THE EFFECT OF UREA ON THE YIELD AND PROTEIN CONTENT OF TWO CULTIVARS OF MUNGBEAN

BY

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TO
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CERTIFICATE

This is to certify that the thesis entitled **"The Effect of Urea on the Yield and Protein Content of Two Cultivars of Mungbean"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **Agricultural Chemistry**, embodies the result of a piece of bonafide research work carried out by **Md. Ahsan Habib**, Registration number: **08-03180** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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THE EFFECT OF UREA ON THE YIELD AND PROTEIN CONTENT OF TWO CULTIVARS OF MUNGBEAN

ABSTRACT

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University during the period from March to June 2010 to study the effect of urea on the yield and protein content of two cultivars of mungbean BARI mug-1 and BARI mug-5. The two factors experiment was laid out in Randomized Complete Block Design (RCBD) (factorial) with three replications. Data on different yield contributing characters and yield were recorded. At 20, 30, 40, 50, 60 DAS and at harvest the taller plant (11.81 cm, 23.40 cm, 34.36 cm, 42.90 cm, 54.97 cm and 61.33 cm) was recorded from BARI mug-5, whereas the shorter plant (10.69 cm, 21.26 cm, 31.27 cm, 40.01 cm, 51.34 cm and 57.33 cm) from BARI mug-1. The higher seed yield (1.65 t/ha) was observed from BARI mug-5, whereas the lower seed yield (1.45 t/ha) from BARI mug-1. The higher stover yield (2.70 t/ha) was recorded from BARI mug-5, again the lower stover yield (2.24 t/ha) from BARI mug-1. The maximum protein (27.36%) was recorded for BARI mug-5 than minimum protein of BARI mug-1 (26.39%). At 20, 30, 40, 50, 60 DAS and harvest, the tallest plant (12.36 cm, 24.13 cm, 35.52 cm, 43.79 cm, 56.35 cm and 62.64 cm) was observed from 30 kg N ha^{-1}, again the shortest (9.42 cm, 19.54 cm, 28.65 cm, 36.87 cm, 48.39 cm and 55.05 cm) from control (0 kg N ha^{-1}). The highest seed yield (1.73 t/ha) was obtained from 30 kg N ha^{-1}, again the lowest seed yield (1.24 t/ha) from control (0 kg N ha^{-1}). The highest stover yield (2.78 t/ha) was observed from 30 kg N ha^{-1}, while the lowest stover yield (2.03 t/ha) from control (0 kg N ha^{-1}). The maximum protein content (27.52%) was found from 30 kg N ha^{-1} and the minimum protein content (25.49%) from control (0 kg N ha^{-1}). At 20, 30, 40, 50, 60 DAS and harvest the tallest plant (12.76 cm, 24.47 cm, 35.76 cm, 45.13 cm, 57.03 cm and 63.65 cm) was observed from BARI mug-5 at 30 kg N ha^{-1}, while the shortest (7.41 cm, 17.63 cm, 23.10 cm, 31.77 cm, 42.96 cm and 50.30 cm) from BARI mug-1 at control (0 kg N ha^{-1}) condition. The highest seed yield (1.82 t/ha) was recorded from BARI mug-5 at 30 kg N ha^{-1} and the lowest seed yield (1.05 t/ha) from BARI mug-1 at control (0 kg N ha^{-1}) condition. The highest stover yield (2.84 t/ha) was observed from BARI mug-5 at 30 kg N ha^{-1}, whereas the lowest stover yield (1.36 t/ha) from BARI mug-1 at control (0 kg N ha^{-1}) condition. The maximum protein content (28.08%) was recorded from BARI mug-5 at 30 kg N ha^{-1} and the minimum protein content (25.04%) from BARI mug-1 at control (0 kg N ha^{-1}) condition.

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CHAPTER I

INTRODUCTION

Bangladesh is a developing country. The land of our country is limited but the population is very high. Due to our huge population we have to produce more food in our 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, 2007). The remaining land has been cultivating with rice, wheat, maize, oils, pulse and other crops. Now a days/recently pulse has been shifted to marginal land to give space for the cereal crops. Moreover, pulses with poor yielding ability do not get farmers' choice in cultivating pulses on the main land.

Some farmers of the villages grow various pulse crops at this present scenario. Among the pulses grasspea, lentil, mungbean, blackgram, chickpea, field pea and cowpea are common. The pulse crop is an important food crop because it provides a cheap source of easily digestible dietary protein which complements the staple rice in the country. According to FAO (1999), per capita requirement of pulse by human should be 80 g, whereas it is only about 10 g in Bangladesh (BBS, 2007) thus the ideal cereal of 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.

Mungbean plays an important role to supplement protein in the cereal-based low-protein diet of the people of Bangladesh, but the acreage production of mungbean is gradually declining (BBS, 2007). However, it is one of the least cared crops. Mungbean is cultivated with minimum tillage, local varieties with fertilizers, pesticides and no weed control measure. All these factors are responsible for low yield of mungbean which is incorporable with the yields of developed countries of the yield (FAO, 1999). At present the area under pulse crops is 0.406 million hectares with a production of 0.322 million tones where mungbean is cultivated in the area of 0.108 million hectares (BBS, 2007). The average yield of mungbean is 0.69 t ha^{-1} (BBS, 2007). The management of fertilizer especially nitrogen and mungbean variety is the important factor that greatly affects the growth, development and yield of this crop.

Pulses although fix nitrogen from the atmosphere, there is evident that application of nitrogenous fertilizers become helpful in increasing the yield (Patel *et al.*, 1984). Nitrogen is most useful for pulse crops because it is the component of protein (BARC, 1997). Nitrogen plays a vital role as a constituent of protein, nucleic acid and chlorophyll. It is also the most identical element to manage in a fertilization system such that an adequate, but not excessive amount of nitrogen is available during the entire growing season (Anon., 1972). An adequate supply of nitrogen is essential for vegetative growth and desirable yield (Yoshizawa *et al.*, 1981). On the other hand, excessive application of nitrogen is not only uneconomical, but it can prolong the growing period and delay crop maturity. Excessive amount of nitrogen application causes physiological disorder (Obreza and Vavrina, 1993).

Hence, the present study was undertaken to maximize the seed yield of mungbean varieties with nitrogen fertilizer. Considering the above circumstances, the present investigation has been undertaken with the following objectives:

i. To investigate the effect of nitrogen on the growth and yield of mungbean variety.

ii. To assess nitrogen content in plant.

iii. To determine the protein content in seed

CHAPTER II

REVIEW OF LITERATURE

In Bangladesh and in many countries of the world mungbean is an important pulse crop. The crop has conventional less attention by the researchers on various aspects because normally it grows without care or management practices. Based on this a very few research work related to growth, yield and development of mungbean have been carried out in our country. However, researches are going on in home and abroad to maximize the yield of mungbean. Variety and fertilizer, especially nitrogen fertilizer play an important role in improving mungbean yield. But research works related to variety and nitrogen on mungbean are limited in Bangladesh context. However, some of the important and informative works and research findings related to the variety and nitrogen so far been done at home and abroad on have been reviewed in this chapter under the following headings-

2.1 Effects of nitrogen on plant characters of mungbean

A study was conducted by Nigamananda (2007) in Uttar Pradesh, India during 2005-06 to evaluate the effect of N application time as basal and as DAP (diammonium phosphate) or urea spray and plant growth regulator (NAA at 40 ppm) on the yield and yield components of green gram cv. K-851. The recommended rate of N:P:K (20:50:20 kg ha^{-1}) as basal was used as a control. Treatments included: 1/2 basal N + foliar N as urea or DAP at 25 or 35 days after sowing (DAS); 1/2 basal N + 1/4 at 25 DAS + 1/4 at 35 DAS as urea or DAP; and 1/2 basal N + 1/2 foliar spraying as urea or DAP + 40 ppm NAA. Results showed that 2% foliar spray as DAP and NAA, applied at 35 DAS, resulted in the highest values for number of pods/plant (38.3), seeds/pod, test weight, flower number, fertility coefficient and 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 biological and grain yield (3.66 and 1.63 t ha^{-1}, respectively) compared to cv. Pusa 105. Differences in the values of the parameters examined. NP rates had no significant effects on both the biological and grain yield of the crop.

A field experiment was conducted by Raman and Venkataramana (2006) during February to May 2002 in Annamalainagar, Tamil Nadu, India to investigate the effect of foliar nutrition on crop nutrient uptake and yield of green gram (*V. radiata*). There were 10 foliar spray treatments, consisting of water spray, 2% diammonium phosphate (DAP) at 30 and 45 days after sowing, 0.01% Penshibao, 0.125% Zn chelate, 30 ppm NAA, DAP + NAA, DAP + Penshibao, DAP + Zn chelate, DAP + Penshibao + NAA, and DAP + NAA + Zn chelate. Crop nutrient uptake, yield and its attributes (number of pods per plant and number of seeds per pod) of green gram augmented significantly due to foliar nutrition. The foliar application of DAP + NAA + Penshibao was significantly superior to other treatments in increasing the values of N, P and K uptakes, yield attributes and yield. The highest grain yield of 1529 kg ha^{-1} was recorded with this treatment.

Oad and Buriro (2005) conducted a field experiment to determine the effect of different NPK levels (0-0-0, 10-20-20, 10-30-30, 10-30-40 and 10-40-40 kg ha^{-1})

on the growth and yield of mung bean cv. AEM 96 in Tandojam, Pakistan, during the spring season of 2004. The different NPK levels significantly affected the crop parameters. The 10-30-30 kg NPK ha^{-1} was the best treatment, recording plant height of 56.25, germination of 90.50%, satisfactory plant population of 162.00, prolonged days taken to maturity of 55.50, long pods of 5.02 cm, seed weight per plant of 10.53 g, seed index of 3.52 g and the highest seed yield of 1205.2 kg ha^{-1}. There was no significant change in the crop parameters beyond this level.

Nadeem *et al.* (2004) studied the response of mungbean cv. NM-98 to seed inoculation and different levels of fertilizer (0-0, 15-30, 30-60 and 45-90 kg 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 along with 60 kg P_2O_5 ha^{-1}.

Mozumder *et al.* (2003) conducted an experiment to study the effect of different nitrogen levels viz. 0, 20, 40, 60 and 80 kg N ha^{-1} on Binamoog-2 and they observed that increase of nitrogen fertilizer increased seed yield up to 40 kg N ha^{-1} and that was 1607 kg ha^{-1}.

Malik *et al.* (2003) conducted an experiment to determine the effect of varying levels of nitrogen (0, 25, and 50 kg ha^{-1}) and phosphorus (0, 50, 75 and 100 kg ha^{-1}) on the yield and quality of mungbean cv. NM-98 in 2001. They observed that number of flowers per plant was found to be significantly higher by 25kg N ha^{-1}. Number of seeds per pod was significantly affected by varying levels of nitrogen and phosphorus. Growth and yield components were significantly affected by varying levels of nitrogen and phosphorus. A fertilizer combination of 25 kg N + 75 P kg 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.

Yakadri *et al.* (2002) studied the effect of nitrogen (40 and 60 kg ha^{-1}) on crop growth and yield of green gram (cv. ML-267). Application of nitrogen at 20 kg ha^{-1} resulted in the significant increase in leaf area ratios indicating better partitioning of leaf dry matter.

The effects of N (0, 10, 20 and 30 kg ha^{-1}) and P (0, 20, 40 and 60 kg ha^{-1}) on mung bean 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 of 1999-2000. The number of branches, number of pods per plant, number of seeds per pod, 100-seed weight and straw yield increased with increasing P rates, whereas grain yield increased with increasing rates of up to 40 kg P ha^{-1} only.

Mahboob and Asghar (2002) studied the effect of seed inoculation at different nitrogen levels on mungbean at the agronomic research station, Farooqabad in Pakistan. They revealed that various yield components like 1000 grain weight were affected significantly with 50-50-0 NPK kg ha^{-1}. Again they revealed that seed inoculation +50-50-0 NPK kg ha^{-1} exhibited superior performance in respect of seed yield (955 kg ha^{-1}).

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}) were tested. They observed that the number of pods per plant was increased with the increasing rates of N up to 40 kg ha^{-1} followed by a decrease with further increase in N. They also observed that 1000-seed weight increased with increasing rates of N up to 40 kg ha^{-1} along with increasing rates of P.

A field experiment was carried out by Sharma and Sharma (1999) during summer seasons at Golaghat, Assam, India. 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 levels 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 levels 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}.

Tank *et al.* (1992) observed when mungbean was fertilized with 20 kg N along with to 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 per plant.

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}.

Suhartatik (1991) in a study observed that increased application of NPK fertilizers significantly increased the plant height of mungbean. Bali *et al.* (1991) conducted a field trail one mungbean in kharif seasons on silty clay loam soil. They revealed that 1000 seed weight increased with 40 kg N ha^{-1} 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. Results from field experiments conducted by Mahadkar and Saraf (1988) during summer season of mungbean showed 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}.

