GROWTH AND YIELD VARIATIONS IN LENTIL FERTILIZED WITH DIFFERENT FORMS OF UREA

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DHAKA-1207

DECEMBER, 2013

GROWTH AND YIELD VARIATIONS IN LENTIL FERTILIZED WITH DIFFERENT FORMS OF UREA

BY

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REGISTRATION NO.:07-02414

A Thesis

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

SEMESTER: JULY- DECEMBER,2013

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CERTIFICATE

This is to certify that thethesis entitled,**"GROWTH AND YIELD VARIATIONS IN LENTIL FERTILIZED WITH DIFFERENT FORM OF UREA"**submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka-1207, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE inAGRONOMY,**embodies the result of a piece of bona fide research work carried out by**FARZANAAKTAR,**Registration No.**07-02414**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, as has been availed of during the course of this investigation has duly been acknowledged.

(Prof. Dr. Md. Fazlul Karim)
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Dated:
Place:Dhaka, Bangladesh

ACKNOWLEDGEMENT

All praises to almighty Allah Rabbul Al-Amin for His gracious kindness and infinite mercy in all the endeavors of the author to let her successfully complete the research work and the thesis leading to the degree of Master of Science.

The author would like to express her heartfelt gratitude and most sincere appreciations to her supervisor Prof. Dr. Md. FazlulKarim, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka-1207, for his valuable guidance, advice, immense help, encouragement and support throughout the study. Likewise grateful appreciation is conveyed to Co-supervisorDr.Md. AbdullahhilBaque,Associate Professor,Department of Agronomy,Sher-e-Bangla Agricultural University, Dhaka-1207, for his constant encouragement, cordial suggestions, constructive criticisms and valuable advice to complete the thesis.

The author would like to express her deepest respect and boundless gratitude to all the respected teachers of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka-1207, for their valuable teaching, sympathetic co-operation, and inspirations throughout the course of this study and research work.

The author would like to express her heartfelt gratitude to National science and information and communication technology, Ministry of Science and Technology, Government of the people's republic of Bangladesh to provide the scholarship to continue the research for the betterment of the nation.

The author wishes to extend her special thanks toFaria, Muna, Fima, Nibedita,Samanta,Satie, Shammifor their help during experimentation.

The author is deeply indebted and grateful toher parents and other relative's for their moral support, encouragement and love with cordial understanding.

Finally the author appreciatesthe assistance rendered by the staff members of the Department of Agronomy and farm, Sher-e-Bangla Agricultural University, Dhaka-1207, who have helped her during the period of study.

December, 2013 ***The Author***

GROWTH AND YIELD VARIATIONS IN LENTIL FERTILIZED WITH DIFFERENT FORMS OF UREA

ABSTRACT

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during rabiseason from November 2012 to March 2013 to study the response of growth and yield of lentil was cultivated with different forms of urea [prilled urea, (PU) and urea super granules, (USG)].The variety BARImasur6 was used as test crop. The treatment consisted of fourteen variations as T_1 = Prilled urea (PU) broadcasted, T_2= PU given between two rows, T_3 = USG placed at 10 cm distance (avoid one row), T_4 = USG placed at 10 cm distance (avoid two rows), T_5 = USG placed at 10 cm distance (avoid three rows), T_6 = USG placed at 20 cm distance (avoid one row), T_7 = USG placed at 20 cm distance (avoid two rows), T_8 = USG placed at 20 cm distance (avoid three rows), T_9 = USG placed at 30 cm distance (avoid one row), T_{10} = USG placed at 30 cm distance (avoid two rows), T_{11} = USG placed at 30 cm distance (avoid three rows), T_{12} = USG placed at 40 cm distance (avoid one row), T_{13} = USG placed at 40 cm distance (avoid two rows), T_{14} = 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 showed significant variations among the treatments in respect of major studied parameters. The tallest plant, maximum branches plant^{-1} and above ground dry weight plant^{-1} at each growth stage were observed with T_6 [USG placed at 20 cm distance (avoid one row)] and lowest value of these parameters were recorded fromT_{14} [USG placed at 40 cm distance (avoid three rows)].Pods plant^{-1}(47.96), seeds pod^{-1}(2.14), 1000 seed weight (26.33g), seed yield (2.11t ha^{-1}), stover yield (2.87t ha^{-1}) and biological yield (4.98t ha^{-1}) were recorded maximum with T_6[USG placed at 20 cm distance (avoid one row)] and minimum values were recorded fromT_{14}[USG placed at 40 cm distance (avoid three rows)] in all these parameters.USG placed at 10 cm depth at 20-30 cm distance showed similar performance. It was evident that USG performed better than prilled urea.

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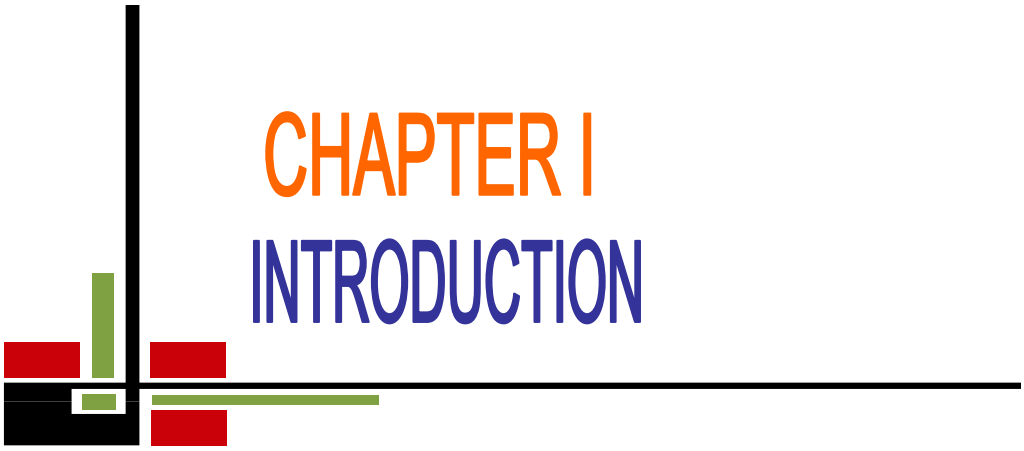

CHAPTER I
INTRODUCTION

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INTRODUCTION

Lentil (*Lensculinaris*L. Medik) under family Fabaceae is one of the most important pulse crops grown in Bangladesh. In Bangladesh it is popularly known as masur.It is well known pulse crop as it isa cheap source of easily digestible dietary protein for the human being. It supplies about four times protein and eight times riboflavin than rice when the caloric value of lentil is equal to rice (Anonymous, 1966).It is a good source of food for human being, livestocks and organic matter with nitrogen for soil enrichment (Miah, 1976).According to WHO/FAO percapita requirement of pulse should be 45 g, whereas it is only about 12 g in Bangladesh (BBS, 2010) which is very low and attributed by lower production of pulse crops.It's grain contains 59.8% carbohydrate, 25.8% protein, 10% moisture, 4% mineral and 3% vitamin (Khan, 1981; Kaul, 1982). Sufficient amount of vitamins viz. vitamin-A 16I U; thiamine 0.23 mg and vitamin C 2.5 mg are available in lentil seed (Anonymous, 1976).It offered a nutritious value with cereals as balanced food for human being(Abu-Shakra and Tannous, 1981). In spite of so many advantages,lentil is an ideal crop to be fitted in cropping systems either as main crop or intercrop grown with oil seed whichis important to increase cropping intensity and achieve food security of our country.

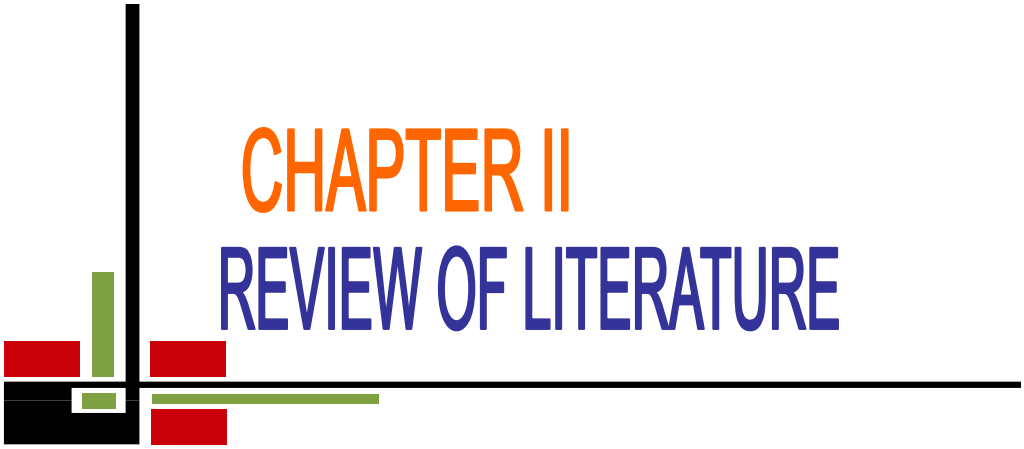
Farmers in this country are very interested to cultivate rice, maize and wheat to earn more with maximum production from cereals.They do not like to give space for cultivating pulse crop due to low yield.Thus pulses have been pushed down to marginal lands where they cannot produce their potential yields.

Lentil (*Lens culinaris*) isthe second most important pulse crop considering area and production, but stands first in the consumers' preference in Bangladesh (Ezzat*et al*., 2005).Itranks third among the lentil growing countries of Asia pacific region (FAO, 2004). The area under lentil production in Bangladesh is about77320hawith a production of 71100 m tons with an average yield of 918.18 kg ha^{-1} (BBS, 2010). The average yield of lentil is very low comparing with productivity found in other countries.The reason behind it is minimum use of high yielding variety and lack of proper agronomic management.Being legumecrop lentil gets minimum nitrogen rate as basal dose.

Among the fertilizers, nitrogen plays a vital role in producing higher grain yield. Nitrogen is the key element for the production of crops and it is highly deficient in Bangladesh soils. Rate of N application has a great influence on growth, development and yield of lentil.Prilledurea (PU) is a fast releasing nitrogenous fertilizer which is usually broadcast in lentil that causes considerable loss as ammonia volatilization, immobilization, denitrification and surface run off etc. On the other hand, deep placement of slow releasing nitrogenous fertilizer urea supergranules (USG) reduces loss as well as increases its use efficiency in dry land *rabi* crops.Now a days the use of USG is getting priority in cereal cultivation.Now-a-daysthe importance of use of USG has been popularized at home and abroad.The growth and yield of rice and wheat have been increased significantly with USG application (Hasanuzzaman*et al.*,2009).Beside this yield improvement with USG itself cuts nitrogen requirements by 20-50% in cereal cultivation(Crasswell and Datta, 1980). Thisadvantageous form of urea is to be used in all sort of crop cultivation.It is reported that pulse crop translocates energy towards its reproductive traits during its onset of flowering and poddingstopping nourishment of Rhizobia.It means pulse stops feeding Rhizobia during its flowering stage.It gives supports to reproductive units.Still then there is great abortion rate of flowers and pods of pulse (Adams, 1967).It is evident that the basal applied nitrogen in pulse is not sufficient to support the emerged flowers and pods in the plant.In addition the nitrogen fixation is stopped during this reproductive stage which is a great problem forreducing yield ofpulse crops(Patel *et al.,* 1984). The use of USG in cereal crops opens our eyesto useslow releasing USG may be an option of improving pulse yields with continuous support to their reproductive units. Information regarding application of (USG) in lentil is surprisingly low.Keeping this in mind the present experiment was under taken to improve lentil yield by using nitrogen in the form of USG.

The objectives of the experiment are as follows-

- To study thecomparativeperformanceof prilled urea and urea super granulesas nitrogen fertilizer,
- To study the growth and yield of lentil under different method of nitrogen application and
- To select a suitable nitrogenmanagement system for maximizing yield of lentil.



CHAPTER II
REVIEW OF LITERATURE

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REVIEW OF LITERATURE

Lentil is one of the important pulse crops and the crop has less concentration by the researchers on various aspects because normally it grows with less care or management practices. A very few studies regarding improvement of growth, development and yield of lentil have been carried out in our country as well as many other countries of the world. This chapter presents a comprehensive review of the works which have been done in the country and many other countries of the world with regards to the effect of different levels and forms of nitrogen application on different types of crops. Under the present study, the performance of prilled urea and urea supergranules were studied on the growth and yield of lentil.

