the physical, chemical and biological properties of soil and also increase soil fertility status through biological nitrogen fixation (BNF) from the atmosphere.

Mungbean is widely grown in India, Pakistan, Bangladesh, Burma, Thailand, China, Indonesia and also grown in parts of east and central Africa, the West Indies, USA and Australia (Gowda and Kaul, 1982). The production has been decreasing due to reduced acreage at the advent of boro rice cultivation area. Therefore, to meet the situation, it is necessary to boost up the production through varietal development and proper management practices. Fitting them in our usual cropping system and use of seed inoculation with effective *Bradyrhizobium* strains should get priority to produce more nodulation, nitrogen fixation, vigorous growth and higher seed yield.

Mungbean is cultivated in late rabi (last week of January to first week of February), Kharif-1(second week of February to first week of March) and Kharif-2 (first week of august to first week of September) seasons, respectively in the southern, the north and north-western and the south-western regions in Bangladesh. But it is cultivated in both summer and winter season in many countries of the world.

Mungbean has special importance in intensive crop production system of our country for its short growing period and also it is drought tolerant. It can be cultivated in low rainfall areas, but fares well in areas with 750 - 900 mm rainfall (Kay, 1979). The crop is grown with residual moisture under rain fed conditions in Bangladesh. It is traditionally grown through the country during the Rabi (September to December) season but considerable acreage has been sown in Kharif-1 (March to May) season.

Farmers of Bangladesh generally grown mungbean by one ploughing but they use almost no fertilizer. There is a plenty scope of increasing the yield of mungbean per unit area with improved management practices and by using proper fertilizer doses. The farmers of this country hardly use fertilizer due to their poor socio economic condition; as a result the yield becomes low. But it has great potentials to increase in yield. Adequate supply of chemical fertilizer or bio-fertilizer is essential for growth and yield of the crop.

In Bangladesh most of the lands are deficient in organic matter. Farmers generally use NPK i.e. chemical fertilizers usually in the forms of Urea, TSP and MP. Among the fertilizer elements, nitrogen plays a key role in mungbean production. It affects the vegetative growth, development and yield. The important role of nitrogenous fertilizer in increasing Mungbean yield has been widely recognized (Asad *et al.,* 2004). Mungbean yield may be increased by 20-45% by proper utilization of nitrogen fertilizer (Hayat *et al.,* 2004). The prices of these fertilizers are very high and often unavailable in the market at the time of urgency. For this reason, the poor and marginal farmers cannot afford to buy and apply balanced fertilizer. As a result, their crops do not give highest yield. The imbalanced application of chemical fertilizers is detrimental to the environment and our land losses its fertility status. These Problems are likely to become serious in future. Biological nitrogen Fixation (BNF) resulting from symbiosis between legume crops and root nodule bacterium *Bradyrhizobium* can ameliorate these problem by reducing the chemical N-fertilizer input required to ensure productivity (Hayat *et al.,* 2004). Now a days a number of organisms like *Bradyrhizobium* has been identified to use as biological nitrogen fixation agent for fixing atmospheric nitrogen by processing with legume crops and make to available to the plants.

To reduce the production cost and to fulfill the demand of more pulse production could be achieved through seed inoculation with *Bradyrhizobium* strains. *Bradyrhizobium* inoculation increased mungbean seed yield from 15% to 45%

(BINA, 2008; Bhuiyan *et al,* 2008). Another report showed that Bangladesh inoculation of *Bradyrhizobium* with mungbean seed increased 57% effective nodule, 77% dry matter production, 64% grain yield and 40% hay yield (Chanda *et al*, 1991)

Bhuiyan *et al.* (2007) reported that Rhizobium inoculation significantly increased root nodules. In Bangladesh, few studies have been conducted on the effects of bio-fertilizer along with urea compared to control on Mungbean. Keeping the above point of view, the study was undertaken to evaluate the effects of Nitrogen and bio-fertilizers on the growth and yield of Mungbean with the following objectives:

- To assess the effect of bio-fertilizer along with nitrogenous fertilizer (urea) on growth and yield of three mungbean varieties; and
- To find out the suitable combination of bio-fertilizer and urea doses for mungbean production.

CHAPTER 2

REVIEW OF LITERATURE

The research work related to nitrogenous fertilizer and bio-fertilizer is not sufficient in Bangladesh. However, important and informative research findings related to nitrogenous (Urea) and bio-fertilizer regarding the effect on plant height, nodulation, dry matter production and grain yield of mungbean and few other legume crops have been reviewed and discussed in this chapter.

2.1 Effect Of Rhizobium / *Bradyrhizobium* Inoculation

2.1.1 Effect Of Rhizobium / *Bradyrhizobium* Inoculation on Plant Height

Hayat *et al.* (2004) observed a field experiment to find out the effect of N and *Rhizobium* sp. inoculation on the yield, N uptake of mungbean was investigated during kharif season and observed that the highest plant height, branch number, total dry matter production production was obtained with inoculation + 30 kg N ha^{-1}.

Bhattacharya and Pal (2001) observed a field trial in west Bengal, India to study the effect of rhizobium inoculation with P & Mo on the growth of summer green gram and reported that plant height significantly increased compared to uninoculated control.

Hasanuzzaman (2001) and Solaiman (2002) conducted field experiments on mungbean seed inoculation with *Bradyrhizobium* and observed that plant height significantly increased compared to uninoculated control.

Kavathiya and Pandey (2000) conducted a pot experiment on mungbean seed inoculation with *Rhizobium* inoculant on seed and reported that seed inoculation resulted in significant increase of plant height over uninoculated control.

Mozumder (1998) conducted a field experiment with different strains of *Bradyrhizobium* inoculant on mungbean seed and reported that plant height significantly increased compared to uninoculated control.

Rahman (1989) observed that *Rhizobium* inoculation either along with or in presence of P, K fertilizer increased black gram plant height significantly.

Samantaray *et el*. (1990) found that plant height of mungbean were the highest when inoculation was done with rhizobium.

Sultan (1993) conducted a field trial where mungbean seeds were inoculated with *Rhizobium*. They reported that *Rhizobium* inoculation significantly increased plant height over uninoculated control.

Sudhakar *et al.* (1989) showed that *Rhizobium* inoculation on black gram increased crop growth rate compared to uninoculated control.

Thakur and Panwar (1995) conducted a field experiment where *Vigna radiata* cv. Pusa-105 and PS-16 were given seed inoculation with *Bradyrhizobium* and soil inoculation with VAM fungus or a combination of both. They observed that inoculation either singly or combined increased plant height over uninoculated control.

Thakuria and Saharia (1990) reported that different varieties of mungbean differed significantly in respect of plant height, 1000-seed weight and grain yield.

2.1.2 Effect of *Rhizobium / Bradyrhizobium* inoculation on nodulation

Anjum *et al.* (2006) carried out a field experiment on mungbean *(Vigna radiata)* is capable of fixing atmospheric nitrogen through *Rhizobium* species living in its root nodules to evaluate the effect of inoculations and nitrogen levels on performance of mungbean. He reported that seed inoculation was more effective and gave better results than uninoculated.

Hossain and Solaiman (2004) conducted a field experiment to study *the* effects of *Rhizobium* inoculation on the nodulation, plant growth, yield attributes, seed and straw yields, and seed protein content of six mungbean (*Vigna radiata)* cultivars. *Rhizobium* strains TAL169 and TAL 441 were used for inoculation of the seeds and Two-thirds of seeds of each cultivar were inoculated with *Rhizobium* inoculant and the remaining one-third of seeds was kept uninoculated. The number and dry weight of nodules plant^{-1}, 1000-seed weight, seed and stover yields, and seed protein content of the crop increased significantly due to inoculation of the seeds with *Rhizobium* strains.

Kavathiya and Pandey (2000) carried out a pot experiment with *Rhizobium* on mungbean and reported that maximum seed germination (96.6%), plant height (54.6 cm), fresh shoot weight (5.33 g), fresh root weight (4.42 g) and nodulation (69 healthy nodules plant^{-1}) was recorded in the *Rhizobium* treatment.

Bhuyan *et al.* (1998) conducted a field experiment at regional Agricultural Research Station, Ishwardi, Pabna to study the effect of seed inoculation with *Bradyrhizobium*. They reported that inoculation significantly increased nodule number plant^{-1} than uninoculated and control.

Bhuiya *et al.* (1984) carried out a field experiment at BAU farm and observed that the inoculation of mungbean gave the higher dry weight of nodules and shoot plant^{-1} over control. They also found that inoculated plant produced larger sized nodule than uninoculated plant.

Das *et al.* (1997) carried out a field trial where *Vigna radiata* cv. Nayagarh local seeds were inoculated with *rhizobium* and/or VAM culture which was applied at 15 kg ha^{-1}. They evaluated that number of nodules was increased with inoculation compared with uninoculated control.

Gosh and Poi (1998) conducted a pot experiment where Kalai (*Vigna mungo)*, mungbean *(Vigna radiata)* and lentils were inoculated with *Rhizobium, Bacillus* *polyxima* and *Glomus fasciculatum* in different combinations. They observed that nodulation and population of micro -organisms in the rhizosphere were the highest from combined inoculation with all three micro-organisms.

Hoque and Barrow (1993) conduct field trials on soyabean, mungbean and lentil at various locations of Bangladesh. They found that the inoculants markedly increased nodule number and nodule dry weight of soybean, lentil and mungbean compared with uninoculated control treatment.

Islam *et al*. (1999) carried out an experiment to study the performance of some *Bradyrhizobial* inoculants on soybean at BINA experimental farm, Mymensingh. They reported that total nodule number was significantly the highest in inoculant & the lowest in uninoculated treatments.They also reported that all the *Bradyrhizobium* inoculation treatments performed better in nodulation of soybean.

Mandal and Ray (1999) conducted a field trail where mungbean cv. 105, B1 and Hooghly local varieties were untreated, seed inoculated with *Rhizobium* and 20, 30 or 40 kg ha^{-1} as urea was given. They reported that nodulation was the greatest with inoculation.

Sultan (1993) conduct a field trial where lentil seeds were inoculated with *Rhizobium* inoculums and reported that *Rhizobium* inoculation significantly increased plant height than uninoculated control.

Patra and Bhattacharya (1997) conduct a field trial with *Vigna radiata* cv. B-l, *Rhizobium* and urea (25 kg ha^{-1}). They found that all treatments increased nodulation compared with controls and also reported that the highest number of nodules was given by *Rhizobium* + urea combination.

Sattar and Podder (1988) carried out a greenhouse experiment with lentil to study the effectiveness of *Rhizobium* isolates $L_{1,}$ L_5, L7, L_{DIN} and L_{NIL} and evaluate that the isolate L_1, L_{NIL} and L_5 increased nodule compared to uninoculated control.

Sattar and Ahmed (1995) carried out a field experiment on mungbean (*Vigna radiate L.)* to study the response of inoculation with *Bradyrhizobium* inoculants incorporating BINA 403, B1NA 407, RC 3824 and RC 3825 strains as single and mixed culture and found that *Bradyrhizobium* inoculation enhanced the number of nodules and nodule weight significantly.

Sharma *et al.* (1995) reported that seed inoculation with *Rhizobium* and application of 40 kg P_20_5 ha^{-1} in chickpea either alone or in combination increased nodulation and yield significantly compared to uninoculated control.

Rasal (1995) conducted an experiment where green gram was given seed inoculation with *Aspergillus awamori* or Microbes alone or in combination with *Rhizobium* and/or the recommended rate of P fertilizer (RRP). He observed that number and dry weight of nodules were the highest with inoculation with *Aspergillus awamori* + *Rhizobium* + *RRP*.

Senanayake (1995) carried out an experiment in a growth chamber with cowpea cv. MI-35, seedlings were inoculated with a *Rhizobium* strain ClAT 301 or SLM 602 and exposed to concentrations of 0, 0.5, 1.0 and 2.0 m M $KN0_3$. N fixation was the highest with 1.0 mM KNO_3 in plants inoculated with the *Rhizobium* strain Cl at 301; N fixation was decreased when the strain SLM 602, N fixation remained about at 1.0 and 2.0 mM KNO_3 and the activity was lowest with 0.5 mM KNO_3 with both strains. The nodule fresh weight was the highest with 0.5 mM KNO_3 in both inoculation treatments. Plant dry weight was enhanced with the highest N rate.

Solaiman and Habibullah (1990) carried out an experiment on groundnut and observed that highest number of nodules (33.7$plant^{-1}$) was found on the plant inoculated with *rhizobia* and 28.10% better dry matter yield was enhanced when inoculated.

2.1.3. Effect of *Rhizobium / Bradyrhizobium* inoculation on shoot, root and total dry matter

Mian *et al.* (2005) conducted an experiment at the Soil Science Field Laboratory of Bangladesh Agricultural University, Mymensingh during kharif season. The result was found that significantly increased of shoot, root and total dry matter due to *Bradyrhizobium* inoculation.

Alam *et al.* (2006) conducted a field experiment in Mymensingh, Bangladesh during the summer season to study the response of mungbean with five cultures of phosphate dissolving micro-organisms and all the cultures significantly increased the root and shoot dry matter.

Chowdhury *et al.* (2000) carried out a field experiment during kharif season of 1995 on mungbean where seed inoculation was done with *Rhizobium* strains. They reported that the use of *Rhizobium* enhanced 50% dry matter of mungbean.

Barakha and Heggo (1998) conduct a greenhouse experiment where black gram seeds were inoculated with *Bradyrhizobium* and sown in pots in steam sterilized soil that had been amended with super phosphate (0.5 g kg^{-1} soil). They found that inoculation with *Bradyrhizobia* increased black gram shoot and root dry weights compared to uninoculated control. The highest increase in root and shoot was found with application of *Bradyrhizobium* up to 167% and 400%, respectively.

Sattar and Ahmed (1995) carried out a field experiment at the farm of Agricultural Research Center, Rajbari on mungbean. Mungbean was inoculated with *Bradyrhizobium* and obtained significant increase in straw and total protein yield.

Hoque and Hashem (1992) found that the use of *Rhizobium* inoculants as bio-fertilizer was remarkably beneficial on nodule number, nodule weight, shoot weight and total dry matter weight of soybean and groundnut.

Bhuiyan and Obiduliah (1992) carried out a field experiment on mungbean and reported that *Rhizobium* inoculation increased nodule number, nodule weight, shoot weight and pod yield significantly.

Podder *et al.* (1989) observed a field experiment with 6 isolates of lentil and found significant increase in grain and straw yields due to *Rhizobium* inoculation. They also obtained 28-42 percent increase in yield over uninoculated control.

Asghar *et al.* (1998) carried out an experiment on lentil and found that *Rhizobium* inoculation increased nodule number, nodule dry weight and root dry weight.

Khan *et al.* (1985) reported that inoculation of black gram seed with different *Rhizobium* strains showed highly significant effect on dry matter yield and nodulation. They also reported that the strains BAU 524 gave higher amount of dry matter.

Gill *et al.* (1985) conducted a field experiment on mungbean and found that inoculation significantly increased the number of branches plant^{-1}, pods plant^{-1}, seeds plant^{-1}, straw, seed yield and harvest index.

Manjunath and Bagyaraj (1984) obtained the response of cowpea and pigeon pea to dual inoculation with *Glomus fasciculate* and or *Rhizobium* sp with and without added P (22kg ha^{1}) in a deficient non sterile soil. They recorded that plants inoculated with both the organisms and supplemented with P gave the highest shoot and NP contents.

Hoque *et al.* (1980) carried out two field trials on Bragg soybean with *Brady rhizobium japonicum* strain in both peat and soil based inoculants and found 83% higher nodulation, 15% higher dry shoot weight and 40% higher nodule weight over uninoculated control.

Rao and Sharma (1980) studied with different inoculum levels of rhizobia on symbiosis with soybean and black gram and showed that seeds of soybean inoculated with 2.0 x 10.4 cells seed^{-1} gave the highest number and fresh weight of nodule.

2.1.4 Effect of *Rhizobium / Bradyrhizobium* inoculation on yield:

The effect of inoculation on yield of mungbean and other legumes was observed by many researchers. Some of the works are reviewed below:

Delic *et al.* (2009) conducted a field experiment on *mungbean* with *rhizobial* inoculation and estimated that inoculation plants produced significantly better shoot dry weight (SDW), seed yield, total N content as well as protein yield in respect to over control. According to plant shoot yield and yield are effectively increased without significant differences in comparison to its treatment in combination with mineral nitrogen as well as uninoculated control.

Bhuiyan *et al.* (2008) carried out a field studies with and without *Bradyrhizobium* with five mungbean varieties to evaluate the yield and yield attributes of mungbean. They observed that that application of *Bradyrhizobium* inoculant produced significant effect on seed and stover yields. Seed inoculation significantly enhanced seed (27% increase over control in 2001 and 29% increase over control in 2002) and stover (2.31 t ha $^{-1}$ in 2001 and 2.04 t ha $^{-1}$ in 2002) yields of mungbean. *Bradyrhizobium* inoculation also significantly increased pods plant^{-1}, seeds pod^{-1} and 1000-seed weight. Inoculated variety produced the highest seed and stover yields as well as yield attributes such as pods plant^{-1} and seed pod^{-1}.

Bhuiyan *et al.* (2007) carried out an experiment with or without *Bradyrhizobium* in five mungbean varieties at Bangladesh Agricultural University Farm during kharif-1 in 2001 and kharif-1in 2002 seasons to study about nodulation, biomass production and yield of mungbean. Five mungbean varieties viz. BARI Mung-2, BARI Mung-4, BARI Mung-5, BINA Mung-2 and Barisal local, and rhizobial inoculum (*Bradyrhizobium* strain BAUR-604) was used for the study. Application of *Bradyrhizobium* inoculant produced significant effects on plant height, plant dry weight, nodulation, shoot dry weight, seed and hay yields. Seed inoculation significantly enhanced seed yields (27% increase over control in 2001 and 29% enhance over control in 2002) and straw (2.31 t ha^{-1} in 2001 and 2.04 t ha^{-1} in 2002) yields of mungbean.

An experiment was observed by Mozumder *et al.* (2005) from March to June 2003 in Mymensingh, Bangladesh to evaluate the response of summer mungbean cultivars Binamoog-2 and Kanti to *Bradyrhizobium* inoculation. Nitrogen was applied as urea, whereas liquid mixture of *Bradyrhizobium* inocula (BINA MB 441, BINA MB169 and BINA MB 301) were mixed with the seeds before sowing. Data were noted dry matter weight, number of nodules, dry matter of nodules, plant dry weight of nodule, plant height, leaf area index, number of branches $plant^{-1}$, number of pods $plant^{-1}$, percentage of mature pods, number of seeds pod^{-1}, percentage of filled seeds, 1000-seed weight, seed weight $plant^{1}$, seed yield, straw yield and harvest index. Benefit cost (BC) ratio was also noted. The highest seed yield (1461 kg ha^{-1}`) found in the treatment with 40 kg N ha^{-1}.

Asraf *et al.* (2003) conducted a field trail to evaluate the effects of seed inoculation of a bio-fertilizer and NPK application on the performance mungbean. He observed that the tallest plants (69.93 cm) were obtained with seed inoculation + 50:50:0 kg NPK ha^{-1} and seed inoculation + 50:50:50 kg ha^{-1} found in the highest number of pods $plant^{-1}$ (28.97) and seed yield (1053 kg ha^{-1}).

Kumar *et al.* (2003) carried out a field experiment to study the effect different levels of N (0. 10, 20, 30 kg ha^{-1}) and P (0, 20, 40. 60 kg ha^{-1}) with rhizobium inoculam on nutrient content and nutrient uptake of mungbean genotypes during summer. The N and P uptake increased significantly with 20kg N and 40 kg P_20_5, ha^{-1} over the control.

Solaiman (2002) conducted a field experiment with *Bradyrhizobium* on seed inoculation of mungbean and found that inoculated seed significantly increased grain yield compared with uninoculated control.