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. They also stated that the application of nitrogen, phosphorus and potassium fertilizers in combination resulted in the significant increase in seed yield of mungbean. They also stated that application of nitrogen, phosphorus and potassium fertilizers combinedly resulted in significant increases in 1000 seed weight of mungbean.

Patel and Parmer (1986) conducted an experiment on the response of green gram to varying levels 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 per plant.

In trials, on clay soils during the summer season Patel *et al.* (1984) observed the effect of N levels (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 per plant. They observed that application of 40 kg P_2O_5 ha^{-1} along with 20 kg N ha^{-1} significantly increased the 1000-seed weight of mungbean.

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 Effects of varieties on plant characters of mungbean

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

To study the nature of association between *Rhizobium phaseoli* and mungbean an experiment was conducted by Muhammad *et al.* (2006). Inocula of two Rhizobium strains, Tal-169 and Tal-420 were applied to four mungbean genotypes viz., NM-92, NMC-209, NM-98 and Chakwal Mung-97. A control treatment was also included for comparison. The experiment was carried out at the University of Arid Agriculture, Rawalpindi, Pakistan, during kharif, 2003. Both the strains in association with NM-92 had higher nodule dry weight, which was 13% greater than other strains x mungbean genotypes combinations. Strain Tal-169 was specifically more effective on genotype NCM-209 and NM-98 compared with NM-92 and Chakwal Mung-97. Strain Tal-420 increased branches plant^{-1} of all the genotypes. Strain Tal-169 in association with NCM-209 produced the highest yield of 670 kg ha^{-1} which was similar (590 kg ha^{-1}) in case of NCM-209 either inoculated with strain Tal-420 or uninoculated. Variety NM-92 produced the lowest grain yield (330 kg ha^{-1}) either inoculated with strain Tal-420 or uninoculated.

Islam *et al.* (2006) carried out an experiment at the field laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh during the period from March 2002 to June 2002 to evaluate the effect of biofertilizer (*Bradyrhizobium*) and plant growth regulators (GA3 and IAA) on growth of 3 cultivars of summer mungbean (*Vigna radiata* L.). Among the mungbean varieties, BINA moog 5 performed better than that of BINA moog 2 and BINA moog 4.

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

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

Rahman *et al.* (2005) conducted an experiment with mungbean in Jamalpur, Bangladesh, from February to June 1999, involving 2 planting methods, i.e. line sowing and broadcasting; 5 mungbean cultivars, namely Local, BARI moog 2, BARI moog 3, BINA moog 2 and BINA moog 5; and 5 sowing dates. Significantly the highest dry matter production ability was found in 4 modern mungbean cultivars, and dry matter partitioning was found highest in seeds of BINA moog 2 and lowest in Local. However, the local cultivar produced the highest portion of dry matter in leaf and stem.

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

A field experiment was conducted by Raj and Tripathi (2005) in Jodhpur, Rajasthan, India, during the kharif seasons, to evaluate the effects of cultivar (K-851 and RMG-62) as well as nitrogen (0 and 20 kg/ha) and phosphorus levels (0, 20 and 40 kg ha^{-1}) on the productivity of mungbean. K-851 produced significantly higher values for seed and straw yields as well as yield attributes (plant height, pods $plant^{-1}$, seeds pod^{-1} and 1000-seed weight) compared with RMG-62. Higher net return and benefit:cost (B:C) ratio were also obtained with K-851 (Rs. 6544 ha^{-1} and 1.02, respectively) than RMG-62 (Rs. 4833 ha^{-1} and 0.76, respectively).

Chaisri *et al*. (2005) conducted a yield trial involving 6 recommended cultivars (KPS 1, KPS 2, CN 60, CN 36, CN 72 and PSU 1) and 5 elite lines (C, E, F, G, H) under Kasetsart mungbean breeding project in Lopburi Province, Thailand, during the dry (February-May 2002), early rainy (June-September 2002) and late rainy season (October 2002-January 2003). Line C, KPS 1, CN 60, CN 36 and CN 72 gave high yields in the early rainy season, while line H, line G, line E, KPS 1 and line C gave high yields in the late rainy session. Yield trial of the 6 recommended mungbean cultivars was also conducted in the farmer's field.

Two summer mungbean cultivars, i.e. BINA moog 2 and BINA moog 5, were grown during the kharif-1 season (February-May) of 2001, in Mymensingh, Bangladesh, under no irrigation or with irrigation once at 30 days after sowing (DAS), twice at 30 and 50 DAS, and thrice at 20, 30 and 50 DAS by Shamsuzzaman *et al*. (2004). Data were recorded for days to first flowering, days to first leaf senescence, days to pod maturity, flower + pod abscission, root, stem+leaf, pod husk and seed dry matter content, pods $plant^{-1}$, seeds pod^{-1}, 100-seed weight, seed yield, biological yield and harvest index. The two cultivars tested were synchronous in flowering, pod maturity and leaf senescence, which were significantly delayed under different irrigated frequencies. BINA moog 2 performed slightly better than BINA moog 5 for most of the growth and yield parameters studied.

An experiment was conducted by Abid *et al*. (2004) in Peshawar, Pakistan, during the 2002 summer season to study the effect of sowing dates on the agronomic traits and yield of mungbean cultivars NM-92 and M-1. Data were recorded for days to emergence, emergence/m^2, days to 50% flowering, days to physiological maturity, plant height at maturity and grain yield. Sowing on 15 April took more number of days to emergence but showed maximum plant height. The highest emergence/m^2 and higher mean grain yield was recorded in NM-92 than M-1.

A field experiment was conducted by Apurv and Tewari (2004) during kharif season of 2003 in Uttaranchal, India, to investigate the effect of *Rhizobium* inoculation and fertilizer on the yield and yield components of three mungbean cultivars (Pusa 105, Pusa 9531 and Pant mung 2). Pusa 9531 showed higher yield components and grain yield than Pusa 105 and Pant mung 2.

To find out the effects of *Rhizobium* inoculation on the nodulation, plant growth, yield attributes, seed and stover yields, and seed protein content of six mung bean (*Vigna radiata*) cultivars were investigated by Hossain and Solaiman (2004). The mungbean cultivars were BARI mung-2, BARI mung-3, BARI mung-4, BARI mung-5, BINA mung-2 and BU mung-1. Among the cultivars, BARI mung-4 performed the best in all aspects showing the highest seed yield of 1135 kg/ha. *Rhizobium* strain TAL169 did better than TAL441 in most of the studied parameters. It was concluded that BARI mung 4 in combination with TAL169 performed the best in terms of nodulation, plant growth, seed and stover yields, and seed protein content.

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

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

Seed treatment with biofertilizers in controlling foot and root rot of mungbean cultivars BINA moog-3 and BINA moog-4 was investigated by Mohammad and Hossain (2003) under field conditions in Pakistan. Treatment of seeds of BINA moog-3 with biofertilizer showed a 5.67% increase in germination over the control, but in case of BINA moog-4 10.81% increase in germination over the control was achieved by treating seeds with biofertilizer. The biofertilizers caused 77.79% reduction of foot and root rot disease incidence over the control along with BINA moog-3 and 76.78% reduction of foot and rot disease in BINA moog-4. Seed treatment with biofertilizer also produced up to 20.83% higher seed yield in BINA moog-3 and 12.79% higher seed yield BINA moog-4 over the control.

Three mungbean cultivars (LGG 407, LGG 450 and LGG 460) and two urd bean [black gram] cultivars (LBG 20 and LBG 623) were sown on 15 June 2001 in Lam, Guntur, Andhra Pradesh, India, by Durga *et al.* (2003) and subjected to severe moisture stress during the first 38 days after sowing (DAS) and only a rainfall of 21.4 mm was received during this period. Mungbean registered higher root length (11.83%), root volume (37.50), root weight (31.43%), lateral roots (81.71%), shoot length (13.04%), shoot weight (84.62%), leaf number (25.75%), leaf weight (122.86%) and leaf area (108.60%) than the urd bean. Mungbean recorded better leaf characters than urd bean, but root and shoot characters were better in the latter. Among the mungbean cultivars, LGG 407 recorded the highest yield. Between the urd bean cultivars, LBG 20 had a higher yield than LBG 623. Among the mung bean cultivars, LGG 407 was the most tolerant, while in urd bean, LBG 20 was more efficient in avoiding early drought stress than LBG 623.

Taj *et al.* (2003) carried out an experiment to find out the effects of sowing rates (10, 20, 30 and 40 kg seed/ha) on the performance of 5 mungbean cultivars (NM-92, NM 19-19, NM 121-125, N/41 and a local cultivar) were studied in Ahmadwala, Pakistan, during the summer season of 1998. Among the cultivars, NM 121-125 recorded the highest average pods per plant (18.18), grains per pod (9.79), 1000-grain weight (28.09 g) and grain yield (1446.07 kg ha^{-1}).

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

The development phases and seed yield were evaluated by Infante *et al.* (2003) in mungbean cultivars ML 267, Acriollado and VC 1973C under the agroecological conditions of Maracay, Venezuela, during May-July 1997. The differentiation of the development phases and stages, and the morphological changes of plants were studied. The variable totals of pod clusters, pods per plant, seeds per pods and pod length were also studied. The earliest cultivar was ML 267 with 34.87 days to flowering and 61.83 to maturity. There were significant differences for total pod clusters per plant and pods per plant, where ML 267 and Acriollado had the highest values. The total seeds per pod of VC 1973C and Acriollado were significantly greater than ML 267. Acriollado showed the highest yield with 1438.33 kg/ha.

Seeds of mungbean cultivars BM-4, S-8 and BM-86 were inoculated with *Rhizobium* strains M-11-85, M-6-84, GR-4 and M-6-65 before sowing in a field experiment conducted by Navgire *et al.* (2001) in Maharashtra, India during the kharif season of 1993-94 and 1995-96. S-8, BM-4 and BM-86 recorded the highest mean nodulation (16.66), plant biomass (8.29 q/ha) and grain yield (4.79

q/ha) during the experimental years. S-8, BM-4 and BM-86 recorded the highest nodulation, plant biomass and grain yield.

Hamed (1998) carried out two field experiments in Shalakan, Egypt, to evaluate mung bean cultivars Giza 1 and Kawny 1 under 3 irrigation intervals after flowering (15, 22 and 30 days) and 4 fertilizer treatments: inoculation with *Rhizobium* (R) + Azotobacter (A) + 5 (N_1) or 10 kg N/feddan (N_2), and inoculation with R only +5 (N_3) or 10 kg N/feddan (N_4). Kawny 1 surpassed Giza 1 in pod number per plant (24.3) and seed yield (0.970 t/feddan), while Giza 1 was superior in 100-seed weight (7.02 g), biological and straw yields (5.53 and 4.61 t/feddan, respectively). While Kawny 1 surpassed Giza 1 in oil yield (35.78 kg/feddan), the latter cultivar recorded higher values of protein percentage and yield (28.22% and 264.6 kg/feddan). The seed yield of both cultivars was positively and highly significantly correlated with all involved characters, except for 100-seed weight of Giza 1 and branch number per plant of Kawny 1.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University during the period from March to June 2010 to study the effect of urea on the yield and protein content of two cultivars of mungbean. This chapter includes materials and methods that were used in conducting the experiment. The details materials and methods of this experiment are presented below under the following headings:

3.1 Experimental site

The experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The experimental site is situated between $23^{0}74^{/}$N latitude and $90^{0}35^{/}$E longitude (Anon., 1989).

3.2 Soil

The soil of the experimental field belongs to the Tejgaon series under the Agroecological Zone, Madhupur Tract (AEZ- 28) and the General Soil Type is Deep Red Brown Terrace Soils. A composite sample was made by collecting soil from several spots of the field at a depth of 0-15 cm before the initiation of the experiment. The collected soil was air-dried, ground and passed through 2 mm sieve and analyzed for some important physical and chemical properties. The analytical data of the soil sample collected from the experimental area were determined in the SRDI, Soil Testing Laboratory, Khamarbari, Dhaka and presented in Appendix I.

3.3 Climate

The climate of experimental site is subtropical, characterized by three distinct seasons, the monsoon from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979). Meteorological data related to the temperature, relative humidity and rainfalls during the period of the experiment was collected from the Bangladesh Meteorological Department (Climate Division), Sher-e-Bangla Nagar and presented in Appendix II.

3.4 Planting material

The variety BARI mug-1 and BARI mug-5 was used as the test crops. The seeds were collected from the Pulse Seed Division of Bangladesh Agricultural Research Institute, Joydevpur, Gajipur. BARI mug-1 and BARI mug-5 are the released varieties of mungbean, which was recommended by the national seed board. They grow both in *Kharif* and *Rabi* season. Life cycle of this variety ranges from 55-60 days. Maximum seed yield is 1.1-1.5 t/ha.

