GROWTH AND YIELD RESPONSE OF MUNGBEAN TO THE APPLICATION OF PRILLED AND SUPER GRANULE UREA

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MY BELOVED PARENTS

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CERTIFICATE

This is to certify that the thesis entitled **"Growth and Yield Response of Mungbean to the Application of Prilled and Super Granule Urea"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **Master of Science** in **Agronomy**, embodies the result of a piece of bonafide research work carried out by **Mirza Mobashwerul Haque**, Registration number: **06-01948** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:

Dhaka, Bangladesh

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GROWTH AND YIELD RESPONSE OF MUNGBEAN TO THE APPLICATION OF PRILLED AND SUPER GRANULE UREA

ABSTRACT

The experiment was conducted at the farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from September to December 2012 to study the growth and yield response of mungbean to the application of prilled and super granule urea. The variety BARI mung-6 was used as the test crop. The experiment consists of the following treatments- T_1 = Prilled urea (PU) broadcast, T_2 = PU given in furrows, T_3 = PU given between two rows, T_4 = PU and seeds given in same furrows, T_5 = USG placed at 10 cm depth at 10 cm distance (avoid one row), T_6 = USG placed at 10 cm depth at 10 cm distance (avoid two rows), T_7 = USG placed at 10 cm depth at 10 cm distance (avoid three rows), T_8 = USG placed at 10 cm depth at 20 cm distance (avoid one row), T_9 = USG placed at 10 cm depth at 20 cm distance (avoid two rows), T_{10} = USG placed at 10 cm depth at 20 cm distance (avoid three rows), T_{11} = USG placed at 10 cm depth at 30 cm distance (avoid one row), T_{12} = USG placed at 10 cm depth at 30 cm distance (avoid two rows), T_{13} = USG placed at 10 cm depth at 30 cm distance (avoid three rows), T_{14} = USG placed at 10 cm depth at 40 cm distance (avoid one row), T_{15} = USG placed at 10 cm depth at 40 cm distance (avoid two rows) and T_{16} = USG placed at 10 cm depth at 40 cm distance (avoid three rows). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth, yield and yield contributing characters of mungbean were recorded and significant variations was observed among the studied characters. Treatment T_2 (PU given in furrows) registered the maximum plant height (18.61 cm, 24.35 cm, 37.60 cm, 45.98 cm an 50.57 cm), the maximum number of leaves plant^{-1} (4.03, 10.20, 17.93, 20.50 and 22.57), the maximum number of branches plant^{-1} (1.53, 4.26, 4.57, 5.11 and 6.00) and the highest above ground dry matter plant^{-1} (8.55 g, 9.61 g, 10.71 g and 12.08 g) at 20, 30, 40, 50, 60 DAS and harvest, respectively. The minimum plant height (10.67 cm, 17.51 cm, 28.38 cm, 34.67 cm and 38.61 cm), the minimum number of leaves plant^{-1} (3.10, 6.73, 11.73, 13.03 and 14.90), the minimum number of branches plant^{-1} (1.13, 2.39, 2.88, 2.92 and 3.33) and the lowest above ground dry matter plant^{-1} (5.14 g, 6.02 g, 6.87 g and 9.40 g, respectively) were observed with from T_{16} (USG placed at 10 cm depth at 40 cm distance - avoid three rows) at all growth stages. The maximum yield contributing characters like pods plant^{-1} (25.93), pod length (7.26 cm), seeds pod^{-1} (9.46) and 1000-seeds weight (42.60 g) were found when crop was given prilled urea in furrow (T_2). Plant showed minimum pods plant^{-1} (16.87), pod length (5.52 cm), seeds pod^{-1} (5.73) and 1000-seed weight (33.38 g) when treated with lower amount of USG (T_{16}). The highest seed yield, stover, biological yield were noted as 1.94 t ha^{-1}, 2.85 t ha^{-1} and 4.79 t ha^{-1} from T_2, respectively, when T_{16} showed the minimum seed yield (1.13 t ha^{-1}), stover yield (1.52 t ha^{-1}) and biological yield (2.65 t ha^{-1}).

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CHAPTER I

INTRODUCTION

Mungbean (*Vigna radiata* L.) is one of the most important pulse crop as fifth crop of Bangladesh and belongs to the family Fabaceae. The area under pulse crops in Bangladesh 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 with production of 0.03 million tons (BBS, 2010).

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, 2010). The remaining land has been cultivating 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 farmers' 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 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. The average value of pulse production (736 kg ha^{-1}) is very low comparing the value of other countries of world (FAO, 2002).

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, 2010). In fact, it is one of the least cared crops. Mungbean is cultivated with minimum tillage, local varieties no or minimum fertilizers, pesticides and very early or very late sowing, no irrigation and drainage facilities etc. when nitrogen is very loosing nutrient with broadcast application. Nitrogen given as basal, is very limiting when plant requires adequate at different stage of its growth. All these factors combindely responsible for low yield of mungbean (Hussain *et al*., 2008). Mansoor (2007) noted that lack of attention on fertilizer application in proper way with appropriate amount is identified for lowering mungbean yields. Being leguminous in nature, mungbean needs low nitrogen but requires optimum during is onset of flowering and podding.

Experimental findings revealed that pulse crop stop to nourish *Rhizobia* rather translocally energy towards development of flowers and pods. Thus, nitrogen fixation is totally ceased during reproductive stage which eventually hampers the development of reproductive traits. In this situation nitrogen given as basal to the crop is not sufficiently available to the plant for nourishing its flowers and pods thus seed yield value is lower (Patel *et al.,* 1984; BARC, 2005).

So, nitrogen management is required synchronizing this demand of plant growth stages. Triggering nitrogen at the plant demand would be attempt towards yield improvements of pulse. Keeping this in mind attention is given on nitrogen placement or use of Urea Super Granule (USG) in pulse. Both these ways of nitrogen placement might have some influencing technique that would be better utilization by the major nutrient for nitrogen for its maximum seed yield. The maximum grain yield in rice (6.8 t ha^{-1}) was recorded by Bhardwaj and Singh (1993), when placing nitrogen fertilizer as prilled or USG.

Hence, the present study was undertaken to maximize the seed yield of mungbean with nitrogen fertilizer application as prilled urea (PU) and urea super granule (USG) with following objectives:

- To study the comparative performance of prilled urea and USG on the growth and yield of mungbean
- To select a suitable application methods of prilled urea or USG for maximum yield of mungbean.

CHAPTER II

REVIEW OF LITERATURE

In Bangladesh and in many countries of the world mungbean is an important pulse crop. The crop has been given less attention by the researchers on nitrogen management because normally it grows without low 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. Fertilizer, especially nitrogen plays an important role in improving mungbean yield. But research works related to nitrogen application or uses of USG are limited in Bangladesh context. However, some of the important and informative works and research findings related to the effect of nitrogen on mungbean and placement of different forms of urea in other crops so far have been done at home and abroad on have been reviewed in this chapter under the following headings-

2.1 Effects of prilled urea on mungbean

2.1.1 Plant height

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 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 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. 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.

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

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.

2.1.2 Leaves $plant^{-1}$

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. They observed that number of leaves $plant^{-1}$ was significantly affected by varying levels of nitrogen.

2.1.3 Branches $plant^{-1}$

Malik *et al.* (2003) conducted a study 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. They observed that number of branches per plant 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 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. The number of branches increased with increasing N rates.

2.1.4 Dry matter content

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 dry matter content in above ground part.

2.1.5 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 (38.3).

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 and reported that the number of pods per plant 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}) 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.

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 per plant.

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.

2.1.6 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 (7.67).

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 seeds pod^{-1}.

2.1.7 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}) were tested. They observed 1000-seed weight increased with increasing rates of N up to 40 kg ha^{-1}.

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}.

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 seed weight of mungbean.

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. 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.

2.1.8 Seed yield

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 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 mungbean in Tandojam, Pakistan. The different NPK levels 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 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.

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. They observed that 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.

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 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 levels 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}).

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}.

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.

2.1.9 Stover yield

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 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 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}) were tested and the experimented results they stated that the stover yield increased with increasing N up to 40 kg ha^{-1}.

2.1.10 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 Effect of urea super granules on crops

Akter (2010) carried out a field experiment at Sher-e-Bangla Agricultural University, Dhaka to assess the comparative advantages of using urea super granule (USG) over prilled urea and also the effect of different management of nitrogenous fertilizer on growth, yield and yield attributing characters of mustard and reported that plant height, number of branches $plant^{-1}$, number of leaves $plant^{-1}$, total dry matter, number of siliqua $plant^{-1}$, siliqua length, number of seeds $siliqua^{-1}$, 1000-seed weight and seed yield (t ha^{-1}) was found highest when USG was applied as basal dose and all the characters showed lowest value when USG was applied at 25 DAS. It was also noted that USG reduces 40% use of urea which lowers 20% of total cost in mustard production.

Hussain *et al*. (2010) conducted a number of experiments at Farming System Research and development (FSRD) site at Tangail for three consecutive years to evaluate the efficiency of USG application over prilled urea on the yield of cabbage and recorded highest head yield (78.1 t/ha) was obtained with recommended dose of N as USG.

Ahmed *et al*. (2010) conducted a field experiment in farmers field at the MLT site at Madhupur and Ghatail upazila with four treatment on the production of hybrid maize. The highest grain yield (10.30 t/ha) was obtained from the plot treated with recommended dose of N as USG which was similar to that of plots treated with 10% less than recommended dose of N as USG (9.44 t/ha). The recommended dose of N as prilled urea gave yield of 9.2 t/ha.

Department of Agricultural Extension (DAE) conducted 432 demonstrations of the effect of USG on boro rice in 72 thanas of 31 districts during the 1996-97 winter season. It was reported that USG plots, on an average, produced higher yields than the PU plots while applying 30 to 40% less urea in the form of USG (Islam and Black, 1998).

Vijaya and Subbaiah (1997) conducted an experiment with rice cv. IET 1444 treated with fertilizer @ 90 kg N ha^{-1} as prilled urea, large granular urea or urea super granules (USG) and 70 kg P_2O_5 ha^{-1} as single superphosphate or large diammonium phosphate, both applied by broadcasting or placement methods. They showed that plant height, number of tillers, root length, number and weight of panicles, N and P uptake, dry matter and grain yield of rice increased with increasing urea super granule size and were greater with the deep placement of both N and P compared to their broadcasting application.

Panday and Tiwari (1996) observed that grain yield was the highest with N applied as a basal dose of USG or mussoorie rock phosphate urea, (MRPU) applied in two split applications.

Das and Singh (1994) reported that grain yield and N use efficiency by rice were greater for deep placed USG than for USG broadcast and incorporated or three split applications of PU. Mishra *et al.* (1994) carried out a field experiment with rice cv. sita giving 0 or 80 kg N ha^{-1}as urea, USG and neem, lac, rock phosphate or karanj coated urea and showed that the highest grain yield was (3.39 t ha^{-1})obtained by urea in three split applications.

Subbaiah *et al.* (1994) reported that the highest grain yield (6.12 t ha^{-1}) was obtained with USG, 4.76 with PU + SSP and the lowest 2.89 t ha^{-1} with the control. Grain yield, N use efficiency and apparent N recovery are consistently higher particularly during the *boro* season when N as USG is deep placed. The efficiency is further improved if hole is properly closed immediately after deep point placement of USG.

Quayum and Prasad (1994) showed that application of N up to 112.5 kg ha^{-1} increased grain (4.37 t ha^{-1}) and straw (5.49 t ha^{-1}) yields with fertile grain $panicle^{-1}$ being the highest at this N rate. N applied as USG gave the best yield and yield attributes. It is reported that the slow release fertilizers were effective for rainfed lowland rice.

Patel and Mishra (1994) carried out an experiment on rice applied with 0, 30, 60 or 90 kg N ha^{-1} as Mussorie rock phosphate-coated urea, neem cake-coated urea, gypsum coated urea, USG or prilled urea. The coated materials were incorporated before transplanting, urea super granules were placed 5-10 cm deep a week after transplanting and urea was applied in 3 split doses. They showed that N rate had no significant effect on panicle length, percent sterility and harvest index.