Navgire *et al.* (2001) observed an experiment on mungbean cultivars to different *Rhizobium* strains under rainfed conditions. Seeds of mungbean cultivars BM-4, S-8 and BM-86 were inoculated with *Rhizobium* strains M-l 1-85, M-6-84. Cultivars S-8, BM-4 and BM-86 noted the highest result in nodulation, plant biomass production and grain yield during the experimental years.

Hasanuzzaman (2001) carried out a field experiment where mungbean seeds were inoculated with *Bradyrhizobium* strain and found that *Bradyrhizobium* inoculum significantly enhanced the grain yield compared with uninoculated control.

Chowdhury *et al.* (2000) carried out a pot experiment during *Kharif* in 1995 with mungbean seeds inoculated with *Bradyrhizobium* strain. They recorded that seed yield enhanced significantly when the seed were inoculated with *Bradyrhizobium strain.*

Islam *et al.* (1999) carried out a field experiment on the performance of some bradyrhizobial inoculants on soybean. There were 8 treatments viz. uninoculated, urea @ 50kg N ha^{-1}, TSP @ 60 kg inoculation P_20_5 ha^{-1}, inoculants RCR 3407, THA 5, TAL 102, and mixed inoculants alone and in combination with TSP. They recorded that all the *Bradyrhizobium* inoculants gave higher yield of soybean. Grain yield was recorded highest (1350 kg ha^{-1}) in mixed inoculant S+ TSP and lowest in uninoculated control.

Podder *et al.* (1999) carried out a field experiment at Brahmaputra Floodplain soil to study the effect of seed inoculation with eight *bradyrhizobial* strains. They studied better performance of inoculation in number of pod $plant^{-1}$, number of seed $plant^{-1}$, 1000-seed weight and seed yield compared to uninoculated control.

Upadhyay *et al.* (1999) evaluated a pot experiment where green gram seed was inoculated with *Rhizobium* or not inoculated and 0-60 kg P_2O_5 ha^{-1} was given. And recorded that seed yield was higher with inoculation (2.02 VS, 1.87 t ha^{-1}). It was also recorded that it was increased with up to 40 kg P_20_5 .

Bhuiyan *et al.* (1998) was recorded that *Rhizobium* seed inoculation with 1kg Mo ha^{-1}& 1kg B per ha increased nodule number, nodule weight and shoot weight and seed yield, hay compared with the control. Seed yield was 107% and 148% higher compared to control in two consecutive growth seasons.

Gupta *et al.* (1998) observed a field experiment on chickpea and found that seed yields were increased with inoculation and the application 40 kg P_2O_5 ha^{-1} as SSP produced the highest mean yield of 1.06 t ha^{-1}.

Mozumder (1988) carried out a field experiment on mungbean where seed inoculated with different strains of *Bradyrhizobium* and was recorded that grain yield significantly enhanced over uninoculated control.

Paul (1998) conducted a pot experiment where mungbean cv. PS-16 was seed inoculated singly with 5 *Rhizobium* strains and exposed to 3 water regime sand and recorded that seed yield was not increased by inoculation under excess water or normal irrigation conditions. But under drought conditions, seed yield was increased by inoculation, particularly with strains N 11 and D 4.

Poonam and Khurana (1997) evaluated a field experiment to study the effect of single and multi- strain inoculants of *Rhizobium* on summer mungbean variety SML32 and stated that the number of nodules and grain yield were superior in multi strain inoculants than single strain. On an average, single strain and multi strain *Rhizobium* inoculants enhanced the yield by 10.4% and 19.3% over uninocuiated control, respectively.

Saraf and Shivakumar (1996) stated that seed yield was better with inoculation than no inoculation (1.03 vs. 0.88 t ha^{-1}) and seed yield was the highest (1.24 t ha^{-1}) with 60 kg P_20_5 ha^{-1} in green gram.

Sharma and Khurana (1997) evaluated the effectiveness of single and multi-strain inoculants in field with summer mungbean variety SML 32 and found that gram yield was superior in multi strain inoculants. On an average, single strain and multi strain *Rhizobium* inoculants increased the grain yield by 10.4% and 19.3% over uninoculated control, respectively.

Gupta and Namdeo (1996) studied in a field experiment of black gram that seed inoculation increased seed yield by 9.6-27% and number of nodules $plant^{-1}$ ranged from 12 to 22 with inoculation compared with N application and dry weight of nodules $plant^{-1}$ ranged from 32 to 62 mg with inoculation compared to 23 mg with N application and 27 mg with no inoculation.

Deka and Kakati (1996) carried out a field experiment in Rabi 1986/87 at Jorhat, Assam, India. *Vigna radiata* cv. K-851 was given seed or soil inoculation with *Rhizobium* strains Majuli-10 or CRP-21 and application of 0- 60 kg P_2O_5 ha^{-1}. Seed yield, total N and P uptake at harvest were not significantly different between *Rhizobium* strains, but better with seed inoculation compared with soil inoculation.

Konde and Deshmukh (1996) conducted that plant dry weight and other yield components were generally increased by inoculation in chickpea.

Mathan *et al.* (1996) was observed a field experiment black gram during the monsoon season of 1991-92 at Coimbatore, Tamil Nadu. They recorded that a total of 7 treatments comprising various combinations of N, P, K, FYM, NAA and seed inoculated with *Rhizobium.* The application of 25 kg N as urea + 50 kg P_2O_5 ha^{-1} as single super phosphate + 750 kg enriched FYM + 6.25 t FYM +ammonium phosphate at flower initiation and 15 days later + seed inoculation with *Rhizobium* produced the highest seed yields of 0.72 t ha^{-1} in 1991 and 0.62 t in 1992, compared with the control yields of 0.42 and 0,42 t, respectively. The seed crude protein content was increased by 14.5% and 15.4% in the highest yielding treatments compared with the controls in both the years.

Rajput and Singh (1996) observed a field experiment during the summer seasons of 1991-92 in Uttar Pradesh, cowpea cv. Pusa komal was seed inoculated with *Rhizobium.* Seed inoculated with *Rhizobium* enhanced yield by 10.85% compared with no inoculation.

Shukla and Dixit (1996) conducted a field experiment where *Vigna radiata* cv. Pusa Baishakhi was seed inoculated with *Rhizobium* or not inoculated, sown in rows 20, 30 or 40 cm apart and given 0-60 kg P_20_5 ha^{-1}. They noted that seed inoculation increased seed yield.

Sattar *et al.* (1995) conducted a greenhouse trial on chickpea where chickpea was inoculated with two local isolates of *Bradyrhizobium*, either singly or as a mixed culture and found that the inoculation gave significant increases in N accumulation and seed yield.

Chowdhury and Rosario (1994) reported that seed inoculated with *Rhizobium* increased the seed yield of mungbean.

Tripathi *et al.* (1994) stated that soybeans, mungbean, Urd and groundnuts were grown on a clay loam soil in 1985 and 1986. Five N treatments were applied through 2 sources: no N sources (control), 20 kg N ha^{-1}, *Rhizobium* seed inoculants alone, inoculants with 10 kg N ha^{-1}, and inoculants with 20 kg N ha^{-1}. It was reported that the combination of inoculants + 20 kg N ha^{-1} gave the highest crop yields and the maximum number of root nodules. Soybeans and groundnuts gave comparatively higher yields than mungbean and Urd. The use of inoculants alone on soybeans increased yields by 22.5% compared with 20 kg N ha^{-1} and the net profit was correspondingly better. In other crops the effect of inoculants was similar to that of fertilizer treatments and so the cost of fertilizer could be saved by the use of inoculants alone.

Ardeshna *et al.* (1993) described that mungbean seed yield increased with the application of 20 kg N ha^{-1} as urea, 40 kg P_2Os as single super phosphate and seed inoculation with Rhizobium.

Khurana and Poonam (1993) observed with the *Bradyrhizobium* strains (LMR 107, KM 1, M 10, GMBS 1 and MO 5) and *Vigna radiata* cv. ML 267 and PS 16. Under field condition, seed inoculation with *Bradyrhizobium* strains enlarged the seed yield by 21.5% and 35.1% in ML 267 and PS 16 respectively over uninoculated controls.

Sharma *et al.* (1993) detected that in pot experiments seed and straw yield of *Vigna radiata* cv. Pusa, Baishakhi increased with the rises of P up to or equivalent of 60 kg P ha^{-1} and with Rhizobium inoculation and with a starter dose of nitrogen.

Hoque and Hashem (1992) detected that inoculation of soybean seeds with Bradyrhizobium inoculum gave the maximum nodule weight, shoot dry weight and hay yield and equally effective in enhancing grain yield of green gram.

Prasad and Ram (1992) stated that green gram cv. Pusa Baishakhi on alluvial soil, *Bradyrhizobium* strains inoculum and 2.5 ppm of both Zn and Cu gave the maximum seed yield (1.27tha^{-1}) compared to 0.86 t ha-^{1} in control.

Pandher *et al.* (1991) conducted that inoculation of *Vigna radiata* cv. ML 131 with single and multiple strains of *Rhizobium* enlarged seed yield. Multiple strain inoculation did not proliferation DW of plants compared with uninoculated control.

Basu and Bandypadhyay (1990) earned out a field trail during the kharif (monsoon) season in West Bengal where mungbean seed was inoculated with Rhizobium strain M-10 or JCA1 and grown in presence of 30-40 kg N ha^{-1}.

Inoculation improved numbers of pods plant^{-1} number of seeds pod^{-1} and N uptake. JCa-1 was superior to M-10. Number of pods plant^{-1}, seeds pod^{-1}, 1000 seed weight and N uptake enhanced with increased in N rates up to 30 kg N ha^{-1}.

Ahmed (1989) studied the response of inoculation with Rhizobium inoculants incorporating B1NA 403, B1NA 407, RCR 3824, RCR 3825 strain as single and mixed cultures and 4 levels of phosphorous (0, 30, 60 and 90 kg ha^{-1} from triple super phosphate) with a basal dose of potassium @ 30 kg K_20 ha^{-1} from muriate of potash on growth, root nodulation, yield and yield contributing characters and protein and phosphorous content of mungbean Rhizobium inoculation enlarged significantly the number of nodules, nodule weight, root and shoot length and weight, grain, hay and total protein yields.

Podder *et al.* (1989) accompanied a field trial with 5 isolates of lentil and found that grain and hay yields were increased significantly by Rhizobium inoculation.

Rahman (1989) stated significantly higher number of nodules per plant, root and shoot dry weight, number of pods per plant; 1000-seeds weight and grain yield due to inoculation over control in soybean.

Yousef *et al.* (1989) informed a field experiment of mungbean grown on a silty clay (pH-8.0) soil irrigated at 40, 80 and 120% of the potential evapotranspiration (PET) from a pan. Before sowing, seeds were inoculated with Rhizobium. Inoculation and irrigation at 80 and 120% PET increased number of pods and dry weight of plant. Inoculation also increased N and P content in seeds.

Gupta *et al.* (1988) carried out a pot trials where *Vigna radiata* grown in a P deficient soil and found that seed inoculation with Rhizobium and or application of 40 kg P ha^{-1} improved the plant dry weight and seed yield plant^{-1}.

Maitiet *et al.* (1988) carried out a trials with green gram and lentil grown in soils given (a) 60 or (b) 100kg ha^{-1} each of P_20_5, seed inoculation with Rhizobium increased nodule nitrogenous activity by 36-54% in *Vigna radiata* and 28-34% in lentils. Nitrogen and seed inoculation improved the *Vigna radiata* seed yields by 15-20 % and 5-10%, respectively but had no significant effect on seed yields.

Patel *et al.* (1988) in a trial with green gram grown in the summer season (irrigation with 80 mm water irrigation at irrigation water depth; cumulative pan evaporation rates of 0.5, 0.7 or 0.9) reported that seed yields of 1.01, 1.20 and 1.24 t ha^{-1} respectively. The application of 20 kg N ha^{-1} or seed inoculation with Rhizobium + 10 kg N ha^{-1} gave similar yields of 1.21- 1.25 t ha^{-1} compared with 1.02 with no inoculation or N.

Prasad and Ram (1988) carried out a pot trial with *Vigna radiata* cv. Pusa Baisakhi using Cu and Zn with soil @ 0, 2.5 and 5.0 ppm and or Rhizobium for nodulation. They found that inoculation + 2.5 ppm Zn + 2.5 ppm Cu gave the maximum values for plant dry weight, nodule dry weight $plant^{-1}$, nodule , N content and seed yield ha^{-1}.

Sattar and Podder (1988) observed in a field experiment that Rhizobium isolates L_5, L_I and LN_{I2} increased the grain yield of lentil and that improved values were 11.5, 14.5 and 9.75 t ha^{-1} respectively, over the uninoculated control.

Bhuiyan *et al.* (1986) recorded increased yields of grain yield and straw of grass pea by 20% and 25% respectively, through inoculation with Rhizobium strain BAU 539 over uninoculated control.

Patel *et al.* (1986) stated that response of Rhizobium inoculation in respect of nodulation and grain yield was found to be significantly high.

Ali and Chandra (1985) established that rhizobium inoculation increased grain yield of most of the pulse crops from 10-15% but the legume required a specific group of rhizobia.

Gill *et al*. (1985) described that inoculation increased number of branches plant^{-1}, seeds plant^{-1}, straw and grain yield and harvest index of Mungbean.

Iswama and Marwada (1982) observed marked increase in seed yield of (*Vigna radiata*) due to Rhizobium inoculation in pot culture experiment.

Srivastava and Tewari (1981) stated that inoculation and phosphorous increased the grain and straw yields and harvest index in green gram with a slight advantage from split application but their grains were not significant.

Bisen *et al.* (1980) observed 1.70 t ha^{-1} lentil yield due to inoculation and that was 1.64 t ha^{-1} in uninoculated control.

Hoque *et al.* (1980) found that 83% higher nodulation, 15% higher dry shoot weight and 40% higher nodule weight over uninoculated control on Bragg soybean with 7 *Rhizobium japonicum* strain in both peat and soil based inoculants.

From the review of literature it was observed that Brady rhizobium inoculant's has significant effect on the nodulation, growth and yield performance of mungbean and it differs from variety to variety. Thus the present work was undertaken with three mungbean varieties and five fertilizer treatments including bio-fertilizer to assess their effect mungbean varieties.

CHAPTER 3

MATERIALS AND METHODS

A field experiment was conducted at the research farm of Sher-e-Bangla Agricultural University (SAU), Dhaka, during Kharif-1 (March to June), 2014 to study on the feasibility of reducing nitrogenous fertilizer through bio-fertilizer on mungbean. Materials used and methodologies followed in the present study have been described in this chapter.

3.1 Experimental site and soil

Geographically the trial field was located at 90° 33 E longitude and 23° 77 N latitude at a height of 8.6m above the mean sea level. It belongs to the AEZ 28, Madhupur Tract (FAO, 1988). It was deep red brown terrace soil and belonged to Nodda cultivated series. The soil was sandy loam in texture having pH 6.10. General characteristics of the soil are presented in Appendix -I and Appendix-II.

3.2 Climate

The climate of the experimental area was sub-tropical. The climate was considered by high temperature and dense rainfall during kharif season (March-September) and light rainfall during Rabi season (October-March) associated with moderately low temperature. The usual weather conditions during the study period have been presented in Appendix-III.

3.3 Planting materials

Three mungbean varieties viz. BARI mung 5, BARI mung 6 and BINA moog 8 were used as the planting materials for the investigation.

3.3.1 BARI mung 5

This variety was established by Pulses Research Centre of Bangladesh Agricultural Research Institute (BARI) in 1997. Plant height of this variety ranges from 45 to 50 cm and seeds are green in color. Thousand seed weight is about 41 to 42g. This variety requires 60 to 65 days to mature in the summer season. It is tolerant the Cercospora leaf spot and to resistant to yellow mosaic virus. The special character of this variety is its bold sidedness, synchronous maturity. The average seed yield of this cultivar is 1400-1500 kg ha^{-1}.

3.3.2 BARI mung 6

This variety was released from Bangladesh Agricultural Research Institute in 2003. The height of this variety ranges from 45 to 55cm and seeds are green in colour. Thousand seed weight is about 45-50g. The variety requires 55 to 65 days to mature in the summer season. It is tolerant to the Cercospora leaf spot and resistant to yellow mosaic virus. The main characteristic of this variety is its bold sidedness, synchronous maturity .The average seed yield of this cultivar is about 1800 kg ha^{-1} (BARI, 2003).

3.3.3 BINA moog 8

It was developed by Bangladesh Institute of Nuclear Agriculture (BINA). The height of the variety ranges from 60 to 75 cm and seeds are light green in color. It requires 60 to 75 days to mature in the summer season. It is also resistant to the Cercospora leaf spot and tolerant to yellow mosaic virus. One of the special characteristics of this cultivar is synchronization of pod ripening. The average seed yield is about 1500-1800kg ha^{-1}.

3.4 Collection of *Bradyrhizobium* inoculam as bio-fertilizer

The *Bradyrhizobium* inoculams used in the experiment were collected from the Soil Microbiology Laboratory of BINA, Mymensing. Liquid B1NA-MB culture (viz. BINA-MB 441) used in the study.

3.5 Treatments

Two factor and their interaction were used in the experiment. These were:

A)Variety-3(Mainplot)

V_1=BARI mung 5

V_2=BARI mung 6

V_3 = BINA moog 8

B) Bio-fertilizer and different doses of nitrogen fertilizer (urea) combination (Sub-plot)

T_1 = Recommended nitrogenous fertilizer dose (Control)

T_2 = Bio-fertilizer + 25% nitrogenous fertilizer (urea) of the recommended dose

T_3 = Bio-fertilizer + 50% nitrogenous fertilizer (urea) of the recommended dose

T_4 = Bio-fertilizer + 75% nitrogenous fertilizer (urea) of the recommended dose

T_5 = Bio-fertilizer + 100% nitrogenous fertilizer (urea) of the recommended dose

C) Combination of variety and bio-fertilizer with different doses of nitrogenous fertilizers (urea)

1. $V_1 \times T_1$	6. $V_2 \times T_1$	11. $V_3 \times T_1$
2. $V_1 \times T_2$	7. $V_2 \times T_2$	12. $V_3 \times T_2$
3. $V_1 \times T_3$	8. $V_2 \times T_3$	13. $V_3 \times T_3$
4. $V_1 \times T_4$	9. $V_2 \times T_4$	14. $V_3 \times T_4$
5. $V_1 \times T_5$	10. $V_2 \times T_5$	15. $V_3 \times T_5$

3.6 Land preparation

The experimental land was opened with a power tiller on March 15, 2014. Ploughing and cross cultivating were done with power tiller followed by laddering. Land preparation was completed on March 23, 2014 and was ready for sowing seeds.

3.7 Experimental design and layout

The experiment was laid out in a split plot design having three replications. The unit plot size was 6 m^2 (3 m × 2 m). The total number of treatments was (3 variety × 5 level bio-fertilizer and nitrogen fertilizer combination) 15 and the number of plots were 45. The replications were separated by 1m distance and plots were separated by 0.75m. Laying out of the experiment was done on March 23, 2014.

3.8 Fertilization

The experimental plots were fertilized as per the designed treatments. Nitrogen, Phosphorus, Potassium and sulpher were applied in the form of urea, triple super phosphate, Muriate of potash and Gypsum, respectively. The rate of urea, TSP, MP, Gypsum were 40, 80, 30, 4 kg ha^{-1}, respectively. All the fertilizers except urea were incorporated into the soil plot wise before sowing of seeds. Urea was applied as per treatment of the experiment.

3.9 Inoculation of seeds

Just before seeds sowing, the seeds were kept in polyethylene bags and were mixed with required amount of molasses and water for putting a sticky layer on the seed surface. Thereafter, bio-fertilizer was mixed thoroughly with the seeds with a view to putting a blackish layer on the seed surface. The seeds were dried in the shade or in a cool dry place to avoid sticking together before sowing.

3.10 Sowing of seeds

Seeds were sown on the furrows on 24th March, 2014 and the furrows were covered by soils soon after seeding. During the sowing day the sky was clear and seeds were sown in the morning. The line to line distance was maintained at 25 cm with continuous distribution of seeds in the line.