2.1Effect of different managements of nitrogen on growth attributes

2.1.1 Plant height

Kabir*et al.* (2014) carried out a field experiment to study the effect of prilled urea and urea super granules on the growth and yield of irrigated wheat. The experiment consisted of sixteen treatments as T_1: prilled urea (PU) broadcast@100 kg N ha^{-1}, T_2: PU placed in the side furrow@100kg N ha^{-1}, T_3: PU placed between two rows@100kg N ha^{-1}, T_4: PU & seed in the same furrow@100kg N ha^{-1}, T_5: Urea Super Granule (USG) at 5 cm depth as basal@75kg N ha^{-1}, T_6: USG placed at 5 cm depth at 10 DAS@75kg N ha^{-1}, T_7: USG placed at 5 cm depth at 20 DAS@75kg N ha^{-1}, T_8: USG placed at 5 cm depth at 30 DAS@75kg N ha^{-1}, T_9: USG placed at 10 cm depth as basal@75kg N ha^{-1}, T_{10}: USG placed at 10 cm depth at 10 DAS@75kg N ha^{-1}, T_{11}: USG placed at 10 cm depth at 20 DAS@75kg N ha^{-1}, T_{12}: USG placed at 10 cm depth at 30 DAS@75 kg N ha^{-1}, T_{13}: USG placed at 15 cm depth as basal@75 kg N $ha^{-1,}$ T_{14}: USG placed at 15 cm depth at 10 DAS@75kg N ha^{-1}, T_{15}: USG placed at 15 cm depth at 20 DAS@75kg N ha^{-1} and T_{16}: USG placed at 15 cm depth at 30 DAS@75 kg N ha^{-1}. Application of PU and USG as nitrogen fertilizer had significant positive effect on growth contributing characters of irrigated wheat. The tallest plant (97.73 cm), was recorded in T_{11} (USG placed at 10 cm depth at 20 DAS@75 kg N ha^{-1}) than other treatments. The use of USG was found very effective in respect of

money save and increase yield of irrigated wheat. USG is to be applied in the irrigated wheat at 10 cm depth at 10-20 days after sowing@ 75 kg N ha^{-1}.

Islam *et al*. (2011)laid out a field experiment with a view to finding out the effect of appropriate dose of USG on growth and yield of wheat. Six levels of nitrogencontrol (T_0), 100% nitrogen of BARI recommendeddose applied as prilled urea (T_1), 25% nitrogen of BARI recommended dose applied as USG (T_2), 50% nitrogen of BARI recommended dose applied as USG (T_3), 75% nitrogen of BARI recommended dose applied as USG (T_4) and 100% nitrogen of BARI recommended dose applied as USG (T_5) were applied as treatments for growth and yield of wheat var.Bijoy for this study. Among the application of USG, treatment T_5 (100% nitrogen of BARI recommended dose applied as USG) produced the superior results on morpho-physiological and growth characters of wheat.T_5(100% nitrogen of BARI recommended dose applied as USG)produced the highest plant height (95.77 cm).

Rojina (2010) carried out an experiment to find out 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. Four nitrogen Treatment (T_1= Normal urea, T_2 = USG as basal, T_3 = USG at 15 DAS and T_4 = USG at 25 DAS) and three mustard varieties (BARI Sarisha-11, BARI Sarisha-13 and BARI Sarisha-14) were used as treatment variables in the experiment. Results indicate that the plant growth characters were significantly influenced by USG application. Plant height was found highest when USG was applied as basal dose and all the characters showed lowest value when USG was applied at 25 DAS.

Erman*et al*. (2009) conducted a field experiment during 2005-2006 and 2006-2007 growing seasons to determine the effects of *Rhizobium* inoculation and different levels of nitrogen on the yield and growth of field pea (*Pisumsativum*sp. *Arvense* L.). Nitrogen application had significant effect on the plant height, number of branches, root and shoot dry weight, number of nodules in both years. Plant heightnumber of nodules, crude protein rate and root dry weight were higher with application of 20 kg N ha^{-1} while seed yield, shoot dry weight and number of branches were higher with application of 60 kg N ha^{-1}, in the 2 seasons.

Alam(2002) laid out an experiment at the agronomy field laboratory, BAU Mymensingh during the boro season with three varieties and four level of USG.He also found higher plant height with the increase level of USG/4 hill.

Mishra *et al*. (1999) conducted a field experiment during 1994-1995 in Bhubaneswar, Orissa,India, and reported that rice cv.Lalate was given 76 kg N ha^{-1} as USG at 0, 7 and 14 for 21 days after transplanting(DAT) and reported that USG application increased plant height.

Vijaya and Subbaiah (1997) showed that plant height of rice increased with the application of USG and were greater with the deep placement method of application both N and P compared with broadcasting.

Sing and Sing (1986) reported that rice plant height increases significantly with the increase in the level and forms of nitrogen forms of nitrogen from 27to 87 kg Nha^{-1}.Deep placement of urea super granules (USG) resulted in the highest plant height than prilled urea.

2.1.2 Branches plant^{-1}

Afrin (2013) carried out an experiment to find outthe effect of variety and nitrogen fertilizer management urea on the growth and yield of transplant aman rice viz. BR11, BRRI dhan49 and BINA dhan7. The effect of variety and nitrogen fertilizer management was significant in respect of higher number of tillers $hill^{-1}$. The higher number of tillers $hill^{-1}$ (11.16tha^{-1}) was obtained from 6 cm depth of placement of USG.

Ahmed (2013) evaluated the effect of urea super granules (USG) as a source of nitrogen on the yield and yields components of transplant aman ricecultivars BRRI dhan39, BRRI dhan46 and BINA dhan7. Five levels of N (viz. 0, 60, 120 kg ha^{-1} as PU and 60, 120 kg ha^{-1} as USG) were taken as treatment combination. All the crop characters studied except 1000-grain weight were influenced significantly by the levels of nitrogen fertilizer. The dose 120 kg N ha^{-1} as USG performed beston total no. of tillers of transplant aman rice.

Rima (2013) observed that placement of USG appeared as an effective approach includingagronomic efficiency and recovery efficiency of USG in three modern varieties of rice such as, i) BINA dhan7 ii) BRRI dhan46 ii) BRRI dhan50 under four sources and doses of USG viz., i) Control (No pellets of USG), ii) location specific soil test based fertilizer recommendation (BARC, 2005) iii) BINA/BRRI recommended dose and iv) BARC (For AEZ-9) recommended dose.The highest number of total tillers hill^{-1}, effective tillers hill^{-1}in BRRI dhan46 was recorded. It was observed that in most of the cases, all the varieties performed better in respect of their recovery efficiency with location specific soil test based fertilizer recommendation. Therefore, placement of USG (75.5 kg N ha^{-1}) appeared as an effective approach including agronomic efficiency and recovery efficiency of USG for nitrogenous fertilizer management in transplant aman rice.

Jabin*et al.* (2012) conducted a field experiment to study theinfluence of application method of prilled urea and urea suppergranule on yield of mustard. Thetreatments comprised of T_1(Prilled Urea (PU) broadcasted, conventional method), T_2(PU given inthe side furrows), T_3(PU given between two rows), T_4 (PU and seed given in the same furrows),T_5 (Urea Super Granules (USG) placed at 5 cm depth as basal), T_6(USG placed at 5 cm depth at 10days after sowing DAS), T_7(USG placed at 5 cm depth at 20 DAS), T_8(USG placed at 5 cm depth at30 DAS), T_9 (USG placed at 10 cm depth as basal), T_{10}(USG placed at 10 cm depth at 10 DAS),T_{11}(USG placed at 10 cm depth at 20 DAS), T_{12}(USG placed at 10 cm depth at 30 DAS), T_{13}(USGplaced at 15 cm depth as basal), T_{14}(USG placed at 15 cm depth at 10 DAS), T_{15} (USG placed at 15cm depth at 20 DAS) and T_{16}(USG placed at 15 cm depth at 30 DAS). Results showed that USGplaced at 5 cm depth at 20 DAS gave the highest branches plant^{-1} (6.86).

Miah *et al.*(2012) studied the effects of two slow release nitrogenous fertilizer named prilled urea (PU) and urea super granule (USG) on growth, yield and quality of BRRI dhan28. There were ten treatments combinations consisting of two forms of urea *viz.*, PU and USG and five levels of each form (0, 110, 180, 240 and 300 kg ha^{-1}). Application of different forms and doses of urea had significant effect on total tillers of BRRI dhan28. The results suggest that urea super granule @ 240 kg ha^{-1}may be suitable for better growth of bororice cv. BRRI dhan28.

Nur (2012) evaluated the effect of variety and placement method of urea super granule (USG) on the yield performance of T.aman rice varieties. The experiment consisted of three aman rice varieties viz., Pajam, BR11, BRRI dhan40 and four placement method viz., broadcasting method of Prilled urea, USG placement by hand, by BAU USG applicator and by BARI USG applicator. The highest number of total tillers per hill, effective tillers per hill was found from the hand placement method of USG.

Vijaya and Subbaiah (1997) stated that number of tillers in rice plant increased with the use of USG and were greater with the deep placement method of application comparing with N broadcasting.

Kamal *et al.* (1991) laid out a field experiment in Kharif season of 1985 and 1986 on rice cv.Joya with different level of nitrogen @ 29, 58 and 87 kg ha^{-1} as urea super granules(USG).Among the three doses of nitrogen total tillers per hill was the highest when 87 kg N $ha^{-1}$was applied.They also reported that productive tillers also higher with the same dose of nitrogen.

Jee and Mahaptra (1989) found that number of panicles per square meter in rice plant were significantly higher @90 kg ha^{-1} as deep placed urea super granules (USG) than split application of urea.

Mirzeo and Reddy (1989) worked with different modified urea material and levels of N@30,60 and 90 kg with rice. They reported that root zone placement of urea super granules(USG) produced the highest number of tillers at 30 or 60 days after transplanting.Urea super granules gave 14.0 and 8.8% more panicles per square meter in 1983 and 7.6 and 8.4% more panicles per square meter in 1984 than neem coated urea or prilled urea, respectively.

Rama *et al*.(1989) mentioned that in rice plant the number of panicles per square meter increased significantly when nitrogen level increased from 40 to 120 kg N ha^{-1} as different modified urea materials.Urea super granules (USG) produced significantly higher number of panicles per square meter and grains per panicle than split application of prilled urea.

2.1.3Dry matter content

Miah*et al.* (2004) found that total dry matter production was affected notably by the use of USG.USG applied plots gave higher total dry matter compared to urea irrespective of number of seedling transplanted $hill^{-1}$.

Sinha*et al.* (2003) fertilized rapeseed cv.B-9 plants with 0, 30, and 60 kg ha^{-1} under irrigated or non-irrigated condition. They observed that dry matter accumulation increased with increasing rate of nitrogen.

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.

Rambabu*et al.* (1983) stated that different forms and methods of application of N fertilizers to rice grown under flooded conditions, placement of N as USG (1 and 2 g size) in the root zone at transplanting was the most effective in increasing dry matter production and lowest with urea as a basal drilling.

2.2 Effect of nitrogen managements on yield and yield attributes

2.2.1 Pods $plant^{-1}$

Kabir*et al.* (2014) found that application of PU and USG as nitrogen fertilizer had significant positive effect on yield and yield contributing characters of irrigated wheat. The maximumgrains $spike^{-1}$ (42.33)was recorded in T_{11} (USG placed at 10 cm depth at 20 DAS@75 kg N ha^{-1}) than other treatments. The use of USG was found very effective in respect of money save and increase yield of irrigated wheat. USG is to be applied in the irrigated wheat at 10 cm depth at 10-20 days after sowing@ 75 kg N ha^{-1}.

Jabin*et al.* (2012)studied theinfluence of application method of prilled urea and urea suppergranule on yield of mustard and found that USGplaced at 5 cm depth at 20 DAS gave the highest siliquae $plant^{-1}$(58.60) compared to PU application.Use of USG had two fold advantages over conventional use of PU.

Islam *et al*. (2011) carried out a field experiment consisted of six levels ofnitrogencontrol (T_0), 100% nitrogen of BARI recommendeddose applied as prilled urea (T_1); 25% nitrogen of BARI recommended dose applied as USG (T_2), 50% nitrogen of BARI recommended dose applied as USG (T_3), 75% nitrogen of BARI recommended dose applied as USG (T_4) and 100% nitrogen of BARI recommended dose applied as USG (T_5) to assess the growth and yield of wheat var. Bijoy. Among the application of USG, treatment T_5 produced the superior results on morpho-physiological and growth characters of wheat. As results, T_5 produced the highest number of grains spike^{-1} (46.27).

Aslam*et al*. (2010) studied the appropriate method of fertilizer application with the selection of Rhizobium strain for exploitation of its natural symbiosis with chickpea for effective nodulation, maximum grain yield and grain protein contents in chickpea. In this experiment two fertilizer application methods i.e. Fertilizer broadcast (F_1) and Band placement (F_2) and five rhizobium inoculation strains along with a control; Uninoculation (I_0), Mezo rhizobium (I_1), Rhizobium (I_2), Biozote (I_3), Agro bacterium (I_4) and Biofertilizer (I_5) were studied in split plot arrangements. Yield and yield components were significantly affected by fertilizer band placement and seed inoculation. Maximum number of pods plant^{-1} (36.50) was recorded in fertilizer band placement.

