INFLUENCE OF VARIETY AND RHIZOBIUM INOCULANT ON THE NODULATION, GROWTH AND YIELD OF MUNGBEAN

BY

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CERTIFICATE

This is to certify that the thesis entitled, "**INFLUENCE OF VARIETY AND *RHIZOBIUM* INOCULANT ON THE NODULATION, GROWTH AND YIELD OF MUNGBEAN**" submitted to the **DEPARTMENT OF AGRONOMY,** Sher-e-Bangla Agricultural University, Dhaka in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (MS)** in **AGRONOMY** embodies the result of a piece of bonafide research work carried out by **FAILA SABERIN**, Registration No. **01026** under my supervision and guidance.

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

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Dedicated to

My

Beloved Parents

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ABSTRACT

An experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka during the period from April to July, 2007 to study the influence of variety and *Rhizobium* inoculant on the nodulation, growth and yield of mungbean (*Vigna radiata*). The treatment consisted of three varieties of mungbean viz. V_1= BARI mung 3, V_2= BARI mung 4, BARI mung 5 and rhizobium inoculant viz. R_0=No inoculant, R_1= BARI Rvr 405, R_2= BINA MB 1 and tested in Randomized Complete Block Design (RCBD) with three replications. Results showed that variety had significant effect on growth, yield and yield components of mungbean. Compared to other varieties BARI mung 5 gave the highest number of pods plant^{-1}, seeds pod^{-1}, total dry weight plant^{-1}, 1000 seed weight, seed yield and harvest index, whereas, BARI mung 4 gave the highest number of nodules plant^{-1}, higher dry weight of nodules plant^{-1}, plant height, branches plant^{-1}, number of nodules plant^{-1}. Among the two rhizobium inoculant BARI Rvr 405 showed better performance. Both the variety inoculated with BARI Rvr 405 gave significantly higher plant height, number of branches plant^{-1}, number of nodules plant^{-1}and nodule dry weight plant^{-1} whereas, variety BARI mung 5 inoculated with BARI Rvr 405 (V_3R_1) produced higher above ground dry weight and significantly greater yields and yield components of mungbean which was statistically similar to BARI mung 5 inoculated with BINA MB 1 (V_3R_2), BARI mung 4 with BARI Rvr 405 (V_2R_1) and BARI mung 4 with BINA MB 1 (V_2R_2), respecitvely.

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LIST OF ABBRIVIATIONS

BARI	=	Bangladesh Agricultural Research Institute
cm	=	Centimeter
°C	=	Degree Celsius
DAS	=	Days after sowing
et al.	=	and others *(et alibi)*
g	=	gram (s)
DMRT	=	Duncan Multiple Range Test
MOP	=	Muriate of Potash
m	=	Meter
p^H	=	Hydrogen ion concentration
RCBD	=	Randomized Complete Block Design
TSP	=	Triple Super Phosphate
t ha^{-1}	=	ton per hectare
%	=	Percent

Chapter 1

Introduction

CHAPTER 1

INTRODUCTION

Pulse are important food crop and grown all over the country round the year. Pulses occupy a unique position in agriculture due to its high protein content in seed and capacity of fixing atmospheric nitrogen. Legumes have been building and conserving soil fertility since the beginning of agriculture. Among pulse crops, Mungbean (*Vigna radiata* L.) is a good source of vegetable protein and can play vital role in the national economy.

Mungbean ranks 1st position in price but in respect of acreages and production it ranks 4th position in Bangladesh (Sarkar *et al.,* 1982). According to FAO (1999) recommendation, per capita requirement of pulse is 80g/head/day whereas it is only 10.0 g/day in Bangladesh (BBS, 2006).

In Bangladesh, the source of protein is not sufficient for the large population. The source of animal protein is very limited for the population but the plant protein can be obtained very easily and economically. Mungbean is one of the most important pulse crops in the country for its high digestibility, good flavor and high protein content. Mungbean seeds contain 51 % carbohydrate, 26% protein, 3% minerals and 3% vitamins (Kaul, 1982). Mungbean covers an area of 383400 ha and production was about 316000 metric tons (BBS, 2004). The average yield of mungbean in the country is about 570 kg ha^{-1} (BBS, 2007). Mungbean has special importance in intensive crop production system of the country for its short growing period.

Moreover, cultivation of mungbean can improve the physical, chemical and biological properties of soil as well as increase soil fertility status through biological nitrogen fixation (BNF). In legumes nitrogen fixation starts with the formation of root nodules. *Rhizobium* invades the roots and resides within the cortex cell. Within a week after infection small nodules are visible with nacked eye. Biofertilizer can add 20-200 kg nitrogen / ha / annum by fixation and can increase crop yield by 10-50% (Naidu *et al.*, 1994).

Farmers of Bangladesh generally grow mungbean without fertilizer. The farmers of this country can not use fertilizer due to their poor socio economic condition; as a result the yield becomes low although it has great potentials to increase in yield. There is an abundant scope of increasing the yield of mungbean per unit area with higher yielding variety and by using proper fertilizer. Adequate supply of chemical fertilizer or biofertilizer is essential for normal growth and yield of the crop. The price of chemical fertilizer is very high and often is unavailable in the market. For this reason, the poor and marginal farmers cannot afford to apply balanced fertilizers; as a result their crops are not able to produce expected yield. The imbalanced application of chemical fertilizers is also detrimental to the environment. On the other hand, there is an organism, *Rhizobiumn / Bradyrhizobium* which can fix atmospheric nitrogen by symbiotic process with the root system of legume crops and makes available to the plants. *Bradyrhizobium* inoculation increased mungbean seed yield by 4.3% to 16.2% (Vaishya *et al.*, 1983). In Bangladesh inoculation with *Bradyrhizobium* increased 57% effective nodule, 77% dry matter production, 64% grain yield and 40% hay yield of mungbean (Chanda *et al.*, 1991). If the available HYV mungbean could be cultivated with optimum chemical fertilizer or biofertilizer, the daily intake of pulse by our population would have been increased.

So, the present investigation was under taken to study the effect of *Rhizobium* inoculation on the nodulation growth and yield of mungbean varieties.

Considering the above facts, the present study was undertaken with the following objectives;

1. To determine the yield of HYVs mungbean
2. To determine the effect of inoculation on the nodulation and yield of mungbean.
3. To study the effect of interaction between variety and inoculation on the nodulation, growth and yield of mungbean.

Chapter 2

Review of literature

CHAPTER 2

REVIEW OF LITERATURE

2.1 Effect of varieties on growth characteristics of mungbean

2.1.1 Nodule number

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

Solaiman *et al.* (2003) studied on the response of mungbean cultivars BARI mung 2, BARI mung 3, BARI mung 4, BARI mung 5, Bina moog-2 and BU mung-1 to *Rhizobium sp.* strains TAL169 and TAL441. It was observed that inoculation of the seeds increased nodulation.

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

2.1.2 Nodule weight

Ali *et al.* (2004) conducted an experiment at BARI, Joydebpur, Gazipur to find out the response of inoculation with different plant genotypes of mungbean. Inoculated plants gave significantly higher nodule weight.

Bhuiyan *et al.* (2003) carried out a field experiment at Regional Agricultural Research Station (RARS), Rahmatpur, Barisal and found that inoculated plants gave significantly higher nodule weight.

2.1.3 Dry matter

From an experiment at BARI, Joydebpur, Gazipur. Ali *et al.* (2004) showed that inoculated plants gave significantly higher root weight, shoot weight.

Solaiman, *et al.* (2003) reported that inoculation of the seeds increased dry matter production.

Bhuiyan *et al.* (2003) conducted a field experiment with mungbean at Regional Agricultural Research Station (RARS), Rahmatpur, Barisal. Each variety was tested with/without inoculation. Inoculated plants gave significantly higher root weight and shoot weight.

2.1.4 Yield

Ali *et al.* (2004) conducted an experiment with mungbean varieties at BARI, Joydebpur, Gazipur. Each variety was tested with and without inoculation. Inoculated plants gave significantly higher stover yield and seed yield compared to non-inoculated plants. Among 3 varieties, BARI mung-1 produced the highest yield (1.35 t ha^{-1}).

Bhuiyan *et al.* (2003) conducted a field experiment at Regional Agricultural Research Station (RARS), Rahmatpur, Barisal. Inoculated plants gave significantly higher stover yield and seed yield compared to non-inoculated plants. Among 4 varieties, BARI mung 2 produced higher yield. The variety BARI mung 2 gave the highest seed yield (1.38 t/ha) with inoculation.

2.2 Effect of *Rhizobium* inoculation on different characters of mungbean

2.2.1 Nodulation

2.2.1.1 Nodule number

Pandher *et al.* (2006) reported that inoculation of *Vigna radiata* cv. ML 131 with single and multiple strains of *Rhizobium* increased root nodule number of mungbean.

Singh and Tarafdar (2001) conducted a field study in Kanpur, India to determine the effects of *Rhizobium* (strain M-10) on the yield and quality of mung (*Vigna radiata*). Seeds were inoculated with *Rhizobium* suspension at 107 to 108 cells/g. The inoculation significantly increased the number of nodules by 14% over control.

Bhattacharyya and Pal (2001) conducted a field experiment in West Bengal, India, to study the effect of *Rhizobium* inoculation, P and Mo on the growth of summer green gram cv. T-44. Inoculation and application of P and Mo significantly influenced the number of nodules per plant.

Mahmoud and Abd-Alla (2001) conducted a field experiment on the effect of *Bradyrhizobium*-mungbean symbiosis to study the effect on the growth, nodulation and nitrogen fixation of mungbean. It was observed that inoculation significantly enhanced nodulation and nitrogen fixation of mungbean.

Gomaa (2000) executed a field trial on mungbean with biofertilizer. The results showed that *Bradyrhizobium* combined with Azospirillum and/or Candida in the presence of low levels of chemical fertilizers (30 or 60% of the recommended dose of NPK) ameliorated nodulation of mungbean. The highest number of nodule (76 $plant^{-1}$) was recorded due to the treatment of *Bradyrhizobium* + Candida + 30% NPK and the lowest (22 nodules $plant^{-1}$) from control (*Bradyrhizobium* + 100% NPK).

Islam *et al.* (1999) reported that nodule number was significantly lowest in uninoculated and the highest in inoculants treatments. All the *Bradyrhizobium* inoculation treatments performed better in nodulation of soybean.

Bhuyan *et al.* (1998) reported that inoculation with *Bradyrhizobium* significantly increased nodule number per plant of soyabean than uninoculated.

Provorov *et al.* (1998) reported that seed inoculation of mungbean (*Vigna radiata*) with strain CIAM1901 of *Bradyrhizobium* increased the number of root nodules by 254%.

Sharma and Khurana (1997) reported that in case of the application of single and multistrain inoculants of *Rhizobium* in summer mungbean variety, number of nodules was superior in multistrain inoculants.

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

Das *et al*. (1997) inoculated seeds of *Vigna radiata* cv. Nayagarh with *Rhizobium* and/or VAM culture at 15 kg ha^{-1}. They observed that number of nodules increased with inoculation compared with uninoculated control.

Sharma *et al.* (1995) observed that seed inoculation with *Rhizobium* and application of 40 kg P_2O_5 ha^{-1} in chickpea (*Cicer arietinum*) either alone or in combination enhanced nodulation significantly over the uninoculated control.

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

Sattar and Ahmed (1995) studied that the response of inoculation with *Bradyrhizobium* inoculants incorporating BINA 403, BINA 407, RC 3824 and RC 3825 strains as single and mixed culture on mungbean. They observed that *Bradyrhizobium* inoculation increased the number of nodules significantly.

Rai (1988) reported that chickpea with *Cicer rhizobium* and *Glomus albidus* increased nodules per plant, nodule leg hemoglobin content and nitrogenous activity.

Podder (1987) observed that rhizobial strains such as 3910 (USA), 6006 (Roth) and 3824 (Roth) showed better nodulation of blackgram.

Maurya and Sanoria (1986) reported that inoculation of chickpea seeds with two *Rhizobium* strains alone and with two Azotobacter strains and/or Pseudomonas increased nodulation.

Khan *et al.* (1985) reported that inoculation of blackgram seed with different *Rhizobium* strains showed significant effect on nodulation.

Hoque *et al.* (1980) reported that Bragg soybean with *Bradyrhizobium japonicum* strain increased 83% higher nodulation of soybean.

2.2.1.2 Nodule fresh weight

Sattar and Ahmed (1995) studied the response of inoculation with *Bradyrhizobium* inoculants incorporating BINA 403, BINA 407, RC 3824 and RC 3825 strains as single and mixed culture on mungbean. They observed that *Bradyrhizobium* inoculation increased nodule fresh weight significantly.

