GROWTH AND YIELD PATTERN OF BLACKGRAM AS AFFECTED BY DIFFERENT NITROGEN APPLICATION METHODS

DOLON CHANDRA RAY

DEPARTMENT OF AGRONOMY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA-1207

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DOLON CHANDRA RAY

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APPROVED BY:

Prof. Dr. Md. Fazlul Karim	**Prof. Dr. Md. Shahidul**
Supervisor	Co-Supervisor

Prof. Dr. H. M. M. Tariq Hossain
Chairman
Examination Committee

DEPARTMENT OF AGRONOMY

Sher-e-Bangla Agricultural University

Sher-e-Bangla Nagar, Dhaka-1207

CERTIFICATE

This is to certify that the thesis entitled **"Growth and Yield Pattern of Blackgram as Affected by Different Nitrogen Application Methods"** 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 **Dolon Chandra Ray**, Registration number: **11-04702** 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: December, 2013

Dhaka, Bangladesh

Prof. Dr. Md. Fazlul Karim

Supervisor

Department of Agronomy

Sher-e-Bangla Agricultural University

Dhaka-1207

DEDICATED

TO

MY BELOVED PARENTS

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The Author

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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 response of blackgram with maximum utilization of nitrogen given in different method. The variety BARI mass-3 was used as the test crop. The experiment consisted of the following treatments as T_0 = Prilled urea (PU) broadcast, T_1 = PU given in furrows, T_2 = PU given between two rows, T_3 = PU and seeds given in same furrows, T_4 = USG placed at 10 cm distance (avoid one row), T_5 = USG placed at 10 cm distance (avoid two rows), T_6 = USG placed at 10 cm distance (avoid three rows), T_7 = USG placed at 20 cm distance (avoid one row), T_9 = USG placed at 20 cm distance (avoid two rows), T_9 = USG placed at 20 cm distance (avoid three rows), T_{10} = USG placed at 30 cm distance (avoid one row), T_{11} = USG placed at 30 cm distance (avoid two rows), T_{12} = USG placed at 30 cm distance (avoid three rows), T_{13} = USG placed at 40 cm distance (avoid one row), T_{14} = USG placed at 40 cm distance (avoid two rows) and T_{15} = USG placed at 40 cm distance (avoid three rows). USG (1.8 g) placed at 10 cm depth in each case. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Results revealed that data on different growth, yield and yield contributing characters of blackgram were recorded and significant variations were observed among the studied characters. Treatment T_1 (PU given in furrows) registered the maximum plant height (22.22 cm, 53.91 cm, 53.91cm, 74.86 cm an 76.53 cm), leaves plant^{-1} (4.03, 10.20, 17.93, 20.50 and 22.57), branches plant^{-1} (1.53, 4.26, 4.57, 5.11 and 6.00) and highest total dry weight (0.43 g, 4.57 g, 15.01 g, 28.31 g and 21.19 g) at 15, 35, 55, 75 DAS and harvest, respectively. The minimum plant height (18.47 cm, 43.47 cm, 43.47 cm, 57.50 cm and 53.79 cm), leaves plant^{-1} (3.10, 6.73, 11.73, 13.03 and 14.90), branches plant^{-1} (1.13, 2.39, 2.88, 2.92 and 3.33) and the lowest total dry weight (0.26 g, 3.05 g, 11.83 g, 23.04 g and 16.13 g, respectively) were observed with T_{15} (USG placed at 10 cm depth at 40 cm distance avoiding three rows) at all growth stages. The maximum yield contributing characters like pods plant^{-1} (20.10), pod length (4.57 cm), seeds pod^{-1} (6.80) and 1000-seeds weight (60.93 g) were found when crop was given prilled urea in furrow (T_1). Plant showed minimum pods plant^{-1} (15.23), pod length (3.87 cm), seeds pod^{-1} (6.21) and 1000-seed weight (55.95 g) when treated with lower amount of USG (T_{15}). The highest seed yield, stover yield and biological yield were noted as 1.32 t ha^{-1}, 2.23 t ha^{-1} and 3.55 t ha^{-1} from T_1, respectively, when T_{15} showed the minimum seed yield (1.00 t ha^{-1}), stover yield (1.52 t ha^{-1}) and biological yield (2.39 t ha^{-1}). It was evident that the results with prilled urea were more or less similar with urea super granule.

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LIST OF ACRONYMS

AEZ Agro Ecological Zone
Anon. Anonymous
BARC Bangladesh Agricultural Research
Council BARI Bangladesh Agricultural Research
Institute
BBS Bangladesh Bureau of Statistics
BRAC Bangladesh Rural Advancement Committee
cm Centi meter
CV % Percent Coefficient of
Variance
DAE Department of Agricultural Extension
DAS Days After Sowing
et al. And others
e.g. *exempli gratia* (L), for
example etc. Etcetera
FAO Food and Agricultural
Organization g Gram (s)
HI Harvest Index
i.e. *id est* (L), that
is
IRRI International Rice Research Institute
Kg Kilogram (s)
LSD Least Significant
Difference m^2 Meter squares
M.S. Master of Science
NGO Non-Governmental Organization
No. Number
NS Non significant
SAU Sher-e-Bangla Agricultural University
SRDI Soil Resource and Development
Institute
RCBD Randomized complete block design
TDM Total dry matter
T ha^{-1} Ton per hectare
UNDP United Nations Development Program
°C Degree Centigrade
% Percentage

CHAPTER I

INTRODUCTION

Blackgram (*Vigna mungo*L.) is an important legume protein rich crop, which belongs to sub-family Papillionaceae under the family fabaceace. This is the native of India, and is well known by the names of mashkalai, and urid. It has great value as food, fodder and green manure. In addition to improving the soil fertility, it is a cheap source of protein for direct human consumption. The crop not only fix free atmospheric $N_{2,}$ but also enrich the soil with NPK for the growth of succeeding crops (Sen, 1996).

Pulses are important crops in Bangladesh. They occupy an area of about 627 thousands hectares with an annual production of 231 thousands metric tons (BBS, 2011). Pulses mainly being the Rabi season crops, which are losing area under cultivation each year due to increase in cultivation of boro, wheat, maize, vegetables etc. with increasing facilities of irrigation. Blackgram is an important pulse ranking the third both in acreage and production among the pulses (BBS, 2011). It grows well in north or north-west part of Bangladesh, especially in Rajshahi and Chapai Nawabganj districts. But in case of southern districts it is less cultivated due to ignorance and different types of soil and environmental factors.

On the other hand, malnutrition is a serious problem that has been a great threat to cripple the whole nation in Bangladesh. Pulse, a protein rich crop, plays an important role in human nutrition. It is the cheapest source of protein for the poor and is called the poor men's meat (Mian *et al*. 1976). Pulses contain a remarkable amount of proteins, minerals, vitamins and carbohydrates. Among the various pulses, blackgram is important one, which contains approximately 25-28% protein, 4.5-5.5% ash, 0.5-1.5% oil, 3.5-4.5% fibre and 62.65% carbohydrate on dry weight basis (Kaul *et al*. 1982). It contains major amino acids like methionine, cysteine, lycine etc. which are excellent components of protein for human nutrition. It has been used as food providing major source of protein in cereal based diet. The dried whole seeds or split are used to make dhal, soups, and curries, which are added to various spiced or fried dishes. The daily consumption of pulses in Bangladesh is only 12.27 g per capita compared to 45.0 g, recommended by Food and Agricultural Organization (FAO, 2003).

Blackgram plays an important role to supplement protein in the cereal-based low-protein diet of the people of Bangladesh, but the acreage production of blackgram is gradually declining (BBS, 2011). In fact, it is one of the least cared crops. Blackgram 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 are combined responsible for low yield of blackgram (Hussain *et al*., 2008).

Soils of Bangladesh are mostly deficient in nitrogen. Nitrogen increases the dry matter and protein percentage of grain as well as methionine and triptophen contents in seed with the increased of levels of applied nitrogen (Vidhate *et al*., 1986). Slow rate of dry matter accumulation during pre-flowering phase, on-set of leaf senescence during the period of pod development and low partitioning efficiency of assimilates to grain are identified as the main physiological constraints for increasing yield. Adequate supply of N may minimize the yield reduction through reduced those constraints. Probably that is why blackgram is highly responsive to nitrogen. Leaf area is made up of the total green lamina area of emerged leaves (Keating and Carberg, 1993). Saini and Thakur (1996) stated that moderate doses of nitrogen (60 kg N per hectare) significantly increased the plant height, branches plant^{-1} and leaf area index of grain legumes compared to no N. The higher grain yield of blackgram is associated with significantly superior yield attributes e.g. pods per plant and 1000-seed weight (Singh *et al*., 1993).