Bhale and Salunke (1993) conducted a field trial to study the response of upland irrigated rice to nitrogen applied through urea and USG. They found that grain yield increased with up to 120 kg urea and 100 kg USG. Singh *et al*. (1993) opined that grain yield and N uptakes increased with increased rate of N application and were the highest with deep placed USG. Bhardwaj and Singh (1993) observed that placement of 84 kg N as USG produced a grain yield of 6.8 t ha^{-1} which was similar to placing 112 kg USG and significantly greater than other nitrogen sources and rates.

Reddy *et al.* (1991) carried out a field experiment in 1984 to study the effects of different N sources on rice cv. Jaya and Mangala. They found that the highest grain yield of 5863 kg $ha^{-1}$was gained from cv. Jaya treated with 112 kg ha^{-1} of urea super granules (USG) placed in the root zone.

Narayanan and Thangamuthu (1991) carried out field experiments on rice cv. TKM9 and IR 20 at combatore, Tamil Nadu in 1984-85, N was applied at 30, 60 or 90 kg ha^{-1} using USG placed at a depth of 10 cm in the main plot. They noted that maximum yields of grain and straw were obtained from 90 kg N ha^{-1}, while the lowest was under the control treatment.

Suhartatik (1991) reported that point placement of urea super granule with lime significantly increased the leaf area index of mungbean.

Rama *et al.* (1989) mentioned that the number of panicles m^{-2} increased significantly when nitrogen level increased from 40 to 120 kg N ha^{-1} as different modified materials. Urea super granules (USG) produced significantly higher number of panicles m^{-2} and grains $panicle^{-1}$ than split application of prilled urea. Patra and Padhi (1989) stated that USG recorded the lowest number of tiller $hill^{-1}$, panicles $hill^{-1}$ and shortest panicle. Jee and Mahapatra (1989) also observed that number of panicles m^{-2} were significantly higher @ 90 kg N ha^{-1} as deep placed urea super granules (USG) than split application of urea.

Chauhan and Mishra (1989) conducted field experiments at pantnagar with rice applying 40, 80 or 120 kg N ha^{-1} as five different forms of urea. They reported that USG point placed one week after transplanting gave the highest mean DM yield and PU gave the lowest grain yield while deep placed USG gave the highest grain yield of 4.08, 4.86 and 5.17 t ha^{-1} at 40, 80 and 120 kg N ha^{-1}, respectively in 1983 corresponding 1984 yields were 4.05, 4.75 and 5.39 t ha^{-1}.

Chakravorti *et al.* (1989) reported that applying 37.5 75.0 and 112.5 kg N ha^{-1} as USG to rice gave rice yield of 3.85, 5.22 & 5.48 t ha^{-1}, respectively compared with 3.10, 4.29 and 4.97 t respectively, with N as urea and 1.95 without N. Rao and Ghai (1989) reported that SCU did not influence grain yield, LCU decreased yields and USG increased yield significantly.

Lal *et al.* (1988) conducted a field experiment on a silty loam soil during the rainy season of 1981-83 to evaluate the performance of USG and SCU in transplanted rice. They reported that placement of N as USG and broadcast incorporation of SCU were superior to prilled urea (applied in three split surface dressings) at 29, 58 and 87 kg N ha^{-1} but not at 116 kg N ha^{-1}. SCU gave the highest response followed by USG and both maintained superiority over PU upto 87 kg N ha^{-1}.

Sarder *et al.* (1988) conducted a field experiment at Mymensingh on wetland rice applying urea, USG and sulphur coated urea (SCU) at 23.7, 47.4 and 94.8 kg N ha^{-1}. Urea was broadcast in three split applications, USG was point placed at transplanting and SCU was broadcast and incorporated at transplanting. SCU was more efficient than the conventional method of urea application and point placement of USG only at the highest N rate, giving higher grain yield and greater plant height, panicle length and total number of grains $panicle^{-1}$ than the other N sources. At lower N rate, the crop's response was similar. USG did not show any advantage over conventional urea application.

Raja *et al.* (1987) conducted an experiment with rice cv. Pravath and six different forms of nitrogen and mentioned that nitrogen as USG gave the highest average yield of 5.44 t compared with 4.64-4.92 t for nitrogen in five other forms. The USG at 75 kg N ha^{-1} gave the highest yield of 7.2 t ha^{-1}. Juang and Wang (1987) stated that nitrogen rates were insignificant for both the broadcasting and deep placement.

Sardar and Verma (1987) conducted an experiment in New Delhi, India and reported that larger urea granule causes slow release of nitrogen and results significant increase in leaf area index (LAI) of mungbean.

Singh and Singh (1986) worked with different levels of nitrogen as urea, super granules (USG), sulphur coated urea and prilled urea @ 27, 54 and 87 kg ha^{-1}. They reported that number of tillers m^{-2} increased with increasing nitrogen fertilizer. The number of tillers m^{-2} was significantly greater in urea super granules than prilled urea in all levels of nitrogen. USG increased the net return with urea alone. N as USG placed in the root zone in soil gave significantly higher Yields than N as neem cake coated urea, dicyandiamide incorporated urea mixed with moist soil or urea (Reddy *et al.*, 1986).

Patel and Chandrawanshi (1986) conducted an experiment with rice cv. Sunuidhi (R-23.84) growing without N, or with 40 kg N ha^{-1} as urea broadcast and incorporated as a basal dose before sowing, USG applied in rows and seeds drilled in alternate rows, urea or USG and seed drilled in the same furrow. They reported that the treatments did not significantly affect the number of panicles m^{-2} but yield was highest (2.4 t ha^{-1}) in the last of the above treatments.

Rajagopalan and Palaniasamy (1985) carried out an experiment with rice cv. TK 43 giving 50 or 75 kg N ha^{-1} as neem-cake coated urea, coal coated urea and USG in the kharif season. They found that greatest plant height (83 cm), umber of panicles $hill^{-1}$ (10.00), panicle length (21 cm) and number of filled grains $panicle^{-1}$ (85) were obtained with 75 kg N as USG ha^{-1}. Grain and straw yields were also highest with N on USG at either application rate.

Singh and Singh (1984) conducted a rainfed trial with rice on a calcareous silt-loam soil and reported that 29-87 kg N ha^{-1} as USG and SCU before transplanting gave rice yields of 3.7 and 3.69 t ha^{-1}, respectively, compared with 3.56 t with urea in three split dressings, 3.45 t with urea at transplanting only.

Kumar and Singh (1983) carried out an experiment with rice cv. Hindham grown by applying 29-116 kg N ha^{-1} under flooded condition and stated that 87 kg N ha^{-1} in the form of USG gave the highest yield which was 14.4% more compared to split application of urea.

Rambabu *et al.* (1983) reported that of various forms and methods of application of N fertilizers to rice grown under flooded conditions, placement of N as USG (1 g sizes) in the root zone at transplanting was most effective in increasing DM production, rice yield, N uptake and apparent recovery of applied N, followed by SCU incorporated before transplanting. Yield and N recovery were lowest with urea applied as basal drilling.

In trails in several countries rice was given 0-176 to kg N ha^{-1} at each of three growth stages as urea or USG applied broadcast, incorporated or deep placed. Recovery of N was generally higher with USG than with urea and less than urea was needed to give the same grain yield (Yamada *et al*., 1981). Umar *et al.* (1981) conducted field trials at Maros, Langrang and Sulawesc and found that grain yield of low land rice was not affected by N application date and did not differ when N was applied as mudballs, urea briquets or USG. At Langrang, S-coated urea gave higher yield than urea alone.

Yamda *et al.* (1981) stated that in trials in several countries rice was given 0176 kg ha^{-1} at each of three growth stages at urea or USG applied broadcast, incorporated or deep placed. Recovery of N was generally higher with USG than with urea and comparatively less amount USG was needed than urea to give the same grain yield. The superior performance of USG in increasing rice yield and fertilizers N efficiency has shown the new product to be suitable for paddy in many Asian countries, where urea is already a common fertilizer. The Product is 40-50% more efficient than conventional urea (Juang, 1980).

It may be understood from the above reviews that nitrogen is an important nutrient for mungbean crop which is given as basal or foliar spray. On the other hand, USG is emerging as an important nitrogen encouragement for crops with higher yields.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted during the period from September to December 2012 to study the growth and yield response of mungbean to the application of prilled and super granule urea. The details of the materials and methods i.e. location of experimental site, soil and climate condition of the experimental plot, materials used, design of the experiment, data collection procedure and procedure of data analysis has been 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, grind and passed through 2 mm sieve and analyzed at Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka for some important physical and chemical properties. The results showed that the soil composed of 27% sand, 43% silt, 30% clay and organic matter 0.78%, which have been 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. 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 found maximum temperature 34.8^0C and minimum temperature 13.5^0C during the study period and details are presented in Appendix II.

3.4 Planting material

The variety BARI mung-6 was used as the test crop. The seeds were collected from the Pulse Seed Division of Bangladesh Agricultural Research Institute, Joydevpur, Gazipur. BARI mung-6 is the released variety 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 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 02 and 09 September 2012, respectively. Experimental land was divided into 48 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 in the experimental plot. Urea was applied as prilled urea (PU) and urea super granule (USG) as per treatment. Prilled urea was applied in broadcasts, furrow and between two furrows. TSP and MoP were applied at the rate of 40 and 50 kg per hectare, respectively following the Bangladesh Agricultural Research Institute (BARI) recommendation for mungbean cultivation. All of the fertilizers were applied during final land preparation.

3.7 Treatments of the experiment

The experiment consists of the following treatments:

T_1 = Prilled urea (PU) broadcast

T_2 = PU given in furrows

T_3 = PU given between two rows

T_4 = PU and seeds given in same furrows

T_5 = USG placed at 10 cm depth at 10 cm distance (avoid one row)

T_6 = USG placed at 10 cm depth at 10 cm distance (avoid two rows)

T_7 = USG placed at 10 cm depth at 10 cm distance (avoid three rows)

T_8 = USG placed at 10 cm depth at 20 cm distance (avoid one row)

T_9 = USG placed at 10 cm depth at 20 cm distance (avoid two rows)

T_{10} = USG placed at 10 cm depth at 20 cm distance (avoid three rows)

T_{11} = USG placed at 10 cm depth at 30 cm distance (avoid one row)

T_{12} = USG placed at 10 cm depth at 30 cm distance (avoid two rows)

T_{13} = USG placed at 10 cm depth at 30 cm distance (avoid three rows)