Bhuiyan and Obidullah (1992) reported that mungbean with *Rhizobium* inoculation significantly increased nodule fresh weight.

2.2.1.3 Nodule dry matter

Sharma and Khurana (1997) reported that in case of the application of single and multistrain inoculants of *Rhizobium* in summer mungbean variety, nodule dry biomass was superior in multistrain inoculants.

Solaiman and Habibullah (1990) observed that in case of mungbean the highest number of nodules (33.7 plant^{-1}) was found on the plant inoculated with *Rhizobia* and 28.10% better nodule dry matter yield was found under inoculation.

Bhuiya *et al*. (1984) observed that the inoculation with *Bradyrhizobium* inoculant, mungbean gave the higher dry weight of nodules compared to control.

2.2.2 Growth characterstics

2.2.2.1 Plant height

Sharma and Upadhyay (2003) observed that mungbean seed inoculation with the local strain resulted in the maximum values for plant height.

Bhattacharyya and Pal (2001) observed in a field experiment to study the effect of *Rhizobium* inoculation, P and Mo on the growth of summer green gram cv. T-44. Inoculation and application of P and Mo significantly influenced plant height.

Kavathiya and Pandey (2000) observed that seed inoculation resulted in significant increase in plant height of mungbean compared to uninoculated control.

Sattar and Ahmed (1995) were reported that Mungbean with *Rhizobium* inoculum increased plant height compared to control.

Samantaray *et al*. (1990) observed that shoot length of mungbean was the highest when inoculation was done with *Rhizobium*.

Thakuria and Saharia (1990) reported that different varieties of mungbean differed significantly in respect of plant height incase of *Rhizobium* inoculation.

Fakir *et al.* (1988) reported that the application of inoculum and phosphorous with N caused the longest plant height of soyabean.

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

2.2.2.2 Branches $plant^{-1}$

Gill *et al.* (1985) reported that inoculation with *Rhizobium* increased the number of branches per plant.

2.2.2.3 Plant growth

Sekhon *et al.* (2002) stated that *Rhizobium* inoculation and nitrogen on biological nitrogen fixation had a significant effect on growth of mungbean (*Vigna radiate).*

Podder (1987) observed that rhizobial strains such as 3910 (USA), 6006 (Roth) and 3824 (Roth) showed better plant growth of black gram.

2.2.2.4 Dry matter

Sharma and Upadhyay (2003) staed that seed of mungbean inoculation with the local strain resulted in the maximum values for dry matter accumulation.

Bhattacharyya and Pal (2001) conducted an experiment to study the effect of *Rhizobium* inoculation, P and Mo on the growth of summer green gram cv. T-44. Inoculation and application of P and Mo significantly influenced dry matter accumulation in the shoot.

Srivastav and Poi (2000) observed symbiotic efficiencies of greengram (*V. radiata*) and blackgram (*V. mungo*) after inoculation with a native *Bradyrhizobium* strain and the residual effects of 7 *Bradyrhizobium* strains (NG-13/1, M-10, Kuthi AR-1, Jca-1, Caj-3, NK-4 and Caj6/1) in neutral pH soil, had a significant effect on nitrogen uptake and grain yield. Inoculation with M-10 strain in green gram resulted in the highest dry matter production and nitrogen fixation.

Chowdhury *et al.* (2000) studied that dry matter production increased with *Rhizobium* inoculation and increasing P rate. Dry matter was partitioned prior to and at flowering was about 20 and 50% of total dry matter at maturity. Dry matter accumulation after flowering greatly influenced seed yield, as most of the photosynthate produced at this stage is used for pod and seed development. Seeds contributed the majority of dry matter content at harvest.

Asghar *et al.* (1998) conducted an experiment on lentil and observed that *Rhizobium* inoculation increased root dry weight.

Bhuiyan *et al.* (1998) stated that *Rhizobium* seed inoculation with 1 kg Mo ha^{-1} and 1 kg B ha^{-1} increased shoot dry weight compared to the control.

Vasilas and Furman (1993) stated that nodulation of soybean plant by strains of *Bradyrhizobium japonicum* increased total shoot weight by

29% over uninoculated control.

Bhuiyan and Obidullah (1992) stated that mungbean with *Rhizobium* inoculation significantly increased shoot weight.

Hoque and Hashem (1992) observed that inoculation of soybean seeds with *Bradyrhizobium* inoculum gave the highest shoot dry weight and stover yield of soybean and groundnut.

Fakir *et al.* (1988) reported that biomass production, was the highest with application of inoculum and phosphorous and all the effects were significantly higher over the control.

Gupta *et al.* (1988) conducted 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} increased the plant dry weight.

Mandal and Chahal (1987) conducted an experiment on mungbean and found that *Rhizobium* inoculation along with 40 ppm N gave maximum dry weight of root and shoot in mungbean plants.

Khan *et al.* (1985) reported that inoculation of blackgram seed with different *Rhizobium* strains showed that the strains BAD 524 influence plant to have more dry matter.

Hoque *et al.* (1980) stated that Bragg soybean with *Bradyrhizobium japonicum* strain increased 15% higher dry shoot weight of soybean.

2.2.3 Yield

Pandher *et al.* (2006) reported that inoculation of *Vigna radiata* cv. ML 131 with single and multiple strains of *Rhizobium* increased seed yield.

Anjum *et al.* (2006) observed that yield and yield components of mungbean crop were significantly affected by *Rhizobium* inoculation of both seed and soil and fertilizer application. Seed inoculation was more effective and gave better yield than soil inoculation.

Patra and Bhattacharyya (2005) conducted an experiment with combinations of *Rhizobium* inoculation and urea (25 kg/ha) and grain yield ascertained. The field trial indicated that plants seed inoculated with *Rhizobium* plus urea fertilizer exhibited significantly higher yields compared with the controls being 31.53% and 37.52% higher in the first and second years, respectively.

Singh and Pareek (2003) conducted a field experiment to investigate the effect of P fertilizers (0, 15, 30, 45 and 60 kg P_2O_5 ha^{-1}) and biofertilizers (*Rhizobium* sp.; phosphate solubilizing bacteria, PSB; and combination of *Rhizobium* + PSB) on the growth and yield of mungbean cv. RMG 62. All biofertilizer treatments increased growth and yield characters, except pod length and test weight.

Sharma and Upadhyay (2003) achieved that mungbean seed inoculation with the local strain resulted the highest yield and number of pods per plant.

Solaiman (2002) reported that *Bradyrhizobium* on seed inoculation of mungbean significantly increased grain yield compared with uninoculated control.

Singh and Tarafdar (2001) conducted a field study in Kanpur, India to determine the effects of *Rhizobium* (strain M-10) on the yield and quality of mung (*Vigna radiata*). Seeds were inoculated with *Rhizobium* suspension at 107 to 108 cells g^{-1}. The inoculation significantly increased crop biomass (14%), seed (16%) and straw yields, total N fixation (22%), straw and seed protein contents, and total N uptake by seed and straw.

Hasanuzzaman (2001) found that mungbean seeds inoculated with *Bradyrhizobium* strain significantly increased the grain yield compared with uninoculated control.

Sharma (2001) observed with three strains of *Bradyrhizobium* (Ludhiana, local isolated and IARI) were inoculated in seeds of mungbean cv. Pusa Baisakhi. Crop growth rate, relative growth rate, days to 50% flowering, days to maturity and grain yield were at maximum when mungbean seeds were treated with the local isolate.

Chowdhury *et al.* (2000) reported that mungbean seed inoculation with *Rhizobium* strains was most effective for increasing seed yield.

Srivastav and Poi (2000) observed symbiotic efficiencies of greengram (*V. radiata*) and blackgram (*V. mungo*) after inoculation with a native *Bradyrhizobium* strain and the residual effects of 7 *Bradyrhizobium* strains (NG-13/1, M-10, Kuthi AR-1, Jca-1, Caj-3, NK-4 and Caj6/1) in neutral pH soil, had a significant effect on nitrogen uptake and grain yield. Inoculation with NK-4 into blackgram resulted in the highest nitrogen uptake and grain yield.

Bhuiyan *et al.* (1998) stated that *Rhizobium* seed inoculation with 1 kg Mo ha^{-1} and 1 kg B ha^{-1} increased seed yield compared with the control. Seed yield was 107% and 148% higher over control in two consecutive growth seasons.

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

Provorov *et al.* (1998) reported that seed inoculation of mungbeans (*Vigna radiata*) with strain CIAM1901 of *Bradyrhizobium* increased the herbage mass by 46.6%, seed mass by 39.2%, 1000-seed weight by 16%, seed N content by 58.3% and seed starch content by 30.0%.

Shanna and Khurana (1997) studied the effectiveness of single and multi strain inoculants in field with summer mungbean variety SML 32 and found that grain 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.

Saraf and Shivakumar (1996) reported that seed yield was higher 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_2O_5 ha^{-1} in chickpea.

Sharma *et al.* (1995) observed that seed inoculation with *Rhizobium* and application of 40 kg P_2O_5 ha^{-1} in chickpea (*Cicer arietinum*) either alone or in combination enhanced yield significantly over the uninoculated control.

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

Sarker *et al.* (1993) reported that *Rhizobium* inoculation along with P application and *Rhizobium* inoculation along with Azotobacter chroococcum were equally effective in enhancing grain yield of greengram.

Bhuiyan and Obidullah (1992) reported that mungbean with *Rhizobium* inoculation significantly increased pod yield.

Thakuria and Saharia (1990) reported that different varieties of mungbean differed significantly in respect of 1000 seed weight and grain yield incase of *Rhizobium* inoculation.

Sangakhara and Marambe (1989) observed that inoculation significantly increased nodulation of *Vigna radiata* at 21 days after sowing, but had no effect at flowering where N was applied. Seed inoculation and soil inoculation before sowing increased nodule number plant^{-1} at flowering where no N was applied. Inoculation plus applied N (25 kg ha^{-1}) gave seed yields 8.1- 10.1 g plant^{-1}, which was higher compared to N (25 kg ha^{-1}) alone or and 5.2- 6.5 g with inoculation alone and they concluded the seed inoculation was most effective for increasing seed yield.

Mozumder (1988) conducted a field experiment on mungbean where seed inoculated with different strains of *Bradyrhizobium*. He observed that grain yield significantly increased over uninoculated control.

Gupta *et al.* (1988) conducted 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} increased seed yield plant^{-1}.

Chapter 3

Materials and Methods

CHAPTER 3
MATERIALS AND METHODS

The experiment was conducted at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka, during the period from April to July 2007 in the Kharif -1 season with a view to study the "Influence of variety and *Rhizobium* inoculant on the nodulation, growth and yield of mungbean.''

3.1 Site

The experimental field was located at 90° 33' E longitude and 23° 71' N latitude at a height of 9 m above the sea level. The land was medium high and well drained.

3.2 Climate

The climate of the experimental field was sub-tropical and was characterized by high temperature, heavy rainfall during Kharif-l season (April - June) and scanty rainfall during Rabi season (October - March) associated with moderately low temperature.

3.3 Soil

The physical and chemical properties of soil of the experimental site were observed prior to experimentation from 0-15 cm depth. The soil was clay loam in texture and having soil pH varied from 5.47 to 5.63. Organic matter content was very low (0.8%). The physical composition such as sand, silt, clay content were 40%, 40% and 20% respectively. The chemical composition of the macro elements of soil whereas total nitrogen 0.076%, phosphorus 22.09 μg/g soil, potassium 0.15 meq/100 g soil, calcium 3.60 meq/100 g soil, magnesium 1.00 meq/100 g soil and sulphur 25.96 µg/g soil. The micro elements such as boron 0.44 µg/g soil, copper 3.56 µg/g soil, iron 262.9 µg/g soil, manganese 163 µg/g soil and zink 3.31 µg/g soil, respectively are also found in the soil (Appendix I).

3.4 Planting materials

Three mungbean varieties viz. BARI mung 3, BARI mung 4 and BARI mung 5 were used as planting materials for the investigation. These varieties was developed by Pulses Research Centre of Bangladesh Agricultural Research Institute, Joydevpur, Gazipur. Among these varieties BARI mung 3, BARI mung 4 and BARI mung 5 are resistant to Cercospora leaf spot and also resistant to yellow mosaic virus. The salient features of these varieties are described as below:

a) **BARI mung 3**: Plant height was 50-55 cm and days to maturity was 60-65 days after sowing. Seed color was brownish green, 1000 seed weight was 25-29 g and finally yield was 1.0-1.1 t ha^{-1}.

b) **BARI mung 4**: Plant height was 50-55 cm and days to maturity was 60-65 days after sowing. Seed color was green, 1000 seed was 28-32 and finally yield was 1.2-1.4 t ha^{-1}.

c) **BARI mung 5**: Plant height was 45-50 cm and days to maturity 60-65 days after sowing. Seed color was green, 1000 seed weight was 41-42 g and finally yield was 1.2-1.5 t ha^{-1}.