Flower and pod formation is being the major sink during the reproductive phase. Little attention has been paid to exploit maximum N use efficiency and productivity of blackgram through judicious application of nitrogen. Legume plants only depend on the nitrogen fixation shows poor growth and low seed yield, because of the early decline in photosynthesis by decreased supply of nitrogen during the pod filling stage. Harper (1974) reported that both soil N and symbiotic N are required for the optimum soybean production. In trifoliate stage the root nodules are not well established it faced with lack of nitrogen fixation and seed yield decreased (Sarparast, 2000). 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 nitrogen for its maximum seed yield. Bhardwaj and Singh (1993) found maximum grain yield in rice (6.8 t ha^{-1}) when placing nitrogen fertilizer as prilled or USG.

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

- To study the response of blackgram to different application methods of nitrogen.
- To compare the effects of prilled urea and USG on the growth and yield of blackgram.
- To determine the appropriate methods of application of nitrogen for maximum growth and yield of blackgram.

CHAPTER II
REVIEW OF LITERATURE

Research works on Blackgram have been carried out throughout the world. Black gram (*Vigna mungo* L) is an important and well recognized pulse crop of Bangladesh. Recently research organizations of Bangladesh such as BARI and BINA have started extensive research for varietal development and improvement of this crop. The literature on growth, development and yield attributes of Blackgram and other related crops have been reviewed and are presented in this chapter. Literatures on morphophysiological parameters and yield components of blackgram and other crops are presented in this chapter.

2.1 Performance of Blackgram and other crops in relation with nitrogen management

Mahadkar and Saraf (1988) studied the effect of *Rhizobium* inoculation and P and N application on growth and yield of *V. mungo* and its residual effect on fodder sorghum in a 2-year field experiment. They found that fertilizer application were 16 kg P ha^{-1}, 20 kg N ha^{-1} as a starter application or 20 kg N ha^{-1} as top dressing at the pre flowering stage. DM and seed yields were significantly increased by all treatments over their respective controls, particularly by P. The number and DW of nodules were significantly increased by inoculation followed by P and starter N top dressing. DM yield of the following sorghum crops was significantly increased by all treatments.

Surendar *et al.* (2013) was conducted a field experiment in the department of crop physiology at TNAU during 2006 to 2007 to study the effect of basal application of nitrogen in combination with foliar spray of urea and plant growth regulators. Among the treatments, the basal application of nitrogen 25kg ha^{-1} with foliar spray of urea 2% and 0.1 ppm brassinolide significantly expressed the higher values in growth attributes viz., Leaf area index, Crop growth rate, Net assimilation rate and Specific leaf weight by showing higher accumulation of total dry matter production with increased yield of Mungbean.

Nagarajan and Balachandar (2001) carried out a field experiment in Vamban, Tamil Nadu, India, during the kharif season to study the effects of organic amendments on the nodulation and yield of Blackgram cv. Vamban 1. They observed that Biodigested slurry at 5 t ha^{-1} + *Rhizobium* gave the greatest plant height (42.7 and 53.7 cm for Blackgram and Green gram, respectively).

Ardeshna *et al.* (1993) found the Rhizobium inoculation significantly increased the grain yield, the increment being 9.6% compared with no inoculation. Inoculated plants showed significantly greater plant height, number of branches $plant^{-1}$ and pods $plant^{-1}$, which ultimately improved the grain yield.

In a field experiment conducted by Satyanarayanamma *et al.* (1996), five mungbean cultivars were sprayed with 2% urea at pre-flowering, flowering, pod development or at all the combinations or at combination of two of three growth stages. They reported that spraying urea at flowering and pod development stages produced the highest seed yield.

Asaduzzaman *et al.* (2008) reported that different levels of nitrogen showed significantly increased number of leaves per plant of mungbean up to level of 30 kg N ha^{-1}. He found that plant height of mungbean was significantly increased by the application of nitrogen fertilizer at 30 kg ha^{-1} with this treatment.

Mozumdar *et al.* (2003) conducted a field experiment at the Bangladesh Agricultural University, Mymensingh. They tested five levels of nitrogen (0, 20, 40, 60 and 80 kg ha^{-1}) and two varieties of summer mungbean viz., Binamoog-2 and Kanti. The results revealed that nitrogen fertilizer increased seed yield up to 40 kg N ha^{-1} and that was 1607 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 T44. They observed grain yield increased with increasing N rates up to 20 kg ha^{-1}

Bhalu *et al.* (1995) observed that seed yield of blackgram increased with up to 20 kg N and 40 kg P_2O_5.

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. Growth and yield components were significantly affected by varying levels of nitrogen and phosphorus. A fertilizer combination of 25 kg N + 75 kg ha^{-1} resulted with maximum seed yield (1112.96 kg ha^{-1}) and seeds pod^{-1}

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

Srinivas *et al.* (2002) examined the effect of nitrogen (0, 20, 40 and 60 kg ha^{-1}) and P (0, 25, 50 and 75 kg ha^{-1}) on the growth and seed yield of greengram. 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.

Sarkar *et al.* (1989) conducted field trials on the highly acidic soils of Tripura seeds of Blackgram cv. T-9, which were inoculated with a commercially available *Rhizobium* inoculum and treated with finely powdered lime. Treated and untreated seeds were sown at 16 kg seed ha^{-1} in adjacent rows. Number of nodules and pods plant^{-1} were higher in inoculated plants. Inoculated and uninoculated plants yielded 0.68 and 0.54 t ha^{-1}, respectively. Inoculation increased soil N content by 20 kg ha^{-1}, compared with the soil under uninoculated plants.

Upadayay *et al*. (1991) reported that N application markedly increased the seed yield of blackgram in nitrogen deficient sandy loam soil.

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

Akhtaruzzaman (1998) conducted a field experiment on mungbean where plant height increased almost linearly up to 40 kg N ha^{-1} although response of 30 and 40 kg N ha^{-1} was identical.

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

Mohanty *et al*. (1998) reported that Kalamung was the best performing cultivar with a potential grain yield of 793.65 kg ha^{-1} among nine varieties. They also reported that this variety gave the highest number of pods/plant (18.67) and maximum number of seed/pod (10.43).

Bachchhav *et al.* (1994) conducted a field experiment during the summer season with greengram cv. Phule-M. They observed that among nitrogen fertilizers rates (0-45 kg N ha^{-1}) seed yield increased with 30 kg N ha^{-1}.

Singh *et al*. (1993) reported increased seed yield of blackgram with N 20 kg ha^{-1} and P 40 kg ha^{-1}. He also reported similar influence of N when worked with greengram.

Ardeshna *et al.* (1993) conducted a field experiment on clay soil during the rainy season of 1990 to study the response of mungbean to nitrogen. They observed that seed yield increased with the application of nitrogen fertilizer up to 20 kg N ha^{-1} in combination with phosphorus fertilizer up to 40 kg P_2O_5 ha^{-1}.

A field experiment was conducted by Sarkar and Banik (1991) to study the effect of N in combination with 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}.

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

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

Yadav *et al.* (1994) 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.

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.

Hamid (1988) conducted a field experiment to investigate the effect of nitrogen and carbon on the growth and yield performance of mungbean (*Vigna radiate* L. wilczek). He found that the plant height of mungbean cv. Mubarik was found to be increased with nitrogen at 40 kg ha^{-1}.

Patel and Parmar (1986) conducted an experiment to evaluate the response of greengram with 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.

Vidhate *et al.* (1986) explored the response of blackgram to nitrogen fertilization. They observed that an increase in the dose of N fertilizer increased the grain yield. Higher percent of grain yield increased when equal dose of 25 kg N ha^{-1} applied at sowing and at flowering.

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).

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.

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

Raju and Verma **(**1984) carried out a field experiment during summer season of 1979 and 1980 to study the response of mungbean var. Pusabaishaki to varying levels of nitrogen (15, 30, 45 and 60 kg N ha^{-1}) in the presence and absence of seed inoculation with *Rhizobium.* They found that maximum dry matter weight per plant was obtained by the application of 60 kg N ha^{-1} inoculated with *Rhizobium.*

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.

Trung and Yoshida (1983) conducted a field trial on mungbean in nutrient-rich soil, involving 0-100 ppm N as treatments. They observed that maximum plant height at all the stages of plant growth were obtained by the application of 25 ppm N.

Srivastava and Verma (1982) showed that N application at the rate of 15kg ha^{-1} increased the number of green leaves in greengram plants.

In an experiment, Yein *et al.* (1981) applied nitrogen and phosphorus fertilizers to mungbean and reported that combined application of nitrogen and phosphorus fertilizers increased the number of pods per plant. The rate of nitrogen and phosphorus was 50 kg and 75 kg ha^{-1}, respectively.