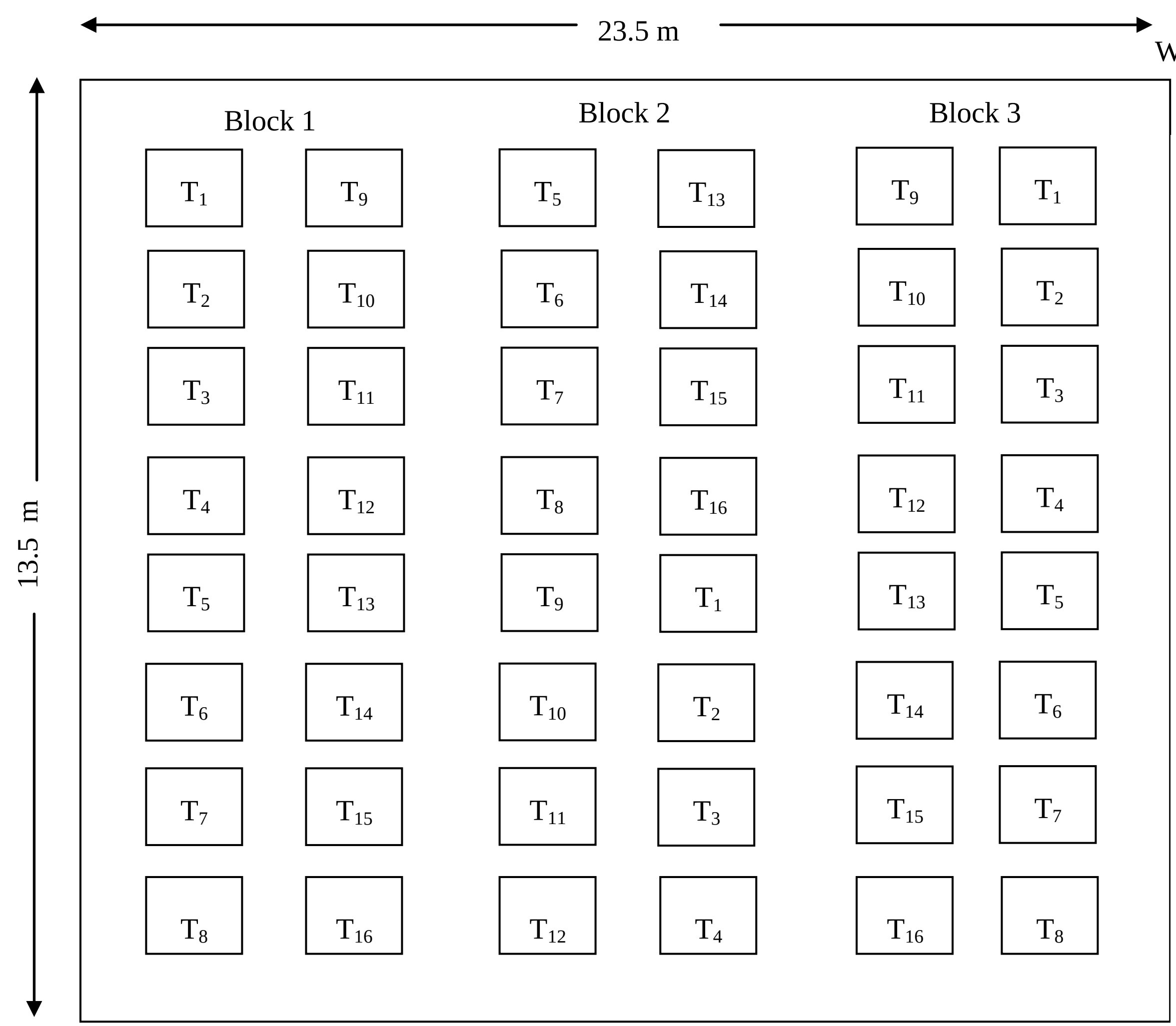
T_{14} = USG placed at 10 cm depth at 40 cm distance (avoid one row)

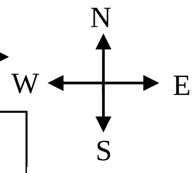
T_{15} = USG placed at 10 cm depth at 40 cm distance (avoid two rows)

T_{16} = USG placed at 10 cm depth at 40 cm distance (avoid three rows)

3.8 Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. An area of 57.5 m × 19.0 m was divided into three equal blocks. Each block was divided into 16 plots where 16 treatment were allotted at randomly. There were 48 unit plots altogether in the experiment. The size of the each unit plot was 5.0 m × 3.0 m. The space between two blocks and two plots were 1.0 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.





Plot size = 3.0 m × 1.0 m

Plot to plot: 0.5 m

Replication to replication: 1.0 m

T_1 = Prilled urea (PU) broadcast
T_2 = PU given in furrows
T_3 = PU given between two rows
T_4 = PU and seeds given in same furrows
T_5 = USG placed at 10 cm depth at 10 cm distance (avoid one row)
T_6 = USG placed at 10 cm depth at 10 cm distance (avoid two rows)
T_7 = USG placed at 10 cm depth at 10 cm distance (avoid three rows)
T_8 = USG placed at 10 cm depth at 20 cm distance (avoid one row)
T_9 = USG placed at 10 cm depth at 20 cm distance (avoid two rows)
T_{10} = USG placed at 10 cm depth at 20 cm distance (avoid three rows)
T_{11} = USG placed at 10 cm depth at 30 cm distance (avoid one row)
T_{12} = USG placed at 10 cm depth at 30 cm distance (avoid two rows)
T_{13} = USG placed at 10 cm depth at 30 cm distance (avoid three rows)
T_{14} = USG placed at 10 cm depth at 40 cm distance (avoid one row)
T_{15} = USG placed at 10 cm depth at 40 cm distance (avoid two rows)
T_{16} = USG placed at 10 cm depth at 40 cm distance (avoid three rows)

Figure 1. Field layout of the experimental plot

3.9 Sowing of seeds in the field

The seeds of mungbean were sown on 09 September, 2012. 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 for data recording. Plant height, number of leaves per plant, branches per plant were recorded from selected plants at an interval of 10 days started from 20 -50 DAS and to harvest.

3.12 Harvest and post harvest operations

Harvesting was done when 90% of the pods became brown to black in color and it was done at 07 December, 2012**.** 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

3.13.1 Crop Growth Characters

Plant height

The height of plant was recorded in centimeter (cm) at 20, 30, 40, 50 DAS (Days after sowing) and harvest. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot that were tagged earlier. The height was measured from the ground level to the tip of the plant with the help of a meter scale.

Leaves plant^{-1}

The number of laves plant^{-1} was recorded at 20, 30, 40, 50 DAS and harvest. Data were recorded by counting leaves from each plant and as the average of 10 plants selected at random from the inner rows of each plot.

Branches plant^{-1}

Total number of branches plant^{-1} was recorded at 20, 30, 40 and 50 DAS and harvest. Data were recorded by counting branches from each plant and as the average of 10 plants selected at random from the inner rows of each plot.

Above ground dry matter plant^{-1}

Data from ten sample plants from each plot were collected and gently washed with tap water, thereafter soaked with paper towel. The sample was oven dried at 70^{0}C for 72 hours. Then oven-dried samples were transferred into a desiccator and allowed to cool down to room temperature, thereafter dry weight of plant was taken and expressed in gram. Above ground dry matter plant^{-1} was recorded at 20, 30, 40 and 50 DAS.

Estimated growth parameter

Using the data on total dry matter from each specific treatment, Crop Growth Rate (CGR) and Relative Growth Rate (RGR) growth parameters were derived with following formulae (Hunt, 1978):

Crop Growth Rate (CGR)

Crop growth rate was calculated using the following formula:

$$CGR = \frac{1}{GA} \times \frac{W_2 - W_1}{T_2 - T_1} \text{ g m}^{-2}\text{day}^{-1}$$

Where,

GA = Ground area (m^2)

W_1 = Total dry weight at previous sampling date (T_1)

W_2 = Total dry weight at current sampling date (T_2)

T_1 = Date of previous sampling

T_2 = Date of current sampling

Relative Growth Rate (RGR)

Relative growth rate was calculated using the following formula:

$$RGR = \frac{LnW_2 - LnW_1}{T_2 - T_1} \quad (\text{g g}^{-1}\text{day}^{-1})$$

Where,

W_1 = Total dry weight at previous sampling date (time T_1)

W_2 = Total dry weight at current sampling date (time T_2)

T_1 = Date of previous sampling

T_2 = Date of current sampling

Ln = Natural logarithm

3.13.2 Yield contributing characters and yield of mungbean

Pods plant^{-1}

Number of total pods of selected plants from each plot were counted and the mean numbers were expressed as plant^{-1} basis. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot.

Pod length

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

Seeds pod^{-1}

Seeds pod^{-1} was recorded randomly from selected plants at the time of harvest. Data were recorded as the average of 10 pods selected at random from the inner rows of each plot.

Weight of 1000 seeds

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

Seed yield hectare^{-1}

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

Stover yield hectare^{-1}

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

Biological yield

Seed yield and stover yield together were regarded as biological yield. The biological yield was calculated with the following formula:

Biological yield = Seed yield + Stover yield.

Harvest index

Harvest index was calculated from the seed yield and stover yield of mungbean for each plot and expressed in percentage.

$$HI = \frac{\text{Economic yield (seed weight)}}{\text{Biological yield (Total dry weight)}} \times 100$$

3.14 Statistical analysis

The data obtained for different parameters were statistically analyzed using MSTAT-C software. 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 growth and yield response of mungbean to the application of prilled and super granule urea. Data on different growth, yield and yield contributing characters of mungbean were recorded. The results have been presented with the help of table and graphs and possible interpretations given under the following headings:

4.1 Plant height

Statistically significant variation was recorded in terms of plant height of mungbean at 20, 30, 40 and 50 DAS and harvest for the different nitrogen management under the present trial (Table 1). At 20 DAS, the longest plant (18.61 cm) was observed from T_2 [PU given in furrows] which was statistically similar with T_1 [Prilled urea (PU) broadcast] (17.71 cm), T_5 [USG placed at 10 cm depth at 10 cm distance (avoid one row)] (17.57 cm), T_6 [(USG placed at 10 cm depth at 10 cm distance (avoid two rows)] (17.26 cm) and T_7 [USG placed at 10 cm depth at 10 cm distance (avoid three rows)] (17.15 cm). The shortest plant was recorded T_{16} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (10.67 cm) and as per with T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid two rows)] (10.68 cm) and T_{13} [USG placed at 10 cm depth at 30 cm distance (avoid three rows)] (11.35 cm).

At 30 DAS, T_2 [PU given in furrows] gave the taller (24.35 cm) and was followed by T_1 [Prilled urea (PU) broadcast] (22.89 cm), T_5 [USG placed at 10 cm depth at 10 cm distance (avoid one row)] (22.80 cm) and T_6 [(USG placed at 10 cm depth at 10 cm distance (avoid two rows)] (22.64 cm). Shortest plant was observed from T_{16} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (17.51 cm) and similar with T_{12} [USG placed at 10 cm depth at 30 cm distance (avoid two rows)] (18.98 cm) and T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid two rows)] (19.15 cm).

Table 1. Effect of nitrogen managements on plant height of mungbean

Treatment	Plant height (cm)				
	20 DAS	30 DAS	40 DAS	50 DAS	Harvest
T_1	17.71 ab	22.89 ab	36.38 ab	45.12 ab	49.68 ab
T_2	18.61 a	24.35 a	37.60 a	45.98 a	50.57 a
T_3	16.17 b-e	20.57 b-d	34.04 b-d	42.45 a-d	45.73 de
T_4	15.97 b-e	21.90 bc	33.60 b-d	42.86 a-d	46.95 b-d
T_5	17.57 a-c	22.80 ab	35.60 a-c	44.01 a-c	49.03 a-c
T_6	17.26 a-c	22.64 ab	35.27 a-d	43.83 a-d	48.29 a-d
T_7	17.15 a-d	21.25 b-d	35.38 a-d	43.43 a-d	48.80 a-c
T_8	16.46 b-e	20.91 b-d	34.71 a-d	43.08 a-d	47.03 b-d
T_9	16.55 b-e	21.68 bc	33.82 b-d	43.26 a-d	47.45 b-d
T_{10}	15.16 de	21.65 bc	33.15 b-d	43.02 a-d	46.58 cd
T_{11}	15.60 c-e	20.24 cd	33.82 b-d	42.12 b-d	46.06 c-e
T_{12}	15.11 de	18.98 de	32.49 c-e	40.07 de	42.36 fg
T_{13}	11.35 f	20.69 b-d	31.82 de	37.97 ef	40.50 gh
T_{14}	14.68 e	20.03 cd	33.12 b-d	40.70 c-e	43.56 ef
T_{15}	10.68 f	19.15 de	29.60 ef	35.45 f	39.35 h
T_{16}	10.67 f	17.51 e	28.38 f	34.67 f	38.61 h
$S\bar{x}$	0.909	1.025	1.503	1.668	1.311
CV(%)	7.07	5.84	7.43	9.64	12.44

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

T_1 = Prilled urea (PU) broadcast

T_2 = PU given in furrows

T_3 = PU given between two rows

T_4 = PU and seeds given in same furrows

T_5 = USG placed at 10 cm depth at 10 cm distance (avoid one row)

T_6 = USG placed at 10 cm depth at 10 cm distance (avoid two rows)

T_7 = USG placed at 10 cm depth at 10 cm distance (avoid three rows)

T_8 = USG placed at 10 cm depth at 20 cm distance (avoid one row)

T_9 = USG placed at 10 cm depth at 20 cm distance (avoid two rows)

T_{10} = USG placed at 10 cm depth at 20 cm distance (avoid three rows)

T_{11} = USG placed at 10 cm depth at 30 cm distance (avoid one row)

T_{12} = USG placed at 10 cm depth at 30 cm distance (avoid two rows)

T_{13} = USG placed at 10 cm depth at 30 cm distance (avoid three rows)

T_{14} = USG placed at 10 cm depth at 40 cm distance (avoid one row)

T_{15} = USG placed at 10 cm depth at 40 cm distance (avoid two rows)

T_{16} = USG placed at 10 cm depth at 40 cm distance (avoid three rows)

At 40 DAS, the longest plant (37.60 cm) was observed from T_2 [PU given in furrows] which was statistically similar with T_1 [Prilled urea (PU) broadcast] (37.60 cm), T_5 [USG placed at 10 cm depth at 10 cm distance (avoid one row)] (35.60 cm), T_6 [(USG placed at 10 cm depth at 10 cm distance (avoid two rows)] (35.27 cm), T_7 [USG placed at 10 cm depth at 10 cm distance (avoid three rows)] (35.38 cm) and T_8 [USG placed at 10 cm depth at 20 cm distance (avoid one row)] (34.71). The shortest plant was recorded T_{16} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (28.38 cm) and as per with T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid two rows)] (29.60 cm).