3.11 Germination of seeds

Seed germination occurred from 4th day of sowing. On the 5th day the percentage of germination was more than 85% and on the 6th day nearly all the plants came out of the soil.

3.12 Intercultural operations

3.12.1 Weeding and thinning

Weeding and thinning were done at 15 days after sowing (DAS) when the plant attained at height of about 20-25 cm. Plant to plant distance was maintained at 5-6 cm. Second weeding was done at 30 DAS when the plants attained about 35-45 cm height.

3.12.2 Irrigation and drainage

A light irrigation was given 16 days after sowing. During experimental period, there was heavy rainfall for several times. So it was essential to remove the excess water from the field.

3.12.3 Insect and pest control

The crop was attacked by pod borer and was successfully controlled by the application of Malathion 57 EC @ 1.5 L ha^{-1} at the time of 50% pod formation stage (50 DAS).

3.13 Determination of maturity

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

3.14 Harvesting and sampling

Pods were harvested three times**.** The crop was1st harvested on 28th may, 2014 from prefixed 1.0 m^2 areas for recording yield data and 2nd harvest was done on 8th june, 2014. Harvests were completed by 15th june, 2014. Before harvesting five plants were selected randomly from each plot and were uprooted for recording yield contributing characters data. The plants of prefixed 1.0 m^2 areas were harvested plot wise and were bundled separately, tagged and brought to the threshing floor of Agronomy Field Laboratory of SAU.

3.15 Threshing

The crop was sun dried for 4 days by placing them on the open threshing floor. Seeds were separated from the plants by threshing the bundles with the help of bamboo stick.

3.16 Drying, cleaning and weighing

The seeds were dried in the sun for reducing the moisture in the seeds to maintain the constant level. The dried seeds and stover were cleaned and weighed.

3.17 Data collection

The data on the following parameters were recorded from each plot:

3.17.1 Growth characters data

- Plant height (cm)
- Number of branches plant^{-1}
- Number of leaves plant^{-1}

- Total Dry matter weight of plant^{-1} (g)
- Number of nodules plant^{-1}
- Dry weight of nodules plant^{-1} (mg)

13.17.2 Yield contributing parameters

- Number of pods plant^{-1}
- Pod length (cm)
- Number of seeds pod $^{-1}$
- Weight of 1000 seed (g)

13.17.3 Yield and harvest index

- Seed yield (t ha^{-1})
- Stover yield (t ha^{-1})
- Biological yield (t ha^{-1})
- Harvest index (%)

13.18 Outline of data recording

13.18.1 Growth parameters

Data on growth parameters were recorded from 5 selected plants from each plot. Nodulation and dry matter yield were noted from the selected plant at 15days interval started from 15 DAS.

13.18.1.1 Plant height (cm)

The plant height was taken from the ground level to the tip of the 5 selected plants and was expressed in cm. The data was recorded from each plot at 15, 30, 45 DAS and at harvest. Then the average plant height was noted.

13.18.1.2 Number of branch plant^{-1}

Number of branches of selected 5 plants were recorded of each plot at 15, 30, 45 DAS and at harvest. Then the average number of branches per plant was determined.

13.18.1.3 Number of leaves plant^{-1}

Number of leaves were counted from selected 5 plant samples at 15, 30, 45 DAS and at harvest. After that the mean value was noted.

13.18.1.4 Dry matter weight plant^{-1} (g)

Dry matter weight plant^{-1} was calculated from the 3 plants collected from the inner rows to avoid border effect at 15, 30, 45 DAS and at harvest. Then the average of plant weight was recorded.

13.18.1.5 Number of nodules plant^{-1}

Plants sample were uprooted carefully with the help of nirani at 30 and 45 DAS for counting the nodules plant^{-1}. From each plot, 3 plants were selected randomly and the roots of the uprooted plants were washed carefully in water. Then nodules from the main roots and branch roots were counted and the average number of nodules plant^{-1} was recorded.

13.18.1.6 Dry weight of nodules plant $^{-1}$(mg)

Collected and counted nodules were oven dried maintaining a temperature of 65°C until constant weight was reached and the dry weight was recorded with an electric balance.

13.18.2 Yield contributing parameters

13.18.2.1 Number of pods plant^{-1}

Number of pods was counted from randomly selected 5 plants and then their mean value was noted.

13.18.2.2 Pod length (cm)

The pod length was measured from randomly selected 10 pods of each plot and then the average pod length was calculated.

13.18.2.3 Number of seeds pod^{-1}

Number of seeds pod^{-1} was counted from randomly selected 10 pods of each plot and then the average seed number was recorded.

13.18.2.4 Weight of 1000 seed (g)

1000-seeds were counted, which were taken from the seeds sample of each plot individually, then weight was taken in an electrical balance and data were noted.

13.18.3 Yield and harvest index

13.18.3.1 Grain yield (t ha^{-1})

Seeds obtained from 1.0 m^2 area of each unit plot were dried in sun. Then weighed out and the seed weight was expressed as t ha^{-1}.

13.18.3.2 Stover yield (t ha^{-1})

After threshing of the harvested plants and the pods shell were sun dried for several days to a constant weight to record the stover yield. The stover yield plot^{-1} was converted to t ha^{-1}.

13.18.3.3 Biological yield (t ha^{-1})

Biological yield was calculated using the following formula:

Biological yield = Grain yield + stover yield

13.18.3.4 Harvest index (%)

Harvest index was calculated on the ratio of grain yield to biological yield and expressed in terms of percentage. It was calculated by using the following formula:

$$\text{HI } \% = \frac{\text{Seed yield}}{\text{Economic yield}} \times 100$$

13.18 Statistical analysis

The data collected on different parameters were statistically analyzed to obtain the level of significance using the MSTAT- C computer package program. Mean difference among the treatments were tested with least significant differences (LSD) at 5% level of significance.

CHAPTER 4

RESULTS AND DISCUSSION

The results obtained from the present study focused on different parameters related to bio-fertilizer and variety effects on growth, yield and yield contributing characters have been presented and discussed in this chapter.

4.1 Growth parameters

4.1.1 Plant height

4.1.1.1 Effect of varieties

The figure revealed that the effect of varieties on plant height was significant of all stages of the growth (Fig.1 and Appendix iv). The height of the plant increased gradually from 15 to 45 DAS after that plant height decreased gradually from 45 DAS to at harvest. The rate of increasing of plant height was more rapid from 15 to 30 DAS. The variety V_3 (BINA moog 8) showed its superiority on plant height for all stages of growth (27.11, 52.82, 62.71, 59.78 cm at 15, 30, 45 DAS and at harvest, respectively). The variety V_1 (BARI mung 5) showed the lowest plant

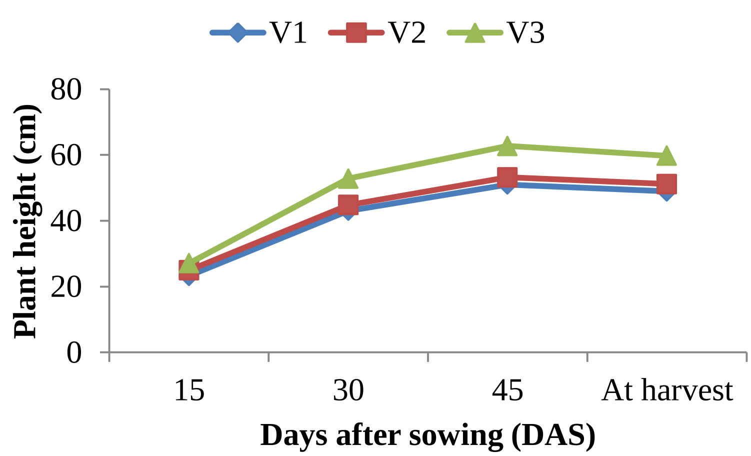

Figure 1. Effect of different varieties on plant height of mungbean at different days after sowing (LSD $_{(0.05)}$ = 2.40, 5.14, 6.19 and 2.93 at 15, 30, 45 DAS and at harvest, respectively).

Here, V_1= BARI mung 5, V_2 = BARI mung 6 and V_3= BINA moog 8

height (23.28, 43.06, 51.01, 48.94 cm at 15, 30, 45 DAS and at harvest) for all the stages of growth. The result was in agreement with the findings of Begum (2008) who reported the plant height differed among varieties.

4.1.1.2 Effect of bio-fertilizer with different doses of nitrogenous fertilizer (urea) combination

The plant height was significantly influenced by bio-fertilizer with different doses of urea combination treatments for 15, 30, 45 DAS and at harvest (Fig. 2 and Appendix iv). The highest plant height (27.19, 49.98, 59.29, 57.42 cm at 15, 30, 45 DAS and at harvest, respectively) was recorded in T_5 (bio-fertilizer + 100% nitrogenous fertilizer of the recommended dose) treated plot which was

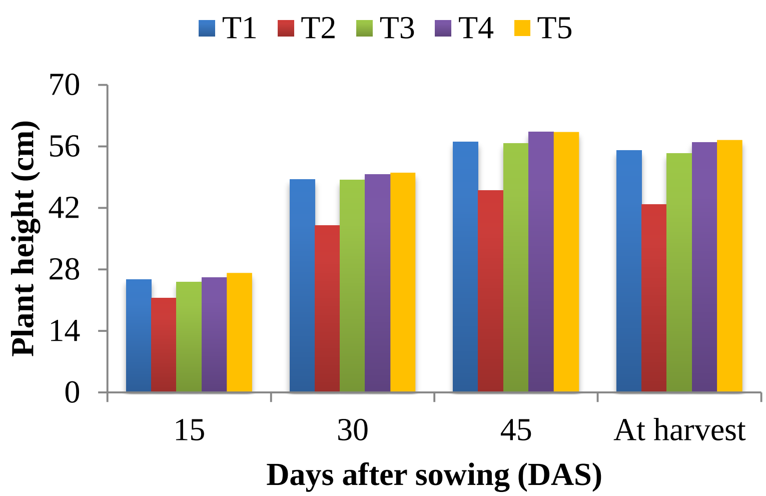

Figure 2. Effect of bio-fertilizer with different doses of nitrogenous fertilizer combination on plant height of mungbean at different days after sowing ($LSD_{(0.05)}$ = 2.05, 3.59, 3.69 and 2.96 at 15, 30, 45 DAS and at harvest, respectively).

Here, T_1 = Recommended nitrogen dose

T_2 = Bio-fertilizer (120g) + 25% nitrogenous fertilizer (urea) of the recommended dose

T_3 = Bio-fertilizer (120g) + 50% nitrogenous fertilizer (urea) of the recommended dose

T_4 = Bio-fertilizer (120g) + 75% nitrogenous fertilizer (urea) of the recommended dose

T_5 = Bio-fertilizer (120g) + 100% nitrogenous fertilizer (urea) of the recommended dose

statistically similar with T_4 and T_1 at all sampling date. The lowest plant height (21.45, 38.03, 45.91 and 42.74cm at 30, 45 DAS and at harvest, respectively) was found from T_2 (bio-fertilizer + 25% nitrogenous fertilizer of the recommended dose) treated plots. The plant height of mungbean was higher in bio-fertilizer applied plot reported by Akhtaruzzaman (2004) which supported the present experiment.

4.1.1.3 Interaction effect of variety and bio-fertilizer with different doses of urea combination

Interaction of variety × fertilizer doses exerted significant effect on plant height (Table 1 and Appendix iv). The interaction of V_3T_5 (BINA moog 8 × bio-fertilizer + 100% nitrogenous fertilizer of the recommended dose) gave significantly tallest plant height (28.82, 55.51, 65.33 and 64.15cm at 15, 30, 45 and at harvest, respectively) which was not significantly different from the interaction of V_3T_4, V_3T_3, V_3T_1, at all stages of growth. V_1T_5, V_2T_1, V_2T_3, V_2T_4 and V_2T_5 are also statistically identical with V_3T_5 at 15 DAS. On the other hand, the lowest plant height (19.38, 34.66, 41.46 and 38.44cm at 15, 30, 45 DAS and at harvest, respectively) was observed in interaction of V_1T_2 (BARI mung 5 × bio-fertilizer + 25% nitrogenous fertilizer of the recommended dose).

Table1. Interaction effect of different varieties and bio-fertilizer with different doses of urea on plant height of mungbean at different days after sowing

Treatment combination	Different days after sowing			
	15	30	45	At harvest
V_1T_1	22.81 d-f	44.46 b	52.44 bc	50.14 bc
V_1T_2	19.38 f	34.66 c	41.46 d	38.44 d
V_1T_3	23.78 c-e	43.47 b	50.91 c	50.14 bc
V_1T_4	24.65 b-d	45.77 b	55.02 bc	52.46 bc
V_1T_5	25.77 a-d	46.94 b	55.22 bc	53.51 bc
V_2T_1	26.24 a-d	46.47 b	54.41 bc	52.80 bc
V_2T_2	20.43 ef	35.32 c	42.75 d	41.29 d
V_2T_3	25.50 a-d	46.88 b	54.33 bc	52.68 bc
V_2T_4	25.61 a-d	47.74 b	57.27 bc	54.50 b
V_2T_5	26.97 a-c	47.49 b	57.31 b	54.59 b
V_3T_1	28.02 ab	54.39 a	64.34 a	62.20 a
V_3T_2	24.54 b-d	44.12 b	53.51 bc	48.50 c
V_3T_3	26.11 a-d	54.60 a	64.92 a	60.29 a
V_3T_4	28.07 ab	55.47 a	65.46 a	63.76 a
V_3T_5	28.82 a	55.51 a	65.33 a	64.15 a
LSD $_{(0.05)}$	**3.55**	**6.22**	**6.39**	**5.12**
CV (%)	**8.39**	**7.87**	**6.81**	**5.7**

Here, T_1 = Recommended nitrogenous fertilizer of the dose

T_2 = Bio-fertilizer (120g) + 25% nitrogenous fertilizer (urea) of the recommended dose

T_3 = Bio-fertilizer (120g) +50% nitrogenous fertilizer (urea) of the recommended dose

T_4 = Bio-fertilizer (120g) + 75% nitrogenous fertilizer (urea) of the recommended dose

T_5 = Bio-fertilizer (120g) + 100% nitrogenous fertilizer (urea) of the recommended dose

V_1= BARI mung 5, V_2 = BARI mung 6 and V_3= BINA moog 8

4.1.2 Number of branches plant^{-1}

4.1.2.1 Effect of varieties

The number of branches plant^{-1} increased gradually from 15 to 45 DAS after that it was decreased from 45 DAS to at harvest (Fig. 3 and Appendix v). The rate of increasing of number of branches plant^{-1} was more rapid from 15 to 30 DAS. The variety V_2 (BARI mung 6) showed its superiority in producing number of branches plant^{-1} for all stages of growth (1.39, 2.15, 2.35 and 2.18 at 15, 30, 45 DAS and at harvest, respectively) which was statistically similar with V_3 (BINA mung 8) at 45 DAS. The variety V_1 (BARI mung 5) showed the lowest number of branches plant^{-1} (1.15, 1.72, 2.04 and 1.87 at 15, 30, 45 DAS and at harvest, respectively) for all the stages of growth which was statistically identical with V_3 (BINA mung 8) at 15, 30 DAS and at harvest, respectively.

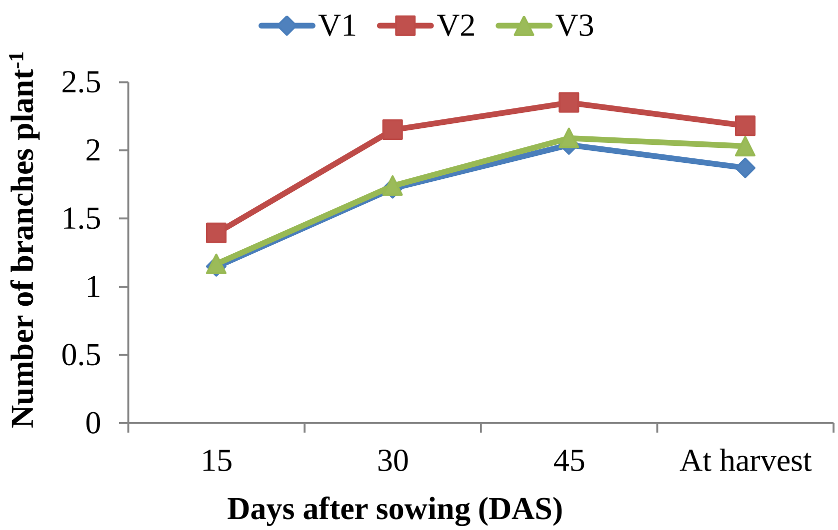

Figure 3. Effect of different varieties on number of branches plant^{-1} of mungbean at different days after sowing (LSD $_{(0.05)}$ = 0.11, 0.15, 0.31 and 0.11 at 15, 30, 45 DAS and at harvest, respectively)

Here, V_1= BARI mung 5, V_2 = BARI mung 6 and V_3= BINA moog 8

4.1.2.2 Effect of bio-fertilizer with different doses of nitrogenous fertilizer (urea) combination

The number of branches plant^{-1} was significantly influenced by bio-fertilizer with different doses of urea at 15, 30, 45 DAS and at harvest, respectively (Fig. 4 and Appendix v). The highest number of branches plant^{-1} (3.20, 8.60, 9.91 and 5.17 at 15, 30, 45 DAS and

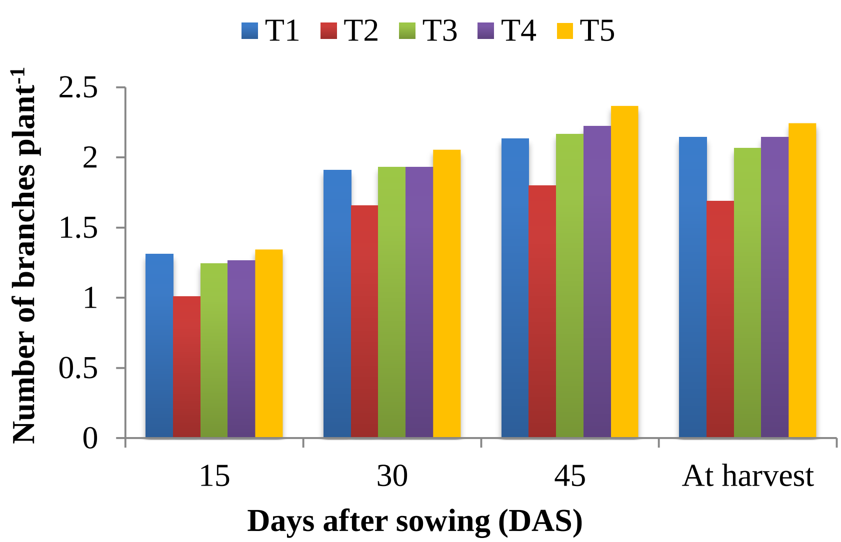

Figure 4. Effect of bio-fertilizer with different doses of nitrogenous fertilizer combination on number of branches plant^{-1} of mungbean at different days after sowing (LSD $_{(0.05)}$ = 0.09, 0.09, 0.17 and 0.11 at 15, 30, 45 DAS and at harvest, respectively)

Here, T_1 = Recommended nitrogenous fertilizer dose

T_2 = Bio-fertilizer (120g) + 25% nitrogenous fertilizer (urea) of the recommended dose

T_3 = Bio-fertilizer (120g) + 50% nitrogenous fertilizer (urea) of the recommended dose

T_4 = Bio-fertilizer (120g) + 75% nitrogenous fertilizer (urea) of the recommended dose

T_5 = Bio-fertilizer (120g) + 100% nitrogenous fertilizer (urea) of the recommended dose

at harvest, respectively) was recorded from T_5 (bio-fertilizer + 100% nitrogenous fertilizer of the recommended dose) treated plots which was not significantly different from T_4 (bio-fertilizer + 75% nitrogenous fertilizer of the recommended dose) at all sampling date. The lowest number of branches plant^{-1} (1.01, 6.60, 7.22 and 3.22 at 15, 30, 45 DAS and at harvest, respectively) was observed in T_2 (bio-fertilizer + 25% nitrogenous fertilizer of the recommended dose) which was significantly different from others combination.