3.5 Treatments

A) Variety: Three

V_1= BARI mung 3

V_2=BARI mung 4

V_3 =BARI mung 5

B) *Rhizobium* inoculant

R_0= No inoculant

R_1= BARI Rvr 405

R_2= BINA MB1

So, the treatment combinations of this experiment were:

V_1R_0, V_1R_1, V_1R_2, V_2R_0, V_2R_1, V2R2, V_3R_0, V_3R_1 and V_3R_2.

3.6 Collection of inoculums as biofertilizer

The *Rhizobium* inoculum used in the present study was collected from the Soil Science Division, BARI, Joydebpur, Gazipur and Microbiology Laboratory of BINA, Mymensingh.

3.7 Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (factorial) with three replications. Each replication had 9 unit plots to which the treatment combinations were assigned at random. The unit plot size was 4.5m x 3m.

3.8 Land preparation

The experimental land was started to prepare on 9th April, 2007. Ploughing and cross ploughing were done with country plough followed by laddering. Land preparation was completed on 11th April, 2007 and was ready for sowing seeds.

3.9 Fertilizer application

The experimental plots were fertilized with 40 kg urea, 80 kg triple super phosphate (TSP) and 30 kg muriate of potash (MP) per hectare. All the fertilizers were incorporated into the soil before sowing of seeds. Nitrogen fertilizer was not given in the plot where biofertilizer was used and given where not used. Mungbean seeds were inoculated with *Rhizobium* inoculant just before sowing at the rate of 5 kg per hectare as per treatment.

3.10 Inoculation of seeds

The seeds were taken in polyethylene bags and were soaked with required amount water for putting a sticky layer on the seed surface. Thereafter, powdered inoculants were mixed thoroughly with the seeds as per treatment with a view to putting a blackish layer on the seed surface. The seeds were dried in the shade before sowing.

3.11 Sowing of seeds

Seeds were sown on 12th April 2007 maintaining the spacing as 30 cm row to row distance. Seeds were sown as continuous method.

3.12 Intercultural operations

3.12.1 Thinning and weeding

Thinning was done after 15 days after sowing (DAS) to maintain plant spacing as 10 cm. First weeding was done at 25 DAS when the plant attained at a height of about 20 cm. Second weeding was done at 40 days after sowing. Light irrigation was given at 30 days after sowing. The crop was attacked by pod borer and was controlled by the application of Malathion 57 EC @ 1.5 l ha^{-1} at the time of 50% pod formation stage (55 DAS).

3.12.2 Determination of maturity

When 80% of the pods turned brown color, the crop was assessed to attain maturity.

3.12.3 Harvesting and sampling

The crop was harvested on 4th July, 2007 from prefixed 2.7 m^2 areas from centre of a plot for recording yield data. Before harvesting ten plants were selected randomly from each plot and were uprooted for recording yield contributing characters data. The plants of prefixed $2.7m^2$ areas were harvested plot wise and were bundled, tagged and brought to the threshing floor of Agronomy Field Laboratory.

3.12.4 Threshing

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

3.12.5 Drying, cleaning and weighing

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

3.13 Recording of data

The following data were recorded from the each treatment.

A. Growth parameters:

i) Plant height (cm)
ii) Number of branches $plant^{-1}$
iii) Number of nodules $plant^{-1}$
iv) Dry weight of nodules $plant^{-1}$ (mg)
v) Total Dry matter yield $plant^{-1}$ (g)

B. Yield contributing parameters:

i) Number of pods $plant^{-1}$
ii) Number of seeds pod^{-1}
iii) Weight of 1000 seed (g)

C. Yield and harvest index:

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

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

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

iv) Harvest index (%)

3.14 Outline of data recording

A. Growth parameters:

Data on growth parameters were recorded from ten selected plants from each plot. Nodulation and dry matter yield were recorded from the selected plant at 20 day interval started from 20 DAS.

i) Plant height (cm):

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

ii) Number of branch $plant^{-1}$:

Number branches of individual plant was recorded from the selected plants and determined the average number of branch per plant.

iii) Number of nodules $plant^{-1}$:

Five plants were selected randomly from each plot. They were uprooted carefully with the help of nirani for counting the nodules per plant. Then the roots of the uprooted plants were washed carefully and the number of nodules $plant^{-1}$ was recorded.

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

Counted nodules were oven dried maintaining a temperature of 80^0 C for 2 days until constant weight was reached and the dry weight was recorded with an electric balance and the mean value was determined.

v) Total dry matter yield per plant (g):

The plants were separated from different plant parts and then kept in the oven at 80^0 C for 2 days to reach a constant weight. Then total dry weight of plant parts were taken with an electric balance. The mean values were determined.

B. Yield contributing characters:

i) Number of pods plant^{-1}:

Number of pods was counted from randomly selected 10 plants and then their mean value was recorded.

ii) Number of seeds pod^{-1}:

Number of seeds pod^{-1} was counted from twenty randomly selected pods and then the average seed number was calculated.

iii) Weight of 1000 seed (g):

1000 seeds were counted, which were taken from the seed sample of each plot separately, then weight was taken in an electrical balance and data was recorded.

C. Yield and harvest index:

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

Seeds obtained from 2.7m^2 area of each unit plot were dried in sun and weighed out. The seed weight was then converted as t ha^{-1}. The grain moisture content was measured by using a digital moisture meter. Seed yield was adjusted to 12% moisture content.

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

Straw obtained from 2.7 m^2 area of each unit plot were dried in sun and weighed out. The straw weight was expressed as t ha^{-1}.

iii) Biological yield (t ha^{1})

Biological yield was calculated using the following formula:

Biological yield = Grain yield + Stover yield.

iv) Harvest Index (%)

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

$$\text{Harvest Index} = \frac{\text{Seed yield}}{\text{Biological yield}} \times 100$$

3.15 Data analysis

Data recorded for different parameters were compiled and analyzed by the MSTAT-C programme. Mean differences among the treatments were tested with Duncan's Multiple Range Test (DMRT) at 5% level.

Chapter 4

Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSION

The results of the experiment have been presented and discussed and compared as far as possible with the results of other scientists.

4.1 Response of growth characters of mungbean

4.1.1 Plant height

4.1.1.1 Effect of variety

The result revealed that the effect of variety on plant height was significant at 40 and 60 DAS, but not significant at 20 DAS (Fig.1). BARI mung 4 gave the highest plant height at 40 and 60 DAS, that was 54.5cm and 64.23 cm, respectively and the lowest height were 48.37 cm and 56.56 cm obtained from BARI mung 3 at 40 and 60 DAS, respectively. BARI mung 5 showed intermediate result (51.03 cm) at 40 DAS and similar result (56.60 cm) was showed with BARI mung 3. The result was in agreement with the findings of Thakuria and Saharia (1990) who reported that plant height differed among the varieties.

4.1.1.2 Effect of *Rhizobium* inoculant

The plant height was significantly influenced by different types of *Rhizobium at* 20, 40 and 60 DAS. The inoculation of rhizobium significantly increased plant height at 20, 40 and 60 DAS and the highest height was recorded as 25.20 cm, 55.63 cm and 63.87 cm in BARI Rvr 405 *Rhizobium* treated plots and the lowest 21.79 cm, 44.06 cm and 54.63 cm in control, respectively (Fig. 2). BINA MB 1 treated plants showed the moderate result (51.65 cm and 57.6 cm) at 40 and 60 DAS respectively which were significantly higher over control. Similar findings was obtained by Kavathiya and Pandey (2000), they observed that seed inoculation resulted in significant increase of plant height of mungbean compared to uninoculated control.

4.1.1.3 Combined effect of variety and *Rhizobium* inoculant

The combined effect was found significant for plant height at 20, 40 and 60 DAS (Table 1). At 20 DAS, significantly highest plant height (27.54 cm) was recorded from treatment V_3R_2 and followed by V_2R_1 (26.90 cm) and V_3R_1 (25.42 cm). The lowest plant height (20.74 cm) was obtained from V_1R_0 which was similar to V_3R_0 (21.92 cm). At 40 and 60 DAS, V_2R_1 showed the highest height (55.07 and 64.05 cm, respectively) and V_1R_0 gave the lowest result (46.22 and 55.6 cm, respectively). At 40 DAS, V_3R_1 and V_2R_2 showed similar results with V_2R_1. At 40 and 60 DAS, the significantly lower height were recorded from V_3R_0 (47.55 cm) and V_3R_2 (56.48 cm), V_1R_2 (56.47 cm), V_3R_0 (55.62 cm), respectively, which were similar to that of V_1R_0 at 40 and 60 DAS. Thakuria and Saharia (1990) reported that different varieties of mungbean differed significantly in respect of plant height incase of *Rhizobium* inoculation which supported the above results.

