NODULATION, GROWTH AND YIELD OF MUNGBEAN AS AFFECTED BY NITROGEN MANAGEMENT

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TO

MY BELOVED PARENTS

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CERTIFICATE

*This is to certify that the thesis entitled **"NODULATION, GROWTH AND YIELD OF MUNGBEAN AS AFFECTED BY NITROGEN MANAGEMENT"** 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 (M.S.)** in **AGRONOMY,** embodies the results of a piece of bona fide research work carried out by **MD. SAHENUZZAMAN,** Registration. No. **07-02338** under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

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

Dated:

Dhaka, Bangladesh

(Prof. Dr. Parimal Kanti Biswas)
Supervisor

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The Author

NODULATION, GROWTH AND YIELD OF MUNGBEAN AS AFFECTED BY NITROGEN MANAGEMENT

ABSTRACT

An experiment was carried out at Sher-e-Bangla Agricultural University farm, Dhaka to investigate the nodulation, growth and yield of mungbean *(Vigna radiata* L.*)* as affected by nitrogen management during the period from April 2014 to July 2014. The trial comprised of two varieties and five nitrogen management such as V_1= BARI mung 4 and V_2= BARI mung 6, F_1 =No nitrogen (control), F_2 = 20 kg N ha^{-1} as basal, F_3 = 10 kg N ha^{-1} as basal + 10 kg N ha^{-1} as split, F_4 = 40 kg N ha^{-1} as basal and F_5 = 20 kg N ha^{-1} as basal + 20 kg N ha^{-1} as split. The experiment was laid out in split-plot design with three replications where two varieties were assigned in the main plot and five nitrogen level in the sub-plot. Plant height, nodulation, shoot length, root length, total dry matter production, number of branches plant^{-1}, pods plant^{-1}, number of seeds pod^{-1},1000-seeds weight, seed yield, stover yield, biological yield, harvest index and shelling percentage were compared for different treatments. Results revealed that, 20 kg N ha^{-1} as basal + 20 kg N ha^{-1} as split (F_5) influenced significantly on most of the growth, yield parameters and yield of mungbean. BARI mung 6 (V_2) gave the higher yield (1.08 t ha^{-1}) than BARI mung 4 (V_1) (0.29 t ha^{-1}) which was 272.41 % higher than V_1. Application of 20 kg N ha^{-1} as basal + 20 kg N ha^{-1} as split (F_5) greatly influenced the seed yield and produced 22.58% higher yield compare to the no N application (F_1). The highest seed yield (1.17 t ha^{-1}) was recorded form BARI mung 6 with the interaction of 20 kg N ha^{-1} as basal + 20 kg N ha^{-1} as split and the minimum seed yield was recorded from the interaction of BARI mung 4 with no nitrogen.

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LIST OF ACRONYMS

%	= Percent
^0C	= Degree Celsius
AEZ	= Agro-Ecological Zone
BARI	= Bangladesh Agricultural Research Institute
BAU	= Bangladesh Agricultural University
BBS	= Bangladesh Bureau of Statistics
Co	= Cobalt
CV%	= Percentage of coefficient of variance
cv.	= Cultivar
DAE	= Department of Agricultural Extension
DAS	= Days after sowing
et al	=And others
FAO	= Food and Agriculture Organization
g	= gram(s)
ha^{-1}	= Per hectare
HI	= Harvest Index
kg	= Kilogram
LSD	= Least Significant Difference
Max	= Maximum
mg	= milligram
Min	= Minimum
MP	= Muriate of Potash
N	= Nitrogen
No.	= Number
NPK	= Nitrogen, Phosphorus and Potassium
NS	= Not significant
SAU	= Sher-e-Bangla Agricultural University
SRDI	= Soil Resources and Development Institute
TSP	= Triple Super Phosphate
Wt.	= Weight

Chapter 1
Introduction

CHAPTER 1

INTRODUCTION

Mungbean (*Vigna radiata* L.) is an important pulse crop of Bangladesh under the family Fabaceae that contains 51% carbohydrate, 26% protein, 3% minerals and 3% vitamins (Khan, 1981 and Kaul, 1982). As an excellent source of vegetable protein, it is extensively grown in the tropical and sub-tropical regions. It is used as dhal (soup) but in many countries sprouted seeds are widely used as vegetables. The high lysine content makes mungbean a good complementary food for rice-based diets (Chen *et al.,* 1987).

The area under pulse crops in Bangladesh is 7.48 lac hectares with a production of 7.81 lac metric tones and 1.09 metric tones ha^{-1} where mungbean is cultivated in the area of 1.73 lac hectares with production of 1.81 lac metric tones and 1.04 metric tones ha^{-1} (DAE, 2014).

Bangladesh is a developing country with limited land and very high population. Due to the huge population it needs to produce more food in limited land. Moreover due to the high population pressure the total cultivable lands have been decreasing day by day at a rate of one lac hectare per year for urbanization and other essentialities (BBS, 2010). The remaining land has been cultivated with rice, wheat, maize, oils, pulse and other crops. Pulse has been pushed down to marginal land to give space for the cereal crops. Moreover, pulses with poor yielding ability do not get farmer choice in cultivating pulses on the main land.

Pulse crop is an important food crop because it provides a cheap source of easily digestible dietary protein which complements the staple rice food for better nourishment of human body. Per capita requirement of pulse should be 80 g, whereas it is only about 10 g in Bangladesh (BBS, 2010) thus the ideal cereal and pulse ratio (10:1) is not maintained which is now 30:1. This is fact that national production of the pulses is not adequate to meet the population demand. The average value of pulse production (1537.7 kg ha^{-1}) is very low comparing the value of other countries of the world (FAOSTAT, 2013).

The low yield of grain legumes in general is the high requirement and proper management of nitrogen for the formation and development of prominent grains (Alberada and Bower, 1983). To produce one unit of seeds, mungbean needs as much as three times more nitrogen than that needed by cereals like rice. Mungbean requires a large amount of nutrients in 2-3 phases (Trung and Yoshida, 1985). The former peak in the vegetative structures and the later peak in the reproductive phase are mainly for the production and development of seeds. Mungbean needs much more N at the reproductive stage than it due in the vegetative stage.

Nitrogen constituents one of the major essential plant nutrients and the successful crop production depends mainly upon the availability of nitrogen in adequate amounts. The requisition and accumulation of reduced nitrogen is second only to carbohydrate in terms of the importance for the plant growth and development, yet nitrogen is perhaps the single most important factor limiting the crop yields.

Due to the competition with cereal crops, pulses are being pushed to the marginal lands where nutrients limitations are severe. As a result, pulse area and productivity are decreasing day by day. Poor nodulation and pod setting in many soils are associated with nutrients that are not properly supplied by the farmers. There is an exigency in our country to increase mungbean yield through proper soil fertility management practices. Therefore, research on nutrient requirements of mungbean should he undertaken on an urgent basis. Furthermore, systematic and comprehensive research efforts on fertilizer management especially on nitrogen in order to increase yield potential of mungbean are inadequate. Information on the response of physiological characteristics of mungbean to the added nitrogenous fertilizer is also meager. Without an adequate underlaying of the dry matter production and the underlaying physiological process of crop growth, development and yield of mungbean under different N treatments, any attempt to improve the yield potential of mungbean may not be successful. Considering the above facts the present work was conducted to evaluate the response of nitrogen on mungbean production with the following objectives:-

- To determine the nodulation pattern, growth, crop characters and yield of mungbean.
- To observe the nodulation, growth and yield of mungbean under different nitrogen levels.
- To study the interaction effect between nitrogen and variety on the nodulation, growth and yield of mungbean.

Chapter 2

Review of literature

CHAPTER 2

REVIEW OF LITERATURE

Mungbean is an important pulse crop of global economic importance. Extensive research work on this crop has been done in several countries, especially in the South East Asia for the improvement of its yield and quality. In Bangladesh little attention has so far been given for the improvement of mungbean. Recently Bangladesh Agricultural Research Institute and Bangladesh Institute of Nuclear Agriculture have started research on varietals development and various agronomic management of the crop.

Very few information was available regarding the effect of nitrogen of mungbean on the seed yield and its quality. Although this idea was not a recent one but research findings in this regard was scanty. Some of the pertinent works on these technologies reviewed in this chapter.

2.1 Effect on growth parameters

2.1.1 Plant emergence

Perez-Fernandez *et al.* (2006) conducted an experiment on the seed germination in response to chemicals: Effect of nitrogen and pH in the media and observed that nitrogenous compounds increased germination.

Osman *et al.* (1991) conducted an experiment on the effect of soil temperature, moisture and nitrogen on *Striga asiatica* (L.) Kuntze seed germination, viability and emergence on sorghum (*Sorghum bicolor* L.) roots under field conditions and found that nitrogen rates of 0, 25, 50 and 100 kg ha^{-1} resulted in the emergence of 11, 34, 38 and 40 Striga plants $plot^{-1}$, respectively.

Agenbag and Villiers (1989) conducted an experiment on the effect of nitrogen fertilizers on the germination and seedling emergence of wild oat (*A. fatua* L.) seed in different soil types and reported that 25 to 35% higher seedling emergence obtained from the application of nitrogen fertilizers.

2.1.2 Plant height

Khalilzadeh *et al.* (2012) conducted an experiment on growth characteristics of mungbean (*Vigna radiata* L.) affected by foliar application of urea and bio-organic fertilizers. They found that foliar application of urea and organic manure substantially improved the plant height.

Asaduzzaman (2008) found that plant height of mungbean was significantly increased by the application of Nitrogen fertilizer at 30 kg ha^{-1}.

A field experiment was conducted by Raman and Venkataramana (2006) in Annamalainagar, Tamil Nadu, India to investigate the effect of foliar nutrition on crop nutrient uptake and yield of greengram (*Vigna radiata*). There were 10 foliar spray treatments, consisting of water spray, 2% diammonium phosphate at 30 and 45 days after sowing, 0.01% Penshibao, 0.125% Zn chelate, 30 ppm NAA. Crop nutrient uptake, yield and its attributes (number of pods per plant and number of seeds per pod) of greengram augmented significantly due to foliar nutrition. The foliar application of 2% diammonium phosphate + NAA + Penshibao was significantly superior to other treatments in increasing the values of yield attributes.

Oad and Buriro (2005) conducted a field experiment to determine the effect of different NPK level (0-0-0, 10-20-20, 10-30-30, 10-30-40 and 10-40-40 kg ha^{-1}) on the growth and yield of mung bean cv. AEM 96 in Tandojam, Pakistan. The different NPK level significantly affected the crop parameters. The 10-30-30 kg NPK ha^{-1} was the best treatment, recording plant height of 56.25 cm.

In a pot experiment at Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, Masud (2003) observed the highest plant height with the application of 30 kg N ha^{-1} while Ghosh (2004) found the highest plant height at applying 25 kg N ha^{-1}.

Saini and Thakur (1996) stated that nitrogen at 30 and 40 kg ha^{-1} significantly increased the plant height of blackgram compared with no N.

Quah and Jaafar (1994) noted that plant height of mungbean was significantly increased by the application of nitrogen fertilizer 50 kg ha^{-1}.

Suhartatik (1991) in a study observed that increased application of NPK fertilizers significantly increased the plant height of mungbean.

Jamro *et al*. (1990) observed that application of 90 kg N ha^{-1} significantly increased the plant height of blackgram.

Results of an experiment, conducted by Sardana and Verma (1987) in Delhi, India, revealed that application of nitrogen, phosphorus and potassium fertilizers in combination resulted in significant increase in plant height of mungbean.

Trung and Yoshida (1983) conducted a field trial on mungean in nutrient soil containing 0-100 ppm N in the form of ammonium nitrate or 10 or 100 ppm N as urea, sodium nitrate, ammonium nitrate or ammonium sulphate. They observed that maximum plant height was obtained by 25 ppm N at all the stages of development.

2.1.3 Leaves $plant^{-1}$

Khalilzadeh *et al.* (2012) conducted an experiment on growth characteristics of mung bean (*Vigna radiata* L.) affected by foliar application of urea and bio-organic fertilizers. They found that foliar application of urea and organic manure substantially improved leaves $plant^{-1}$.

Sultana *et al.* (2009) conducted an experiment at the experimental field of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka to evaluate the effect of nitrogen and weed managements on mungbean (*Vigna radiata* L.). They found that application of 20 kg N ha^{-1} as basal + 20 kg N ha^{-1} with one weeding at vegetative stage showed significantly higher number of leaves $plant^{-1}$.

Malik *et al.* (2003) conducted an experiment to determine the effect of varying level of nitrogen (0, 25, and 50 kg ha^{-1}) and phosphorus (0, 50, 75 and 100 kg ha^{-1}) on the yield and quality of mungbean cv. NM-98. They observed that number of leaves $plant^{-1}$ was significantly affected by varying level of nitrogen.

2.1.4 Shoot length

Akbar *et al.* (2013) conducted an experiment on the interactive effect of cobalt and nitrogen on growth, nodulation, yield and protein content of field grown pea and observed that the greatest shoot length in the 60 kg N ha^{-1} and 20 g Co ha^{-1}.

Khalilzadeh *et al.* (2012) conducted an experiment on growth characteristics of mungbean (*Vigna radiata* L.) and found that foliar application of urea and organic manure substantially improved shoot length.

2.1.5 Root length

Akbar *et al.* (2013) conducted an experiment on the interactive effect of cobalt and nitrogen on growth, nodulation, yield and protein content of field grown pea and observed that the greatest root length in the 60 kg N ha^{-1} and 20 g Co ha^{-1}.

Khalilzadeh *et al.* (2012) conducted an experiment on growth characteristics of mungbean (*Vigna radiata* L.) and reported that foliar application of urea and organic manure substantially improved root length.

2.1.6 Number and dry weight of nodule

Malik *et al.* (2014) conducted an experiment on synergistic use of rhizobium, compost and nitrogen to improve growth and yield of mungbean (*Vigna radiata* L.*)* and found that the combined application of Rhizobium, compost and 75% of the recommended mineral nitrogen (RMN) gave maximum number of nodules and dry weight.

Nursu'aidah *et al.* (2014) conducted an experiment on growth and photosynthetic responses of longbean (*Vigna unguiculata*) and mungbean (*Vigna radiata*) response to fertilization and found that mungbean grown without fertilizer produced the highest number of nodules per plant.

Khalilzadeh *et al.* (2012) conducted an experiment on growth characteristics of mungbean (*Vigna radiata* L.*)* and found that foliar application of urea and organic manure substantially improved number and dry weight of nodule.

Mozumder *et al.* (2003) conducted an experiment to study the effect of *Bradyrhizobium* inoculation at different nitrogen level viz. 0, 20, 40, 60 and 80 kg N ha^{-1} on Binamoog-2. *Bradyrhizobium* inoculation and observed that nitrogen negatively affected on nodulation.

Maldal and Ray (1999) observed in a field experiment where mungbean cv. B 105, B1 and Hooghly local were untreated, seed inoculated with *Rhizobium* and 20, 30 or 40 kg N ha^{-1} as urea were given. They revealed that nodulation was greatest with inoculation in B 105.

Provorov *et al.* (1998) observed that seed inoculation of mungbean (*Vigna radiata*) with Strain CLAM 1901 of *Bradyrhizobium* increased number of root nodules by 24 %, herbage by 46.6%, seed mass by 39.2%, 1000-seeds weight by 16% and seed N by 30%. These results were equivalent to applying 120 kg N ha^{-1}.

Mozumder (1998) conducted a field trail at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from March 1994 to June 1994 to study the effects of five nitrogen level on two varieties of summer mungbean and reported that nitrogen produced negative effect on nodule production and starter dose of nitrogen (40 kg ha^{-1}) gave the maximum seed yield (1607 kg ha^{-1}).

Tripathi *et al*. (1994) conducted an experiment regarding soybean, mungbean and groundnut grown on a clay soil in 1985 and 1986. Five N treatments were applied through 2 source: No N sources (control), 20 N kg ha^{-1}, *Rhizobium* seed inoculum alone, inoculum with 10 kg N ha^{-1}, and inoculum with 20 kg N ha^{-1}. The combination of inoculants + 20 kg N ha^{-1}gave the highest crop yield and the maximum number of root nodules. Soybeans and groundnuts gave comparatively higher yields than *V. mungo* and *V. radiata.*

Santos *et al.* (1993) observed on mungbean cv. Berken, grown in pots in podzolic soil using 7 level of N (0, 25, 50, 100, 200, 400 and 500 kg ha^{-1} as NH_4NO_3. They noted that nodule number increased strongly, between flowering and maturity; in plants grown at 100 kg ha^{-1}, suggesting a delay in nodulation occurred. Poor nodulation and depletion of soil N as indicated by the low N concentration in the young mature leaves at the maturity stages. Plants grown at 400 and 500 kg ha^{-1} N failed to nodulation.

Hoque and Barrow (1993) conducted a field trail at various locations in Bangladesh and found that the, inoculants markedly increased nodule number and nodule dry weight of soybean, lentil and mungbean compared to uninoculated control and urea-N treatments.

Murakami *et al*. (1990) reported that without N fertilizer, N fixation started at 12 days after sowing (DAS) increased rapidly at 34 DAS (flowering) to reach a peak at 45 DAS had a secondary peak at 60 DAS and then decreased until the plant died (83 DAS). With N fertilizer, N fixation started at 14 DAS, increased slowly to reach a much lower peak at 50 DAS and then decreased. Nodulation was greatly decreased by applied N, but fixation per unit nodule weight was similar in both N treatments. The percentage N derived from the air of 78 mungbean cultivar was 0-100% at 33 DAS and 760% in all cultivars at 60 DAS. The author suggested that these cultivars might respond more to applied N than high fixing cultivars.

2.1.7 Dry matter production

Sultana *et al.* (2009) conducted an experiment at the experimental field of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka to evaluate the effect of nitrogen and weed managements on mungbean (*Vigna radiata* L.). They found that application of 20 kg N ha^{-1} as basal + 20 kg N ha^{-1} with one weeding at vegetative stage showed significantly higher dry matter production.

Asaduzzaman *et al.* (2008) conducted an experiment at the experimental field of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka to evaluate the response of mungbean (*Vigna radiata* L.) to nitrogen and irrigation management. They found that 30 kg N ha^{-1} as basal with one irrigation at flower initiation stage (35 DAS) significantly improved dry matter accumulation of mungbean.

Yakadri *et al.* (2002) studied the effect of nitrogen (40 and 60 kg ha^{-1}) on crop growth and yield of greengram (cv. ML-267). Application of nitrogen at 20 kg ha^{-1} resulted in the significant increase in dry matter content in above ground part.

Santos *et al.* (1993) carried out an experiment on mungbean cv. Berken grown in pots in podzolic soil with 7 level of N (0, 25, 50, 100, 200, 400 and 500 kg ha^{-1}), applied as

NH_4NO_3 and noted that application of N up to 200 kg ha^{-1} increased the total dry matter, higher rates decreased it.

Chowdhury and Rosario (1992) studied the effects of 0, 30, 60 or 90 kg N ha^{-1} on the growth and yield performance of mungbcan at Los Banos, Philippines in 1988. They observed that N @ 30 kg ha^{-1} showed significant difference in dry matter yield of mungbean up to a certain level (60 kg N ha^{-1}).

Leelavathi *et al.* (1991) reported that different levels of nitrogen showed significant difference in seed and dry matter production up to a certain level (60 kg N ha^{-1}).

Agbenin *et al.* (1991) found that applied N significantly increased growth components, dry matter yield and nutrient uptake over the control.

Yein (1982) carried out two year field experiment in Assam. India on mungbean *(Vigna radiata)* and reported that combined application of nitrogen and phosphorus significantly increased the dry weight of the plants.

2.2 Effect on yield attributing characters

2.2.1 Branches plant^{-1}

Sultana *et al.* (2009) conducted an experiment at the experimental field of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka to evaluate the effect of nitrogen and weed managements on mungbean (*Vigna radiata* L.).They found that application of 20 kg N ha^{-1} as basal + 20 kg N ha^{-1} with one weeding at vegetative stage showed significantly more number of branches (1.67) $plant^{-1}$.

Malik *et al.* (2003) conducted a study to determine the effect of varying level of nitrogen (0, 25, and 50 kg ha^{-1}) and phosphorus (0, 50, 75 and 100 kg ha^{-1}) on the yield and quality of mungbean cv. NM-98. They observed that number of branches $plant^{-1}$ was found to be significantly higher by 25 kg N ha^{-1}.

The effects of N (0, 10, 20 and 30 kg ha^{-1}) and P (0, 20, 40 and 60 kg ha^{-1}) on mungbean cultivars MH 85-111 and T44 were determined in a field experiment conducted by Rajender *et al*. (2002) in Hisar, Haryana, India during the summer. The number of branches increased with increasing N rates.

Ansari and Afridi (1990) found that soaking of *V. radiata* on K 851 in 0.1-0.5% pyridoxine solution significantly enhanced leaf N, P concentration at different growth stages and number of branches increased with increasing N concentration.

2.2.2 Pods plant^{-1}

Nursu'aidah *et al.* (2014) conducted an experiment on growth and photosynthetic responses of longbean (*Vigna unguiculata*) and mungbean (*Vigna radiata*) response to fertilization and they found that mungbean grown without fertilizer produced the highest number of pods plant $^{-1}$.

Sultana *et al.* (2009) conducted an experiment at the experimental field of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka to evaluate the effect of nitrogen and weed managements on mungbean (*Vigna radiata* L.). They found that application of 20 kg N ha^{-1} as basal + 20 kg N ha^{-1} with one weeding at vegetative stage showed significantly higher pods plant $^{-1}$.

A study was conducted by Nigamananda and Elamathi (2007) in Uttar Pradesh, India to evaluate the effect of N application time as basal urea spray and use of plant growth regulator (NAA at 40 ppm) on the yield and yield components of greengram cv. K-851. The recommended rate of N: P: K (20:50:20 kg ha^{-1}) as basal was used as a control. Treatments were as included: 1/2 basal N + foliar N as urea at 25 or 35 days after sowing (DAS); 1/2 basal N + 1/4 at 25 DAS + 1/4 at 35 DAS as urea; and 1/2 basal N + 1/2 foliar spraying as urea + 40 ppm NAA. 2% foliar spray of urea and NAA, applied at 35 DAS, resulted in the highest values for number of pods plant $^{-1}$ (38.3).

Kulsum (2003) reported that different level of nitrogen showed significantly increased pods plant $^{-1}$ of blackgram up to N 60 kg ha^{-1}.

The effects of N (0, 10, 20 and 30 kg ha^{-1}) and P (0, 20, 40 and 60 kg ha^{-1}) on mungbean cultivars MH 85-111 and T44 were determined in a field experiment conducted by Rajender *et al*. (2002) in Hisar, Haryana, India during the summer and reported that the number of pods plant $^{-1}$ increased with increasing N rates.

Srinivas *et al.* (2002) conducted an experiment on the performance of mungbean at 0, 25 and 60 kg N ha^{-1}) and 0, 25, 50 and 60 kg P ha^{-1}) and observed that the number of pods plant $^{-1}$ was increased with the increasing rates of N up to 40 kg ha^{-1} followed by a decrease with further increase in N.

Tank *et al*. (1992) observed when mungbean was fertilized with 20 kg N along with level of 40 kg P_2O_5 ha^{-1} increased seed yield significantly over the unfertilized control. They also reported that mungbean fertilized with 20 kg N ha^{-1} along with 75 kg P_2O_5 ha^{-1} significantly increased the number of pods plant $^{-1}$.

Basu and Bandyopadhyay (1990) conducted a field trail during the Kharif season in west Bengal where *Vigna radiata* was inoculated with *Rhizobium* strain M-10 or Jca_1 and grown in presence of 0-40 kg N ha^{-1}. Inoculation increased number of pods plant $^{-1}$ and seeds pod^{-1} and N uptake. Jca_1 was superior to M-10. Number of pods plant $^{-1}$ and N uptake increased with increasing N rates up to 30 kg N ha^{-1}. Nitrogen uptake decreased at the highest N application rate.

Patel and Parmar (1986) conducted an experiment on the response of greengram to varying level of nitrogen and phosphorus. They observed that increasing N application to rainfed mungbean (cv. Gujrat-1) from 0 to 50 kg N ha^{-1} increased the number of pods plant $^{-1}$.

In trials, on clay soils during the summer season Patel *et al.* (1984) observed the effect of N level (0, 10, 20 and 30 kg N ha^{-1}) and that of the P (0, 10, 20, 40, 60 and 80 kg P_2O_5 ha^{-1}) on the growth and seed yield of mungbean. In that experiment, it was found that application of 30 kg N ha^{-1} along with 40 kg P_2O_5 ha^{-1} significantly increased the number of pods plant $^{-1}$.

2.2.3 Length of pod

Azadi *et al.* (2013) conducted an experiment on the effect of different nitrogen level on seed yield and morphological characteristic of mungbean in the climate condition of Khorramabad and they found that the highest pod length was obtained at 150 kg ha^{-1} urea.