4.1.2.3 Interaction effect of variety with bio-fertilizer with different doses of urea combination

The Interaction of variety × fertilizer doses exerted significant effect on number of branches plant^{-1} at 15, 30, 45 DAS and at harvest (Table 2 and Appendix v). The interaction effect of V_2T_5 (1.57, 2.53, 2.50, 2.40 at 15, 30, 45 DAS and at harvest, respectively) showed the highest number of branches plant^{-1} which was not statistically different from V_3T_4 at all sampling dates and V_2T_3 except 15 DAS, V_2T_1 at 15 DAS. On the contrast, lowest number of branches plant^{-1} was recorded from interaction of V_1T_2 at 15, 30, 45 DAS and at harvest. Interaction of V_1T_4, V_3T_3, V_3T_4 and V_1T_3 showed statistically similar number of branches plant^{-1} at 30 DAS.

Table 2. Interaction effect of different varieties and bio-fertilizer with different doses of urea on number of branches plant^{-1} of mungbean at different days after sowing

Treatment combination	Days after sowing (DAS)			
	15	30	45	At harvest
V_1T_1	1.13 d-f	1.83 de	2.30 a-d	2.07 e-g
V_1T_2	0.93 g	1.60 gh	1.70 f	1.57 i
V_1T_3	1.20 de	1.73 e-g	2.13 b-e	1.80 gh
V_1T_4	1.20 de	1.67 fg	2.03 de	1.97 gh
V_1T_5	1.27 cd	1.77 d-f	2.30 a-d	2.03 e-g
V_2T_1	1.43 ab	2.03 c	2.07 c-e	2.02 d-g
V_2T_2	1.10 ef	1.90 cd	1.87 ef	1.81 fg
V_2T_3	1.40 bc	2.33 a	2.37 a-c	2.23 ab
V_2T_4	1.47 ab	2.43 ab	2.48 ab	2.34 ab
V_2T_5	1.57 a	2.47 a	2.53 a	2.50 a
V_3T_1	1.37 bc	1.87 de	2.03 de	1.97 cd
V_3T_2	1.00 fg	1.47 h	1.83 ef	1.60 i
V_3T_3	1.13 d-f	1.73 e-g	2.00 d-f	1.93 gh
V_3T_4	1.13 d-f	1.67 fg	2.20 b-d	2.17 c-f
V_3T_5	1.20 de	1.87 de	2.30 a-d	2.20 c-e
LSD $_{(0.05)}$	**0.15**	**0.15**	**0.30**	**0.18**
CV (%)	**7.41**	**4.83**	**8.35**	**5.35**

Here, T_1 = Recommended nitrogenous fertilizer dose

T_2 = Bio-fertilizer (120g) + 25% nitrogenous fertilizer (urea) of the recommended dose

T_3 = Bio-fertilizer (120g) + 50% nitrogenous fertilizer (urea) of the recommended dose

T_4 = Bio-fertilizer (120g) + 75% nitrogenous fertilizer (urea) of the recommended dose

T_5 = Bio-fertilizer (120g) + 100% nitrogenous fertilizer (urea) of the recommended dose

V_1= BARI mung 5, V_2 = BARI mung 6 and V_3= BINA moog 8

4.1.3 Number of leaves plant^{-1}

4.1.3.1 Effect of varieties

Number of leaves plant^{-1} of different varieties presented in figure 5 (Appendix vi). The figure revealed that the number of leaves plant^{-1} was enhanced from 15 to 45 DAS and after 45 DAS number of leaves plant^{-1} reduced drastically. The rate of increase was more rapid from 15 to 30 DAS then 30 to 45 DAS. The variety V_2 showed its superiority in producing number of leaves plant^{-1} for all stages of growth (3.33, 8.65, 9.91 and 64.74 at 15, 30, 45 DAS and at harvest, respectively) was recorded from V_2 (BARI mung 6) which was statistically similar with V_3 (BINA moog 8) at 15 DAS. The variety V_1 (BARI mung 5) showed the lowest number of leaves plant^{-1} (2.94, 7.51, 8.25 and 3.81 at 15, 30, 45, DAS and at harvest, respectively) which was statistically similar with all growth stages of V_3.

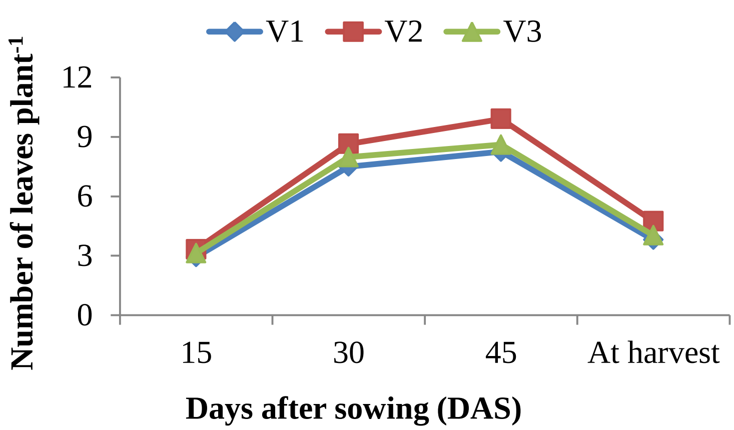

Figure. 5 Effect of different varieties on number of leaves plant^{-1} of mungbean at different days after sowing (LSD $_{(0.05)}$ = 0.22, 0.30, 0.55 and 0.24 at 15, 30, 45 DAS and at harvest, respectively)

Here, V_1= BARI mung 5, V_2 = BARI mung 6 and V_3= BINA moog 8

4.1.3.2 Effect of bio-fertilizer with different doses of nitrogenous fertilizer (urea) combination

The number of leaves plant^{-1} was significantly influenced by bio-fertilizer with different doses of urea at 15, 30, 45 DAS and at harvest, respectively (Fig. 6 and Appendix vi).

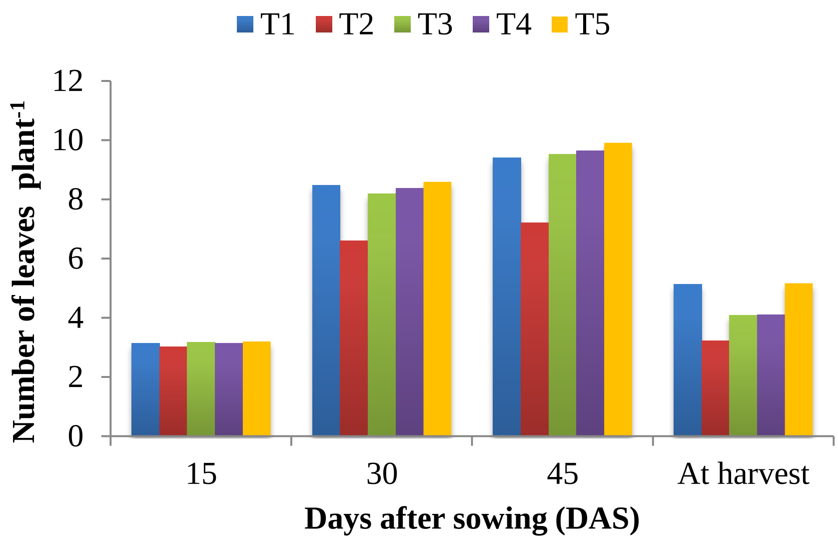

Figure 6. Effect of bio-fertilizer with different doses of nitrogenous fertilizer combination on number of leaves plant^{-1} of mungbean at different days after sowing (LSD $_{(0.05)}$ = 0.22, 0.40, 0.42 and 0.45 at 15, 30, 45 DAS and at harvest, respectively).

Here, T_1 = Recommended nitrogenous fertilizer dose

T_2 = Bio-fertilizer (120g) + 25% nitrogenous fertilizer (urea) of the recommended dose

T_3 = Bio-fertilizer (120g) + 50% nitrogenous fertilizer (urea) of the recommended dose

T_4 = Bio-fertilizer (120g) + 75% nitrogenous fertilizer (urea) of the recommended dose

T_5 = Bio-fertilizer (120g) + 100% nitrogenous fertilizer (urea) of the recommended dose

The highest number of leaves plant^{-1} (3.20, 8.60, 9.91 and 5.17 at 15, 30, 45 DAS and at harvest, respectively) was recorded from T_5 (bio-fertilizer + 100% nitrogenous fertilizer of the recommended doses) treated plots which was not significantly different from T_3 (bio-fertilizer + 50% nitrogenous fertilizer of the recommended dose) at 15 DAS; T_4 (bio-fertilizer + 75% nitrogenous fertilizer of the recommended dose) at 15, 30 and 45 DAS. The lowest number of branches plant^{-1} (6.60, 7.22 and 3.22 at 30, 45 DAS and at harvest, respectively) was observed in T_2 (Bio-fertilizer + 25% nitrogenous fertilizer of the recommended dose) which was statistically different from others.

4.1.3.3 Interaction effect of variety and Bio-fertilizer with different doses of urea combination

The interaction effect of variety × fertilizer dose exerted significant effect on number of leaves plant^{-1} at 15, 30, 45 DAS and at harvest, respectively (Table 3 and Appendix vi). The interaction of V_2T_5 (3.28, 9.28, 11.24 and 5.81 at 15, 30, 45 DAS and at harvest, respectively) gave the highest number of leaves plant^{-1} which was not statistically different from interaction of V_2T_3 at 15, 30 DAS; V_2T_4 at 15, 30 and 45 DAS; V_3T_4 at 15 DAS and V_2T_1 at harvest. On the contrast, lowest number of leaves plant^{-1} was recorded from V_1T_2 at 15, 30, 45 DAS and at harvest which was statistically similar with V_1T_1, V_1T_3, V_1T_5, V_3T_1, V_3T_2 and V_3T_3 at 15 DAS. But at harvest V_2T_2, V_3T_2, V_3T_3 and V_3T_4 interactions were similar with V_1T_2.

Table 03. Interaction effect of different varieties and fertilizer management on number of leaves plant^{-1} of mungbean at different days after sowing

Treatment combination	Days after sowing (DAS)			
	15	30	45	At harvest
V_1T_1	2.90 de	8.07 b-e	9.21 cd	4.55 b-d
V_1T_2	2.76 e	6.15 g	7.30 e	2.95 g
V_1T_3	2.98 b-e	7.88 d-f	8.65 d	3.89 c-e
V_1T_4	2.95 c-e	7.44 ef	8.57 d	3.91 c-e
V_1T_5	3.12 a-e	7.99 c-e	9.00 cd	4.57 bc
V_2T_1	3.44 a	8.71 ab	9.53 c	5.76 a
V_2T_2	3.18 a-d	7.30 f	7.21 e	3.69 e-g
V_2T_3	3.41 a	8.70 ab	10.36b	4.6 bc
V_2T_4	3.34 ab	9.26 a	11.19 a	4.66 bc
V_2T_5	3.28 a-c	9.28 a	11.24 a	5.81 a
V_3T_1	3.09 a-e	8.66 a-c	9.46 c	5.09 ab
V_3T_2	3.12 a-e	6.34 g	7.14 e	3.03 fg
V_3T_3	3.11 a-e	7.98 c-f	8.56 d	3.15 e-g
V_3T_4	3.14 a-d	8.41 b-d	9.16 cd	3.72 e-g
V_3T_5	3.19 a-d	8.51 b-d	9.48 c	5.13 ab
$LSD_{(0.05)}$	**0.37**	**0.68**	**0.73**	**0.78**
CV (%)	**7.06**	**5.05**	**4.85**	**11.09**

Here, T_1 = Recommended nitrogenous fertilizer dose

T_2 = Bio-fertilizer (120g) + 25% nitrogenous fertilizer (urea) of the recommended dose

T_3 = Bio-fertilizer (120g) + 50% nitrogenous fertilizer (urea) of the recommended dose

T_4 = Bio-fertilizer (120g) + 75% nitrogenous fertilizer (urea) of the recommended dose

T_5 = Bio-fertilizer (120g) + 100% nitrogenous fertilizer (urea) of the recommended dose

V_1= BARI mung 5, V_2 = BARI mung 6 and V_3= BINA moog 8

4.1.4 Dry weight plant^{-1}

4.1.4.1 Effect of varieties

Dry weight plant^{-1} due to varieties of mungbean has been presented in figure 7 (Appendix vii). The figure revealed that the dry of plant^{-1} increased gradually from 15 DAS to at harvest. The rate of increase was more rapid from 30 to 45 DAS and the rate of increase was slower in early and later stages of growth. The variety V_3 (BINA moog 8) showed the highest dry matter plant^{-1} for all growth stages (.65, 1.95, 4.05 and 4.80g at 15, 30, 45 DAS and at harvest, respectively) which was statistically similar to V_2 (BARI mung 6) at 45 DAS and at harvest, respectively. On the other hand, the Variety V_1 (BARI mung 5) showed the lowest dry weight of plant^{-1} (.05, 1.56, 3.62 and 3.81 at 15, 30, 45 and at harvest, respectively) which was statistically similar to V_2 (BARI mung 6) at 30 DAS. The result was in agreement with the findings of Salahuddin (2006) who reported the dry weight plant^{-1} differed among varieties.

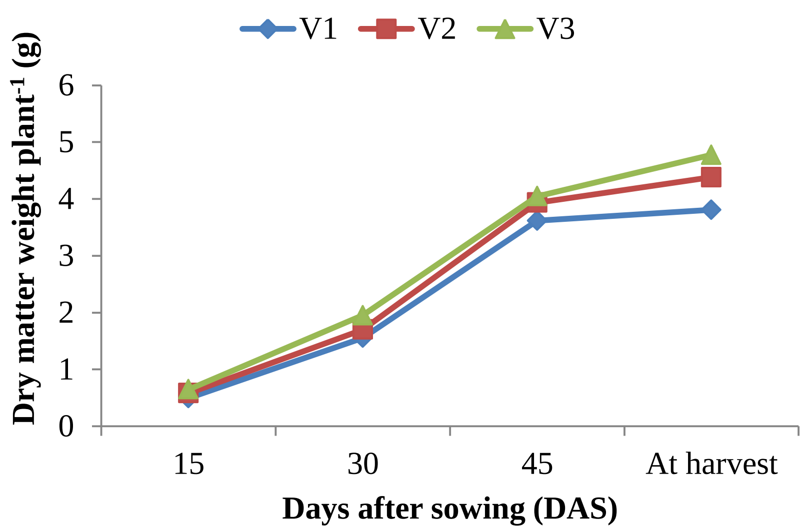

Figure. 7 Effect of different varieties on dry matter weight plant^{-1} of mungbean at different days after sowing (LSD $_{(0.05)}$ = 0.03, 0.15, 0.22 and 0.51 at 15, 30, 45 DAS and at harvest, respectively).

Here, V_1= BARI mung 5, V_2 = BARI mung 6 and V_3= BINA moog 8

4.1.4.2 Effect of bio-fertilizer with different doses of nitrogenous fertilizer (urea) combination

Dry weight plant^{-1} increased steadily with the age of plants and the highest dry weight was recorded at harvest stages (Fig. 8 and Appendix vii)). The dry weight plant^{-1} was significantly influenced by bio-fertilizer at 15, 30, 45 DAS and at harvest (Fig. 8). The highest dry weight of plant^{-1} (.73, 1.93, 4.36 and 4.94 at 15, 30, 45 DAS and at harvest, respectively) was recorded in T_5 treated plots which was statistically similar with T_4 at all stages of growth; T_3 at harvest and T_1at 30 DAS and at harvest.

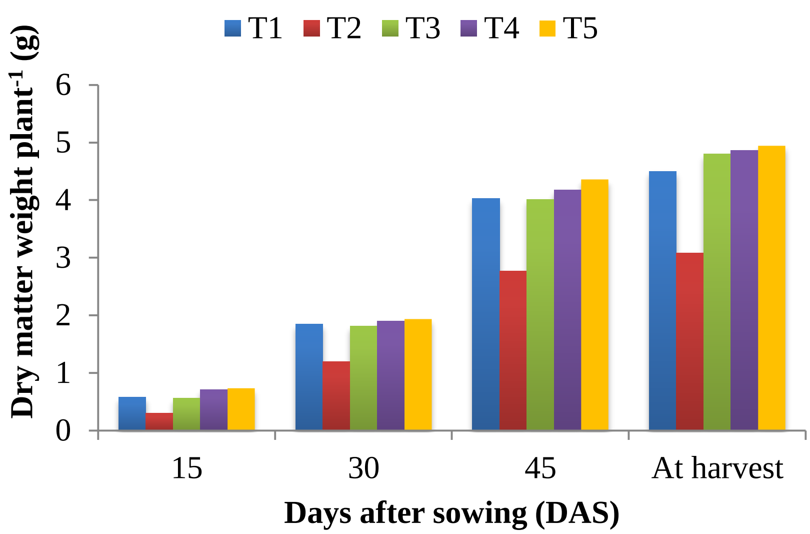

Figure 8. Effect bio-fertilizer with different doses of nitrogenous fertilizer combination on dry matter weight plant^{-1} of mungbean at different days after sowing (LSD $_{(0.05)}$ = 0.03, 0.12, 0.25 and 0.36 at 15, 30, 45 DAS and at harvest, respectively).

Here, T_1 = Recommended nitrogenous fertilizer dose

T_2 = Bio-fertilizer (120g) + 25% nitrogenous fertilizer (urea) of the recommended dose

T_3 = Bio-fertilizer (120g) + 50% nitrogenous fertilizer (urea) of the recommended dose

T_4 = Bio-fertilizer (120g) + 75% nitrogenous fertilizer (urea) of the recommended dose

T_5 = Bio-fertilizer (120g) + 100% nitrogenous fertilizer (urea) of the recommended dose

The lowest dry weight plant^{-1} (.30, 1.19, 2.76 and 3.08 at 15, 30, 45 DAS and at harvest, respectively) was found from T_2 treated plots. The dry weight plant^{-1} of mungbean was higher in bio-fertilizer applied plot reported by Akhtaruzzaman (2004) which supported the present experiment.

4.1.4.3 Interaction effect of variety and Bio-fertilizer with different doses of urea combination

Interaction of variety × fertilizer exerted significant effect on dry weight plant^{-1} (Table 4 and Appendix vii). The highest dry weight plant^{-1} (.76, 2.19, 4.56 and 5.39g at 15, 30, 45 DAS and at harvest, respectively) was recorded in V_3T_5 (BINA mung 8 × bio-fertilizer + 100% nitrogenous fertilizer of the recommended dose) treated plots which was not significantly different from the V_3T_4 at all stages of growth and V_3T_3 at all sampling dates except 15 DAS. On the other hand, the lowest dry weight plant^{-1} (.25, 1.24, 2.40 and 2.47g at 15, 30, 45 DAS and at harvest, respectively) was observed in V_1T_2.