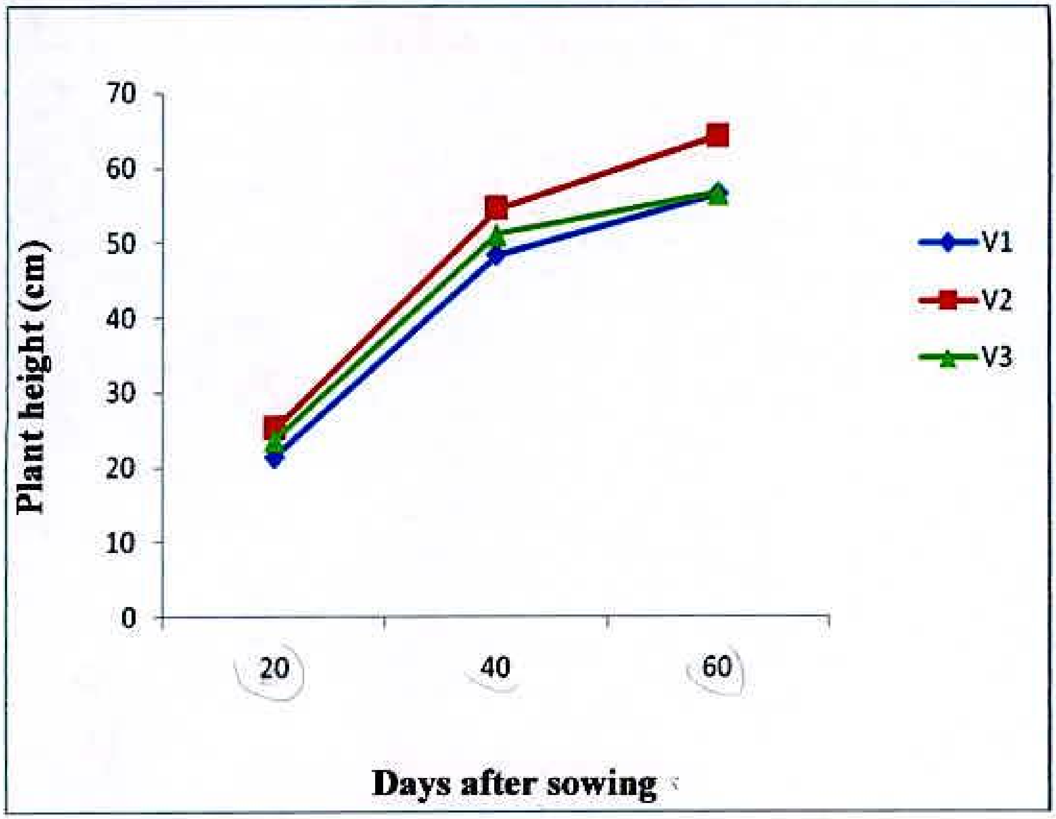

Fig 1. Effect of variety on plant height of mungbean plant at different days

V_1 = BARI mung 3
V_2 = BARI mung 4
V_3 = BARI mung 5

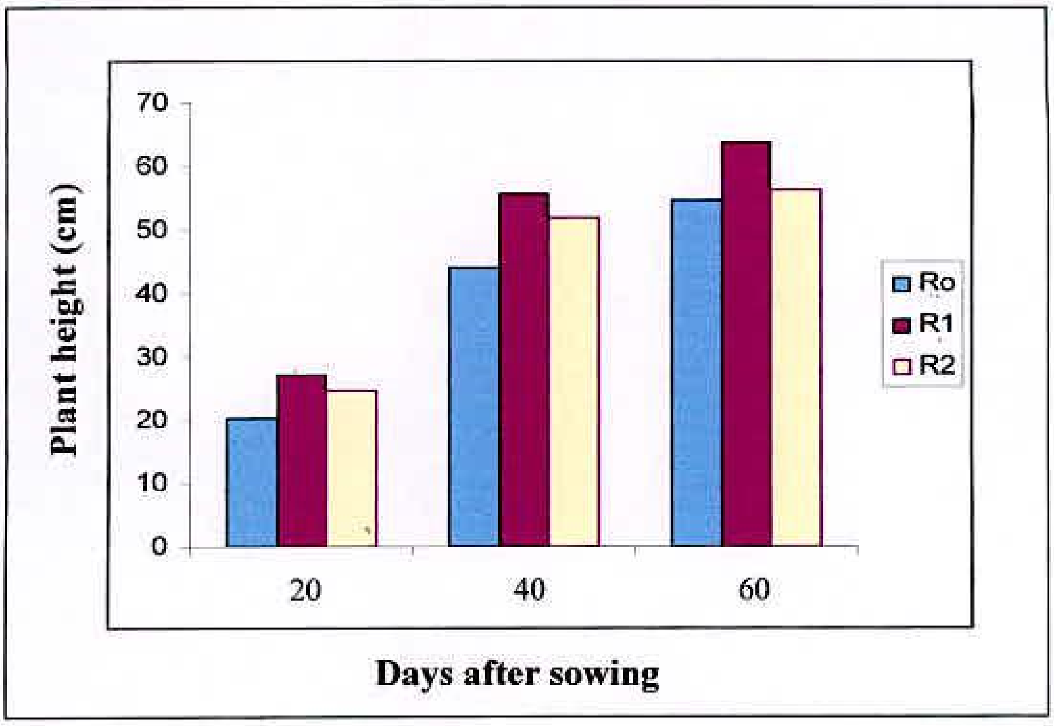

Fig 2. Effect of *Rhizobium* inoculant on plant height of mungbean at different days

R_0 = No inoculant
R_1 = BARI Rvr- 405
R_2 = BINA MB 1

Table 1. Combined effect of variety and *Rhizobium* inoculant on plant height of mungbean at different days

Treatments	Plant height (cm)		
	20 DAS	40 DAS	60 DAS
V_1R_0	20.74 d	46.22 f	55.60 c
V_1R_1	24.29 b	52.00 bc	60.22 b
V_1R_2	23.00 bc	50.18 cd	56.47 c
V_2R_0	22.70 c	49.28 de	59.43 b
V_2R_1	26.90 a	55.07 a	64.05 a
V_2R_2	24.92 b	53.25 ab	60.30 b
V_3R_0	21.92 cd	47.55 ef	55.62 c
V_3R_1	25.42 a	53.33 ab	60.23 b
V_3R_2	27.54 a	51.52 bc	56.48 c
$s_{\bar{x}}$	0.599	0.592	0.755
CV (%)	9.40	7.20	4.88

V_1 = BARI mung 3 R_0 = No inoculant
V_2 = BARI mung 4 R_1 = BARI Rvr- 405
V_3 = BARI mung 5 R_2 = BINA MB 1

4.1.2 Number of branches plant^{-1}

4.1.2.1 Effect of variety

Variety had no significant effect on number of branches plant^{-1} at different growth stages of mungbean plant (Table 2), though BARI mung 4 produced the maximum number of branches plant^{-1} at all growth stages. BARI mung 3 produced the lower number of branches plant^{-1} at different days.

Table 2. Effect of variety on number of branches of mungbean plant at different days

Treatments	Number of branches plant^{-1}		
	20 DAS	40DAS	60DAS
V_1	0.26	1.08	1.87
V_2	0.35	1.43	2.45
V_3	0.29	1.22	2.17
$s_{\bar{x}}$	0.012	0.012	0.100
CV (%)	12.48	4.25	5.57

V_1 = BARI mung 3
V_2 = BARI mung 4
V_3 = BARI mung 5

4.1.2.2 Effect of *Rhizobium* inoculant

Different types of *Rhizobium* had significant effect on the number of branches plant^{-1} at different growth stages of mungbean (Fig. 3). This observation was not significant at 20 DAS but significant at 40 and 60 DAS. The maximum branches plant^{-1} 1.36 and 2.40 were obtained at 40 and 60 DAS, respectively with BARI Rvr 405 *Rhizobium* treated plots. Minimum number of branches plant^{-1} 1.03 and 1.73 were observed at 40 and 60 DAS, respectively with control treatment. BINA MB 1 treated plants gave the results 1.34 and 2.36 branches plant^{-1} at 40 and 60 DAS, respectively, which were not significantly different from BARI Rvr 405 *Rhizobium* treated plants. The result was in agreement with the findings of Gill *et al.* (1985) who reported that inoculation with *Rhizobium* increased the number of branches plant^{-1}.

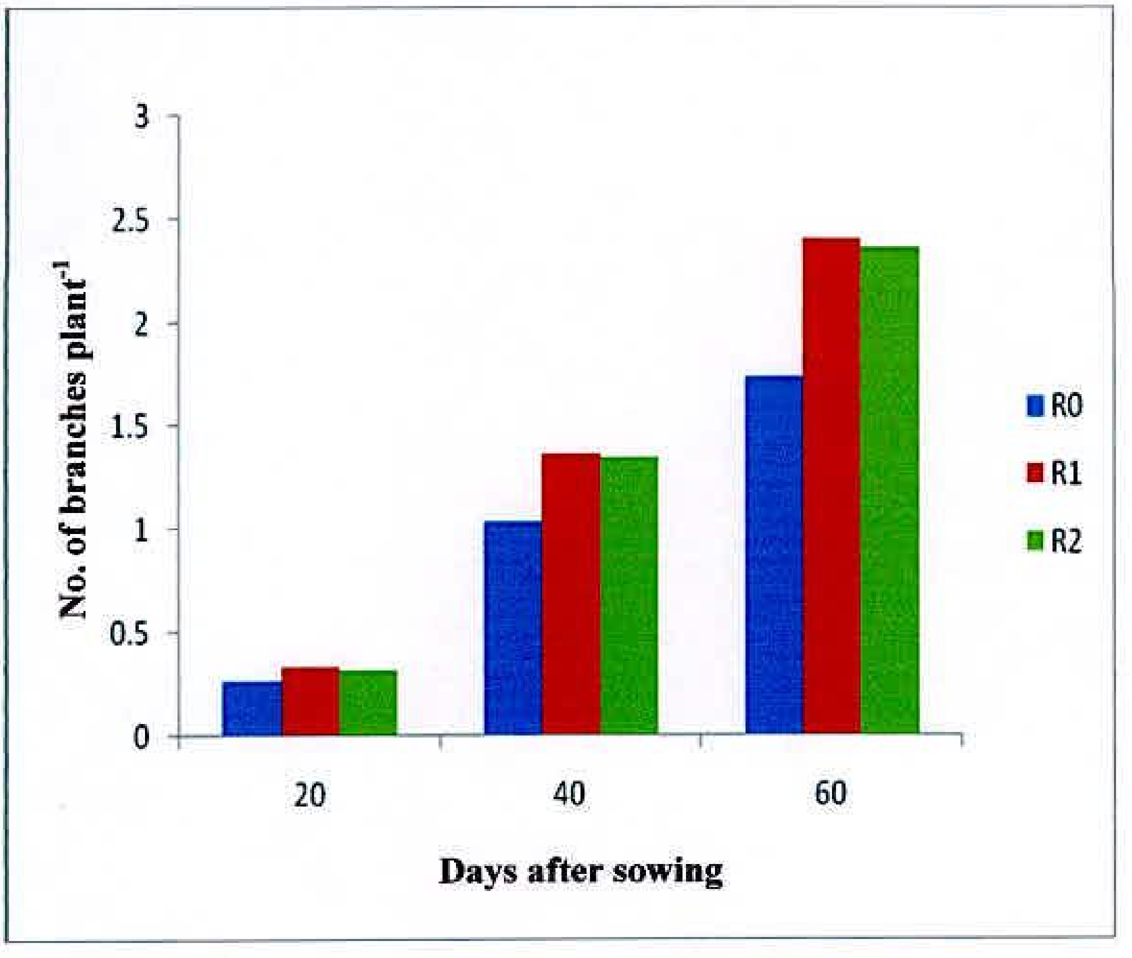

Fig 3. Effect of *Rhizobium* inoculant on branches of mungbean plant at different days

R_0 = No inoculant
R_1 = BARI Rvr- 405
R_2= BINA MB 1

4.1.2.3 Combined effect of variety and *Rhizobium* inoculant

The combined effect between variety and *Rhizobium* was significant in respect of number branches plant^{-1}at 40 and 60 DAS but not at 20 DAS (Table 3). At 40 and 60 DAS, the highest number of branches plant^{-1} (1.59 and 2.81) was found in V_3R_1. At 40 DAS, V_3R_2 gave the result (1.53) which was similar with V_3R_1 and lowest number of branches was found in V_1R_0 (0.94) and followed by V_2R_0 (0.99), V_1R_1 (1.10) and V_3R_0 (1.15). At 60 DAS, treatment V_3R_2 (2.72), V_2R_1 (2.48) and V_2R_2 (2.31) gave significantly similar number of branches to that of V_3R_1 (2.81). Significantly lowest number of branches plant^{-1} (1.65) was produced in V_1R_0 and followed by V_2R_0 (1.73), V_3R_0 (1.82) and V_1R_2 (2.06).

Table 3. Combined effect of variety and *Rhizobium* inoculant on number of branches of mungbean plant at different days

Treatments	No. of branches plant^{-1}		
	20 DAS	40 DAS	60 DAS
V_1R_0	0.24	0.94 f	1.65 d
V_1R_1	0.26	1.10 def	1.90 cd
V_1R_2	0.30	1.21 cde	2.06 bcd
V_2R_0	0.26	0.99 ef	1.73 d
V_2R_1	0.32	1.37 bc	2.48 ab
V_2R_2	0.30	1.32 cd	2.31 abc
V_3R_0	0.28	1.15 cdef	1.82 cd
V_3R_1	0.40	1.59 a	2.81 a
V_3R_2	0.38	1.53 ab	2.72 a
$S_{\bar{x}}$	0.009	9.51	7.97
CV (%)	12.72	0.0685	0.1746

V_1 = BARI mung 3 R_0 = No inoculant
V_2 = BARI mung 4 R_1 = BARI Rvr 405
V_3 = BARI mung 5 R_2 = BINA MB 1

4.1.3 Number of nodules plant^{-1}

4.1.3.1 Effect of variety

Significant variation was observed among the varieties in respect of number of nodules plant^{-1} at 20, 40 and 60 DAS (Fig. 4). BARI mung 4 produced the highest number of nodules plant^{-1} at 20, 40 and 60 DAS, which was 8.33, 17.34 and 38.03, respectively. The lowest number (6.23, 13.2 and 30.47) was in BARI mung 3 at 20, 40 and 60 DAS, respectively.

4.1.3.2 Effect of *Rhizobium* inoculant

A significant variation observed in case of number of nodules plant^{-1} due to different types of *Rhizobium* application at 20, 40 and 60 DAS. In general, number of nodules plant^{-1} increased with the advances of growth stages (Fig-5). At 20, 40 and 60 DAS the highest number of nodules plant^{-1} (8.35, 21.66 and 39.00, respectively) was counted in only BARI Rvr 405 *Rhizobium* applied plant. The lowest number of nodules plant^{-1} (6.07, 14.46 and 31.06) was recorded in control plant at 20, 40 and 60 DAS, respectively. The result corroborates with the findings of Pandher *et al.* (2006). They reported that inoculation of *Vigna radiata* cv. ML 131 with single and multiple strains of *Rhizobium* increased root nodules of mungbean.

4.1.3.3 Combined effect of variety and *Rhizobium* inoculant

The combined effect between variety and *Rhizobium* was significant in respect of number of nodules plant^{-1} at 40 and 60 DAS (Table 4). At 20 DAS there was no significant effect on number of nodules plant^{-1}. At 40 and 60 DAS the highest number of nodules plant^{-1} (19.50 and 38.52) was found in V_2R_1 interaction and followed by V_3R_1 in each growth stage. Significantly lowest number of nodules plant^{-1} (13.83 and 30.77) was produced in V_1R_0 interactions at 40 and 60 DAS, respectively.