3.5 Land preparation

The land was irrigated before ploughing. After having 'zoe' condition the land was first opened with the tractor drawn disc plough. Ploughed soil was brought into desirable fine tilth by 4 ploughing and cross-ploughing, harrowing and laddering. The stubble and weeds were removed. The first ploughing and the final land preparation were done on 20 and 29 March 2010, respectively. Experimental land was divided into unit plots following the design of experiment.

3.6 Fertilizer application

Urea, Triple super phosphate (TSP) and Muriate of potash (MoP) were used as a source of nitrogen, phosphorous and potassium, respectively. Urea was applied as per treatment. T.S.P. and MoP were applied at the rate of 40 and 50 kg per hectare, respectively following the Bangladesh Agricultural Research Institute (BARI) recommendation. All of the fertilizers except urea were applied during final land preparation and urea was applied in three equal installments at 15, 25 and 35 days after sowing (DAS).

3.7 Treatments of the experiment

The experiment consists of two factors:

Factor A: Mungbean variety (2)

i) V_1= BARI mug-1

ii) V_2= BARI mug-5

Factor B: Inorganic fertilizer nitrogen (4 levels)

i) N_0 = 0 kg N/ha (Control)

ii) N_1= 10 kg N/ha

iii) N_2= 20 kg N/ha

iv) N_3= 30 kg N/ha

There were in total 8 (2×4) treatment combinations such as V_1N_0, V_1N_1, V_1N_2, V_1N_3, V_2N_0, V_2N_1, V_2N_2 and V_2N_3.

3.8 Experimental design and layout

The two factors experiment was laid out in Randomized Complete Block Design (RCBD) (factorial) with three replications. An area of 29.5 m × 9.5 m was divided into three equal blocks. Each block was divided into 8 plots where 8 treatment combinations were allotted at randomly. There were 24 unit plots altogether in the experiment. The size of the each unit plot was 3.0 m × 2.0 m. The space between two blocks and two plots were 1.0 m and 0.5 m, respectively.

3.9 Sowing of seeds in the field

The seeds of mungbean were sown on March 30, 2010. Before sowing seeds were treated with Bavistin to control the seed borne disease. The seeds were sown in solid rows in the furrows having a depth of 2-3 cm. Row to row distance was 30 cm.

3.10 Intercultural operations

3.10.1 Thinning

Seeds started germination of four DAS. Thinning was done two times; first thinning was done at 8 DAS and second was done at 15 DAS to maintain optimum plant population in each plot.

3.10.2 Irrigation and weeding

Irrigation was done as per requirements. The crop field was weeded as per treatment.

3.10.3 Protection against insect and pest

At early stage of growth few worms (*Agrotis ipsilon*) and virus vectors (jassid) infested the young plants and at later stage of growth pod borer (*Maruca testulalis*) attacked the plant. Dimacron 50EC was sprayed at the rate of 1 litre/ha to control the insects.

3.11 Crop sampling and data collection

Ten plants from each treatment were randomly selected and marked with sample card. Plant height, branches plant^{-1} were recorded from selected plants at an interval of 10 days started from 20 DAS to harvest.

3.12 Harvest and post harvest operations

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

3.13 Data collection

The following data were recorded

i. Plant height
ii. Branches per plant
iii. Dry matter content per plant
iv. Days to 1st flowering
v. Days to 80% pod maturity
vi. Pods per plant
vii. Pod length
viii. Seeds per plant
ix. Weight of 1000 seeds
x. Seed yield per hectare
xi. Stover yield (t ha^{-1})
xii. Nitrogen content in seeds
xiii. Protein content in seeds

3.14 Procedure of data collection

3.14.1 Plant height

The plant height was measured with a meter scale from the ground level to the top of the plants and the mean height was expressed in cm.

3.14.2 Number of branches per plant

The number of branches plant^{-1} was counted from selected plants. The average number of branches per plant was determined.

3.14.3 Dry matter content per plant

Collected plants including roots, stem (with pods) and leaves was oven dried at 70^{0}C for 72 hours then transferred into desiceator and allowed to cool down to the room temperature and final weight was taken and converted into dry matter content per plant.

3.14.4 Days to 1st flowering

Days to 1st flowering were measured by counting the number of days required to start flower initiation in each plot.

3.14.5 Days to 80% pod maturity

Days to 80% pod maturity were measured by counting the number of days required to attain maturity of 80% pods. Maturity was measured on the basis of brown colour of leaves and stem and dark grey colour of pods.

3.14.6 Pods per plant

Numbers of total pods of selected plants from each plot were counted and the mean numbers were expressed as per plant basis. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot.

3.14.7 Pod length

Pod length was taken of randomly selected twenty pods and the mean length was expressed on per pod basis.

3.14.8 Seeds per plant

The number of seeds per plant was recorded randomly from selected plants at the time of harvest. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot.

3.14.9 Weight of 1000 seeds

One thousand cleaned, dried seeds were counted randomly from each harvest sample and weighed by using a digital electric balance and weight was expressed in gram (g).

3.14.10 Seed yield per hectare

The seeds collected from 6 (3 m ×2 m) square meter of each plot were sun dried properly. The weight of seeds was taken and converted the yield in t ha^{-1}.

3.14.11 Stover yield per hectare

The stover collected from 6 (3 m ×2 m) square meter of each plot was sun dried properly. The weight of stover was taken and converted the yield in t ha^{-1}.

3.15 Estimation of the amount of nitrogen from the supplied sample by Macro Kjeldahl method

Principle:

The macro kjeldahl method was used to determine the total nitrogen consisting of organic and ammonium forms. It is a wet oxidation procedure where complex form of nitrogen in sample was converted to simple nitrogen. Three steps were involved in this method. These are as follows:

1. Digestion:

In this step the organic nitrogen was converted to ammonium sulphate by sulphuric acid and digestion accelerators (Catalyst Mixture) at a temperature of 360-440^{0}C.

N (organic form) + H_2SO_4--------------------- $(NH_4)_2SO_4$

2. Distillation:

In this step, the solution was made alkaline for the distillation of ammonia. The distillated ammonia was received in boric acid solution.

$(NH_4)_2SO_4 + NaOH \longrightarrow Na_2SO_4 + NH_3 + H_2O$

$NH_3 + H_3BO_3 \longrightarrow (NH_4)_2BO_3 + H_2O$

3. Titration:

To determine the amount of NH_3, ammonium borate was titrated with standard sulphate acid.

$(NH_4)_3BO_3 + H_2SO_4 \longrightarrow (NH_4)_2SO_4 + H_3BO_3$

Apparatus Required

1. Kjedahl Flask
2. Distillation apparatus
3. Volumetric flask
4. Burette with stand
5. Pipette
6. Electric oven
7. Kjeldahl digestion stand
8. Conical flask
9. Measuring cylinder
10. Electric Balance
11. Dropper
12. Beaker

Chemicals Required:

1. Sulphuric acid (H_2SO_4) – concentrated
2. Potassium sulphate (K_2SO_4) – AR grade
3. Copper sulphate ($CuSO_4.5H_2O$) – AR grade
4. Selenium powder
5. Sodium hydroxide (NaOH) Commercial
6. Boric acid (H_3BO_3)
7. Bromocresol green ($C_{21}H_{14}Br_4O_5S$)
8. Methyl red ($C_{15}H_{15}N_3O_2$)
9. Sodium carbonate (Na_2CO_3)

Preparation of different Reagents:

1. Preparation of boric acid solution (4%):

20g H_3BO_3 was taken in a 500 mL volumetric flask containing about 150-200mL hot distilled water. The flask was shaken thoroughly and the volume was made up to the mark with distilled water.

2. Preparation of mixed indicator Solution:

0.5g bromocresol green and 0.1g methyl red was taken in a 100mL volumetric flask containing about 30-40mL ethanol/methanol. The flask was shaken thoroughly and the volume was made up to the mark with methanol/ethanol.

3. Preparation of sodium hydroxide solution (40%):

400g NaOH was taken in a one litre volumetric flask containing about 200mL distilled water. The flask was shaken thoroughly and then the volume was made up to the mark with distilled water.

4. Preparation of standard H_2SO_4 Solution (0.05N):

Exactly 1.4 mL of concentrated H_2SO_4 (AR grade) was taken is a one litre volumetric flask containing about 300mL distilled water. The flask was shaken thoroughly and the volume was made up to the mark with distilled water

5. Preparation of Na_2CO_3 solution (0.05N):

Exactly 0.265g oven dried Na_2CO_3 (AR grade) was taken in a one litre volumetric flask containing about 30-40 mL distilled water. The flask was shaken thoroughly and then the volume was made up to the mark with distilled water. Then H_2SO_4 was standardized by this Na_2CO_3 solution.

Procedure:

A. Digestion

1) Exactly 1.0g plant or 5.0g soil sample was taken in a kjeldahl flask. The sample was previously oven dried.
2) About 5.0g catalysts mixer (K_2SO_4: $CuSO_4$. $5H_2O$: Se=100: 10:1) was added in to the flask.
3) About 25mL H_2So_4 was also added in to the flask.
4) The flask was heated until the solution become clear.
5) The flask was then allowed to cool and the about 120mL of distilled water was added and 5-6 glass bead into the flask.

B. Distillation

1) After digestion. 40% NaOH 125mL was added in to the kjeldahl flask.
2) The flask was attached quickly to the distillation set and then the flask was heated continuously.
3) In the meantime. 25mL of 4% boric acid solution and 2-4 drops of mixed indicator was taken in 500mL receiver conical flask.
4) About 150 mL distillate was collected into receiver conical flask.
5) The conical flask was then removed.

C. Titration

1) The distillate was titrated with standard H_2SO_4 taken from a burette until the green color completely turns to pink color at the end point.
2) The same procedure was followed for a blank sample.
3) The result was calculated using the following formula:

Calculation:

$$\% N = (T-B) \times N \times 1.4/S$$

Where,

T = Titration value for sample (ml.)

B = Titration value for blank (mL)

N = Normality of H_2SO_4

S = Weight of the sample (g)

1.4 = Conversion factor

Nitrogen % is converted into protein by multiplying with a factor 6.25 for pulses.

3.16 Statistical analysis

The data obtained for different parameters were statistically analyzed to find out the significant difference of different mungbean variety and nitrogen on yield and yield contributing characters of mungbean. The mean values of all the characters were calculated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the treatment means was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to study the effect of urea on the yield and protein content of two cultivars of mungbean. Data on different yield contributing characters, yield, nitrogen and protein content on seeds were recorded. The analyses of variance (ANOVA) of the data on different parameters are presented in Appendix III-VI. The results have been presented with the help of table and graphs and possible interpretations given under the following headings:

4.1 Plant height

Plant height varied significantly at 20, 30, 40, 50, 60 DAS and at harvest of BARI mug-1 and BARI mug-5 under the present trial (Table 1). At 20, 30, 40, 50, 60 DAS and harvest the taller plant (11.81 cm, 23.40 cm, 34.36 cm, 42.90 cm, 54.97 cm and 61.33 cm, respectively) was recorded from V_2 (BARI mug-5), whereas the shorter plant (10.69 cm, 21.26 cm, 31.27 cm, 40.01 cm, 51.34 cm and 57.33 cm) from V_1 (BARI mug-1). Different varieties produced different plant height on the basis of their varietal characters. Raj and Tripathi (2005) reported that cultivar K-851 gave significantly longest plant compared with RMG-62.

Different level of nitrogen showed significant variation on plant height at 20, 30, 40, 50, 60 DAS and at harvest (Table 1). At 20, 30, 40, 50, 60 DAS and at harvest, the tallest plant (12.36 cm, 24.13 cm, 35.52 cm, 43.79 cm, 56.35 cm and 62.64 cm, respectively) was observed from N_3 (30 kg N/ha), which was statistically identical with N_2 (20 kg N/ha). Again the shortest plant was recorded from N_0 (0 kg N/ha). Malik *et al.* (2003) reported that growth components were significantly affected by varying levels of nitrogen.

Interaction effect of mungbean variety and level of nitrogen showed significant differences on plant height at 20, 30, 40, 50, 60 DAS and at harvest (Table 2). At 20, 30, 40, 50, 60 DAS and at harvest the tallest plant (12.76 cm, 24.47 cm, 35.76 cm, 45.13 cm, 57.03 cm, 63.65 cm, respectively) was observed from V_2N_3 (BARI mug-5 + 30 kg N/ha), which is statistically identical with V_1N_2, V_1N_3, V_2N_1 and V_2N_2, while the shortest (7.41 cm, 17.63 cm, 23.10 cm, 31.77 cm, 42.96 cm and 50.30 cm, respectively) from V_1N_0 (BARI mug-1 + 0 kg N/ha).