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}

Department of Agricultural Extension (DAE) conducted 432 demonstrations of the effect of USG on boro rice in 72 thana of 31 districts during the 1996-97 winter seasons. 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).

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.

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 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}.

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}.
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.

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 ofpanicles, 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 in transplanted rice 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 experimenton 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.

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}.

Yamada *et al.* (1981) stated that in trials in several countries rice was given 0-176 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 besuitable for paddy in many Asian countries, where urea is already a common fertilizer. The Product is 40-50% more efficient than conventional 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.

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.

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 khari fseason. 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.

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.

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.

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.

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.

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 in corporation 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 up to 87 kg N 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.

It may be understood from the above reviews that nitrogen is an important nutrient for blackgram 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 at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from September, 2012 to December, 2012.

3.1 Site description

3.1.1 Geographical location

The experimental area was situated at $23^0 77'$ N latitude and $90^0 33'$ E longitude at an altitude of 8.6 meter above the sea level (Anon., 2004).

3.1.2 Agro-Ecological Region

The experimental site belongs to the Agro-ecological zone of "The Modhupur Tract", AEZ-28. This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain.

3.1.3 Climate

Experimental site was located in the subtropical monsoon climatic zone, set aparted by winter during the months from November to February (Rabi season). Plenty of sunshine and moderately low temperature prevails during experimental period, which is suitable for blackgram growing in Bangladesh

3.1.2 Soil

The soil of the experimental field belongs to the Tejgaon series under the Agro ecological 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 and analyzed from Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka. The collected soil was air-dried, grind and passed through 2 mm sieve and analyzed for some important physical and chemical properties. The analytical data of the soil sample collected from the experimental area were 27% sand, 43% silt, 30% clay, organic matter 0.78% and details are presented in Appendix II.

3.2 Description of the experimental materials

3.2.1 Planting material

The variety BARI mash-3 was used as the test crops. The seeds were collected from the Pulse Seed Division of Bangladesh Agricultural Research Institute, Joydevpur, Gazipur. BARI mash-3 is the released variety of blackgram, which was recommended by the national seed board. They grow both in Kharif and Rabi season. Life cycle of this variety ranges from 65-70 days. Maximum seed yield is 1.5-1.6 t ha^{-1}.

3.3 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.

3.4 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 blackgram cultivation. All of the fertilizers were applied during final land preparation. USG (1.8 g) placed at 10 cm depth following treatments variables.

3.5 Treatments of the experiment

The experiment consists of the following treatments:

T_0 = Prilled urea (PU) broadcast
T_1 = PU given in furrows
T_2 = PU given between two rows
T_3 = PU and seeds given in same furrows
T_4 = USG placed at 10 cm distance (avoid one row)
T_5 = USG placed at 10 cm distance (avoid two rows)
T_6 = USG placed at 10 cm distance (avoid three rows)
T_7 = USG placed at 20 cm distance (avoid one row)
T_8 = USG placed at 20 cm distance (avoid two rows)
T_9 = USG placed at 20 cm distance (avoid three rows)
T_{10} = USG placed at 30 cm distance (avoid one row)
T_{11} = USG placed at 30 cm distance (avoid two rows)
T_{12} = USG placed at 30 cm distance (avoid three rows)
T_{13} = USG placed at 40 cm distance (avoid one row)
T_{14} = USG placed at 40 cm distance (avoid two rows)
T_{15} = USG placed at 40 cm distance (avoid three rows)
[USG (1.8 g) placed at 10 cm depth in each case]

3.6 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 treatments 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 Appendix I.

3.7 Sowing of seeds in the field

The seeds of blackgram 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.

3.8 Intercultural operations

3.8.1 Thinning

Emergence of seedling was completed within 7 days after sowing. Excess seedlings were thinned out two times to keep plant to plant distance at 10 cm. First thinning was done after 15 days of sowing which is done to remove unhealthy seedlings. The second thinning was done 5 days after first thinning by hand.

3.8.2 Weeding

First weeding was done at 30 days after sowing (DAS) and then necessary weeding to keep the plots free from weeds and to keep the soil loose and aerated.

3.8.3 Irrigation and drainage

Irrigation was done after first weeding. Irrigation was applied as and when it was needed. Proper drainage system was also developed for draining out excess water.

3.8.4 Disease and pest management

At mid growing stage plant was infested by Cercospora leaf spot. Some plant also infested by Yellow mosaic virus. For controlling Cercospora leaf spot Admire 200SL (Imidachloprid) @ 0.25 ml/lit was sprayed 3 times 10 days interval. On the other hand the infested plants by Yellow mosaic virus are removed by hand picking.

3.9 Harvesting, threshing and drying

The crop was harvested on two times, first harvest was done on December 06, 2012 and second harvest was done December 13, 2012 at full maturity of the crop when the color of leaf turned yellow and dropped off. The harvested crop of each plot was bundled and tagged properly. The bundles were sun dried for 3–4 days and brought to a clean floor. Seeds and other plant parts were separated for collecting the data. Separated seeds, straw and other parts of black gram were also dried in sun for 2–3 days and the plot wise weights were recorded.

3.10 Sampling and data collection

The first crop sampling was done on 20 days after sowing (DAS) starts from 15 DAS and continued up to harvest. Harvesting of the blackgram was done after 85 days of sowing. Data were recorded for 10 individual plants per plots in each replication. Yield data were also collected after harvest. The plants were separated into shoot including leaf and roots and then their dry weight were recorded after drying them in oven at $80\pm2^{O}C$ for 72 hours.

3.11 Data collection

3.11.1 Morphological characters

Data on the following parameters were collected.

3.11.1.1 Plant height

Plant height was measured in centimeter by a meter scale at 20 days interval from 15 DAS up to harvest from the ground surface to the top of the main shoot. The mean height was expressed in cm.

3.11.1.2 Leaves per plant

Number of leaves per plant was counted at 15, 35, 55, 75 DAS and harvest. .

3.11.1.3 Branches per plant

Number of branches per plant was counted at 35, 55 and harvest. .

3.11.1.4 Total dry matter (TDM)

The plant parts such as shoot including leaves and roots were detached and were kept separately in oven at 80 ± 2^{O} C for 72 hours. The oven dried samples were weighed for dry matter production. The total dry matter production was calculated from the summation of shoots and roots.

3.11.2 Yield and yield contributing characters

3.11.2.1 Pods plant^{-1}

Pods were separated from sample plants and the total number of pods were counted and recorded. Average number of pods per plant was calculated.

3.11.2.2 Seeds pod^{-1}

Number of seeds pod^{-1} was recorded after harvesting of the crop from the ten randomly selected pods from five pre–selected plants was counted. The seeds per pod were calculated from their mean values.

3.11.2.3 Pod length (cm)

Pod length was measured in centimeter (cm) scale from randomly selected ten pods. Mean value of them was recorded according to the treatments.

3.11.2.4 1000–grains weight

One thousand cleaned, dried seeds were counted randomly from each sample and weighed by using a digital electric balance at the stage the grain retained 12% moisture and the mean weight were expressed in gram.

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

After harvesting, the grains were removed from the separated pods and then dried in sun for 2–3 days. Finally, grain weights were taken on individual plot basis at moisture content of 12% and then converted into t ha^{-1}.

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

After harvesting, the grain less straw was drayed in sun for 2–3 days. Finally, straw weights were taken on individual plot basis at moisture content of 12% and then converted into t ha^{-1}.

3.11.2.7 Biological yield

The biological yield was calculated with the following formula–

Biological yield= Grain yield + Straw yield

3.11.2.8 Harvest index (%)

It denotes the ratio of economic yield to biological yield and was calculated with the following formula.

$$\% \text{ Harvest index (HI)} = \frac{\text{Economic yield}}{\text{Biologicalyield}} \times 100$$

3.12 Statistical analysis

The data obtained from experiment on various parameters were statistically analyzed by MSTAT–C computer program. The mean values for all the parameters were calculate and the analysis of variance (ANOVA) for the characters was accomplished. The significant of differences between pair of means was tested by the Least Significant Differences (LSD) test at 5 % levels of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to study the response of blackgram variety to different nitrogen management. Data on different growth, yield and yield contributing characters of blackgram 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 blackgram at 15, 35, 55, 75 DAS and harvest for the different nitrogen management under the present trial (Appendix IV).

At 15 DAS, T_1 [PU given in furrows] gave maximum taller plant (22.22 cm) followed by T_0 [Prilled urea (PU) broadcast] (21.48 cm), $T_{2,}$ $T_{4,}$ $T_{5,}$ $T_{6,}$ $T_{7,}$ and $T_{8,}$ treatments. Shortest plant was observed from T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (18.47 cm) and similar all other treatments except $T_{0,}$ T_1 and T_4 treatments (Table 1).