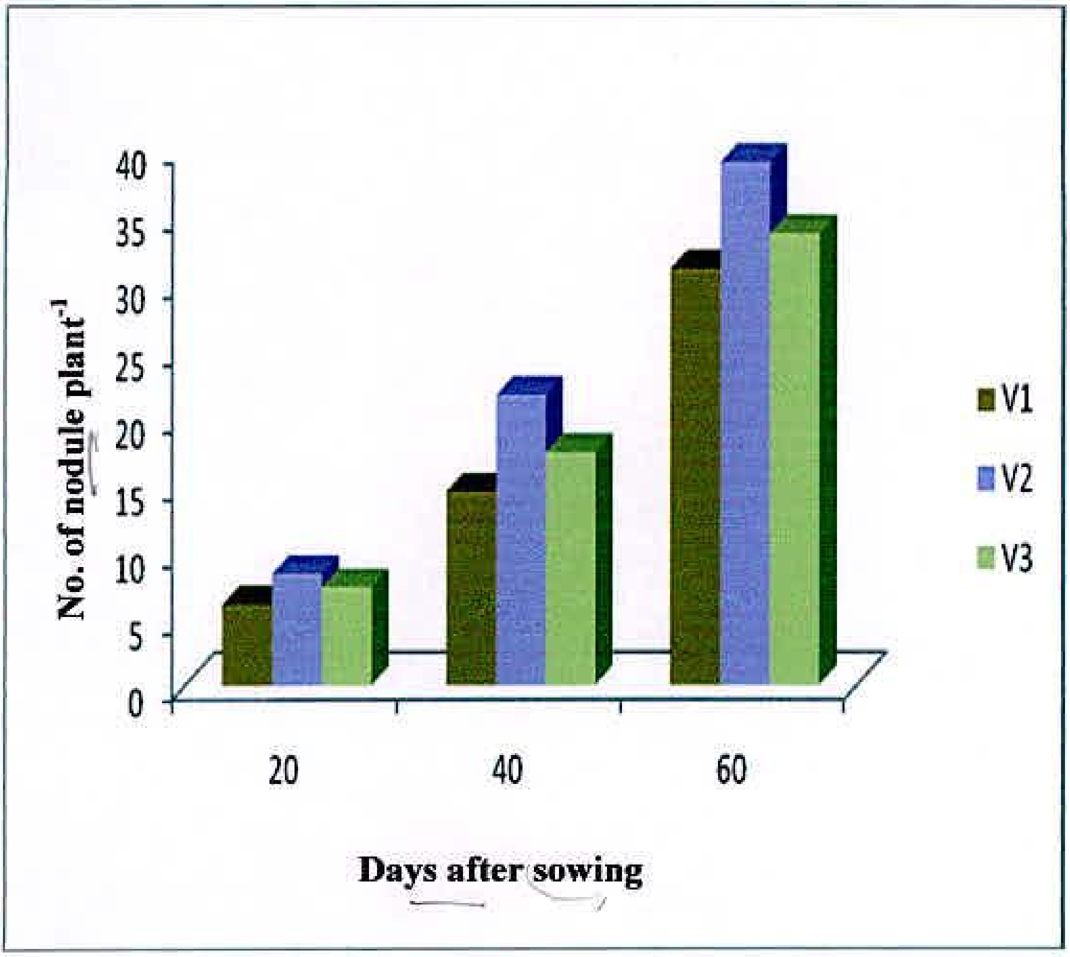

Fig. 4. Effect of variety on number of nodules of mungbean plant at different days

V_1 = BARI mung 3
V_2 = BARI mung 4
V_3 = BARI mung 5

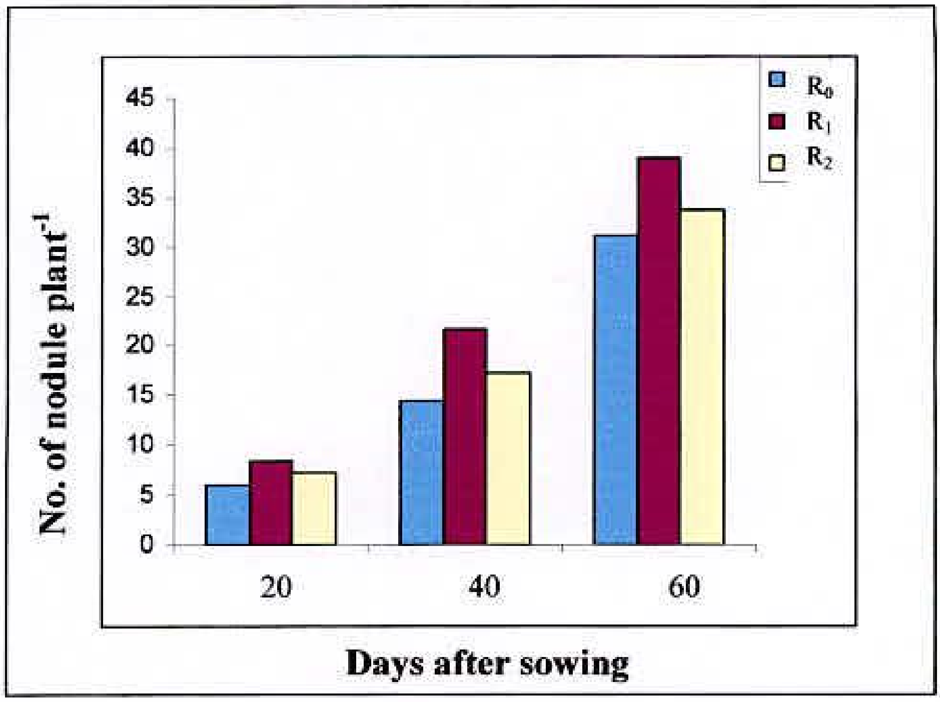

Fig. 5. Effect of *Rhizobium* inoculants on number of nodules of mungbean plant at different days

R_0 = No inoculant

R_1 = BARI Rvr- 405

R_2= BINA MB 1

Table 4. Combined effect of variety and *Rhizobium* inoculant on number of nodules of mungbean plant at different days

Treatments	No. of nodules plant^{-1}		
	20 DAS	40 DAS	60 DAS
V_1R_0	6.15	13.83 d	30.77 d
V_1R_1	7.29	17.59 b	34.73 b
V_1R_2	6.87	15.28 bc	32.08 c
V_2R_0	7.20	15.91 b	34.55 b
V_2R_1	8.34	19.50 a	38.52 a
V_2R_2	7.84	17.36 b	35.86 b
V_3R_0	6.69	14.82 c	33.75 bc
V_3R_1	7.84	18.41 a	36.73 a
V_3R_2	7.33	16.27 b	34.08 b
$S_{\bar{x}}$	0.168	0.245	0.561
CV (%)	9.14	12.82	6.74

V_1 = BARI mung 3 R_0 = No inoculant
V_2 = BARI mung 4 R_1 = BARI Rvr- 405
V_3 = BARI mung 5 R_2 = BINA MB 1

4.1.4 Dry weight of nodules plant^{-1}

4.1.4.1 Effect of variety

The three varieties of mungbean had significant effect on dry weight of nodules plant^{-1} at 40 and 60 DAS but showed no significant effect at 20 DAS (Fig. 6). BARI mung 4 showed the highest dry weight at 40 and 60 DAS that was 2.01 and 4.42 mg where the BARI mung 3 showed the lowest dry weight of nodules plant^{-1} (1.49 and 3.54 mg) at 40 and 60 DAS, respectively.

4.1.4.2 Effect of *Rhizobium* inoculant

Different types of *Rhizobium* had significant effect on dry weight of nodules plant^{-1} at 40 and 60 DAS but no significant effect at 20 DAS. The highest dry weight (2.52and 4.38 mg) was found in BARI Rvr 405 *Rhizobium* treated plot and the lowest dry weight of nodules plant^{-1} (1.68 and 3.56 mg) was found at controlled condition during 40 and 60 day of growth stages, respectively (Fig. 7). This result was supported by Bhuiya *et al.* (1984) who observed that the inoculation with *Bradyrhizobium* inoculant, mungbean gave the higher dry weight of nodules over control.

4.1.4.3 Combined effect of variety and *Rhizobium* inoculants

Interaction of variety and *Rhizobium* showed significant effect on dry weight of nodules plant^{-1} at 20, 40 and 60 DAS (Table 5). V_2R_1 produced the highest dry weight of nodule plant^{-1} at all growth stages which were 0.97, 2.27 and 4.40 mg respectively. At 20 DAS, V_2R_2 (0.91 mg), V_3R_1 (0.90 mg), V_1R_1 (0.85 mg), V_3R_2 (0.85 mg) and V_2R_0 (0.84 mg) produced significantly similar dry weight as V_2R_1 produced. At 40 DAS, V_2R_2 (2.02 mg), V_1R_1 (2.01 mg) and V_3R_1 (2.14 mg) had similar dry weights to V_2R_1. At 60 DAS, V_3R_1 (4.19 mg) and V_2R_2 (4.16 mg) gave at per dry weight to V_2R_1. The lowest dry weight 0.72, 1.58 and 3.55 mg was found in V_1R_0 interaction at 20, 40 and 60 DAS respectively.

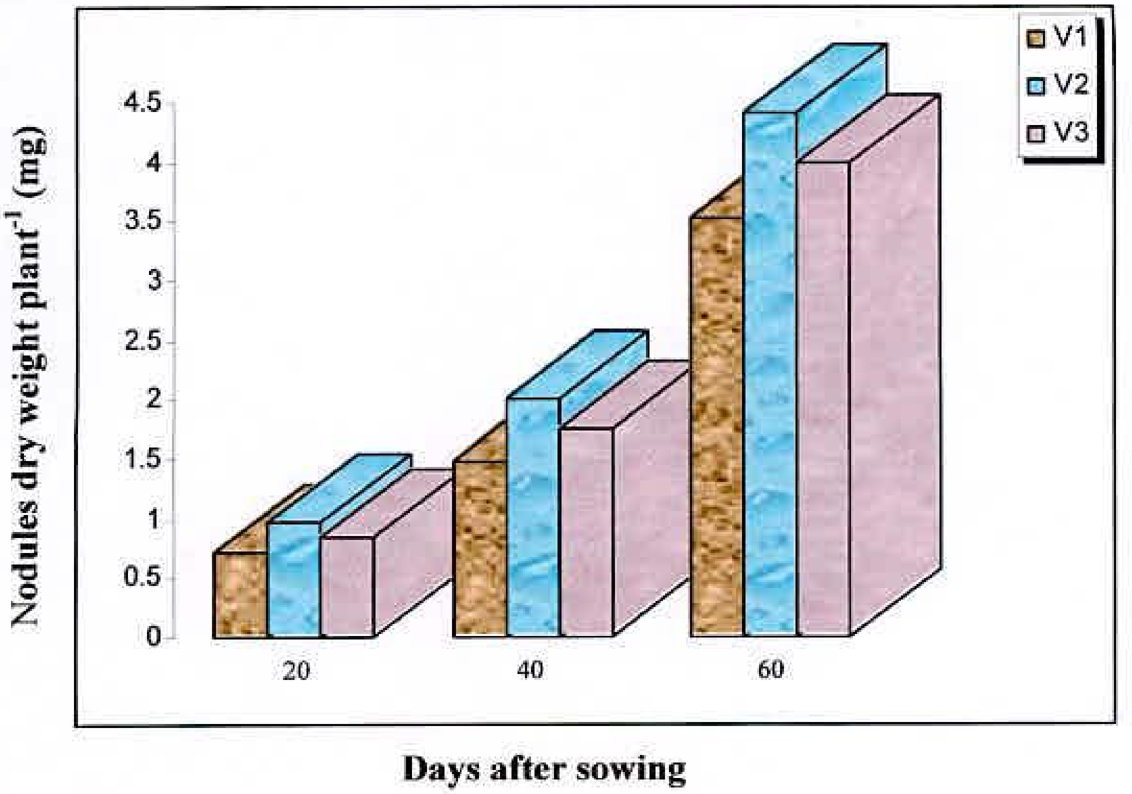

Fig. 6. Effect of variety on nodule dry weight of mungbean plant at different days