4.2 Number of branches per plant

Significant variation was recorded for number of branches per plant at 20, 30, 40, 50, 60 DAS and at harvest of BARI mug-1 and BARI mug-5 under the present trial (Appendix IV). At 20, 30, 40, 50, 60 DAS and at harvest the maximum number of branches per plant (2.05, 4.39, 8.47, 15.00, 17.98 and 21.19, respectively) was found from V_2 (BARI mug-5) and the minimum number (1.91, 3.84, 7.97, 13.53, 15.84 and 19.77, respectively) from V_1 (BARI mug-1) (Figure 1). Management practices influence the number of branches per plant but variety itself manipulated the number of branches per plant. Aghaalikhani *et al.* (2006) worker with two cultivars (Partow and Gohar) and a line of mungbean (VC-1973A) and found that this line was superior to the other cultivars due to its number of branches per plant.

Table 1. Effects of varieties and levels of nitrogen on plant height of mungbean

Treatment	Plant height (cm) at					
	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	Harvest
Variety						
V_1	10.69 b	21.26 b	31.27 b	40.01 b	51.34 b	57.33 b
V_2	11.81 a	23.40 a	34.36 a	42.90 a	54.97 a	61.33 a
Level of Significance	**	**	*	**	**	**
$LSD_{(0.05)}$	0.686	0.683	2.500	1.637	2.009	1.550
CV(%)	6.97	5.49	8.70	6.51	5.32	6.98
Levels of nitrogen						
N_0	9.42 c	19.54 c	28.65 b	36.87 b	48.39 c	55.05 c
N_1	11.05 b	21.90 b	32.48 a	41.87 a	52.56 b	58.43 b
N_2	12.17 a	23.75 a	34.60 a	43.27 a	55.32 ab	61.18 a
N_3	12.36 a	24.13 a	35.52 a	43.79 a	56.35 a	62.64 a
Level of Significance	**	**	**	**	**	**
$LSD_{(0.05)}$	0.970	0.966	3.536	2.315	2.841	2.191
CV(%)	6.97	5.49	8.70	6.51	5.32	6.98

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

V_1: BARI mug-1 V_2: BARI mug-5

N_0: 0 kg N/ha (Control) N_1: 10 kg N/ha

N_2: 20 kg N/ha N_3: 30 kg N/ha

**→ Significant at 1% level; * → Significant at 5% level

Table 2. Comparison effect of varieties and levels of nitrogen on plant height of mungbean

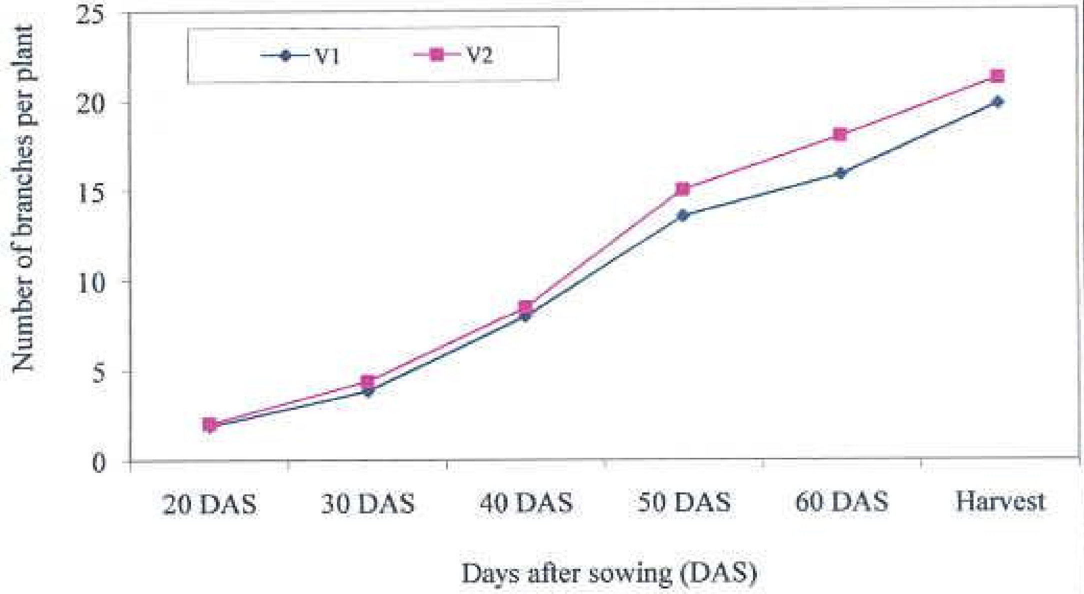
Variety	N dose	Plant height (cm) at					
		20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	Harvest
BARI mug-1	N_0	7.41 c	17.63 c	23.10 b	31.77 c	42.96 c	50.30 d
	N_1	10.19 b	20.41 b	31.70 a	39.73 b	50.14 b	56.96 c
	N_2	12.41 a	23.24 a	35.00 a	43.38 a	55.23 a	60.41 ab
	N_3	11.95 a	23.78 a	35.28 a	42.45 ab	55.66 a	61.63 ab
BARI mug-5	N_0	11.43 ab	21.46 b	34.21 a	41.97 ab	53.82 ab	59.80 bc
	N_1	11.92 a	23.40 a	33.26 a	44.00 a	54.98 a	59.91 bc
	N_2	11.93 a	24.27 a	34.21 a	43.16 ab	55.41 a	61.95 ab
	N_3	12.76 a	24.47 a	35.76 a	45.13 a	57.03 a	63.65 a
Level of Significance		**	**	**	**	**	**
$LSD_{(0.05)}$		1.372	1.367	5.000	3.274	4.017	3.099
CV(%)		6.97	5.49	8.70	6.51	5.32	6.98

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

N_0: 0 kg N/ha (Control) N_1: 10 kg N/ha

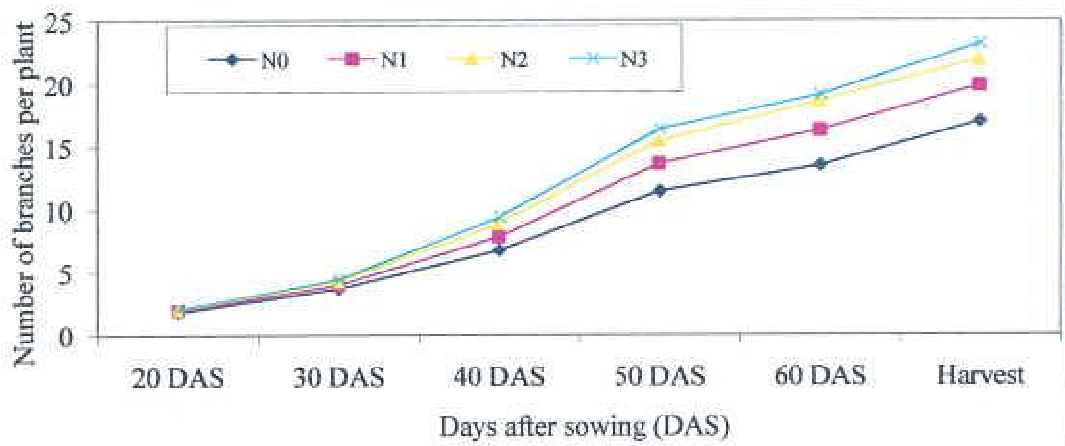
N_2: 20 kg N/ha N_3: 30 kg N/ha

** → Significant at 1% level; * → Significant at 5% level



V_1: BARI mug-1 V_2: BARI mug-5

Figure 1. Effects of varieties on number of branches per plant of mungbean



N_0: 0 kg N/ha (Control) N_1: 10 kg N/ha
N_2: 20 kg N/ha N_3: 30 kg N/ha

Figure 2. Effects of levels of nitrogen on number of branches per plant of mungbean

Number of branches per plant showed significant variation due to the effect of different level of nitrogen at 20, 30, 40, 50, 60 DAS and at harvest (Appendix IV). At 20, 30, 40, 50, 60 DAS and at harvest, the maximum number of branches per plant (2.08, 4.45, 9.42, 16.45, 19.15 and 23.17, respectively) was recorded from N_3 (30 kg N/ha) (Figure 2), which was statistically identical (2.05, 4.30, 8.87, 15.47, 18.60 and 21.90) with N_2 (20 kg N/ha) and followed (1.95, 4.00, 7.82, 13.67, 16.35 and 19.85) by N_1 (10 kg N/ha), while the minimum number of branches per plant (1.83, 3.72, 6.77, 11.47, 13.55 and 17.02) from N_0 (0 kg N/ha).

Statically significant difference was recorded due to the interaction effect of mungbean variety and level of nitrogen on number of branches per plant at 20, 30, 40, 50, 60 DAS and at harvest (Table 3). At 20, 30, 40, 50, 60 DAS and at harvest the maximum number of branches per plant (2.13, 4.60, 9.43, 16.67, 19.53 and 23.67, respectively) was recorded from V_2N_3 (BARI mug-5 + 30 kg N/ha) which was statistically identical with V_1N_2 and V_2N_3. On the other hand the minimum number of branches per plant (1.67, 3.17, 6.30, 8.80, 10.80 and 13.60) was found from V_1N_0 (BARI mug-1 + 0 kg N/ha).

4.3 Dry matter content in plant

Dry matter content per plant showed significant variation at 20, 30, 40, 50, 60 DAS and at harvest for BARI mug-1 and BARI mug-5 (Table 4). At 20, 30, 40, 50, 60 DAS and at harvest the higher dry matter content per plant (6.86 g, 8.69 g, 10.70 g, 13.67 g, 16.41 g and 19.92 g, respectively) was obtained from V_2 (BARI mug-5). On the other hand, the lower dry matter content per plant

Table 3. Comparison effect of varieties and levels of nitrogen on number of branches per plant of mungbean

Variety	N dose	Number of branches per plant at					
		20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	Harvest
BARI mug-1	N_0	1.67 c	3.17 d	6.30 d	8.80 e	10.80 d	13.60 d
	N_1	1.90 b	3.80 c	7.20 c	13.47 d	15.70 c	19.70 c
	N_2	2.03 ab	4.10 bc	8.93 ab	15.60 ab	18.10 ab	22.13 abc
	N_3	2.03 ab	4.30 ab	9.40 a	16.23 a	18.77 a	22.67 ab
BARI mug-5	N_0	2.00 ab	4.27 ab	7.23 c	14.13 bcd	16.30 c	20.43 bc
	N_1	2.00 ab	4.20 abc	8.43 b	13.87 cd	17.00 bc	20.00 c
	N_2	2.07 a	4.50 ab	8.80 ab	15.33 abc	19.10 a	21.67 abc
	N_3	2.13 a	4.60 a	9.43 a	16.67 a	19.53 a	23.67 a
Level of Significance		*	*	**	**	**	**
$LSD_{(0.05)}$		0.136	0.388	0.662	1.582	1.566	2.376
CV(%)		7.89	5.39	5.61	6.33	5.29	6.62

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

N_0: 0 kg N/ha (Control) N_1: 10 kg N/ha

N_2: 20 kg N/ha N_3: 30 kg N/ha

** → Significant at 1% level; * → Significant at 5% level

(6.20 g, 7.91 g, 9.78 g, 12.38 g, 15.32 g and 18.28 g, respectively) from V_1 (BARI mug-1). Rahman *et al.* (2005) reported that the highest dry matter production ability was found in 4 modern mungbean cultivars, and dry matter partitioning was found highest in seeds of BINA mung 2 and lowest in Local.

Statistically significant variation was obtained dry matter content per plant at 20, 30, 40, 50, 60 DAS and at harvest due to different level of nitrogen (Table 4). At 20, 30, 40, 50, 60 DAS and at harvest the highest dry matter content per plant (7.36 g, 9.18 g, 11.88 g, 14.42 g, 17.42 g and 21.48 g, respectively) was found from N_3 (30 kg N/ha), The lowest dry matter content per plant (5.77 g, 6.82 g, 8.41 g, 11.15 g, 13.36 g and 15.40 g) from N_0 (control i.e. 0 kg N/ha) at 20, 30, 40, 50, 60 DAS and at harvest, respectively.

Dry matter content per plant at 20, 30, 40, 50, 60 DAS and at harvest showed significant differences due to the interaction effect of mungbean variety and level of nitrogen (Table 5). At 20, 30, 40, 50, 60 DAS and at harvest the highest dry matter content per plant (7.42 g, 9.28 g, 12.29 g, 14.43 g, 18.08 g and 21.63 g, respectively) was attained from V_2N_3 (BARI mug-5 + 30 kg N/ha), while the lowest dry matter content per plant (4.58 g, 5.11 g, 6.35 g, 9.60 g, 11.02 g and 13.83 g) from V_1N_0 (BARI mug-1 + 0 kg N/ha).