Rojina (2010) found in an experiment that yield and yield attributing characters of mustardwere significantly influenced by USG application. Four nitrogenous fertilizer (T_1= Normal urea, T_2 = USG as basal, T_3 = USG at 15 DAS and T_4 = USG at 25 DAS) and three mustard varieties (BARI Sarisha-11, BARI Sarisha-13 and BARI Sarisha-14) were used as treatment variables in the experiment.Number of siliquaplant^{-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.

BARI (2008) conducted several experimentsto find out the effect of USG on various crops as brinjal, potato,hybrid maize etc. and established that these crops gives higher fruits per plant, tuber per haulm, cob per plant, respectively.

2.2.2Seeds pod^{-1}

BARI (2008) conducted experiment to find out the effect of USG on hybrid maize and found that 10% less application of N than the recommended dose as USG gave the highest grain per cob (476) than prilled urea.

Jabin*et al.* (2012)found that USGplaced at 5 cm depth at 20 DAS gave the highest seeds siliqua^{-1} (32.00) which reflected in higher values of seed yield(3.59 t ha^{-1}). Use of USG had two fold advantages over conventional use of PU.

2.2.3 1000 seed weight

Ahmed*et al.* (2000) conducted a field experiment to study the effect of point placement of urea super granules (USG) and broadcasting prilledurea (PU) as sources of N in T. aman rice.USG and PU were applied @40, 80, 120 or 160 kg N ha^{-1}.They reported that USG was more efficient to increase 1000-grain weight of T. aman ricethan PU.

Kabir*et al.* (2014) found that application of PU and USG as nitrogen fertilizer had significant positive effect on yield and yield contributing characters of irrigated wheat. The maximum 1000 grain weight (40.11 g) was recorded in T_{11} (USG placed at 10 cm depth at 20 DAS@75 kg N ha^{-1}) than other treatments.

Jabin*et al.* (2012)studied theinfluence of application method of prilled urea and urea suppergranule on yield of mustard. Results showed that USGplaced at 5 cm depth at 20 DAS gave the highest 1000 grain weight (3.56 g) which reflected in higher values of seed yield(3.59 t ha^{-1}), biological yield (6.78 t ha^{-1}) and harvest index (52.62%) compared to PU application.Use of USG had two fold advantages over conventional use of PU.

2.2.4 Seed yield

Kabir*et al.* (2014) conducted an experiment to study the effect of prilled urea and urea super granule on the growth and yield of irrigated wheat. The maximumgrain yield (4.00 t ha^{-1})was recorded in T_{11} (USG placed at 10 cm depth at 20 DAS@75 kg N ha^{-1}) than other treatments. However the highest harvest index (45.45%) was obtained

from the treatment T_6 (USG placed at 5 cm depth 10 DAS@ 75 kg N ha^{-1}). The use of USG was found very effective in respect of money save and increase yield of irrigated wheat. USG is to be applied in the irrigated wheat at 10 cm depth at 10-20 days after sowing@ 75 kg N ha^{-1}.

Rima (2013) observed that placement of USG appeared as an effective approach including agronomic efficiency and recovery efficiency of USG for nitrogenous fertilizer management in transplant aman rice.

Zohra *et al.* (2013) carried out an experiment to find out the yield performance of three transplant *aman*rice namely, BINA dhan7, BRRI dhan46 and Kalizira were evaluated under five levels of urea super granules (USG) viz. control (no USG), one, two, three and four pelletof USG/4 hills providing 0, 30, 60, 90 and 120 kg N $ha^{-1,}$ respectively, and recommended dose of prilled urea were evaluated. Grain yield was found the highest (4.91 t ha^{-1}) from the level of 2 pellets of USG/4 hills and straw yield was found the highest (6.60 t ha^{-1}) from the level of 4 pellets of USG/4 hills. It was observed that in most of the cases, all the varieties performed better for their yield contributing characters with 2 pellets of USG/4 hills compared to any other levels.

Jabin*et al.* (2012)found in an experiment that USGplaced at 5 cm depth at 20 DAS gave the highest siliquae $plant^{-1}$ (58.60),seeds $siliqua^{-1}$ (32.00), 1000 grain weight (3.56 g) which reflected in higher values of seed yield(3.59 t ha^{-1}), biological yield (6.78 t ha^{-1}) and harvest index (52.62%) compared to PU application.Use of USG had two fold advantages over conventional use of PU.

Sarker*et al.*(2012)conductedan experiment to find out the effect of Urea Super Granule (USG) on cabbage. There were five treatments viz. T_1: recommended nitrogen (N) doseas prilled urea (PU), T_2: recommended N dose as USG, T_3: 10% less than recommended dose of N as USG, T_4: 20% less than recommended dose of N as USG, and T_5: farmers practice (average of 20 farmers N dose used as PU) used in the experiment. Results revealed that yield of cabbage increased significantly due to application of USG over PU. The highest head yield ofcabbage 92.04 and 91.36 t ha^{-1} were obtained from the USG (recommended dose) in 2007-08 and 2008-09, respectively which was statistically similar with USG 10% less than recommended dose (84.78 t ha^{-1}) instead of traditional PU. The treatments T_3 and T_4 were found

more effective over PU, and N loss was also minimum than that of prilled urea where 10-20% N fertilizer could be saved by using USG instead of traditional PU.

Nur (2012)revealed that the placement method of USG exerted a significant influence on the yield and yield contributing characters of Transplanted aman rice. Grain and straw yields were the highest (5.13 and 5.21 t ha^{-1}, respectively) from the hand placement method of USG.

Nusrat(2012) investigated the effects of prilled urea (PU), urea super granule (USG) alone and in combination with poultry manure (PM) on the rice field water properties and yields of T. Aus rice (cv. BR 21). Application of nitrogen as prilled urea, USG alone or in combination with poultry manure significantly increased yield components, grain and straw yields of BR 21 rice. The N, P, K and S contents in the grain and straw of BR 21 rice and their total uptake were influenced profoundly due to application of PU, USG alone or in combination with poultry manure. In case of rice field water properties, the USG generated available NH_4-N slowly but spontaneously over the entire growth period compared to prilled urea indicating a beneficial role of USG.

Miah *et al.*(2012) found that application of different forms and doses of urea had significant effect on grain and straw yield of BRRI dhan28. The content of protein in grain was influenced significantly due to different doses, whereas the content of starch was not affected significantly by the different forms and doses of urea. A positive and significant correlation was found between grain yield and yield attributes in grain.

Azam*et al* (2012) conducted a field experiment to investigate the effect of urea super granule (USG) on the growth and yield of potato. Five treatments were the same in two rabi seasons. *viz.* T_1 = Recommended dose of nitrogen as prilled urea (PU), T_2 = Recommended dose of nitrogen as urea super granule (USG), T_3 = 10% less of recommended dose of nitrogen as USG, T_4 = 20% less of recommended dose of nitrogen as USG and T_5 = Farmers practice (average of 20 farmers N dose used as PU). Significant variation was observed in different treatments. The highest yield of potato 33.21 t/ha were obtained from the recommended N dose of USG followed by

USG 10% less than recommended dose of N (31.51 t/ha) during 2008-09. In the year 2009-10 higher yield was obtained from the T_2 treatment (32.33 t ha^{-1}) followed by T_3 (30.87 t ha^{-1}). By reducing 10% N losts through USG application more or equal returns can be obtained over prilled urea application.

Hasanuzzaman*et al.* (2012) carried out afield experiment to study the response of hybrid rice to different levels of nitrogen andphosphorus. Results indicated that the effect of nitrogen showed significant variation in respect of yield contributing characters andyield. About 10% more grain yield was measured from urea super granules thanprilled urea.

Hussian*et al.* (2010)conducted a number of experiments for three consecutive years to evaluate the efficiency of USG application over prilled urea on the yield of cabbage. They reported that, yield and yield contributing characters of cabbage significantly responded to the application of USG. The highest head yield (78.1 t ha^{-1}) was obtained with the recommended dose of N as USG. The 10% and 20% reduction i. e. 175 kg USG ha^{-1} and 155 kg USG ha^{-1} also gave higher yield (77.1t ha^{-1}, 72.0 t/ha respectively) than that of recommended dose of prilled urea application.

Islam *et al*. (2011) usedsix levels ofnitrogencontrol (T_0), 100% nitrogen of BARI recommendeddose applied as prilled urea (T_1); 25% nitrogen of BARI recommended dose applied as USG (T_2), 50% nitrogen of BARI recommended dose applied as USG (T_3), 75% nitrogen of BARI recommended dose applied as USG (T_4) and 100% nitrogen of BARI recommended dose applied as USG (T_5) in a field experiment with a view to finding out the effect of appropriate dose of USG on growth and yield of wheat var. Bijoy.100% nitrogen of BARI recommended dose applied as USG (T_5)produced the highestgrain yield (2.42t ha^{-1}) and straw yield (4.06tha^{-1}).

Aslam*et al*. (2010) found thatyield and yield componentsof chickpea were significantly affected by fertilizer band placement. Maximum number of pods $plant^{-1}$ (36.50) and1000 grain weight (29.19 g) was recorded in fertilizer band placement. Fertilizer band placement increased grain yield by 10 % (3279 to 3772 kg ha^{-1}) during 2004-05. It was concluded that, fertilizer band placement along with Bio fertilizer inoculation was the best for higher yield and grain protein contents in chickpea.

Rojina (2010) carried out an experiment to find out the effect of different management of nitrogenous fertilizer on growth, yield and yield attributing characters of mustard. She found thatyield and yield attributes of mustard were significantly influenced by USG application.When USG was applied as basal dosesiliqua plant^{-1}, siliqua length, number of seed siliqua^{-1}, 1000-seed weight, and seed yield (t ha^{-1}) were found highest and all the characters showed lowest value when USG was applied at 25 DAS. USG was used as basal dose which reduce 40% use off prilled and 20% of total cost in mustard cultivation.

Ahmed *et al.* (2010) conducted a field experiment with four treatments on the production of hybrid maize. The highest grain yield (10.30t/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 (9.44t/ha). The recommended dose of N as Prilled urea gave yield of 9.21t/ha. The maximum gross return (Tk.131428 /ha) was obtained from plots treated with recommended dose of N as USG.

Erman*et al*. (2009) laid out a field experiment to determine the effects of *Rhizobium* inoculation and different levels of nitrogen on the yield and growth of field pea (*Pisumsativum*sp. *Arvense* L.). Nitrogen application had significant effect on seed yield, biomass yield, harvest index, number of pods, as well as crude protein rate of field pea. Number of pods, harvest index, number of nodules, crude protein rate were higher with application of 20 kg N ha^{-1} while seed yield was higher with application of 60 kg N ha^{-1}.

Hasanuzzaman*et al.*(2009) carried out an experiment to find out the economic and effective method of urea application in rice crop.Growth and yield of rice was significantly affected by different methods of urea application. In all the case except plant height and straw yield Ureasupergranules @ 75 kg ha^{-1} gave the highest result. Application of USG @ 75 kg ha^{-1} produced 22.03% and5.88% more yield than granular urea application at 2 and 3 equal splits. Foliar spray of urea produced the lowest yield components and yield in this study.

Kabir*et al*. (2009) laid out an experiment to find out the effect of urea super granules (USG), prilled urea (PU) and poultry manure (PM) on the yield and yield attributes of

transplant amanrice varieties. It was observed that the highest grain yield (5.17 t ha^{-1}) was obtained from full dose of USG (1.8g) and other inorganic fertilizers, which was similar to that obtained from full dose of USG (1.8g) + PM at 2.5 t ha^{-1} followed by full dose of PU + PM at 2.5 t ha^{-1}. It was assessed that a considerable portion (31.25%) of PU nitrogen could be saved by using USG (1.8g) together with other inorganic fertilizers or with PM at 2.5 t ha^{-1}.

BARI (2008) conducted several experiments to find out the effect of USG on various crops as brinjal potato, hybrid maize etc. and established that these crops gives higher fruit per plant, tuber per haulm, cob per plant, respectively.

Peterson (2007) found that placement of compound NPK fertilizer increased the grain yield and the quality parameters like grain size and grade when weeds are controlled mechanically by harrowing in barley. The effect of fertilizer placement on grain yield and quality decreased in the order NPK> NP> N> P.