V_1 = BARI mung 3
V_2 = BARI mung 4
V_3 = BARI mung 5

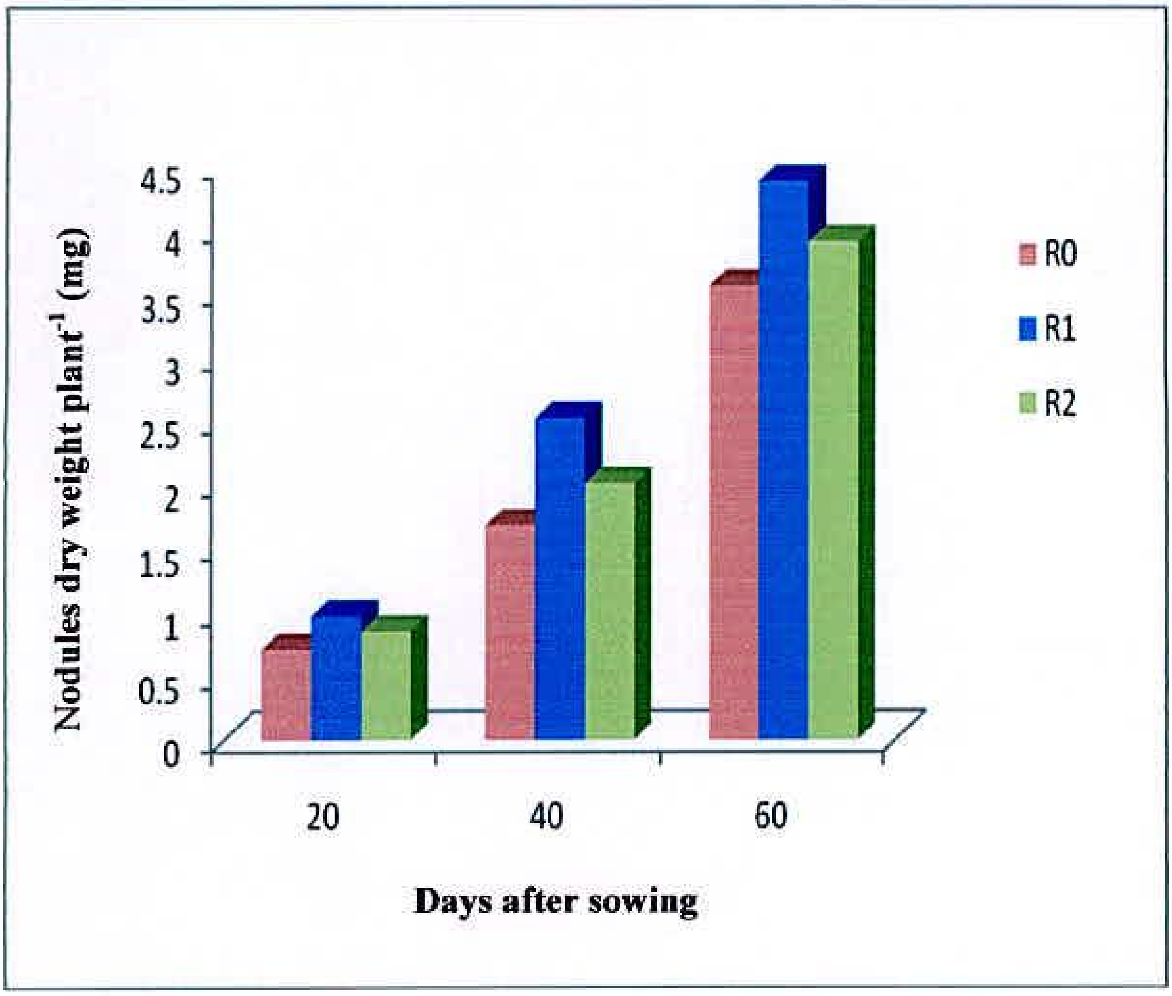

Fig. 7. Effect of *Rhizobium* inoculant on nodules dry weight of mungbean plant at different days

R_0 = No inoculant
R_1 = BARI Rvr- 405
R_2= BINA MB 1

Table 5. Combined effect of variety and *Rhizobium* inoculant on nodule dry weight of mungbean plant at different days

Treatments	Nodule dry weight plant^{-1}		
	20 DAS	**40 DAS**	**60 DAS**
V_1R_0	0.72d	1.58c	3.55 e
V_1R_1	0.85ab	2.01a	3.96 bcd
V_1R_2	0.79c	1.22c	3.72 de
V_2R_0	0.84ab	1.85b	3.99 bc
V_2R_1	0.97a	2.27a	4.40 a
V_2R_2	0.91a	2.02a	4.16 ab
V_3R_0	0.78c	1.72b	3.79 cde
V_3R_1	0.90a	2.14a	4.19 ab
V_3R_2	0.85ab	1.63bc	3.94 bcd
$S_{\bar{x}}$	0.0194	0.0240	0.0769
CV (%)	8.95	13.79	6.74

V_1 = BARI mung 3 — R_0 = No inoculant
V_2 = BARI mung 4 — R_1 = BARI Rvr- 405
V_3 = BARI mung 5 — R_2 = BINA MB 1

4.1.5 Total dry weight plant^{-1}

4.1.5.1 Effect of variety

Significant variation in dry weight plant^{-1} was observed among the three varieties at 20, 40, and 60 DAS. Each variety increased its dry matter gradually up to harvest (Fig. 8). Initially the dry matter production was very slow then maximum at 60 DAS. The maximum total dry matter plant^{-1} (0.51, 1.39 and 3.94g) was recorded in BARI mung 5, while the intermediate (0.47, 1.36 and 3.65g) was observed in case of BARI mung 4 and the lowest (0.43, 1.31 and 3.32g) was observed in BARI mung 3 at

20, 40, and 60 DAS, respectively. The result was supported by Solaiman *et al.* (2003) who observed positive response of mungbean cultivars BARI mung-2, BARI mung 3, BARI mung 4, BARI mung 5, Bina moog-2 and BU mung-1 to *Rhizobium sp.* strains TAL169 and TAL441. Inoculation of the seeds increased dry matter production.

4.1.5.2 Effect of *Rhizobium* inoculant

Different types of *Rhizobium* exerted significant effect on total dry weight plant^{-1} at 40 and 60 DAS but not showed any significant effect on 20 DAS. (Fig. 9). Due to application of different types of *Rhizobium* the plant enhanced its growth and dry matter production increased significantly over control. Fig. 9 showed that BARI- *Rhizobium* treated plot produced the maximum dry matter plant^{-1} (0.58 g, 2.13 g, 4.06 g) at 20, 40, and 60 DAS respectively and the lowest (0.33, 1.51 and 3.29 g) was in control plot, respectively. This result was similar to Chowdhury *et al.* (2000) who studied that dry matter production increased with *Rhizobium* inoculation.

4.1.5.3 Combined effect of variety and *Rhizobium* inoculant

Combination of varieties with different types of *Rhizobium* showed significant variation in 40 and 60 DAS but not at 20 DAS (Table 6). In case of 40 DAS, V_2R_1, V_3R_1 and V_1R_1 produced the highest dry weight plant^{-1} which was 1.75 g, 1.74 g and 1.73 g, respectively. But at 60 DAS, V_2R_2 gave the maximum dry weight (4.02 g) and followed by V_2R_1 (3.96 g). On the other hand, variety without inoculation (V_1R_0, V_2R_0 and V_3R_0) produced the lowest dry weight that was 0.38 g, 1.41 g and 3.31 g, respectively.

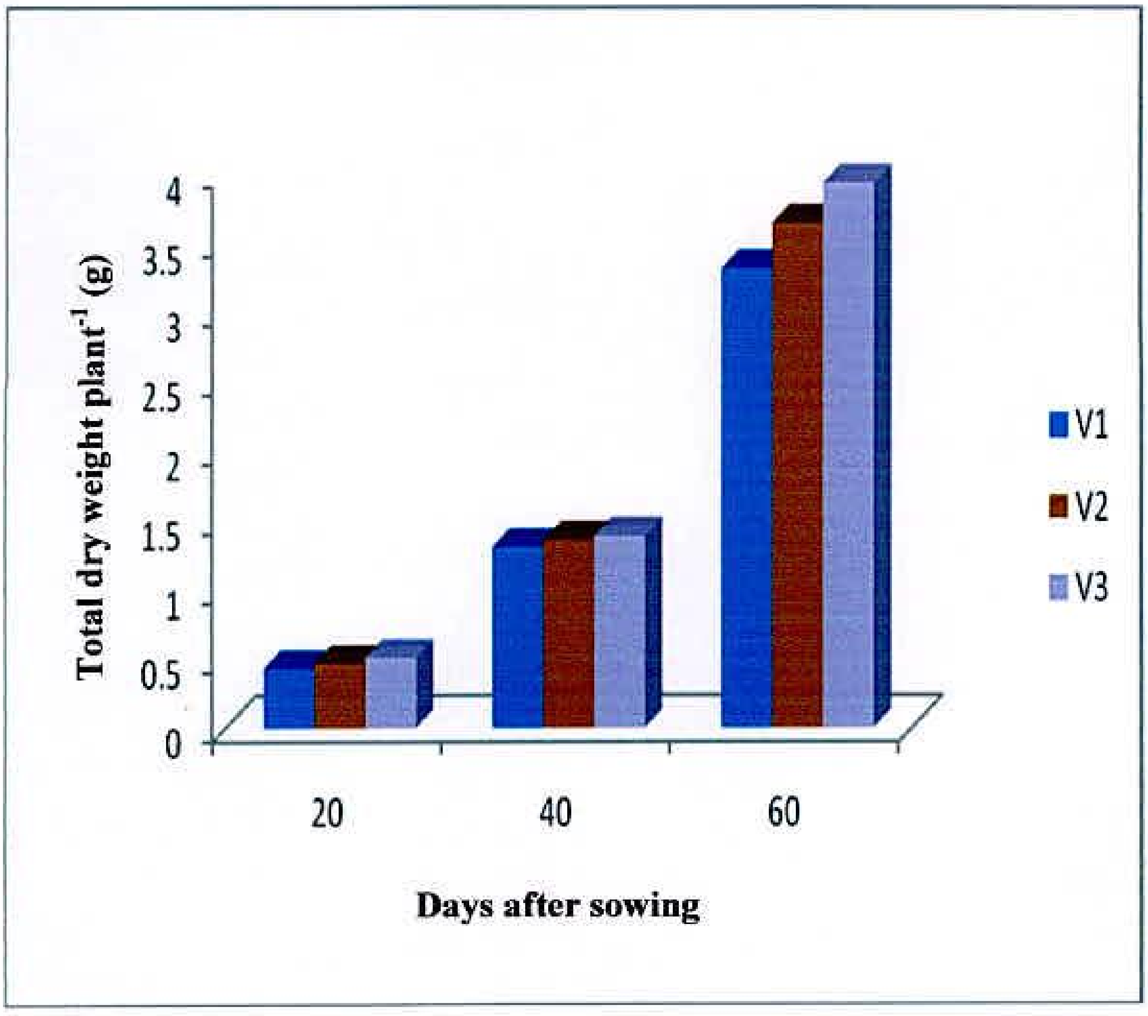

Fig. 8. Effect of variety on total dry weight of mungbean plant at different days

V_1 = BARI mung 3
V_2 = BARI mung 4
V_3 = BARI mung 5

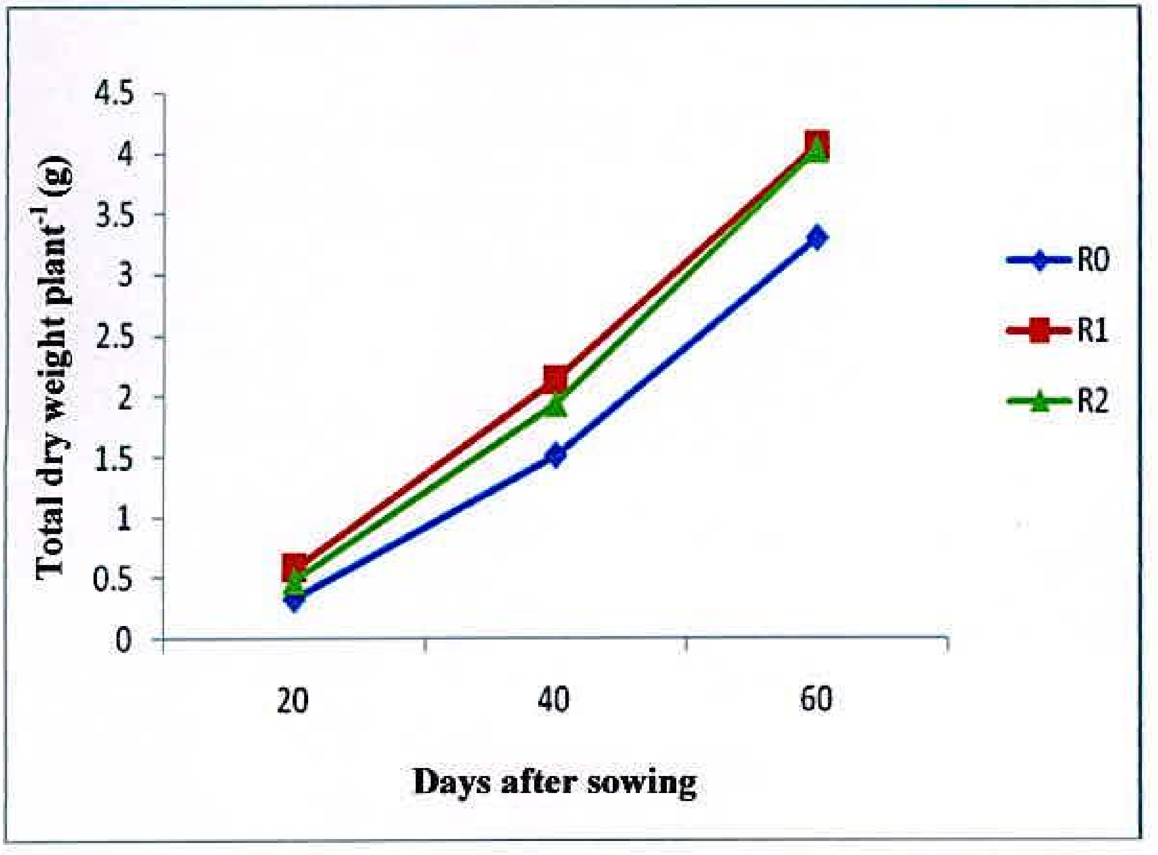

Fig. 9. Effect of *Rhizobium* inoculant on total dry weight of mungbean plant at different days