At 35 DAS, the longest plant (53.91 cm) was observed from $T_{1,}$ which was statistically similar to T_0, T_5, T_7, $T_{8,}$ T_{10} and T_{11} treatment. The shortest plant was recorded in T_{15} (43.47 cm) and was similar to all other treatments except $T_{0,}$ T_1 and T_{11} treatments (Table 1).

At 55 DAS, the longest plant (53.91 cm) was observed from T_1 [PU given in furrows], which was statistically similar to $T_{0,}$ $T_{2,}$ $T_{4,}$ $T_{5,}$ T_6 and T_7 treatments. The shortest plant was recorded in T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (43.47 cm) and was similar to all other treatments except $T_{0,}$ T_1 and T_4 treatments.

At 75 DAS the longest plant (74.86 cm) was observed from T_1 [PU given in furrows], which was statistically similar with $T_{0,}$ $T_{2,}$ $T_{3,}$ $T_{4,}$ $T_{5,}$ $T_{6,}$ $T_{7,}$ $T_{8,}$ and T_{10} treatments. The shortest plant was recorded in T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (57.50 cm) and as per with $T_{2,}$ $T_{3,}$ $T_{8,}$ $T_{9,}$ $T_{10,}$ $T_{11,}$ $T_{12,}$ $T_{13,}$ and T_{14} treatments.

At harvest, T_1 [PU given in furrows] produced the tallest (76.53 cm) and was followed by $T_{0,}$ $T_{2,}$ $T_{3,}$ $T_{4,}$ $T_{5,}$ $T_{6,}$ T_7 and T_8 treatments. Shortest plant was observed from T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (53.79 cm) which was statistically similar with $T_{2,}$ $T_{3,}$ $T_{9,}$ $T_{10,}$ $T_{11,}$ $T_{12,}$ $T_{13,}$ and T_{14} treatments. T_1 was found very influential to 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 and could be used. Malik *et al.* (2003) reported that plant height was significantly affected by nitrogen fertilizer. Akter (2010) reported that plant height was the highest when USG (1.8 g) was applied as basal dose and the lowest when USG was applied at 25 DAS in mustard.

Table 1. Effect of nitrogen managements on the plant height of blackgram at different days after sowing

Treatments	Plant height (cm)				
	15 DAS	**35 DAS**	**55 DAS**	**75 DAS**	**At harvest**
T_0	21.48 ab	50.74 a-c	51.72 ab	72.76 ab	72.28 ab
T_1	22.22 a	53.91 a	53.91 a	74.86 a	76.53 a
T_2	20.10 a-c	46.43 b-d	48.53 a-d	68.15 a-d	65.72 a-d
T_3	19.53 bc	43.52 d	46.43 b-d	65.11 a-d	65.21 a-d
T_4	21.44 ab	45.27 b-d	50.74 a-c	71.89 a-c	71.43 ab
T_5	20.70 a-c	48.75 a-d	50.25 a-d	70.79 a-c	71.21 ab
T_6	20.52 a-c	43.77 d	48.75 a-d	69.68 a-c	70.59 a-c
T_7	20.38 a-c	50.25 a-d	48.71 a-d	69.31 a-c	70.07 a-c
T_8	19.71 a-c	48.71 a-d	47.18 b-d	65.70 a-d	68.47 a-c
T_9	19.20 bc	47.18 b-d	45.93 b-d	61.62 b-d	62.29 b-d
T_{10}	19.34 bc	48.53 a-d	46.23 b-d	64.98 a-d	65.10 a-d
T_{11}	19.07 bc	51.72 ab	45.27 b-d	61.43 b-d	62.13 b-d
T_{12}	18.70 c	46.23 b-d	43.77 d	61.26 b-d	61.08 b-d
T_{13}	18.89 bc	45.93 b-d	44.76 cd	61.39 b-d	61.90 b-d
T_{14}	18.68 c	44.76 cd	43.52 d	60.42 cd	58.30 cd
T_{15}	18.47 c	43.47 d	43.47 d	57.50 d	53.79 d
SE	0.7657	2.009	2.009	3.410	3.623
CV %	6.66	7.33	7.33	8.94	9.51

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

T_0 = Prilled urea (PU) broadcast
T_1 = PU given in furrows

T_2 = PU given between two rows

T_3 = PU and seeds given in same furrows

T_4 = USG placed at 10 cm distance (avoid one row)

T_5 = USG placed at 10 cm distance (avoid two rows)

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

T_7 = USG placed at 20 cm distance (avoid one row)

T_8 = USG placed at 20 cm distance (avoid two rows)

T_9 = USG placed at 20 cm distance (avoid three rows)

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

T_{11} = USG placed at 30 cm distance (avoid two rows)

T_{12} = USG placed at 30 cm distance (avoid three rows)

T_{13} = USG placed at 40 cm distance (avoid one row)

T_{14} = USG placed at 40 cm distance (avoid two rows)

T_{15} = USG placed at 40 cm distance (avoid three rows)
[USG placed at 10 cm depth in each case]

4.2 Leaves plant^{-1}

Data revealed that leaves plant^{-1} varied significantly at 15, 35, 55, 75 DAS and harvest for different nitrogen management (Appendix V).

At 15 DAS, the maximum number of leaves plant^{-1} (4.03) was observed from T_1 [PU given in furrows], which was statistically similar with T_0, T_2, T_4, T_5, T_6, T_{12} Treatments. The minimum number of leaves plant^{-1} was recorded in T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (3.10), which was statistically similar to T_{11} and T_{14} Treatments (Table 2).

At 35 DAS, T_1 [PU given in furrows] gave maximum leaves plant^{-1} (10.20) and was followed by T_0 [Prilled urea (PU) broadcast] (9.47), T_4 [USG placed at 10 cm depth at 10 cm distance (avoid one row)] (9.46). Minimum number of leaves plant^{-1} was observed from T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (6.73) and was significantly different from all other treatments.

At 55 DAS, the maximum number of leaves plant^{-1} (17.93) was observed from T_1 [PU given in furrows] which was statistically similar to T_0 [Prilled urea (PU) broadcast] (17.03) and T_4 [USG placed at 10 cm depth at 10 cm distance (avoid one row)] (16.97), The minimum number of leaves plant^{-1} was recorded in T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (11.73) and statistically similar to T_{14} [USG placed at 10 cm depth at 40 cm distance (avoid two rows)] (12.57).

At 75 DAS, the maximum leaves plant^{-1} (20.50) was observed from T_1 [PU given in furrows], which was statistically similar to T_0 and T_4 Treatments. The minimum leaves plant^{-1} was recorded in T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (13.03) and was significantly different from all other treatments.

At harvest, T_1 [PU given in furrows] gave maximum leaves plant^{-1} (22.57) and was statically similar to T_0, T_4, $T_{5,}$ $T_{6,}$ T_8 and T_{12} Treatments. Minimum leaves plant^{-1} was observed from T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (14.90) and similar to T_{11} and T_{14} Treatments. 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 the highest when USG (1.8 g) was applied as basal dose and the lowest when USG was applied at 25 DAS in mustard.

Table 2. Effect of nitrogen managements on the number of leaves plant^{-1} of blackgram at different days after sowing

Treatment	Number of leaves plant^{-1}				
	15 DAS	**35 DAS**	**55 DAS**	**75 DAS**	**At harvest**
T_0	4.00 ab	9.47 ab	17.03 ab	19.83 ab	21.93 ab
T_1	4.03 a	10.20 a	17.93 a	20.50 a	22.57 a
T_2	3.77 a-d	8.80 b-e	14.90 e-g	18.73 bc	19.47 c-f
T_3	3.67 cd	8.30 d-f	15.33 d-f	18.03 c	18.57 d-f
T_4	3.93 a-c	9.46 a	16.97 ab	19.70 ab	21.60 a-c
T_5	3.90 a-c	9.30 bc	16.43 b-d	18.90 bc	21.60 a-c
T_6	3.87 a-c	8.93 b-d	16.33 b-d	18.57 c	21.20 a-c
T_7	3.40 ef	7.50 f	14.50 fg	16.80 d	17.73 fg
T_8	3.73 b-d	8.43 de	14.93 e-g	18.27 c	20.40 a-e
T_9	3.50 de	8.53 c-e	15.23 d-f	18.47 c	18.20 ef
T_{10}	3.70 cd	7.97 ef	15.93 b-e	18.47 c	20.07 b-e
T_{11}	3.23 fg	8.23 d-f	14.03 g	15.10 e	16.07 gh
T_{12}	3.83 a-c	8.83 b-e	15.57 c-f	16.90 d	20.53 a-d
T_{13}	3.70 cd	8.17 d-f	15.40 c-f	17.90 cd	18.90 d-f
T_{14}	3.13 g	7.57 f	12.57 h	14.53 e	15.70 gh
T_{15}	3.10 g	6.73 g	11.73 h	13.03 f	14.90 h
$\bar{\text{SE}}$	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 at 0.05 level of probability