Khalil *et al.* (2006) conducted a field experiment to know the recovery of spring wheat with urea super granules. They observed that the translocation of N from vegetative part to grain portion during grain filling stage (67-116 DAA) was 34.9% with the USG and 28.7% with PU, resulting in (711 kg/ha) more grain yield with the former than the later. Irrespective of urea sizes fertilizer nitrogen recovery in crop increased linearly until 67 or 70. Being highest (75-78%) with the USG point placed at 2.5 cm depth. Results suggest that the USG technique could increase yield and fertilizer use efficiency of spring wheat and decrease gaseous nitrogen losses over the PU.

Humphreys *et al.* (2006) reported that recovery of nitrogen from point placement of urea of super granule was 49% higher than prilled urea. The increase in plant nitrogen recovery consequently increases plant height, number of leaf,tillering and a yield or agronomic efficiency of rice plant.

Singh and Singh (2006) conducted two field experiments for two crop cycles each for two years on an entities over *Citronella Java*. They found that the oil yields were 9% higher in USG than that of PU and N recovery of USG and PU were 31 and 21% respectively.

Trierweiler and Omae (2005) recorded that the maize grain yield response to added N was very highly significant and the regression analysis predicted a maximum yield of 7.6 t ha^{-1} from 210 Kg N ha^{-1}. A consistent yield depression occurred at 320 kg N ha^{-1} rate in all placement treatments. Placement of urea on dry soil gave significantly higher yields than did placement on wet soil. The data indicated that substantial N losses occurred when urea was broadcasted on wet surface.

Riaz*et al*. (2004) found that furrow irrigation method with band placement of N considerably increased leaf area $plant^{-1}$, crop growth rate, net assimilation rate, number of grains cob^{-1}, 1000-grain weight and grain yield (6.72%) than broadcast method.

Tewari*et al*. (2004) stated that the deep placement of slow release fertilizer kept nodule dry weight, higher in the maturing stage of seed, possibly through abundant supply of photo assimilate to the nodules by supporting leaf area and activity until late reproductive stages in the soybean plants, and the results indicated that deep placement of calcium cynamide or coated urea enhanced total amount of N_2 fixation activity 50 percent higher, which ultimately increased seed yield.

Talukder*et al.* (2004) conducted an experiment to observe the efficiency of Urea super granule on tomato for two years. Two years results revealed that USG had significant positive effect on the yield of tomato as compared to prilled urea. The recommended dose of N (150 kg/ha) from USG gave highest marketable fruit yield of 79.13 t/ha in the 1^{st} year and 73.60 t/ha in the 2^{nd} year. They also observed that when 150 kg and 135 kg/ha of N applied from USG gave 11% and 2% higher yield of tomato than that of using 150 kg/ha N from prilled urea, respectively.

Rao*et al.* (2004) studied the effect of prilled urea, neem coated urea and urea super granules on a perennial aromatic herb, geranium (*Pelargoniumgraveolens*) grown on a sandy loam soil. They reported that, application of nitrogen increased the biomass and essential oil yields. USG and neem coated urea significantly increased the yields over prilled urea. The concentration and quality of essential oil were not influenced either by levels or carrier of N.

Hasan*et al.* (2002) determined the response of hybrid (Sonar Bangla-1 and Alok 6201) and inbred (BRRI dhan 34) rice varieties to the application methods of urea super granules (USG) and prilled urea (PU) and reported that the effect of application method of USG and PU was not significant in respect of 1000-grain weight.

Miah and Ahmed (2002) conducted an experiment and found that deep placement of urea super granules (USG) has been proven to improve N efficiency. In terms of N recovery, agronomical and physiological efficiency, rice varieties utilized N more efficiency when applied as super granules in deep placement.

Saikia*et al.* (2002) reported the response of Indian mustard cv. Pusa giant grown in New Delhi, India during rabi season of 1998-99. They found that those varieties response positively to the use of USG than prilled urea and neem coated urea.

Jaiswal and Sing (2001) conducted a field experiment on comparative efficiency of urea super granules and prilled urea both at 60 and 120 kg ha^{-1} on rice cultivation under different planting method during 1996-97 and 1997-98 in Faizabad, Uttar Pradesh, India.They stated that transplanting method with USG placement proved to be best for maximum grain yield (4.53 t ha^{-1}) and deep placement of USG increased N use efficiency (31.7%) compared to conventional method of urea application.

Lehrsch*et al.*(2000) showed that placement of N and P fertilizers at the time of planting directly in the seed furrow improved crop uptake, and grain yield in maize. Many researchers reported that maize yieldsreduced with broadcast application of N compared with injected N sources or placements.

Ahmed *et al.*(2000) reported that point placement of urea super granules(USG) and broadcasting ofprilled urea (PU)as sources of N has a significant effecton T.amanrice.USG and PU were applied @40,80,120 or 160 kg N ha^{-1}.They found that USG was more efficient than PU irrespective of nitrogen level in producing filled grains $penicle^{-1}$ and 1000- grain weight.

Alam*et al.* (2000)carried out a socio economic study in two rice production environment (Gazipur and Tangail) to assess the comparative advantages of using urea super granule (USG) over prilled urea (PU) in modern rice production and to examine the differences in producers technical efficiency between USG urea and non-

user in crop management. Results revealed that comparatively low amount (36%) of urea was needed in modern boro rice production using USG instead of PU though 15% more labor was needed while weeding cost was a bit lower in USG using plots. Results also indicated additional yield of 0.87 t/ha by using USG and this yield gain additional benefit of TK. 11506/ha.

Balaswamy(1999) found that in an experiment deep placement of nitrogen as urea super granules reduced the weight of weeds resulting in more panicles and filled grains and also increased the grain yield of rice over the split application of prilled urea by 0.43 and 0.3 t ha^{-1} in 1985 and 1986, respectively.

Haque (1998) conducted a field experiment on potato with four treatments (1) Control (without any fertilizer), (2) 100 Kg N/ha from prilled urea, (3) USG, 2; 73 kg N ha^{-1} from USG (4) USG-3; 109 kg N ha^{-1} from USG point placement. USG greatly increased yield of potato tubers both at BAU farm and farmers field at Madhupur. Maximum potato tubers yield at BAU farm was from USG-3 treatment which was 24.16 t/ha compared to 17.52 t/ha from prilled urea application. Maximum yield of potato tubers at farmer's field was obtained from USG-3 treatment which was 26.50 t/ha compared to 20.78 t/ha from same dose of prilled urea application.

Singh and singh (1997) experimented during 1987 in Uttar Pradesh, India. Dwarf rice cv. jaya was given 90 or 120 kg N ha^{-1} as urea super granules, large granular urea or neem cake coated urea. N was applied basally,or in 2 equal splits(basally and panicle initiation). They found that grain yield was highest with 120 kg N (4.65ha^{-1}) was not affected by N source and was higher with split application.

Surendra*et al*. (1995)laid out an experiment during rainy season in rice plant with nitrogen level @0, 40, 80, 120 kg ha^{-1}.They showed that urea super granules produced significantly more panicle/hill, filled grains/panicle, panicle weight and grain yield than prilled urea@80 kg N ha^{-1}.

Quayum and Prasad (1994) conducted field trials during Kharif season with 5 rates of N (0, 37.5, 75, 112.5 and 150 kg ha^{-1}) and six different sources of Nitrogen with rice cv. Sita and found that application of 112.5 kg N ha^{-1} increased grain (4.37 t ha^{-1}) and

straw yields(5.49 t ha^{-1}).They also reported that N as USG gave the best yield and concluded that slow release fertilizers were effective for rainfed lowland rice.

Pandey and Tripathi (1994) reported that application of urea super granule at the rate of 112 kg/ha^{-1} significantly improved the yield components of rice like productive tillers, panicle length, fertile spikelets per panicle and 1000 grain weight.

Thakur (1991) studied the influence of levels, forms of urea and method of application of nitrogen in rice during Kharif season.He observed that yield attributes and grain yield differed significantly due to the levels and sources of nitrogen applied. Placement of nitrogen at 60kg ha^{-1} through urea super granules (USG) produced the highest number of panicle/unit area, panicle weight, number of grains/panicle, 1000-grain weight, which ultimately gave the highest grain yield of 4.77 t ha^{-1} in 1987 and 4.94t ha^{-1}.

Roy *et al*. (1991) compared deep placement of urea super granules (USG) by hand and machine and prilled urea (PU) by 2 to 3 split applications in rainfed rice during 1986 and 1987.They reported that USG performed better than PU in all the parameters tested. Significant difference was observed in 1000-grain weight and highest grain weight was obtained from USG (by hand) treated plots.

Mohanty*et al*. (1989) observed that placement of USG in rice gave significantly higher grain and straw yields of 36 and 39% in dry and 17 and 18% in wet season, respectively than split application of PU.

Katyal*et al.* (1988) observed that leaching losses of urea super granules (USG)-N could be decreased by about 20% by the placement of four 0.25 g granules at four points instead of 1 g granule at one point. In field micro plots, the placement of approximately 30 granules of 0.30 g size instead of 9 granules of 1.00 g size resulted in reduced leaching of USG-N and, in turn, increased rice yield. In a follow-up field study, the advantage of more frequently placed USG was confirmed. As compared with 1 g USG placed in the usual manner in the center of four rice hills, increasing the density of placement in soil produced 15% more rice grain. Further increase in rice yield could be obtained by increasing the number of USG placed in the soil and decreasing the size of the granule from 1.00 g to 0.70 or 0.35 g. With USG of 0.35

and 0.70 g yields were equal or sometimes even slightly higher than split application of prilled urea on a heavily percolating, low-CEC, light-textured soil.

Patel and Deshai (1987) carried out an experiment on rice applying N @58.87 or 16 kg ha^{-1} as sulphur coated urea, urea super granules (USG) and phosphorus coated urea. They reported 58.87 kg ha^{-1} as urea super granules placed at 10-12 cm depth gave the highest yield (4.34t ha^{-1}) and number of panicles/m^2.

Singh and Mishra (1992) laid out a field experiment on a calcareous alluvial sandy loam soil to see the comparative effect of prilled urea and urea super granules on yield and quality of Sugarcane. Use of USG up to 75% of the recommended dose of N increased sugar and sugarcane yields significantly as comparison with prilled urea. USG was found stimulating ammonification significantly in the soil than priled urea and reduced nitrification significantly.

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

Yadav*et al.* (1990) conducted a field experiment on sugarcane. Urea super granules (USG),neem-cake coated urea (NCU), dicyanamide-treated Urea (DCD) and the traditional N source prilled urea (PU) were used to supply 150 kg N/ha. Uptake and recovery of N were significantly greater using USG than NCU, DCD and PU.

Mahapatra*et al.* (1990) conducted a field experiments in two wet and two dry seasons to evaluate efficiencies of different urea based fertilizers and methods of application for irrigated and rainfed rice. They found that 10% less USG gave significantly superior results than 100% prilled urea.

In recent year, a deep understanding on mechanism causing poor utilization help to develop cultural practices to improve nitrogen use deficiency (NUE) in low land rice. Urea super granule (USG) a physical modification of ordinary urea is considered a slowly available N fertilizer and found deficient when properly deep placed (Savant and Stangel, 1990). Deep placement of USG at the rate of 120 kg/ha significantly increased the grain and straw yield over prilled urea. (Das and singh, 1994; Mishra and Gupta, 1995).

Surendra*et al*. (1995) reported that placement of urea supergranules increased N use efficiency. The highest grain yield was obtained with 150 kg N ha^{-1} as urea supergranules with 489 panicles m^{-2} and 122 grains panicle

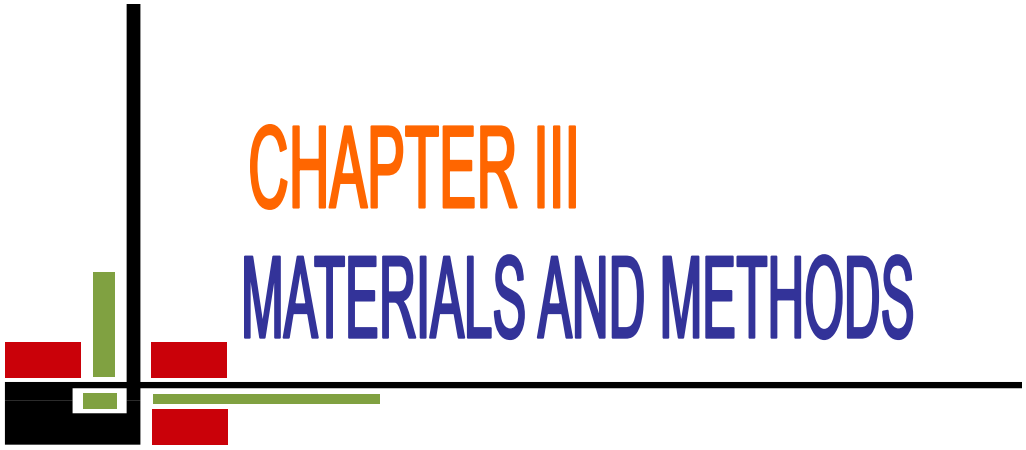
Sardana and Verma (1987) conducted an experiment and reported that larger urea granule causes slow release of nitrogen and results significant increase in leaf are index (LAI) of mungbean.