At 50 DAS the longest plant (45.98 cm) was observed from T_2 [PU given in furrows] which was statistically similar with T_1 [Prilled urea (PU) broadcast] (45.12 cm), T_5 [USG placed at 10 cm depth at 10 cm distance (avoid one row)] (44.01 cm) and T_6 [(USG placed at 10 cm depth at 10 cm distance (avoid two rows)] (43.83 cm) and T_7 [USG placed at 10 cm depth at 10 cm distance (avoid three rows)] (43.43 cm). The shortest plant was recorded T_{16} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (34.67 cm) and as per with T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid two rows)] (35.45 cm).

At harvest, T_2 [PU given in furrows] gave the taller (50.57 cm) and was followed by T_1 [Prilled urea (PU) broadcast] (49.68 cm), T_5 [USG placed at 10 cm depth at 10 cm distance (avoid one row)] (49.03 cm) and T_6 [(USG placed at 10 cm depth at 10 cm distance (avoid two rows)] (48.29 cm). Shortest plant was observed from T_{16} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (38.61 cm) and similar T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid two rows)] (39.35 cm). T_2 was found very influential is give maximum taller plants as plants were able to uptake nitrogen efficiently from placed urea in furrows when nutrient requirement was varied at different growth stages. Use of USG was found to be effective it was economic to cultivate. Malik *et al.* (2003) reported that plant height was significantly affected by nitrogen fertilizer. Akter (2010) reported that plant height was highest when USG was applied as basal dose and lowest when USG was applied at 25 DAS in mustard.

4.2 Leaves plant^{-1}

Data revealed that leaves plant^{-1} varied significantly at 20, 30, 40 and 50 DAS and harvest for different nitrogen management (Table 2). At 20 DAS, the maximum leaves plant^{-1} (4.03) was observed from T_2 [PU given in furrows] which was statistically similar with T_1 [Prilled urea (PU) broadcast] (4.00), T_5 [USG placed at 10 cm depth at 10 cm distance (avoid one row)] (3.93), T_6 [(USG placed at 10 cm depth at 10 cm distance (avoid two rows)] (3.90) and T_7 [USG placed at 10 cm depth at 10 cm distance (avoid three rows)] (3.87). The minimum leaves plant^{-1} was recorded T_{16} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (3.10) and as per with T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid two rows)] (3.13).

At 30 DAS, T_2 [PU given in furrows] gave maximum leaves plant^{-1} (10.20) and was followed by T_1 [Prilled urea (PU) broadcast] (9.47), T_5 [USG placed at 10 cm depth at 10 cm distance (avoid one row)] (9.46) and T_6 [(USG placed at 10 cm depth at 10 cm distance (avoid two rows)] (9.30). Minimum leaves plant^{-1} was observed from T_{16} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (6.73) and similar with T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid two rows)] (7.57).

At 40 DAS, the maximum leaves plant^{-1} (17.93) was observed from T_2 [PU given in furrows] which was statistically similar with T_1 [Prilled urea (PU) broadcast] (17.03), T_5 [USG placed at 10 cm depth at 10 cm distance (avoid one row)] (16.97), T_6 [(USG placed at 10 cm depth at 10 cm distance (avoid two rows)] (16.43) and T_7 [USG placed at 10 cm depth at 10 cm distance (avoid three rows)] (16.33). The minimum leaves plant^{-1} was recorded T_{16} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (11.73) and as per with T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid two rows)] (12.57).

At 50 DAS, the maximum leaves plant^{-1} (20.50) was observed from T_2 [PU given in furrows] which was statistically similar with T_1 [Prilled urea (PU) broadcast] (19.83), T_5 [USG placed at 10 cm depth at 10 cm distance (avoid one row)]

Table 2. Effect of nitrogen managements on number of leaves plant^{-1} of mungbean

Treatment	Number of leaves plant^{-1}				
	20 DAS	30 DAS	40 DAS	50 DAS	Harvest
T_1	4.00 ab	9.47 ab	17.03 ab	19.83 ab	21.93 ab
T_2	4.03 a	10.20 a	17.93 a	20.50 a	22.57 a
T_3	3.77 a-d	8.80 b-e	14.90 e-g	18.73 bc	19.47 c-f
T_4	3.67 cd	8.30 d-f	15.33 d-f	18.03 c	18.57 d-f
T_5	3.93 a-c	9.46 a	16.97 ab	19.70 ab	21.60 a-c
T_6	3.90 a-c	9.30 bc	16.43 b-d	18.90 bc	21.60 a-c
T_7	3.87 a-c	8.93 b-d	16.33 b-d	18.57 c	21.20 a-c
T_8	3.40 ef	7.50 f	14.50 fg	16.80 d	17.73 fg
T_9	3.73 b-d	8.43 de	14.93 e-g	18.27 c	20.40 a-e
T_{10}	3.50 de	8.53 c-e	15.23 d-f	18.47 c	18.20 ef
T_{11}	3.70 cd	7.97 ef	15.93 b-e	18.47 c	20.07 b-e
T_{12}	3.23 fg	8.23 d-f	14.03 g	15.10 e	16.07 gh
T_{13}	3.83 a-c	8.83 b-e	15.57 c-f	16.90 d	20.53 a-d
T_{14}	3.70 cd	8.17 d-f	15.40 c-f	17.90 cd	18.90 d-f
T_{15}	3.13 g	7.57 f	12.57 h	14.53 e	15.70 gh
T_{16}	3.10 g	6.73 g	11.73 h	13.03 f	14.90 h
$S\bar{x}$	0.121	0.378	0.532	0.521	0.988
CV(%)	8.01	5.34	7.22	9.57	6.13

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

T_1 = Prilled urea (PU) broadcast

T_2 = PU given in furrows

T_3 = PU given between two rows

T_4 = PU and seeds given in same furrows

T_5 = USG placed at 10 cm depth at 10 cm distance (avoid one row)

T_6 = USG placed at 10 cm depth at 10 cm distance (avoid two rows)

T_7 = USG placed at 10 cm depth at 10 cm distance (avoid three rows)

T_8 = USG placed at 10 cm depth at 20 cm distance (avoid one row)

T_9 = USG placed at 10 cm depth at 20 cm distance (avoid two rows)

T_{10} = USG placed at 10 cm depth at 20 cm distance (avoid three rows)

T_{11} = USG placed at 10 cm depth at 30 cm distance (avoid one row)

T_{12} = USG placed at 10 cm depth at 30 cm distance (avoid two rows)

T_{13} = USG placed at 10 cm depth at 30 cm distance (avoid three rows)

T_{14} = USG placed at 10 cm depth at 40 cm distance (avoid one row)

T_{15} = USG placed at 10 cm depth at 40 cm distance (avoid two rows)

T_{16} = USG placed at 10 cm depth at 40 cm distance (avoid three rows)

(19.70). The minimum leaves plant^{-1} was recorded T_{16} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (13.03) and as per with T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid two rows)] (14.53).

At harvest, T_2 [PU given in furrows] gave maximum leaves plant^{-1} (22.57) and was followed by T_1 [Prilled urea (PU) broadcast] (21.93), T_5 [USG placed at 10 cm depth at 10 cm distance (avoid one row)] (21.60) and T_6 [(USG placed at 10 cm depth at 10 cm distance (avoid two rows)] (21.60). Minimum leaves plant^{-1} was observed from T_{16} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (14.90) and similar T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid two rows)] (15.70). Yakadri *et al.* (2002) reported that application of nitrogen at 20 kg ha^{-1} resulted in the significant increase in number of leaves per plant of greengram. Akter (2010) reported that number of leaves plant^{-1} was highest when USG was applied as basal dose and lowest when USG was applied at 25 DAS in mustard.

4.3 Branches plant^{-1}

Branches plant^{-1} varied significantly at 20, 30, 40 and 50 DAS and harvest for different nitrogen management under the present trial (Table 3). At 20 DAS, the maximum branches plant^{-1} (1.53) was observed from T_2 [PU given in furrows] which was statistically similar with T_1 (1.50), T_5 [USG placed at 10 cm depth at 10 cm distance (avoid one row)] (1.50), T_6 [(USG placed at 10 cm depth at 10 cm distance (avoid two rows)] (1.47) and T_7 [USG placed at 10 cm depth at 10 cm distance (avoid three rows)] (1.43). The minimum branches plant^{-1} was recorded T_{16} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (1.13) and as per with T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid two rows)] (1.17).

At 30 DAS, T_2 [PU given in furrows] gave maximum branches plant^{-1} (4.26) and was followed by T_1 [Prilled urea (PU) broadcast] (3.95), T_5 [USG placed at 10 cm depth at 10 cm distance (avoid one row)] (3.84) and T_6 [(USG placed at 10 cm depth at 10 cm distance (avoid two rows)] (3.51). Minimum branches plant^{-1} was

Table 3. Effect of nitrogen managements on number of branches plant^{-1} of mungbean

Treatment	Number of branches plant^{-1}				
	20 DAS	30 DAS	40 DAS	50 DAS	Harvest
T_1	1.50 ab	3.95 ab	4.33 ab	4.95 a	5.51 ab
T_2	1.53 a	4.26 a	4.57 a	5.11 a	6.00 a
T_3	1.43 a-c	3.20 d-g	3.68 cd	4.39 a-c	4.75 cd
T_4	1.40 bc	3.59 b-e	3.94 bc	4.59 ab	4.87 b-d
T_5	1.50 ab	3.84 a-c	4.07 a-c	4.93 a	5.48 ab
T_6	1.47 ab	3.51 b-e	4.13 a-c	4.86 a	5.16 bc
T_7	1.43 a-c	3.68 b-d	3.88 bc	4.81 a	5.11 bc
T_8	1.33 cd	3.35 b-f	3.74 b-d	4.62 ab	5.01 b-d
T_9	1.40 bc	3.05 e-g	3.66 cd	4.44 a-c	4.61 c-e
T_{10}	1.43 a-c	3.31 c-f	3.51 c-e	4.60 ab	4.99 b-d
T_{11}	1.40 bc	3.17 d-g	3.03 ef	3.30 d-f	5.09 b-d
T_{12}	1.40 bc	3.40 b-f	3.65 cd	3.84 c-e	4.05 ef
T_{13}	1.43 a-c	3.05 e-g	3.56 c-e	3.94 b-d	4.42 de
T_{14}	1.27 d	2.83 f-h	3.76 b-d	4.44 a-c	3.72 fg
T_{15}	1.17 e	2.69 gh	3.24 d-f	3.25 ef	3.51 fg
T_{16}	1.13 e	2.39 h	2.88 f	2.92 f	3.33 g
$S\bar{x}$	0.045	0.262	0.274	0.322	0.285
CV(%)	6.87	9.61	8.82	8.80	7.41

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

T_1 = Prilled urea (PU) broadcast

T_2 = PU given in furrows

T_3 = PU given between two rows

T_4 = PU and seeds given in same furrows

T_5 = USG placed at 10 cm depth at 10 cm distance (avoid one row)

T_6 = USG placed at 10 cm depth at 10 cm distance (avoid two rows)

T_7 = USG placed at 10 cm depth at 10 cm distance (avoid three rows)

T_8 = USG placed at 10 cm depth at 20 cm distance (avoid one row)

T_9 = USG placed at 10 cm depth at 20 cm distance (avoid two rows)

T_{10} = USG placed at 10 cm depth at 20 cm distance (avoid three rows)

T_{11} = USG placed at 10 cm depth at 30 cm distance (avoid one row)

T_{12} = USG placed at 10 cm depth at 30 cm distance (avoid two rows)

T_{13} = USG placed at 10 cm depth at 30 cm distance (avoid three rows)

T_{14} = USG placed at 10 cm depth at 40 cm distance (avoid one row)

T_{15} = USG placed at 10 cm depth at 40 cm distance (avoid two rows)

T_{16} = USG placed at 10 cm depth at 40 cm distance (avoid three rows)

observed from T_{16} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (2.39) and similar with T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid two rows)] (2.69).