2.2.4 Seeds pod^{-1}

A study was conducted by Nigamananda and Elamathi (2007) in Uttar Pradesh, India to evaluate the effect of N application time as basal urea spray and use of plant growth regulator (NAA at 40 ppm) on the yield and yield components of greengram cv. K-851. The recommended rate of N:P:K (20:50:20 kg ha^{-1}) as basal was used as a control. Treatments were as included: 1/2 basal N + foliar N as urea at 25 or 35 days after sowing (DAS); 1/2 basal N + 1/4 at 25 DAS + 1/4 at 35 DAS as urea; and 1/2 basal N + 1/2 foliar spraying as urea + 40 ppm NAA. 2 % foliar spray of urea and NAA, applied at 35 DAS, resulted in the highest seeds pod^{-1} (7.67).

Malik *et al*. (2003) investigated the effect of varying level of nitrogen (0, 25 and 50 kg ha^{-1}) and P (0, 50, 75 and 100 kg ha^{-1}) on the yield and quality of mungbean cv. NM-98 during 2001. It was found that number seeds pod^{-1} were significantly affected by varying level of nitrogen and phosphorous.

Quah and Jaafar (1994) noted that seed yield of mungbean increased significantly by the application of nitrogen fertilizer at 50 kg ha^{-1}.

Patel and Parmar (1986) conducted an experiment on the response of greengram to varying level of nitrogen and phosphorus. They observed that increasing N application to rainfed mungbean (cv. Gujrat-1) from 0 to 50 kg N ha^{-1} increased the number of seeds pod^{-1}.

2.2.5 Weight of 1000-seeds

Srinivas *et al.* (2002) conducted an experiment on the performance of mungbean at 0, 25 and 60 kg N ha^{-1} and 0, 25, 50 and 60 kg P ha^{-1} and observed 1000-seeds weight increased with increasing rates of N up to 40 kg ha^{-1}.

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

Bali *et al.* (1991) conducted a field trail on mungbean in kharif season on silty clay loam soil. They revealed that 1000 seeds weight increased with 40 kg N ha^{-1} and 60 kg P_2O_5 ha^{-1}.

Basu and Bandyopadhyay (1990) conducted a field trail during the Kharif season in west Bengal where *Vigna radiata* was inoculated with *Rhizobium* strain M-10 or Jca_1 and grown in presence of 0-40 kg N ha^{-1}. Inoculation increased number of pods $plant^{-1}$ and seeds $plant^{-1}$ and N uptake. Jca_1 was superior to M-10. 1000 seeds weight and N uptake increased with increasing N rates up to 30 kg N ha^{-1}. Nitrogen uptake decreased at the highest N application rate.

Results of an experiment, conducted by Sardana and Verma (1987) in Delhi, India, revealed that application of nitrogen, phosphorus and potassium fertilizers in combination resulted in significant increases in 1000 seeds weight of mungbean.

In trials, on clay soils during the summer season Patel *et al.* (1984) observed the effect of N level (0, 10, 20 and 30 kg N ha^{-1}) and that of the P (0, 10, 20, 40, 60 and 80 kg P_2O_5 ha^{-1}) on the growth and seed yield of mungbean. They observed that application of 40 kg P_2O_5 ha^{-1} along with 20 kg N ha^{-1} significantly increased the 1000-seeds weight of mungbean.

2.2.6 Seed yield

Hossain *et al.* (2014) conducted an experiment to investigate the comparative roles of nitrogen (50 kg ha^{-1}) and inoculums *Bradyrhizobium* (1.5 kg ha^{-1}) in improving the yield of two mungbean varieties (BARI mung-5 and BARI mung-6) at the Sher-e-Bangla Agricultural University (SAU) Farm, Dhaka. BARI Mung-6 performed higher seed yield than BARI Mung-5.

Malik *et al.* (2014) conducted an experiment on synergistic use of *Rhizobium*, compost and nitrogen to improve growth and yield of mungbean (*Vigna radiata* L.) and found that the combined application of *Rhizobium*, compost and 75% of the recommended mineral nitrogen (RMN) gave maximum grain yield $plant^{-1}$.

Azadi *et al.* (2013) conducted an experiment on the effect of different nitrogen level on seed yield and morphological characteristic of mungbean in the climate condition of Khorramabad and they found that the highest seed yield and pod length was obtained at 150 kg ha^{-1} urea.

Akbar *et al.* (2013) conducted an experiment on the interactive effect of cobalt and nitrogen on growth, nodulation, yield and protein content of field grown pea and observed that the highest seed yield in the treatment the 60 kg N ha^{-1} and 10 g Co ha^{-1}.

Sadeghipour *et al. (*2010) conducted an experiment on the production of mungbean (*Vigna radiata* L.) by nitrogen and phosphorus fertilizer application and they found that the maximum seed yield was obtained when 90 kg N ha^{-1} and 120 kg P_2O_5 ha^{-1} was applied.

Sultana *et al.* (2009) conducted an experiment at the experimental field of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka to evaluate the effect of nitrogen and weed managements on mungbean (*Vigna radiata* L.). They found that application of 20 kg N ha^{-1} as basal + 20 kg N ha^{-1} with one weeding at vegetative stage showed significantly higher seed yield ha^{-1} (1982.05 kg).

Asaduzzaman *et al.* (2008) conducted an experiment at the experimental field of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka to evaluate the response of mungbean (*Vigna radiata* L.) to nitrogen and irrigation management. They found that 30 kg N ha^{-1} as basal with one irrigation at flower initiation stage (35 DAS) gave significantly maximum seed yield plant^{-1} (5.53 g).

A study was conducted by Nigamananda and Elamathi (2007) in Uttar Pradesh, India to evaluate the effect of N application time as basal urea spray and use of plant growth regulator (NAA at 40 ppm) on the yield and yield components of greengram cv. K-851. The recommended rate of N: P: K (20:50:20 kg ha^{-1}) as basal was used as a control. Treatments were as included: 1/2 basal N + foliar N as urea at 25 or 35 days after sowing (DAS); 1/2 basal N + 1/4 at 25 DAS + 1/4 at 35 DAS as urea; and 1/2 basal N + 1/2 foliar spraying as urea + 40 ppm NAA. 2% foliar spray of urea and NAA, applied at 35 DAS, resulted in the highest grain yield (9.66 q ha^{-1}).

Tickoo *et al*. (2006) carried out an experiment on mungbean cultivars Pusa 105 and Pusa Vishal were sown at 22.5 and 30 m spacing and supplied with 36-46 and 58-46 kg NP ha^{-1} in a field experiment conducted in Delhi, India during the kharif season of 2000. Cultivar Pusa Vishal recorded higher grain yield (1.63 t ha^{-1}) compared to cv. Pusa 105.

A field experiment was conducted by Raman and Venkataramana (2006) in Annamalainagar, Tamil Nadu, India to investigate the effect of foliar nutrition on crop nutrient uptake and yield of greengram (*V. radiata*). There were 10 foliar spray treatments, consisting of water spray, 2% diammonium phosphate at 30 and 45 days after sowing, 0.01% Penshibao, 0.125% Zn chelate, 30 ppm NAA. Crop nutrient uptake, yield and its attributes (number of pods per plant and number of seeds per pod) of greengram augmented significantly due to foliar nutrition. The foliar application of urea + NAA + Penshibao was significantly superior to other treatments in increasing the values of yield. The highest grain yield of 1529 kg ha^{-1} was recorded with this treatment.

A field study conducted by Sharma and Sharma (2006) for two years at the Indian Agricultural Research Institute, New Delhi on a sandy clay loam soil showed that the application of NP increased the total grain production of a rice-wheat-mungbean cropping system by 0.5-0.6 t ha^{-1}, NK by 0.3-0.5 t ha^{-1} and NPK by 0.8-0.9 t ha^{-1} compared to N alone, indicating that the balanced use of primary nutrients was more advantageous than their imbalanced application.

Oad and Buriro (2005) conducted a field experiment to determine the effect of different NPK level (0-0-0, 10-20-20, 10-30-30, 10-30-40 and 10-40-40 kg ha^{-1}) on the growth and yield of mungbean in Tandojam, Pakistan. The different NPK level significantly affected the crop parameters. The 10-30-30 kg NPK ha^{-1} was the best treatment, recording the highest seed yield of 1205.2 kg ha^{-1}.

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

Mozumder *et al.* (2003) conducted an experiment to study the effect of *Bradyrhizobium* inoculation at different nitrogen level viz. 0, 20, 40, 60 and 80 kg N ha^{-1} on Binamoog-2. *Bradyrhizobium* inoculation increased dry matter production, nodulation, pod production, seed yield and harvest index and observed that increase of nitrogen fertilizer increased seed yield up to 40 kg N ha^{-1} and straw yield up to 60 kg N ha^{-1}.

Malik *et al.* (2003) conducted an experiment to determine the effect of varying level of nitrogen (0, 25, and 50 kg ha^{-1}) and phosphorus (0, 50, 75 and 100 kg ha^{-1}) on the yield and quality of mungbean cv. NM-98. They observed that a fertilizer combination of 25 kg N + 75 kg P ha^{-1} resulted with maximum seed yield (1112.96 kg ha^{-1}).

Rajender *et al*. (2003) investigated the effects of N (0, 10, 20 and 30 kg ha^{-1}) and P (0, 20, 40 and 60 kg ha^{-1}) fertilizer rates on mungbean genotypes MH 85-111 and T_{44}. Grain yield increased with increasing N rates up to 20 kg ha^{-1}. Further increase in N did not affect yield.

The effects of N (0, 10, 20 and 30 kg ha^{-1}) and P (0, 20, 40 and 60 kg ha^{-1}) on mungbean cultivars MH 85-111 and T44 were determined in a field experiment conducted by Rajender *et al*. (2002) in Hisar, Haryana, India during the summer and reported that grain yield increased with increasing rates of up to 40 kg N ha^{-1} only.

Mahboob and Asghar (2002) studied the effect of seed inoculation at different nitrogen level on mungbean at the agronomic research station, Farooqabad in Pakistan. They revealed that seed inoculation + 50-50-0 NPK kg ha^{-1} exhibited superior performance in respect of seed yield (955 kg ha^{-1}).

Kamal *et al.* (2001) conducted an experiment at the BARI farm during rainy season for 2000-2001 to determine the effect of various level of fertilizer and weeding of mungbean. Superior grain yield (1430kg ha^{-1}) was found when fertilized @ 20-60-30 NPK kg $ha^{-1}$with two hand weedings at 20 and 30 DAE were used. This was followed by that obtained (1368 kg ha^{-1}) by using inoculum + 60-30 PK kg ha^{-1} with two hand weedings at 20 and 30 DAE. This result showed that application of fertilizer @ 20-60-30 kg ha^{-1} combine with two hand weedings at 20 and 30 DAE was economical for yield as well as quality seed production of mungbean.

A field experiment was carried out by Sharma and Sharma (1999) during summer seasons at Golaghat, Assam, India where mungbean was grown using farmers practices (no fertilizer) or using a combinations of fertilizer application (30 kg N + 35 kg P_2O_5 ha^{-1}). Seed yield was 0.40 ton ha^{-1} with farmer's practices, while the highest yield was obtained by the fertilizer application (0.77 ton ha^{-1}).

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

Patel *et al.* (1992) conducted a field trial to evaluate the response of mungbean to sulphur fertilization under different level of nitrogen and phosphorus. Greengram cv. Gujrarat 2 and K 851 were given 10 kg N + 20 kg P ha^{-1}, 20kg N + 40 kg P ha^{1} and 0, 10, 20 or 30 kg S ha^{-1} as gypsum. Seed yield was 1.2 and 1.24 t ha^{-1} in Gujrarat 2 K 851 respectively 20 kg N + 40 kg P ha^{-1}.

A field experiments was conducted by Sarkar and Banik (1991) to study the effect of N and P on yield of mungbean. Results showed that application of N along with P significantly increased the seed yield of mungbean. The maximum seed yield was obtained with the combination of 20 kg N and 60 kg P_2O_5 ha^{-1}.

Arya and Kalra (1988) reported that application of N at the rate of 50 kg ha^{-1} along with 50 kg P ha^{-1} increased mungbean yield. Another experimental result from field experiments conducted by Mahadkar and Saraf (1988) of mungbean revealed that the application of N with P and K at 20:25 kg ha^{-1} gave higher seed yield.

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

An experiment was conducted by Trung and Yoshida (1983) using 0-100 ppm N as treatment in the form of ammonium nitrate or 10 or 100 ppm N as urea, sodium nitrate, ammonium nitrate or ammonium sulphate. They found that seed yield of mungbean increased with the increase in N up to 50 ppm.

2.2.7 Stover yield

Hossain *et al.* (2014) conducted an experiment to investigate the comparative roles of nitrogen (50 kg ha^{-1}) and inoculums *Bradyrhizobium* (1.5 kg ha^{-1}) in improving the yield of two mungbean varieties (BARI mung-5 and BARI mung-6) at the Sher-e-Bangla Agricultural University (SAU) Farm, Dhaka. BARI Mung-6 performed higher stover yield than BARI Mung-5.

Rajender *et al*. (2003) investigated the effects of N (0, 10, 20 and 30 kg ha^{-1}) and P (0, 20, 40 and 60 kg ha^{-1}) fertilizer rates on mungbean genotypes MH 85-111 and T_{44}. Stover yield increased with increasing N rates up to 20 kg ha^{-1}. Further increase in N did not affect yield.

The effects of N (0, 10, 20 and 30 kg ha^{-1}) and P (0, 20, 40 and 60 kg ha^{-1}) on mungbean cultivars MH 85-111 and T44 were determined in a field experiment conducted by Rajender *et al*. (2002) in Hisar, Haryana, India during the summer and reported that straw yield increased with increasing N rates.

Srinivas *et al.* (2002) conducted an experiment on the performance of mungbean at 0, 25 and 60 kg N ha^{-1} and 0, 25, 50 and 60 kg P ha^{-1} and stated that the stover yield increased with increasing N up to 40 kg ha^{-1}.

2.2.8 Biological yield

Tickoo *et al*. (2006) carried out an experiment on mungbean cultivars Pusa 105 and Pusa Vishal were sown at 22.5 and 30 m spacing and supplied with 36-46 and 58-46 kg NP ha^{-1} in a field experiment conducted in Delhi, India. Cultivar Pusa Vishal recorded higher biological (3.66 1.63 t ha^{-1}) compared to cv. Pusa 105.

Rajender *et al*. (2003) investigated the effects of N (0, 10, 20 and 30 kg ha^{-1}) and P (0, 20, 40 and 60 kg ha^{-1}) fertilizer rates on mungbean genotypes MH 85-111 and T_{44}. Biological yield increased with increasing N rates up to 20 kg ha^{-1}. Further increase in N did not affect biological yield.

Results of an experiment conducted by Sardana and Verma (1987) in Delhi, India and stated that the application of nitrogen, phosphorus and potassium fertilizers in combination resulted in the significant increase in biological yield of mungbean.

2.2.9 Harvest index

Mozumder *et al*. (2003) conducted an experiment to study the effect of *Bradyrhizobium* inoculation at different nitrogen level viz. 0, 20, 40, 60 and 80 kg N ha^{-1} on Binamoog-2 *Bradyrhizobium* inoculation and observed that nitrogen negatively affected on harvest index.

In a field experiment carried out by Mozumder (1998) at the Agronomy field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from March 1994 to June 1994 studied with five nitrogen level (0. 20, 40, 60 and 80 kg N ha^{-1}) and two varieties of summer munghean *viz*. Binamoog-2 and Kanti, results revealed that nitrogen produced negative effect of harvest index. Harvest index (%) was decreased by higher nitrogen level.

Chapter 3
Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

The experiment was conducted at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from April to July, 2014. Detailed of the experimental materials and methods followed in the study are presented in this chapter. The experiment was conducted to study the effect of nitrogen management on nodulation, growth and the yield of mungbean.

3.1 Site description

3.1.1 Geographical location

The experimental area was situated at 23°77′N latitude and 90°33′E longitude at an altitude of 8.6 meter above the sea level (Anon., 2004).

3.1.2 Agro-ecological region

The experimental field belongs to the Agro-ecological zone of "The Modhupur Tract", AEZ-28 (Anon., 1988a). This was a region of complex relief and soils developed over the Modhupur clay, where flood plain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain (Anon., 1988b). The experimental site was shown in the map of AEZ of Bangladesh in Appendix I.

3.1.3 Climate

The area has sub tropical climate, characterized by high temperature, high relative humidity and heavy rainfall with occasional gusty winds in Kharif season (April-September) and scanty rainfall associated with moderately low temperature during the Rabi season (October-March). Weather information regarding temperature, relative humidity and rainfall prevailed at the experimental site during the study period were presented in Appendix II.

3.1.4 Soil

The soil of the experimental site belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH ranged from 5.6-6.5 and had organic matter 1.10-1.99%. The experimental area was flat having available irrigation and drainage system and above flood level. Soil samples from 0-15 cm depths were collected from experimental field. The analyses were done by Soil Resource and Development Institute (SRDI), Dhaka. The physical and chemical properties of the soil were presented in Appendix III.

3.2 Details of the experiment

3.2.1 Treatments

Two sets of treatment included in the experiment; the first set comprised of two variety of Mungbean namely BARI mung 4 and BARI mung 6, the second set consisted of five treatments of nitrogen level. Two sets of treatments were as follows:

Factor A: Variety (2):

1. BARI mung 4 (V_1)
2. BARI mung 6 (V_2)

Factor B: Nitrogen Management (5):

1. No Nitrogen (F_1)
2. 20 Kg N ha^{-1} as Basal (F_2)
3. 10 Kg N ha^{-1} as Basal + 10 Kg N ha^{-1} as Split (F_3)
4. 40 Kg N ha^{-1} as Basal (F_4) and
5. 20 Kg N ha^{-1} as Basal + 20 Kg N ha^{-1} as Split (F_5)

3.2.2 Experimental design and layout

The experiment was laid out in a split-plot design with three replications having variety in the main plots and nitrogen management in the sub-plots. There were 10 treatment combinations. The total numbers of unit plots were 30. The size of unit plot was 3.0 m by 2.4 m. The distances between plot to plot and replication to replication were 0.75 m and 1.0 m, respectively. The layout of the experiment has been shown in Appendix IV.

3.3 Crop/Planting Material

BARI mung 4 and BARI mung 6 were used as plant material.

3.3.1 Description of crop: Variety (BARI mung 4)

The seeds of BARI mung 4, a mungbean variety was used as experimental material. BARI mung 4 was developed by Bangladesh Agricultural Research Institute (BARI). This variety grows erect to a height of 52-57 cm. It takes 34-36 days after emergence to flower and reaches physiological maturity within 60-65 days after emergence. Leaves of the variety are trifoliate, alternate, and green. Leaf pubescence is present. Petiole length is short and greenish purple. The corolla is yellowish green. Seeds are drum-shaped and light green. One thousand seeds weigh 29 g only. The variety produced an average seed yield of 1-1.3 t ha^{-1}.

3.3.2 Description of crop: Variety (BARI mung 6)

The seeds of BARI mung 6, a modern mungbean variety was used as experimental material. BARI mung 6 was developed by Bangladesh Agricultural Research Institute (BARI). The plants life cycle lasts for 55-58 days and synchronous type. The plants are erect, stiff and less branched. Each plant contains 15-20 pods. Each pod is around 10 cm long and contains 8-10 seeds. Seeds are large and green in colour and drum shaped. The seed yield of BARI mung 6 range from 1.4-1.5 t ha^{-1}.

3.3.3 Description of Recommended chemical fertilizer

The recommended chemical fertilizer dose was 100, 55 and 1 kg ha^{-1} of TSP, MP and BA respectively (Hussain *et al*., 2006). All the fertilizers were applied by broadcasting and was mixed with soil thoroughly at the time of final land preparation after making plot.

3.3.4 Description of nitrogen management:

The nirtogen fertilizer (urea) was applied as basal dose by broadcasting and mixed with soil thoroughly. The split dose of nitrogen was applied by top dressing at 25 days after sowing.

3.4 Crop management

3.4.1 Seed collection

Seeds of BARI mung 4 and BARI mung 6 were collected from Pulse Seed Section, BARI, Joydebpur, Gazipur, Bangladesh.

3.4.2 Seed sowing

The seeds (BARI mung 4 and BARI mung 6 having more than 80% germination) were sown by hand in 30 cm apart from lines with continuous spacing at about 3 cm depth at the rate of 40 g $plot^{-1}$ on 13 April, 2014.

3.4.3 Collection and preparation of initial soil sample

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

3.4.4 Preparation of experimental land

A pre sowing irrigation was given on 08 April, 2014. The land was open with the help of a tractor drawn disc harrow on 11 April, 2014, then ploughed with rotary plough twice followed by laddering to achieve a medium tilth required for the crop under consideration. All weeds and other plant residues of previous crop were removed from the field. Immediately after final land preparation, the field layout was made on April 13, 2014 according to experimental specification. Individual plots were cleaned and finally prepared the plot.

3.4.5 Fertilizer application

The specific plots area were fertilized @ 100, 55 and 1 kg ha^{-1} of TSP, MP, BA and 10 t ha^{-1} cowdung respectively. The entire amounts of triple super phosphate (TSP), muriate of potash (MP), boric acid (BA) and cowdung were applied as basal dose at final land preparation. The urea fertilizer was applied as per treatment. The split dose of nitrogen was applied by top dressing at 25 days after sowing.

3.4.6 Intercultural operations

3.4.6.1 Thinning

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

3.4.6.2 Weeding

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

3.4.6.3 Application of irrigation water

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

3.4.6.4 Drainage

There was a heavy rainfall during the experimental period. Drainage channel were properly prepared to easy and quick drained out of excess water.

3.4.6.5 Plant protection measures

The crop was infested by insects and diseases. Those were effectively and timely controlled by applying recommended insecticides and fungicides.

3.4.7 Harvesting and post harvest operation

Maturity of crop was determined when 80-90% of the pods become blackish in color. The harvesting of BARI mung 4 and BARI mung 6 were done up to 25 June, 2014. Ten pre-selected plants per plot from which different yield attributing data were collected and $3.6m^2$ areas from middle portion of each plot was separately harvested and bundled, properly tagged and then brought to the threshing floor for recording grain and straw yield. Threshing was done using pedal thresher. The grains were cleaned and sun dried to a moisture content of 14%. Straw was also sun dried properly. Finally grain and straw yields $plot^{-1}$ were determined and converted to ton ha^{-1}.

3.4.8 Recording of data

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

A. Crop growth characters

i. Plant emergence (no. m^{-2})

ii. Plant height (cm) at 15 days interval

iii. Leaves $plant^{-1}$(No.) at 15 days interval

iv. Shoot length (cm) $plant^{-1}$ at 15 days interval

v. Root length (cm) $plant^{-1}$ at 15 days interval

vi. Number of nodules $plant^{-1}$ at 15 days interval

vii. Dry weight of nodules $plant^{-1}$ at 15 days interval

viii. Dry matter production at 15 days interval

B. Yield and other crop characters

i. Number of branches $plant^{-1}$

ii. Number of pods $plant^{-1}$

iii. Length of pod

iv. Number of seeds pod^{-1}

v. Weight of 1000-seeds

vi. Seed yield

vii. Stover yield

viii. Biological yield

ix. Harvest index

x. Shelling percentage

3.4.9 Detailed procedures of recording data

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

A. Crop growth characters

3.4.9.1 Plant emergence (no. m^{-2})

A $1m^2$ area of each plot was selected from where emerged plants were counted daily up to a constant number when germination stopped.

3.4.9.2 Plant height (cm)

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

3.4.9.3 Root length (cm) $plant^{-1}$

The sub-samples of 5 plant $plot^{-1}$ uprooted from second line and root length from five plants was counted at 20, 35 and 50 and the mean value was determined.

3.4.9.4 Number of nodules

The 5 plants $plot^{-1}$ from second line was uprooted and total number of nodules from five plants was counted at 20, 35, 50 DAS and the mean value determined**.**

3.4.9.5 Dry weight of plant (g)

The sub-samples of 5 plant plot^{-1} uprooted from second line were oven dried until a constant leveled, from which the weights of above ground dry matter were recorded at 15 days intervals and at harvest.

B. Yield and other crop characters

3.4.9.6 Number of branches plant^{-1}

Branches number was counted from ten pre-selected plants and the mean value was determined.

3.4.9.7 Pods plant^{-1} (No.)

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

3.4.9.8 Seeds pod^{-1} (No.)

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

3.4.9.9 Weight of 1000-seeds (g)

One thousand cleaned dried seeds were counted randomly from each sample and weighed by using a digital electric balance at the stage the grain retained 14% moisture and the mean weight were expressed in gram.

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

Grain yield was determined from the central 3.6 m^2 area of each plot and expressed as t ha^{-1} and adjusted with 14% moisture basis. Moisture content was measured by using a digital moisture tester.

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

Straw yield was determined from the central 3.6 m^2 area of each plot. After separation of seeds, the sub-samples were oven dried to a constant weight and finally converted to t ha^{-1}.