Table 4. Effects of varieties and levels of nitrogen on dry matter content per plant of mungbean

Treatment	Dry matter content per plant (g) at					
	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	Harvest
Variety						
V_1	6.20 b	7.91 b	9.78 b	12.38 b	15.32 b	18.28 b
V_2	6.86 a	8.69 a	10.70 a	13.67 a	16.41 a	19.92 a
Level of Significance	**	**	*	**	*	**
$LSD_{(0.05)}$	0.393	0.582	0.822	0.600	0.859	0.523
CV(%)	6.87	8.01	9.17	5.26	6.18	8.13
Levels of nitrogen						
N_0	5.77 b	6.82 c	8.41 c	11.15 c	13.36 c	15.40 c
N_1	5.99 b	8.20 b	9.66 b	12.70 b	15.77 b	18.77 b
N_2	6.99 a	8.99 ab	11.01 a	13.84 a	16.93 ab	20.74 a
N_3	7.36 a	9.18 a	11.88 a	14.42 a	17.42 a	21.48 a
Level of Significance	**	**	**	**	**	**
$LSD_{(0.05)}$	0.555	0.823	1.163	0.849	1.215	0.740
CV(%)	6.87	8.01	9.17	5.26	6.18	8.13

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

V_1: BARI mug-1 V_2: BARI mug-5

N_0: 0 kg N/ha (Control) N_1: 10 kg N/ha

N_2: 20 kg N/ha N_3: 30 kg N/ha

**→ Significant at 1% level; * → Significant at 5% level

Table 5. Comparison effect of varieties and levels of nitrogen on dry matter content per plant of mungbean

Variety	N dose	Dry matter content per plant (g) at					
		20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	Harvest
BARI mug-1	N_0	4.58 d	5.11 b	6.35 d	9.60 d	11.02 d	13.83 d
	N_1	5.69 c	8.14 a	9.20 c	11.82 c	14.76 c	17.40 c
	N_2	7.24 a	9.11 a	11.30 ab	13.69 ab	17.43 ab	20.55 ab
	N_3	7.30 a	9.07 a	11.48 ab	14.40 a	16.75 ab	21.33 a
BARI mug-5	N_0	6.97 ab	8.54 a	10.47 bc	12.70 bc	15.70 bc	16.96 c
	N_1	6.30 bc	8.26 a	10.12 bc	13.57 ab	16.78 ab	20.13 b
	N_2	6.75 ab	8.87 a	10.72 abc	13.99 ab	16.43 abc	20.93 ab
	N_3	7.42 a	9.28 a	12.29 a	14.43 a	18.08 a	21.63 a
Level of Significance		**	**	**	**	**	**
$LSD_{(0.05)}$		0.785	1.164	1.645	1.201	1.719	1.046
CV(%)		6.87	8.01	9.17	5.26	6.18	8.13

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

N_0: 0 kg N/ha (Control) N_1: 10 kg N/ha

N_2: 20 kg N/ha N_3: 30 kg N/ha

**→ Significant at 1% level; * → Significant at 5% level

4.4. Days to 1st flowering

BARI mug-1 and BARI mug-5 showed significant differences for days to 1st flowering under the present trial (Table 6). The maximum days to 1st flowering (37.75) was found from V_1 (BARI mug-1), again the minimum days to 1st flowering (35.75) from V_2 (BARI mug-5). Days to 1st flowering varied for different varieties might be due to genetical and environmental influences as well as management practices. Shamsuzzaman *et al.* (2004) reported Binamung-2 performed slightly better than Binamung-5 for synchronous in flowering.

Days to 1st flowering differed significantly for different level of nitrogen under the present experiment (Table 6). The maximum days to 1st flowering (38.00) was recorded from N_0 (control i.e. 0 kg N/ha), which was statistically similar (37.67 and 36.17) with N_1 (10 kg N/ha) and N_3 (30 kg N/ha). On the other hand, the minimum days to 1st flowering (35.17) was recorded from N_2 (20 kg N/ha).

Variety and level of nitrogen showed significant variation on days to 1st flowering due to the interaction effect (Table 7). The maximum days to 1st flowering (42.33) was observed from V_1N_0 (BARI mug-1 + 0 kg N/ha)), again the minimum days (33.67) from V_2N_0 (BARI mug-5 + 0 kg N/ha).

4.5 Days to 80% pod maturity

Days to 80% pod maturity showed statistically significant variation for BARI mug-1 and BARI mug-5 under the present trial (Table 6). The maximum days to 80% pod maturity (71.17) was observed from V_2 (BARI mug-5), while the minimum days to 80% pod maturity (68.87) from V_1 (BARI mug-1).

Table 6. Effects of varieties and levels of nitrogen on yield contributing characters and yield of mungbean

Treatment	Days to 1st flowering	Days to 80% pod maturity	Pod length (cm)	Number of seeds per plant	Weight of 1000 seeds (g)	Seed yield (t/ha)	Stover yield (t/ha)
Variety							
V_1	37.75 a	68.87 b	3.01 b	285.09 b	20.36 b	1.45b	2.24 b
V_2	35.75 b	71.17 a	3.52 a	310.03 a	21.09 a	1.65 a	2.70 a
Level of Significance	**	**	**	**	*	**	**
$LSD_{(0.05)}$	1.312	1.258	0.194	15.12	0.647	0.068	0.184
CV(%)	8.08	6.05	6.79	5.80	8.56	5.18	8.54
Levels of nitrogen							
N_0	38.00 a	73.27 a	2.81 b	266.97 b	18.84 c	1.24 c	2.03 c
N_1	37.67 a	70.93 b	3.26 a	285.88 b	20.37 b	1.55 b	2.40 b
N_2	35.17 b	67.27 c	3.45 a	316.23 a	21.70 a	1.69 a	2.68 a
N_3	36.17 ab	68.60 c	3.55 a	321.17 a	21.99 a	1.73 a	2.78 a
Level of Significance	*	**	**	**	**	**	**
$LSD_{(0.05)}$	1.855	1.779	0.274	21.38	0.915	0.096	0.260
CV(%)	8.08	6.05	6.79	5.80	8.56	5.18	8.54

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

V_1: BARI mug-1 V_2: BARI mug-5

N_0: 0 kg N/ha (Control) N_1: 10 kg N/ha

N_2: 20 kg N/ha N_3: 30 kg N/ha

** → Significant at 1% level; * → Significant at 5% level

Table 7. Comparison effect of varieties and levels of nitrogen on yield contributing characters and yield of mungbean

Variety	N dose	Days to 1st flowering	Days to 80% pod maturity	Pod length (cm)	Number of seeds per plant	Weight of 1000 seeds (g)	Seed yield (t/ha)	Stover yield (t/ha)
BARI mug-1	N_0	42.33 a	74.87 a	2.00 c	214.97 d	16.65 d	1.05 d	1.36 c
	N_1	38.67 b	70.20 b	2.93 b	283.93 c	20.51 bc	1.47 c	2.29 b
	N_2	35.33 cde	63.53 d	3.46 a	314.73 abc	22.09 a	1.64 b	2.62 ab
	N_3	34.67 de	66.87 c	3.67 a	326.73 a	22.17 a	1.64 b	2.72 a
BARI mug-5	N_0	33.67 e	71.67 b	3.61 a	318.97 ab	21.03 abc	1.43 c	2.70 a
	N_1	36.67 bcd	71.67 b	3.60 a	287.83 bc	20.23 c	1.63 b	2.50 ab
	N_2	35.00 cde	71.00 b	3.45 a	317.73 ab	21.30 abc	1.75 ab	2.74 a
	N_3	37.67 bc	70.33 b	3.43 a	315.60 abc	21.81 ab	1.82 a	2.84 a
Level of Significance		**	**	**	**	**	*	**
$LSD_{(0.05)}$		2.623	2.517	0.388	30.24	1.294	0.136	0.367
CV(%)		8.08	6.05	6.79	5.80	8.56	5.18	8.54

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

N_0: 0 kg N/ha (Control) N_1: 10 kg N/ha
N_2: 20 kg N/ha N_3: 30 kg N/ha

**→ Significant at 1% level; * → Significant at 5% level

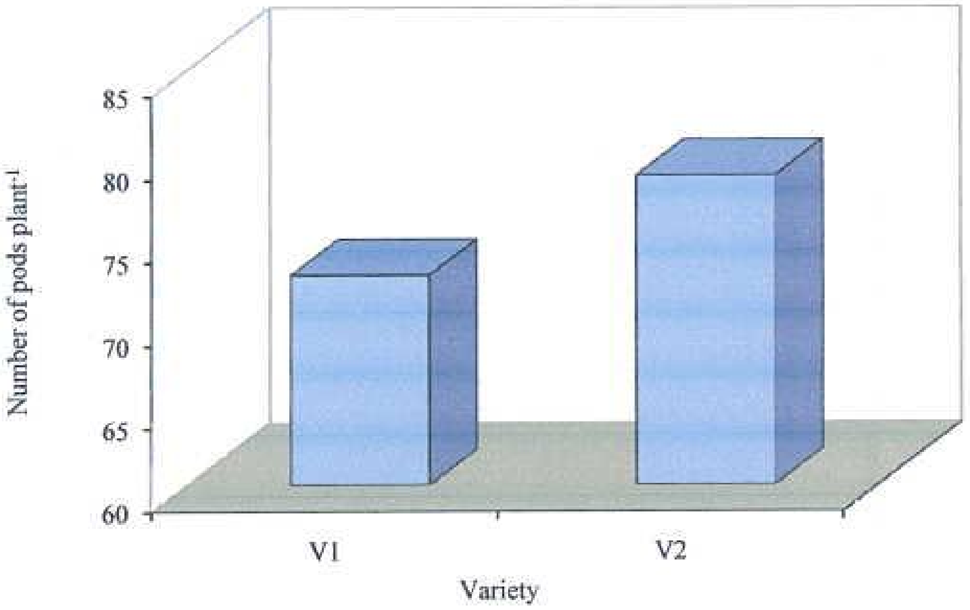
Aghaalikhani *et al.* (2006) reported that VC-1973A was superior to cultivars Partow and Gohar due to its early and uniform seed maturity

Different level of nitrogen showed significant differences on days to 80% pod maturity (Table 6). The maximum days to 80% pod maturity (73.27) was observed from N_0 (0 kg N/ha), which was closely followed (70.93) by N_1 (10 kg N/ha), while the minimum days to 80% pod maturity (67.27) from N_2 (20 kg N/ha) which was statistically similar (68.60) with N_3 (30 kg N/ha).

Interaction effect of mungbean variety and level of nitrogen showed significant variation for days to 80% pod maturity (Table 7). The maximum days to 80% pod maturity (74.87) was found from V_1N_0 (BARI mug-1 + 0 kg N/ha) and the minimum (63.53) from V_1N_2 (BARI mug-1 + 20 kg N/ha).

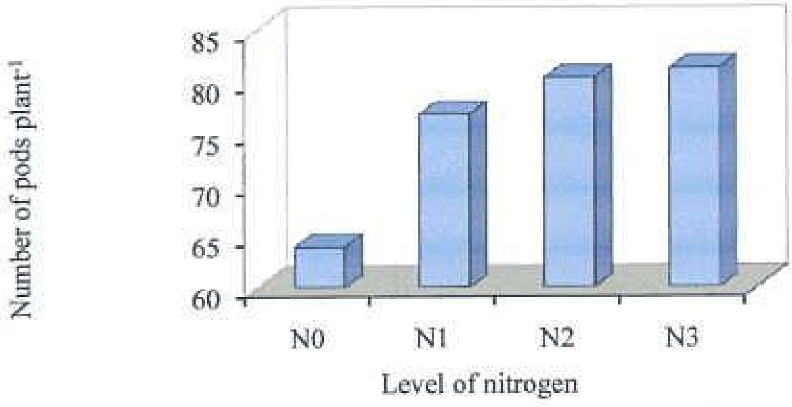
4.6 Pods per plant

In the context of number of pods per plant significant variation was recorded for BARI mug-1 and BARI mug-5 (Figure 3). The higher number of pods per plant (78.65) was recorded from V_2 (BARI mug-5), whereas the lower number of pods per plant (72.65) from V_1 (BARI mug-1). Different varieties responded differently to input supply, method of cultivation and the prevailing environment during the growing season. Raj and Tripathi (2005) reported that cultivar K-851 gave significantly higher values for pods per plant compared with RMG-62.