Table 4. Interaction effect of different varieties and fertilizer doses on dry matter weight plant^{-1} of mungbean at different days after sowing

Treatment combination	Days after sowing (DAS)			
	15	30	45	At harvest
V_1T_1	0.44 f	1.68 e-g	4.03 c-e	4.28 fg
V_1T_2	0.25 h	1.24 h	2.40 g	2.47 h
V_1T_3	0.42 f	1.55 g	3.77 e	4.27 de
V_1T_4	0.68 d	1.62 fg	3.89 de	4.32 c-e
V_1T_5	0.69 cd	1.68 e-g	4.00 c-e	4.38 c-e
V_2T_1	0.59 e	1.78 d-f	4.30 a-d	4.43 ef
V_2T_2	0.30 gh	1.01 i	2.91 f	3.19 g
V_2T_3	0.58 e	1.85 c-e	3.85 e	4.85 b-d
V_2T_4	0.70 b-d	1.93 b-d	4.11 b-e	4.89 bc
V_2T_5	0.74 a-c	1.90 b-d	4.51 ab	4.94 a-c
V_3T_1	0.70 cd	2.07 ab	3.75 e	4.17 ef
V_3T_2	0.34 g	1.32 h	2.99 f	3.59 fg
V_3T_3	0.68 d	2.03 a-c	4.42 a-c	5.22 ab
V_3T_4	0.75 ab	2.14 a	4.52 ab	5.39 ab
V_3T_5	0.76 a	2.19 a	4.56 a	5.52 a
LSD $_{(0.05)}$	**0.05**	**0.21**	**0.43**	**0.62**
CV (%)	**5.77**	**7.11**	**6.65**	**8.49**

Here, T_1 = Recommended nitrogenous fertilizer dose

T_2 = Bio-fertilizer (120g) + 25% nitrogenous fertilizer (urea) of the recommended dose

T_3 = Bio-fertilizer (120g) + 50% nitrogenous fertilizer (urea) of the recommended dose

T_4 = Bio-fertilizer (120g) + 75% nitrogenous fertilizer (urea) of the recommended dose

T_5 = Bio-fertilizer (120g) + 100% nitrogenous fertilizer (urea) of the recommended dose

V_1= BARI mung 5, V_2 = BARI mung 6 and V_3= BINA moog 8

4.1.5 Number of nodules plant^{-1}

4.1.5.1 Effect of varieties

The result showed that the effect of varieties on number of nodules plant^{-1} was significant at 30 and 45 DAS (Fig. 9 and Appendix viii). The highest number of nodules plant^{-1} (104.1 and 213.6 at 30 and 45 DAS, respectively) was recorded from V_2 (BARI mung 6), while intermediate (79.67 and 164.3 at 30 and 45 DAS, respectively) in V_3 (BINA moog 8) and the lowest number of nodules plant^{-1} (71.47 and 139.6) was obtained from V_1 (BARI mung 5) at 30 and 45 DAS, respectively.

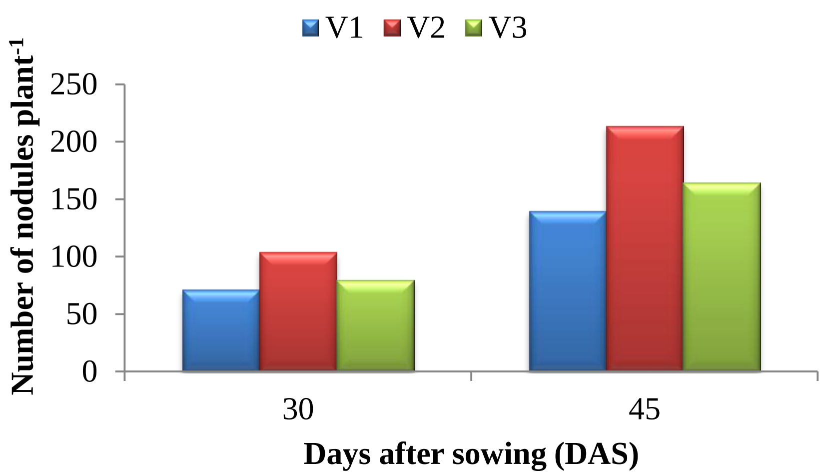

Figure 9. Effect of different varieties on number of nodule plant^{-1} of mungbean at different days after sowing (LSD $_{(0.05)}$ = 3.67 and 8.42 at 30 and 45 DAS, respectively)

Here, V_1= BARI mung 5, V_2 = BARI mung 6 and V_3= BINA moog 8

4.1.5.2 Effect of bio-fertilizer with different doses of nitrogenous fertilizer (urea) combination

Bio-fertilizer and different doses of nitrogenous fertilizer (urea) treatment exerted significant effect on number of nodules plant^{-1} at 30 and 45 DAS (Fig. 10 and Appendix viii). Irrespective of different treatments number of nodules plant^{-1} was higher in 45 DAS than 30 DAS sampling dates. The highest number of nodules plant^{-1} (90.60 and 194.1 at 30 and 45 DAS, respectively) was recorded from T_5 (bio-fertilizer +100% nitrogenous fertilizer of the recommended doses) treated plots which was

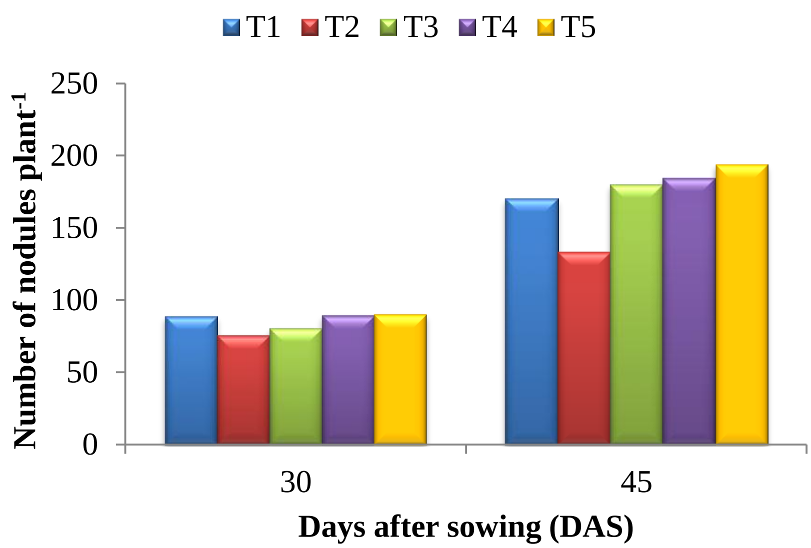

Figure 10. Effect of bio-fertilizer with different doses of nitrogenous fertilizer combination on number of nodules plant^{-1} of mungbean at different days after sowing (LSD $_{(0.05)}$= 5.38 and 8.01 at 30 and 45 DAS, respectively).

Here, T_1 = Recommended nitrogenous fertilizer dose dose

T_2 = Bio-fertilizer (120g) + 25% nitrogenous fertilizer (urea) of the recommended dose

T_3 = Bio-fertilizer (120g) + 50% nitrogenous fertilizer (urea) of the recommended dose

T_4 = Bio-fertilizer (120g) + 75% nitrogenous fertilizer (urea) of the recommended dose

T_5 = Bio-fertilizer (120g) + 100% nitrogenous fertilizer (urea) of the recommended dose

not significantly different from T_4 (bio-fertilizer +75% nitrogenous fertilizer of the recommended doses) at 30 DAS, while intermediate from T_3 (bio-fertilizer +50% nitrogen of the recommended dose) at 30 and 45 DAS, respectively. The lowest number of nodules plant^{-1} (133.3 at 45 DAS) was observed in T_2 (bio-fertilizer + 25% nitrogenous fertilizer of the recommended dose) treated plots.

4.1.5.3 Interaction effect of variety and bio-fertilizer with different doses of urea combination

Interaction of variety × fertilizer dose was highly significant in respect of number of nodules plant^{-1}at 30 and 45 DAS (Table 5 and Appendix viii). The highest number of nodules plant^{-1} (107.1 and 249.9 at 30 and 45 DAS, respectively) was found from V_2T_5 (BARI mung 6 × 100% nitrogenous fertilizer of the recommended dose) which was statistically identical with V_2T_4 at all stages of growth and V_2T_1 at 30 DAS. Significantly lowest number of nodules plant^{-1} (62.00 and 107.1 at 30 and 45 DAS, respectively) was produced in V_1T_2 interaction which was statistically identical with V_1T_3 at 30 DAS.

Table 5. Interaction effect of different varieties and fertilizer doses on number of nodule plant^{-1} and nodule dry weight plant^{-1} of mungbean at different days after sowing

Treatment combination	Number of nodule plant^{-1}		Nodule dry weight plant^{-1} (mg)	
	Days after sowing (DAS)			
	30	**45**	**30**	**45**
V_1T_1	74.00 d	154.4 fg	1.90 a	6.47 cd
V_1T_2	62.00 e	107.1 j	1.34 d	4.07 e
V_1T_3	64.67 e	133.8 hi	1.63 c	7.01 bc
V_1T_4	74.67 d	145.0 gh	1.90 ab	7.29 b
V_1T_5	82.04 cd	157.5 e-g	2.03 a	7.34 b
V_2T_1	112.6 a	185.6 c	2.00 a	8.71 a
V_2T_2	91.15 bc	163.8 d-f	1.66 bc	6.10 d
V_2T_3	96.05 b	231.4 b	2.11 a	9.18 a
V_2T_4	113.6 a	237.3 ab	2.14 a	9.34 a
V_2T_5	107.1 a	249.9 a	2.14 a	9.43 a
V_3T_1	80.20 d	170.7 de	1.98 a	7.43 b
V_3T_2	74.00 d	129.2 i	1.23 d	4.38 e
V_3T_3	80.80 d	175.3 cd	1.91 a	7.00 bc
V_3T_4	80.67 d	171.4 d	1.93 a	7.61 b
V_3T_5	82.67 cd	175.0 cd	1.99 a	7.66 b
LSD $_{(0.05)}$	**9.31**	**13.88**	**0.24**	**0.79**
CV (%)	**6.5**	**4.77**	**7.88**	**6.42**

Here, T_1 = Recommended nitrogenous fertilizer dose

T_2 = Bio-fertilizer + 25% nitrogenous fertilizer (urea) of the recommended dose

T_3 = Bio-fertilizer + 50% nitrogenous fertilizer (urea) of the recommended dose

T_4 = Bio-fertilizer + 75% nitrogenous fertilizer (urea) of the recommended dose

T_5 = Bio-fertilizer + 100% nitrogenous fertilizer (urea) of the recommended dose

V_1= BARI mung 5, V_2 = BARI mung 6 and V_3= BINA moog 8

4.1.6 Dry weight of nodules plant^{-1}

4.1.6.1 Effect of varieties

The result showed that the effect of varieties on dry weight of nodules plant^{-1} was significant at 30 and 45 DAS, respectively (Fig. 11 and Appendix viii). The highest dry weight of nodules plant^{-1} (2.00, 8.55 at 30 and 45 DAS, respectively) was recorded from V_2 (BARI mung 6), while the lowest dry weight of nodules plant^{-1} (1.76, 6.43 at 30 and 45 DAS, respectively) in V_1 (BARI mung 5) which was not statistically different from V_3 (BINA moog 8) at 30 and 45 DAS, respectively.

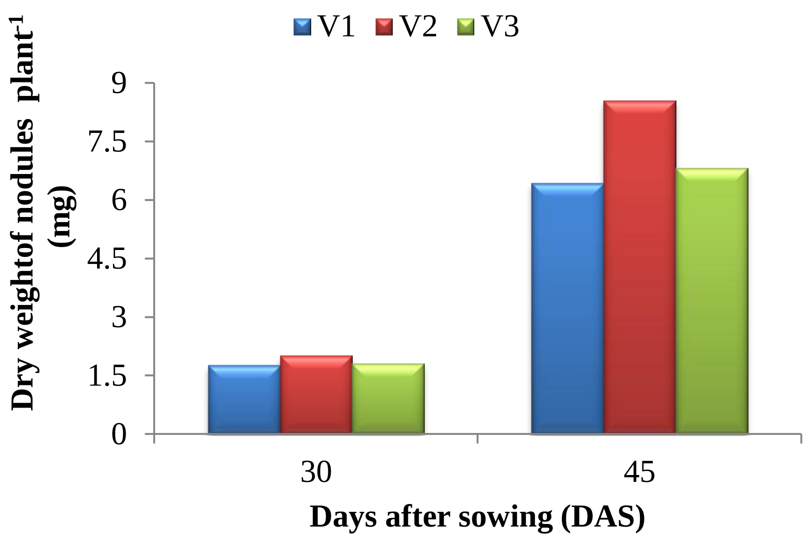

Figure 11. Effect of different varieties on dry weight of nodule plant^{-1} of mungbean at different days after sowing (LSD $_{(0.05)}$ = 0.11 and 0.44 at 30 and 45 DAS, respectively).

Here, V_1= BARI mung 5, V_2 = BARI mung 6 and V_3= BINA moog 8

4.1.6.2 Effect of bio-fertilizer with different doses of nitrogenous fertilizer (urea) combination

Bio-fertilizer and different doses of nitrogenous fertilizer (urea) treatment exerted significant effect on number of nodules plant^{-1} at 30 and 45 DAS (Appendix viii). The figure 12 shows that 45 DAS showed highest dry weight of nodules plant^{-1} than 30 DAS, irrespective of bio-fertilizer with nitrogen doses combination. The highest dry weight of nodules plant^{-1} (2.05 and 8.14 at 30 and 45 DAS, respectively) was

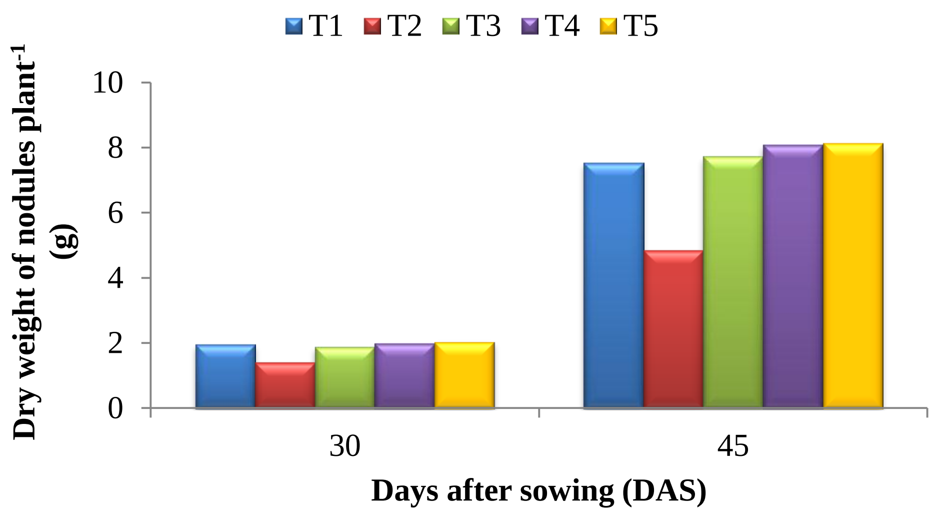

Figure 12. Effect of bio-fertilizer with different doses urea combination on dry weight of nodule plant^{-1} of mungbean at different days after sowing (LSD $_{(0.05)}$ = 0.14 and 0.45 at 30 and 45 DAS, respectively)

Here, T_1 = Recommended nitrogenous fertilizer dose

T_2 = Bio-fertilizer (120g) + 25% nitrogenous fertilizer (urea) of the recommended dose

T_3 = Bio-fertilizer (120g) + 50% nitrogenous fertilizer (urea) of the recommended dose

T_4 = Bio-fertilizer (120g) + 75% nitrogenous fertilizer (urea) of the recommended dose

T_5 = Bio-fertilizer (120g) + 100% nitrogenous fertilizer (urea) of the recommended dose

recorded from T_5 (bio-fertilizer +100% nitrogenous fertilizer of the recommended dose) treated plots which was not significantly different from T_4 at 30 DAS, while intermediate from T_3 (Bio-fertilizer + 50% nitrogenous fertilizer of the recommended dose) at 30 and 45 DAS, respectively and T_3 is statistically similar with T_1 at 30 and 45 DAS, respectively. The lowest dry weight of nodules plant^{-1} (1.41 and 4.85 at 30 and 45 DAS, respectively) was observed in T_2 treated plots.

4.1.6.3 Interaction effect of variety and bio-fertilizer with different doses of urea combination

The interaction of variety × fertilizer dose was highly significant in respect of dry weight of nodules plant^{-1} at 30 and 45 DAS, respectively (Table 6 and Appendix viii). The highest dry weight of nodules plant^{-1} (2.14 and 9.42 at 30 and 45 DAS, respectively) was found in V_2T_5 interaction which was statistically similar with treatment combination of V_2T_4 at all stages of growth; V_2T_3, V_2T_1, V_1T_5 ,V_3T_3 and V_3T_5 at 30 DAS; V_2T_1, V_2T_3 and V_2T_4 at 45 DAS, respectively. Significantly lowest dry weight of nodules plant^{-1} (1.23 and 4.07 at 30 and 45 DAS, respectively) was produced in V_1T_2 interaction which was statistically similar with V_3T_2 at 45 DAS.

4.2. Yield contributing parameters

4.2.1 Number of pods plant^{-1}

4.2.1.1 Effect of varieties

The effect of varieties on number of pods plant^{-1} was significant (Fig. 13 and Appendix ix). The highest Number of pods plant^{-1} (24.54) was recorded from V_2 (BARI mung 6), while the lowest number of pods plant^{-1} (21.19) in V_1 (BARI mung 5) which was statistically similar with BINA moog 8.

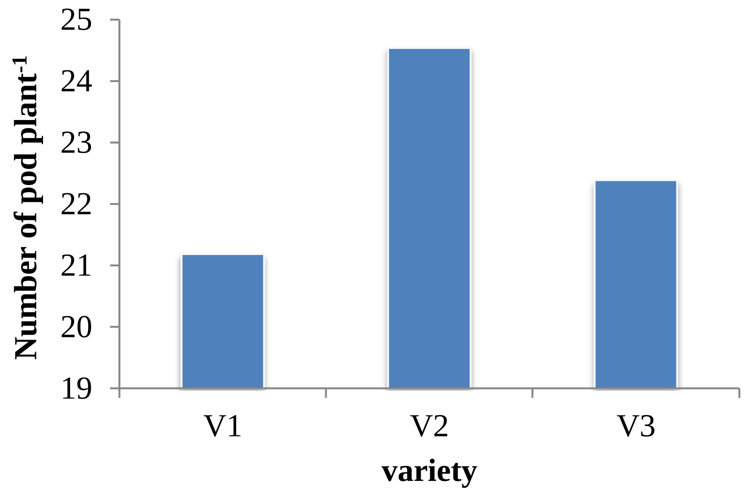

Figure 13. Effect of different varieties on number of pod plant^{-1} of mungbean (LSD $_{(0.05)}$ = 2.11)

Here, V1= BARI mung 5, V2 = BARI mung 6 and V3= BINA moog 8

4.2.3.2 Effect of bio-fertilizer with different doses of nitrogenous fertilizer (urea) combination

The number of pods plant^{-1} was significantly influenced by bio-fertilizer with different doses of urea (Fig. 14 and Appendix ix). The highest number of pods plant^{-1} (25.08) was recorded in T_5 (Bio-fertilizer +100% nitrogenous fertilizer of the recommended dose) treated plot which was statistically similar with T_3 (bio-fertilizer + 50% nitrogenous fertilizer of the recommended dose); T_4 (bio-fertilizer +75% nitrogenous fertilizer of the recommended dose) and T_1 (recommended doses of nitrogenous fertilizer). The lowest number of pods plant^{-1} (19.45) was found from T_2 (bio-fertilizer + 25% nitrogenous fertilizer of the recommended doses) treated plots. The number of pods plant^{-1} was observed higher in bio-fertilizer applied plot also reported by Salahuddin (2006) who supported the present experiment.

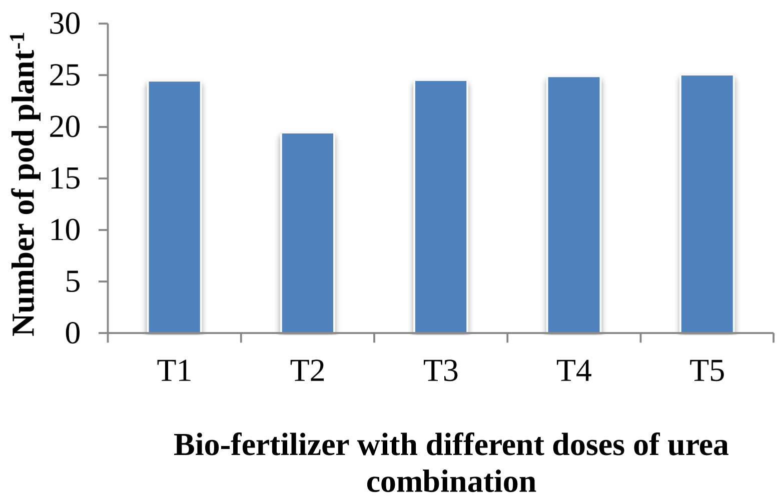

Figure 14: Effect of bio-fertilizer with different doses of urea combination on number of pod plant^{-1} of mungbean (LSD $_{(0.05)}$ = 1.61)

Here, T_1 = Recommended nitrogenous fertilize dose

T_2 = Bio-fertilizer (120g) +25% nitrogenous fertilizer (urea) of the recommended dose

T_3 = Bio-fertilizer (120g) + 50% nitrogenous fertilizer (urea) of the recommended dose

T_4 = Bio-fertilizer (120g) + 75% nitrogenous fertilizer (urea) of the recommended dose

T_5 = Bio-fertilizer (120g) + 100% nitrogenous fertilizer (urea) of the recommended dose

4.2.3.3 Interaction effect of variety and bio-fertilizer with different doses of urea combination

The interaction between variety × fertilizer doses combination was highly significant in respect of number of pods plant^{-1} (Table 6 and Appendix ix). The highest number of pods plant^{-1} (27.62) was found in V_2T_5 interaction which was statistically similar with treatment combination of V_2T_4, V_2T_3 and V_2T_1.