At 40 DAS, the maximum branches plant^{-1} (4.57) was observed from T_2 [PU given in furrows] which was statistically similar with T_1 [Prilled urea (PU) broadcast] (4.33), T_5 [USG placed at 10 cm depth at 10 cm distance (avoid one row)] (4.07) and T_6 [(USG placed at 10 cm depth at 10 cm distance (avoid two rows)] (4.13). The minimum branches plant^{-1} was recorded T_{16} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (2.88) and as per with T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid two rows)] (3.24).

At 50 DAS, the maximum branches plant^{-1} (5.11) was observed from T_2 [PU given in furrows] which was statistically similar with T_1 [Prilled urea (PU) broadcast] (4.95), T_5 [USG placed at 10 cm depth at 10 cm distance (avoid one row)] (4.93), T_6 [(USG placed at 10 cm depth at 10 cm distance (avoid two rows)] (4.86) and T_7 [USG placed at 10 cm depth at 10 cm distance (avoid three rows)] (4.81). The minimum branches plant^{-1} was recorded T_{16} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (2.92) and as per with T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid two rows)] (3.25).

At harvest, T_2 [PU given in furrows] gave maximum branches plant^{-1} (6.00) and was followed by T_1 [Prilled urea (PU) broadcast] (5.51) and T_5 [USG placed at 10 cm depth at 10 cm distance (avoid one row)] (5.48). Minimum branches plant^{-1} was observed from T_{16} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (3.33) and similar T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid two rows)] (3.51). T_2 was found very influential is give highest branches as plants were able to uptake nitrogen efficiently from placed urea in furrows when nutrient requirement was varied at different growth stages. Rajender *et al*. (2002) reported that branches of mungbean increased with increasing N rates. Akter (2010) reported that number of branches plant^{-1} was highest when USG was applied as basal dose and lowest when USG was applied at 25 DAS in mustard.

4.4 Above ground dry matter plant^{-1}

Different nitrogen management varied significantly at 20, 30, 40 and 50 DAS for above ground dry matter plant^{-1} of mungbean (Table 4). At 20 DAS the maximum above ground dry matter plant^{-1} (8.55 g) was observed from T_2 [PU given in furrows] which was statistically similar with T_1 [Prilled urea (PU) broadcast] (7.57 g), T_5 [USG placed at 10 cm depth at 10 cm distance (avoid one row)] (7.70 g). The minimum above ground dry matter plant^{-1} was recorded T_{16} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (5.14 g) and as per with T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid two rows)] (5.79 g).

At 30 DAS, T_2 [PU given in furrows] gave maximum above ground dry matter plant^{-1} (9.61 g) and was followed by T_1 [Prilled urea (PU) broadcast] (8.43 g), T_5 [USG placed at 10 cm depth at 10 cm distance (avoid one row)] (8.39 g). Minimum above ground dry matter plant^{-1} was observed from T_{16} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (6.02 g) and similar with T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid two rows)] (7.03 g).

At 40 DAS, the maximum above ground dry matter plant^{-1} (10.71 g) was observed from T_2 [PU given in furrows] which was statistically similar with T_1 [Prilled urea (PU) broadcast] (10.30 g), T_5 [USG placed at 10 cm depth at 10 cm distance (avoid one row)] (10.00 g). The minimum above ground dry matter plant^{-1} was recorded T_{16} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (6.87 g) and as per with T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid two rows)] (8.10 g).

At 50 DAS the maximum above ground dry matter plant^{-1} (12.08 g) was observed from T_2 [PU given in furrows] which was statistically similar with T_1 [Prilled urea (PU) broadcast] (12.04 g), T_5 [USG placed at 10 cm depth at 10 cm distance (avoid one row)] (11.33 g). The minimum above ground dry matter plant^{-1} was recorded from T_{16} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (9.40 g) and as per with T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid two rows)] (9.49 g).

Table 4. Effect of nitrogen managements on above ground dry matter plant^{-1} of mungbean

Treatment	Above ground dry matter plant^{-1} (g)			
	20 DAS	30 DAS	40 DAS	50 DAS
T_1	7.57 ab	8.43 b	10.30 ab	12.04 a
T_2	8.55 a	9.61 a	10.71 a	12.08 a
T_3	6.61 bc	7.95 b-e	9.39 cd	11.80 ab
T_4	5.57 cd	6.85 e-g	8.60 de	9.30 e
T_5	7.70 ab	8.39 a-c	10.00 a-c	11.33 a-d
T_6	5.85 cd	7.34 b-f	8.83 de	10.50 b-e
T_7	5.80 cd	7.27 c-f	8.71 de	10.50 b-e
T_8	6.63 bc	8.03 b-d	9.33 cd	9.90 de
T_9	5.56 cd	6.91 e-g	8.24 ef	11.50 ab
T_{10}	5.47 cd	6.81 fg	7.65 fg	11.42 a-c
T_{11}	6.11 cd	7.44 b-f	9.53 b-d	10.53 b-e
T_{12}	6.63 bc	7.80 b-f	8.67 de	10.00 c-e
T_{13}	6.67 bc	7.91 b-f	9.37 cd	11.60 ab
T_{14}	5.51 cd	7.12 d-f	8.60 de	9.79 e
T_{15}	5.79 cd	7.03 d-g	8.10 ef	9.49 e
T_{16}	5.14 d	6.02 g	6.87 g	9.40 e
$S\bar{x}$	0.510	0.482	0.413	0.695
CV(%)	9.67	7.65	5.56	7.23

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

T_1 = Prilled urea (PU) broadcast

T_2 = PU given in furrows

T_3 = PU given between two rows

T_4 = PU and seeds given in same furrows

T_5 = USG placed at 10 cm depth at 10 cm distance (avoid one row)

T_6 = USG placed at 10 cm depth at 10 cm distance (avoid two rows)

T_7 = USG placed at 10 cm depth at 10 cm distance (avoid three rows)

T_8 = USG placed at 10 cm depth at 20 cm distance (avoid one row)

T_9 = USG placed at 10 cm depth at 20 cm distance (avoid two rows)

T_{10} = USG placed at 10 cm depth at 20 cm distance (avoid three rows)

T_{11} = USG placed at 10 cm depth at 30 cm distance (avoid one row)

T_{12} = USG placed at 10 cm depth at 30 cm distance (avoid two rows)

T_{13} = USG placed at 10 cm depth at 30 cm distance (avoid three rows)

T_{14} = USG placed at 10 cm depth at 40 cm distance (avoid one row)

T_{15} = USG placed at 10 cm depth at 40 cm distance (avoid two rows)

T_{16} = USG placed at 10 cm depth at 40 cm distance (avoid three rows)

4.5 Crop growth rate

Crop growth rate (CGR) of mungbean showed non significant variation at 20-30 DAS, 30-40 DAS and significant for 40-50 DAS for different nitrogen management under the present trial (Table 5). At 20-30 DAS, the highest CGR (21.53 g $m^{-2}day^{-1}$) was attained from T_{14}, while the lowest CGR (8.89 g $m^{-2}day^{-1}$) was found from T_5. At 30-40 DAS, the highest CGR (27.88 g $m^{-2}day^{-1}$) was recorded from T_{11}, whereas the lowest CGR (11.20 g $m^{-2}day^{-1}$) was found from T_{10}. At 40-50 DAS, the highest CGR (50.28 g $m^{-2}day^{-1}$) was observed from T_{10}, whereas the lowest CGR (7.55 g $m^{-2}day^{-1}$) was found from T_8.

4.6 Relative growth rate

Statistically non significant variation was recorded for relative growth rate (RGR) of mungbean at 20-30 DAS, 30-40 DAS and 40-50 DAS it was significant for different nitrogen management under the present trial (Table 6). At 20-30 DAS, the highest RGR (0.031 g g^{-1} day^{-1}) was found from T_{14}, while the lowest RGR (0.008 g g^{-1} day^{-1}) was found from T_5. At 30-40 DAS, the highest RGR (0.025 g g^{-1} day^{-1}) was recorded from T_{11}, whereas the lowest RGR (0.010 g g^{-1} day^{-1}) was found from T_2. At 40-50 DAS, the highest RGR (0.040 g g^{-1} day^{-1}) was recorded from T_{10}, whereas the lowest RGR (0.006 g g^{-1} day^{-1}) was observed from T_8.

4.7 Pods plant^{-1}

Pods plant^{-1} of mungbean varied significantly due to different nitrogen management under the present trial (Figure 2). The highest number of pods plant^{-1} (25.93) was recorded from T_2 which was statistically similar (25.67, 24.93, 24.60, 24.13, 24.00 and 23.87) with T_1, T_5, T_6, T_7, T_9 and T_8, respectively, whereas the lowest number of pods plant^{-1} (16.87) was observed from T_{16} which was similar (18.33) with T_{15}. T_2 had 53.7% more pods over T_{16} when amount of USG was given minimum. Data represents that use of prilled urea and USG supported plant with maximum dry matter production which eventually produced maximum number of pods plant^{-1}. Patel and Parmer (1986) 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}.