V_1: BARI mug-1 V_2: BARI mug-5

Figure 3. Effects of varieties on number of pods per plant of mungbean



N_0: 0 kg N/ha (Control) N_1: 10 kg N/ha

N_2: 20 kg N/ha N_3: 30 kg N/ha

Figure 4. Effects of levels of nitrogen on number of pods per plant of mungbean

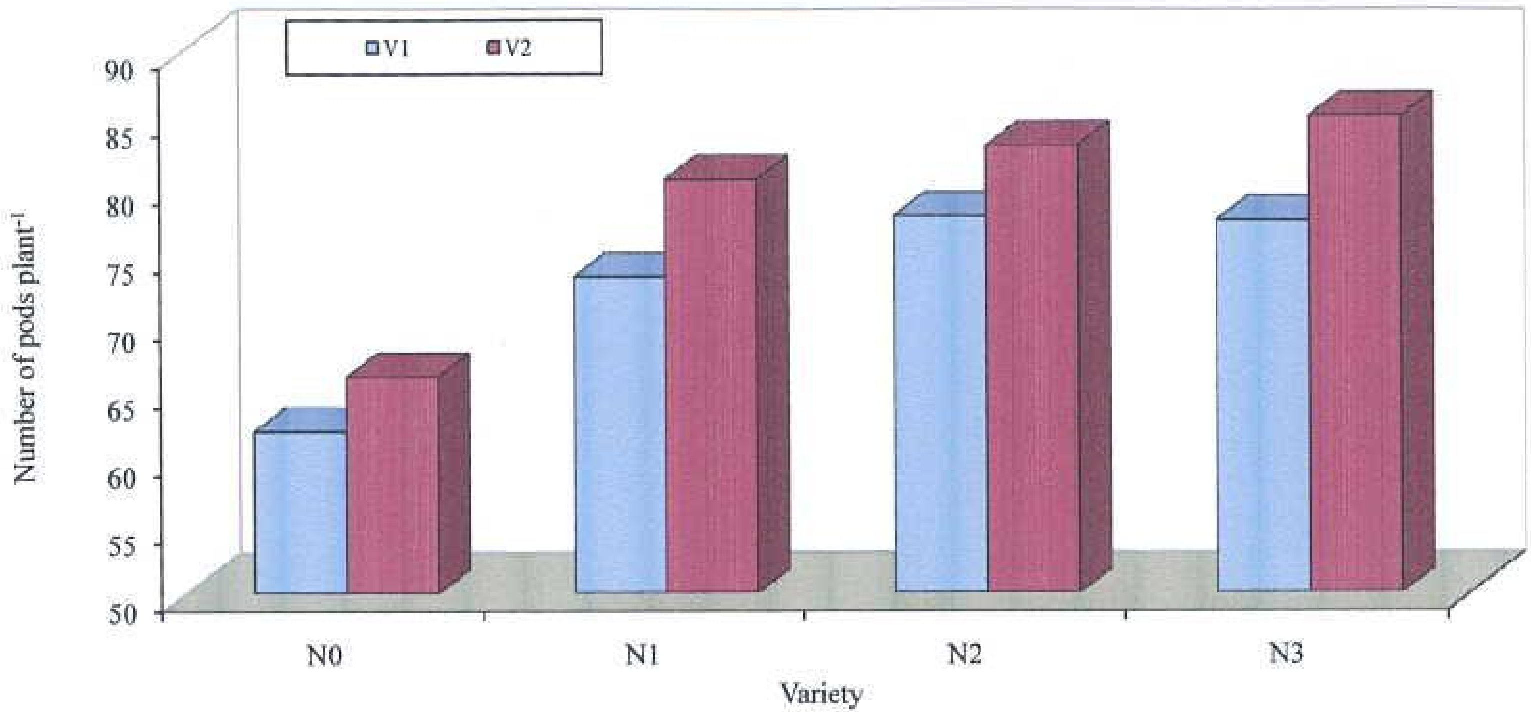
Number of pods per plant varied significantly for different level of nitrogen (Figure 4). The highest number of pods per plant (81.32) was found from N_3 (30 kg N/ha), which was statistically similar (80.42) with N_2 (20 kg N/ha) and closely followed (76.90) by N_1 (10 kg N/ha). On the other hand, the lowest number of pods per plant (63.97) from N_0 (control i.e. 0 kg N/ha).

Statistically significant variation was recorded due to the interaction effect of mungbean variety and level of nitrogen on number of pods per plant (Figure 5). The highest number of pods per plant (85.17) was recorded from V_2N_3 (BARI mug-5 + 30 kg N/ha) and the lowest number of pods per plant (61.97) from V_1N_0 (BARI mug-1 + 0 kg N/ha).

4.7 Pod length

Statistically significant variation was recorded for pod length in BARI mug-1 and BARI mug-5 under the present experiment (Table 6). The longer pod (3.52 cm) was recorded from V_2 (BARI mug-5), whereas the shorter pod (3.01 cm) from V_1 (BARI mug-1).

Different level of nitrogen showed significant variation on pod length (Table 6). The longest pod (3.55 cm) was found from N_3 (30 kg N/ha), which was statistically similar (3.45 cm and 3.26 cm) with N_2 (20 kg N/ha) and N_1 (10 kg N/ha) and the shortest pod (2.81 cm) from N_0 (0 kg N/ha).



V_1: BARI mug-1 N_0: 0 kg N/ha (Control) N_1: 10 kg N/ha

V_2: BARI mug-5 N_2: 20 kg N/ha N_3: 30 kg N/ha

Figure 5. Comparison effect of varieties and levels of nitrogen on number of pods per plant of mungbean

Variety and level of nitrogen showed significant differences on pod length due to interaction effect (Table 7). The longest pod (3.67 cm) was attained from V_1N_3 (BARI mug-1 + 30 kg N/ha), while the shortest pod (2.00 cm) from V_1N_0 (BARI mug-1 + 0 kg N/ha).

4.8 Seeds per plant

Number of seeds per plant varied significantly for BARI mug-1 and BARI mug-5 under the present experiment (Table 6). The higher number of seeds per plant (310.03) was found from V_2 (BARI mug-5), again the lower number of seeds per plant (285.09) from V_1 (BARI mug-1).

Significant variation was recorded for different level of nitrogen on number of seeds per plant (Table 6). The highest number of seeds per plant (321.17) was obtained from N_3 (30 kg N/ha), which was statistically identical (316.23) with N_2 (20 kg N/ha). On the other hand, the lowest number of seeds per plant (266.97) from N_0 (00 kg N/ha) which was statistically identical (285.88) with N_1 (10 kg N/ha). Malik *et al.* (2003) reported that number of seeds per plant was significantly affected by varying levels of nitrogen.

Interaction effect of mungbean variety and level of nitrogen varied significantly on number of seeds per plant (Table 7). The highest number of seeds per plant (326.73) was recorded from V_1N_3 (BARI mug-1 + 30 kg N/ha), while the lowest number of seeds per plant (214.97) from V_1N_0 (BARI mug-1 + 0 kg N/ha).

4.9 Weight of 1000 seeds

Weight of 1000 seeds showed significant differences for BARI mug-1 and BARI mug-5 under the present experiment (Table 6). The maximum weight of 1000 seeds (21.09 g) was observed from V_2 (BARI mug-5) and the minimum weight (20.36 g) from V_1 (BARI mug-1). Raj and Tripathi (2005) reported that cultivar K-851 gave significantly higher values for 1000-seed weight compared with RMG-62.

Statistically significant variation was observed on weight of 1000 seeds due to different level of nitrogen (Table 6). The maximum weight of 1000 seeds (21.99 g) was recorded from N_3 (30 kg N/ha), which was statistically identical (21.70 g) with N_2 (20 kg N/ha) and closely followed (20.37 g) by N_1 (10 kg N/ha), again the minimum weight of 1000 seeds (18.84 g) from N_0 (0 kg N/ha).

Weight of 1000 seeds showed significant differences due to interaction effect of mungbean variety and level of nitrogen (Table 7). The maximum weight of 1000 seeds (22.17 g) was found from V_1N_3 (BARI mug-1 + 30 kg N/ha) which was statistically similar to V_1N_2, while the minimum weight of 1000 seeds (16.65 g) from V_1N_0 (BARI mug-1 + 30 kg N/ha).

4.10 Seed yield per hectare

Significant variation was recorded for seed yield of mungbean in BARI mug-1 and BARI mug-5 under the present trial (Table 6). The higher seed yield (1.65 t/ha) was observed from V_2 (BARI mug-5), whereas the lower seed yield (1.45 t/ha) from V_1 (BARI mug-1). Seed yield varied for different varieties might be due to genetical and environmental influences as well as management practices. Quaderi *et al.* (2006) reported that mungbean varieties, Binamoog-5 performed better than that of Binamoog-4 in context of yield. Tickoo *et al.* (2006) recorded that the cultivar Pusa Vishal recorded higher grain yield (1.63 t/ha) compared to cv. Pusa 105.

Different level of nitrogen showed significant variation on seed yield of mungbean (Table 6). The highest seed yield (1.73 t/ha) was obtained from N_3 (30 kg N/ha), which was statistically similar (1.69 t/ha) with N_2 (20 kg N/ha), again the lowest seed yield (1.24 t/ha) from N_0 (0 kg N/ha). Nadeem *et al.* (2004) reported that the application of fertilizer significantly increased the yield and the maximum seed yield was obtained when 30 kg N ha^{-1} was applied.

Interaction effect of mungbean variety and level of nitrogen showed significant differences on seed yield of mungbean (Table 7). The highest seed yield (1.82 t/ha) was recorded from V_2N_3 (BARI mug-5 + 30 kg N/ha) and the lowest seed yield (1.05 t/ha) from V_1N_0 (BARI mug-1 + 0 kg N/ha).

4.11 Stover yield per hectare

Statistically significant variation was recorded for stover yield of BARI mug-1 and BARI mug-5 under the present experiment (Table 6). The higher stover yield (2.70 t/ha) was recorded from V_2 (BARI mug-5), again the lower stover yield (2.24 t/ha) from V_1 (BARI mug-1). Bhati *et al.* (2005) mungbean cv. PDM-54 showed 13.7% higher fodder yield than the local cultivar.

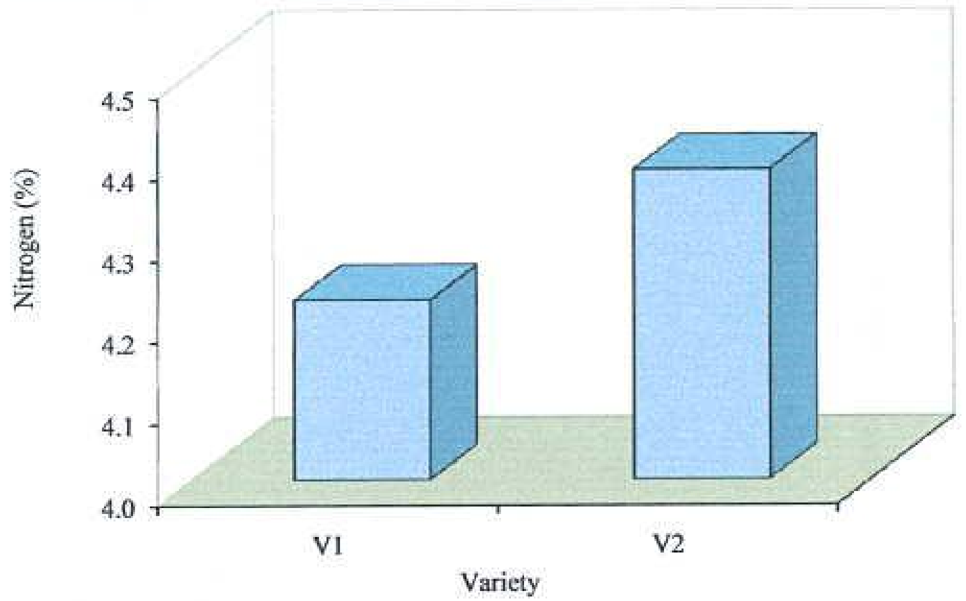
Stover yield of mungbean varied significantly for different level of nitrogen (Table 6). The highest stover yield (2.78 t/ha) was observed from N_3 (30 kg N/ha), which was statistically identical (2.68 t/ha) with N_2 (20 kg N/ha), while the lowest stover yield (2.03 t/ha) from N_0 (0 kg N/ha).

Variety and level of nitrogen showed significant differences on stover yield of mungbean due to interaction effect (Table 7). The highest stover yield (2.84 t/ha) was observed from V_2N_3 (BARI mug-5 + 30 kg N/ha), whereas the lowest stover yield (1.36 t/ha) from V_1N_0 (BARI mug-1 + 0 kg N/ha).

4.12 Nitrogen content in seeds

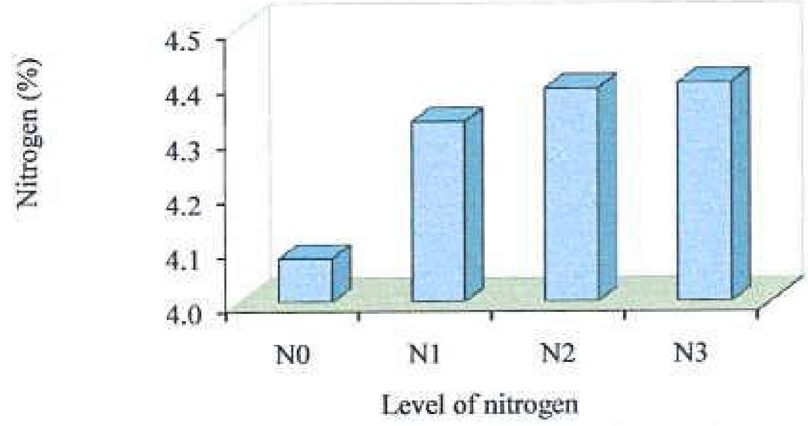
Significant variation was recorded for BARI mug-1 and BARI mug-5 in the context of nitrogen content in seeds (Figure 6). The maximum nitrogen (4.38%) was recorded from V_2 (BARI mug-5), whereas the minimum nitrogen (4.22%) from V_1 (BARI mug-1). Different varieties responded differently to input supply, method of cultivation and the prevailing environment during the growing season. Raj and Tripathi (2005) reported that cultivar K-851 gave significantly higher values for pods per nitrogen content compared with RMG-62.