T_0 = Prilled urea (PU) broadcast
T_1 = PU given in furrows
T_2 = PU given between two rows
T_3 = PU and seeds given in same furrows
T_4 = USG placed at 10 cm distance (avoid one row)
T_5 = USG placed at 10 cm distance (avoid two rows)
T_6 = USG placed at 10 cm distance (avoid three rows)
T_7 = USG placed at 20 cm distance (avoid one row)
T_8 = USG placed at 20 cm distance (avoid two rows)
T_9 = USG placed at 20 cm distance (avoid three rows)
T_{10} = USG placed at 30 cm distance (avoid one row)
T_{11} = USG placed at 30 cm distance (avoid two rows)
T_{12} = USG placed at 30 cm distance (avoid three rows)
T_{13} = USG placed at 40 cm distance (avoid one row)
T_{14} = USG placed at 40 cm distance (avoid two rows)
T_{15} = USG placed at 40 cm distance (avoid three rows)
[USG placed at 10 cm depth in each case]

4.3 Branches plant^{-1}

Branches plant^{-1} varied significantly at 15, 35, 55, 75 DAS and harvest for different nitrogen management under the present trial (Appendix VI).

At 15 DAS, the maximum branches plant^{-1} (1.53) was observed from T_1 [PU given in furrows] which was statistically similar with T_0, T_2, T_4, T_5, T_6, T_9 and T_{12} treatments. The minimum branches plant^{-1} was recorded in T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (1.13) and was similar to T_{14} treatment (Table 3).

At 35 DAS, the maximum branches plant^{-1} (4.26) was observed from T_1 [PU given in furrows], which was statistically similar with T_0 and T_4 treatments. The minimum branches plant^{-1} was recorded in T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (2.39) and was similar to T_{13} and T_{14} treatments.

At 55 DAS, the maximum branches plant^{-1} (4.57) was observed from T_1 [PU given in furrows], which was statistically similar with T_0, T_4, and T_5 treatments. The minimum branches plant^{-1} was recorded in T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (2.88) and was similar to T_{14} treatment.

At 75 DAS, the maximum branches plant^{-1} (5.11) was observed from T_1 [PU given in furrows], which was statistically similar with T_0, T_2, T_3, T_4, T_5, T_6, T_7, T_8, T_9 and T_{13} treatments. The minimum branches plant^{-1} was recorded in T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (2.92) and similar to T_{10} and T_{14} treatments.

At harvest, T_1 [PU given in furrows] gave maximum branches plant^{-1} (6.00) and was followed by T_0 and T_4 treatment. Minimum branches plant^{-1} was observed from T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (3.33) which was similar to T_{13} and T_{14} treatments. T_1 was found very influential in producing highest branches plant^{-1} by enabling to uptake nitrogen efficiently from placed urea in furrows when nutrient requirement was varied at different growth stages. Rajender *et al*. (2003) reported that branches of blackgram increased with increasing N rates. Akter (2010) reported that number of branches plant^{-1} was the highest when USG (1.8 g) was applied as basal dose and the lowest when USG was applied at 25 DAS in mustard.

Table 3. Effect of nitrogen managements on the branches plant^{-1} of blackgram at different days after sowing

Treatment	Number of branches plant^{-1}				
	15 DAS	35 DAS	55 DAS	75 DAS	Harvest
T_0	1.50 ab	3.95 ab	4.33 ab	4.95 a	5.51 ab
T_1	1.53 a	4.26 a	4.57 a	5.11 a	6.00 a
T_2	1.43 a-c	3.20 d-g	3.68 cd	4.39 a-c	4.75 cd
T_3	1.40 bc	3.59 b-e	3.94 bc	4.59 ab	4.87 b-d
T_4	1.50 ab	3.84 a-c	4.07 a-c	4.93 a	5.48 ab
T_5	1.47 ab	3.51 b-e	4.13 a-c	4.86 a	5.16 bc
T_6	1.43 a-c	3.68 b-d	3.88 bc	4.81 a	5.11 bc
T_7	1.33 cd	3.35 b-f	3.74 b-d	4.62 ab	5.01 b-d
T_8	1.40 bc	3.05 e-g	3.66 cd	4.44 a-c	4.61 c-e
T_9	1.43 a-c	3.31 c-f	3.51 c-e	4.60 ab	4.99 b-d
T_{10}	1.40 bc	3.17 d-g	3.03 ef	3.30 d-f	5.09 b-d
T_{11}	1.40 bc	3.40 b-f	3.65 cd	3.84 c-e	4.05 ef
T_{12}	1.43 a-c	3.05 e-g	3.56 c-e	3.94 b-d	4.42 de
T_{13}	1.27 d	2.83 f-h	3.76 b-d	4.44 a-c	3.72 fg
T_{14}	1.17 e	2.69 gh	3.24 d-f	3.25 ef	3.51 fg
T_{15}	1.13 e	2.39 h	2.88 f	2.92 f	3.33 g
SE	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 at 0.05 level of probability

T_0 = Prilled urea (PU) broadcast
T_1 = PU given in furrows
T_2 = PU given between two rows
T_3 = PU and seeds given in same furrows
T_4 = USG placed at 10 cm distance (avoid one row)
T_5 = USG placed at 10 cm distance (avoid two rows)
T_6 = USG placed at 10 cm distance (avoid three rows)
T_7 = USG placed at 20 cm distance (avoid one row)
T_8 = USG placed at 20 cm distance (avoid two rows)
T_9 = USG placed at 20 cm distance (avoid three rows)
T_{10} = USG placed at 30 cm distance (avoid one row)
T_{11} = USG placed at 30 cm distance (avoid two rows)
T_{12} = USG placed at 30 cm distance (avoid three rows)
T_{13} = USG placed at 40 cm distance (avoid one row)
T_{14} = USG placed at 40 cm distance (avoid two rows)
T_{15} = USG placed at 40 cm distance (avoid three rows)
[USG placed at 10 cm depth in each case]

4.4 Total Dry Weight (g)

Different nitrogen management varied significantly at 15, 35, 55, 75 DAS and harvest for total dry weight of blackgram (Appendix VII).

At 15 DAS the highest total dry weight (0.43 g) was observed in T_1 [PU given in furrows] which was statistically similar to all other treatments except $T_{12,}$ $T_{14,}$ and T_{15} treatments. The lowest total dry weight (.26 g) which was recorded in T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] and similar to $T_{2,}$ $T_{3,}$ $T_{7,}$ $T_{8,}$ $T_{9,}$ $T_{10,}$ $T_{11,}$ $T_{12,}$ T_{13} and T_{14} treatments (Table 4).

At 35 DAS, T_1 [Prilled urea (PU) broadcast] gave maximum total dry weight (4.573 g) followed by T_0, T_2, T_3, T_4, T_5, T_6, T_7, T_8, T_9 and T_{10} treatments. Minimum total dry weight was observed from T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (3.05 g) which was similar with T_2, T_3, T_6, T_7, T_8, T_9, T_{10}, T_{11}, T_{12}, T_{13} and T_{14} treatments.

At 55 DAS, the maximum total dry weight (15.01 g) was observed from T_1 [PU given in furrows], which was statistically similar to T_0, T_2, T_3, T_4, T_5, T_6, T_7, and T_8 treatments. The minimum total dry weight was recorded in T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] (11.83 g) which was similar to all other treatment except T_0 and T_1

At 75 DAS the maximum total dry weight (28.31 g) was found in T_1 [PU given in furrows], which was statistically similar to T_0, T_2, T_3, T_4, T_5, T_6, T_7, T_8, T_9, $T_{10,}$ T_{11} and T_{13} treatments. The minimum total dry weight (23.04 g) was recorded in T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] which was similar to T_2, T_3, T_6, T_7, T_8, T_9, T_{10}, T_{11}, T_{12}, T_{13} and T_{14} treatments.

At harvest the maximum total dry weight (21.19 g) was found in T_1 [PU given in furrows], which was statistically similar to all other treatments except $T_{12,}$ T_{14} and T_{15} treatments. The minimum total dry weight (16.13 g) was recorded in T_{15} [USG placed at 10 cm depth at 40 cm distance (avoid three rows)] which was similar to all other treatments except T_0 and T_1 treatments.