R_0 = No inoculant
R_1 = BARI Rvr- 405
R_2= BINA MB 1

Table 6. Combined effect of variety and *Rhizobium* inoculant on total dry weight of mungbean plant at different days

Treatments	Total dry weight plant^{-1}		
	20 DAS	40 DAS	60 DAS
V_1R_0	0.38	1.41 c	3.31 d
V_1R_1	0.50	1.73 a	3.66 c
V_1R_2	0.45	1.63 b	3.68 c
V_2R_0	0.39	1.44 c	3.06 e
V_2R_1	0.51	1.75 a	3.96 ab
V_2R_2	0.46	1.66 b	4.02 a
V_3R_0	0.39	1.44 c	3.21 de
V_3R_1	0.52	1.74 a	3.85 b
V_3R_2	0.47	1.65 b	3.84 b
$s_{\bar{x}}$	0.0083	0.0191	0.0506
CV (%)	11.99	9.79	9.25

V_1 = BARI mung 3 R_0 = No inoculant
V_2 = BARI mung 4 R_1 = BARI Rvr- 405
V_3 = BARI mung 5 R_2= BINA MB 1

4.1.6 Number of pods plant^{-1}

4.1.6.1 Effect of variety

Number of pods plant^{-1} is one of the most important yield contributing character of mungbean. The three varieties of mungbean showed a significant variation in case of pods plant^{-1}. BARI mung 5 produced the highest number of pods plant^{-1} (12.72), BARI mung 4 (11.22) and BARI mung 3 (10.72) produced statistically similar number of pods plant^{-1}(Table 7).

4.1.6.2 Effect of *Rhizobium* inoculant

Different types of *Rhizobium* showed a significant difference in case of number of pods plant^{-1}. The highest number of pods plant^{-1} (13.17) was found in BARI Rvr 405 *Rhizobium* treated plot and the lowest number of pods (9.83) was found in control plot (Table 8).The intermediate number of pods plant^{-1} was observed from BINA MB 1(11.67). The result was in conformity with the findings of Gill *et al.* (1985) who reported that inoculation significantly increased the number of pods plant^{-1}.

4.1.6.3 Combined effect of variety and *Rhizobium* inoculant

The interaction of variety and *Rhizobium* showed significant effect on number of pods plant^{-1} (Table 9). The highest number of pods plant^{-1} (14.33) was observed in V_3R_1 interaction which was significantly similar to V_2R_1 (12.63) and V_3R_2 (12.83) while it was the lowest (9.00) in V_1R_0 which was as per to V_2R_0.

Table 7. Effect of variety on yield and yield contributing characters of mungbean

Treatments	Pods plant^{-1} (No.)	Seeds pod^{-1} (No.)	1000 seed weight (g)	Seed yield (t ha^{-1})
V_1	10.72 b	10.56 b	35.79 b	0.88 c
V_2	11.22 b	10.56 b	34.85 b	0.95 b
V_3	12.72 a	11.22 a	37.52 a	1.03 a
$s_{\bar{x}}$	0.2257	0.1483	0.5451	0.0177
CV (%)	5.86	4.13	4.54	4.42

V_1 = BARI mung 3
V_2 = BARI mung 4
V_3 = BARI mung 5

Table 8. Effect of *Rhizobium* inoculants on yield and yield contributing characters of mungbean

Treatments	Pods plant^{-1} (No.)	Seeds pod^{-1} (No.)	1000 seed weight (g)	Seed yield (t ha^{-1})
R_0	9.83 c	10.22 b	34.27 b	0.84 b
R_1	13.17 a	11.22 a	37.29 a	1.01 a
R_2	11.67 b	10.89 a	36.59 a	1.00 a
$s_{\bar{x}}$	0.2257	0.1483	0.5451	0.0177
CV (%)	5.86	4.13	4.54	4.42

R_0 = No inoculant
R_1 = BARI Rvr- 405
R_2 = BINA MB 1

4.1.7 Number of seeds pod^{-1}

4.1.7.1 Effect of variety

Varieties had significant effect in respect of number of seeds pod^{-1}. BARI mung 5 produced the highest number of seeds pod^{-1} (11.22) and BARI mung 4 and BARI mung 3 produced the lowest number of seeds pod^{-1} that is 10.56 (Table 7).

4.1.7.2 Effect of *Rhizobium* inoculant

Rhizobium application significantly affected the number of seeds pod^{-1}. BARI Rvr 405 *Rhizobium* treated plots showed the highest number of seeds pod^{-1} (11.22) and control plots showed the lowest number of seeds pod^{-1} (10.22) while BINA MB 1 gave the intermediate number of seeds pod^{-1} (10.89) (Table 8). The result was in agreement with the findings of Gill *et al.* (1985) who reported that inoculation with *Rhizobium* increased the number of seeds pod^{-1}.

4.1.7.3 Combined effect of variety and *Rhizobium* inoculant

Variety and *Rhizobium* interaction effect on seeds pod^{-1} was significant. The highest number of seeds pod^{-1} (12.37) was produced by V_3R_1 interaction which was similar to V_3R_2 (11.53) and V_1R_0 treatment produced the lowest number of seeds pod^{-1} (9.10) (Table 9).

Table 9. Combined effect of variety and *Rhizobium* inoculant on yield and yield contributing characters of mungbean

Treatments	Pods plant^{-1} (No.)	Seeds pod^{-1} (No.)	1000 seed weight (g)	Seed yield (t ha^{-1})
V_1R_0	9.00 d	9.10d	34.07c	0.78d
V_1R_1	12.33b	11.00b	36.91ab	0.94bc
V_1R_2	10.83bc	10.47b	36.38b	0.96b
V_2R_0	9.50 d	10.00bc	32.95d	0.84c
V_2R_1	12.63ab	11.00b	36.33b	1.01ab
V_2R_2	11.33c	10.60bc	35.27bc	1.00ab
V_3R_0	11.00c	10.67bc	35.97bc	0.92bc
V_3R_1	14.33a	12.37a	38.67a	1.10a
V_3R_2	12.83ab	11.53a	38.12a	1.08a
$S_{\bar{x}}$	0.39	0.26	0.94	0.03
CV(%)	14.73	8.47	5.01	10.78

V_1 = BARI mung 3 R_0 = No inoculant
V_2 = BARI mung 4 R_1 = BARI Rvr- 405
V_3 = BARI mung 5 R_2= BINA MB 1

4.1.8 Weight of 1000 seeds

4.1.8.1 Effect of variety

Thousand seed weight of three varieties differed significantly from each other (Table 7). Maximum weight (37.52 g) of 1000 seed was obtained from BARI mung 5. BARI mung 3 (35.79) and BARI mung 4 (34.85) produced similar weight. The present result was consistent with the findings of Thakuria and Saharia (1990).

4.1.8.2 Effect of *Rhizobium* inoculant

Different types of *Rhizibium* showed significant difference in case of 1000-seed weight (Table 8). Highest 1000-seed weight (37.29 g) was found in BARI Rvr 405 *Rhizobium* treated plots and second highest 1000- seed weight (36.59 g) was obtained from BINA MB 1 treated plots and the lowest 1000-seed weight (34.27 g) was obtained from control plot.

4.1.8.3 Combined effect of variety and *Rhizobium* inoculant

The combined effect of variety with different *Rhizobium* was significant in respect of 1000 seed weight. Thousand seed weight was the highest (38.67 g) in V_3R_1 interaction which was significantly similar to V_3R_2 (38.12 g) and V_1R_1 (36.91 g). V_2R_0 gave the lowest (32.95 g) seed weight (Table 9). Almost similar result was also obtained by Thakuria and Saharia (1990) who reported that different varieties of mungbean with Rhizobium inoculation differed significantly in respect of 1000- seed weight and grain yield.

4.1.9 Seed yield

4.1.9.1 Effect of variety

The effect of three varieties on yield was significant. BARI mung 5 produced the highest seed yield (1.03 t ha^{-1}). BARI mung 4 produced the intermediate level of seed yield (0.95 t ha^{-1}) and the lowest (0.88 t ha^{-1}) seed yield was obtained with BARI mung 3 (Table-7).

4.1.9.2 Effect of *Rhizobium* inoculant

Different types of *Rhizobium* showed significant effect in case of yield of mungbean varieties. BARI Rvr 405 *Rhizobium* treated plots showed the highest yield (1.01 t ha^{-1}) which was similar to followed by BINA MB 1 treated plot (1.00 t ha^{-1}). Control plot showed the lowest yield (0.84 t ha^{-1}) (Table 8). Gill *et al.* (1985) reported similar views of seed yield. They reported that inoculation significantly increased seed yield of mungbean.

4.1.9.3 Combined effect of variety and *Rhizobium* inoculant

The combined effect of variety with *Rhizobium* was found significant in respect of seed yield (Table 9). The highest seed yield (1.10 t ha^{-1}) was obtained from V_3R_1 which was similar to V_3R_2 (1.08 t ha^{-1}), V_2R_1 (1.01 t ha^{-1}) and V_2R_2 (1.00 t ha^{-1}).The maximum seed yield was attributed to the highest number of pods $plant^{-1}$, seeds pod^{-1} and 1000- seed weight. The lowest seed yield (0.78 t ha^{-1}) was recorded from V_1R_0 interaction treatment. This results was similar with the findings of Solaiman (2002) who reported that *Bradyrhizobium* on seed inoculation of mungbean significantly increased grain yield compared with uninoculated control.

4.1.10 Stover yield

4.1.10.1 Effect of variety

Mungbean varieties showed significant differences in stover production (Table 10). BARI mung 5 produced the highest stover yield (2.05 t ha^{-1}). BARI mung 4 produced the intermediate value of stover yield (1.92 t ha^{-1}) and BARI mung 3 gave the minimum yield (1.84 t ha^{-1}).

4.1.10.2 Effect of *Rhizobium* inoculant

Rhizobium inoculation showed significant differences in stover yield. Stover production was higher in both the biofertilizer viz. BARI Rvr 405 (1.98 t ha^{-1}) and BINA MB 1 (1.97 t ha^{-1}) compared to control (1.84 t ha^{-1}) (Table 11). These results were consistent with the findings of

Mozumder (1988) who observed that seed yield significantly increased over uninoculated control.

4.1.10.3 Combined effect of variety and *Rhizobium* inoculants

The stover yield was significant with the combined effect of variety and *Rhizobium*. The highest yield was recorded in V_3R_1 (2.11 t ha^{-1}) followed by V_3R_2 (2.10 t ha^{-1}), V_2R_1 (1.98 t ha^{-1}), V_2R_2 (1.97 t ha^{-1}) and V_3R_0 (1.93 t ha^{-1}). The lowest yield was recorded in V_1R_0 (1.78 t ha^{-1}) combination which was at per with V_2R_0 (1.82 t ha^{-1}), V_1R_2 (1.86 t ha^{-1}) and V_1R_1 (1.87 t ha^{-1}) (Table 12).