Sudhakara and Prasad (1986) conducted a field experiment to study the relative efficiency of prilled urea, urea super granule and neem coated urea. They observed that performance of rice if more or less linear to USG and neem coated USG which were better than prilled urea.

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 besuitable for paddy in many Asian countries, where urea is already a common fertilizer. Theproduct is 40-50% more efficient than conventional urea.

Pillai (1980) found that it was possible to get an extra grain yield as response of one t ha^{-1} by applying 38 kg N ha^{-1} by root zone placement of urea supergranules. To get the same yield with ordinary urea in split doses, it was necessary to apply about 56 kg N ha^{-1}.

From the reviews cited and discussed above, it can be concluded that nitrogenous fertilizer as prilled urea, urea super granules (USG) etc. play a remarkable role for the growth, yield and yield components of different crops. Use of USG on pulse crop particularly lentil could be another economic way of improving yield of lentil.



CHAPTER III

MATERIALS AND METHODS

CHAPTER III
MATERIALS AND METHODS

A field experiment was conducted at the research field of Agronomy, Sher-e Bangla Agricultural University, Dhaka, Bangladesh during the period from November 22, 2012 to March 7, 2013. The materials and methods of this experiment are presented in this chapter under the following headings-

3.1 Experimental Site

The present piece of research work was conducted in the field of Agronomy Department, Sher-e-Bangle Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The location of the site is 23°74'N latitude and 90°35'E longitude with an elevation of 8.2 meter from sea level(Appendix I).

3.2 Weather Condition of the Experimental Site

The climate of the 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. The monthly average temperature, humidity and rainfall during the crop growing period were presented in (Appendix II).The average maximum and minimum temperature were varied from 28.1^{o}C to 34.8°C and 11.1^{o}C to 18.0^{o}C respectively.The relative humidity varied from 55% to 79%. The month November was experienced with maximum total rainfall (227mm).

3.3 Characteristics of Soil

The soil of the experimental area was loamy belonging to the Madhupur Tract under AEZ 28. The soil of the experimental plots were clay loam, land was medium high with medium fertility level (Appendix III).The organic matter and nitrogen status of the soil was poor. The p^{H} varied from 6.00-6.63.

3.4.Planting Material

The seeds of BARImashur6 were collected from Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh. The seeds were healthy, vigorous, well matured and free from other crop seeds and inert materials.

3.5 Experimental treatments

The experiment was a fertilizer trial. Nitrogen was the fertilizer element, prilled and USG urea was applied as fertilizer to supply the nitrogen for the study.

The experiment consisted of the following treatments:

T_1 = Prilled urea (PU) broadcast.

T_2 = PU given between two rows.

T_3 = USG placed at 10 cm distance (avoid one row).

T_4 = USG placed at 10 cm distance (avoid two rows).

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

T_6 = USG placed at 20 cm distance (avoid one row).

T_7 = USG placed at 20 cm distance (avoid two rows).

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

T_9 = USG placed at 30 cm distance (avoid one row).

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

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

T_{12} = USG placed at 40 cm distance (avoid one row).

T_{13} = USG placed at 40 cm distance (avoid two rows).

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

USG (1.8 g) was 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 12m × 34.5mwas divided into three equal blocks. Each block was divided into 14 plots where 14 treatments were allotted randomly. There were 42 unit plots in the experiment. The size of the each unit plot was 4.5 m × 1.5 m. The space between two blocks and two plots were 0.75 m and 0.5 m, respectively. Plant to plant and row to row distances were maintained 10cm and 30 cm, respectively.

3.7 Land preparation

The land of the experimental site was first opened in November with power tiller. Later on, the land was ploughed and cross-ploughed three times followed by

laddering to obtain the desiredtilth. The corners of the land were spaded and larger clods were broken into smaller pieces after ploughing and laddering all the stubbles and uprooted weeds were removed and the land was ready.

3.8 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 broadcast, between two furrows and USG placed at 10 cm depth following other experimental treatment.USG placed in the soil by the use of a stick.TSP and MOP were applied at the rate of 80 and 30 kg per hectare, respectively following the Bangladesh Agricultural Research Institute (BARI) recommendation for lentil cultivation. All the fertilizers were applied during final land preparation.

3.9 Seed sowing

The lentil seeds were sown at November 22 in 2012. Seeds were treated with Bavistin before sowing the seeds to control the seed borne diseases. The seeds were sown in solid rows in the furrows having a depth of 2-3 cm. Line to line distance was 30cm and plant to plant distance was 10 cm.

3.10 Intercultural operations

3.10.1 Thinning

Seeds were germinated four days after sowing (DAS). Thinning was done two times; first thinning was done at 10 DAS and second was done at 15 DASmaintained 10 cm between plants to obtain proper plant population in each plot.

3.10.2 Irrigation and weeding

Irrigation was done at 20 and 30 DAS. The crop field was weeded twice; first weeding was done at 15 DAS and second at 30 DAS.

3.10.3 Protection against pests

At early stage of growth few worms and virus vectors attacked the young plants and at latter stage pod borer attacked the plant. Dimacron 50EC was sprayed at the rate of 1litre ha^{-1} for two times.

3.11 Crop sampling

Ten plants from each plot were randomly marked inside the central row of each plot with the help of sample card for data collection.

3.12 Harvesting and processing

The crop was harvested when more than 80% pods were riped at 7 March. For collection of data the harvested crops were separated treatment wise. After separation pods were dried in sunlight, and then shelled and the seeds were cleaned properly. Straw weight was recorded after oven drying. Seed weight was recorded after 3 days sun drying.

3.13 Collection of data

A.Growth parameters

i.Plant height (cm) (20 days interval starting from 20 DAS)

ii. Branches plant^{-1}(no.) (20 days interval starting from 40 DAS)

iii. Above ground dry weight plant^{-1} (g) (20,40,60,80 DAS and at harvest)

B. Yield contributing characters

i. Pods plant^{-1}(no.)

ii. Seeds pod^{-1}(no.)

iii. Weight of 1000 seeds (g)

C. Yield and harvest Index

i.Seed yield (t ha^{-1})

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

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

iv. Harvest index (%)

3.14 Procedure of data collection

3.14.1 Plant height (cm)

Plant height of 10 randomly selected plants was measured with a meter scale from the ground level to the tip of the plants and the mean height was expressed in cm. Data were recorded from the inner rows of each plot starting from 20 DAS at 20 days intervalup toharvest.

3.14.2 Branches plant^{-1}(no.)

Branches were counted from selected plants starting from 40 DAS at 20days intervalup to harvest. The total branches of 10 plants were averaged to have number of branches plant^{-1}.

3.14.3Above ground dry matter plant^{-1}(g)

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 plants was taken and expressed in gram. Above ground dry matter plant^{-1} was recorded at 20, 40, 60, 80 DAS and harvest.

3.14.4Pods plant^{-1}(no.)

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

3.14.5 Seeds pod^{-1} (no.)

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.

3.14.6Weight of 1000 seeds(g)

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

3.14.7Seed yield (t ha^{-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}.

3.14.8Stover yield (t ha^{-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}.

3.14.9Biological yield (t ha^{-1})

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

Biological yield = Seed yield + Stover yield.

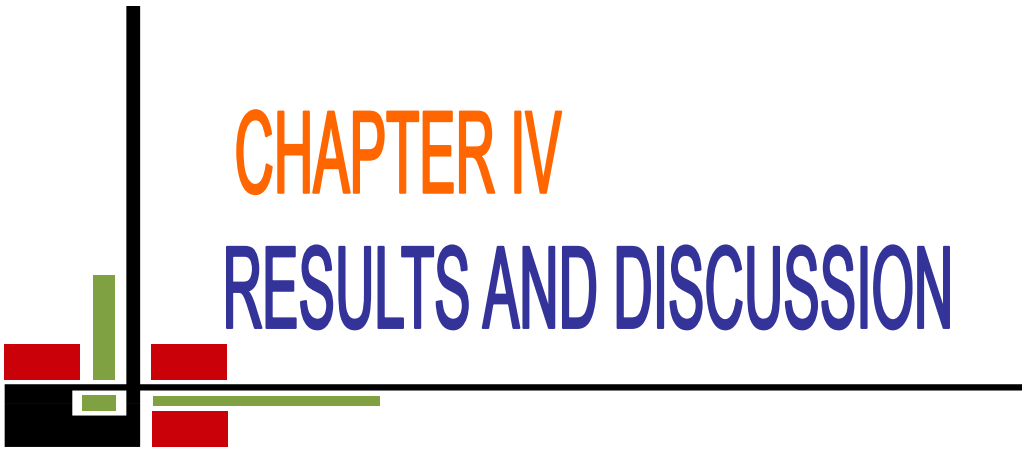
3.14.10Harvest index(%)

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

$$HI = \frac{\text{Economic yield (seed weight)}}{\text{Biological yield (Total dry weight)}} X100$$

3.15 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

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The experiment was conducted to study the growth and yield response of lentil to the application of prilled urea andurea super granules. Data on different growth yield and yield contributing characters of lentil were recorded. The results have been presented with the help of tables, graphs and possible interpretations under the following headings:

4.1 Growth attributes of lentil

4.1.1 Plant height (cm)

Plant height of lentil was affected significantly by different placement of prilled urea andurea super granules (Table 1).At 20 DAS, the tallest plant (7.76cm) was found in T_7 [USG placed at 20 cm distance (avoid two rows)] which was statistically similar with T_3[USG placed at 10 cm distance (avoid one row)], T_5 [USG placed at 10 cm distance (avoid three rows)], T_9 [USG placed at 30 cm distance (avoid one row)], T_6 [USG placed at 20 cm distance (avoid one row)], T_{10} [USG placed at 30 cm distance (avoid two rows)], T_4 [USG placed at 10 cm distance (avoid two rows)], T_{11} [USG placed at 30 cm distance (avoid three rows)], T_1 [Prilled urea (PU) broadcasted], T_{13} [USG placed at 40 cm distance (avoid two rows)], T_2 [PU given between two rows], T_8[USG placed at 20 cm distance (avoid three rows)],T_{12} [USG placed at 40 cm distance (avoid one row)].The shortest plant (6.94cm) was found in T_{14}[USG placed at 40 cm distance(avoid three rows)] which was statistically similar with T_3[USG placed at 10 cm distance (avoid one row)], T_5 [USG placed at 10 cm distance (avoid three rows)], T_9 [USG placed at 30 cm distance (avoid one row)], T_6[USG placed at 20 cm distance (avoid one row)], T_{10}[USG placed at 30 cm distance (avoid two rows)], T_4[USG placed at 10 cm distance (avoid two rows)], T_{11} [USG placed at 30 cm distance (avoid three rows)], T_1 [Prilled urea (PU) broadcasted], T_{13}[USG placed at 40 cm distance (avoid two rows)], T_2 [PU given between two rows], T_8[USG placed at 20 cm distance (avoid three rows)],T_{12} [USG placed at 40 cm distance (avoid one row)].

At 40 DAS, maximum plant height (11.03cm) was found in T_6 [USG placed at 20 cm distance(avoid one row)], which was statistically similar with T_1 [Prilled urea (PU) broadcasted], T_{10} [USG placed at 30 cm distance (avoid two rows)], T_{12} [USG placed at 40 cm distance (avoid one row)], T_{13}[USG placed at 40 cm distance (avoid two rows)],T_7 [USG placed at 20 cm distance (avoid two rows)], T_4[USG placed at 10 cm distance (avoid two rows)], T_2 [PU given between two rows], T_3[USG placed at 10 cm distance (avoid one row)], T_5 [USG placed at 10 cm distance (avoid three rows)].The shortest plant (6.94cm) was found in T_{14} [USG placed at 40 cm distance (avoid three rows)] which was statistically similar with T_8[USG placed at 20 cm distance (avoid three rows)], T_9 [USG placed at 30 cm distance (avoid one row)], T_{11} [USG placed at 30 cm distance (avoid three rows)],T_5 [USG placed at 10 cm distance (avoid three rows)], T_3[USG placed at 10 cm distance (avoid one row)], T_2 [PU given between two rows], T_4 [USG placed at 10 cm distance (avoid two rows)].