Significantly lowest number of pods $plant^{-1}$ (29.74) was produced in V_1T_2 interactions which was statistically similar with V_1T_3 interaction.

4.2.2 Pod length (cm)

4.2.2.1 Effect of varieties

The result showed that the effect of varieties on pod length was significant (Fig. 15 and Appendix ix). The highest pod length (9.68cm) was recorded from V_3 (BINA mung 8), while the lowest pod length (7.25 cm) in V_1 (BARI mung 5) which was not statistically different from V_2 (BARI mung 6).

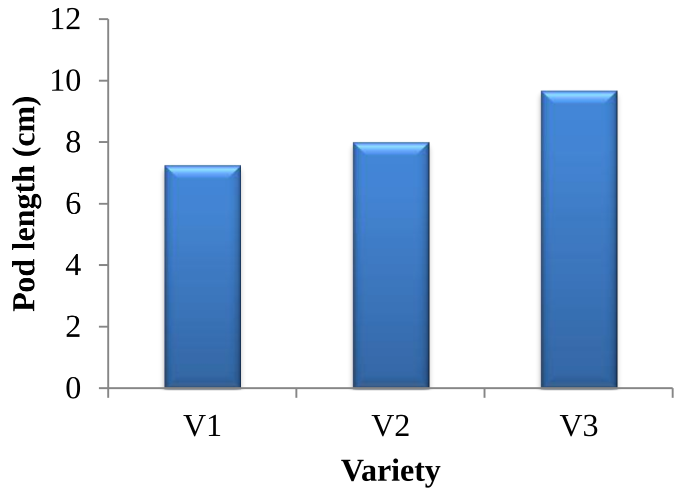

Figure 15. Effect of different varieties on pod length of mungbean (LSD $_{(0.05)}$ = 1.01)

Here, V_1= BARI mung 5, V_2 = BARI mung 6 and V_3= BINA mung 8

4.2.2.2 Effect of bio-fertilizer with different doses of nitrogenous fertilizer (urea) combination

The pod length was significantly influenced by bio-fertilizer with different doses of urea (Fig. 16 and Appendix ix). The highest pod length (8.91 cm) was recorded in T_5 (bio-fertilizer +100% nitrogenous fertilizer of the recommended doses) treated plot which was statistically similar with T_3 (bio-fertilizer + 50%

nitrogenous fertilizer of the recommended dose); T_4 (bio-fertilizer + 75% nitrogenous fertilizer of the recommended dose); T_1 (recommended dose of nitrogenous fertilizer). The lowest pod length (6.18 cm) was found from T_2 (Bio-fertilizer + 25% nitrogenous fertilizer of the recommended dose) treated plots. The pod length of mungbean was higher in bio-fertilizer applied plot reported by Akhtaruzzaman (2004) who supported the present experiment.

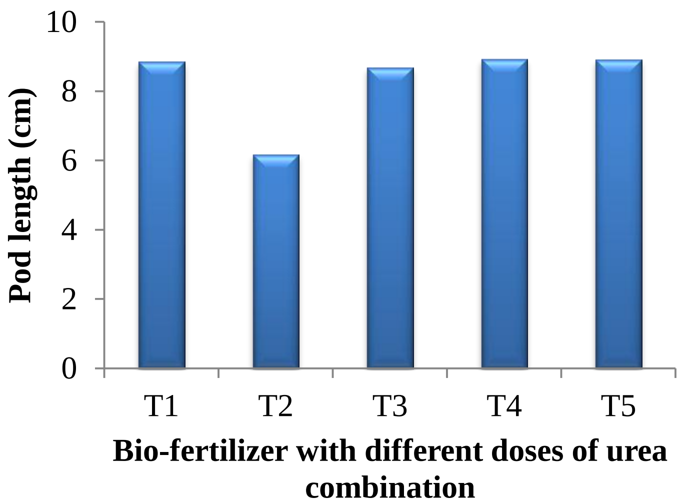

Figure 16. Effect of bio-fertilizer with nitrogenous fertilizer doses on pod length of mungbean (LSD $_{(0.05)}$ = 0.70)

Here, T_1 = Recommended nitrogen dose

T_2 = Bio-fertilizer + 25% nitrogenous fertilizer (urea) of the recommended dose

T_3 = Bio-fertilizer + 50% nitrogenous fertilizer (urea) of the recommended dose

T_4 = Bio-fertilizer + 75% nitrogenous fertilizer (urea) of the recommended dose

T_5 = Bio-fertilizer + 100% nitrogenous fertilizer (urea) of the recommended dose

4.2.1.3 Interaction effect of variety with bio-fertilizer with different doses of urea combination

The interaction between variety × fertilizer doses combination was highly significant in respect of pod length (Table 6 an Appendix ix). The highest pod length (10.46) was found in V_3T_5 interaction which was statistically similar with treatment combination of V_3T_4 and V_3T_3. Significantly lowest number of pods plant^{-1} (5.85cm) was produced in V_1T_2 interaction which was statistically similar with V_2T_2 and V_3T_2 interaction.

Table 6. Interaction effect of different variety and fertilizer combination on pod length, seeds pod^{-1}, pods plant^{-1}, 1000 seed weight of mungbean

Treatment combination	Pod length (cm)	Seeds pod^{-1} (no.)	Pods plant^{-1} (no.)	1000 seed wt. (g)
V_1T_1	7.43 cd	7.79 c	23.61 b-f	36.85 f
V_1T_2	5.85 e	5.10 d	17.75 i	29.74 g
V_1T_3	7.42 cd	9.95 b	20.18 g-i	38.97 d-f
V_1T_4	7.67 b-d	9.94 b	21.28 f-h	39.00 d-f
V_1T_5	7.90 bc	10.01 b	23.15 b-f	38.81 ef
V_2T_1	8.82 b	12.28 a	25.68 ab	46.26 a
V_2T_2	6.17 e	5.65 d	21.65 e-h	35.68 f
V_2T_3	8.07 bc	12.60 a	25.70 ab	45.87 ab
V_2T_4	8.57 bc	12.39 a	26.53 a	46.15 a
V_2T_5	8.38 bc	12.38 a	27.62 a	46.50 a
V_3T_1	10.31 a	10.51 b	24.18 b-e	42.33 cd
V_3T_2	6.51 de	7.547 c	18.95 hi	30.68 g
V_3T_3	10.56 a	9.93 b	21.58 e-h	41.47 c-e
V_3T_4	10.56 a	10.08 b	22.79 c-g	42.67 bc
V_3T_5	10.46 a	10.13 b	24.47 b-d	41.68 c-e
LSD $_{(0.05)}$	**1.21**	**1.14**	**2.79**	**3.42**
CV (%)	**8.62**	**6.94**	**7.29**	**5.05**

Here, T_1 = Recommended nitrogenous feritilizer dose

T_2 = Bio-fertilizer (120g) + 25% nitrogenous fertilizer (urea) of the recommended dose

T_3 = Bio-fertilizer (120g) + 50% nitrogenous fertilizer (urea) of the recommended dose

T_4 = Bio-fertilizer (120g) + 75% nitrogenous fertilizer (urea) of the recommended dose

T_5 = Bio-fertilizer (120g) + 100% nitrogenous fertilizer (urea) of the recommended dose

V1= BARI mung 5, V_2 = BARI mung 6 and V_3= BINA moog 8

4.2.2 Number of seeds pod^{-1}

4.2.1.1 Effect of varieties

The result showed that the effect of varieties on number of seeds pod^{-1} was significant (Fig. 17 and Appendix ix). The highest number of seeds pod^{-1} (11.06) was recorded from V_2 (BARI mung 6), while the lowest number of seeds pod^{-1} (8.56) in V_1 (BARI mung 5).

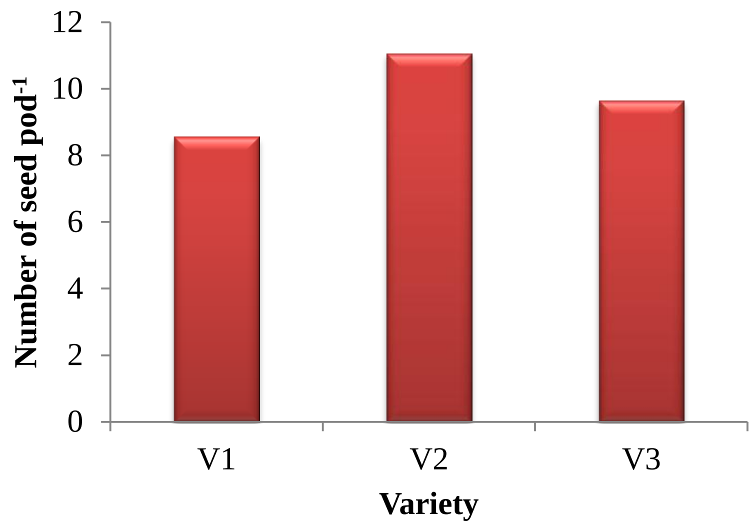

Figure 17. Effect of different varieties on number of seed pod^{-1} of mungbean (LSD $_{(0.05)}$ = 0.88)

Here, V_1= BARI mung 5, V_2 = BARI mung 6 and V_3= BINA moog 8

4.2.1.2 Effect of bio-fertilizer with different doses of nitrogenous fertilizer (urea) combination

The number of seeds pod^{-1} was significantly influenced by bio-fertilizer with different doses of urea (Fig. 18 and Appendix ix). The inoculation of bio-fertilizer significantly increased number of seeds pod^{-1}. The highest number of seeds pod^{-1} (10.84) was recorded in T_5 (Bio-fertilizer +100% nitrogenous fertilizer of the recommended dose) treated plot which was statistically similar with T_3 (Bio-fertilizer+ 50% nitrogenous fertilizer of the recommended dose); T_4 (Bio-fertilizer +75% nitrogenous fertilizer of the recommended dose) and T_1 (Recommended nitrogenous fertilizer dose). The lowest number of seeds pod^{-1} (6.10) was found from T_2 treated plots. The number of seeds pod^{-1} was higher in bio-fertilizer applied plot reported by Akhtaruzzaman (2004) who supported the present experiment.

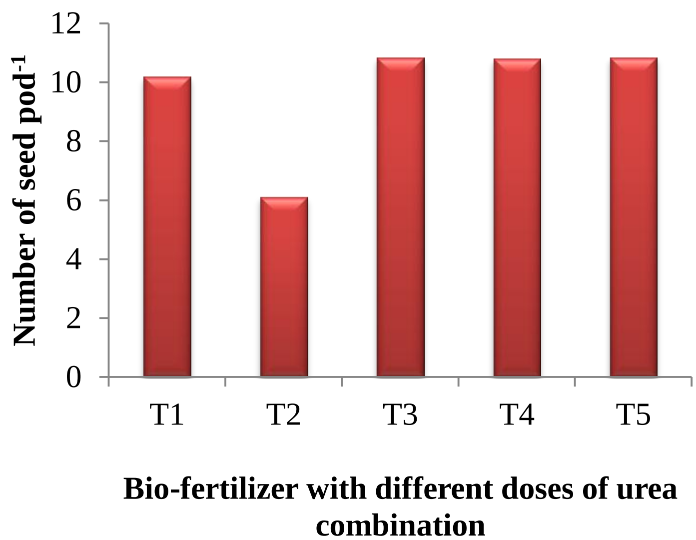

Figure 18. Effect of bio-fertilizer with different doses of urea combination on number of seed pod^{-1} of mungbean (LSD $_{(0.05)}$ = 0.66)

Here, T_1 = Recommended nitrogenous dose

T_2 = Bio-fertilizer + 25% nitrogenous fertilizer of the recommended dose

T_3 = Bio-fertilizer + 50% nitrogenous fertilizer (urea) of the recommended dose

T_4 = Bio-fertilizer + 75% nitrogenous fertilizer (urea) of the recommended dose

T_5 = Bio-fertilizer + 100% nitrogenous fertilizer (urea) of the recommended dose

4.2.2.3 Interaction effect of variety and bio-fertilizer with different doses of urea combination

The interaction between variety × fertilizer doses was highly significant in respect Of number of seeds pod^{-1} (Table 6 and Appendix ix). The highest number of seeds pod^{-1} (12.38) was found in V_2T_5 interaction which was statistically similar with treatment combination of V_2T_4, V_2T_3 and V_2T_1. Significantly lowest number of seeds pod^{-1} (5.10) was produced in V_1T_2 interactions.

4.2.4 1000 seed weight

4.2.4.1 Effect of varieties

The result showed that the effect of varieties on 1000 seed weight was significant (Fig. 19 and Appendix ix).The highest number of 1000 seed weight (44.09g) was recorded from V_2 (BARI mung 6), while the lowest weight 1000 seed (36.67g) was found in V_1 (BARI mung 5) and intermidate result was found from BINA mung 8 (39.77 g).The present results were consistent with the findings of Thakuria and Saharia (1990).

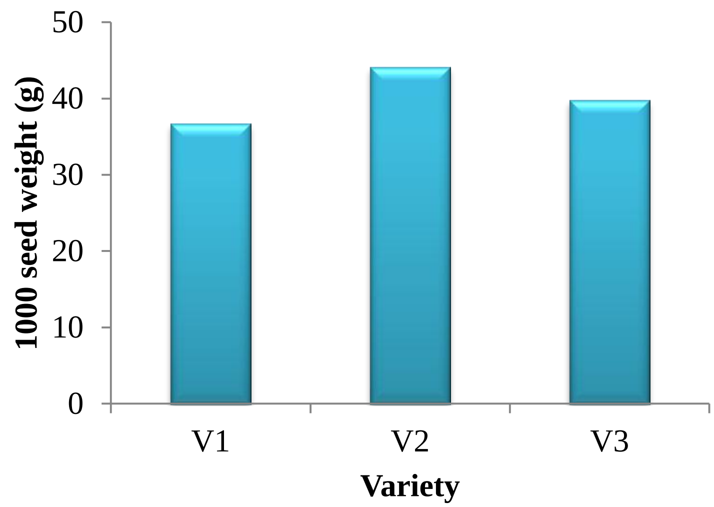

Figure19. Effect of different varieties on 1000 seed weight of mungbean (LSD $_{(0.05)}$ = 2.78)

Here, V_1= BARI mung 5, V_2 = BARI mung 6 and V_3= BINA moog 8

4.2.4.2 Effect of bio-fertilizer with different doses of nitrogenous fertilizer (urea)

Fertilizer application significantly affected the weight 1000 seed (Fig. 20 and Appendix ix). The inoculation of bio-fertilizer was significantly increased 1000 seed weight. The highest 1000 seed weight (42.33) was recorded in T_5 (Bio-fertilizer + 1000% nitrogenous fertilizer of the recommended dose) treated plot which was statistically similar with T_3 (Bio-fertilizer +50% nitrogenous fertilizer of the recommended dose), T_4 (Bio-fertilizer + 75% nitrogenous fertilizer of the recommended dose) and T_1. The lowest weight of 1000 seed (32.03) was found from T_2 (Bio-fertilizer + 25% nitrogenous fertilizer of the recommended dose) treated plots. The weight of 1000 seed was higher in bio-fertilizer applied plot reported by Salahuddin (2006) who supported the present experiment.

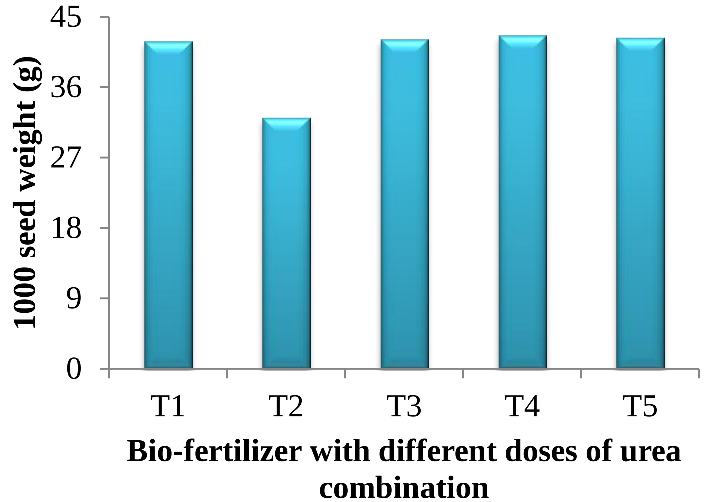

Figure 20. Effect of bio-fertilizer with different doses of urea combination on 1000 seed weight of mungbean (LSD $_{(0.05)}$ = 1.98)

Here, T_1 = Recommended nitrogenous dose

T_2 = Bio-fertilizer (120g) + 25% nitrogenous fertilizer (urea) of the recommended dose

T_3 = Bio-fertilizer (120g) + 50% nitrogenous fertilizer (urea) of the recommended dose

T_4 = Bio-fertilizer (120g) + 75% nitrogenous fertilizer (urea) of the recommended dose

T_5 = Bio-fertilizer (120g) + 100% nitrogenous fertilizer (urea) of the recommended dose

4.2.5.3 Interaction effect of variety and bio-fertilizer with different doses of urea combination

The interaction of variety × fertilizer dose was highly significant in respect Of 1000 seed weight (Table 6 and Appendix ix). The highest thousand seed weight (46.50g) was found in V_2T_5 (BARI mung 6) with T_5 treatment combination (bio-fertilizer +100% nitrogenous fertilizer of the recommended doses) interaction which was statistically similar with treatment combination of V_2T_4, V_2T_3 and

V_2T_1. Significantly lowest 1000 seed weight (29.74) was produced in V_1T_2 interactions.

4.3 Seed yield and harvest index

4.3.1 Seed yield (t ha^{-1})

4.3.1.1 Effects of varieties

The result showed that the effect of varieties on seed yield was significant (Figure 21 and Appendix x). Among the three varieties, V_2 (BARI mung 6) gave the highest seed yield (1.58 t ha^{-1}), while the lowest was (1.29 t ha^{-1}) was found in V_1 (BARI mung 5) and intermediate result was found from BINA mung 8 (1.44 t ha^{-1}). The present results were consistent with the findings of Salauddin (2006). The result revealed that BARI mung 6 out yielded BARI mung 5, BINA moog 8 by 0.29 and 0.14 t ha^{-1} , respectively.