Nitrogen content in seeds of mungbean varied significantly for different level of nitrogen (Figure 7). The maximum nitrogen content (4.40%) was found from N_3 (30 kg N/ha), which was statistically similar (4.39%) with N_2 (20 kg N/ha) and closely followed (4.33%) by N_1 (10 kg N/ha). On the other hand, the minimum nitrogen content (4.08%) from N_0 (control i.e. 0 kg N/ha).



V_1: BARI mug-1 V_2: BARI mug-5

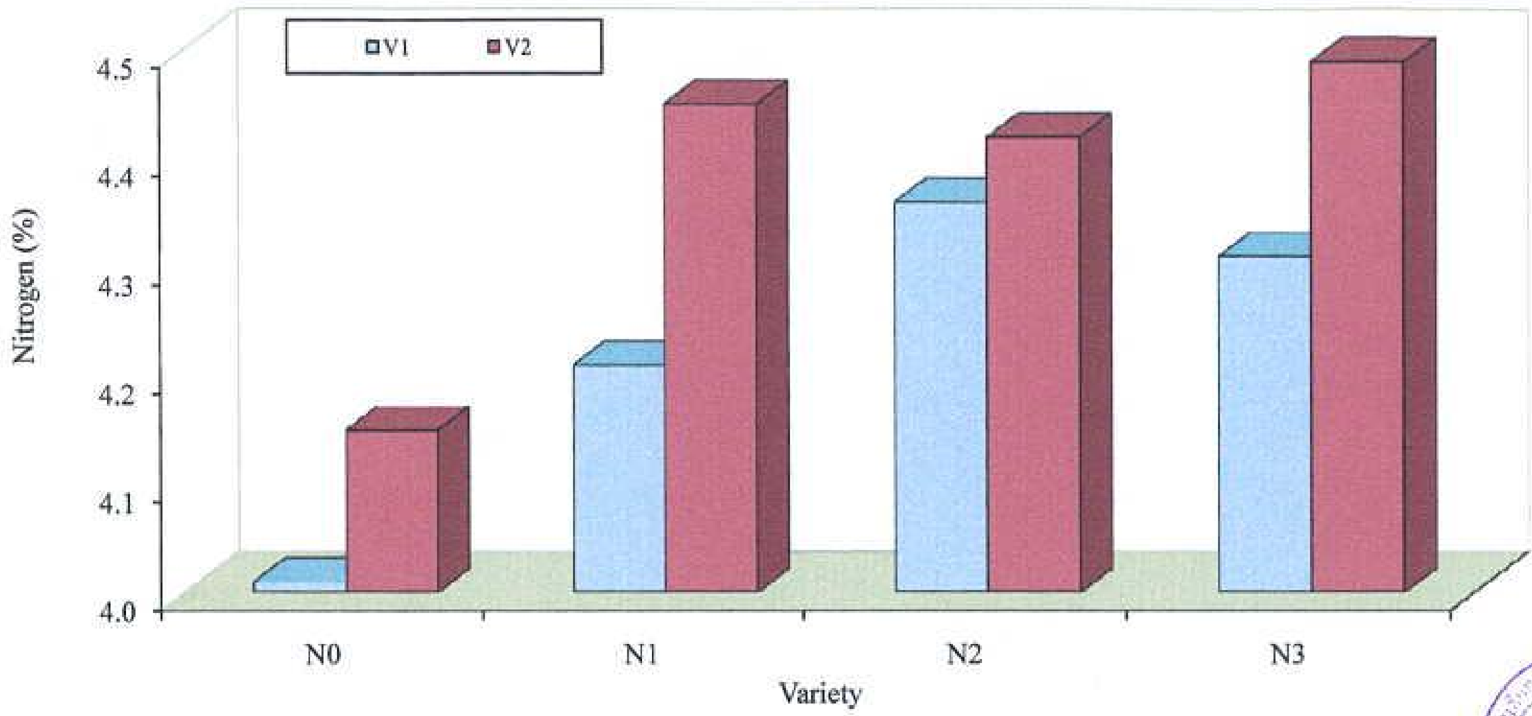
Figure 6. Effects of varieties on nitrogen content in seeds of mungbean



N_0: 0 kg N/ha (Control) N_1: 10 kg N/ha

N_2: 20 kg N/ha N_3: 30 kg N/ha

Figure 7. Effects of levels of nitrogen on nitrogen content in seeds of mungbean



V_1: BARI mug-1

V_2: BARI mug-5

N_0: 0 kg N/ha (Control)

N_1: 10 kg N/ha

N_2: 20 kg N/ha

N_3: 30 kg N/ha

Figure 8. Comparison effect of varieties and levels of nitrogen on nitrogen content in seeds of mungbean

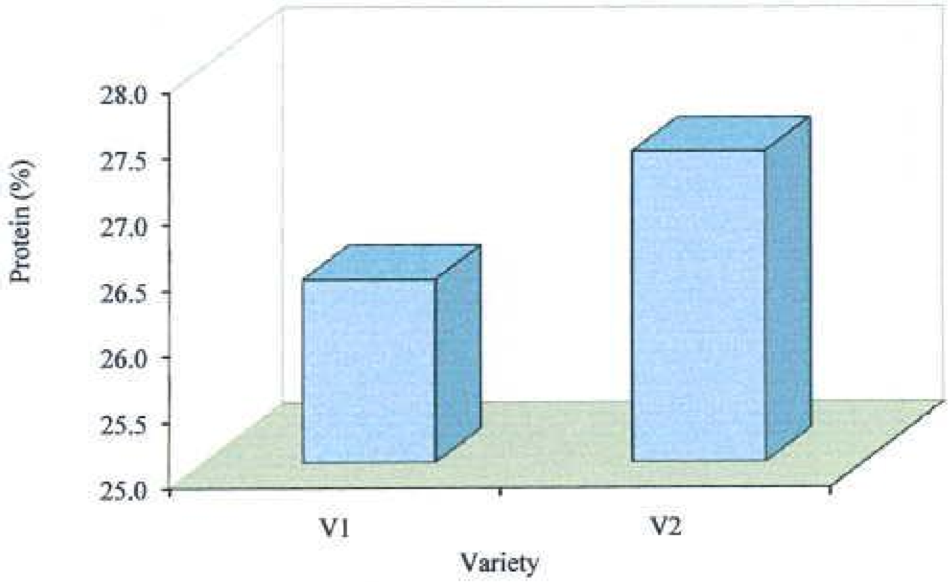
Statistically significant variation was recorded due to the interaction effect of mungbean variety and level of nitrogen on nitrogen content in seeds (Figure 8). The maximum nitrogen content (4.49%) was recorded from V_2N_3 (BARI mug-5 + 30 kg N/ha) and the minimum nitrogen content (4.01%) from V_1N_0 (BARI mug-1 + 0 kg N/ha).

4.13 Protein content in seeds

Significant variation was recorded for BARI mug-1 and BARI mug-5 in the context of protein content in seeds (Figure 9). The maximum protein (27.36%) was recorded from V_2 (BARI mug-5), whereas the minimum protein (26.39%) from V_1 (BARI mug-1). Different varieties responded differently to input supply, method of cultivation and the prevailing environment during the growing season. Raj and Tripathi (2005) reported that cultivar K-851 gave significantly higher values for pods per protein content compared with RMG-62.

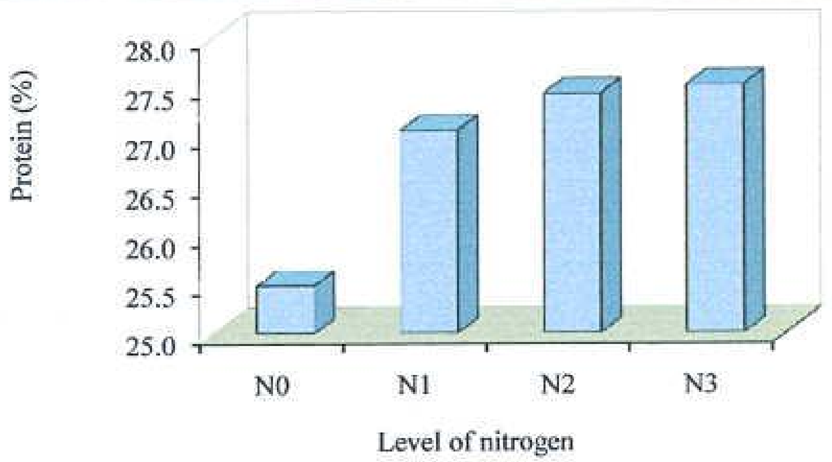
Protein content in seeds of mungbean varied significantly for different level of protein (Figure 10). The maximum protein content (27.52%) was found from N_3 (30 kg N/ha), which was statistically similar (27.43%) with N_2 (20 kg N/ha) and closely followed (27.06%) by N_1 (10 kg N/ha). On the other hand, the minimum protein content (25.49%) from N_0 (control i.e. 0 kg N/ha).

Statistically significant variation was recorded due to the interaction effect of mungbean variety and level of protein on protein content in seeds (Figure 11). The maximum protein content (28.08%) was recorded from V_2N_3 (BARI mug-5 + 30 kg N/ha) and the minimum (25.04%) from V_1N_0 (BARI mug-1 + 0 kg N/ha).



V_1: BARI mug-1 V_2: BARI mug-5

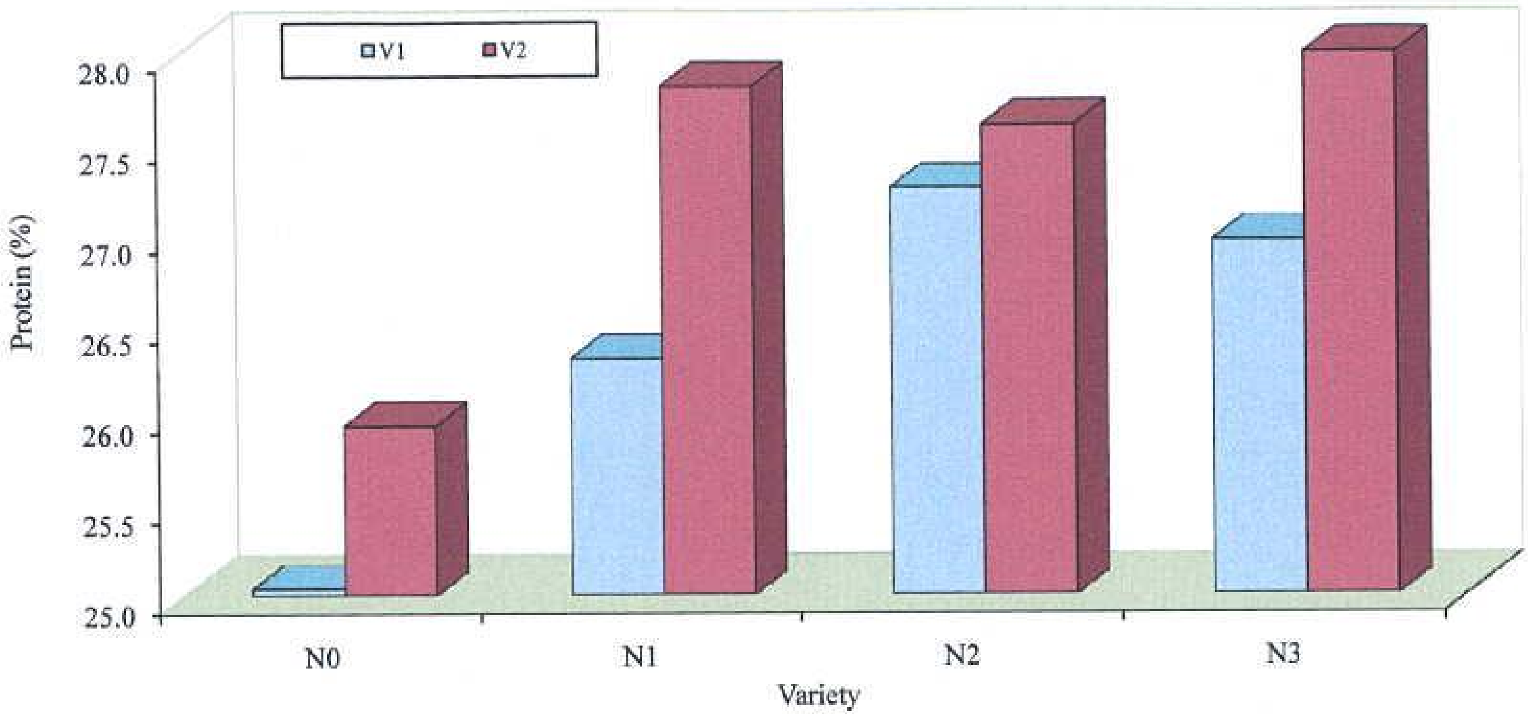
Figure 9. Effects of varieties on protein content in seeds of mungbean



N_0: 0 kg N/ha (Control) N_1: 10 kg N/ha

N_2: 20 kg N/ha N_3: 30 kg N/ha

Figure 10. Effects of levels of nitrogen on protein content in seeds of mungbean



V_1: BARI mug-1 N_0: 0 kg N/ha (Control) N_1: 10 kg N/ha

V_2: BARI mug-5 N_2: 20 kg N/ha N_3: 30 kg N/ha

Figure 11. Comparison effect of varieties and levels of nitrogen on protein content in seeds of mungbean

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University during the period from March to June 2010 to study the effect of urea on the yield and protein content of two cultivars of mungbean. The variety BARI mug-1 and BARI mug-5 was used as the test crops.