At 60 DAS, maximum plant height (15.82 cm) was observed in T_6 [USG placed at 20 cm distance(avoid one row)], which was statistically similar with T_{13}[USG placed at 40 cm distance (avoid two rows)], T_2 [PU given between two rows], T_7 [USG placed at 20 cm distance (avoid two rows)], T_{12} [USG placed at 40 cm distance (avoid one row)], T_1 [Prilled urea (PU) broadcasted], T_8[USG placed at 20 cm distance (avoid three rows)], T_4[USG placed at 10 cm distance (avoid two rows)], T_{10} [USG placed at 30 cm distance (avoid two rows)], T_5 [USG placed at 10 cm distance (avoid three rows)], T_9 [USG placed at 30 cm distance (avoid one row)], T_3[USG placed at 10 cm distance (avoid one row)], T_{11} [USG placed at 30 cm distance (avoid three rows)].Lowest plant height (12.50cm) was observed in T_{14}[USG placed at 40 cm distance(avoid three rows)] which was statistically similar with T_{11} [USG placed at 30 cm distance (avoid three rows)], T_3[USG placed at 10 cm distance (avoid one row)], T_9 [USG placed at 30 cm distance (avoid one row)], T_5 [USG placed at 10 cm distance (avoid three rows)], T_{10} [USG placed at 30 cm distance (avoid two rows)], T_4[USG placed at 10 cm distance (avoid two rows)], T_8[USG placed at 20 cm distance (avoid three rows)], T_1 [Prilled urea (PU) broadcasted], T_{12} [USG placed at 40 cm distance (avoid one row)].

At 80 DAS, the tallest plant (24.86 cm) was found in T_6 [USG placed at 20 cm distance (avoid one row)] which was statistically similar with T_1[Prilled urea (PU) broadcasted], T_2 [PU given between two rows], T_{12} [USG placed at 40 cm distance (avoid one row)], T_8[USG placed at 20 cm distance (avoid three rows)], T_3[USG placed at 10 cm distance (avoid one row)], T_5 [USG placed at 10 cm distance (avoid three rows)], T_{10} [USG placed at 30 cm distance (avoid two rows)], T_{11} [USG placed at 30 cm distance (avoid three rows)], T_9 [USG placed at 30 cm distance (avoid one row)],T_7 [USG placed at 20 cm distance (avoid two rows)], T_4[USG placed at 10 cm distance (avoid two rows)].The shortest plant (19.39cm) was found in T_{14}[USG placed at 40 cm distance(avoid three rows)] which was statistically similar with T_4 [USG placed at 10 cm distance (avoid two rows)], T_7 [USG placed at 20 cm distance (avoid two rows)], T_9 [USG placed at 30 cm distance (avoid one row)], T_{11}[USG placed at 30 cm distance (avoid three rows)].

At harvest, maximum plant height (25.62cm) was found in T_8[USG placed at 20 cm distance (avoid three rows)], T_6 [USG placed at 20 cm distance (avoid one row)], T_{10} [USG placed at 30 cm distance (avoid two rows)], T_2 [PU given between two rows], T_9[USG placed at 30 cm distance (avoid one row)], T_5 [USG placed at 10 cm distance (avoid three rows)], T_{13}[USG placed at 40 cm distance (avoid two rows)], T_7 [USG placed at 20 cm distance (avoid two rows)], T_{12} [USG placed at 40 cm distance (avoid one row)], T_1 [Prilled urea (PU) broadcasted], T_4 [USG placed at 10 cm distance (avoid two rows)],T_3 [USG placed at 10 cm distance (avoid one row)], T_{11}[USG placed at 30 cm distance (avoid three rows)].Shortest plant (21.50cm) was found in T_{14}[USG placed at 40 cm distance(avoid three rows)] which was statistically similar with T_{11} [USG placed at 30 cm distance (avoid three rows)], T_3[USG placed at 10 cm distance (avoid one row)], T_4[USG placed at 10 cm distance (avoid two rows)], T_1 [Prilled urea (PU) broadcasted], T_{12} [USG placed at 40 cm distance (avoid one row)], T_7 [USG placed at 20 cm distance (avoid two rows)], T_{13}[USG placed at 40 cm distance (avoid two rows)], T_5 [USG placed at 10 cm distance (avoid three rows)], T_9 [USG placed at 30 cm distance (avoid one row)], T_2 [PU given between two rows], T_{10} [USG placed at 30 cm distance (avoid two rows)]. It was found that plants were able to uptake nitrogen efficiently from USG placedat 20 cm distance (avoid one row).

Nitrogen fertilizers are essential for vegetative growth of plant.Application of granular urea at higher rate facilitated higher vegetative growth.It might be due to continuous availability of N from the deep placed USG that released N slowly and it enhanced growth of crop. These findings are in harmony with Sing and Sing(1992)andIslam *et al*. (2009).They reported that USG produced taller plants than prilledurea.The increase in plant height could be due to either cell elongation or cell multiplication or tissue differentiation or both of them which was influenced by optimum levels of fertilizer.The plant height was not affected by different level of USG reported by Rahman (2003).

Table 1.Effect ofapplication of prilled urea and urea super granules on plant height of lentil

Treatment	Plant height (cm)									
	20 DAS		40DAS		60DAS		80DAS		Harvest	
T_1	7.31	ab	11.00	a	15.07	ab	24.80	a	23.00	ab
T_2	7.27	ab	10.37	a-d	15.37	a	24.41	a	24.73	ab
T_3	7.60	ab	10.25	a-d	13.65	ab	23.20	a	22.37	ab
T_4	7.38	ab	10.48	a-d	14.55	ab	21.80	ab	22.97	ab
T_5	7.52	ab	10.20	a-d	14.47	ab	23.01	a	24.20	ab
T_6	7.44	ab	11.03	a	15.82	a	24.86	a	25.62	a
T_7	7.76	a	10.53	a-d	15.28	a	22.22	ab	23.43	ab
T_8	7.22	ab	10.01	cd	14.71	ab	23.75	a	25.83	a
T_9	7.45	ab	10.10	b-d	14.20	ab	22.32	ab	24.20	ab
T_{10}	7.43	ab	10.95	ab	14.53	ab	22.92	a	25.33	ab
T_{11}	7.32	ab	10.12	b-d	13.57	ab	22.37	ab	22.33	ab
T_{12}	7.22	ab	10.71	a-c	15.10	ab	23.81	a	23.03	ab
T_{13}	7.27	ab	10.71	a-c	15.57	a	23.00	a	23.67	ab
T_{14}	6.94	b	9.74	d	12.50	b	19.39	b	21.50	b
SE	0.19		0.25		0.78		1.02		1.19	
CV (%)	5.57		6.73		9.2		7.67		8.65	

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

USG (1.8g) was placed at 10 cm depth in each case.

4.1.2Branches plant^{-1} (no.)

Significant differences was recorded for the application of prilled urea and urea super granules in terms of branches plant^{-1} of lentil at 40, 60, 80,100DAS and harvest (Table 2). The study revealed that throughout the growing period T_6 [USG placed at 20 cm distance(avoid one row)] performed the best in producing the highest number of branches plant^{-1}of lentil.

At 40 DAS, the highest number of branches plant^{-1} (2.50) was recorded in T_6 [USG placed at 20 cm distance(avoid one row)]. The lowest number of branches plant^{-1} (1.20) was recorded in T_{14} [USG placed at 40 cm distance(avoid three rows)].

At 60 DAS, the highest number of branches plant^{-1} (6.07) was found in T_6 [USG placed at 20 cm distance(avoid one row)]. The lowest number of branches plant^{-1} (3.16) was found in T_{14} [USG placed at 40 cm distance(avoid three rows)] treatment.

At 80 DAS, the highest number of branches plant^{-1} (12.17) was found in T_6 [USG placed at 20 cm distance(avoid one row)]which was statistically similar with T_7[USG placed at 20 cm distance (avoid two rows)]. The lowest number of branches plant^{-1} (7.40) was found in T_5[USG placed at 10 cm distance (avoid three rows)] which was statistically similar with T_2(PU given between two rows).

At 100 DAS, the highest number of branches plant^{-1} (12.30) was found in T_6 [USG placed at 20 cm distance(avoid one row)] treatmentwhich was statistically similar with T_{11}[USG placed at 30 cm distance (avoid three rows)]. The lowest number of branches plant^{-1} (6.33) was found in T_{14} [USG placed at 40 cm distance(avoid three rows)].

At harvest, maximum number of branches plant^{-1}(14.59) was found in T_6 (USG placed at 20 cm distance (avoid one row)] treatmentwhich was statistically similar with T_{11} [USG placed at 30 cm distance (avoid three rows)]. The minimum number of branches plant^{-1} (7.51) was found in T_{14} [USG placed at 40 cm distance(avoid three rows)].Increased number of branches in USG than PU might be due to uniform uptake of N by plant as it required.Similar result was reported by Vijaya and Subbaiah(1997).They found increased number of tiller per plant with the deep placement of USG.

Table 2.Effect of application of prilled urea and urea super granules on branches plant^{-1} of lentil

Treatment	Number of branch plant^{-1}									
	40 DAS		60 DAS		80 DAS		100DAS		Harvest	
T_1	2.10	c	5.27	d	8.20	g	11.11	c	13.21	cd
T_2	2.30	b	4.07	g	7.80	gh	8.24	g	10.05	h
T_3	2.00	c	4.33	f	9.30	f	9.17	ef	10.81	fg
T_4	1.50	ef	5.83	b	9.40	f	9.50	e	11.09	fg
T_5	1.80	d	4.03	g	7.40	h	9.16	ef	10.48	gh
T_6	2.50	a	6.07	a	12.17	a	12.30	a	14.59	a
T_7	1.50	f	4.33	f	11.93	ab	11.29	bc	13.60	bc
T_8	1.50	f	4.20	fg	10.67	d	10.22	d	12.79	d
T_9	1.80	d	4.90	e	11.70	bc	9.45	ef	11.87	e
T_{10}	1.80	d	5.50	c	11.40	bc	11.03	c	13.57	b-d
T_{11}	1.70	de	3.70	h	11.67	bc	11.91	ab	14.08	ab
T_{12}	1.60	d-f	4.03	g	11.30	c	10.78	cd	13.25	cd
T_{13}	1.40	f	5.40	cd	10.10	e	8.77	fg	11.39	ef
T_{14}	1.20	g	3.16	i	10.70	d	6.33	h	7.51	i
SE	0.06		0.06		0.51		0.66		0.72	
CV(%)	6.13		6.30		8.59		8.87		6.20	

T_1 = Prilled urea (PU) broadcast T_2 = PU given between two rows

T_3 = USG placed at 10 cm distance (avoid one row) T_4 = USG placed at 10 cm distance (avoid two rows)

T_5 = USG placed at 10 cm distance (avoid three rows) T_6 = USG placed at 20 cm distance (avoid one row)

T_7 = USG placed at 20 cm distance (avoid two rows) T_8 = USG placed at 20 cm distance (avoid three rows)

T_9 = USG placed at 30 cm distance (avoid one row) T_{10} = USG placed at 30 cm distance (avoid two rows)

T_{11} = USG placed at 30 cm distance (avoid three rows) T_{12} = USG placed at 40 cm distance (avoid one row)

T_{13} = USG placed at 40 cm distance (avoid two rows) T_{14} = USG placed at 40 cm distance (avoid three rows

USG (1.8g) was placed at 10 cm depth in each case.

4.1.3Above ground dry matter(g plant^{-1})

The dry matter production in plant was very slow at early growth stage then increased from 60 DAS to harvest.Dry matter production exerted significant difference due to nitrogen management (Table 3).

At 20 DAS, the highest above grounddry matter of lentil (0.78g) was found in T_6 [USG placed at 20 cm distance (avoid one row)] which was statistically similar with T_4 [USG placed at 10 cm distance (avoid two rows)], T_2 [PU given between two row], T_3 [USG placed at 10 cm distance (avoid one row)], T_{10} [USG placed at 30 cm distance (avoid two rows)], T_5 [USG placed at 10 cm distance (avoid three rows)], T_8 [USG placed at 20 cm distance (avoid three rows)], T_7 [USG placed at 20 cm distance (avoid two rows)], T_9 [USG placed at 30 cm distance (avoid one row)], T_{11} [USG placed at 30 cm distance (avoid three rows)], T_{12} [USG placed at 40 cm distance (avoid one row)].The lowest above ground dry matter of lentil (0.52g) was found in T_{14}[USG placed at 40 cm distance (avoid three rows)]which was statistically similar with T_1 [Prilled urea (PU) broadcast], T_{13}[USG placed at 40 cm distance (avoid two rows)], T_7[USG placed at 20 cm distance (avoid two rows)], T_{12}[USG placed at 40 cm distance (avoid one row)], T_{11} [USG placed at 30 cm distance (avoid three rows)], T_9[USG placed at 30 cm distance (avoid one row)], T_8 [USG placed at 20 cm distance (avoid three rows)], T_5 [USG placed at 10 cm distance (avoid three rows)], T_3 [USG placed at 10 cm distance (avoid one row)].