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

Seed yield and straw yield were all together regarded as biological yield. Biological yield was calculated with the following formula:

Biological yield (t ha^{-1}) = Seed yield (t ha^{-1}) + Stover yield (t ha^{-1})

3.4.9.13 Harvest index (%)

Harvest index denotes the ratio of economic yield (seed yield) to biological yield and was calculated with following formula (Donald, 1963; Gardner *et al*., 1985).

$$\text{Harvest index (\%)} = \frac{\text{Seed yield}}{\text{Biological yield}} \times 100$$

3.4.9.14 Shelling percentage

The shells of the harvested pods from each plot were collected and dried under sun. After that the weight of the shells and seeds were recorded from which shelling percentage was calculated as per following formula:

$$\text{Shelling (\%)} = \frac{\text{Seed yield}}{\text{Pod yield}} \times 100$$

3.4.10 Chemical analysis of soil samples

Soil samples were analyzed for both physical and chemical properties in the laboratory of the SRDI, Farmgate, Bangladesh (Appendix IIIa and IIIb). The properties studied included pH, organic matter, total N, available P and exchangeable K. The soil was analyzed following standard methods. Particle-size analysis of soil was done by Hydrometer method and soil pH was measured with the help of a glass electrode pH meter using soil water suspension of 1:2.5.

3.4.11 Statistical analysis

All the collected data were analyzed following the analysis of variance (ANOVA) technique using MSTAT-C package and the mean differences were adjudged by LSD technique (Gomez and Gomez, 1984).

Chapter 4

Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSION

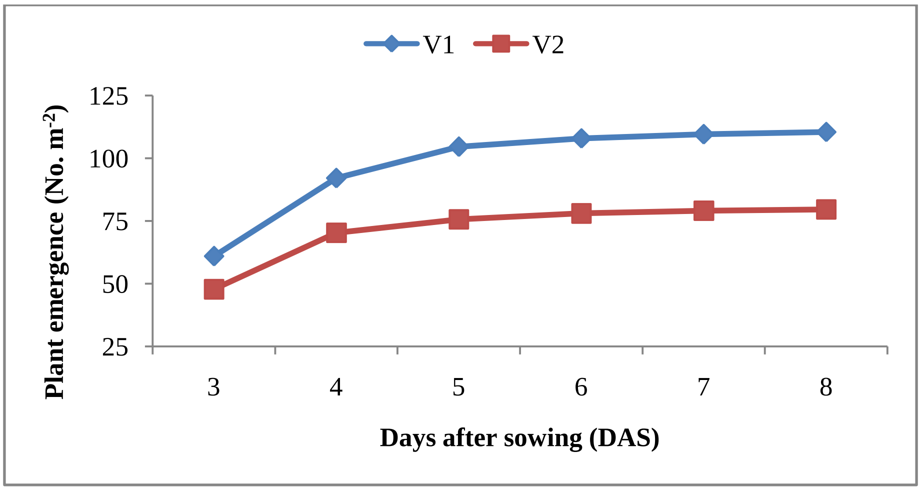
Results obtained from the present study regarding the effects of nitrogen level and their interactions on the yield and yield components of two mungbean varieties have been presented, discussed and compared in this chapter. The analytical results have been presented in Table 1 through Table 11, Figure 1 through Figure 38 and Appendix V through Appendix XIII.

4.1 Crop growth characters

4.1.1 Plant emergence (No. m^{-2})

4.1.1.1 Effect of variety

The plant emergence of mungbean was not significantly influenced by varietal variation at all the data collecting days (Appendix V and Figure 1). The result revealed that, the V_1 gave the higher number of plant emergence (60.93, 92.07, 104.53, 107.93, 109.53 and 110.47 at 3, 4, 5, 6, 7 and 8 DAS, respectively) where as V_2 gave the lower number of plant emergence (47.80, 70.33, 75.68, 78.00, 79.07 and 79.60 at 3, 4, 5, 6, 7 and 8 DAS, respectively).

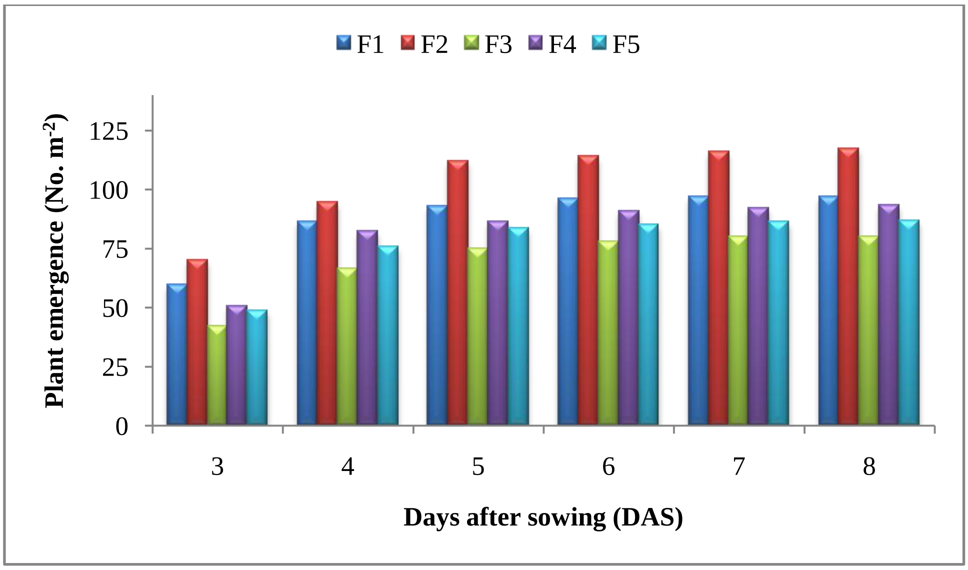


V_1 = BARI mung 4 and V_2 = BARI mung 6

Figure 1. Effect of variety on emergence of mungbean at different days after sowing

4.1.1.2 Effect of different levels of nitrogen

Nitrogen level had significant effect on plant emergence (Appendix V and Figure 2) all data collecting days. The highest plant emergence (70.33, 94.67, 112.3, 114.2, 116.2 and 117.5 at 3, 4, 5, 6, 7 and 8 DAS, respectively) were obtained from treatment F_2 which was statistically similar with treatment F_1 at 3 DAS; F_1, F_4 and F_5 at 4 DAS; F_1 at 5 DAS; F_1 at 6 DAS; F_1 at 7 DAS and F_1 at 8 DAS respectively whereas the lowest plant emergence (42.17, 66.50, 75.17, 78.00, 79.83 and 80.17 at 3, 4, 5, 6, 7 and 8 DAS, respectively) were obtained from treatment F_3 which was statistically similar with treatment F_5 and F_4 at 3 DAS; F_5, F_4 and F_1 at 4 DAS; F_5, F_4 and F_1 at 5 DAS; F_5, F_4 and F_1 at 6 DAS; F_5, F_4 and F_1 at 7 DAS and F_5, F_4 and F_1 at 8 DAS, respectively.



F_1 = No nitrogen; F_2 = 20 kg N as basal; F_3 = 10 kg N as basal + 10 kg N as split; F_4 = 40 kg N as basal and F_5 = 20 kg N as basal + 20 kg N as split

Figure 2. Effect of different nitrogen levels on emergence of mungbean at different days after sowing (LSD $_{(0.05)}$ = 17.32, 24.14, 22.5, 22.57, 22.63 and 22.79 at 3, 4, 5, 6, 7 and 8 DAS, respectively)

4.1.1.3 Interaction effect of variety and different levels of nitrogen

Significant interaction effect between the variety and nitrogen level was observed at 3, 4, 5, 6, 7 and 8 DAS in plant emergence (Appendix V and Table 1). The maximum plant emergence (71 and 103 at 3 and 4 DAS, respectively) were obtained from the V_1F_1 combination which was statistically similar with treatment combinations V_2F_2,

V_1F_2, V_1F_5, V_2F_4, V_1F_3 and V_2F_1 at 3 DAS; V_1F_2, V_1F_5, V_2F_2, V_2F_4, V_1F_4, V_1F_3 and V_2F_1 at 4 DAS, respectively. Again the highest plant emergence (124.0, 125.7, 128.7 and 130.3 at 5, 6, 7 and 8 DAS, respectively) consistently given by treatment combination V_1F_2 which was statistically similar with treatment combinations V_1F_1, V_1F_5, V_2F_2, V_1F_3 at 5 DAS; V_1F_1, V_1F_5, V_2F_2 and V_1F_3 at 6 DAS; V_1F_1, V_1F_5, V_2F_2, V_1F_3 at 7 DAS and V_1F_1, V_1F_5 and V_2F_2 at 8 DAS. The lowest plant emergence (30.67, 51.67, 57 and 58.67 at 3, 4, 5, 6 DAS, respectively) consistently given by treatment combination V_2F_3 which was statistically similar with treatment combinations V_2F_5, V_1F_4, V_2F_1 and V_1F_3 at 3 DAS; V_2F_5, V_2F_1, V_1F_4, V_1F_3 and V_2F_4 at 4 DAS; V_2F_5, V_2F_1, V_1F_4 and V_2F_4 at 5 DAS and V_2F_5 and V_2F_1 at 6 DAS. At 7 and 8 DAS the lowest plant emergence (60 and 61, respectively) were given by combination V_2F_5 which shows similarity with V_2F_3, V_2F_1 and V_2F_4 at 7 DAS and V_2F_3, V_2F_1 and V_2F_4 at 8 DAS.

Table 1. Interaction effect of variety and nitrogen level on emergence of mungbean at different days after sowing (DAS)

Treatments	Plant emergence (no. m^{-2}) at different days after sowing					
	3	4	5	6	7	8
V_1F_1	71 a	103 a	111.7 ab	114.7 ab	115.3 ab	115.3 ab
V_1F_2	70 a	101 a	124.0 a	25.7 a	128.7 a	130.3 a
V_1F_3	53.67 a-d	81.33 a-c	93.33 a-c	97.33a-c	98 a-c	98.00 bc
V_1F_4	45.33 b-d	79.3 a-c	84.33 b-d	91 b-d	93 b-d	95.67 bc
V_1F_5	64.67 ab	95.67 a	109.3 ab	111 ab	112.7 ab	113.0 ab
V_2F_1	48.33 a-d	70.33 a-c	74.33 cd	78 c-e	78.6 c-e	78.67 cd
V_2F_2	70.67 a	88.33 ab	100.7 a-c	102.7a-c	103.7a-c	104.7 a-c
V_2F_3	30.67 d	51.67 c	57 d	58.67 e	61.67 de	62.33 d
V_2F_4	56.33 a-c	85.33 a-c	88.67 b-d	91.33 bc	91.33b-e	91.33 b-d
V_2F_5	33.00 cd	56 bc	57.67 d	59.33 de	60 e	61.00 d
LSD $_{(0.05)}$	24.50	34.14	31.81	31.92	32.00	32.22
CV (%)	26.03	24.29	20.4	19.84	19.60	19.59

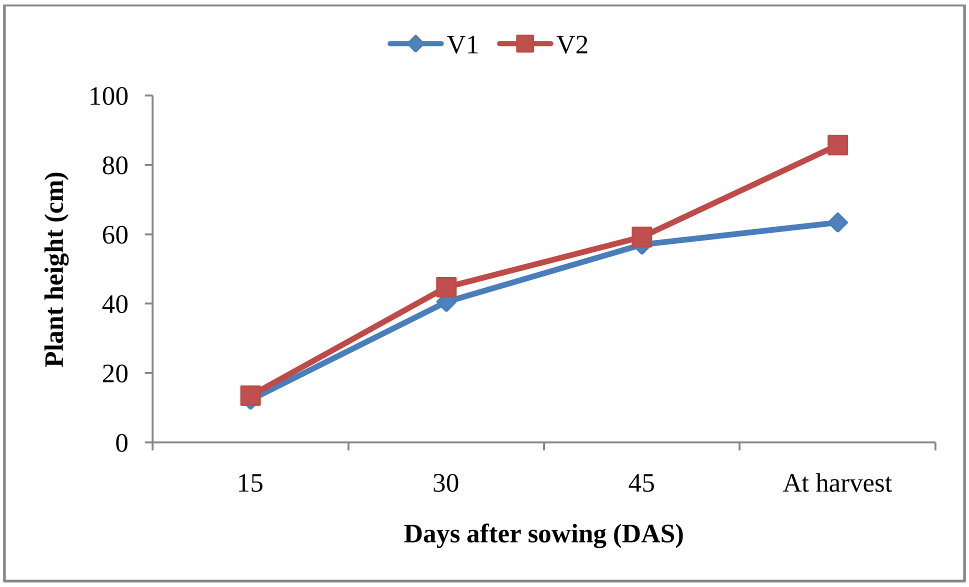
V_1 = BARI mung 4; V_2 = BARI mung 6; F_1 = No nitrogen; F_2 = 20 kg N as basal; F_3 = 10 kg N as basal + 10 kg N as split; F_4 = 40 kg N as basal and F_5 = 20 kg N as basal + 20 kg N as split

4.1.2 Plant height (cm)

4.1.2.1 Effect of variety

The plant height of mungbean was significantly influenced by varietal variation at 15 DAS and at harvest but it was insignificant at 30 DAS and 45 DAS (Appendix VI and Figure 3).

The result revealed that at 15 DAS, The V_2 produced the taller plant (13.47 cm) and the V_1 gave the shorter plant (12.29 cm) and the same trend of plant height was also observed at harvest. At 30 DAS and 45 DAS no significant variation of plant height observed between the two varieties through numerically the tall plant height (44.78 cm and 59.19 cm, respectively) was found from V_2 and lower plant height (40.47 and 56.97 cm) was found from V_1. This variation in plant height might be attributed to their genetic characters. It agreed with the result of Ghosh (2004) and Thakuria and Shaharia (1990). They reported that different varieties of mungben differed significantly in plant height.

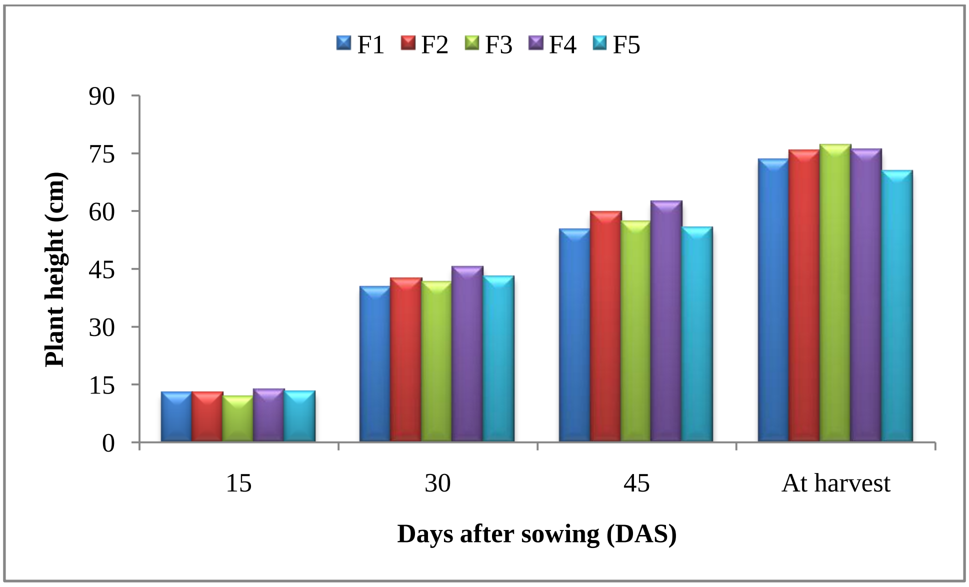


V_1 = BARI mung 4 and V_2 = BARI mung 6

Figure 3. Effect of variety on plant height of mungbean at different days after sowing (LSD $_{(0.05)}$ = 1.09 and 16.85 at 15 DAS and at harvest, respectively)

4.1.2.2 Effect of different levels of nitrogen

Nitrogen level had no significant effect on plant height throughout the growing season (Appendix VI and Figure 4). The tallest plant height (13.65, 45.50, 62.51 and 77.51 cm at 15, 30, 45 DAS and at harvest, respectively) was obtained in F_5 treatment and shortest plant height (11.99 cm) was obtained from F_3 at 15 DAS; 40.38, 55.24 and 70.43 cm from treatment F_1 at 30, 45 DAS and at harvest, respectively. These findings was corroborated with the results reported by Masud (2003); Ghosh (2004); Quah and Jaafar (1994) and Hamid (1991). They found that application of N increased the plant height significantly.



F_1 = No nitrogen; F_2 = 20 kg N as basal; F_3 = 10 kg N as basal + 10 kg N as split; F_4 = 40 kg N as basal and F_5 = 20 kg N as basal + 20 kg N as split

Figure 4. Effect of different nitrogen levels on plant height of mungbean at different days after sowing

4.1.2.3 Interaction effect of variety and different levels of nitrogen

Significant interaction effect between the variety and nitrogen level was observed at 15, 30, 45 DAS and at harvest in plant height (Appendix VI and Table 2). At 15 DAS, the tallest plant was obtained from the V_2F_5 combination (14.52 cm) which was statistically similar with all the interactions except V_1F_1. The shortest plant height (11.13 cm) was found in V_1F_1 which was statistically similar with all the interactions except V_2F_5 treatment combination. At 30 DAS, the tallest plant was obtained from the V_2F_5 combination (46.09 cm) which was statistically similar with all the interaction except V_1F_1. The shortest plant height (35.22 cm) was in V_1F_1 which was similar to V_1F_2, V_1F_3, V_1F_5 and V_2F_1. At 45 DAS, the tallest plant height was recorded from V_2F_5 interaction (65.53 cm) which was statistically similar with all the interactions except V_1F_1. The shortest plant height (49.59 cm) was when no nitrogen with V_1 which was statistically similar to all the treatment combinations except V_2F_5. At harvest, the tallest plant (89.28 cm) was obtained from the V_2F_5 interaction which was statistically similar with the interaction of V_2F_4, V_2F_3, V_2F_2 and V_2F_1 and the shortest plant (60.09 cm) was recorded from the V_1F_1 combination which was statistically similar with V_1F_2, V_1F_3 and V_1F_4. It was probably owing to the similar response of mungbean varieties to fertilizers in respect of plant height.

Table 2. Interaction effect of variety and nitrogen level on plant height of mungbean at different days after sowing (DAS)

Treatments	Plant height (cm) at different days after sowing			
	15	30	45	At harvest
V_1F_1	11.13 b	35.22 b	49.59 b	60.09 b
V_1F_2	11.91 ab	41.39 ab	54.82 ab	62.23 b
V_1F_3	11.95 ab	40.25 ab	55.45 ab	63.37 b
V_1F_4	12.61 ab	44.90 a	56.45 ab	64.14 b
V_1F_5	12.54 ab	40.58 ab	53.45 ab	67.00 b
V_2F_1	12.03 ab	43.04 ab	57.89 ab	80.94 a
V_2F_2	13.39 ab	43.64 a	61.51 ab	82.73 a
V_2F_3	13.59 ab	45.53 a	62.13 ab	87.41 a
V_2F_4	13.79 ab	45.59 a	64.49 ab	88.32 a
V_2F_5	14.52 a	46.09 a	65.53 a	89.28 a
LSD $_{(0.05)}$	2.66	7.93	12.54	10.27
CV (%)	11.94	10.75	12.48	7.96

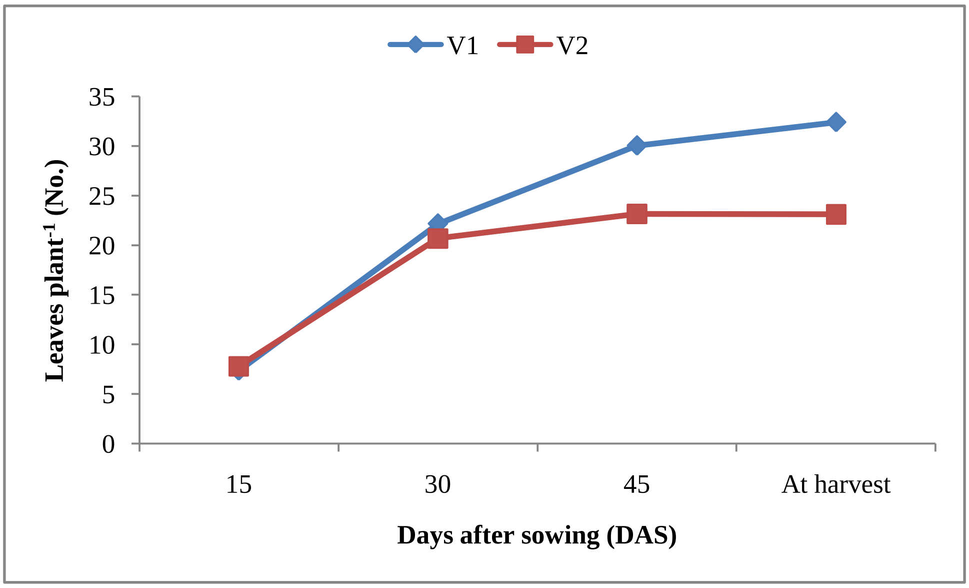
V_1 = BARI mung 4; V_2 = BARI mung 6; F_1 = No nitrogen; F_2 = 20 kg N as basal; F_3 = 10 kg N as basal + 10 kg N as split; F_4 = 40 kg N as basal and F_5 = 20 kg N as basal + 20 kg N as split

4.1.3 Leaves plant^{-1} (No.)

4.1.3.1 Effect of variety

Leaves plant^{-1} was significantly influenced by the variety at 45 DAS but insignificant at 15, 30 DAS and at harvest (Appendix VII and Figure 5).

At 45 DAS, the higher number of leaves plant^{-1} (30.04) was found in V_1 and the lower leaves plant^{-1} (23.15) was found in V_2. At 15, 30 DAS and at harvest, there was no significant variation of leaves plant^{-1} observed for two varieties.



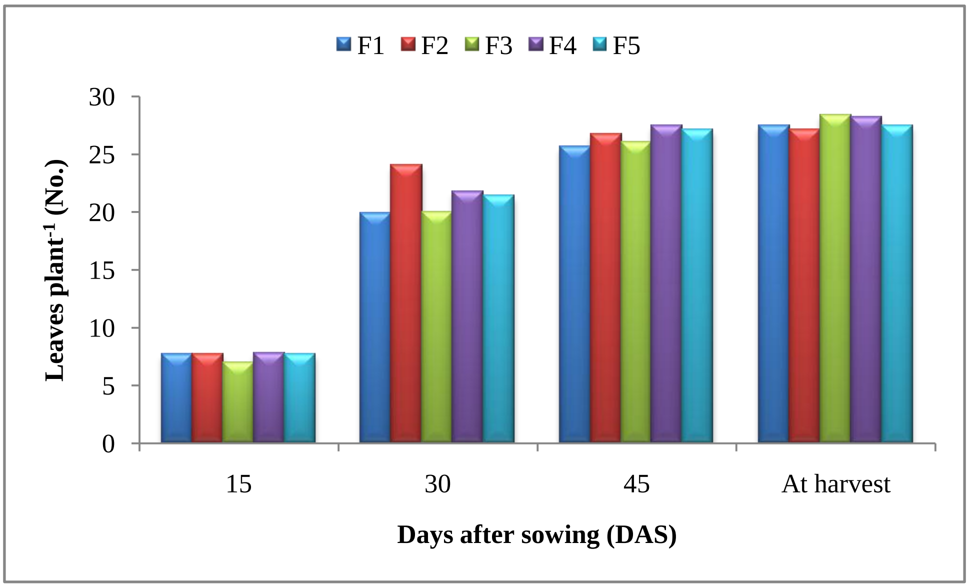
V_1 = BARI mung 4 and V_2 = BARI mung 6

Figure 5. Effect of variety on leaves plant^{-1} of mungbean at different days after sowing (LSD $_{(0.05)}$ = 2.11 at 45 DAS)

4.1.3.2 Effect of different levels of nitrogen

Leaves plant^{-1} of mungbean had significantly influenced by the different nitrogen levels at 15 and 30 DAS but insignificant at 45 DAS and at harvest (Appendix VII and Figure 6).

At 15 DAS, the maximum leaves plant^{-1} (7.8) found in F_4 treatment which was statistically similar with rest of the treatments except F_3 and F_3 produced the minimum leaves plant^{-1} (7.00). At 30 DAS, treatment F_2 produced the maximum leaves plant^{-1} (24.05) that was followed by the F_4 (21.77) and F_5 (21.40) and no nitrogen (F_1) produced the minimum leaves plant^{-1} (19.93) which was statistically similar with rest of the nitrogen level except F_2. At 45 DAS and at harvest, there was no significant variation of leaves plant^{-1} observed among the nitrogen level.



F_1 = No nitrogen; F_2 = 20 kg N as basal; F_3 = 10 kg N as basal + 10 kg N as split; F_4 = 40 kg N as basal and F_5 = 20 kg N as basal + 20 kg N as split

Figure 6. Effect of different nitrogen levels on leaves plant^{-1} of mungbean at different days after sowing (LSD $_{(0.05)}$ = 0.60 and 3.34 at 15 and 30 DAS respectively)

4.1.3.3 Interaction effect of variety and different levels of nitrogen

Interaction effect of variety and different levels of nitrogen had significant influence on leaves plant^{-1} at 15, 30 and 45 DAS and at harvest (Appendix VII and Table 3). At 15 DAS, treatment combinations V_1F_4, V_2F_1, V_2F_2 and V_2F_5 produced the maximum leaves plant^{-1} (8.00) which was statistically similar with all treatment combinations except V_1F_3 and the minimum leaves plant^{-1} produced by V_1F_3 (6.6) which was statistically similar with V_1F_1, V_1F_2, V_1F_5 and V_2F_3. At 30 DAS, V_1F_2 produced the maximum leaves plant^{-1} (27.70) which was statistically similar with V_1F_4 and the minimum leaves plant^{-1} (19.20) produced by V_1F_1 which was statistically similar with all treatment combinations except V_1F_2. At 45 DAS, the V_1 produced the maximum leaves plant^{-1} (33.13) with F_4 which was statistically similar with V_1F_2 and V_1F_5 and the minimum leaves plant^{-1} (21.80) produced by V_2F_4 which was statistically similar with V_2F_2, V_2F_1, V_2F_3 and V_2F_5. At harvest, V_1F_4 produced the maximum leaves plant^{-1} (34.80) which was statistically similar with V_1F_3, V_1F_1, V_1F_2 and V_1F_5 and the minimum leaves plant^{-1} (21.60) produced by V_2F_4 interaction which was statistically similar with V_2F_3, V_2F_2, V_2F_1 and V_2F_5.