In case of varietal effect, at 20, 30, 40, 50, 60 DAS and at harvest the taller plant (11.81 cm, 23.40 cm, 34.36 cm, 42.90 cm, 54.97 cm and 61.33 cm) was recorded from V_2, whereas the shorter plant (10.69 cm, 21.26 cm, 31.27 cm, 40.01 cm, 51.34 cm and 57.33 cm) from V_1. At 20, 30, 40, 50, 60 DAS and at harvest the maximum number of branches per plant (2.05, 4.39, 8.47, 15.00, 17.98 and 21.19) was found from V_2 and the minimum number of branches per plant (1.91, 3.84, 7.97, 13.53, 15.84 and 19.77) from V_1. At 20, 30, 40, 50, 60 DAS and at harvest the higher dry matter content per plant (6.86 g, 8.69 g, 10.70 g, 13.67 g, 16.41 g and 19.92 g) was obtained from V_2, whereas the lower dry matter content per plant (6.20 g, 7.91 g, 9.78 g, 12.38 g, 15.32 g and 18.28 g) from V_1. The maximum days to 1st flowering (37.75) was found from V_1, again the minimum days to 1st flowering (35.75) from V_2. The maximum days to 80% pod maturity (71.17) was observed from V_2, while the minimum days to 80% pod maturity (68.87) from V_1. The higher number of pods per plant (78.65) was recorded from V_2, whereas the lower number of pods per plant (72.65) from V_1. The longer pod

(3.52 cm) was recorded from V_2, whereas the shorter pod (3.01 cm) from V_1. The higher number of seeds per plant (310.03) was found from V_2, again the lower number of seeds per plant (285.09) from V_1. The maximum weight of 1000 seeds (21.09 g) was observed from V_2 and the minimum weight (20.36 g) from V_1. The higher seed yield (1.65 t/ha) was observed from V_2, whereas the lower seed yield (1.45 t/ha) from V_1. The higher stover yield (2.70 t/ha) was recorded from V_2, again the lower stover yield (2.24 t/ha) from V_1. The maximum protein (27.36%) was recorded from V_2 whereas the minimum protein (26.39%) from V_1.

In case of nitrogen effect, at 20, 30, 40, 50, 60 DAS and at harvest, the tallest plant (12.36 cm, 24.13 cm, 35.52 cm, 43.79 cm, 56.35 cm and 62.64 cm) was observed from N_3, again the shortest (9.42 cm, 19.54 cm, 28.65 cm, 36.87 cm, 48.39 cm and 55.05 cm) from N_0. At 20, 30, 40, 50, 60 DAS and at harvest, the maximum number of branches per plant (2.08, 4.45, 9.42, 16.45, 19.15 and 23.17) was recorded from N_3, while the minimum number of branches per plant (1.83, 3.72, 6.77, 11.47, 13.55 and 17.02) from N_0. At 20, 30, 40, 50, 60 DAS and at harvest the highest dry matter content per plant (7.36 g, 9.18 g, 11.88 g, 14.42 g, 17.42 g and 21.48 g) was found from N_3, again the lowest dry matter content per plant (5.77 g, 6.82 g, 8.41 g, 11.15 g, 13.36 g and 15.40 g) from N_0. The maximum days to 1st flowering (38.00) was recorded from N_0 and the minimum days to 1st flowering (35.17) was recorded from N_2. The maximum days to 80% pod maturity (73.27) was observed from N_3, while the minimum days to 80% pod maturity (68.60) from N_3. The longest pod (3.55 cm) was found from N_3, and the shortest pod (2.81 cm) from N_0. The highest number of pods per plant (81.32) was found from N_3 and, the lowest number of pods per plant (63.97) from N_0. The maximum weight of 1000 seeds (21.99 g) was recorded from N_3, again the minimum weight of 1000 seeds (18.84 g) from N_0. The highest seed yield (1.73 t/ha) was obtained from N_3, again the lowest seed yield (1.24 t/ha) from N_0. The highest stover yield (2.78 t/ha) was observed from N_3, while the lowest stover yield (2.03 t/ha) from N_0. The maximum protein content (27.52%) was found from N_3 and the minimum protein content (25.49%) from N_0.

Interaction effect of variety and nitrogen, at 20, 30, 40, 50, 60 DAS and at harvest the tallest plant (12.76 cm, 24.47 cm, 35.76 cm, 45.13 cm, 57.03 cm and 63.65 cm) was observed from V_2N_3, while the shortest (7.41 cm, 17.63 cm, 23.10 cm, 31.77 cm, 42.96 cm and 50.30 cm) from V_1N_0. At 20, 30, 40, 50, 60 DAS and at harvest the maximum number of branches per plant (2.13, 4.60, 9.43, 16.67, 19.53 and 23.67) was recorded from V_2N_3 and the minimum number of branches per plant (1.67, 3.17, 6.30, 8.80, 10.80 and 13.60) was found from V_1N_0. At 20, 30, 40, 50, 60 DAS and at harvest the highest dry matter content per plant (7.42 g, 9.28 g, 12.29 g, 14.43 g, 18.08 g and 21.63 g) was attained from V_2N_3, while the lowest dry matter content per plant (4.58 g, 5.11 g, 6.35 g, 9.60 g, 11.02 g and 13.83 g) from V_1N_0. The maximum days to 1st flowering (42.33) was observed from V_1N_0, again the minimum days (33.67) from V_2N_0. The maximum days to 80% pod maturity (74.87) was found from V_1N_0 and the minimum (63.53) from V_1N_2. The highest number of pods per plant (85.17) was recorded from V_2N_3 and the lowest number of pods per plant (61.97) from V_1N_0. The highest number of seeds per plant (326.73) was recorded from V_1N_3, while the lowest number of seeds per plant (214.97) from V_1N_0. The highest longest pod (3.67 cm) was attained from V_1N_3, while the shortest pod (2.00 cm) from V_1N_0. The maximum weight of 1000 seeds (22.17 g) was found from V_1N_3, while the minimum weight of 1000 seeds (16.65 g) from V_1N_0. The highest seed yield (1.82 t/ha) was recorded from V_2N_3 and the lowest seed yield (1.05 t/ha) from V_1N_0. The highest stover yield (2.84 t/ha) was observed from V_2N_3, whereas the lowest stover yield (1.36 t/ha) from V_1N_0. The maximum protein content (28.08%) was recorded from V_2N_3 and the minimum protein content (25.04%) from V_1N_0. Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional compliance and other performance.

2. Another experiment may be carried out with different fertilizers and manure.

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APPENDICES

Appendix I. Physical and chemical characteristics of the experimental soil

1. pH		6.0
2. Particle-size analysis of soil	Sand	29.04
	Silt	41.80
	Clay	29.16
3. Textural Class		Silty Clay
4. Organic matter (%)		0.840
5. Total N (%)		0.067
6. Phosphorous (ppm)		8.333
7. Potassium (ppm)		25.00

Source: SRDI

Appendix II. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from March to June 2010

Month (2010)	Air temperature (^{0}C)		Relative humidity (%)	Rainfall (mm)
	Maximum	Minimum		
March	23.2	16.5	64	12
April	26.2	18.1	61	88
May	27.0	19.2	63	54
June	27.1	16.7	67	145

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka – 1212

Appendix III. Analysis of variance of the data on plant height of mungbean as influenced by varieties and levels of nitrogen management

Source of variation	Degrees of freedom	Mean square Plant height (cm) at					
		20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	Harvest
Replication	2	0.434	0.343	1.930	0.260	0.318	1.524
Factor A (Variety)	1	7.494**	27.280**	57.378*	50.171**	78.855**	96.040**
Factor B (Level of nitrogen)	3	10.906**	26.384**	55.941**	59.885**	75.876**	67.012**
Interaction (A×B)	3	7.508**	3.465**	44.237**	48.059**	45.352**	20.669**
Error	14	0.614	0.609	8.153	3.495	5.262	3.132

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix IV. Analysis of variance of the data on number of branches plant^{-1} of mungbean as influenced by varieties and levels of nitrogen

Source of variation	Degrees of freedom	Mean square Number of branches plant^{-1}					
		20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	Harvest
Replication	2	0.005	0.032	0.090	0.436	0.635	0.343
Factor A (Variety)	1	0.121**	1.812**	1.500**	13.054**	27.520**	12.042*
Factor B (Level of nitrogen)	3	0.076**	0.636**	8.250**	28.814**	38.954**	43.252**
Interaction (A×B)	3	0.026*	0.205*	0.706**	10.080**	7.590**	19.987**
Error	14	0.006	0.049	0.143	0.816	0.800	1.841

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix V. Analysis of variance of the data on dry matter content per plant of mungbean plant as influenced by varieties and levels of nitrogen

Source of variation	Degrees of freedom	Mean square					
		Dry matter content per plant (g) at					
		20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	Harvest
Replication	2	0.144	0.438	0.646	1.099	0.853	0.207
Factor A (Variety)	1	2.587**	3.614**	4.982*	10.045**	7.155*	16.078**
Factor B (Level of nitrogen)	3	3.519**	6.889**	13.941**	12.461**	19.635**	44.342**
Interaction (A×B)	3	2.301**	4.735**	7.741**	3.024**	11.972**	3.383**
Error	14	0.201	0.442	0.882	0.470	0.963	0.357

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix VI. Analysis of variance of the data on yield contributing characters and yield of mungbean as influenced by varieties and levels of nitrogen

Source of variation	Degrees of freedom	Mean square									
		Days to 1st flowering	Days to 80% pod maturity	Number of Pods per plant	Pod length (cm)	Number of seeds per plant	Weight of 1000 seeds (g)	Seed yield (t/ha)	Straw yield (t/ha)	Nitrogen (%)	Protein (%)
Replication	2	1.625	1.542	0.571	0.015	249.529	0.880	0.002	0.013	0.003	0.106
Factor A (Variety)	1	24.000**	31.74**	216.00**	1.540**	3732.52**	3.272*	0.252**	1.220**	0.144**	5.631**
Factor B (Level of nitrogen)	3	10.500*	41.94**	385.79**	0.653**	3956.53**	12.45**	0.300**	0.681**	0.137**	5.353**
Interaction (A×B)	3	36.111**	29.50**	4.434*	1.033**	4237.91**	8.925**	0.023*	0.529**	0.009*	0.345*
Error	14	2.244	2.065	3.949	0.049	298.189	0.546	0.006	0.044	0.003	0.116

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix VII. Effect of varieties and levels of nitrogen on number of pods per plant, nitrogen and protein content in seeds of mungbean

Treatment	Number of pods per plant	Nitrogen (%)	Protein (%)
V_1	72.65 b	4.22 b	26.39 b
V_2	78.65 a	4.38 a	27.36 a
$LSD_{(0.05)}$	1.740	0.048	0.298
Level of Significant	0.01	0.01	0.01
N_0	63.97 c	4.08 c	25.49 c
N_1	76.90 b	4.33 b	27.06 b
N_2	80.42 a	4.39 ab	27.43 ab
N_2	81.32 a	4.40 a	27.52 a
$LSD_{(0.05)}$	2.461	0.068	0.422
Level of Significant	0.01	0.01	0.01
V_1N_0	61.97 f	4.01 e	25.04 e
V_1N_1	73.33 d	4.21 d	26.31 d
V_1N_2	77.83 c	4.36 bc	27.25 bc
V_1N_3	77.47 c	4.31 c	26.96 c
V_2N_0	65.97 e	4.15 d	25.94 d
V_2N_1	80.47 bc	4.45 ab	27.81 ab
V_2N_2	83.00 ab	4.42 ab	27.60 ab
V_2N_3	85.17 a	4.49 a	28.08 a
$LSD_{(0.05)}$	3.480	0.096	0.596
Level of Significance	0.05	0.05	0.05
CV(%)	7.63	5.27	5.27