Table 4. Effect of nitrogen managements on total dry weight of blackgram at different days after sowing

Treatments	Total dry weight (g)				
	15 DAS	35 DAS	55 DAS	75 DAS	At harvest
T_0	0.41 ab	4.53 a	14.29 ab	27.58 ab	19.72 ab
T_1	0.43 a	4.57 a	15.01 a	28.31 a	21.19 a
T_2	0.36 a-c	3.77 a-c	13.05 a-c	25.50 a-d	18.11 ab
T_3	0.35 a-c	4.04 a-c	13.23 a-c	26.52 a-d	18.29 ab
T_4	0.39 ab	4.32 ab	13.58 a-c	27.08 a-c	19.49 ab
T_5	0.39 ab	4.28 ab	13.39 a-c	27.04 a-c	19.40 ab
T_6	0.39 ab	4.07 a-c	13.28 a-c	26.53 a-d	18.38 ab
T_7	0.33 a-c	3.88 a-c	13.13 a-c	26.00 a-d	18.25 ab
T_8	0.33 a-c	3.77 a-c	12.71 bc	25.39 a-d	17.78 ab
T_9	0.33 a-c	3.65 a-c	12.44 bc	25.00 a-d	17.45 ab
T_{10}	0.33 a-c	3.73 a-c	12.50 bc	25.19 a-d	17.50 ab
T_{11}	0.32 a-c	3.40 bc	12.40 bc	24.65 a-d	17.26 ab
T_{12}	0.29 bc	3.23 c	12.08 c	23.98 b-d	16.92 b
T_{13}	0.31 a-c	3.36 bc	12.15 c	24.44 a-d	17.15 ab
T_{14}	0.30 bc	3.21 c	11.94 c	23.26 cd	16.33 b
T_{15}	0.26 c	3.05 c	11.83 c	23.04 d	16.13 b
SE	0.036	0.302	0.626	1.167	1.203
CV %	17.07	14.02	8.39	7.90	11.53

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

T_0 = Prilled urea (PU) broadcast
T_1 = PU given in furrows
T_2 = PU given between two rows
T_3 = PU and seeds given in same furrows
T_4 = USG placed at 10 cm distance (avoid one row)
T_5 = USG placed at 10 cm distance (avoid two rows)
T_6 = USG placed at 10 cm distance (avoid three rows)
T_7 = USG placed at 20 cm distance (avoid one row)
T_8 = USG placed at 20 cm distance (avoid two rows)
T_9 = USG placed at 20 cm distance (avoid three rows)
T_{10} = USG placed at 30 cm distance (avoid one row)
T_{11} = USG placed at 30 cm distance (avoid two rows)
T_{12} = USG placed at 30 cm distance (avoid three rows)
T_{13} = USG placed at 40 cm distance (avoid one row)
T_{14} = USG placed at 40 cm distance (avoid two rows)
T_{15} = USG placed at 40 cm distance (avoid three rows)
[USG placed at 10 cm depth in each case]

4.5 Pods plant^{-1}

Pods plant^{-1} of blackgram varied significantly due to different nitrogen management under the present trial (Appendix VIII). The highest number of pods plant^{-1} (22.17) was recorded from T_1 which was statistically similar to T_2, T_3, T_4 and T_5 whereas the lowest number of pods plant^{-1} (14.44) was observed from T_0 treatment which was statistically similar to T_6, T_7, T_8, T_9, T_{10}, T_{11}, T_{12}, T_{13}, T_{14}, and T_{15} (Table 5). Treatment T_1 registered 34.24% more pods plant^{-1} over T_{15} Treatment. 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 blackgram (cv. Gujrat-1) from 0 to 50 kg N ha^{-1} increased the number of pods plant^{-1}.

4.6 Seeds pod^{-1}

Due to different nitrogen management system, number of seeds pod^{-1} of blackgram varied significantly (Appendix VIII). The highest number of seeds pod^{-1} (8.52) was recorded from T_1, while the lowest number of seeds pod^{-1} (4.73) was observed in T_0 which was similar to T_8, T_9, T_{10}, T_{11}, T_{12}, T_{13}, T_{14}, and T_{15} (Table 5). Treatment T_1 produced 42.61% more seeds pod^{-1} over T_{15} Treatment. Malik *et al.* (2003) reported that number of seeds pod^{-1} was significantly influenced by varying levels of nitrogen.

4.7 Pod length

Pod length of blackgram did not varied significantly due to different nitrogen management practices (Appendix VIII). Numerically it varied from 3.87 to 4.57. Longest pod length (4.57 cm) was recorded from T_1 whereas the shortest pod length (3.87 cm) was observed from T_{15} (Table 5).

4.8 Weight of 1000-seed

Statistically no significant variation was recorded for weight of 1000-seed of blackgram due to different nitrogen management system (Appendix VIII). Numerically it varied from 55.95 to 60.93. The highest weight of 1000-seed (60.93 g) was found from T_1 treatment; whereas the lowest 1000-seed weight (55.95 g) was recorded from T_{15} (Table 5). Akter (2010) reported that 1000-seed weight was highest when USG (1.8 g) was applied as basal dose and lowest when USG was applied at 25 DAS in mustard.

Table 5. Effect of nitrogen managements on pods plant^{-1}, seeds pod^{-1}, pod length and 1000-seed weight of blackgram at harvest

Treatments	Pod plant^{-1}	Seed pod^{-1}	Pod length (cm)	1000-seed weight (g)
T_0	14.44 d	4.73 d	4.43	60.62
T_1	22.17 a	8.52 a	4.57	60.93
T_2	20.89 ab	6.85 b	4.30	57.60
T_3	20.77 ab	6.84 b	4.23	58.53
T_4	19.30 a-c	6.69 b	4.33	60.02
T_5	19.14 a-c	6.57 b	4.30	59.83
T_6	17.91 b-d	6.47 bc	4.17	59.63
T_7	17.73 b-d	6.45 bc	4.13	58.10
T_8	16.93 cd	5.75 b-d	4.10	57.43
T_9	16.43 cd	5.78 b-d	4.03	57.17
T_{10}	16.87 cd	5.73 b-d	4.03	57.37
T_{11}	16.22 cd	5.85 b-d	4.00	56.72
T_{12}	15.87 cd	5.82 b-d	4.00	56.15
T_{13}	15.88 cd	5.75 b-d	3.97	56.47
T_{14}	15.12 d	5.08 cd	3.93	56.02
T_{15}	14.58 d	4.89 d	3.87	55.95
SE	1.180	0.42	0.21	2.441
CV %	11.67	11.95	8.94	7.29

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

T_0 = Prilled urea (PU) broadcast
T_1 = PU given in furrows
T_2 = PU given between two rows
T_3 = PU and seeds given in same furrows
T_4 = USG placed at 10 cm distance (avoid one row)
T_5 = USG placed at 10 cm distance (avoid two rows)
T_6 = USG placed at 10 cm distance (avoid three rows)
T_7 = USG placed at 20 cm distance (avoid one row)
T_8 = USG placed at 20 cm distance (avoid two rows)
T_9 = USG placed at 20 cm distance (avoid three rows)
T_{10} = USG placed at 30 cm distance (avoid one row)
T_{11} = USG placed at 30 cm distance (avoid two rows)
T_{12} = USG placed at 30 cm distance (avoid three rows)
T_{13} = USG placed at 40 cm distance (avoid one row)
T_{14} = USG placed at 40 cm distance (avoid two rows)
T_{15} = USG placed at 40 cm distance (avoid three rows)
[USG placed at 10 cm depth in each case]

4.9 Yield (t ha^{-1})

Yield of blackgram varied significantly with treatment variations (Appendix IX). The highest seed yield (1.32 ton ha^{-1}) was recorded from $T_{1,}$ which was statistically similar to T_0, T_3, T_4, T_5, T_6 and T_7, respectively, whereas the lowest seed yield (1.00 ton ha^{-1}) was observed from T_{15} which was similar to T_7, T_8, T_9, $T_{10,}$ T_{11}, T_{12}, T_{13} and T_{14} treatment, respectively (Figure 1). Treatment T_1 registered 24.24% more yield over T_{15} Treatment. The maximum yield was harvested due to maximum pods $plant^{-1}$, pod length, which had greater number of seeds and 1000 grain weight. It may be reported that prilled urea was placed in furrow probably lost minimum and maximum used by plants in reproductive stage this sources threats growth and yield values. 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.* (1992) reported that application of nitrogenous fertilizers becomes helpful in increasing the yield. 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). Akter (2010) reported that seed yield was highest when USG (1.8 g) was applied as basal dose and lowest value USG was applied at 25 DAS in mustard.