At 40 DAS, the highest above ground dry matter of lentil (1.90g) was found in T_6 [USG placed at 20 cm distance (avoid one row)] which was statistically similar with T_2 [PU given between two row], T_{12} [USG placed at 40 cm distance (avoid one row)]. The lowest above ground dry matter of lentil (0.80g) was found in T_{14} [USG placed at 40 cm distance (avoid three rows)] which was statistically similar with T_5 [USG placed at 10 cm distance (avoid three rows)].

At 60 DAS, the highest above ground dry matter of lentil (6.31g) was found in T_6 [USG placed at 20 cm distance (avoid one row)] which was statistically similar with T_2 [PU given between two row], T_5[USG placed at 10 cm distance (avoid three rows)], T_4 [USG placed at 10 cm distance (avoid two rows)], T_7 [USG placed at 20 cm distance (avoid two rows)], T_3 [USG placed at 10 cm distance (avoid one row)], T_9[USG placed at 30 cm distance (avoid one row)], T_{11}[USG placed at 30 cm distance

(avoid three rows)],T_{12} [USG placed at 40 cm distance (avoid one row)], T_1 [Prilled urea (PU) broadcast]. The lowest above ground dry matter of lentil (3.77g) was found in T_{14} (USG placed at 40 cm distance (avoid three rows)] which was statistically similar with T_{10} [USG placed at 30 cm distance (avoid two rows)], T_8 [USG placed at 20 cm distance (avoid three rows)], T_1 [Prilled urea (PU) broadcast], T_{13}[USG placed at 10 cm depth at 40 cm distance (avoid two rows)], T_{12} [USG placed at 40 cm distance (avoid one row)], T_{11} [USG placed at 30 cm distance (avoid three rows)].

At 80 DAS, the highest above ground dry matter of lentil (9.67g) was found in T_6 [USG placed at 20 cm distance (avoid one row)]. The lowest above ground dry matter of lentil (4.07g) was found in T_{14} [USG placed at 40 cm distance (avoid three rows)].

At harvest, the highest above ground dry matter of lentil (12.86g) was found in T_6 [USG placed at 20 cm distance (avoid one row)]. The lowest above ground dry matter of lentil (5.60g) was found in T_{14}[USG placed at 40 cm distance (avoid three rows)] which was statistically similar with T_1 [Prilled urea (PU) broadcast], T_7 [USG placed at 20 cm distance (avoid two rows)], T_{12} [USG placed at 40 cm distance (avoid one row)], T_{11} [USG placed at 30 cm distance (avoid three rows)], T_3 [USG placed at 10 cm distance (avoid one row)]. Rambabu*et al*. (1983) and Rao*et al.*(1986) reported that USG was the most effective in increasing total dry matter than split application of urea.

Table 3.Effect of application of prilled urea and urea super granules onabove ground dry matter(g plant^{-1}) of lentil

Treatment	above ground dry weight (g)									
	20DAS		40DAS		60 DAS		80DAS		harvest	
T_1	0.53	cd	1.60	bc	4.93	a-c	5.27	f	6.13	fg
T_2	0.69	a-c	1.75	ab	5.75	ab	7.18	cd	11.02	b
T_3	0.69	a-d	1.15	ef	5.29	ab	8.76	b	7.37	d-g
T_4	0.72	ab	1.55	bc	5.55	ab	7.79	c	7.94	c-f
T_5	0.68	a-d	0.97	fg	5.72	ab	7.57	cd	8.44	cd
T_6	0.78	a	1.90	a	6.31	a	9.67	a	12.86	a
T_7	0.64	a-d	1.56	bc	5.47	ab	6.87	de	6.29	e-g
T_8	0.67	a-d	1.16	ef	4.43	bc	5.00	f	9.80	bc
T_9	0.66	a-d	1.29	de	5.18	ab	7.85	c	8.10	c-e
T_{10}	0.69	a-c	1.48	cd	4.40	bc	6.28	e	9.01	cd
T_{11}	0.66	a-d	1.10	ef	4.95	a-c	6.20	e	6.54	e-g
T_{12}	0.65	a-d	1.68	a-c	4.94	a-c	7.36	cd	6.40	e-g
T_{13}	0.59	b-d	1.56	bc	4.80	bc	5.31	f	9.80	bc
T_{14}	0.52	d	0.80	g	3.77	c	4.07	g	5.60	g
SE	0.05		0.08		0.42		0.25		0.58	
CV(%)	14.06		10.06		14.19		6.32		12.12	

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

USG (1.8g) was placed at 10 cm depth in each case.

4.2 Yield contributing charactersandyield of lentil

4.2.1Podsplant^{-1}

Number of pods plant^{-1} is one of the most important yield contributing characters in lentil. The number of pods plant^{-1} was significantly affected byprilled urea and urea super granules placed at different distance(Table 4). The highest number of pods plant^{-1} (47.96) was recorded at T_6 [USG placed at 20 cm distance (avoid one row)] treatment, which was statistically similar withT_{13} (46.82) [USG placed at 40 cm distance (avoid two rows),T_{11} (45.51) [USG placed at 30 cm distance (avoid three rows)], T_2 (45.05) [PU given between two rows],T_5(44.75)[USG placed at 10 cm distance (avoid three rows)], T_4 [USG placed at 10 cm distance (avoid two rows)], T_7 [USG placed at 20 cm distance (avoid two rows)], T_8 [USG placed at 20 cm distance (avoid three rows)],T_9 [USG placed at 30 cm distance (avoid one row)], T_3 [USG placed at 10 cm distance (avoid one row)], T_{10} [USG placed at 30 cm distance (avoid two rows)].The lowest number of pods plant^{-1} (29.00) was recorded from T_{14} [USG placed at 40 cm distance (avoid three rows)] treatment.

Results revealed that T_6[USG placed at 20 cm distance (avoid one row)] gave 31.39% higher pods plant^{-1} than T_1[Prilled urea (PU) broadcast].This might be due to continuous supply of N from the deep placed USG that released N slowly and plants could better utilize it thus yield parameters could response positively.Similar results were also obtained in different experiment. BARI (2008) conducted several experiments on various crops as brinjal, potato, hybrid maize etc. and reported that these crops gave higher fruit plant^{-1}, tuber haulm^{-1},and cob plant^{-1}, respectively with USG application.

4.2.2Seeds pod^{-1}(no.)

Nitrogen management significantly influence the number of seeds pod^{-1}(Table 4).Results showed that the highest seeds pod^{-1} was recorded(2.14) at T_6[USG placed at 20 cm distance (avoid one row)] and the lowest seeds pod^{-1} was found(1.23) at T_{14} [USG placed at 40 cm distance (avoid three rows)]. USG placed at 20 cm distance (avoid one row) produced 37.17% higher seeds pod^{-1} than Prilled urea (PU) broadcasted.This result supported by Kabir*et al*. (2014) where the number of total grains spike^{-1} was significantly the maximum in USG placed at 10 cm depth @75kg N ha^{-1}.

4.2.3 Weight of 1000 seed(g)

Statistically significant variation was recorded for weight of 1000 seeds of lentil due to the application of prilled urea and urea super granules (Table 4). The maximum thousand seed weight (26.33 g) was observed at T_6 [USG placed at 20 cm distance (avoid one row)]treatmentwhich was similar with (24.98 g) T_4 [USG placed at 10 cm distance(avoid two rows)]. The lowest seed weight (17.60 g) was obtained from T_{14}[USG placed at 40 cm distance (avoid three rows)] treatment which was statistically similar with(19.53 g)T_1(Prilled urea broadcasted).The findings also accord with the report by Islam *et al.* (2011)

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

Seed yield is a combined output of various yield components such as pods plant^{-1},seeds pod^{-1} and 1000 seed weight. Seed yield of lentil affected significantly due to different placement of prilled urea and urea super granules(Table 4). USG placed at 20 cm distance(avoid one row) (T_6) produced the highest seed yield (2.11t ha^{-1})which was statistically similar withT_{10}(1.73t ha^{-1})[USG placed at 30 cm distance (avoid two rows)], T_{11}(1.73t ha^{-1})[USG placed at 30 cm distance (avoid three rows)], T_{13}(1.71t ha^{-1})[USG placed at 40 cm distance (avoid two rows)], T_{12}(1.61t ha^{-1})[USG placed at 40 cm distance (avoid one row)], T_3(1.57t ha^{-1})[USG placed at 10 cm distance (avoid one row)], T_4(1.50 t ha^{-1}) [USG placed at 10 cm distance (avoid two rows)].USG placed at 40 cm distance(avoid three rows) (T_{14}) gave the lowest seed yield (0.88t ha^{-1})which was followed by T_1(1.45t ha^{-1})[Prilled urea (PU) broadcasted],T_2(1.45t ha^{-1})[PU given between two rows],T_8(1.39 t ha^{-1}) [USG placed at 20 cm distance (avoid

three rows)],T_9(1.40t ha^{-1}) [USG placed at 30 cm distance (avoid one row)], T_7(1.43t ha^{-1}) [USG placed at 20 cm distance (avoid two rows)].

USG placed at 20 cm distance (avoid one row) (T_6) produced the highest pods $plant^{-1}$, seeds pod^{-1}, and 1000 seed weight which ultimately gave 45.51% higher seed yield than PU broadcasted (T_1).This higher yield might be attributed due to the fact that the plant had nourished with adequate nitrogen fertilizer as it required during growth period thus ultimately gave higher yield components for higher seed yield. This finding was similar with the observations made by Mishra *et al.*(2000), andSing and Sing (1992).

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

Nitrogen management significantly influence on Stover yield of lentil(Table 4). The highest Stover yield (2.87 t ha^{-1}) was obtained from T_6[USG placed at 20 cm distance (avoid one row)] which was statistically similar with T_9 [USG placed at 30 cm distance (avoid one row)], T_{10} [USG placed at 30 cm distance (avoid two rows)], T_{11} [USG placed at 30 cm distance (avoid three rows)], T_{12}[USG placed at 40 cm distance (avoid one row)], T_{13}[USG placed at 40 cm distance (avoid two rows)], T_4 [USG placed at 10 cm distance (avoid two rows)].

The lowest stover yield (1.36 t ha^{-1}) was obtained from T_{14}[USG placed at 40 cm distance (avoid three rows)] which was statistically similar withT_1[Prilled urea (PU) broadcasted] and T_3[USG placed at 10 cm distance (avoid one row)]. Similar Studied were also trend by Rao*et al*. (1986) who reported that the 80 kg N ha^{-1} on rice field as USG placed at 8-10 cm depth in between the hills, gave higher straw yield.

Table 4.Effect of application of prilled urea and urea super granules on yield and yield contributing characters of lentil

Treatment	pods plant^{-1}(no.)		Seedspod^{-1}(no.)		1000-seed weight (g)		Seed yield (t ha^{-1})		Stover yield (t ha^{-1})	
T_1	36.50	b	1.56	ef	19.53	cde	1.45	bc	1.80	cd
T_2	45.05	a	1.30	i	22.82	bc	1.45	bc	2.11	bc
T_3	42.69	ab	1.46	gh	20.91	cd	1.57	ab	2.04	bcd
T_4	40.88	ab	1.47	g	24.98	ab	1.50	abc	2.30	abc
T_5	44.75	a	1.41	h	18.82	de	1.29	bc	1.96	cd
T_6	47.96	a	2.14	a	26.33	a	2.11	a	2.87	a
T_7	41.90	ab	1.73	c	19.92	cde	1.43	bc	2.07	bcd
T_8	40.64	ab	1.67	d	22.37	bc	1.39	bc	2.19	abc
T_9	43.36	ab	1.57	ef	20.15	cde	1.40	bc	2.28	abc
T_{10}	41.89	ab	1.79	b	22.58	bc	1.73	ab	2.41	abc
T_{11}	45.51	a	1.61	e	21.72	cd	1.73	ab	2.77	ab
T_{12}	42.08	ab	1.72	cd	22.60	bc	1.61	ab	2.43	abc
T_{13}	46.82	a	1.53	f	21.23	cd	1.71	ab	2.39	abc
T_{14}	29.00	c	1.23	j	17.60	e	0.88	c	1.36	d
SE	2.39		0.018		0.98		0.19		0.22	
CV(%)	9.83		7.18		7.91		7.03		7.56	

T_1 = Prilled urea (PU) broadcast

T_2 = PU given between two rows

T_3 = USG placed at 10 cm distance (avoid one row)

T_4 = USG placed at 10 cm distance (avoid two rows)

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

T_6 = USG placed at 20 cm distance (avoid one row)

T_7 = USG placed at 20 cm distance (avoid two rows)

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

T_9 = USG placed at 30 cm distance (avoid one row)

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

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

T_{12} = USG placed at 40 cm distance (avoid one row)

T_{13} = USG placed at 40 cm distance (avoid two rows)

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

USG (1.8g) was placed at 10 cm depth in each case.