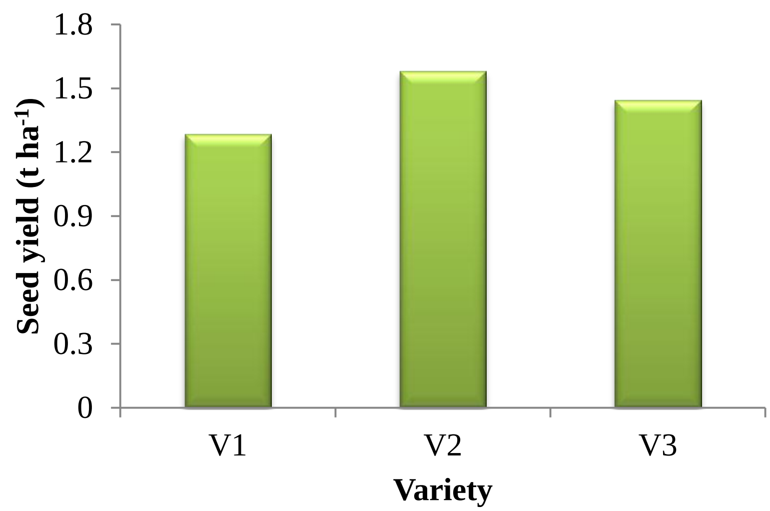

Figure 21. Effect of different varieties on seed yield of mungbean (LSD $_{(0.05)}$ = 0.12)

Here, V_1= BARI mung 5, V_2 = BARI mung 6 and V_3= BINA moog 8

4.3.1.2 Effect of bio-fertilizer with different doses of nitrogenous fertilizer (urea) combination

Fertilizer application significantly affected the seed yield (Fig. 22 and Appendix x). The highest seed yield (1.65t ha^{-1}) was recorded in T_5 (Bio-fertilizer +100% recommended doses Urea + TSP + MP + Gypsum) treated plot which was statistically similar with T_3, T_4 and T_1. The lowest seed yield (1.00 t ha^{-1}) was found from T_2. Vaishya *et al.* (1983), Gill *et al.* (1985), Prasad and ram (1992), Salahuddin (2006) and Islam (2010) reported similar views of seed yield in case of mungbean. They reported that inoculation significantly increased seed yield of mungbean.

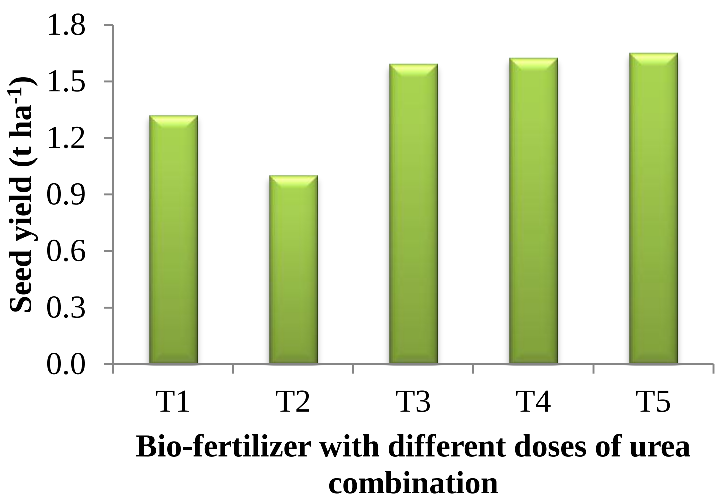

Figure 22. Effect of bio-fertilizer with different doses of nitrogenous fertilizer combination on seed yield of mungbean (LSD $_{(0.05)}$ = 0.13).

Here, T_1 = Recommended nitrogenous dose

T_2 = Bio-fertilizer (120g) + 25% nitrogenous dose (urea) of the recommended dose

T_3 = Bio-fertilizer (120g) + 50% nitrogenous dose (urea) of the recommended dose

T_4 = Bio-fertilizer (120g) + 75% nitrogenous dose (urea) of the recommended dose

T_5 = Bio-fertilizer (120g) +100% nitrogenous dose (urea) of the recommended dose

4.3.1.3 Interaction effect of variety and bio-fertilizer with different doses of urea combination

The interaction between variety × fertilizer doses combination was highly significant in respect Of seed yield (Table 7 and Appendix ix). The highest seed yield (1.84 t ha^{-1}) was found in V_2T_5 interaction which was statistically similar with treatment combination of V_2T_4, V_2T_3 and V_3T_4 V_3T_5, Significantly lowest seed yield (.92 t ha^{-1}) was produced in V_1T_2 interactions. Therefore, it can be inferred from the result that more yield could be obtained if *Bradyrhizobium* inoculation + 50% recommended doses urea was used then T_1. It is evident from the result that reduction of urea upto 50% can be possible without sacrificing significant yield loss.

4.3.2 Stover yield (t ha^{-1})

4.3.2.1 Effects of varieties

The result showed that the effect of varieties on stover yield was significant (Fig. 23 and Appendix x). Among the three varieties, BINA moog 8 (3.63 t ha^{-1}) gave the highest stover yield which was statistically identical with BARI mung 6 (3.48 t ha^{-1}) while the lowest was (3.27 t ha^{-1}) was found in V_1 (BARI mung 5).

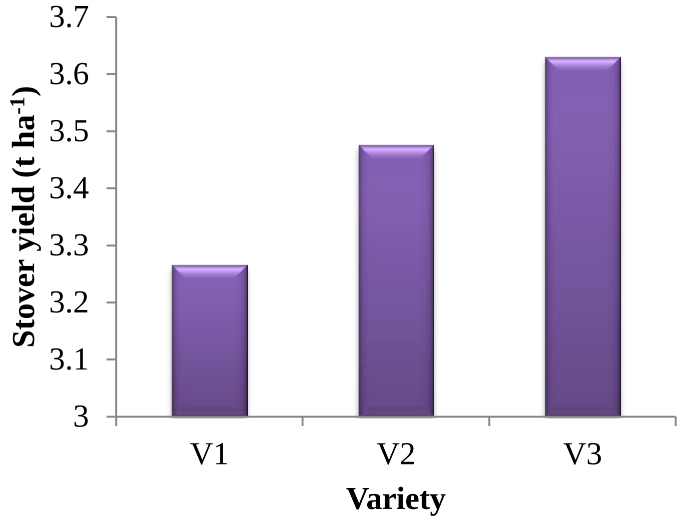

Figure 23. Effect of different varieties on stover yield of mungbean (LSD $_{(0.05)}$ = 0.16)

Here, V_1= BARI mung 5, V_2 = BARI mung 6 and V_3= BINA moog 8

4.3.2.2 Effect of bio-fertilizer with different doses of nitrogenous fertilizer (urea) combination

Fertilizer application significantly affected the stover yield (Fig. 24 and Appendix x). The highest stover yield (3.75t ha^{-1}) was recorded in T_5 (Bio-fertilizer +100% nitrogenous dose (urea) of the recommended dose) treated plot which was statistically similar with T_3 and T_4. The lowest stover yield (3.05 t ha^{-1}) was found from T_2 treated plots which was statistically similar with T_1. Salahuddin (2006) and Islam (2010) reported similar views of seed yield. They reported that inoculation significantly increased seed yield of mungbean.

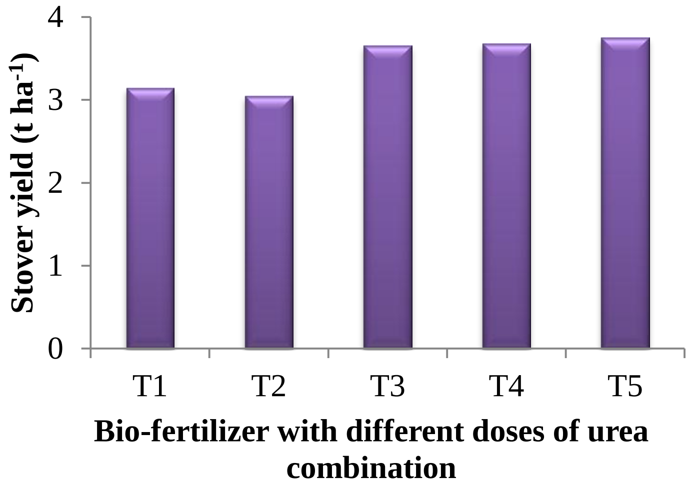

Figure 24. Effect of bio-fertilizer with different doses of urea combination on stover yield of mungbean (LSD $_{(0.05)}$ = 0.21)

Here, T_1 = Recommended nitrogen dose

T_2 = Bio-fertilizer (120g) + 25% nitrogenous dose (urea) of the recommended dose

T_3 = Bio-fertilizer (120g) + 50% nitrogenous dose (urea) of the recommended dose

T_4 = Bio-fertilizer (120g) + 75% nitrogenous dose (urea) of the recommended dose

T_5 = Bio-fertilizer (120g) + 100% nitrogenous dose (urea) of the recommended dose

4.3.2.3 Interaction effect of variety and bio-fertilizer with different doses of urea combination

The interaction between variety × fertilizer doses was highly significant in respect of stover yield (Table 7 and Appendix x). The highest stover yield (3.90 t ha^{-1}) was found in V_3T_5 interaction which was statistically similar with treatment combination of V_2T_4, V_2T_3, V_3T_3 and V_3T_4. Significantly lowest stover yield (2.89 t ha^{-1}) was produced in V_1T_2 interaction which was statistically similar with treatment combination of V_1T_1, V_2T_1 and V_3T_1.

Table 07. Combined effect of different varieties and fertilizer combination on seed yield, stover yield, biological yield, harvest index of mungbean

Treatment combination	Seed yield (t ha^{-1})	Stover yield(t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
V_1T_1	1.19 fg	2.94 h	4.12 fg	28.71 bc
V_1T_2	0.92 h	2.89 h	3.81 g	24.09 d
V_1T_3	1.42 de	3.44 c-f	4.86 b-e	29.20 a-c
V_1T_4	1.44 c-e	3.49 b-e	4.93 a-e	29.35 a-c
V_1T_5	1.47 c-e	3.57 a-e	5.04 a-d	29.21 a-c
V_2T_1	1.43 c-e	3.13 f-h	4.55 d-f	31.48 ab
V_2T_2	1.06 gh	3.03 gh	4.08 fg	25.83 cd
V_2T_3	1.78 ab	3.70 a-d	5.48 ab	32.46 a
V_2T_4	1.81 a	3.73 a-d	5.54 ab	32.72 a
V_2T_5	1.84 a	3.79 a-c	5.63 a	32.73 a
V_3T_1	1.35 ef	3.38 d-g	4.73 c-f	28.60 bc
V_3T_2	1.00 gh	3.24 e-h	4.26 e-g	24.13 d
V_3T_3	1.43 b-d	3.82 ab	5.25 a-c	27.23 bc
V_3T_4	1.50 b-d	3.81 ab	5.33 a-c	28.24 bc
V_3T_5	1.60 bc	3.90 a	5.50 ab	29.09 ab
LSD $_{(0.05)}$	**0.23**	**0.36**	**0.72**	**3.72**
CV (%)	**9.46**	**6.13**	**8.73**	**7.58**

Here, T_1 = Recommended nitrogenous dose

T_2 = Bio-fertilizer (120g) + 25% nitrogenous dose (urea) of the recommended dose

T_3 = Bio-fertilizer (120g) + 50% nitrogenous dose (urea) of the recommended dose

T_4 = Bio-fertilizer (120g) + 75% nitrogenous dose (urea) of the recommended dose

T_5 = Bio-fertilizer (120g) + 100% nitrogenous dose (urea) of the recommended dose

V1= BARI mung 5, V_2 = BARI mung 6 and V_3= BINA moog 8

4.3.3 Biological yield (t ha^{-1})

4.3.3.1 Effects of varieties

The result showed that the effect of varieties on biological yield was significant (Fig. 25 and Appendix x). Among the three varieties, BINA moog 8 (5.07 t ha^{-1}) gave the highest biological yield which was statistically identical with BARI mung 6 (5.06 t ha^{-1}) while the lowest was (3.27 t ha^{-1}) was found in V_1 (BARI mung 5).

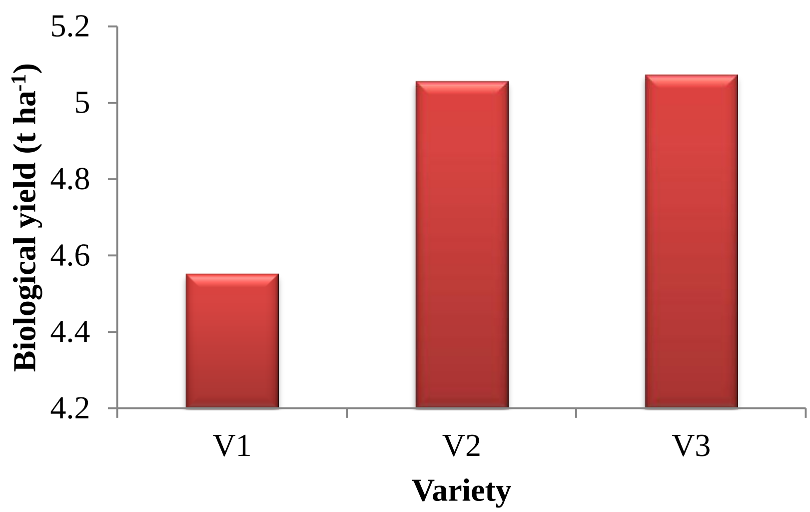

Figure 25. Effect of different varieties on biological yield of mungbean (LSD $_{(0.05)}$ = 0.31)

Here, V_1= BARI mung 5, V_2 = BARI mung 6 and V_3= BINA moog 8

4.3.3.2 Effect of bio-fertilizer with different doses of nitrogenous fertilizer (urea) combination

Fertilizer application significantly affected the biological yield (Figure 26 and Appendix x). The inoculation of bio-fertilizer significantly increased the biological yield (t ha^{-1}). The highest biological yield (5.41t ha^{-1}) was recorded in T_5 which was statistically similar with T_3 and T_4. The lowest biological yield (4.05 t ha^{-1}) was found from T_2 doses treated plots.

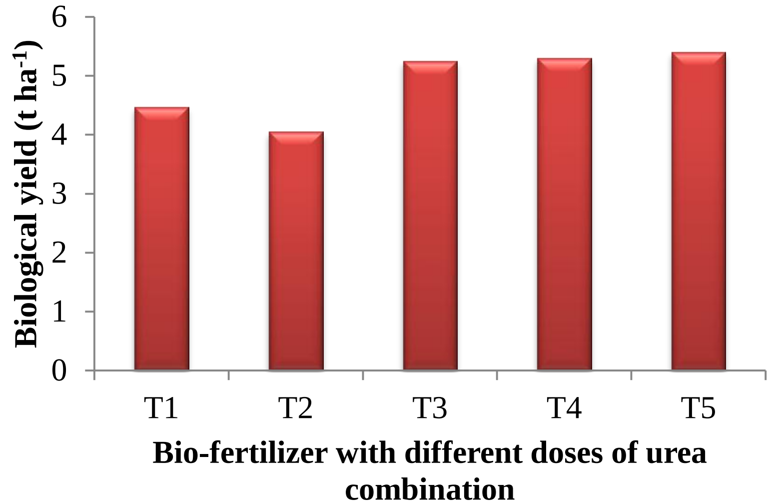

Figure 26 Effect of bio-fertilizer with different doses of nitrogenous fertilizer combination on biological yield of mungbean (LSD $_{(0.05)}$ = 0.42)

Here, T_1 = Recommended nitrogen dose

T_2 = Bio-fertilizer (120g) + 25% nitrogenous dose (urea) of the recommended dose

T_3 = Bio-fertilizer (120g) + 50% nitrogenous dose (urea) of the recommended dose

T_4 = Bio-fertilizer (120g) + 75% nitrogenous dose (urea) of the recommended dose

T_5 = Bio-fertilizer (120g) + 100% nitrogenous dose (urea) of the recommended dose

4.3.3.3 Interaction effect of variety with bio-fertilizer with different doses of urea combination

The interaction between variety × fertilizer doses was highly significant in respect of biological yield (Table 7 and Appendix x). The highest biological yield (5.63 t ha^{-1}) was found in V_2T_5 (BARI mung 6) with T_5 treatment combination interaction which was statistically similar with treatment combination of V_2T_4, V_2T_3 and V_3T_4, V_3T_5. Significantly lowest biological yield (3.81 t ha^{-1}) was produced in V_1T_2 interactionswhich was statistically similar with treatment combination of V_1T_1, V_2T_2 and V_3T_1.

4.3.4 Harvest index

4.3.4.1 Effect of varieties

The result showed that the effect of varieties on harvest index was significant (Fig. 27 and Appendix x). The highest harvest index (31.05 %) was recorded from V_2 (BARI mung 6), while the lowest harvest index (28.11 %) in V_1 (BARI mung 5) which was statistically similar with BINA moog 8.

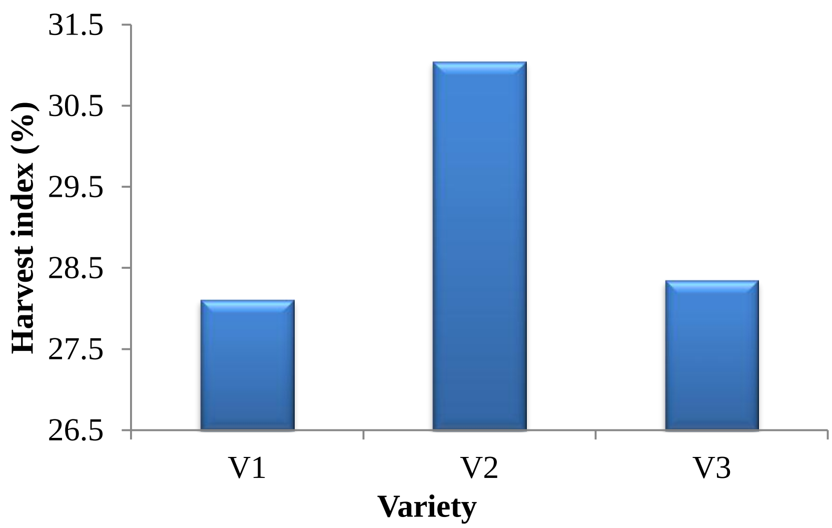

Figure 27. Effect of different varieties on harvest index of mungbean (LSD $_{(0.05)}$ = 2.17)

Here, V_1= BARI mung 5, V_2 = BARI mung 6 and V_3= BINA moog 8

4.3.4.2 Effect of bio-fertilizer with different doses of nitrogenous fertilizer (urea) combination

Fertilizer application significantly affected the harvest index (Fig. 28 and Appendix x). The inoculation of bio-fertilizer significantly increased harvest index. The highest harvest index (30.66%) was recorded in T_4 treated plot which was statistically similar with T_3 and T_1. The lowest harvest index (24.68) was found from T_2 treated plots.

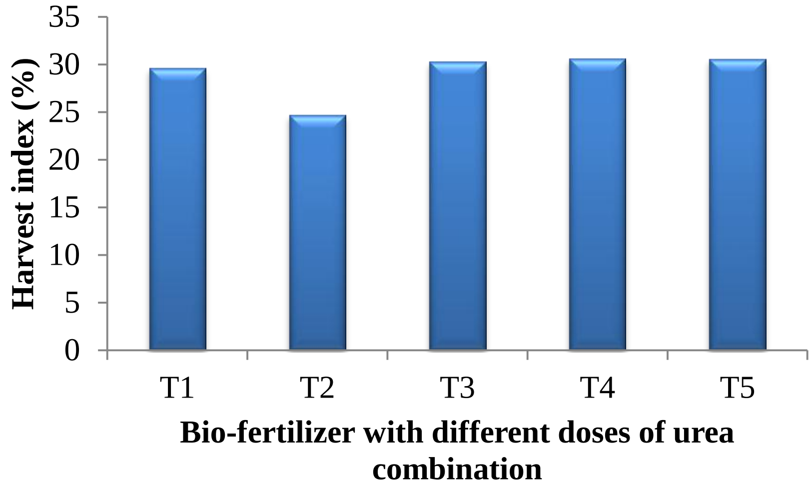

Figure 28: Effect of bio-fertilizer with different doses of nitrogenous fertilizer combination on harvest index of mungbean (LSD $_{(0.05)}$ = 2.15

Here, T_1 = Recommended nitrogenous fertilizer dose

T_2 = Bio-fertilizer (120g) + 25% nitrogenous dose (urea) of the recommended dose

T_3 = Bio-fertilizer (120g) + 50% nitrogenous dose (urea) of the recommended dose

T_4 = Bio-fertilizer (120g) + 75% nitrogenous dose (urea) of the recommended dose

T_5 = Bio-fertilizer (120g) + 100% nitrogenous dose (urea) of the recommended dose

4.3.4.3 Interaction effect of variety and bio-fertilizer with different doses of urea combination

The interaction between variety and fertilizer combination was highly significant in respect of harvest index (Table 7 and Appendix x). The highest harvest index (32.72%) was found in V_2T_5 interaction which was statistically similar with treatment combination of V_2T_4, V_2T_3, V_3T_4 and V_3T_5. Significantly lowest harvest index (24.09%) was produced in V_1T_2 interactions which was statistically similar with treatment combination of V_3T_2.