Table 3. Interaction effect of variety and nitrogen level on leaves plant^{-1} of mungbean at different days after sowing (DAS)

Treatments	Leaves plant^{-1} (No.) at different days after sowing			
	15	30	45	At harvest
V_1F_1	7.40 ab	19.20 b	28.00 b-d	32.40 a
V_1F_2	7.40 ab	27.70 a	30.33 ab	31.20 a
V_1F_3	6.60 b	20.07 b	28.47 bc	33.20 a
V_1F_4	8.00 a	23.27 ab	33.13 a	34.80 a
V_1F_5	7.40 ab	20.60 b	30.27 ab	30.40 ab
V_2F_1	8.00 a	20.67 b	23.27 e	22.60 c
V_2F_2	8.00 a	20.40 b	23.07 e	23.17 c
V_2F_3	7.40 ab	19.87 b	23.60 de	23.60 c
V_2F_4	7.60 a	20.27 b	21.80 e	21.60 c
V_2F_5	8.00 a	22.20 b	24.00 c-e	24.60 bc
LSD $_{(0.05)}$	0.84	4.72	4.66	6.25
CV (%)	6.46	12.72	10.12	13.01

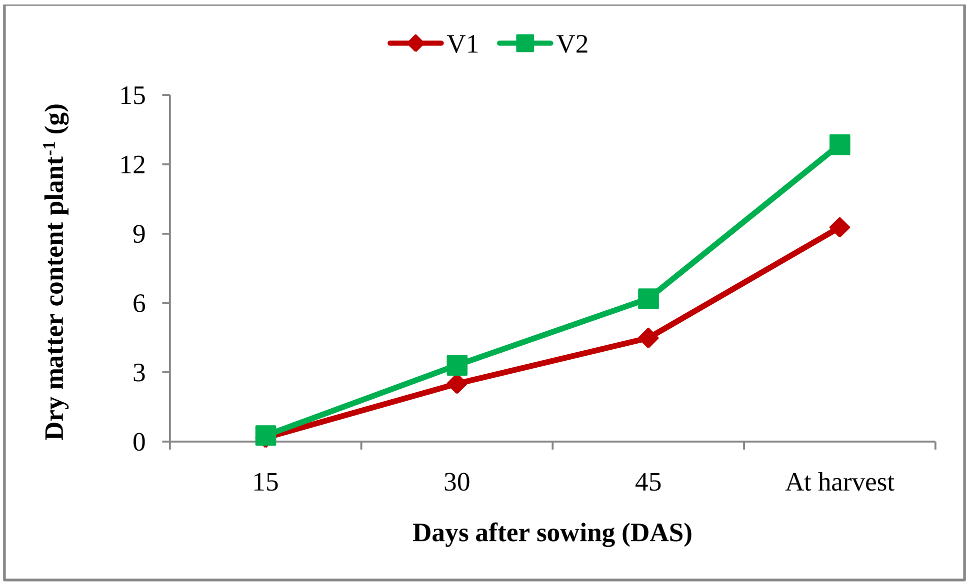
V_1 = BARI mung 4; V_2 = BARI mung 6; F_1 = No nitrogen; F_2 = 20 kg N as basal; F_3 = 10 kg N as basal + 10 kg N as split; F_4 = 40 kg N as basal and F_5 = 20 kg N as basal + 20 kg N as split

4.1.4 Dry matter content plant^{-1} (g)

4.1.4.1 Effect of variety

Variety significantly influenced the total dry matter production at 15, 30, 45 DAS and at harvest (Appendix VIII and Figure 7).

At 15 DAS, the V_2 produced higher dry weight plant^{-1} (0.26 g) compared to V_1 (0.16 g). At 30 DAS, the maximum dry weight plant^{-1} was produced by V_2 (3.30 g) compared to the V_1 (2.50 g). At 45 DAS, the V_2 produced higher dry weight plant^{-1} (6.18 g) compared to the V_1 (4.48 g). At harvest, the V_2 produced the maximum dry weight plant^{-1} (12.85 g) which was 38.62% higher than the V_1 (9.27 g).

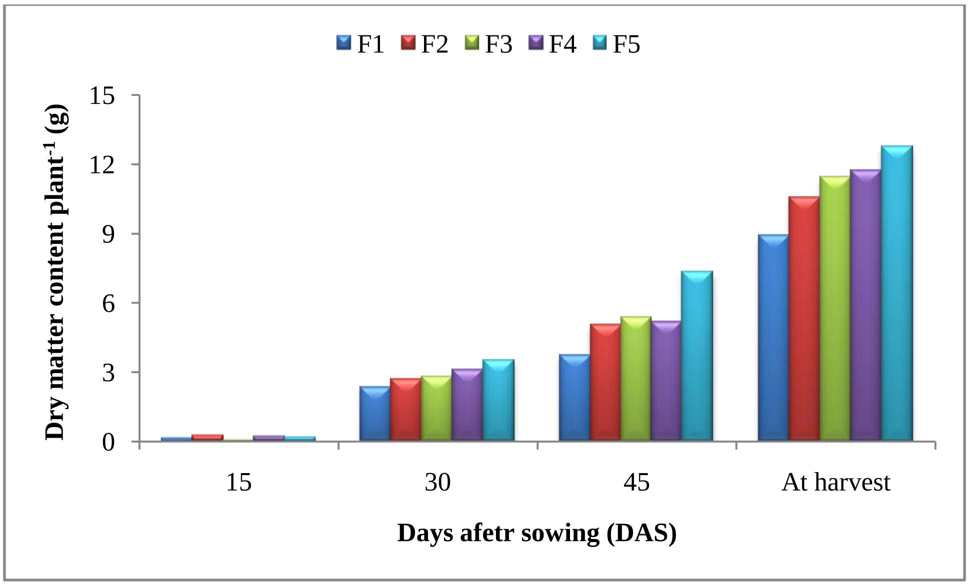


V_1 = BARI mung 4 and V_2 = BARI mung 6

Figure 7. Effect of variety on dry matter content of mungbean at different days after sowing (LSD $_{(0.05)}$ =0.05, 0.07, 0.62 and 1.48 at 15, 30, 45 DAS and at harvest, respectively)

4.1.4.2 Effect of different levels of nitrogen

The total dry weight of plant was significantly influenced by different levels of nitrogen at 15, 30, 45 DAS and at harvest (Appendix VIII and Figure 8). At 15 DAS, the maximum dry weight plant^{-1} (0.26 g) was recorded in F_2 and the minimum dry weight plant^{-1} (0.16 g) was recorded in no nitrogen (F_1) which was statistically at par with F_5. At 30 DAS, the maximum dry weight plant^{-1} (3.53 g) was recorded in F_5 and the minimum dry weight plant^{-1} (2.36 g) was recorded in F_1. At 45 DAS, treatment F_5 produced the maximum dry weight plant^{-1} (7.33 g). The lowest dry weight plant^{-1} (3.72 g) was obtained from the no nitrogen (F_1). At harvest, the maximum dry weight plant^{-1} (12.76) was obtained from the F_5. The lowest dry weight plant^{-1} (8.90 g) was obtained from the no nitrogen (F_1). Dry matter production plant^{-1} was associated with leaf dry wt. plant^{-1}, stem dry wt. plant^{-1}, root dry wt. plant^{-1}, pod dry wet. Plant^{-1} and grain and straw dry weight plant^{-1} recorded during the different stages of mungbean plants. Similar result was found by Mozumder *et al*. (2003); Yein (1982) and Agbenin *et al*. (1991). They found that application of N increased the total dry weight of mungbean plant.



F_1 = No nitrogen; F_2 = 20 kg N as basal; F_3 = 10 kg N as basal + 10 kg N as split; F_4 = 40 kg N as basal and F_5 = 20 kg N as basal + 20 kg N as split

Figure 8. Effect of different nitrogen levels on dry matter content of mungbean at different days after sowing (LSD $_{(0.05)}$ = 0.04, 0.16, 0.31 and 0.67 at 15, 30, 45 DAS and at harvest, respectively)

4.1.4.3 Interaction effect of variety and different levels of nitrogen

Interaction effect of variety and nitrogen level influenced the dry matter production plant^{-1} of mungbean at 15, 30, 45 DAS and at harvest (Appendix VIII and Table 4). At 15 DAS, the highest dry weight plant^{-1} (0.35 g) was observed in the V_2F_5 interaction and lowest dry weight plant^{-1} (0.15 g) was observed in the V_1 with the interaction of F_4 which was statistically similar with V_1F_2, V_1F_1, V_1F_3, V_1F_5 and V_2F_3. However at 30 DAS, the highest dry weight plant^{-1} (4.22 g) was obtained from the V_2F_5 interaction and lowest dry weight plant^{-1} (2.08 g) was observed in the V_1F_1 interaction. Again at 45 DAS, maximum dry weight plant^{-1} (8.89 g) was produced by the V_2F_5 and lowest dry weight plant^{-1} (3.56 g) was observed in the V_1F_1 interaction which shown similarity with V_2F_1. At harvest, the V_2 with the interaction of F_5 produced the highest dry weight plant^{-1} (14.76 g) whereas, the lowest dry weight plant^{-1} was produced by the V_1 with the interaction of F_1 (7.22 g).

Table 4. Interaction effect of variety and nitrogen level on dry matter content of mungbean at different days after sowing (DAS)

Treatments	Dry matter content plant^{-1} (g) at different days after sowing			
	15	30	45	At harvest
V_1F_1	0.17 de	2.08 g	3.56 f	7.22 g
V_1F_2	0.15 e	2.43 ef	4.33 d	8.84 f
V_1F_3	0.18 de	2.42 f	4.30 de	9.52 ef
V_1F_4	0.15 e	2.75 cd	4.45 d	10.02 de
V_1F_5	0.17 de	2.83 cd	5.78 c	10.76 d
V_2F_1	0.22 cd	2.65 de	3.89 ef	10.59 d
V_2F_2	0.29 b	2.95 c	5.78 c	12.33 c
V_2F_3	0.20 de	3.23 b	6.44 b	13.33 b
V_2F_4	0.26 bc	3.46 b	5.89 c	13.41 b
V_2F_5	0.35 a	4.22 a	8.89 a	14.76 a
LSD $_{(0.05)}$	0.05	0.23	0.44	0.95
CV (%)	5.07	4.56	4.77	4.95

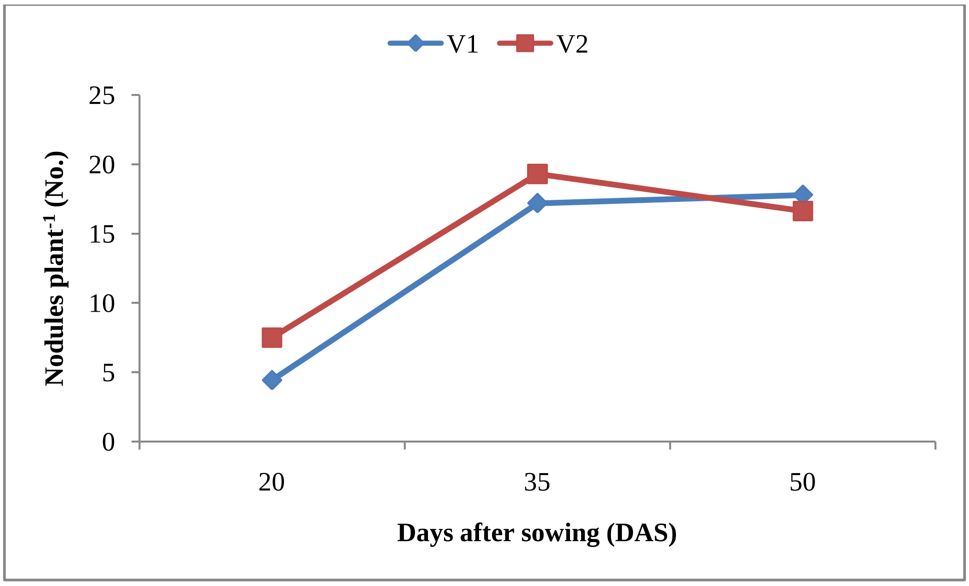
V_1 = BARI mung 4; V_2 = BARI mung 6; F_1 = No nitrogen; F_2 = 20 kg N as basal; F_3 = 10 kg N as basal + 10 kg N as split; F_4 = 40 kg N as basal and F_5 = 20 kg N as basal + 20 kg N as split

4.1.5 Number of nodules plant^{-1}

4.1.5.1 Effect of variety

The total number of nodules plant^{-1} was not significantly influenced for varieties of mungbean throughout the growing season (Appendix IX and Figure 9).

The V_2 produced the maximum total number of nodules plant^{-1} (7.5, 19.31 and 16.64 at 20, 35 and 50 DAS, respectively) and the V_1 gave the minimum total number of nodules plant^{-1} (4.43, 17.19 and 17.79 at 20, 35 and 50 DAS, respectively).

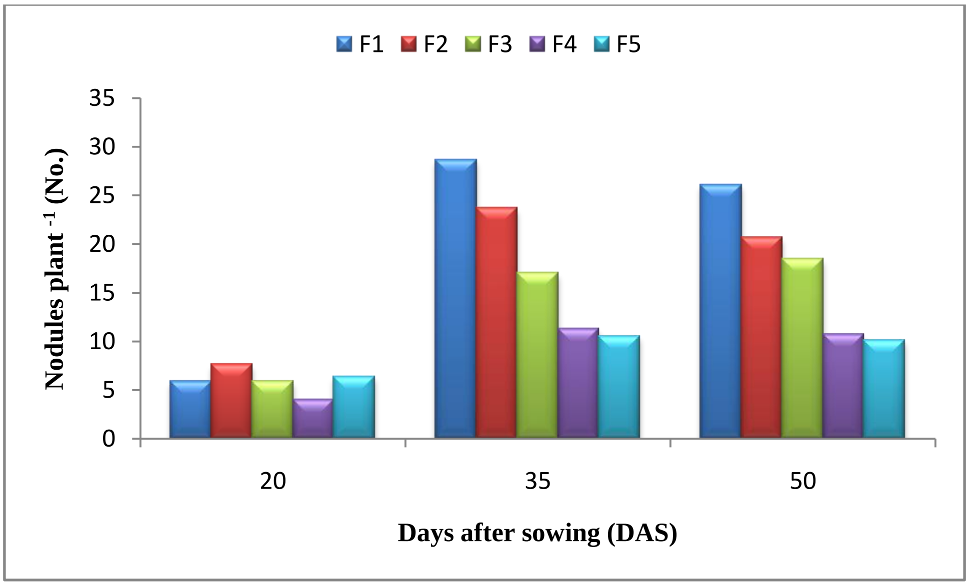


V_1 = BARI mung 4 and V_2 = BARI mung 6

Figure 9. Effect of variety on nodules plant^{-1} of mungbean at different days after sowing

4.1.5.2 Effect of different levels of nitrogen

The different nitrogen levels had highly significant effect in formation of total number of nodules plant^{-1} recorded at 20, 35 and 50 DAS (Appendix IX and Figure 10). At 20 DAS, the maximum total number of nodules plant^{-1} (7.63) was produced by F_2, which was statistically similar to F_5 and the lowest number of nodules plant^{-1} was produced by F_4 (4.02). At 35 DAS, the maximum total number of nodules plant^{-1} (28.67) was produced by F_1 and the lowest number of nodules plant^{-1} was produced by F_5 (10.57) which was statistically similar to F_4. At 35 DAS, the maximum total number of nodules plant^{-1} (26.10) was produced by F_1 which was statistically similar to F_2 and the lowest number of nodules plant^{-1} was produced by F_5 (10.13) which was statistically similar to F_4. Similar result also found by Javaid (2009) who reported that crops grown in unamended soil recorded the highest number of nodules than the application of high rates of N fertilizer. Fertilizer application is not needed to maximize nitrogen fixation in soil. Mungbean grown without fertilizer obtained the highest number of nodules plant^{-1} due to translocation of carbohydrates from nodules to reproductive organ resulting higher pods plant^{-1}.



F_1 = No nitrogen; F_2 = 20 kg N as basal; F_3 = 10 kg N as basal + 10 kg N as split; F_4 = 40 kg N as basal and F_5 = 20 kg N as basal + 20 kg N as split

Figure 10. Effect of different nitrogen levels on nodules plant^{-1} of mungbean at different days after sowing (LSD $_{(0.05)}$ = 1.63, 3.91 and 6.22 at 20, 35 and 50 DAS, respectively)

4.1.5.3 Interaction effect of variety and different levels of nitrogen

Significant interaction effect between the variety and nitrogen level was observed at 20, 35 and 50 DAS on total number of nodules produced plant^{-1} (Appendix IX and Table 5).

At 20 DAS, the highest number of nodules was produced from the V_2 with F_2 (9.8 plant^{-1}) which was statistically similar with the interaction of V_2F_1 (8.03 plant^{-1}). The lowest number of nodule was produced in V_1F_4 (3.23 plant^{-1}) which was statistically similar with the interaction of V_1F_1, V_1F_3, V_2F_4, V_1F_5 and V_1F_2. At 35 DAS, the maximum number of nodules (29.80 plant^{-1}) was obtained from the V_2F_1 which was statistically similar with the interaction of V_1F_1 and V_2F_2. The lowest number of nodule was produced in V_1F_5 (9.67 plant^{-1}) which was statistically similar with the interaction of V_1F_4, V_2F_5 and V_2F_4. At 50 DAS, the maximum nodule was recorded at the V_2F_1 (26.60 plant^{-1}) which was statistically similar with the interaction of V_1F_1, V_1F_2, V_1F_3 and V_2F_2. Statistically the lowest number of nodules was produced from the V_1 with F_5 (9.47 plant^{-1}) which was statistically similar with the interaction of V_2F_4, V_2F_5, V_1F_4 and V_2F_3.

Table 5. Interaction effect of variety and nitrogen level on nodules plant^{-1} of mungbean at different days after sowing (DAS)

Treatments	Nodules plant^{-1} (No.) at different days after sowing		
	20	**35**	**50**
V_1F_1	3.73 d	27.53 a	25.60 a
V_1F_2	5.47 cd	21.53 bc	22.53 ab
V_1F_3	4.33 d	16.73 c-e	20.67 ab
V_1F_4	3.23 d	10.50 f	10.67 cd
V_1F_5	5.37 cd	9.67 f	9.467 d
V_2F_1	8.03 ab	29.80 a	26.60 a
V_2F_2	9.80 a	25.87 ab	18.80 a-c
V_2F_3	7.43 bc	17.27 cd	16.27 b-d
V_2F_4	4.80 d	12.13 d-f	10.73 cd
V_2F_5	7.43 bc	11.47 ef	10.80 cd
LSD $_{(0.05)}$	2.31	5.53	8.793
CV (%)	22.37	17.49	29.51

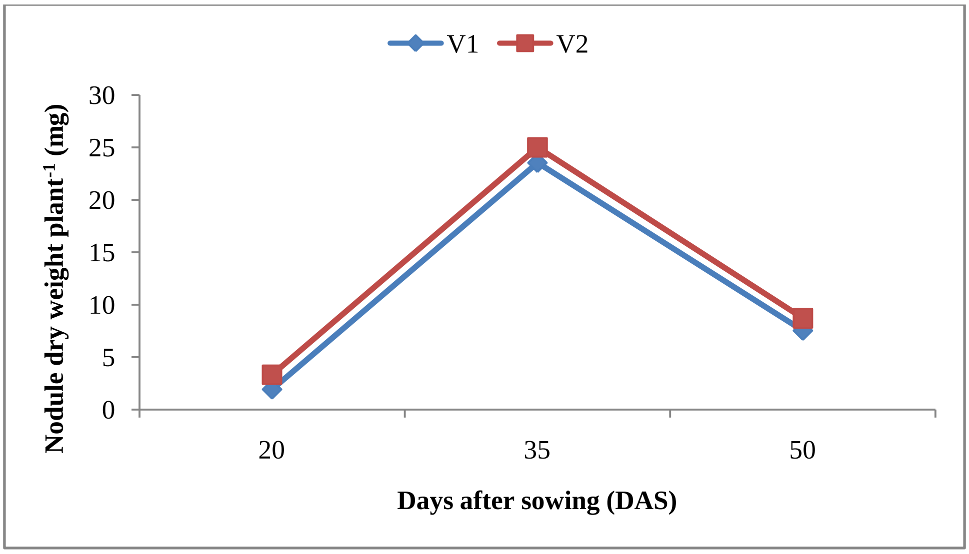
V_1 = BARI mung 4; V_2 = BARI mung 6; F_1 = No nitrogen; F_2 = 20 kg N as basal; F_3 = 10 kg N as basal + 10 kg N as split; F_4 = 40 kg N as basal and F_5 = 20 kg N as basal + 20 kg N as split

4.1.6 Dry weight of nodules (mg)

4.1.6.1 Effect of variety

The dry weight of nodule plant^{-1} had significant effect for varietal variation at 50 DAS only (Appendix IX and Figure 11).

At 50 DAS, the V_2 produced the maximum dry weight of nodules (8.71 mg plant^{-1}) and the V_1 gave the minimum weight (7.53 mg plant^{-1}). In other two data sampling days, dry weight of nodule plant^{-1} were not significant for varietal variation.

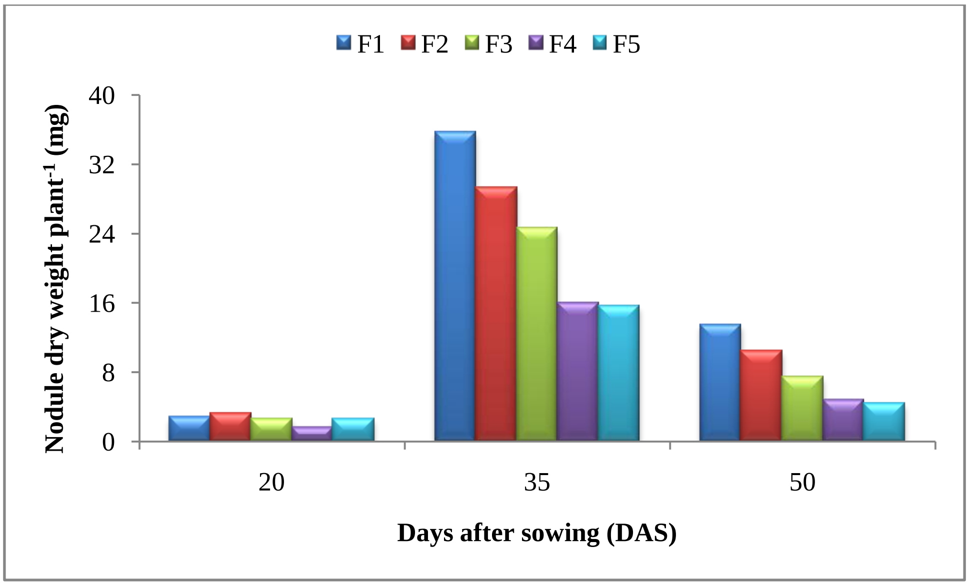


V_1 = BARI mung 4 and V_2 = BARI mung 6

Figure 11. Effect of variety on nodule dry weight of mungbean at different days after sowing (LSD $_{(0.05)}$ = 1.02 at 50 DAS)

4.1.6.2 Effect of different levels of nitrogen

Nitrogen level had significant effect of dry weight of nodules plant^{-1} recorded at 20, 35 and 50 DAS (Appendix IX and Figure 12). At 20 DAS, the maximum dry weight of nodules (3.33 mg plant^{-1}) was produced by F_2 which shown similarity with all the nitrogen level except F_4, the minimum dry weight of nodules (1.67 mg plant^{-1}) was produced by F_4 shown similarity with all the nitrogen level except F_2 . At 35 and 50 DAS, the highest dry weight of nodule (35.67 and 13.48 mg plant^{-1}, respectively) was produced by F_1 and the lowest dry weight of nodules (15.67 and 4.42 mg plant^{-1}, respectively) was produced by F_5 which were significantly similar to F_4 in both two data sampling days. These results coincide with the result of Reynolds (2005); Achakzai (2007) who reported that higher rates of N fertilizer resulted in linear decrease of nodules dry weight as a consequence of regulatory mechanism. Olson *et al.* (1981); Eriksen and Whitney (1984) also reported that application of high rates of N fertilizer decreased dry and fresh nodules weight.