Table 5. Effect of nitrogen managements on crop growth rate of mungbean

Treatment	Crop Growth Rate (g $m^{-2}day^{-1}$)		
	20 DAS-30 DAS	30 DAS-40 DAs	40 DAS-50 DAS
T_1	11.56	24.84	20.05 c-e
T_2	14.12	14.65	18.17 c-e
T_3	17.96	19.11	37.33 a-c
T_4	17.07	23.29	9.33 e
T_5	8.89	21.78	17.78 c-e
T_6	24.16	19.85	22.23 b-e
T_7	19.64	19.13	23.89 b-e
T_8	18.69	17.35	7.55 e
T_9	17.99	17.74	43.48 ab
T_{10}	17.91	11.20	50.28 a
T_{11}	17.81	27.88	13.32 de
T_{12}	15.60	11.56	17.79 c-e
T_{13}	16.57	19.44	29.67 a-e
T_{14}	21.53	19.72	15.91 c-e
T_{15}	16.58	14.22	18.49 c-e
T_{16}	11.69	11.32	33.72 a-d
$S\bar{x}$	NS	NS	2.109
CV(%)	17.36	14.94	11.38

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

T_1 = Prilled urea (PU) broadcast

T_2 = PU given in furrows

T_3 = PU given between two rows

T_4 = PU and seeds given in same furrows

T_5 = USG placed at 10 cm depth at 10 cm distance (avoid one row)

T_6 = USG placed at 10 cm depth at 10 cm distance (avoid two rows)

T_7 = USG placed at 10 cm depth at 10 cm distance (avoid three rows)

T_8 = USG placed at 10 cm depth at 20 cm distance (avoid one row)

T_9 = USG placed at 10 cm depth at 20 cm distance (avoid two rows)

T_{10} = USG placed at 10 cm depth at 20 cm distance (avoid three rows)

T_{11} = USG placed at 10 cm depth at 30 cm distance (avoid one row)

T_{12} = USG placed at 10 cm depth at 30 cm distance (avoid two rows)

T_{13} = USG placed at 10 cm depth at 30 cm distance (avoid three rows)

T_{14} = USG placed at 10 cm depth at 40 cm distance (avoid one row)

T_{15} = USG placed at 10 cm depth at 40 cm distance (avoid two rows)

T_{16} = USG placed at 10 cm depth at 40 cm distance (avoid three rows)

Table 6. Effect of nitrogen managements on relative growth rate of mungbean

Treatment	Relative growth rate (g g^{-1} day^{-1})		
	20 DAS-30 DAS	30 DAS-40 DAs	40 DAS-50 DAS
T_1	0.011	0.020	0.014 c-e
T_2	0.012	0.010	0.012 c-e
T_3	0.018	0.017	0.026 a-d
T_4	0.021	0.023	0.008 de
T_5	0.008	0.018	0.012 c-e
T_6	0.022	0.019	0.017 b-e
T_7	0.023	0.018	0.019 b-e
T_8	0.019	0.015	0.006 e
T_9	0.022	0.018	0.034 ab
T_{10}	0.022	0.012	0.040 a
T_{11}	0.020	0.025	0.010 de
T_{12}	0.016	0.011	0.014 c-e
T_{13}	0.017	0.017	0.021 b-e
T_{14}	0.027	0.019	0.013 c-e
T_{15}	0.020	0.014	0.015 b-e
T_{16}	0.016	0.013	0.031 a-c
$S\bar{x}$	NS	NS	0.008
CV(%)	15.07	11.10	9.35

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

T_1 = Prilled urea (PU) broadcast

T_2 = PU given in furrows

T_3 = PU given between two rows

T_4 = PU and seeds given in same furrows

T_5 = USG placed at 10 cm depth at 10 cm distance (avoid one row)

T_6 = USG placed at 10 cm depth at 10 cm distance (avoid two rows)

T_7 = USG placed at 10 cm depth at 10 cm distance (avoid three rows)

T_8 = USG placed at 10 cm depth at 20 cm distance (avoid one row)

T_9 = USG placed at 10 cm depth at 20 cm distance (avoid two rows)

T_{10} = USG placed at 10 cm depth at 20 cm distance (avoid three rows)

T_{11} = USG placed at 10 cm depth at 30 cm distance (avoid one row)

T_{12} = USG placed at 10 cm depth at 30 cm distance (avoid two rows)

T_{13} = USG placed at 10 cm depth at 30 cm distance (avoid three rows)

T_{14} = USG placed at 10 cm depth at 40 cm distance (avoid one row)

T_{15} = USG placed at 10 cm depth at 40 cm distance (avoid two rows)

T_{16} = USG placed at 10 cm depth at 40 cm distance (avoid three rows)

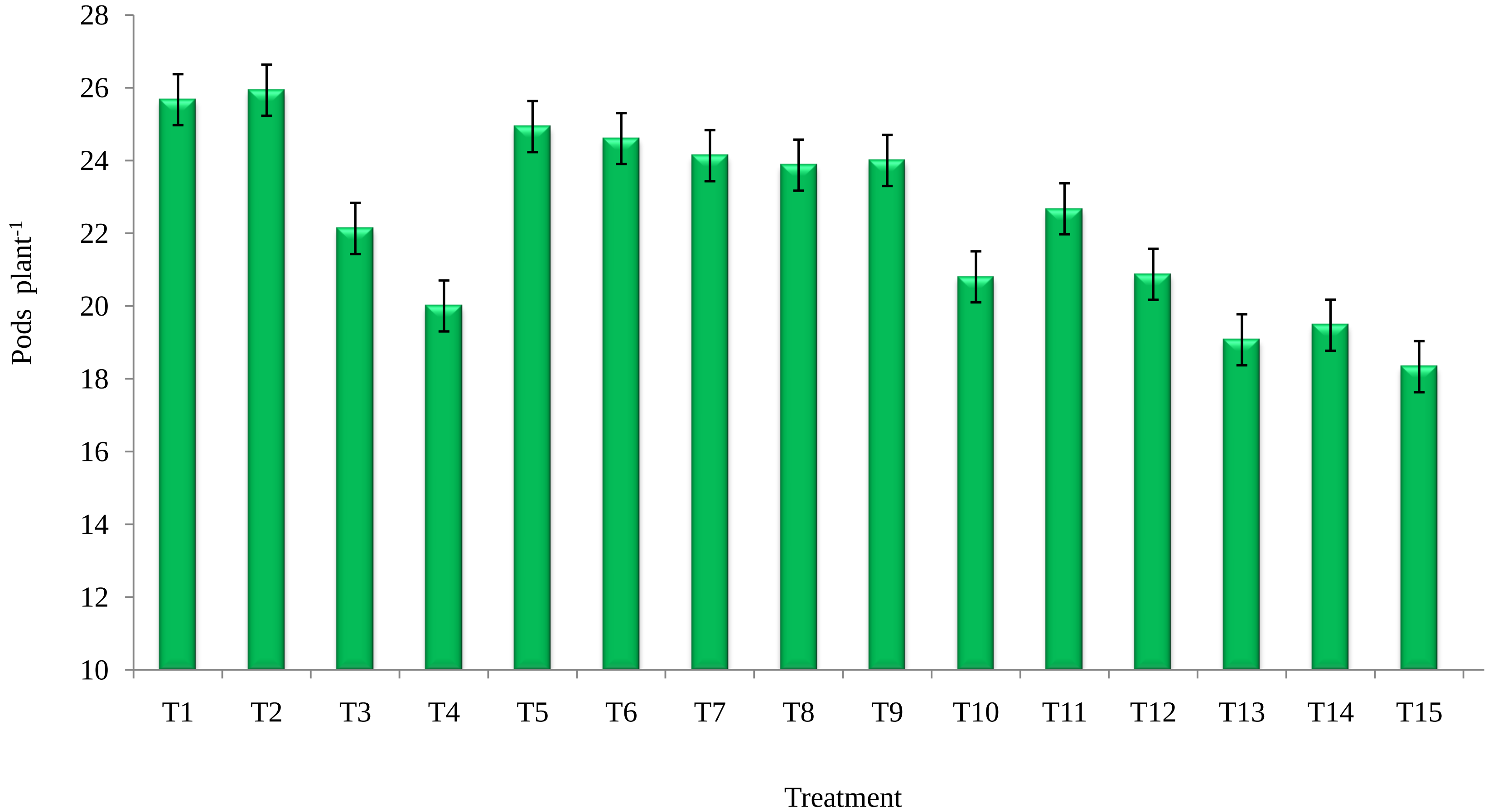


Figure 2. Effect of nitrogen managements on pods plant^{-1} mungbean (Sx = 1.052)

4.8 Seeds pod^{-1}

Due to different nitrogen management number of seeds pod^{-1} of mungbean varied significantly (Figure 3). The highest number of seeds pod^{-1} (9.46) was recorded from T_2 which was statistically similar (9.20, 8.73, 8.62 and 8.57) with T_1, T_5, T_6 and T_7, respectively, while the lowest number of seeds pod^{-1} (5.73) was observed from T_{16} which was similar (6.19 and 6.31) with T_{15} and T_{14} treatment, respectively. Malik *et al.* (2003) reported that number of seeds pod^{-1} was significantly affected by varying levels of nitrogen.

4.9 Pod length

Pod length of mungbean varied significantly due to different nitrogen management (Figure 4). The longest pod (7.26 cm) was recorded from T_2 which was statistically similar (7.20 cm and 7.17 cm) with T_1 and T_5, respectively, whereas the shortest pod (5.52 cm) was observed from T_{16} which was similar (6.15 cm) with T_{15}. T_2 was found very influential is give maximum vegetative as well as reproductive growth as plants were able to uptake nitrogen efficiently from placed urea in furrows when nutrient requirement was varied at different vegetative as well as reproductive growth stages. Use of USG was found to be effective it was economic to cultivate. Srinivas *et al.* (2002) observed that pod length increased with increasing rates of N up to 40 kg ha^{-1}.

4.10 Weight of 1000-seeds

Statistically significant variation was recorded for weight of 1000-seeds of mungbean due to different nitrogen management (Figure 5). The highest weight of 1000-seeds (42.60 g) was found from T_2 which was statistically similar (41.38 g, 40.60 g, 40.27 g and 39.71 g) with T_1, T_5, T_6 and T_7, respectively. On the other hand, the lowest weight (33.38 g) was recorded from T_6 which was statistically similar (33.60 g) with T_{15} treatment. Patel *et al.* (1984) reported that application of 20 kg N ha^{-1} significantly increased the 1000-seed weight of mungbean. Akter (2010) reported that 1000-seed weight was highest when USG was applied as basal dose and lowest when USG was applied at 25 DAS in mustard.

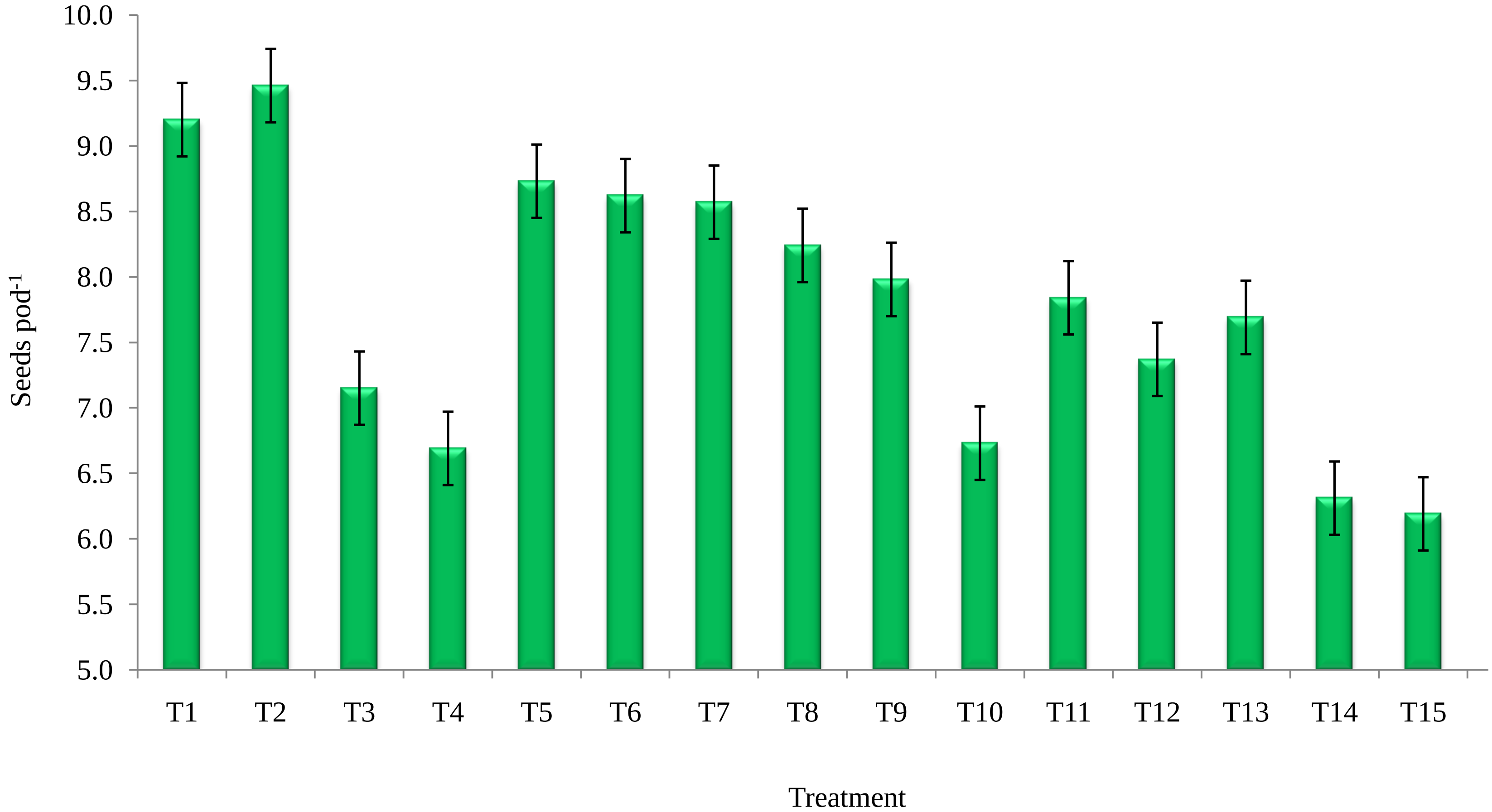


Figure 3. Effect of nitrogen managements on seeds pod^{-1} of mungbean (Sx = 0.482)