CHAPTER 5

SUMMARY AND CONCLUSION

The experiment was conducted at the research farm of Sher-e-Bangla Agricultural University (SAU), Dhaka- 1207 (Tejgaon series under AEZ No. 28) during Kharif-1 (March to June), 2014 to study on the feasibility of reducing nitrogenous fertilizer through bio-fertilizer on mungbean (*Vigna radiata* L.). The soil of the experimental field was general soil type, deep red brown terrace soil. Two factors and their interaction were used in the experiment. These were: A) Variety-3 viz. 1. BARI mung 5 (V_1) 2. BARI mung 6 (V_2) 3. BINA moog 8 (V_3) and B. Bio-fertilizer and different doses of nitrogenous fertilizer (urea) combination viz. 1. T_1 = Recommended nitrogenous fertilizer (control) 2. T_2 = Bio-fertilizer (120g) + 25% nitrogenous fertilizer (urea) of the recommended dose 3. T_3 = Bio-fertilizer (120g) + 50% nitrogenous fertilizer (urea) of the recommended dose 4. T_4 = Bio-fertilizer (120g) + 75% nitrogenous fertilizer (urea) of the recommended dose 5. T_5 = Bio-fertilizer (120g) + 100% nitrogenous fertilizer (urea) of the recommended dose. The experiment was laid out in split plot design with three replications. The unit plot size was 6 m^2 (3 m × 2 m). The replications were separated by 1m distance and plots were separated by 0.75m. Lay out of the experiment was done on March 23, 2014. Variety was placed along the main plot and treatments were placed along with sub-plot. Land preparation was completed on 23rd March, 2014. Mungbean seeds were sown 24th March, 2014. Seeds were placed at about 4-5cm depth from the soil surface. The experimental plots were fertilized as per the designed treatments. Nitrogen, Phosphorus, Potassium and sulpher were applied in the form of urea, triple super phosphate, Muriate of potash and Gypsum, respectively. All the fertilizers except urea were incorporated into the soil plot wise before sowing of seeds. Urea was applied as per treatment of the experiment. Pods were harvested three times**.** The crop was1st harvested on 28th may, 2014 from prefixed 1.0 m^2 areas for recording yield data and 2nd harvest was done on 8th

june, 2014. Harvests were completed by 15th june, 2014. Before harvesting five plants were selected randomly from each plot and were uprooted for recording yield contributing characters data. The data were collected plot wise for plant height (cm), number of branches plant^{-1}, number of leaves plant ^{1}, dry weight of plant^{-1}, number of nodules plant^{-1}, dry weight of nodules plant^{-1}, number of pods plant^{-1}, pod length (cm), number of seeds pod^{-1}, ,weight of 1000-seed (g), seed yield (t ha^{-1}) and stover yield (t ha^{-1}). All the data were statistically analyzed and the mean comparison was made by LSD. The results of the experiment are stated below. Varieties and fertilizer doses and their interaction had significant effect on plant height (cm), number of branches plant^{-1}, number of leaves plant ^{1}, dry weight of plant^{-1}, number of nodules plant^{-1}, dry weight of nodules plant^{-1}, pod length (cm), number of seeds pod^{-1}, number of pods plant^{-1}, weight of 1000-seed (g), seed yield (t ha^{-1}) and stover yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index.

Among 3 varieties BINA moog 8 gave the highest plant height (62.71 cm) at 45 DAS, and BARI Mung 5 gave the lowest plant height (51.01 cm) at 45 DAS. T_5 treated plot gave the highest plant height (59.29cm) at 45 DAS which is statistically identical with T_4, T_3 and T_1. In case of interaction treatment V_3T_5 gave the highest plant height (65.33 cm) at 45 DAS.

The highest number of branches plant^{-1} (2.25) was recorded from BARI mung 6 at 45 DAS whereas the lowest in BARI mung 5 (2.07). T_5 treated plot gave the highest number of branches plant^{-1} (2.37) at 45 DAS which is statistically identical with T_4 and T_1. In case of interaction treatment combination of V_2T_5 gave the highest number of branches plant^{-1} (2.50) which is statistical similar with V_2T_4, V_2T_3, V_3T_4 and V_3T_5 at 45 DAS.

The highest number of leaves plant^{-1} (9.91 at 45 DAS) was recorded from V_2 (BARI mung 6). The lowest number of leaves plant^{-1} obtained from V_1 (BARI mung 5). The highest number of leaves plant^{-1} (9.91 at 45 DAS) was recorded from T_5. The lowest number of leaves plant^{-1} (3.22 at harvest) was observed in T_2 which was statistically different from others. In case of interaction, treatment combination of V_2T_5 gave the highest number of leaves plant^{-1} (11.24 at 45 DAS) which is statistical similar with V_2T_4, V_2T_3, V_3T_4 and V_3T_5 at 45 DAS.

BINA moog 8 gave the highest dry weight of plant^{-1} at all stages of growth. The lowest dry weight of plant^{-1} (3.62g at 45 DAS) was obtained from BARI mung 5. The highest dry weight plant^{-1} (4.94g at harvest) was recorded in T_5 treated plots which was statistically similar with T_3 and T_1 at harvest. The lowest dry weight plant^{-1} (3.08 at harvest) was found from T_2 treated plots. Treatment combination of V_3T_5 gave the highest dry weight plant^{-1} (5.39g at harvest) and the lowest dry weight plant^{-1} (2.47g at harvest) was observed in V_1T_2 (BARI mung 5 × Bio-fertilizer + 25% nitrogenous fertilizer of the recommended dose).

The highest number of nodules plant^{-1} (104.1 and 213.6 at 30 and 45 DAS, respectively) was recorded from BARI mung 6, and the lowest number of nodules plant^{-1} (71.47 and 139.6) was obtained from BARI mung 5 at 30 and 45 DAS, respectively. T_5 gave the highest number of nodules plant^{-1} (194.1 at 45 DAS) and the lowest number of nodules plant^{-1} (133.3 at 45 DAS) was observed in Bio-fertilizer + 25% nitrogenous fertilizer of the recommended dose treated plots. V_2T_5 gave the highest number of nodules plant^{-1} which was statistically similar with V_2T_4 and V_2T_3.

The highest dry weight of nodules plant^{-1} (8.55 at 45 DAS) was recorded from V_2 while the lowest dry weight of nodules plant^{-1} (6.43 at 45 DAS) in V_1. Treatment T_5 gave the highest dry weight of nodules plant^{-1} at all stages of growth whereas the lowest in T_2. Interaction of V_2T_5 gave the highest dry weight plant^{-1} for all stages which is statistically identical with V_2T_4 and V_2T_3.

Among the varieties BARI mung 6 gave the highest number of pods plant^{-1} (24.54) while the lowest number of pods plant^{-1} (21.19) in BARI mung 5. T_5 gave the highest number of pods plant^{-1} (25.08) and the lowest number of pods plant^{-1} (19.45) was found from T_2 treated plots. Interaction of V_3T_5 gave the highest pods plant^{-1} which was statistically identical with V_3T_4 and V_3T_3.

Among the varieties BINA moog 8 gave the highest pod length (9.68cm), while the lowest pod length (7.25 cm) in BARI mung 5. Treatment T_5 gave the highest pod length (8.91 cm) which was statistically similar with T_3, T_4 and T_1. The lowest pod length (6.18 cm) was found from T_2. Interaction of V_3T_5 gave the highest pod length (10.46cm). Significantly lowest pod length (5.85 cm) was produced in V_1T_2 interactions.

Among the varieties BARI mung 6 gave the highest number of seeds pods^{-1} (11.06), while the lowest number of seeds pod^{-1} (8.56) in BARI mung 5. T_5 gave the highest number of seeds pod^{-1} (10.84) and the lowest number of seeds pod^{-1} (6.01) was found from T_2 treated plots. Interaction of V_3T_5 gave the highest seeds pod^{-1} which was statistically identical with V_3T_4 and V_3T_3.

Maximum weight of 1000 seed (44.09g) was obtained in BARI mung 6, while the lowest 1000 seed weight (36.67g) was found in BARI mung 5. Interaction of V_2T_5 gave the maximum weight of 1000 seed (46.50g) which was statistically similar with treatment combination of V_2T_4, V_2T_3 and V_2T_1. Significantly lowest 1000 seed weight (29.74g) was produced in V_1T_2 interactions.

Seed yield and stover yield varied significantly among varieties and fertilizer dose. Among the three varieties BARI mung 6 gave the highest seed yield (1.58 t ha^{-1}), while the lowest seed yield was (1.29 t ha^{-1}) was obtained in BARI mung 5 and intermediate result was found from BINA moog 8 (1.44 t ha^{-1}). The highest seed yield (1.65t ha^{-1}) was recorded in T_5 whereas T_2 gave the lowest seed yield (1.00 t ha^{-1}). Interaction of V_2T_5 gave the highest seed yield (1.84 t ha^{-1}) which was statistically similar with treatment combination of V_2T_4 and V_2T_3. Significantly lowest seed yield (.92 t ha^{-1}) was produced in V_1T_2 interactions.

BINA moog 8 gave the highest stover yield (3.63 t ha^{-1}) and BARI mung 5 gave the lowest stover yield. Interaction of V_3T_5 gave the highest stover yield and V_1T_2 gave the lowest. Harvest index was the highest in BARI mung 6 (31.05%) and it was the lowest in BARI mung 5 (28.11%). Harvest index was the highest in interaction of V_2T_5 which was statistically identical with V_2T_4, V_2T_3, V_2T_1 and V_3T_5.

Therefore, it can be concluded that more yield could be obtained if bio-fertilizer + 100% nitrogenous fertilizer of the recommended dose was used and it was statistically similar with bio-fertilizer + 75% nitrogenous fertilizer (urea) of the recommended dose and bio-fertilizer + 50% nitrogenous fertilizer (urea) of the recommended dose then control. As Treatment T_5, T_4 and T_3 gave statistically similar seed yield. So, we can save 50% nitrogenous fertilizer by using bio-fertilizer without sacrificing seed yield.

RECOMMENDATION

This is the result of single year experiment. So, for higher acceptibility of the result this experiment may be conducted in different agro-ecological zone of Bangladesh by using different types of Bio-fertilizer and varieties.

CHAPTER 6

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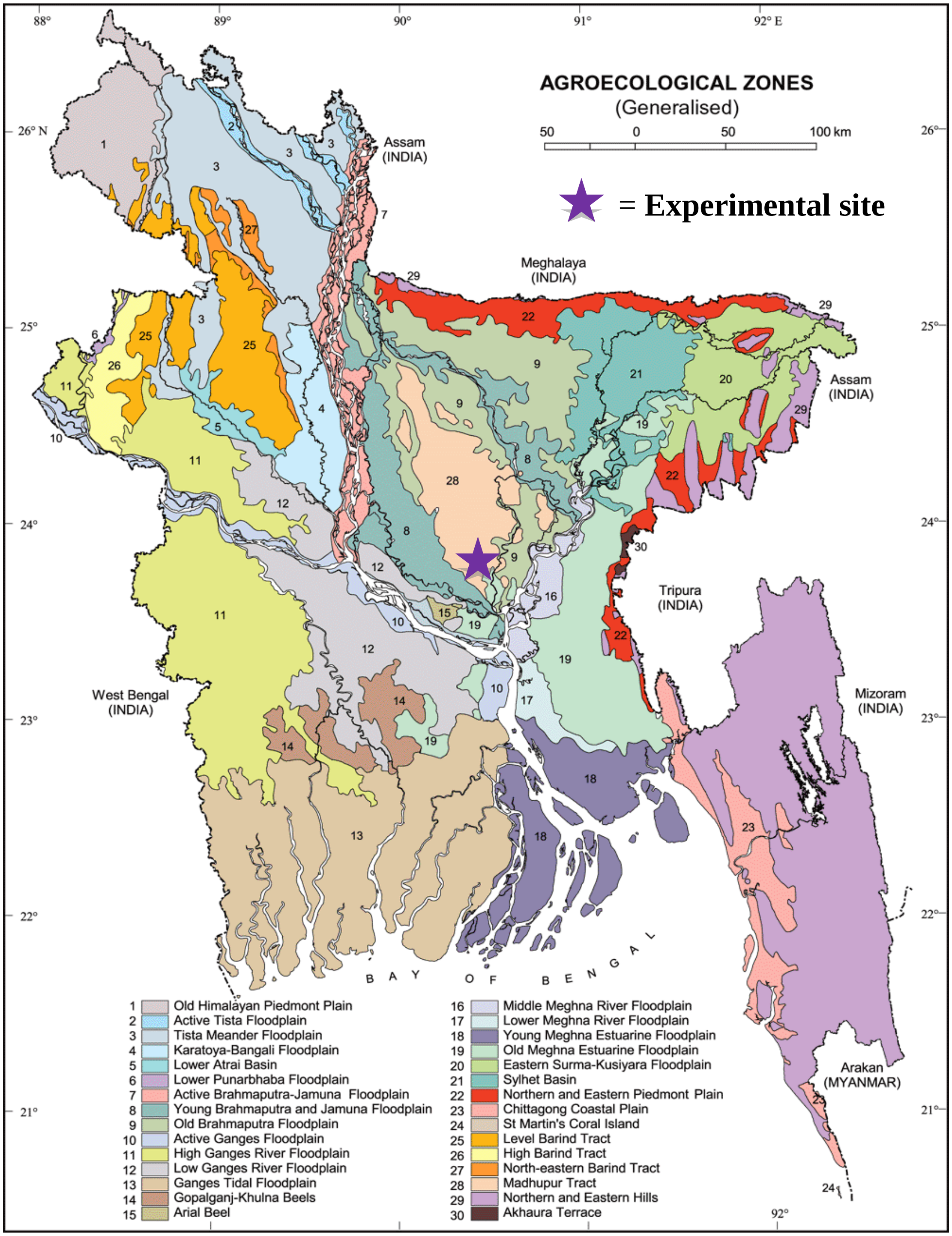
APPENDICES

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	6.1
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.03
Available P (ppm)	20.54
Exchangeable K (me/100 g soil)	0.10

Appendix iii. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period of March, 2014 to July 2014

Month	Air temperature (^0C)		Relative humidity (%)		Rainfall (mm) (total)
	Maximum	Minimum	Maximum	Minimum	
March, 2014	37.4	20.2	80.2	32.4	3.80
April, 2014	39.4	19.4	80.2	39.2	65.60
May, 2014	38.2	19.3	89.2	40	202
June, 2014	37.2	17.4	88.4	46.3	282.7
July, 2014	35.6	18.2	88.2	55.4	107.8

Source: Bangladesh Meteorological Department (Climate division), Dhaka-1212

Appendix iv: Means square values for plant height (cm) of mungbean at different growth stages

Source of variation	Degrees of freedom	Means square values			
		15 DAS	30 DAS	45 DAS	At harvest
Replication	2	23.335	40.606	112.876	137.951
Variety (V)	2	55.442	407.089	580.204*	491.70**
Error (a)	4	5.589	25.669	279.513	8.375
Fertilizer dose(F)	4	42.903*	225.241*	37.232**	9.233**
V× F	8	2.172**	1.205**	2.353	1.223
Error (b)	24	4.441	13.609	14.368	327.654
CV(%)					

*Significant at 5% level, ** Significant at 1% level

Appendix v: Means square values for number of branches plant^{-1} of mungbean at different growth stages

Source of variation	Degrees of freedom	Means square values			
		15 DAS	30 DAS	45 DAS	At harvest
Replication	2	0.142	0.499	0.142	0.259
Variety (V)	2	0.135	1.421**	0.135	0.631*
Error (a)	4	0.096	0.023	0.096	0.011
Fertilizer dose(F)	4	0.032**	0.194**	0.393**	0.415**
V× F	8	0.054	0.070 **	0.054	0.067
Error (b)	24	0.393	0.008	0.032	0.012
CV(%)		7.41	4.83	8.35	5.35

*Significant at 5% level, ** Significant at 1% level

Appendix vi: Means square values for number of leaves plant^{-1} of mungbean at different growth stages

Source of variation	Degrees of freedom	Means square values			
		15 DAS	30 DAS	45 DAS	At harvest
Replication	2	0.419	9.578	7.527	0.034
Variety (V)	2	0.565*	4.979**	11.39**	3.580**
Error (a)	4	0.049	0.088	0.296	0.057
Fertilizer dose(F)	4	0.041	6.117**	10.909**	7.981**
V× F	8	0.0233	0.228	1.781**	0.095
Error (b)	24	0.048	0.165	0.188	0.216
CV(%)		7.06	5.05		11.09

*Significant at 5% level, ** Significant at 1% level

Appendix vii: Means square values for dry weight plant^{-1} of mungbean at different growth stages

Source of variation	Degrees of freedom	Means square values			
		15 DAS	30 DAS	45 DAS	At harvest
Replication	2	0.015	0.097	0.531	1.152
Variety (V)	2	0.088**	0.603*	0.742*	3.568*
Error (a)	4	0.001	0.022	0.047	0.254
Fertilizer dose(F)	4	0.274**	0.852**	3.589**	5.796**
V× F	8	0.008**	0.045*	0.188*	0.047
Error (b)	24	0.001	0.015	0.066	0.135
CV(%)		5.77	7.11	6.65	8.49

*Significant at 5% level, ** Significant at 1% level

Appendix viii: Means square values for number of nodules plant^{-1} and dry weight of nodules of mungbean at different growth stages

Source of variation	Degrees of freedom	Means square values			
		Number of nodules plant^{-1}		Dry weight of nodules	
		30 DAS	45 DAS	30DAS	45DAS
Replication	2	529.001	3044.550	0.257	3.418
Variety (V)	2	4316.275**	21320.828**	0.261*	19.088**
Error (a)	4	13.111	69.018	0.012	0.190
Fertilizer dose(F)	4	392.688**	770.256**	0.601**	16.975**
V× F	8	70.061	4973.104**	0.034	0.118
Error (b)	24	30.541	67.841	0.021	0.218
CV(%)		6.50	4.77	7.88	6.42

*Significant at 5% level, ** Significant at 1% level

Appendix ix: Means square values for pods plant^{-1}, pod length (cm), seeds pod^{-1}, weight of 1000 seed of mungbean

Source of variation	Degrees of freedom	Means square values			
		pods plant^{-1}	pod length	seeds pod^{-1}	Weight of 1000 seed
Replication	2	1.444	0.647	14.222	429.969
Variety (V)	2	43.243*	23.176 **	23.647**	208.371 **
Error (a)	4	4.343	12.926	0.027	187.298
Fertilizer dose(F)	4	48.450**	0.982**	38.173**	7.497**
V× F	8	2.741	0.513	3.693	2.409
Error (b)	24	1.306	0.947	0.188	4.119
CV(%)		7.29	8.62	6.94	5.05

*Significant at 5% level, ** Significant at 1% level

Appendix x: Means square values for seed yield, stover yield, biological yield, and harvest index of mungbean

Source of variation	Degrees of freedom	Means square values			
		Seed yield (t ha^{-1})	stover yield(t ha^{-1})	Biological yield(t ha^{-1})	harvest index
Replication	2	0.028	1.461	2.597	44.147
Variety (V)	2	0.014**	0.501**	1.320*	39.825*
Error (a)	4	0.328	0.025	0.091	4.576
Fertilizer dose(F)	4	0.695**	0.045**	0.023**	58.197**
V× F	8	0.018	0.005	0.182	0.482
Error (b)	24	0.009	0.983	3.249	4.884
CV(%)		9.46	6.13	8.73	7.58

*Significant at 5% level, ** Significant at 1% level