F_1 = No nitrogen; F_2 = 20 kg N as basal; F_3 = 10 kg N as basal + 10 kg N as split; F_4 = 40 kg N as basal and F_5 = 20 kg N as basal + 20 kg N as split

Figure 12. Effect of different nitrogen levels on nodule dry weight of mungbean at different days after sowing (LSD $_{(0.05)}$ = 1.503, 2.826 and 1.602 at 20, 35 and 50 DAS, respectively)

4.1.6.3 Interaction effect of variety and different levels of nitrogen

Significant interaction effect between the variety and nitrogen level was observed at 20, 35 and 50 DAS on dry weight of nodules produced plant^{-1} (Appendix IX and Table 6).

At 20 DAS, the maximum dry weight of nodules (4.33 mg plant^{-1}) was obtained from the V_2F_2 interaction which was statistically similar with the interactions of V_2F_1, V_2F_3, V_2F_5, V_1F_5 and V_1F_2. The lowest dry weight of nodule was produced in V_1F_4 (1.33 mg plant^{-1}) which was statistically similar with the interactions of V_1F_1, V_1F_3, V_2F_4, V_2F_5, V_1F_5, V_2F_3 and V_1F_2. At 35 and 50 DAS, the maximum dry weight of nodule was recorded at V_2F_1 (37.67 and 14.63 mg plant^{-1}, respectively) whereas, statistically the lowest dry weight of nodules was produced in V_1F_5 (13.67 and 4.17 mg plant^{-1}, respectively) which was statistically similar with the interaction of V_2F_5 only at 50 DAS.

Table 6. Interaction effect of variety and nitrogen level on nodule dry weight of mungbean at different days after sowing (DAS)

Treatments	Nodule dry weight plant^{-1} (mg) at different days after sowing		
	20	**35**	**50**
V_1F_1	1.67 c	33.67 b	12.33 b
V_1F_2	2.33 a-c	31.33 b	9.23 c
V_1F_3	2.00 bc	24.67 c	7.67 c
V_1F_4	1.33 c	14.33 de	4.27 e
V_1F_5	2.33 a-c	13.67 e	4.17 e
V_2F_1	4.00 ab	37.67 a	14.63 a
V_2F_2	4.33 a	27.33 c	11.67 b
V_2F_3	3.33 a-c	24.67 c	7.23 cd
V_2F_4	2.00 bc	17.67 d	5.33 de
V_2F_5	3.00 a-c	17.67 d	4.67 e
LSD $_{(0.05)}$	2.13	3.99	2.27
CV (%)	46.64	9.52	16.13

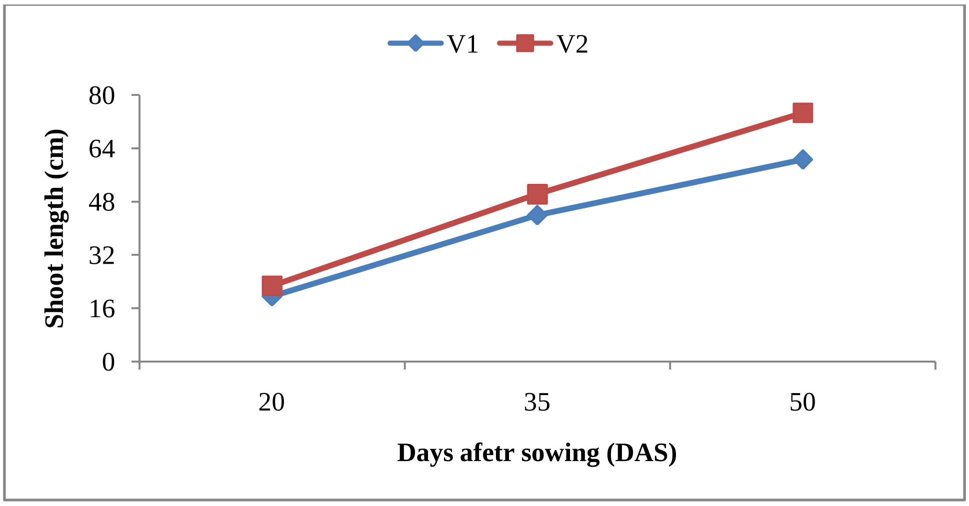
V_1 = BARI mung 4; V_2 = BARI mung 6; F_1 = No nitrogen; F_2 = 20 kg N as basal; F_3 = 10 kg N as basal + 10 kg N as split; F_4 = 40 kg N as basal and F_5 = 20 kg N as basal + 20 kg N as split

4.1.7 Shoot length (cm)

4.1.7.1 Effect of variety

The shoot length of mungbean was significantly varied by varietal difference at 20 and 50 DAS (Appendix X and Figure 13).

At 20 DAS, the V_2 produced the higher shoot length (22.73 cm) and the V_1 gave the shorter shoot length (19.56 cm). At 50 DAS, the V_2 produced the higher shoot length (74.62 cm) and the shorter shoot length produced from V_1 (60.58 cm).

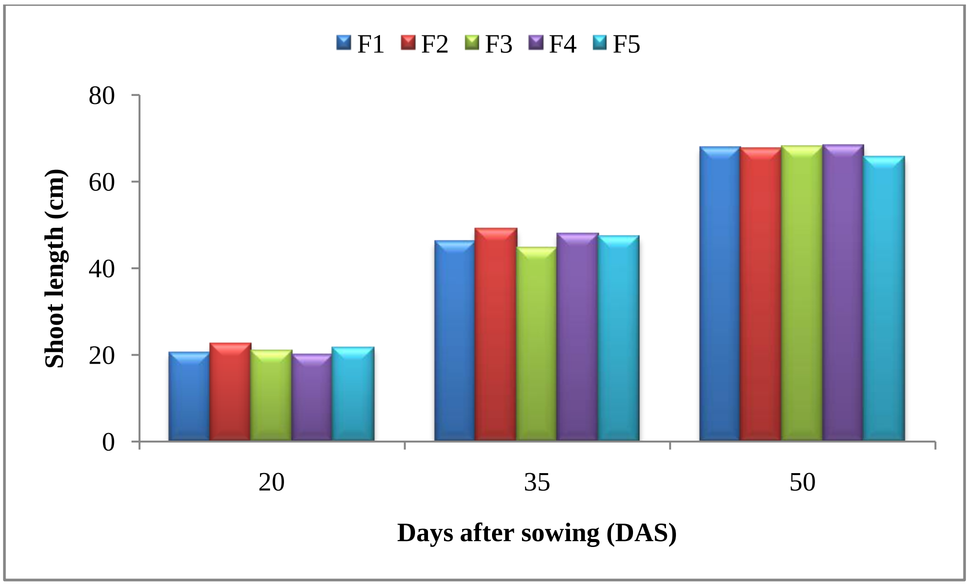


V_1 = BARI mung 4 and V_2 = BARI mung 6

Figure 13. Effect of variety on shoot length of mungbean at different days after sowing (LSD $_{(0.05)}$ = 1.35 and 11.71 at 20 and 50 DAS, respectively)

4.1.7.2 Effect of different levels of nitrogen

Nitrogen level had no significant effect on shoot length (Appendix X and Figure 14). Shoot length was unaffected by the different nitrogen levels at 20, 35 and 50 DAS. At 20 DAS, the numerically maximum shoot length (22.54 cm) was obtained in F_2 and minimum shoot length (20.08 cm) was obtained from F_4. At 35 DAS, the maximum shoot length (49.08 cm) was obtained in F_5 and minimum shoot length (46.24 cm) was obtained from F_1. At 50 DAS, the maximum shoot length (68.45 cm) was obtained in F_5 and minimum shoot length (65.75 cm) was obtained from F_1.



F_1 = No nitrogen; F_2 = 20 kg N as basal; F_3 = 10 kg N as basal + 10 kg N as split; F_4 = 40 kg N as basal and F_5 = 20 kg N as basal + 20 kg N as split

Figure 14. Effect of different nitrogen levels on shoot length of mungbean at different days after sowing

4.1.7.3 Interaction effect of variety and different levels of nitrogen

Significant interaction effect between the variety and nitrogen level was observed at 20, 35, 50 DAS on shoot length (Appendix X and Table 7).

At 20, 35 DAS and at harvest, the tallest shoot length (25.66, 56.05 and 77.97 cm, respectively) was obtained from the V_2F_5 which was statistically similar with the interaction of V_2F_4 and V_2F_3 at 20 DAS; V_2F_4, V_2F_3, V_2F_2 and V_1F_5 at 35 DAS; V_2F_4, V_2F_3, V_2F_2 and V_2F_1 at harvest. The shortest shoot length (18.60 cm) was found in V_1F_1 at 20 DAS which was statistically similar with the interaction of V_1F_4, V_1F_3, V_1F_2, V_1F_5, V_2F_1 and V_1F_2. At 35 DAS, the shortest shoot length (42.11 cm) was found in V_1F_2 which was statistically similar with all the treatment combinations except V_2F_4 and V_2F_5. At 50 DAS, the tallest shoot length was obtained from interaction V_2F_5 (77.97 cm) which was statistically similar with the interaction of V_2F_4, V_2F_3, V_2F_2 and V_2F_1. The shortest shoot length was (58.87 cm) was found in V_1F_1 which was statistically similar with the interaction of V_1F_2, V_1F_3, V_1F_4 and V_1F_5.

Table 7. Interaction effect of variety and nitrogen level on shoot length of mungbean at different days after sowing (DAS)

Treatments	Shoot length (cm) at different days after sowing		
	20	**35**	**50**
V_1F_1	18.60 c	42.67 bc	58.87 b
V_1F_2	19.42 bc	42.11 c	58.93 b
V_1F_3	19.17 bc	43.19 bc	60.90 b
V_1F_4	18.70 c	44.38 bc	62.17 b
V_1F_5	21.92 bc	47.10 a-c	62.03 b
V_2F_1	21.46 bc	46.21 bc	72.63 a
V_2F_2	21.52 bc	47.32 a-c	73.54 a
V_2F_3	22.38 ab	49.82 a-c	74.39 a
V_2F_4	22.63 ab	51.77 ab	74.57 a
V_2F_5	25.66 a	56.05 a	77.97 a
LSD $_{(0.05)}$	3.55	9.39	9.51
CV (%)	9.69	11.52	8.13

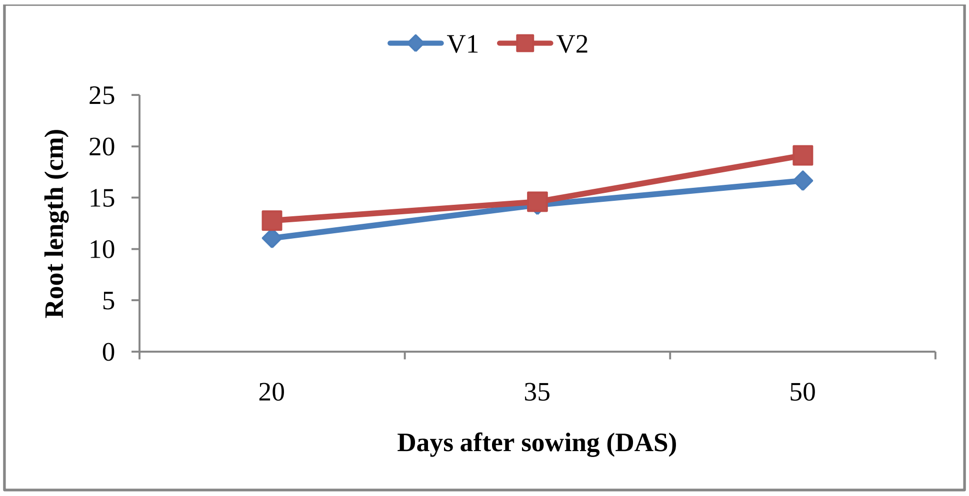
V_1 = BARI mung 4; V_2 = BARI mung 6; F_1 = No nitrogen; F_2 = 20 kg N as basal; F_3 = 10 kg N as basal + 10 kg N as split; F_4 = 40 kg N as basal and F_5 = 20 kg N as basal + 20 kg N as split

4.1.8 Root length (cm)

4.1.8.1 Effect of variety

The root length of two varieties of mungbean was significantly varied at 20 DAS only (Appendix XI and Figure 15).

At 20 DAS, the V_2 produced the higher root length (12.75 cm) and the V_1 gave the shorter root length (11.04 cm). At 35 and 50 DAS, root length was not significantly varied due to varietal difference.

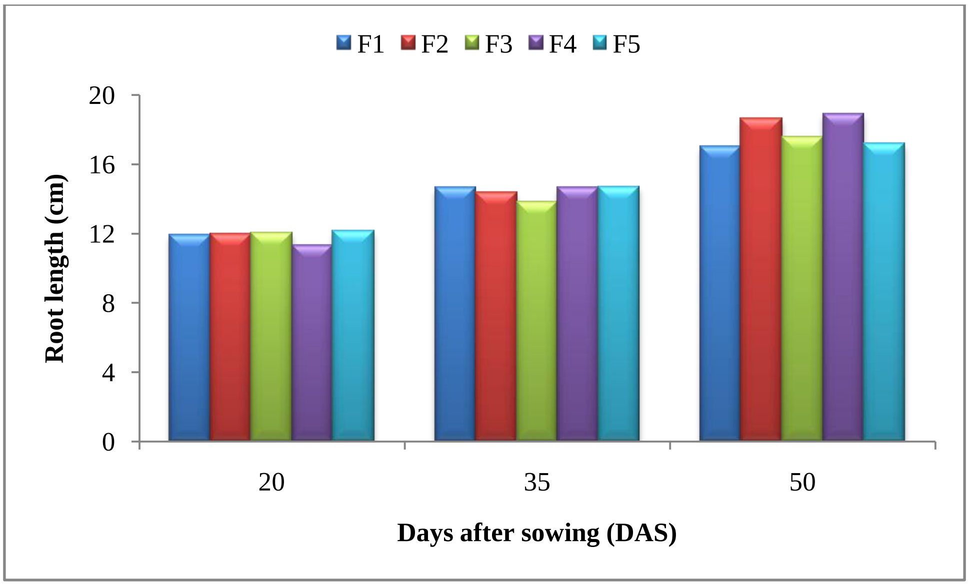


V_1 = BARI mung 4 and V_2 = BARI mung 6

Figure 15. Effect of variety on root length of mungbean at different days after sowing (LSD $_{(0.05)}$ = 1.18 at 20 DAS)

4.1.8.2 Effect of different levels of nitrogen

Nitrogen level had no significant effect on root length throughout the growing season (Appendix XI and Figure 16). Root length was unaffected by the different nitrogen levels at 20, 35 and 50 DAS. At 20 and 35 DAS, the tallest root length (12.14 and 14.72 cm, respectively) was obtained from F_5; at 50 DAS, the tallest root length (18.92 cm) was obtained from F_4. At 20 DAS, the shortest root length (11.34 cm) was obtained from F_4. At 35 DAS, the shortest root length (13.84 cm) was obtained from F_3. At 50 DAS, the shortest root length (17.04 cm) was obtained from F_1.



F_1 = No nitrogen; F_2 = 20 kg N as basal; F_3 = 10 kg N as basal + 10 kg N as split; F_4 = 40 kg N as basal and F_5 = 20 kg N as basal + 20 kg N as split

Figure 16. Effect of different nitrogen levels on root length of mungbean at different days after sowing

4.1.8.3 Interaction effect of variety and different levels of nitrogen

Significant interaction effect between the variety and nitrogen level was observed at 20, 35 and 50 DAS on root length (Appendix XI and Table 8).

At 20 DAS, the tallest root length was obtained from the V_2F_3 (13.59 cm) which was statistically similar with the interaction of V_2F_1, V_2F_4, V_2F_5, V_2F_2, V_1F_5 and V_1F_2. The shortest root length (10.30 cm) was found in V_1F_1 which was statistically similar with the interaction of V_1F_3, V_1F_4, V_1F_5, V_1F_2, V_2F_4 and V_2F_2. At 35 DAS, the tallest root length was obtained from the V_2F_4 (15.75 cm) which was statistically similar with the interaction of V_2F_5, V_2F_1, V_1F_3, V_1F_2, V_1F_1, V_1F_5 and V_2F_2. The shortest root length was (12.56 cm) was found in V_2F_3 which was statistically similar with the interaction of V_1F_4, V_1F_5, V_2F_2, V_1F_1 and V_1F_2. At 50 DAS, the tallest root length was recorded at V_2F_5 (20.76 cm) which was statistically similar with the interaction of V_1F_4, V_1F_3, V_1F_5, V_1F_1 and V_2F_4. The shortest root length (15.90 cm) was in V_2F_3 which was statistically similar with all the interactions except V_2F_5.

Table 8. Interaction effect of variety and nitrogen level on root length of mungbean at different days after sowing (DAS)

Treatments	Root length (cm) at different days after sowing		
	20	**35**	**50**
V_1F_1	10.30 c	14.33 a-c	17.55 ab
V_1F_2	11.77 a-c	14.49 a-c	16.19 b
V_1F_3	10.55 bc	15.13 ab	19.27 ab
V_1F_4	11.05 bc	13.50 bc	19.73 ab
V_1F_5	11.55 a-c	14.00 a-c	18.23 ab
V_2F_1	13.57 a	14.93 ab	16.53 b
V_2F_2	12.26 a-c	14.31 a-c	16.50 b
V_2F_3	13.59 a	12.56 c	15.90 b
V_2F_4	11.62 a-c	15.75 a	18.10 ab
V_2F_5	12.72 ab	15.45 ab	20.76 a
$LSD_{(0.05)}$	2.20	2.04	4.10
CV (%)	10.7	8.14	13.24

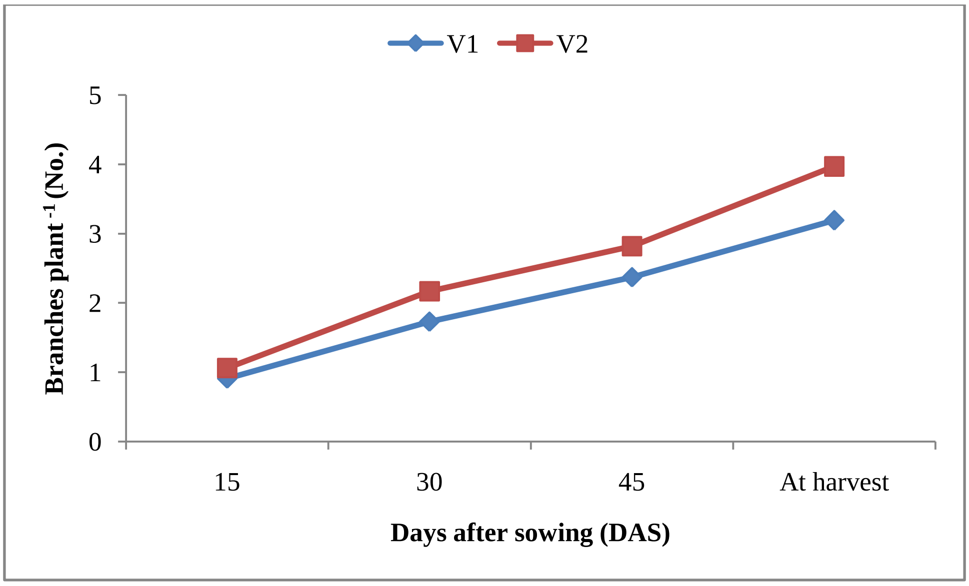
V_1 = BARI mung 4; V_2 = BARI mung 6; F_1 = No nitrogen; F_2 = 20 kg N as basal; F_3 = 10 kg N as basal + 10 kg N as split; F_4 = 40 kg N as basal and F_5 = 20 kg N as basal + 20 kg N as split

4.2 Yield and other crop characters

4.2.1 Number of branches plant^{-1}

4.2.1.1 Effect of variety

The number of branches plant^{-1} was significantly influenced by varietal variation except 15 DAS (Appendix XII and Figure 17). Results showed that, the V_2 produced maximum number of branches plant^{-1} (2.17, 2.82 and 3.97 at 30, 45 DAS and at harvest, respectively) where as the minimum branches plant^{-1} was obtained from V_1 (1.73, 2.37 and 3.19 at 30, 45 DAS and at harvest). The variation in the production of branches plant^{-1} might be due to genetic constituents of the crops.

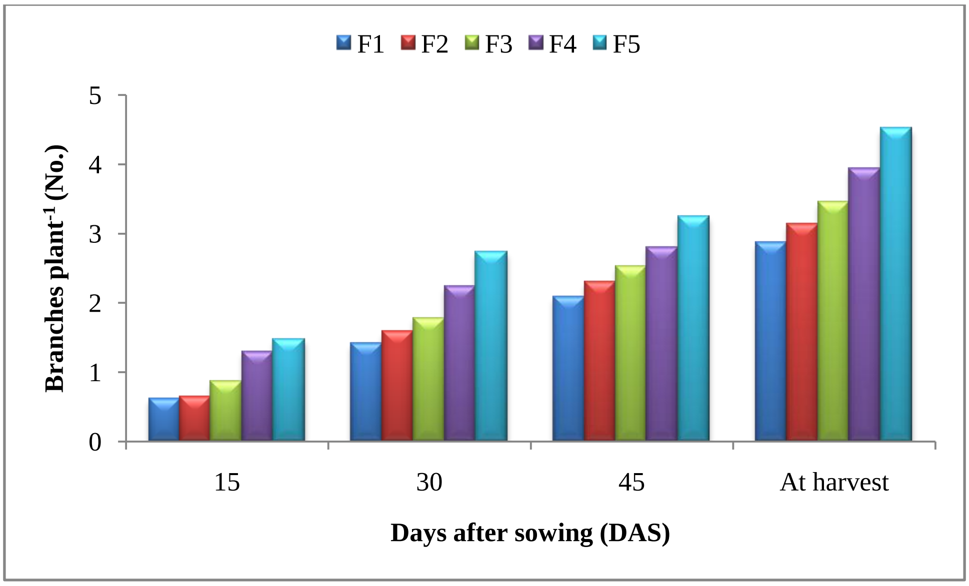


V_1 = BARI mung 4 and V_2 = BARI mung 6

Figure 17. Effect of variety on No. of branches plant^{-1} of mungbean at different days after sowing (LSD $_{(0.05)}$ = 0.20, 0.05 and 0.20 at 30, 45 DAS and at harvest, respectively)

4.2.1.2 Effect of different levels of nitrogen

Different levels of nitrogen significantly influenced the number of branches plant^{-1} (Appendix XII and Figure 18). The maximum number of branches plant^{-1} (1.48, 2.73, 3.25 and 4.52 at 15, 30, 45 DAS and at harvest, respectively) were obtained from the F_5 which was statistically at par with F_4 (1.3) at 15 DAS only. On the other hand the lowest number of branches plant^{-1} (0.62, 1.42, 2.09 and 2.87 at 15, 30, 45 DAS and at harvest, respectively) were obtained from F_1 which was statistically similar with F_2 and F_3 at 15 DAS; F_2 at 30, 45 DAS and at harvest respectively.



F_1 = No nitrogen; F_2 = 20 kg N as basal; F_3 = 10 kg N as basal + 10 kg N as split; F_4 = 40 kg N as basal and F_5 = 20 kg N as basal + 20 kg N as split

Figure 18. Effect of different nitrogen levels on No. of branches plant^{-1} of mungbean at different days after sowing (LSD $_{(0.05)}$ = 0.36, 0.20, 0.23 and 0.28 at 15, 30, 45 DAS and at harvest, respectively)

4.2.1.3 Interaction effect of variety and different levels of nitrogen

The number of branches plant^{-1} was significantly influenced by the interaction effect of variety and different levels of nitrogen (Appendix XII and Table 9). The maximum number of branches plant^{-1} (1.77, 3.03, 3.7 and 5.13 at 15, 30, 45 DAS and at harvest, respectively) were obtained from the V_2 with the interaction of F_5, which was similar to the interaction of V_2F_4 at 15 DAS. The lowest number of branches plant^{-1} (0.53) was obtained from V_2F_1 at 15 DAS which was statistically similar with V_1F_1, V_2F_1, V_1F_2, V_1F_3 and V_2F_3. Again the lowest of branches plant^{-1} (1.27, 1.78 and 2.73 at 30, 45 DAS and at harvest, respectively) were recorded from the combination of V_1F_1 which was statistically similar with V_1F_2 at 30 DAS; V_1F_2, V_1F_3 and V_2F_1 at harvest.