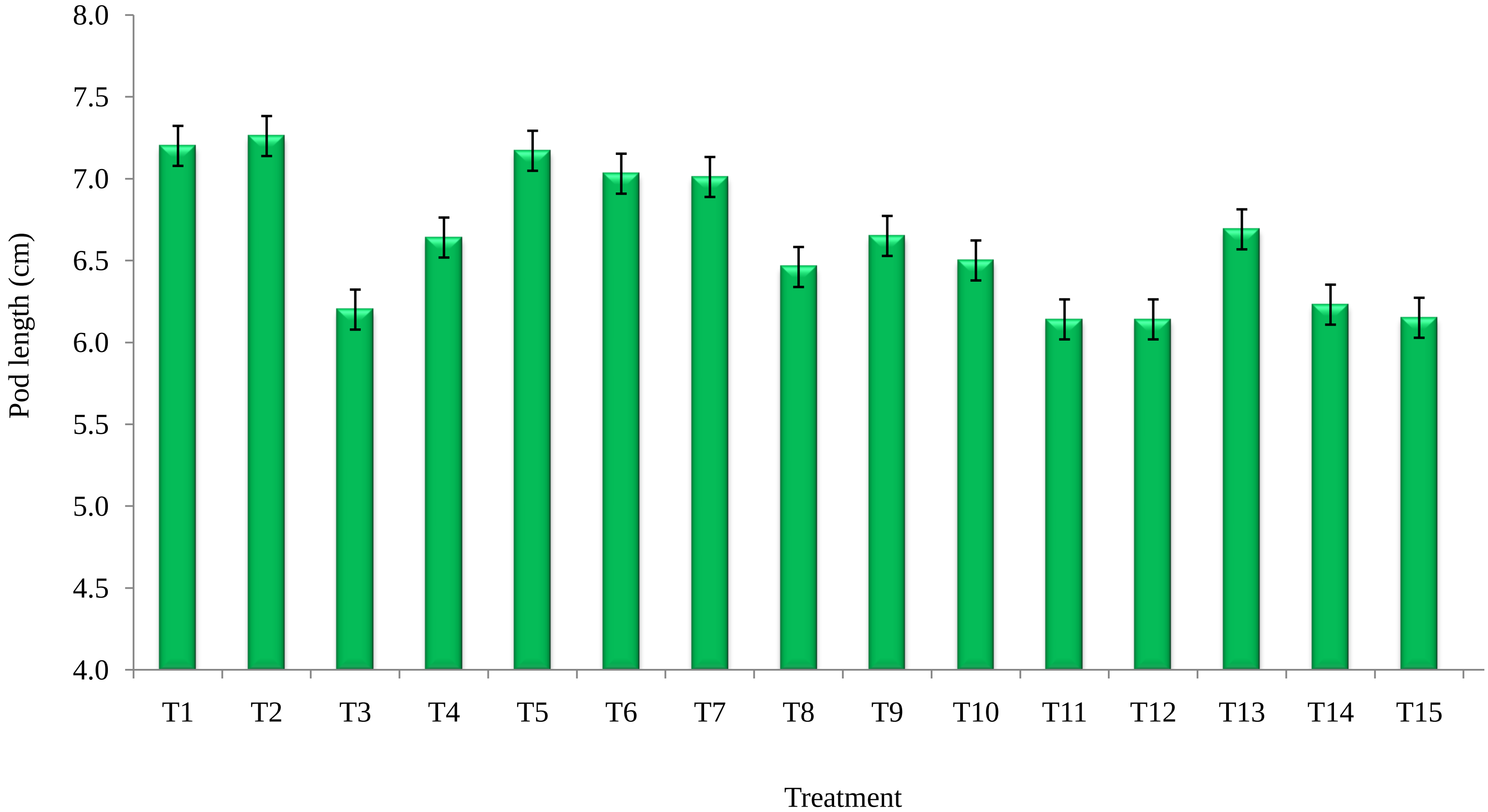


Figure 4. Effect of nitrogen management on pod length mungbean (Sx = 0.392)

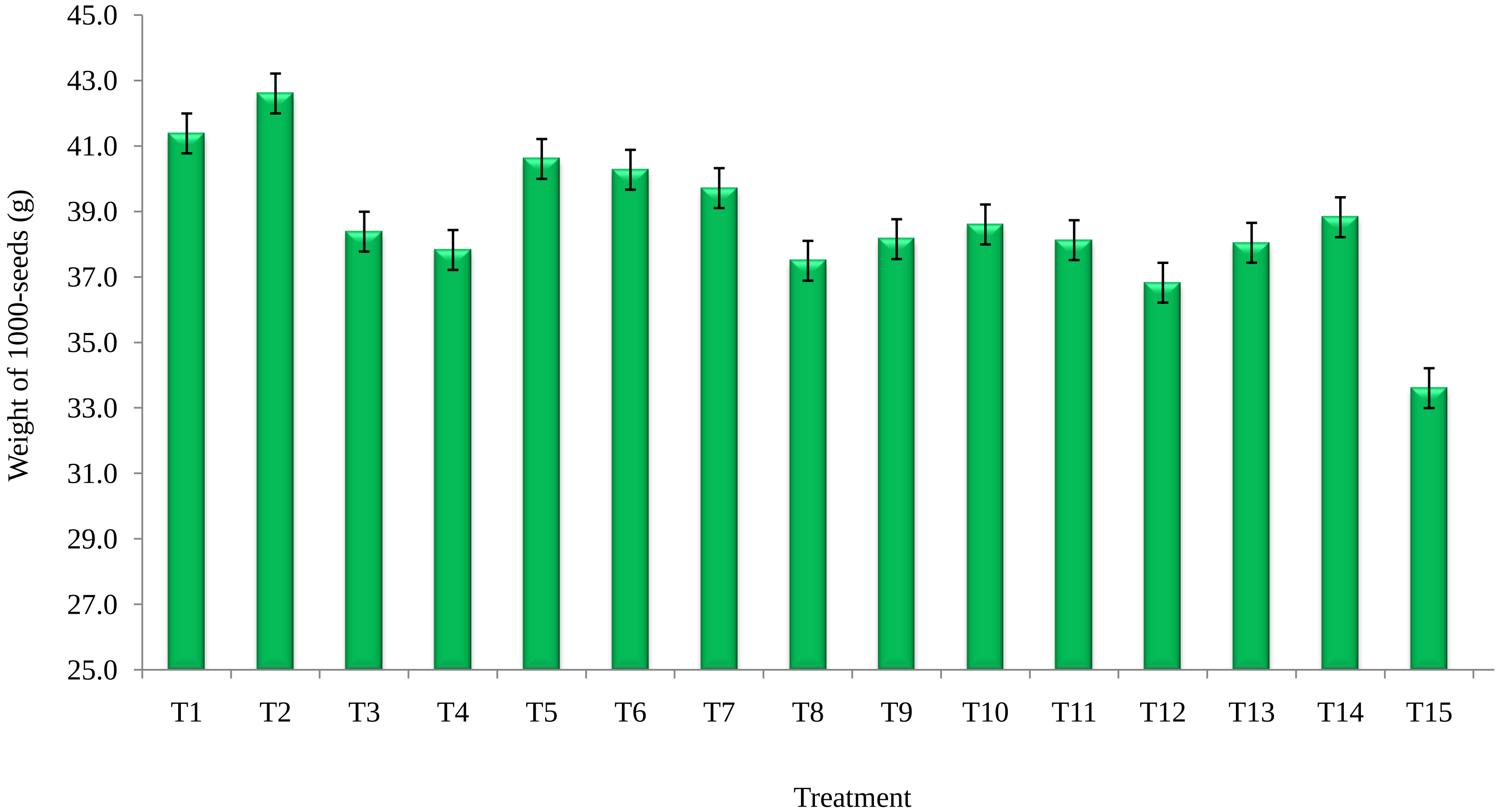


Figure 5. Effect of nitrogen management on weight of 1000-seeds of mungbean (Sx = 1.637)

4.11 Seed yield hectare^{-1}

Seed yield hectare^{-1} of mungbean varied significantly due to different nitrogen management under the present trial (Table 7). The highest seed yield (1.94 t ha^{-1}) was recorded from T_2 which was statistically similar (1.92 t ha^{-1}, 1.90 t ha^{-1}, 1.86 t ha^{-1} and 1.85 t ha^{-1}) with T_1, T_5, T_6 and T_7, respectively, whereas the lowest seed yield (1.13 t ha^{-1}) was observed from T_{16} which was similar (1.15 t ha^{-1} and 1.17 t ha^{-1}) with T_{15}, T_{14} and T_{13} treatment, respectively. T_2 treatment out yielded over T_{16} by 71.68%. The maximum yield was harvested due to maximum pods plant^{-1}, pod length, which had greater number of seeds and 1000 grain weight. 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. Patel *et al.* (1984) reported that application of nitrogenous fertilizers becomes helpful in increasing the yield. Yoshizawa *et al.* (1981) reported that an adequate supply of nitrogen is essential for vegetative growth and desirable yield of pulse crop. The placement of USG at 8-10 cm depth of soil can save 30% nitrogen than prilled urea, increases nutrient absorption, improves soil health and ultimately increases the yields (Singh *et al.*, 1993; Singh and Singh, 1986). Akter (2010) reported that seed yield was highest when USG was applied as basal dose and lowest value USG was applied at 25 DAS in mustard.

4.12 Stover yield hectare^{-1}

Statistically significant variation was recorded for stover yield hectare^{-1} of mungbean due to different nitrogen management under the present trial (Table 7). The highest stover yield (2.85 t ha^{-1}) was observed from T_2 which was statistically similar (2.73 t ha^{-1}, 2.56 t ha^{-1} and 2.51 t ha^{-1}) with T_1, T_5 and T_6, while the lowest stover yield (1.52 t ha^{-1}) was observed from T_{16} which was similar (1.81 t ha^{-1}) with T_{15} treatment. Srinivas *et al.* (2002) observed that stover yield increased with increasing rates of N up to 40 kg ha^{-1}.