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

The results obtained in case of biological yield were found to be significant at the application of prilled urea and urea super granules at different distance (Table 5). The highest biological yield (4.98 t ha^{-1}) was obtained from T_6[USG placed at 20 cm distance (avoid one row)] treatment which was statistically similar withT_{10}-T_{13} and T_4.On the other hand the lowest biological yield (2.24 t ha^{-1}) was obtained from T_{14}[USG placed at 40 cm distance (avoid three rows)] treatment which was statistically similar with T_1 [Prilled urea (PU) broadcasted], T_5[USG placed at 10 cm distance (avoid three rows)].

4.2.7 Harvest index (%)

The harvest index was significantly affected by differentprilled urea andurea super granules placed at different distance (Table 5). The highest harvest index (43.77%) was recorded at T_3[USG placed at 10 cm distance (avoid one row)]treatment. The lowest harvest index (37.90%) was recorded from T_9[USG placed at 30 cm distance (avoid one row)]treatment.

Table 5.Effect of application of prilled urea and urea super granuleson biological yield and harvest index of lentil

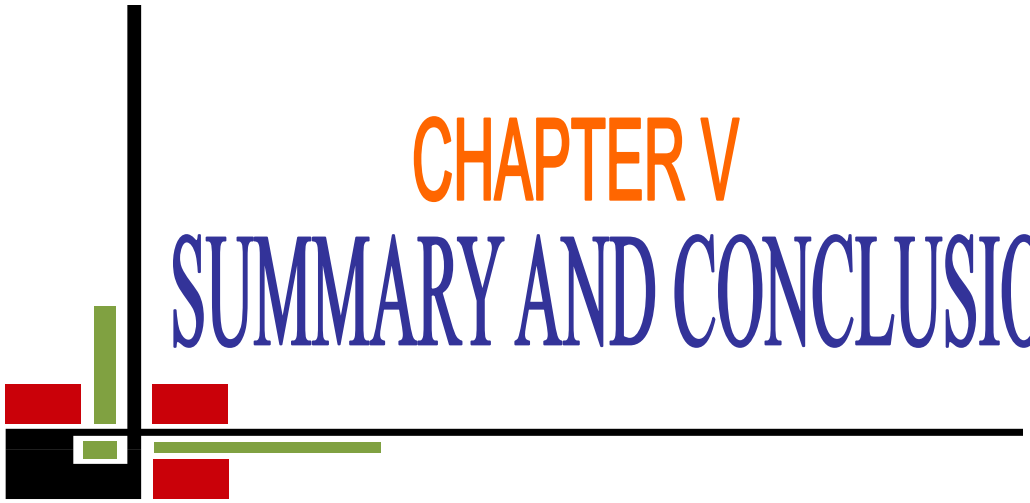
Treatment	Biological yield ($t\ ha^{-1}$)		Harvest index (%)	
T_1	3.12	cd	43.05	ab
T_2	3.56	bc	40.73	a-d
T_3	3.62	bc	43.49	a
T_4	3.80	a-c	39.47	a-d
T_5	3.25	b-d	39.93	a-d
T_6	4.98	a	42.41	a-c
T_7	3.50	bc	41.24	a-d
T_8	3.58	bc	38.28	cd
T_9	3.68	bc	37.90	d
T_{10}	4.14	a-c	41.48	a-d
T_{11}	4.50	ab	37.97	cd
T_{12}	4.04	a-c	38.94	b-d
T_{13}	4.11	a-c	40.98	a-d
T_{14}	2.24	d	40.05	a-d
SE	0.39		1.32	
CV(%)	7.36		8.96	

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

USG (1.8g) was placed at 10 cm depth in each case.

CHAPTER V

SUMMARY AND CONCLUSION



CHAPTER V
SUMMARY AND CONCLUSION

A field experiment was conducted at the research field of Agronomy, Sher-e Bangla Agricultural University, Dhaka in the rabiseason during the period ofNovember2012 to March 2013 with a view to assess the comparative advantages of using urea and super granules over prilled urea on growth, yield and yield attributes of lentil. This experiment consisted of fourteen treatments viz. T_1 = Prilled urea (PU) broadcast, T_2= PU given between two rows, T_3 = USG placed at 10 cm distance (avoid one row), T_4 = USG placed at 10 cm distance (avoid two rows), T_5 = USG placed at 10 cm distance (avoid three rows), T_6 = USG placed at 20 cm distance (avoid one row), T_7 = USG placed at 20 cm distance (avoid two rows), T_8 = USG placed at 20 cm distance (avoid three rows), T_9 = USG placed at 30 cm distance (avoid one row), T_{10} = USG placed at 30 cm distance (avoid two rows), T_{11} = USG placed at 30 cm distance (avoid three rows), T_{12} = USG placed at 40 cm distance (avoid one row), T_{13} = USG placed at 40 cm distance (avoid two rows), T_{14} = USG placed at 40 cm distance (avoid three rows). USG (1.8 g) was placed at 10 cm depth in each case. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The collected data were statistically analyzed for evaluation of the treatment effect. Results showed that a significant variation among the treatments in respect of majority of the observed parameters.

It was observed that plant height was significantly affected due to the different treatments. The tallest plant height (11.03, 15.82, 24.86, and 25.62 cm at 40, 60, 80 DAS and harvest, respectively) was obtained from T_6 [USG placed at 20 cm distance (avoid one row)] but in case of 20 DAS it was (7.76 cm) was obtained from T_7 [USG placed at 20 cm distance (avoid two rows)]. Number of branches plant^{-1} was significantly influenced by different treatments. The highest number of branches plant^{-1} (2.50, 6.07, 12.17,12.30 and 14.59 at 40, 60, 80, 100 DAS and harvest respectively) was obtained from T_6 [USG placed at 20 cm distance (avoid one row)]. Significant variation was observed when considering above ground dry matter plant^{-1} by different methods of prilled urea and urea super granules application at different

distance. The highest above ground dry matter plant^{-1} (0.78g, 1.90g, 6.31g, 9.67g and 12.86 g at 20, 40, 60, 80, DAS and harvest, respectively) was obtained from T_6 [USG placed at 20 cm distance (avoid one row)]. On the other hand,T_1(PU broadcasted) produced plant height(23.00cm), branches plant^{-1}(13.21), above ground dry weight(6.13g) at harvest.

Different levels of nitrogen application had also significant effect on yield and yield components. USG placed at 20 cm distance (avoid one row) (T_6)produced pods plant^{-1}(47.96), seeds pod^{-1}(2.14), 1000-seed weight (26.33g), seedyield (2.11t ha^{-1}), Stoveryield(2.87 t ha^{-1}).On the other hand, PU broadcasted plot produced pods plant^{-1} (36.50), seeds pod^{-1} (1.56), 1000-seed weight (19.53g), seed yield (1.45 t ha^{-1}), Stover yield (1.80 t ha^{-1}).The highest harvest index (43.77%) was recorded at T_3 [USG placed at 10 cm distance (avoid one row)].

Considering the above results, it may be concluded that growth, yield and yield contributing parameters of lentil were significantly varied with different treatment. USG showed better performance than prilled urea in almost all the parameters studied.Results showed that USG placed at 10 cm depth at 20 cm distance (avoid one row) gave significantly better growth, yield and yield attributes of lentil.The maximum seed yield was recorded at 2.11 t ha^{-1} and similar yield could be achieved with USG placed 20-40 cm distance in rows avoiding 2-3 rows.

It is suggested that different crops other than rice could be tried with USG placement to confirm the importance of USG application in our cropping system.

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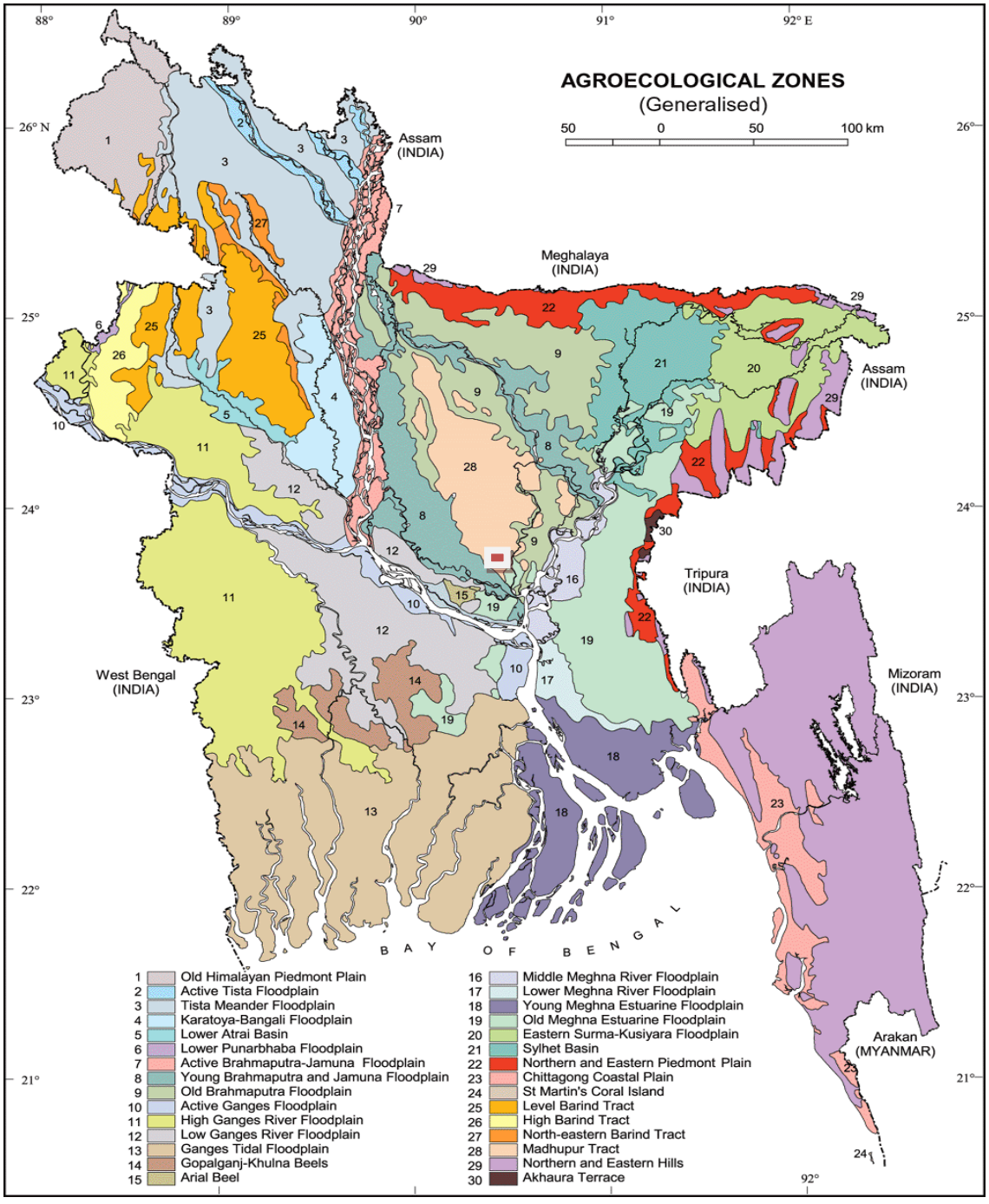
APPENDICES

APPENDICES

Appendix I. Map showing the experimental site under the study



The experimental site under study

Appendix II. Monthly average Temperature, Relative Humidity and Total Rainfall and sunshine of the experimental site during the period from November, 2012 to March, 2013

Month	Air temperature (°c)		Relative humidity (%)	Rainfall (mm) (total)	Sunshine (hr)
	Maximum	Minimum			
November, 2012	34.8	18.0	77	227	5.8
December, 2012	32.3	16.3	69	0	7.9
January, 2013	29.0	13.0	79	0	3.9
February, 2013	28.1	11.1	72	1	5.7
March, 2013	33.9	12.2	55	1	8.7

Source: Bangladesh Meteorological Department (Climate & Weather Division), Agargoan, Dhaka - 1212

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

Soil characteristics	**Analytical results**
Agrological Zone	Madhupur Tract
P^H	6.00 – 6.63
Organic matter	0.84
Total N (%)	0.46
Available phosphorous	21 ppm
Exchangeable K	0.41 meq / 100 g soil

Source: Soil Resource and Development Institute (SRDI), Dhaka