Table 9. Interaction effect of variety and nitrogen level on number of branches plant^{-1} of mungbean at different days after sowing (DAS)

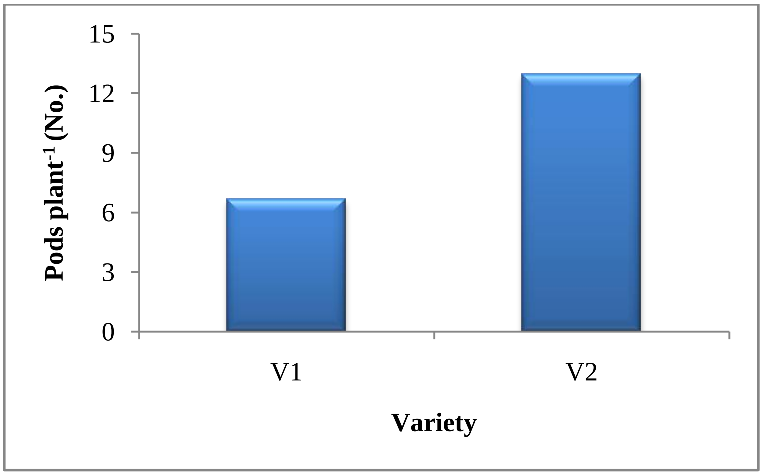
Treatments	No. of branches plant^{-1} (No.) at different days after sowing			
	15	30	45	At harvest
V_1F_1	0.60 de	1.27 f	1.78 f	2.73 e
V_1F_2	0.77 c-e	1.37 ef	2.13 e	2.90 e
V_1F_3	0.87 c-e	1.60 de	2.4 de	3.00 de
V_1F_4	1.10 b-d	1.97 c	2.73 bc	3.40 d
V_1F_5	1.20 bc	2.43 b	2.80 b	3.90 c
V_2F_1	0.63 de	1.57 de	2.40 de	3.00 de
V_2F_2	0.53 e	1.80 cd	2.47 cd	3.37 d
V_2F_3	0.87 c-e	1.97 c	2.67 b-d	3.90 c
V_2F_4	1.50 ab	2.50 b	2.87 b	4.47 b
V_2F_5	1.77 a	3.03 a	3.70 a	5.13 a
LSD (0.05)	0.51	0.28	0.33	0.40
CV (%)	29.76	8.43	7.35	6.49

V_1 = BARI mung 4; V_2 = BARI mung 6; F_1 = No nitrogen; F_2 = 20 kg N as basal F_3 = 10 kg N as basal + 10 kg N as split; F_4 = 40 kg N as basal and F_5 = 20 kg N as basal + 20 kg N as split

4.2.2 Number of pods plant^{-1}

4.2.2.1 Effect of variety

The number of pods plant^{-1} was significantly influenced by varietal variation (Appendix XIII and Figure 19). Results showed that, the V_2 produced maximum number of pods (12.97 plant^{-1}) and the minimum was obtained from V_1 (6.64 plant^{-1}). The variation in the production of pods plant^{-1} might be due to genetic constituents of the crops.

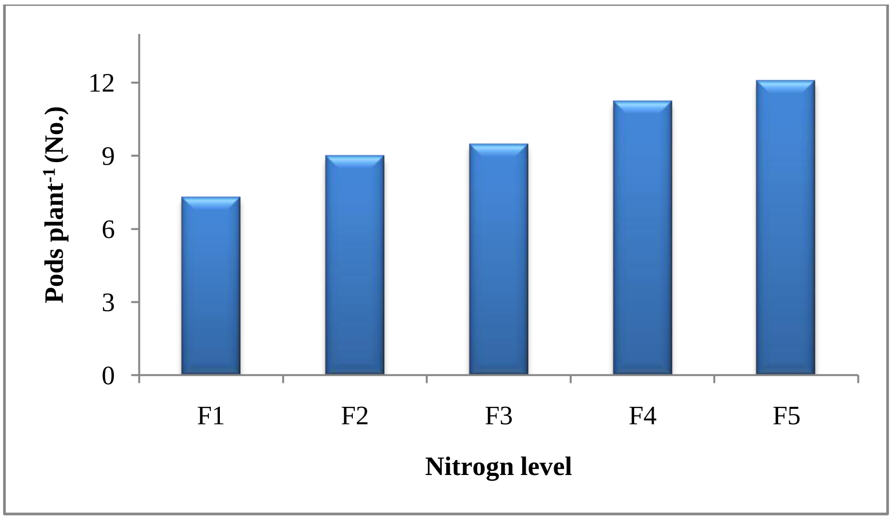


V_1 = BARI mung 4 and V_2 = BARI mung 6

Figure 19. Effect of variety on pods plant^{-1} of mungbean (LSD $_{(0.05)}$ = 1.30)

4.2.2.2 Effect of different levels of nitrogen

Nitrogen level had significant effect on the number of pods plant^{-1}(Appendix XIII and Figure 20). Results revealed that, treatment F_5 produced maximum number of pods (12.07 plant^{-1}) which was statistically at par with F_4 (11.23 plant^{-1}) and the minimum was obtained from F_1 (7.30 plant^{-1}). Similar findings were reported by Sultana *et al.* (2009); Sarkar and Banik (1991); Hamid (1991). They found that application of N increased the number of pods plant^{-1}. This result indicated that nitrogen at early stage contributed much the initial establishment of crop, where as the second dose of nitrogen helped to produce photosynthats that contribute more partitioning towards the pod development. Mungbean grown without fertilizer obtained the highest number of nodules per plant due to translocation of carbohydrates from nodules to reproductive organ resulting higher pods plant^{-1}.



F_1 = No nitrogen; F_2 = 20 kg N as basal; F_3 = 10 kg N as basal + 10 kg N as split; F_4 = 40 kg N as basal and F_5 = 20 kg N as basal + 20 kg N as split

Figure 20. Effect of different nitrogen levels on pods plant^{-1} of mungbean (LSD $_{(0.05)}$ = 1.15)

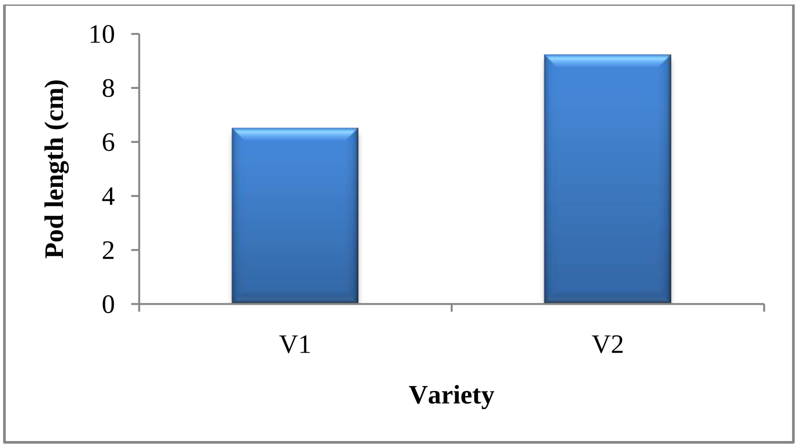
4.2.2.3 Interaction effect of variety and different levels of nitrogen

The number of pods plant^{-1} was significantly influenced by the interaction effect of variety and nitrogen level (Appendix XIII and Table 10). The maximum number of pods plant^{-1} (17.00) was obtained from the V_2F_5. The lowest number of pods plant^{-1} (5.20) was obtained from V_1F_1 which shown similarity with the interaction of V_1F_2 and V_1F_3.

4.2.3 Pod length (cm)

4.2.3.1 Effect of variety

The pod length was significantly influenced by variety (Appendix XIII and Figure 21). The higher (9.20 cm) and lower (6.47 cm) pod length was obtained from V_2 and V_1 respectively.

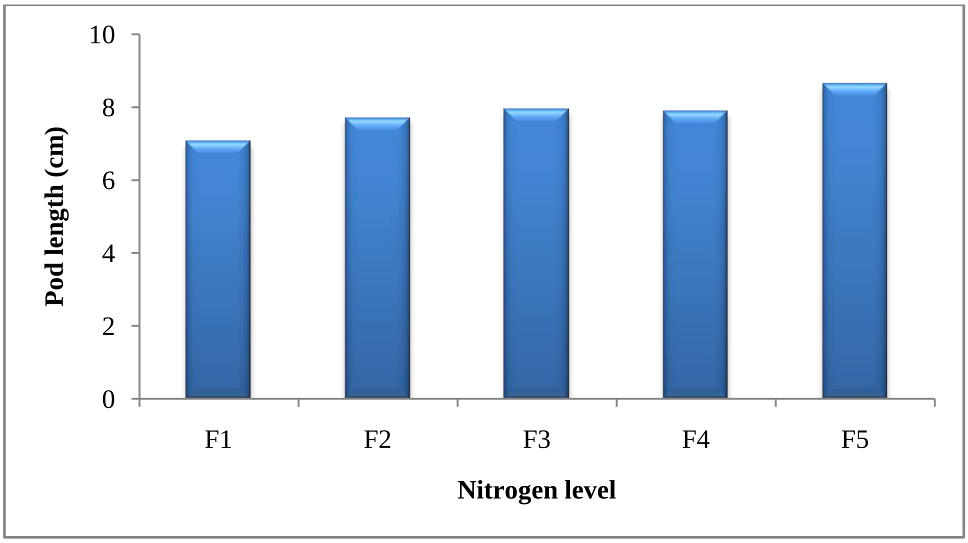


V_1 = BARI mung 4 and V_2 = BARI mung 6

Figure 21. Effect of variety on pod length of mungbean (LSD $_{(0.05)}$ = 7.21)

4.2.3.2 Effect of different levels of nitrogen

There was significant difference observed in pod length due to variation of nitrogen level (Appendix XIII and Figure 22). The higher pod length (8.64 cm) was observed in F_5. The lower pod length (7.04 cm) was observed in F_1 treatment. It agreed with the results of Sardana and Verma (1987). They found that application of nitrogen, phosphorus and potassium fertilizers resulted significant increases in pod length of mungbean.



F_1 = No nitrogen; F_2 = 20 kg N as basal; F_3 = 10 kg N as basal + 10 kg N as split; F_4 = 40 kg N as basal and F_5 = 20 kg N as basal + 20 kg N as split

Figure 22. Effect of different nitrogen levels on pod length of mungbean (LSD (0.05) = 0.59)

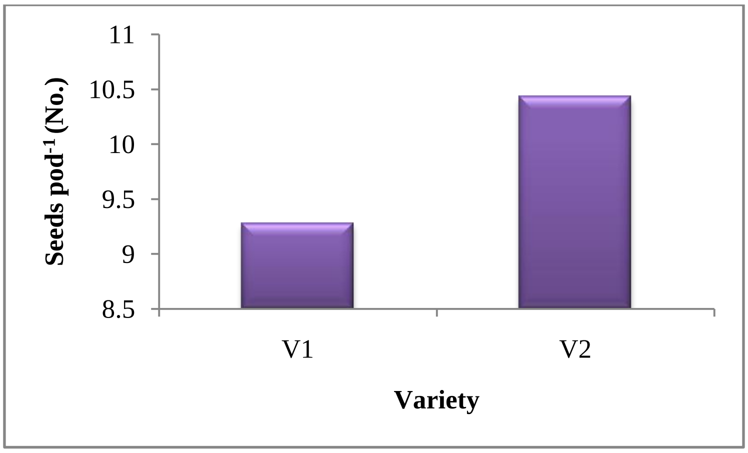
4.2.3.3 Interaction effect of variety and different levels of nitrogen

The pod length was significantly influenced by the interaction effect of variety and nitrogen level (Appendix XIII and Table 10). The highest pod length (9.87 cm) was recorded from the V_2F_5 which was statistically similar with V_2F_4 and V_2F_3. The lowest pod length (5.57 cm) was obtained from the V_1F_1.

4.2.4 Number of seeds pod^{-1}

4.2.4.1 Effect of variety

The number of seeds pod^{-1} was significantly influenced by the variety (Appendix XIII and Figure 23). The V_2 produced higher number of seeds pod^{-1} (10.43) and the V_1 produced lower number of seeds pod^{-1} (9.28). The number of seeds pod^{-1} was 12.39% higher in V_2 than V_1.

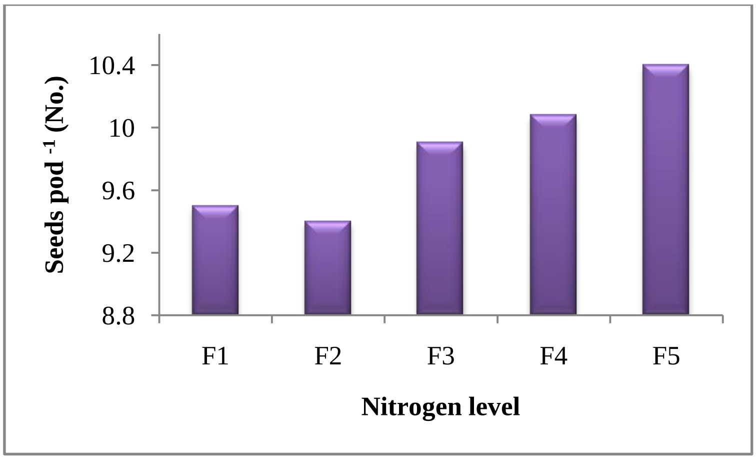


V_1 = BARI mung 4 and V_2 = BARI mung 6

Figure 23. Effect of variety on seeds pod^{-1} of mungbean (LSD $_{(0.05)}$ = 0.42)

4.2.4.2 Effect of different levels of nitrogen

Nitrogen level had no significant effect on the number of seeds pod^{-1} (Appendix XIII and Figure 24). The maximum number of seeds pod^{-1} was recorded from the F_5 (10.40) and the minimum number of seeds pod^{-1} was recorded from F_2 (9.40) through the difference was statistically similar. The result was opposite to the report of Hamid (1991) who stated that the application of N fertilizer produced the higher number of seeds pod^{-1} in mungbean.



F_1 = No nitrogen; F_2 = 20 kg N as basal; F_3 = 10 kg N as basal + 10 kg N as split; F_4 = 40 kg N as basal and F_5 = 20 kg N as basal + 20 kg N as split

Figure 24. Effect of different nitrogen levels on seeds pod^{-1} of mungbean (LSD $_{(0.05)}$ = NS)

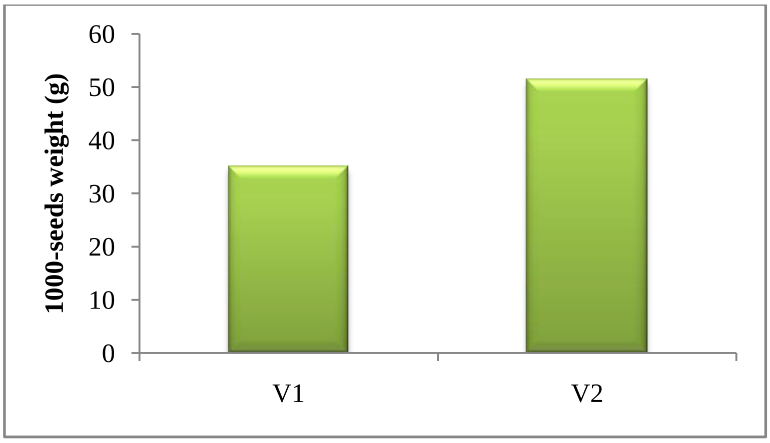
4.2.4.3 Interaction effect of variety and different levels of nitrogen

The number of seeds pod^{-1} was significantly influenced by the interaction effect of variety and nitrogen level (Appendix XIII and Table 10). The highest number of seeds pod^{-1} (11.00) was obtained from V_2 with the interaction of F_5, which was similar with the interaction of V_2F_4, V_2F_3, V_2F_2, V_2F_1, V_1F_5 and V_1F_4. The lowest number of seeds pod^{-1} (8.80) was obtained from V_1 with the interaction of F_1 which was similar with the interaction of V_1F_2, V_1F_3, V_1F_4, V_1F_5, V_2F_1 and V_2F_2.

4.2.5 Weight of 1000-seeds (g)

4.2.5.1 Effect of variety

The weight of 1000-seeds was significantly influenced by the variety (Appendix XIII and Figure 25). The highest weight of 1000-seeds (51.42 g) was obtained from V_2 and the lowest weight of 1000-seeds (34.98 g) was obtained from V_1. The variation of 1000-seeds weight between two varieties might be due to genetic constituents of the crops. The result of the present investigation was similar with the studies conducted by Thakuria and Shaharia (1990); Trung and Yoshida (1983); Sarkar and Banik (1991); Sardana and Verma (1987). They followed that 1000-seeds weight was differed significantly among the mungbean varieties.

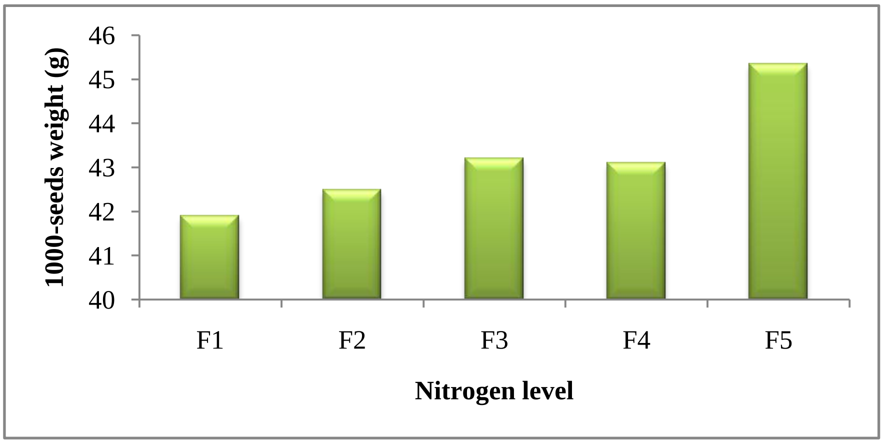


V_1 = BARI mung 4 and V_2 = BARI mung 6

Figure 25. Effect of variety on 1000-seeds weight of mungbean (LSD $_{(0.05)}$ = 1.02)

4.2.5.2 Effect of different levels of nitrogen

There was significant variation observed among the variety and nitrogen level in respect of weight of 1000-seeds (Appendix XIII and Figure 26). The highest weight of 1000-seeds (45.34 g) was obtained from the F_5 and the minimum weight of 1000-seeds (41.90 g) was obtained from the F_1 which was statistically at par with F_2, F_3 and F_4 treatments. These results had agreements with the findings of Trung and Yoshida (1983); Sarkar and Banik (1991); Quah and Jaafar (1994) and also simillar with Sardana and Verma (1987). They reported that 1000-seed wt. in munghean increased with the application of N.



F_1 = No nitrogen; F_2 = 20 kg N as basal; F_3 = 10 kg N as basal + 10 kg N as split; F_4 = 40 kg N as basal and F_5 = 20 kg N as basal + 20 kg N as split

Figure 26. Effect of different nitrogen levels on 1000-seeds weight (g) of mungbean (LSD $_{(0.05)}$ = 1.86)

4.2.5.3 Interaction effect of variety and different levels of nitrogen

Interaction effect between variety and nitrogen level was found significant in respect of weight of 1000-seeds (Appendix XIII and Table 10). The highest weight of 1000-seeds (54.29 g) was obtained from V_2F_5. The lowest weight of 1000-seeds (34.23 g) was obtained from V_1F_2 which was similar with the interaction of V_1F_1, V_1F_3, V_1F_4 and V_1F_5.

Table 10. Interaction effect of variety and nitrogen level on pods plant^{-1}, pod length, seeds pod^{-1} and 1000-seeds wt. of mungbean

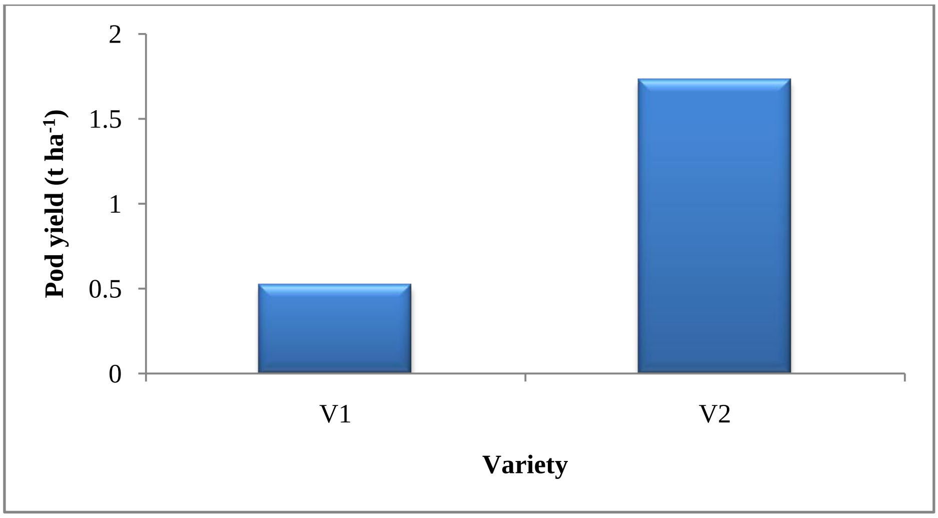
Treatments	Pods plant^{-1} (cm)	Pod length (cm)	Seeds pod^{-1} (No.)	1000 seeds wt. (g)
V_1F_1	5.2 g	5.57 f	8.8 d	34.83 d
V_1F_2	6.13 fg	6.35 e	9.03 cd	34.23 d
V_1F_3	6.47 fg	6.60 e	9.27 b-d	35.12 d
V_1F_4	8.27 de	6.41 e	9.50 a-d	34.34 d
V_1F_5	7.13 ef	7.4 d	9.80 a-d	36.39 d
V_2F_1	9.4 d	8.51 c	10.2 a-d	48.97 c
V_2F_2	11.8 c	9.03 bc	9.77 a-d	50.73 bc
V_2F_3	12.47 c	9.24 a-c	10.53 a-c	51.26 bc
V_2F_4	14.20 b	9.32 ab	10.67 ab	51.85 ab
V_2F_5	17.00 a	9.87 a	11.00 a	54.29 a
LSD $_{(0.05)}$	1.63	0.76	1.55	2.62
CV (%)	9.61	5.63	9.06	3.51

V_1 = BARI mung 4; V_2 = BARI mung 6; F_1 = No nitrogen; F_2 = 20 kg N as basal F_3 = 10 kg N as basal + 10 kg N as split; F_4 = 40 kg N as basal and F_5 = 20 kg N as basal + 20 kg N as split

4.2.6 Pod yield (t ha^{-1})

4.2.6.1 Effect of variety

Pod yield was significantly influenced by the variety (Appendix XIII and Figure 27). The higher pod yield (1.73 t ha^{-1}) was obtained from the V_2 compared to the yield (0.52 t ha^{-1}) of V_1.

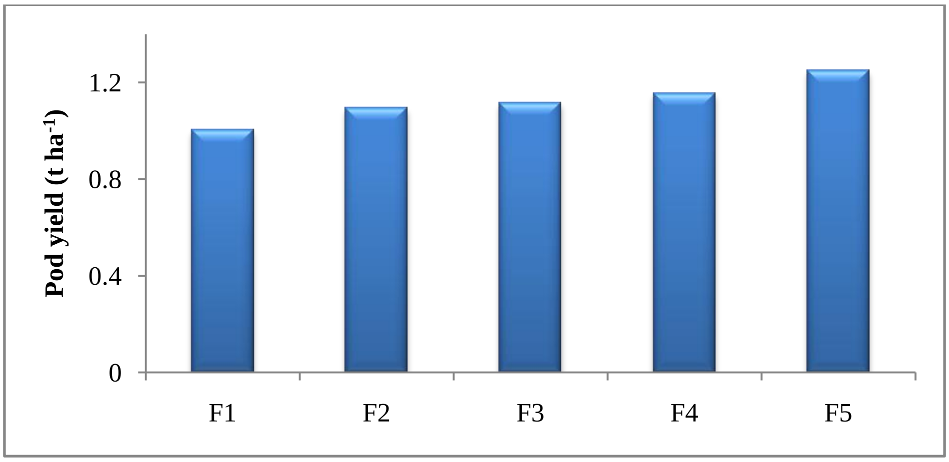


V_1 = BARI mung 4 and V_2 = BARI mung 6

Figure 27. Effect of variety on pod yield of mungbean (LSD $_{(0.05)}$ = 0.13)

4.2.6.2 Effect of different levels of nitrogen

Nitrogen level had significant effect on seed yield (Appendix XIII and Figure 28). The F_5 produced significantly the highest pod yield (1.25 t ha^{-1}) which was similar with the F_4, F_3 and F_2. The lowest seed yield (1.00 t ha^{-1}) was obtained from F_1 which was similar with the F_2, F_3 and F_4.



F_1 = No nitrogen; F_2 = 20 kg N as basal; F_3 = 10 kg N as basal + 10 kg N as split; F_4 = 40 kg N as basal and F_5 = 20 kg N as basal + 20 kg N as split

Figure 28. Effect of different nitrogen levels on pod yield of mungbean (LSD $_{(0.05)}$ = 0.16)

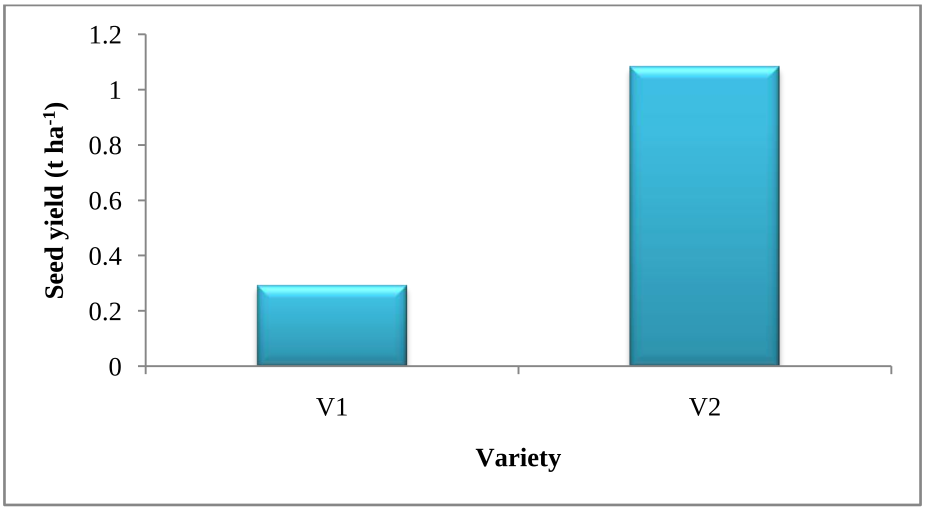
4.2.6.3 Interaction effect of variety and different levels of nitrogen

Interaction effect between variety and nitrogen level was found significant in respect of pod yield (Appendix XIII and Table 11). The highest pod yield (1.87 t ha^{-1}) was obtained from V_2F_5 which was similar with the interaction of V_2F_4, V_2F_3 and V_2F_2. The lowest pod yield (0.45 t ha^{-1}) was obtained from V_1F_1 which was similar with the interaction of V_1F_2, V_1F_3, V_1F_4 and V_1F_5.