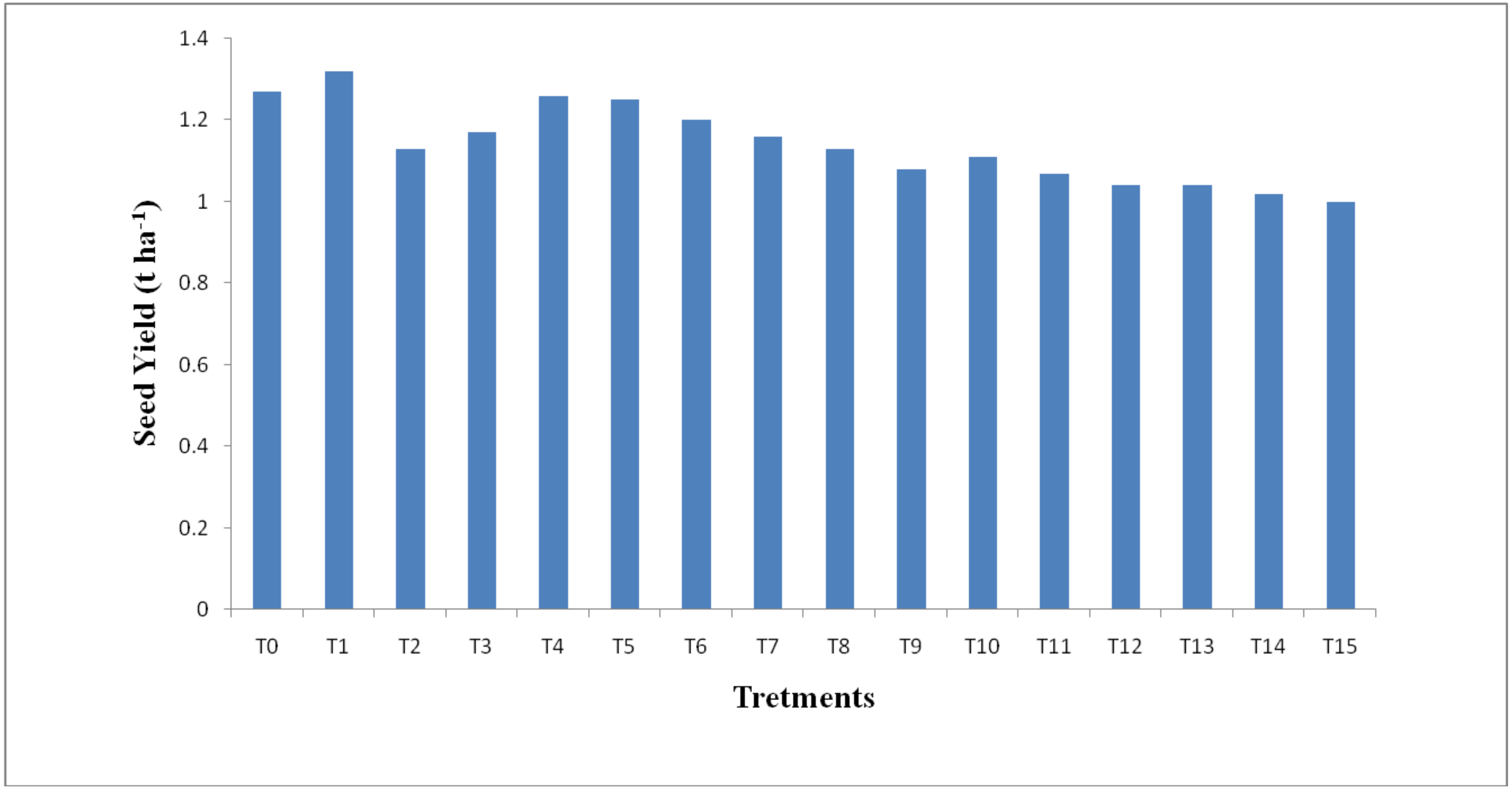

Figure 1. Effect of nitrogen managements on seed yields of blackgram (SE value- 54.50)

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

Statistically significant variation was recorded for stover yield $hectare^{-1}$ of blackgram due to different nitrogen management (Appendix IX). The highest stover yield (2.23 t ha^{-1}) was observed in $T_{1,}$ which was statistically similar to T_0 and T_2, while the lowest stover yield (1.39 t ha^{-1}) was observed in T_{15} treatment which was significantly different from all other treatments (Table 6). Srinivas *et al.* (2002) observed that stover yield increased with increasing rates of N up to 40 kg ha^{-1}.

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

Statistically significant variation was recorded for biological yield of blackgram due to different nitrogen management (Appendix IX). The highest biological yield (3.55t ha^{-1}) was observed in T_1 which was statistically similar to T_0 and T_2, while the lowest biological yield (2.39 t ha^{-1}) was observed in $T_{15,}$ which was similar to T_{14} treatment (Table 6). 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.

4.12 Harvest index

Harvest index of blackgram showed statistically significant variation due to different nitrogen management (Appendix IX). The highest harvest index (41.82%) was observed from T_{15}, whereas the lowest harvest index (33.81%) was observed from T_{12} treatment (Table 6).

Table 6. Effect of nitrogen managements on stover yield, biological yield and harvest index of blackgram

Treatment	Stover yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest index (%)
T_0	2.08 a-c	3.35 ab	37.90 e
T_1	2.23 a	3.55 a	37.18 f
T_2	2.13 ab	3.27 a-c	34.71 h
T_3	2.04 bc	3.21 b-d	36.61 g
T_4	1.92 c-e	3.17 b-d	39.60 c
T_5	1.90 c-e	3.15 b-e	39.69 c
T_6	1.79 d-f	2.99 c-g	40.23 b
T_7	1.91 c-e	3.07 b-f	37.79 e
T_8	1.96 b-d	3.09 b-e	36.52 g
T_9	1.66 f	2.74 fg	39.41 c
T_{10}	1.79 d-f	2.90 d-g	38.43 d
T_{11}	1.81 d-f	2.89 d-g	37.14 f
T_{12}	2.04 bc	3.09 b-e	33.81 i
T_{13}	1.75 ef	2.80 efg	37.29 f
T_{14}	1.68 f	2.70 gh	37.77 e
T_{15}	1.39 g	2.39 h	41.82 a
$S\bar{E}$	0.05	0.11	0.13
CV %	8.94	9.13	10.87

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

T_0 = Prilled urea (PU) broadcast
T_1 = PU given in furrows
T_2 = PU given between two rows
T_3 = PU and seeds given in same furrows
T_4 = USG placed at 10 cm distance (avoid one row)
T_5 = USG placed at 10 cm distance (avoid two rows)
T_6 = USG placed at 10 cm distance (avoid three rows)
T_7 = USG placed at 20 cm distance (avoid one row)
T_8 = USG placed at 20 cm distance (avoid two rows)
T_9 = USG placed at 20 cm distance (avoid three rows)
T_{10} = USG placed at 30 cm distance (avoid one row)
T_{11} = USG placed at 30 cm distance (avoid two rows)
T_{12} = USG placed at 30 cm distance (avoid three rows)
T_{13} = USG placed at 40 cm distance (avoid one row)
T_{14} = USG placed at 40 cm distance (avoid two rows)
T_{15} = USG placed at 40 cm distance (avoid three rows)
[USG placed at 10 cm depth in each case]

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from September to December 2012 to study the response of blackgram in relation to maximum utilization of nitrogen under different application methods. The variety BARI mash-3 was used as the test crop. The experiment consists of the following treatments- T_0= Prilled urea (PU) broadcast, T_1 = PU given in furrows, T_2= PU given between two rows, T_3 = PU and seeds given in same furrows, T_4 = USG placed at 10 cm distance (avoid one row), T_5 = USG placed at 10 cm distance (avoid two rows), T_6 = USG placed at 10 cm distance (avoid three rows), T_7 = USG placed at 20 cm distance (avoid one row), T_8 = USG placed at 20 cm distance (avoid two rows), T_9 = USG placed at 20 cm distance (avoid three rows), T_{10} = USG placed at 30 cm distance (avoid one row), T_{11} = USG placed at 30 cm distance (avoid two rows), T_{12} = USG placed at 30 cm distance (avoid three rows), T_{13} = USG placed at 40 cm distance (avoid one row), T_{14} = USG placed at 40 cm distance (avoid two rows) and T_{15}= USG placed at 40 cm distance (avoid three rows). USG was placed at 10 cm depth in each case. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth, yield and yield contributing characters of blackgram were recorded and significant variations were observed among the studied characters.