Table 7. Effect of nitrogen managements on yields and harvest index of mungbean

Treatment	Seed yield ($t\ ha^{-1}$)	Stover yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest index (%)
T_1	1.92 a	2.73 ab	4.65 ab	41.29
T_2	1.94 a	2.85 a	4.79 a	40.50
T_3	1.28 de	2.28 c-e	3.56 de	35.96
T_4	1.35 c-e	2.21 c-f	3.56 c-e	37.92
T_5	1.90 a	2.56 a-c	4.46 a-c	42.60
T_6	1.86 ab	2.51 a-d	4.37 a-d	42.56
T_7	1.85 ab	2.43 b-d	4.28 b-d	43.22
T_8	1.62 b	2.37 b-d	3.99 c-e	40.60
T_9	1.54 bc	2.37 b-d	3.91 c-e	39.39
T_{10}	1.64 b	2.22 c-f	3.86 c-f	42.49
T_{11}	1.30 de	1.97 e-g	3.27 e-g	39.76
T_{12}	1.63 b	2.37 b-d	4.00 b-d	40.75
T_{13}	1.17 de	2.17 d-g	3.34 d-g	35.03
T_{14}	1.17 de	1.88 fg	3.05 fg	38.36
T_{15}	1.15 e	1.81 gh	2.96 gh	38.85
T_{16}	1.13 e	1.52 h	2.65 h	42.64
$S\bar{x}$	0.105	0.166	0.234	NS
CV(%)	8.48	8.79	8.68	24.22

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

NS= Non significant

T_1 = Prilled urea (PU) broadcast

T_2 = PU given in furrows

T_3 = PU given between two rows

T_4 = PU and seeds given in same furrows

T_5 = USG placed at 10 cm depth at 10 cm distance (avoid one row)

T_6 = USG placed at 10 cm depth at 10 cm distance (avoid two rows)

T_7 = USG placed at 10 cm depth at 10 cm distance (avoid three rows)

T_8 = USG placed at 10 cm depth at 20 cm distance (avoid one row)

T_9 = USG placed at 10 cm depth at 20 cm distance (avoid two rows)

T_{10} = USG placed at 10 cm depth at 20 cm distance (avoid three rows)

T_{11} = USG placed at 10 cm depth at 30 cm distance (avoid one row)

T_{12} = USG placed at 10 cm depth at 30 cm distance (avoid two rows)

T_{13} = USG placed at 10 cm depth at 30 cm distance (avoid three rows)

T_{14} = USG placed at 10 cm depth at 40 cm distance (avoid one row)

T_{15} = USG placed at 10 cm depth at 40 cm distance (avoid two rows)

T_{16} = USG placed at 10 cm depth at 40 cm distance (avoid three rows)

4.13 Biological yield

Statistically significant variation was recorded for biological yield hectare^{-1} of mungbean due to different nitrogen management under the present trial (Table 7). The highest biological yield (4.79 t ha^{-1}) was observed from T_2 which was statistically similar (4.65 t ha^{-1}, 4.46 t ha^{-1} and 4.37 t ha^{-1}) with T_1, T_5 and T_6, while the lowest biological yield (2.65 t ha^{-1}) was observed from T_{16} which was similar (2.96 t ha^{-1}) with T_{15} treatment. Rajender *et al*. (2003) reported that biological yield increased with increasing N rates up to 20 kg ha^{-1} and further increase in N did not affect biological yield.

4.14 Harvest index

Harvest index of mungbean showed statistically non-significant variation due to different nitrogen management under the present trial (Table 7). The highest harvest index (43.22%) was observed from T_7, whereas the lowest harvest index (35.03%) was observed from T_{13} treatment.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from September to December 2012 to study the growth and yield response of mungbean to the application of prilled and super granule urea. The variety BARI mung-6 was used as the test crops. The experiment consists of the following treatments- T_1 = Prilled urea (PU) broadcast, T_2 = PU given in furrows, T_3 = PU given between two rows, T_4 = PU and seeds given in same furrows, T_5 = USG placed at 10 cm depth at 10 cm distance (avoid one row), T_6 = USG placed at 10 cm depth at 10 cm distance (avoid two rows), T_7 = USG placed at 10 cm depth at 10 cm distance (avoid three rows), T_8 = USG placed at 10 cm depth at 20 cm distance (avoid one row), T_9 = USG placed at 10 cm depth at 20 cm distance (avoid two rows), T_{10} = USG placed at 10 cm depth at 20 cm distance (avoid three rows), T_{11} = USG placed at 10 cm depth at 30 cm distance (avoid one row), T_{12} = USG placed at 10 cm depth at 30 cm distance (avoid two rows), T_{13} = USG placed at 10 cm depth at 30 cm distance (avoid three rows), T_{14} = USG placed at 10 cm depth at 40 cm distance (avoid one row), T_{15} = USG placed at 10 cm depth at 40 cm distance (avoid two rows) and T_{16} = USG placed at 10 cm depth at 40 cm distance (avoid three rows). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth, yield and yield contributing characters of mungbean were recorded and significant variations was observed among the studied characters.

Treatment T_2 (PU given in furrows) registered the maximum plant height (18.61 cm, 24.35 cm, 37.60 cm, 45.98 cm an 50.57 cm), the maximum number of leaves plant^{-1} (4.03, 10.20, 17.93, 20.50 and 22.57), the maximum number of branches plant^{-1} (1.53, 4.26, 4.57, 5.11 and 6.00) and the highest above ground dry matter plant^{-1} (8.55 g, 9.61 g, 10.71 g and 12.08 g) at 20, 30, 40, 50, 60 DAS and harvest, respectively. The minimum plant height (10.67 cm, 17.51 cm, 28.38 cm, 34.67 cm and 38.61 cm), the minimum number of leaves plant^{-1} (3.10, 6.73, 11.73, 13.03 and 14.90), the minimum number of branches plant^{-1} (1.13, 2.39, 2.88, 2.92 and 3.33) and the lowest above ground dry matter plant^{-1} (5.14 g, 6.02 g, 6.87 g and 9.40 g, respectively) were observed with from T_{16} (USG placed at 10 cm depth at 40 cm distance - avoid three rows) at all growth stages. At 20-30 DAS, the highest CGR (21.53 g m^{-2}day^{-1}) was attained from T_{14}, while the lowest CGR (8.89 g m^{-2}day^{-1}) from T_5. At 30-40 DAS, the highest CGR (27.88 g m^{-2}day^{-1}) was recorded from T_{11}, whereas the lowest CGR (11.20 g m^{-2}day^{-1}) from T_{10}. At 40-50 DAS, the highest CGR (50.28 g m^{-2}day^{-1}) was observed from T_{10}, whereas the lowest CGR (7.55 g m^{-2}day^{-1}) from T_8. At 20-30 DAS, the highest RGR (0.031 g g^{-1} day^{-1}) was found from T_{14}, while the lowest RGR (0.008 g g^{-1} day^{-1}) from T_5. At 30-40 DAS, the highest RGR (0.025 g g^{-1} day^{-1}) was recorded from T_{11}, whereas the lowest RGR (0.010 g g^{-1} day^{-1}) from T_2. At 40-50 DAS, the highest RGR (0.040 g g^{-1} day^{-1}) was recorded from T_{10}, whereas the lowest RGR (0.006 g g^{-1} day^{-1}) from T_8.

The maximum yield contributing characters like pods plant^{-1} (25.93), pod length (7.26 cm), seeds pod^{-1} (9.46) and 1000-seeds weight (42.60 g) were found when crop was given prilled urea in furrow (T_2). Plant showed minimum pods plant^{-1} (16.87), pod length (5.52 cm), seeds pod^{-1} (5.73) and 1000-seed weight (33.38 g) when treated with lower amount of USG (T_{16}). The highest seed yield, stover, biological yield were noted as 1.94 t ha^{-1}, 2.85 t ha^{-1} and 4.79 t ha^{-1} from T_2, respectively, when T_{16} showed the minimum seed yield (1.13 t ha^{-1}), stover yield (1.52 t ha^{-1}) and biological yield (2.65 t ha^{-1}). The highest harvest index (43.22%) was recorded from T_7, while the lowest (35.03%) was recorded from T_{13}.

From the observed data of present experiment it may be concluded that mungben plant gave maximum seed yield when prilled urea was given in furrows near the seed sown lines or broadcasted as basal dose.

The use of USG showed similar performance of seed yield due to prilled urea when USG placed at 10 cm depth and 10 cm distance avoiding one or two or three rows of mungbean. Such experiment with prilled urea and USG could be tested further in different mungbean cultivated areas of Bangladesh to justify the present findings.

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APPENDICES

Appendix I. Characteristics of experimental field soil is analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomy field , SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
Textural class	silty-clay
pH	5.6
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Appendix II. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from September to December, 2012

Month (2012)	*Air temperature (^oC)		*Relative humidity (%)	*Rainfall (mm) (total)
	Maximum	Minimum		
September	34.8	24.4	81	279
October	26.5	19.4	81	22
November	25.8	16.0	78	00
December	22.4	13.5	74	00

* Monthly average,

* 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 different nitrogen management

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm)				
		20 DAS	30 DAS	40 DAS	50 DAS	Harvest
Replication	2	2.084	0.856	0.203	0.843	2.237
Treatment	15	7.244**	3.859*	7.861*	9.196*	7.804**
Error	30	1.187	1.516	3.346	3.746	2.470

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

Appendix IV. Analysis of variance of the data on leaves plant^{-1} of mungbean as influenced by different nitrogen management

Source of variation	Degrees of freedom	Mean square				
		Leaves plant^{-1}				
		20 DAS	30 DAS	40 DAS	50 DAS	Harvest
Replication	2	0.008	0.141	0.075	0.023	0.014
Treatment	15	0.052*	0.984**	3.561**	4.178**	8.945**
Error	30	0.021	0.207	0.415	0.398	1.404

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

Appendix V. Analysis of variance of the data on branches plant^{-1} of mungbean as influenced by different nitrogen management

Source of variation	Degrees of freedom	Mean square				
		Branches plant^{-1}				
		20 DAS	30 DAS	40 DAS	50 DAS	Harvest
Replication	2	0.0001	0.069	0.023	0.016	0.012
Treatment	15	0.009**	0.365**	0.244*	0.962**	0.716**
Error	30	0.003	0.102	0.108	0.144	0.123

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

Appendix VI. Analysis of variance of the data on above ground dry matter plant^{-1} of mungbean as influenced by different nitrogen management

Source of variation	Degrees of freedom	Mean square			
		Above ground dry matter plant^{-1} (g)			
		30 DAS	40 DAS	50 DAS	60 DAS
Replication	2	0.058	0.378	0.576	0.089
Treatment	15	2.659**	2.347**	3.182**	2.043**
Error	30	0.374	0.334	0.246	0.599

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

Appendix VII. Analysis of variance of the data on crop growth rate of mungbean as influenced by different nitrogen management

Source of variation	Degrees of freedom	Mean square		
		Crop Growth Rate (CGR) at		
		30-40 DAS	40-50 DAS	50-60 DAS
Replication	2	84.261	65.701	79.020
Treatment	15	24.723	98.827	499.709**
Error	30	92.151	80.359	148.147

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

Appendix VIII. Analysis of variance of the data on relative growth rate of mungbean as influenced by different nitrogen management

Source of variation	Degrees of freedom	Mean square		
		Relative Growth Rate (RGR) at		
		30-40 DAS	40-50 DAS	50-60 DAS
Replication	2	0.0001	0.0001	0.0001
Treatment	15	0.0001	0.0001	0.0001**
Error	30	0.0001	0.0001	0.0001

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

Appendix IX. Analysis of variance of the data on yield contributing characters of mungbean as influenced by different nitrogen management

Source of variation	Degrees of freedom	Mean square			
		Pods plant^{-1}	Seeds pod^{-1}	Pod length (cm)	Weight of 1000-seeds (g)
Replication	2	0.806	0.032	0.012	1.058
Treatment	15	6.161**	0.957*	2.185**	17.859**
Error	30	1.552	0.377	0.045	3.269

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

Appendix X. Analysis of variance of the data on yields and harvest index of mungbean as influenced by different nitrogen management

Source of variation	Degrees of freedom	Mean square			
		Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest Index
Replication	2	0.006	0.818	1.215	3.152
Treatment	15	0.068**	4.0041**	8.178*8	12.158
Error	30	0.016	0.3961	0.894	10.045

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