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

4.2.7.1 Effect of variety

Seed yield was significantly influenced by the variety (Appendix XIII and Figure 29). The highest seed yield (1.08 t ha^{-1}) was obtained from the V_2 compared to the yield (0.29 t ha^{-1}) of V_1 which was 272.41% higher than V_1. These results have agreement with the reports of Ashraf *et al*. (2003); Prasad and Ram (1982); Shanmugam and Rangsamy (1983); Thakuria and Shaharia (1990). They noted that different varieties of mungbean differed significantly in case of seed yield. Chinchest *et al*. (1987) of course, disagreed with this result. They reported that there were no differences in yield of various mungbean cultivars treated with fertilizers. Mozumder *et al*. (2003) also reported that application of 40 kg N ha^{-1} gave the highest seed yield.

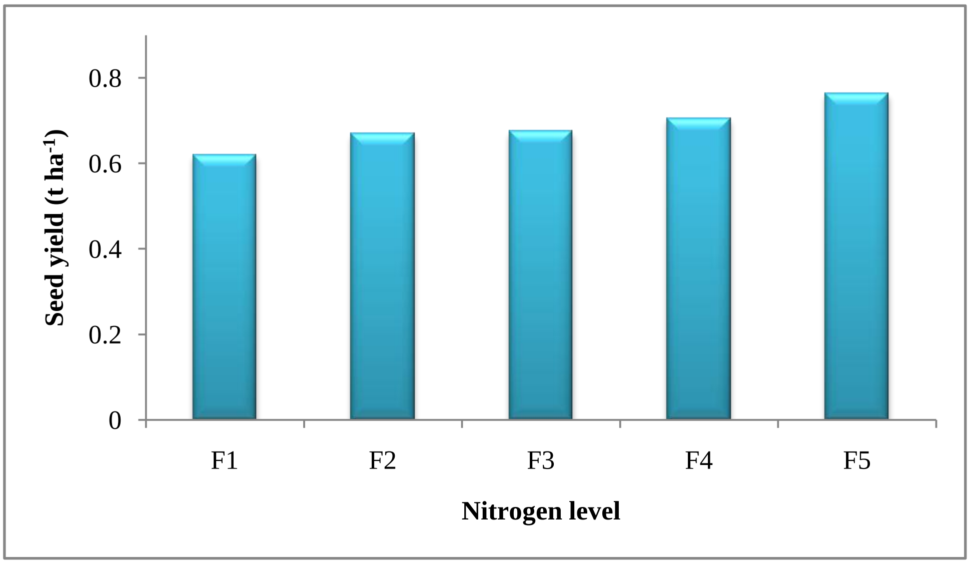


V_1 = BARI mung 4 and V_2 = BARI mung 6

Figure 29. Effect of variety on seed yield of mungbean (LSD $_{(0.05)}$ = 0.11)

4.2.7.2 Effect of different levels of nitrogen

Nitrogen level had significant effect on seed yield (Appendix XIII and Figure 30). The F_5 produced significantly highest seed yield (0.76 t ha^{-1}) which was similar with F_4 and F_3 and the lowest seed yield (0.62 t ha^{-1}) was obtained from F_1 which was similar with F_2, F_3 and F_4. This result was in agreement with the findings reported by Hamid (1991); Sarkar and Banik (1991); Quah and Jaafar (1994) and Mandal and Sikder (1999) but in disagreement with the findings reported by Mahmoud and Gad (1988); Huesca and Orya (1981). The last reports with disagreements explained that N had no significant effects on seed yield of mungbean. This result also showed that application of N at different growth stages of mungbean ultimately increased seed yield. Similar result was also found by Satyanarayanamma *et al.* (1996). They reported that spraying urea at flowering and at pod development stages produced the highest seed yield.



F_1 = No nitrogen; F_2 = 20 kg N as basal; F_3 = 10 kg N as basal + 10 kg N as split; F_4 = 40 kg N as basal and F_5 = 20 kg N as basal + 20 kg N as split

Figure 30. Effect of different nitrogen levels on seed yield of mungbean (LSD $_{(0.05)}$ = 0.09)

4.2.7.3 Interaction effect of variety and different levels of nitrogen

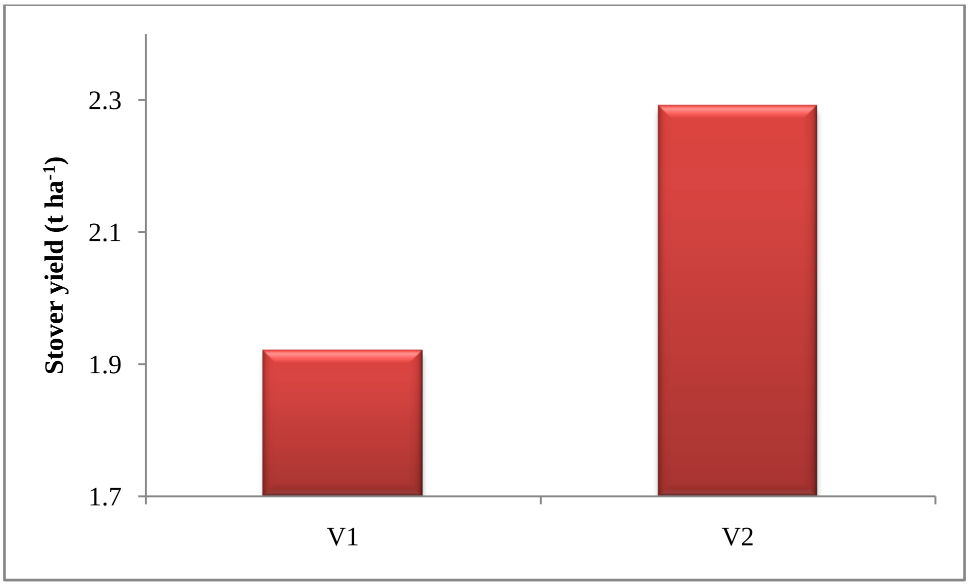
Interaction effect between variety and nitrogen level was found significant in respect of seed yield (Appendix XIII and Table 11). The highest seed yield (1.17 t ha^{-1}) was obtained from V_2F_5 which was similar with the interaction of V_2F_4, V_2F_3 and V_2F_2.

The lowest seed yield (0.25 t ha^{-1}) was obtained from V_1F_1 which were similar with the interaction of V_1F_3, V_1F_2, V_1F_4 and V_1F_5. This result of the present study might be due to the similar response of two varieties to nitrogen.

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

4.2.8.1 Effect of variety

Stover yield was not significantly influenced by the variety (Appendix XIII and Figure 31). The numerically maximum stover yield (2.29 t ha^{-1}) was obtained from the V_2 compared to the yield (1.92 t ha^{-1}) of V_1. The V_2 gave 19.27 % higher yield than the V_1.

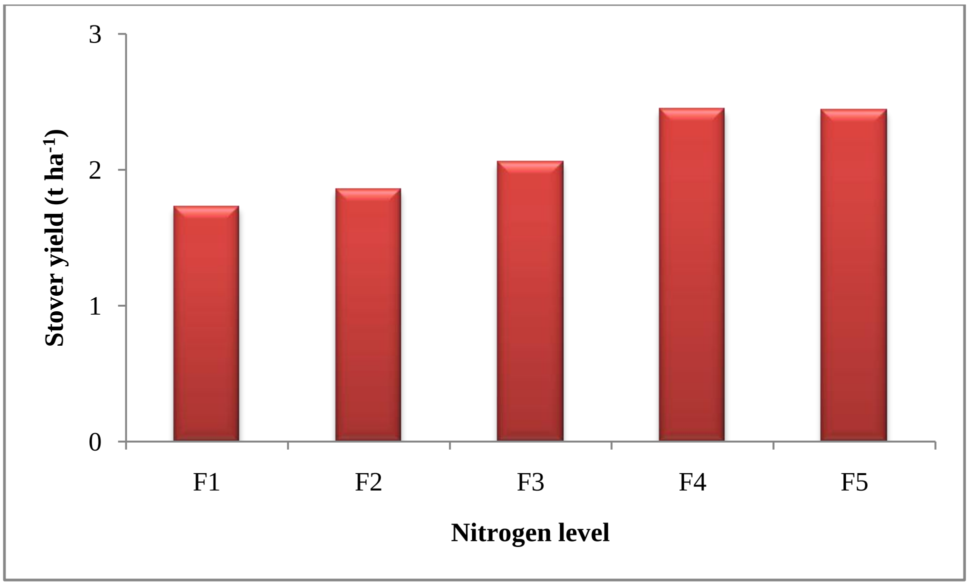


V_1 = BARI mung 4 and V_2 = BARI mung 6

Figure 31. Effect of variety on stover yield of mungbean

4.2.8.2 Effect of different levels of nitrogen

Nitrogen level had significant effect on stover yield (Appendix XIII and Figure 32). The F_4 produced significantly the highest stover yield (2.44 t ha^{-1}) which was similar to F_5. The lowest stover yield (1.73 t ha^{-1}) was obtained from F_1 that similar to F_2. The simillar result was also found by Mahmoud and Gad (1988); Sarkar and Banik (1991). They observed that N application increased the straw production up to a certain level.



F_1 = No nitrogen; F_2 = 20 kg N as basal; F_3 = 10 kg N as basal + 10 kg N as split; F_4 = 40 kg N as basal and F_5 = 20 kg N as basal + 20 kg N as split

Figure 32. Effect of different nitrogen levels on stover yield of mungbean (LSD $_{(0.05)}$ = 0.29)

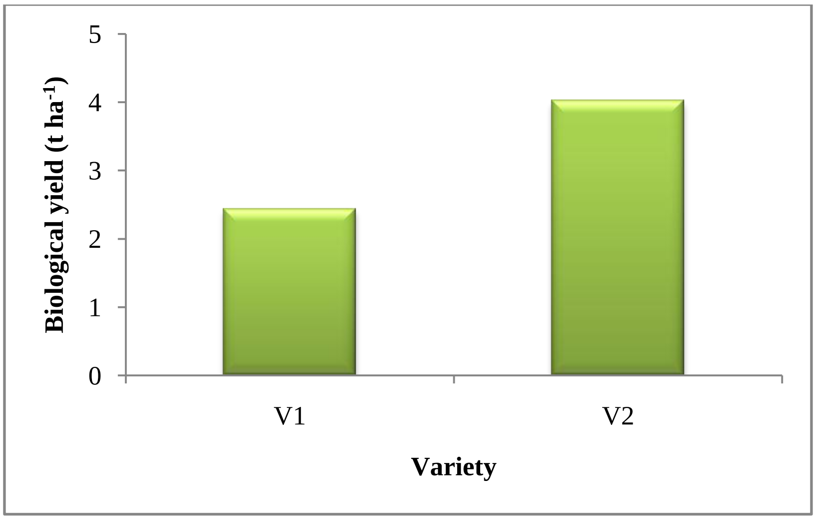
4.2.8.3 Interaction effect of variety and different levels of nitrogen

Interaction effect between variety and nitrogen level was found significant in respect of stover yield (Appendix XIII and Table 11). The highest stover yield (2.67 t ha^{-1}) was obtained from V_2F_5 which was similar to the interaction of V_2F_4, V_1F_4 and V_2F_3. The lowest stover yield (1.47 t ha^{-1}) was obtained from V_1F_1 which was similar to the interaction of V_1F_2 and V_1F_3. It might be due to the maximum number of leaves plant^{-1}, taller plants, higher no. of branches plant^{-1} and number of pods plant^{-1} that contributed to the highest stover yield.

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

4.2.9.1 Effect of variety

Biological yield was significantly influenced by the variety (Appendix XIII and Figure 33). The highest biological yield (4.02 t ha^{-1}) was obtained from the V_2 compared to the yield (2.44 t ha^{-1}) of V_1. The V_2 gave 65.57 % higher biological yield than the V_1.

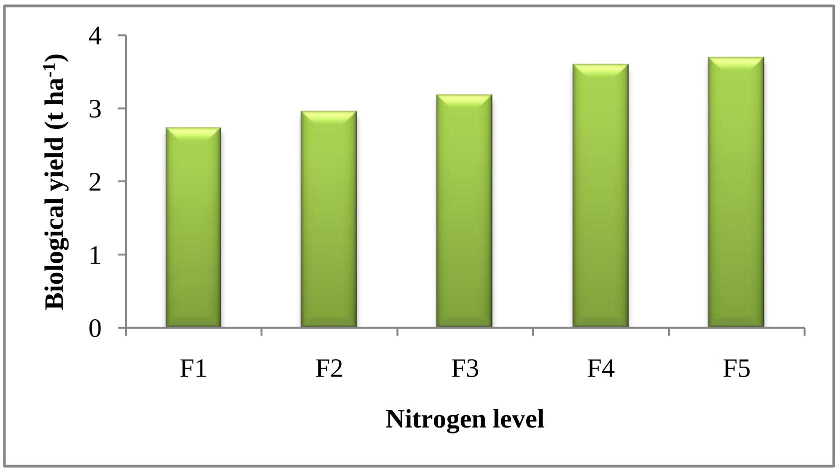


V_1 = BARI mung 4 and V_2 = BARI mung 6

Figure 33. Effect of variety on biological yield of mungbean (LSD $_{(0.05)}$ = 0.54)

4.2.9.2 Effect of different levels of nitrogen

Nitrogen level had significant effect on biological yield (Appendix XIII and Figure 34). The F_5 produced significantly the highest biological yield (3.69 t ha^{-1}) which was similar to F_4. The lowest biological yield (2.73 t ha^{-1}) was obtained from F_1.



F_1 = No nitrogen; F_2 = 20 kg N as basal; F_3 = 10 kg N as basal + 10 kg N as split; F_4 = 40 kg N as basal and F_5 = 20 kg N as basal + 20 kg N as split

Figure 34. Effect of different nitrogen levels on biological yield of mungbean (LSD $_{(0.05)}$ = 0.34)

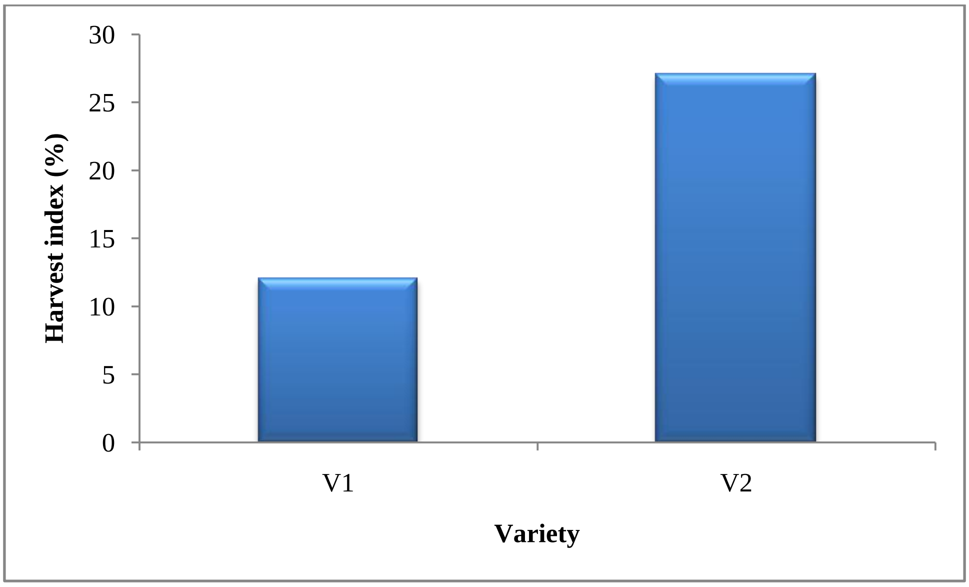
4.2.9.3 Interaction effect of variety and different levels of nitrogen

Interaction effect between variety and nitrogen level was found significant in respect of biological yield (Appendix XIII and Table 11). The highest biological yield (4.54 t ha^{-1}) was obtained from V_2F_5, which was similar to the interaction of V_2F_4. The lowest biological yield (1.92 t ha^{-1}) was obtained from V_1F_1 which was similar to the interaction of V_1F_2 and V_1F_3.

4.2.10 Harvest index (%)

4.2.10.1 Effect of variety

Harvest index was significantly influenced by the varietal variation (Appendix XIII and Figure 35). The higher harvest index (27.07 %) was found from the V_2 and the lower harvest index (12.05%) was found from the V_1.

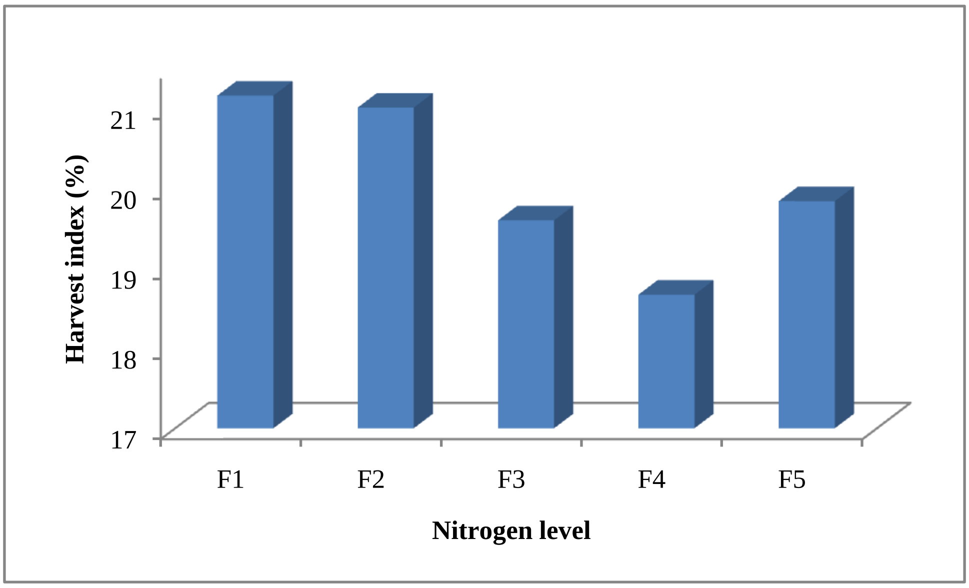


V_1 = BARI mung 4 and V_2 = BARI mung 6

Figure 35. Effect of variety on harvest index of mungbean (LSD $_{(0.05)}$ = 0.53)

4.2.10.2 Effect of different levels of nitrogen

Nitrogen level had significant effect on harvest index (Appendix XIII and Figure 36). Recommended chemical fertilizer produced significantly the highest harvest index (20.66%) which was similar to F_2, F_3 and F_5. The lowest harvest index (18.17%) was obtained from F_4 treatment. The result was similar to the findings of Mozumder (1998), who stated that harvest index (%) was decreased with increased level of N fertilizer. Decreased in Harvest index with increasing N level might be due to higher production of total dry matter than that of grain or seed yield ha^{-1} in the present experiment.



F_1 = No nitrogen; F_2 = 20 kg N as basal; F_3 = 10 kg N as basal + 10 kg N as split; F_4 = 40 kg N as basal and F_5 = 20 kg N as basal + 20 kg N as split

Figure 36. Effect of different nitrogen levels on harvest index of mungbean (LSD $_{(0.05)}$ = 2.40)

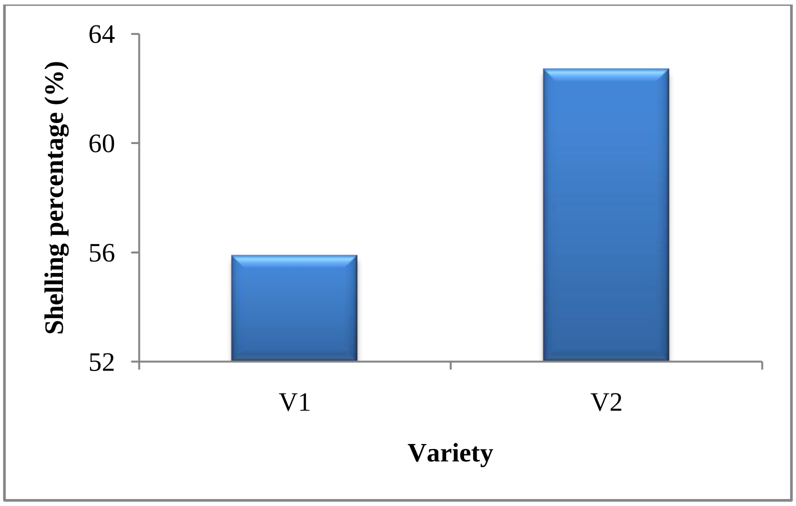
4.2.10.3 Interaction effect of variety and different levels of nitrogen

Interaction effect between variety and nitrogen level was found significant in respect of harvest index (Appendix XIII and Table 11). The highest harvest index (28.87%) was obtained from V_2F_2 which was similar to the interaction of V_2F_1, V_2F_3, V_2F_4 and V_2F_5. The lowest harvest index (10.47%) was obtained from the V_1 with the interaction of $F_{4,}$ which was similar to the interaction of V_1F_1, V_1F_2, V_1F_3 and V_1F_5.

4.2.11 Shelling percentage (%)

4.2.11.1 Effect of variety

Shelling percentage was significant effect by the variety (Appendix XIII and Figure 37). The highest shelling percentage (62.68 %) was found from the V_2 and the lowest shelling percentage (55.88 %) was found from the V_1. The shelling percentage was 12.17 % higher in theV_2 compared to the V_1.

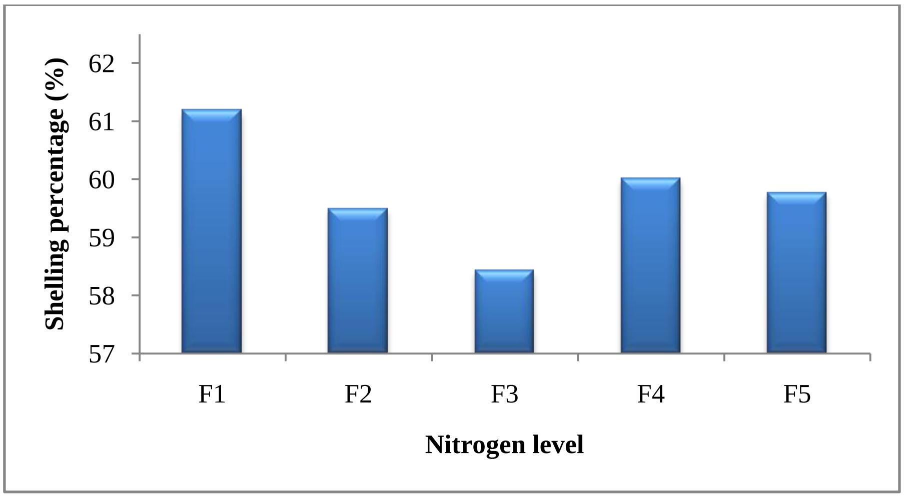


V_1 = BARI mung 4 and V_2 = BARI mung 6

Figure 37. Effect of variety on shelling percentage of mungbean (LSD $_{(0.05)}$ = 4.20)

4.2.11.2 Effect of different levels of nitrogen

Nitrogen level had no significant effect on shelling percentage (Appendix XIII and Figure 38). The F_1 produced the highest shelling percentage (60.68 %) and the lowest shelling percentage (57.92 %) was obtained from F_3.



F_1 = No nitrogen; F_2 = 20 kg N as basal; F_3 = 10 kg N as basal + 10 kg N as split; F_4 = 40 kg N as basal and F_5 = 20 kg N as basal + 20 kg N as split

Figure 38. Effect of different nitrogen levels on shelling percentage of mungbean

4.2.11.3 Interaction effect of variety and different levels of nitrogen

Interaction effect between variety and nitrogen level was found significant in respect of shelling percentage (Appendix XIII and Table 11). The maximum shelling percentage (63.31) was obtained from V_2F_1, which was similar with the interaction of V_2F_4, V_2F_5, V_2F_3, V_2F_2 and V_1F_1. The lowest shelling percentage (53.28) was obtained from V_1F_3 which was statistically at par with V_1F_2, V_1F_5, V_1F_4 and V_1F_1.