Treatment T_1 (PU given in furrows) registered the maximum plant height (22.22 cm, 53.91 cm, 53.91cm, 74.86 cm an 76.53 cm), leaves plant^{-1} (4.03, 10.20, 17.93, 20.50 and 22.57), branches plant^{-1} (1.53, 4.26, 4.57, 5.11 and 6.00) and the highest total dry weight (0.433 g, 4.573 g, 15.01 g, 28.31 g and 21.19 g) at 15, 35, 55, 75 DAS and at harvest, respectively. The minimum plant height (18.47 cm, 43.47 cm, 43.47 cm, 57.50 cm and 53.79 cm), leaves plant^{-1}

(3.10, 6.73, 11.73, 13.03 and 14.90), branches plant^{-1} (1.13, 2.39, 2.88, 2.92 and 3.33) and the lowest total dry weight (0.2667 g, 3.057 g, 11.83 g 23.04 g and 16.13 g respectively) were observed with T_{15} (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} (20.10), pod length (4.57 cm), seeds pod^{-1} (8.52) and 1000-seed weight (60.93 g) were found when crop was given prilled urea in furrow (T_1). Plant showed minimum pods plant^{-1} (15.23) pod length (3.87 cm), seeds pod^{-1} (6.21) and 1000-seed weight (55.95 g) when treated with lower amount of USG (T_{15}). The highest seed yield, stover yield and biological yield were noted as 1.32 t ha^{-1}, 2.23 t ha^{-1} and 3.55 t ha^{-1} from T_1, respectively, when T_{15} showed the minimum seed yield (1.00 t ha^{-1}), stover yield (1.52 t ha^{-1}) and biological yield (2.39 t ha^{-1}). The highest harvest index (41.82%) was recorded from T_{15}, while the lowest (33.81%) was recorded from T_{12}.

From the observed data of present experiment it may be concluded that blackgram plant gave maximum seed yield when prilled urea given in furrows near the seed may facilitate plant to uptake maximum nitrogen for better growth, development and yield of blackgram.

The use of USG showed similar performance of seed yield like prilled urea. Such experiment with prilled urea and USG could be tested further in different blackgram cultivated areas of Bangladesh to justify the present findings.

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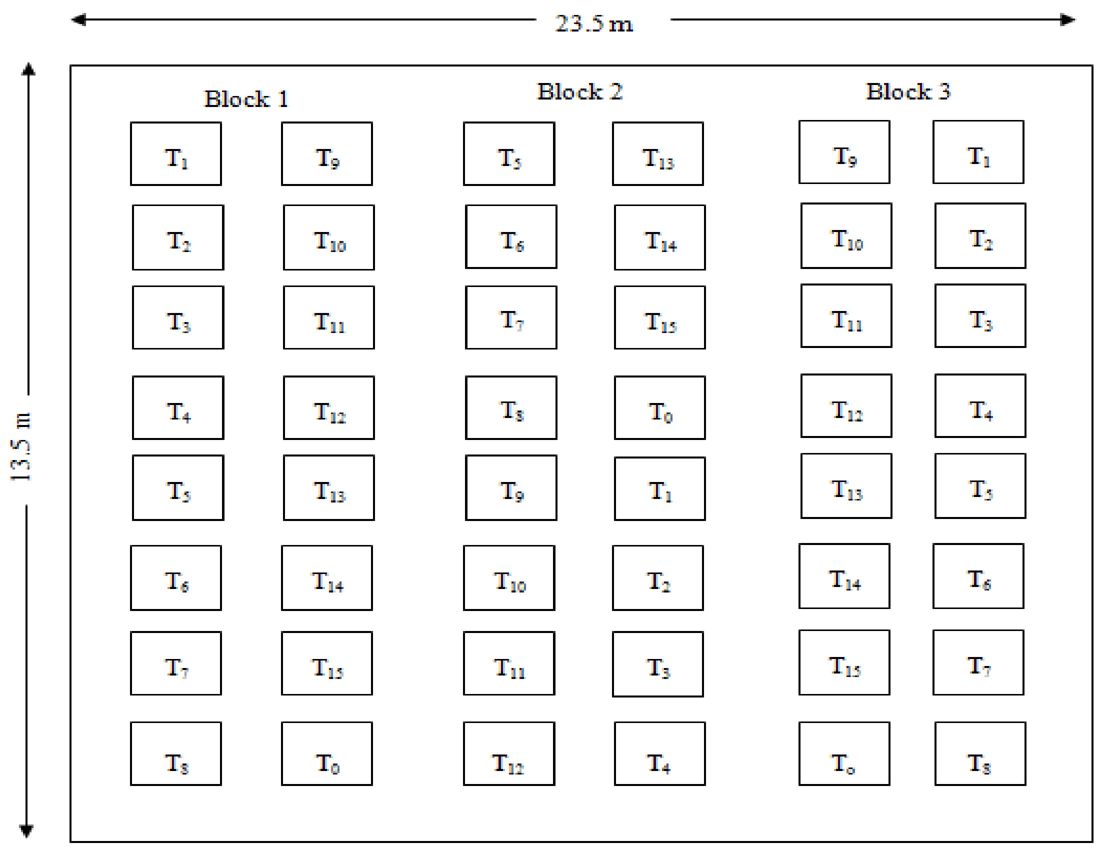
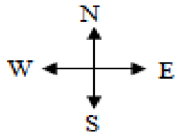
APPENDICES

Appendix I. Layout of the experiment





Plot size = 3.0 m × 1.0 m

Plot to plot: 0.5 m

Replication to replication: 1.0 m

T_0 = Prilled urea (PU) broadcast

T_1 = PU given in furrows

T_2 = PU given between two rows

T_3 = PU and seeds given in same furrows

T_4 = USG placed at 10 cm distance (avoid one row)

T_5 = USG placed at 10 cm distance (avoid two rows)

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

T_7 = USG placed at 20 cm distance (avoid one row)

T_8 = USG placed at 20 cm distance (avoid two rows)

T_9 = USG placed at 20 cm distance (avoid three rows)

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

T_{11} = USG placed at 30 cm distance (avoid two rows)

T_{12} = USG placed at 30 cm distance (avoid three rows)

T_{13} = USG placed at 40 cm distance (avoid one row)

T_{14} = USG placed at 40 cm distance (avoid two rows)

T_{15} = USG placed at 40 cm distance (avoid three rows)

[USG placed at 10 cm depth in each case]

Field layout of the experimental plot

Appendix II. 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 III. 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 IV. Analysis of variance of the data on plant height at different DAS as influenced by different nitrogen management

Sources of variation	DF	Mean square				
		Plant height				
		15 DAS	35 DAS	55 DAS	75 DAS	At harvest
Replication	2	0.328	27.153	27.153	13.276	5.594
Factor A	15	3.846*	28.970*	28.970*	80.005*	106.075*
Error	30	1.759	12.105	12.105	34.877	39.382

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

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

Sources of variation	DF	Mean square				
		Leaves plant^{-1}				
		15 DAS	35 DAS	55 DAS	75 DAS	At harvest
Replication	2	0.008	0.141	0.075	0.023	0.014
Factor A	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 VI. Analysis of variance of the data on branches plant^{-1} of blackgram as influenced by different nitrogen management

Source of variation	Degrees of freedom	Mean square				
		Branches plant^{-1}				
		15 DAS	35 DAS	55 DAS	75 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 VII. Analysis of variance of the data on total dry weight of blackgram as influenced by different nitrogen management

Source of variation	Degrees of freedom	Mean square				
		Total dry weight				
		15 DAS	35 DAS	55 DAS	75 DAS	Harvest
Replication	**2**	0.001	0.032	4.625	0.417	11.799
Treatment	**15**	0.007*	0.677*	2.263**	6.980**	5.358
Error	**30**	0.004	0.285	1.177	4.089	4.345

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

Appendix VIII. Analysis of variance of the data on yield and yield contributing characters of blackgram as influenced by different nitrogen management

Sources of variation	DF	Mean squire			
		Yield and yield contributing characters			
		Pod plant^{-1}	Seed pod^{-1}	Pod length	1000- seed (g)
Replication	2	0.181	5.859	0.013	7.064
Factor A	15	16.500*	2.564*	0.115ns	8.591ns
Error	30	4.176	0.534	0.138	17.879

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

Appendix IX. Analysis of variance of the data on seed yield, stover yield, biological yield and harvest index of blackgram as influenced by different nitrogen management

Sources of variation	DF	Mean squire			
		Yield contributing characters			
		Seed yield	Stover yield	Biological yield	Harvest Index
Replication	2	25361.478	0.025	0.104	2.200
Factor A	15	28541.38*	0.130**	0.240**	12.28**
Error	30	8588.246	0.009	0.034	0.502

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