Table 10. Effect of variety on stover yield, biological yield and harvest index of mungbean

Variety	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest Index (%)
V_1	1.84 c	2.72 b	32.41 b
V_2	1.92 b	2.76 b	33.01 ab
V_3	2.05 a	3.08 a	33.37 a
$s_{\bar{x}}$	0.0313	0.0674	1.0929
CV (%)	4.85	7.08	9.96

V_1 = BARI mung 3
V_2 = BARI mung 4
V_3 = BARI mung 5

Table 11. Effect of *Rhizobium* inoculant on stover yield, biological yield and harvest index of mungbean

Biofertilizer	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest Index (%)
R_0	1.84 b	2.69 b	31.43 b
R_1	1.98 a	3.00 a	33.76 a
R_2	1.97 a	2.87 a	33.60 ab
$s_{\bar{x}}$	0.0313	0.0674	1.0929
CV (%)	4.85	7.08	9.96

R_0 = No inoculant
R_1 = BARI Rvr- 405
R_2= BINA MB 1

4.1.11 Biological yield

4.1.11.1 Effect of variety

The biological yield of mungbean varied significantly among the different varieties (Table 10). BARI mung 5 had the highest biological yield (3.08 t ha^{-1}) and BARI mung 3 (2.72 t ha^{-1}) and BARI mung 4 (2.76 t ha^{-1}) had the lowest biological yield.

4.1.11.2 Effect of *Rhizobium* inoculant

Biofertilizer treatment exerted significant effect on biological yield of mungbean (Table 11). The biological yield was the highest in BARI Rvr – 405 (3.00 t ha^{-1}) which was at per to BINA MB 1(2.87 t ha^{-1}) and the control showed the lowest result (2.69 t ha^{-1}).

4.1.11.3 Combined effect of variety and *Rhizobium* inoculant

Combined effect of variety and *Rhizobium* inoculant had the significant effect in biological yield (Table 12). V_3R_1 and V_3R_2 showed the highest biological yield (3.20 and 3.19 t ha^{-1}) which was similar with V_2R_1 (2.99 t

ha^{-1}) and V_3R_0 (2.85 t ha^{-1}). The lowest biological yield was recorded in V_1R_0 (2.56 t ha^{-1}) which was similar with V_1R_1 (2.81 t ha^{-1}), V_1R_2 (2.79 t ha^{-1}), V_2R_0 (2.66 t ha^{-1}) and V_2R_2 (2.64 t ha^{-1}).

Table 12. Combined effect of variety and *Rhizobium* inoculant on stover yield, biological yield and harvest index of mungbean

Treatments	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest Index (%)
V_1R_0	1.78 c	2.56 c	30.52 b
V_1R_1	1.87 bc	2.81 bc	33.47 ab
V_1R_2	1.86 bc	2.79 bc	33.23 ab
V_2R_0	1.82 bc	2.66 bc	31.58 ab
V_2R_1	1.98 ab	2.99 ab	33.75 ab
V_2R_2	1.97 ab	2.64 bc	33.69 ab
V_3R_0	1.93 abc	2.85 abc	32.18 ab
V_3R_1	2.11 a	3.20 a	34.07 a
V_3R_2	2.10 a	3.19 a	33.87 a
$s_{\bar{x}}$	0.0542	0.1168	1.8930
CV (%)	4.85	7.08	9.96

V_1 = BARI mung 3 　 R_0 = No inoculant
V_2 = BARI mung 4 　 R_1 = BARI Rvr- 405
V_3 = BARI mung 5 　 R_2 = BINA MB 1

4.1.12 Harvest Index

4.1.12.1 Effect of variety

The varieties showed significant differences in harvest index (Table 10). The highest harvest index (33.37%) was recorded in BARI mung 5 which was similar with BARI mung 4 (33.01%) and BARI mung 3 gave lowest harvest index value (32.41%).

4.1.12.2 Effect of *Rhizobium* inoculant

Harvest index differed significantly among the biofertilizers (Table 11). BARI Rvr–405 showed the highest harvest index (33.76%) which was similar to BINA MB 1(33.60%) and control showed the lowest harvest index (31.43%). The results were almost similar with the findings of Gill *et. al.* (1985) who reported that inoculation significantly increased harvest index.

4.1.12.3 Combined effect of variety and *Rhizobium* inoculant

The interaction between varieties and *Rhizobium* inoculant was significant in respect of harvest index (Table 12). The highest harvest index (34.07%) was observed in V_3R_1 interaction which was at per with V_3R_2 (33.87%), V_2R_1 (33.75%), V_2R_2 (33.69%), V_1R_1 (33.47%), V_1R_2 (33.23%), V_3R_0 (32.18%) and V_2R_0 (31.58%). The lowest harvest index value (30.52%) was recorded in V_1R_0 combination. The combination of V_2R_0 (31.58%), V_3R_0 (32.18%), V_1R_2 (33.23%), V_1R_1 (33.47%), V_2R_2 (33.69%) and V_2R_1 (33.75%) gave similar result with V_1R_0 (30.52%).

Chapter 5

Summary and Conclusion

CHAPTER 5

SUMMARY AND CONCLUSION

The experiment was conducted during the period from April to July 2007 at Sher-e-Bangla Agricultural University, Dhaka to study the 'Influence of variety and *Rhizobium* inoculant on the nodulation, growth and yield of mungbean'. The experiment consists of three mungbean varieties viz. BARI mung 3, BARI mung 4 and BARI mung 5 and two kinds of *Rhizobium* viz. BARI Rvr 405, BINA MB 1 and one control (no *Rhizobium*). The experiment was laid in Randomized Complete Block Design (factorial) with three replications. The unit plot size was 4.5m × 3m. Chemical fertilizers were applied as per recommended dose.

Results showed that variety had significant effect on plant height at 40 and 60 DAS. Among the varieties BARI mung 4 gave the highest plant height (64.23 cm) at 60 DAS where BARI mung 3 produced the lowest (56.56 cm.). Different types of *Rhizobium* had significant effect on plant height at 20, 40 and 60 DAS. BARI-*Rhizobium* treated plots gave the highest plant height (55.63cm) at 40 DAS and (63.87 cm) at 60 DAS and in case of combined effect, V_2R_1 gave the highest plant height (64.05 cm) at 60 DAS.

Variety and *Rhizobium* had significant effect on number of nodules and dry weight of nodules plant^{-1}. BARI mung 4 produced the highest number of nodules plant^{-1} (38.03) at 60 DAS where BARI mung 3 produced the lowest (30.47). Only BARI Rvr 405 treated plots showed the highest nodules number (39.00) and the lowest was in control (31.06) at 60 DAS.

The combined effect of V_2R_1 gave the highest number (38.52) and V_1R_0 gave the lowest number (30.77).

BARI mung 4 gave the highest dry weight of nodules plant^{-1} (4.42 mg) than other two varieties. Only BARI Rvr 405 treated plots gave the highest dry weight of nodules plant^{-1} (4.38 mg) than BINA MB 1 and control treated plots. The combined effect of BARI mung 4 with BARI Rvr 405 gave the highest dry weight of nodule plant^{-1} (4.40 mg) than other combined effect at 60 DAS.

Among the three varieties BARI mung 5 gave the highest dry weight plant^{-1} (3.94 g) at 60 DAS than other varieties. BARI Rvr 405 treated plots gave the highest dry weight plant^{-1} at all growth stages where the lowest was in control. The combined effect of V_3R_1 treatment gave the highest dry weight plant^{-1} for all the growth stages than other combined effect.

Among the three varieties BARI mung 5 gave the highest pods plant^{-1} (12.72). The highest number of pods plant^{-1} was observed in BARI Rvr 405 treated plots (13.17) and the lowest (9.83) was in control plots. Combined effect of BARI mung 5 and BARI Rvr 405 gave the highest pods plant^{-1} (14.33) than other combined effect.

Three varieties of mungbean had significant effect on number of seeds pod^{-1} but different types of *Rhizobium* had significant effect on seeds pod^{-1}. Seeds pod^{-1} was the highest (11.22) in BARI Rvr 405 treated plots than control. The combined effect of V_3R_1 gave the highest number of seeds pod^{-1} (12.37) than other combined effect.

Weight of 1000 seed was significantly affected by variety. Maximum weight of 1000 seed (37.52 g) was obtained from BARI mung 5. The lowest was in BARI mung 4 (34.85 g). Different types of *Rhizobium* had significant effect on 1000 seed weight. The highest seed weight (37.29 g) was found from BARI Rvr 405 treated plots and the lowest (34.27 g) was in control. Combined effect of V_3R_1 gave the highest weight (38.67 g) than other combined effect.

The effect of variety on seed yield was significant. BARI mung 5 produced the highest seed yield (1.03 t ha^{-1}) and BARI mung 3 produced the lowest yield (0.88 t ha^{-1}). *Rhizobium* showed significant effect on seed yield. BARI Rvr 405 showed the highest yield (1.01 t ha^{-1}) which was statistically similar to BINA MB 1 (1.00 t ha^{-1}) and the lowest (0.84 t ha^{-1}) was in control. V_3R_1 combined effect gave highest yield (1.10 t ha^{-1}) which was statistically similar to V_3R_2 (1.08 t ha^{-1}) and V_1R_0 showed the lowest yield (0.78 t ha^{-1}).

The stover yield varied significantly among the varieties. BARI mung 5 gave the highest stover yield (2.05 t ha^{-1}) and the lowest was in BARI mung 3 (1.84 t ha^{-1}). BARI Rvr 405 and BINA MB 1 treated plots gave the highest stover yield (1.98 and 1.97 t ha^{-1}) where the lowest in control. The combined effect of V_3R_1 and V_3R_2 treatment gave the highest stover yield (2.11 and 2.10 t ha^{-1}) where V_1R_0 gave the lowest value (1.78 t ha^{-1}).

Among the varieties, BARI mung 5 gave the highest biological yield (3.08 t ha^{-1}) and the lowest was in BARI mung 3 (2.72 t ha^{-1}). BARI Rvr 405 treated plot gave the highest biological yield (3.00 t ha^{-1}) which was not different from BINA MB 1 treated plot (2.87 t ha^{-1}) where as the lowest was in control. Combined effect of V_3R_1 and V_3R_2 treatment gave the highest biological yield (3.20 and 3.19 t ha^{-1}) where V_1R_0 gave the lowest value (2.56 t ha^{-1}).

The effect of variety on harvest index was significant. BARI mung 5 gave the highest harvest index value (33.37%) and the lowest was in BARI mung 3 (32.41%). BARI Rvr 405 treated plots gave the highest harvest index value (33.76%) where the lowest was in control (31.43%). The combined effect of V_3R_1 treatment gave the highest harvest index value (34.07%) where V_1R_0 gave the lowest value (30.52%).

Overall result of the field experiment showed that biofertilizer (*Rhizobium* inoculant) was beneficial for growth, yield and yield contributing characters of three mungbean varieties (BARI mung 3, BARI mung 4 and BARI mung 5). *Rhizobium* inoculant appears to be an effective method of successful mungbean production which may also improve the soil health. For determination of effectiveness of biofertilizer and making any recommendation further trial should be performed in different locations for more conformation. From the above discussion, it is concluded that BARI mung 5 with inoculums like BARI Rvr 405 and BINA MB 1 were the best to produce better mungbean yield during summer season.

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Appendices

APPENDICES

Appendix I. Physical characteristics and chemical composition of soil of the experimental plot

Soil Characteristics	Analytical results
Agrological Zone	Madhupur Tract
P^H	5.47 – 5.63
Organic matter	0.80%
Potassium	0.15 meq/100 g soil
Calcium	3.60 meq/100 g soil
Magnesium	1.00 meq/100 g soil
Total N (%)	0.076%
Phosphorus	22.09 μg/g soil
Sulphur	25.96 μg/g soil
Boron	0.44 μg/g soil
Copper	3.56 μg/g soil
Iron	262.9 μg/g soil
Manganese	163.0 μg/g soil
Zinc	3.31 μg/g soil

Source: Soil Resource Development Institute (SRDI), Khamarbari, Dhaka.

Appendix II. Monthly average air temperature, relative humidity, rainfall and sunshine hours during the experimental period (April, 2007 to August, 2007) at Sher - e - Bangla Agricultural University campus.

Month	Year	Monthly average air temperature (^{0}C)			Average relative humidity (%)	Total rainfall (mm)	Total sunshine (hours)
		Maximum	Minimum	Mean			
April	2006	29.21	16.52	22.86	73.09	172	214.38
May	2006	27.25	14.81	21.03	71.05	175	211.50
June	2007	25.18	17.29	21.24	73.90	182	194.00
July	2007	30.32	18.40	24.36	67.78	185	226.50
August	2007	33.32	21.00	27.16	68.13	180	223.30

Source: Bangladesh Meteorological Department (Climate Division), Agargaon, Dhaka – 1212.