Table 11. Interaction effect of variety and nitrogen level on pod yield, seed yield, stover yield, biological yield, HI and shelling percentage of mungbean

Treatments	Pod yield (t ha^{-1})	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)	Shelling percentage (%)
V_1F_1	0.45 c	0.26 c	1.47 f	1.92 f	13.60 b	58.06 ab
V_1F_2	0.47 c	0.27 c	1.71 ef	2.18 f	12.14 b	55.75 b
V_1F_3	0.48 c	0.27 c	1.87 d-f	2.31 f	11.09 b	53.28 b
V_1F_4	0.55 c	0.31 c	2.41 ab	2.96 e	10.47 b	56.31 b
V_1F_5	0.63 c	0.35 c	2.2 b-d	2.83 e	12.92 b	56.00 b
V_2F_1	1.56 b	0.98 b	1.99 c-e	3.54 d	27.72 a	63.31 a
V_2F_2	1.78 ab	1.07 ab	2 c-e	3.72 cd	28.87 a	62.22 a
V_2F_3	1.75ab	1.09 ab	2.29 a-c	4.04 bc	27.12 a	62.55 a
V_2F_4	1.76 ab	1.10 ab	2.48 ab	4.24 ab	25.87 a	62.71 a
V_2F_5	1.87 a	1.17 a	2.673 a	4.54 a	25.76 a	62.55 a
LSD $_{(0.05)}$	0.23	0.13	0.41	0.48	3.39	5.38
CV (%)	11.74	11.42	11.23	8.53	10.01	5.24

V_1 = BARI mung 4; V_2 = BARI mung 6; F_1 = No nitrogen; F_2 = 20 kg N as basal; F_3 = 10 kg N as basal + 10 kg N as split; F_4 = 40 kg N as basal and F_5 = 20 kg N as basal + 20 kg N as split

Chapter 5
Summary and conclusion

CHAPTER 5

SUMMARY AND CONCLUSION

The field experiment was conducted at the experimental farm of Sher-e-Bangla Agricultural University (SAU), Dhaka, during the period from April 2014 to July 2014 to study the performance of different levels of nitrogen on two varieties of mungbean in Kharif 1 season under the Modhupur Tract (AEZ-28). The experiment was comprised with two varieties viz. BARI mung 4 (V_1) and BARI mung 6 (V_2) and five nitrogen level viz. No nitrogen (F_1), 20 kg N as basal (F_2), 10 kg N as basal + 10 kg N as split (F_3), 40 kg N as basal (F_4) and 20 kg N as basal + 20 kg N as split (F_5). The experiment was laid out in a split-plot design with three replications having variety in the main plots and different nitrogen level in the sub-plots.

The data on crop growth parameters like plant height, number of nodule plant^{-1}, nodule dry weight, dry matter of plant were recorded at different growth stages. Yield and other crop characters like number of branches plant^{-1}, number of pods plant^{-1}, pod length, number of seeds pod^{-1}, 1000-seeds weight, pod yield, seed and stover yield were recorded after harvest. Data were analyzed using MSTAT-C package. The mean differences among the treatments were compared by least significant difference test at 5% level of significance.

Results showed that two varieties of mungbean had significant effect on growth parameters except plant emergence, number of nodules plant^{-1} and stover yield. The rapid increase of plant height and dry weight was observed from 30 days to 45 days of growth stages which was higher in the V_2 (BARI mung 6) compared to the V_1 (BARI mung 4). The higher leaves plant^{-1} was found from V_1 at 45 DAS. The higher shoot and root length at all the growth stages was found from V_2. The V_2 produced maximum number of branch plant^{-1} and maximum number of pods plant^{-1} compared to V_1. The higher number of branches plant^{-1} (3.97), number of seeds pod^{-1} (12.97) were obtained from V_2 and the lower number of branches plant^{-1} (3.19), number of seeds pod^{-1} (6.64) were obtained from V_1. The maximum (9.20 cm) and minimum (6.47 cm) pod length was obtained from V_2 and V_1, respectively. The higher weight of 1000-seeds (51.42 g) was obtained from V_2 and the lower weight of 1000-seeds (34.98 g) was obtained from V_1. The V_2 produced higher pod yield (1.73 t ha^{-1}), seed yield (1.08 t ha^{-1}), the higher stover yield (2.29 t ha^{-1}) and the higher biological yield (4.02 t ha^{-1}) whereas, the V_1 produced the lower pod yield (0.52 t ha^{-1}), seed yield (0.29 t ha^{-1}), the lower stover yield (1.92 t ha^{-1}) and the lower biological yield (2.44 t ha^{-1}). The seed yield increase was found 272 % higher in V_2 than V_1. The maximum harvest index (27.09) was found from V_2 and the lower harvest index (12.05) was found from V_1. The harvest index was 124.81% higher in V_2 compared to V_1. The maximum shelling percentage (62.68) was found in V_2 and the lower shelling percentage (55.88) was found from V_1. The shelling percentage was 12.17 % higher in V_2 compared to V_1.

Nitrogen level also significantly influenced all growth and yield attributes except plant height, shoot length, root length, number of seeds pod^{-1} and shelling percentage. The results revealed that F_2 (20 kg N as basal) gave the highest number of plant emergence at all the growth stages and the lowest one was found from F_3 (10 kg N as basal + 10 kg N as split). However, at harvest the highest plant height was found in the F_5. In case of number of branch plant^{-1} F_5 gave the highest (4.51) and F_1 gave the lowest (2.87) value. The F_2 produced maximum leaves plant^{-1} at 30 DAS. The maximum (12.76 g) dry weight at harvest was recorded form F_5 (20 kg N as basal + 20 kg N as split) and the lowest (8.9 g) dry weight was recorded form F_1 (No nitrogen). The maximum nodules plant^{-1} (28.67), nodule dry wt. plant^{-1} (35.67 mg) at 30 DAS were recorded form F_1 and the lowest (10.57) nodule plant^{-1}, nodule dry wt. plant^{-1} (15.67 mg) were recorded form F_5. The highest pods plant^{-1}(12.07), pod length (8.64 cm), 1000 seeds wt. (45.34 g), pod yield (1.25 t ha^{-1}), seed yield (0.76 t ha^{-1}), stover yield (2.44 t ha^{-1}), biological yield (3.69 t ha^{-1}) were obtained from F_5 and the lowest pods plant^{-1}(7.3), pod length (7.04 cm), 1000 seeds wt. (41.9 g), pod yield (1.00 t ha^{-1}), seed yield (0.62 t ha^{-1}), stover yield (1.73 t ha^{-1}), biological yield (2.73 t ha^{-1}) were obtained from F_1. The highest harvest index (20.66) was found from the F_1 and the lowest harvest index (18.17) was found from F_4 (40 kg N as basal).

Interaction effect of varieties and different levels of nitrogen also significantly affected growth as well as yield and yield contributing characters. The tallest plant height (89.28 cm) was found in the combination of V_2F_5 at harvest and the shortest plant height (60.09 cm) was found in the V_1F_1. The maximum (14.76 g) dry weight at harvest was recorded form combination of V_2F_5 and the lowest (8.9 g) dry weight was recorded form V_2F_1. The maximum nodules plant^{-1}(29.8), nodule dry wt. plant^{-1}

(37.67 mg) at 30 DAS were recorded form V_2F_1 and the lowest (9.67) nodule plant^{-1}, nodule dry wt. plant (13.67 mg) were recorded form V_1F_5. The highest shoot length (77.97 cm), root length (20.76 cm), branches plant^{-1} (5.13), pods plant^{-1}(17.00), pod length (9.87 cm), seeds pod^{-1}(11.00), 1000-seeds wt. (54.29 g), pod yield (1.87 t ha^{-1}), seed yield (1.17 t ha^{-1}), stover yield (2.67 t ha^{-1}), biological yield (4.54 t ha^{-1}), harvest index (25.76), shelling percentage (62.55) were obtained from V_2F_5 at harvest. The lowest shoot length (58.87 cm), branches plant^{-1} (2.73) pods plant^{-1} (5.2), pod length (5.57 cm), seeds pod^{-1}(8.8), pod yield (0.45 t ha^{-1}), seed yield (0.26 t ha^{-1}), stover yield (1.47 t ha^{-1}), biological yield (1.92 t ha^{-1}), harvest index (13.60), were obtained from V_1F_1 at harvest. Again the lowest root length (16.19 cm) was obtained from V_1F_2, lowest 1000 seeds wt. (34.34 g) was recorded from V_1F_4 and the lowest shelling percentage (53.28) was found from V_1F_3 combination.

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

- The mungbean variety, BARI mung 6 showed higher yield (1.08 t ha^{-1}) potential than the variety, BARI mung 4 (0.29 t ha^{-1}).
- The application of 20 kg N as basal + 20 kg N as split treatment showed yield 0.76 t ha^{-1} which was 22.58% higher than the no nitrogen application (0.26 t ha^{-1}).
- The highest seed yield (1.17 t ha^{-1}) was recorded form the interaction of BARI mung 6 with 20 kg N ha^{-1} as basal + 20 kg N ha^{-1} as split than the interaction of BARI mung 4 with no nitrogen.
- The No nitrogen showed higher nodulation than the application of 40 kg N ha^{-1}.

However, to reach a specific conclusion and recommendation the same experiment need to be repeated and more research work should be done over different Agro-ecological zones with other nitrogen levels.

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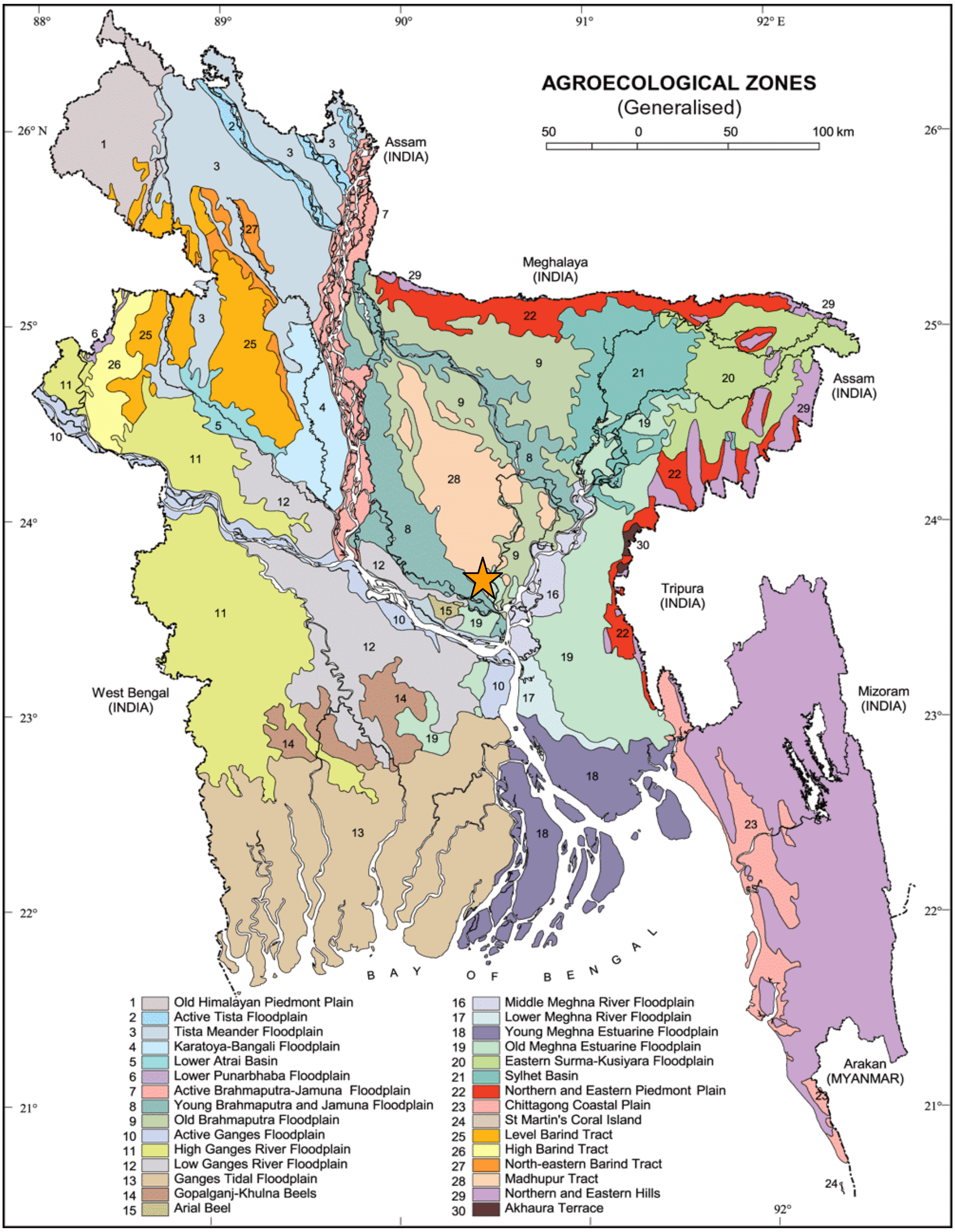
Appendices

APPENDICES

Appendix I. Map showing the experimental sites under study



☆ **The experimental site under study**

Appendix II. Monthly average of air temperature, relative humidity and total rainfall of the experimental site during the period from April to July 2014

Months	Air temperature (^{0}C)		Relative humidity (%)	Total rainfall (mm)
	Maximum	Minimum		
April	33.82	22.85	51.02	2.19
May	33.63	23.69	62.59	6.52
June	32.07	23.27	71.69	10.84
July	32.10	23.20	73.08	7.77

Source: Weather station, Sher-e-Bangla Agricultural University, Dhaka-1207

Appendix IIIa. Physical properties of the soil

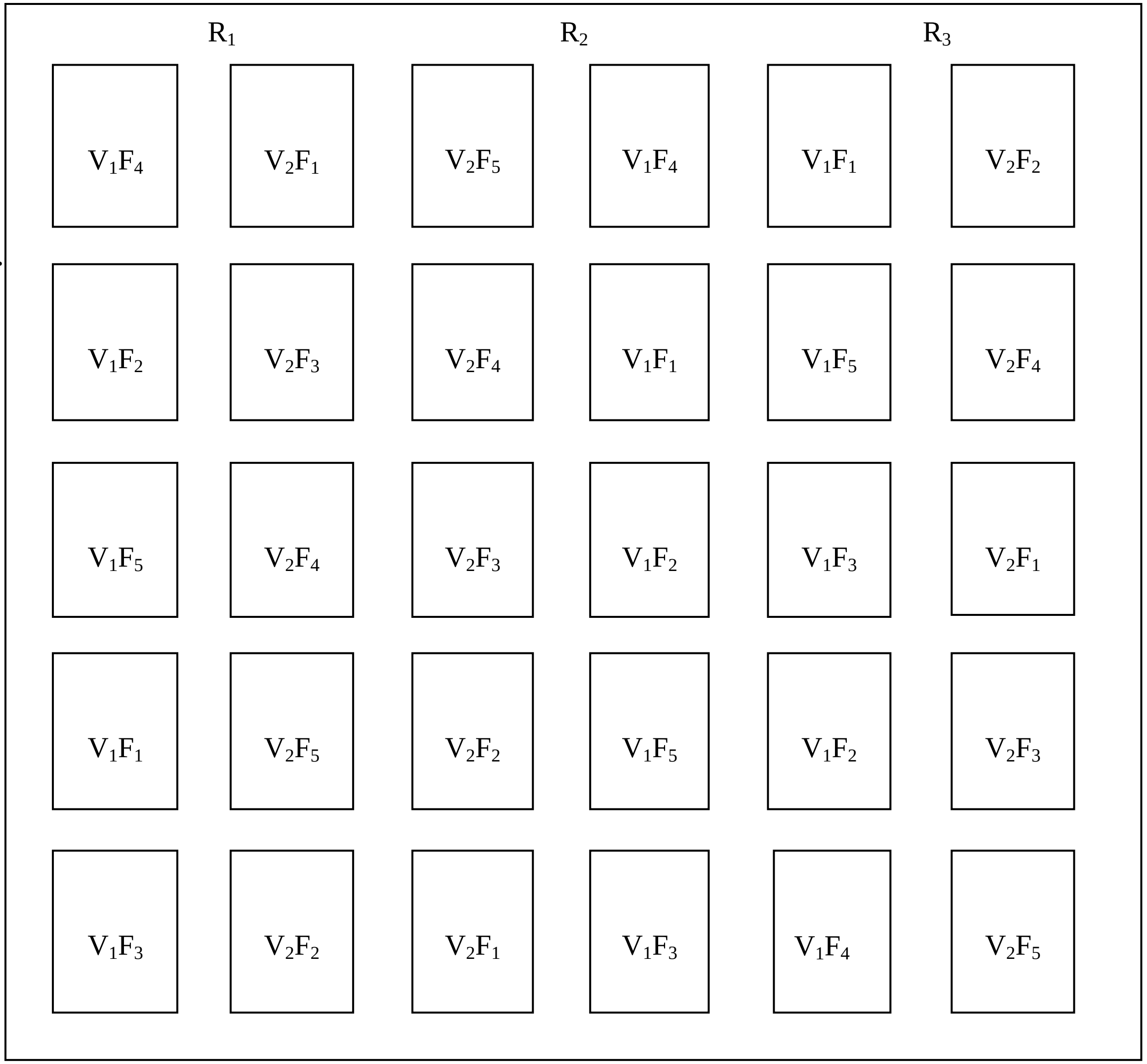
Constituents	Percent
Sand	26
Silt	45
Clay	29
Textural class	Silty clay

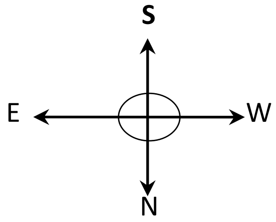
Appendix IIIb. Chemical properties of the soil

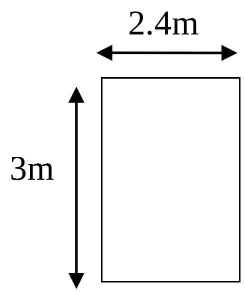
Soil characters	Value	
	Before sowing	After harvest
Organic matter (%)	0.86	1.19
Total nitrogen (%)	0.05	0.06
Phosphorus	6.49 µg/g soil	5.26 µg/g soil
Sulphur	27.62 µg/g soil	10.06 µg/g soil
Calcium	10.06 meq/100g soil	14.08meq/100g soil
Potassium	0.18 meq/100g soil	0.21 meq/100g soil

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

Appendix-IV: Experimental Layout







Plot Size: 3m x 2.4m

Between Plot: 0.75m

Between replication: 1m

Appendix V. Mean square values for emergence of mungbean

Sources of variation	Degrees of freedom	Mean square values at different days after sowing					
		3	4	5	6	7	8
Replication	2	198.03	260.40	492.1	384.93	313.90	286.53
Variety	1	1293.63 NS	3542.53 NS	6249.63 NS	6720.03 NS	6961.63 NS	7145.63 NS
Error (a)	2	375.03	774.53	549.03	630.93	664.63	656.13
Nitrogen level	4	712.45*	686.12*	1173.39*	1123.29*	1144.11*	1194.78*
Variety × Nitrogen level	4	489.21*	508.28*	667.55*	584.28*	534.38*	462.88*
Error (b)	16	200.28	388.93	337.82	340.18	341.73	346.58

* Significant at 5% level

NS Not significant

Appendix VI. Mean square values for plant height of mungbean

Sources of variation	Degrees of freedom	Mean square values at different days after sowing			
		15	30	45	At harvest
Replication	2	9.46	112.15	51.76	0.520
Variety	1	10.40*	139.54 NS	37.09 NS	3752.23*
Error (a)	2	0.48	57.39	89.90	115.02
Nitrogen level	4	2.12 NS	21.74 NS	54.73 NS	41.59*
Variety × Nitrogen level	4	3.56*	19.79*	78.99*	18.35*
Error (b)	16	2.36	20.99	52.52	35.23

* Significant at 5% level

NS Not significant

Appendix VII. Mean square values for leaves plant^{-1} of mungbean

Sources of variation	Degrees of freedom	Mean square values at different days after sowing			
		15	30	45	At harvest
Replication	2	1.17	8.56	18.21	27.78
Variety	1	1.45*	16.58 *	356.39^{NS}	646.82 ^{NS}
Error (a)	2	0.08	14.55	1.80	67.91
Nitrogen level	4	0.64*	17.04*	3.45*	1.60*
Variety × Nitrogen level	4	0.34*	21.00*	10.88*	11.02*
Error (b)	16	0.24	7.43	7.25	13.04

* Significant at 5% level

^{NS} Not significant

Appendix VIII. Mean square values for total dry matter production of mungbean

Sources of variation	Degrees of freedom	Mean square values at different days after sowing			
		15	30	45	At harvest
Replication	2	0.01	0.06	0.01	0.68
Variety	1	0.08*	4.78*	21.56*	97.96*
Error (a)	2	0.01	0.01	0.16	0.89
Nitrogen level	4	0.01*	1.16*	10.06*	12.50*
Variety × Nitrogen level	4	0.01*	0.19*	1.58*	0.12*
Error (b)	16	0.01	0.02	0.07	0.30

* Significant at 5% level

Appendix IX. Mean square values for nodule number and dry weight of mungbean

Sources of variation	Degrees of freedom	Mean square values at different days after sowing					
		20	35	50	20	35	50
		Nodule number			Nodule dry weight		
Replication	2	0.82	1.77	0.121	3.73	3.03	0.80
Variety	1	70.84 NS	33.50 NS	9.86 NS	14.70 NS	16.13 NS	10.30*
Error (a)	2	4.31	8.58	23.27	1.20	5.63	0.42
Nitrogen level	4	10.17*	370.32*	277.53*	2.20*	447.13*	89.08*
Variety × Nitrogen level	4	2.39*	2.92*	11.07*	0.87*	18.13*	2.22*
Error (b)	16	1.78	10.19	25.80	1.50	5.33	1.71

* Significant at 5% level

NS Not significant

Appendix X. Mean square values for shoot length of mungbean

Sources of variation	Degrees of freedom	Mean square values at different days after sowing		
		15	30	45
Replication	2	20.71	177.80	13.17
Variety	1	75.37*	302.10 NS	1478.13*
Error (a)	2	0.74	60.31	55.55
Nitrogen level	4	5.85 NS	17.04 NS	6.90 NS
Variety × Nitrogen level	4	8.53*	40.49*	13.16*
Error (b)	16	4.20	29.41	30.19

* Significant at 5% level

NS Not significan

Appendix XI. Mean square values for root length of mungbean

Sources of variation	Degrees of freedom	Mean square values at different days after sowing		
		15	30	45
Replication	2	3.194	2.37	9.33
Variety	1	21.85*	0.72 NS	45.59 NS
Error (a)	2	0.56	0.01	15.20
Nitrogen level	4	0.62 NS	0.76 NS	4.37 NS
Variety × Nitrogen level	4	2.72*	5.12*	2.63*
Error (b)	16	1.62	1.38	5.60

* Significant at 5% level

NS Not significant

Appendix XII. Mean square values for total no. of branches plant^{-1} of mungbean

Sources of variation	Degrees of freedom	Mean square values at different days after sowing			
		15	30	45	At harvest
Replication	2	0.38	0.24	0.07	0.33
Variety	1	0.18NS	1.50*	1.53*	4.64*
Error (a)	2	0.17	0.02	0.001	0.02
Nitrogen level	4	0.91*	1.71*	1.23*	2.59*
Variety × Nitrogen level	4	0.16*	0.02*	0.14*	0.25*
Error (b)	16	0.09	0.03	0.05	0.05

* Significant at 5% level

NS Not significant

Appendix XIII. Mean square values for crop characters, yield and yield components of mungbean at harvest

Source of variation	Degrees of freedom	Mean square values at harvest									
		Pod plant^{-1} (no.)	Pod length (cm)	Seeds pod^{-1} (no.)	1000-seeds weight (g)	Pod yield (t ha^{-1})	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)	Shelling percentage
Replication	2	0.01	0.49	0.04	0.30	0.01	0.01	0.09	0.05	8.00	9.64
Variety	1	300.83*	55.82*	9.98*	2026.39*	11.05*	4.73*	0.98 ^{NS}	18.61*	1693.5*	345.58*
Error (a)	2	0.68	0.32	0.07	0.42	0.01	0.01	0.08	0.12	0.12	7.15
Nitrogen level	4	21.37*	1.95*	1.03^{NS}	10.18*	0.05*	0.02*	0.65*	1.01*	6.44*	5.95 ^{NS}
Variety × Nitrogen level	4	6.65*	0.06*	0.10*	3.26*	0.01*	0.01*	0.05*	0.05*	3.62*	3.30*
Error (b)	16	0.89	0.19	0.80	2.30	0.02	0.01	0.06	0.08	3.84	9.66

* Significant at 5% level

^{NS} Not significant

LIST OF PLATES

Plate no. 1. (a) Photograph showing the general field view of experimental plot

(b) Photograph showing the general field view of experimental plot (after flowering)

Plate no. 2. (a) Photograph showing the nodulation of BARI mung 4 (no nitrogen)

(b) Photograph showing the nodulation of BARI mung 4 (40 kg nitrogen ha^{-1})

Plate no. 3. (a) Photograph showing the nodulation of BARI mung 6 (no nitrogen)

(b) Photograph showing the nodulation of BARI mung 6 (40 kg nitrogen ha^{-1})