EFFECT OF FORMS OF NITROGENOUS FERTILIZER AND NUMBER OF SEEDLING PER HILL ON THE YIELD OF BORO RICE CV. BRRI dhan 29

by

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CERTIFICATE

This is to certify that the thesis entitled "EFFECT OF FORMS OF NITROGENOUS FERTILIZER AND NUMBER OF SEEDLING PER HILL ON THE YIELD OF BORO RICE CV. BRRI dhan 29" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfilment of the requirements for the degree of ***MASTER OF SCIENCE IN AGRONOMY*** embodies the result of a piece of *bona fide* research work carried out by **Masud Reza**, Registration No. 07-2597 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma in any other institutes.

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

Dated: 25.6.09
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Dedicated to

My Beloved Parents

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ABSTRACT

An experiment was carried out on BRRI dhan 29 at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during November'07 to April'08 to evaluate the effect of three forms of N-fertilizer viz. pilled urea, urea super granules (USG) and foliar spray of urea and four levels of seedling/hill viz. 1, 2, 4 and 6. Forms of N-fertilizer were assigned in main plot and number of seedling/hill in the sub plots in a split-plot design with 3 replications. Effect of forms of nitrogen fertilizer and number of seedling/hill was significant in respect of all the plant and yield attributing characters like plant height, effective tiller/hill, ineffective tiller/hill, grain/panicle, sterile grain/panicle and thousand seed weight. Urea super granules (USG) have significantly highest grain yield (6.4 t/ha) where as lowest straw yield (5.8 t/ha) and lowest grain (5.1 t/ha) was found in the foliar application of urea. Significantly highest grain yield (6.6 t/ha) was obtained from single seedling/hill followed by two seedlings/hill (6.4 t/ha). The highest straw yield (7.5 t/ha) was obtained from six seedlings/hill and the lowest (6.7 t/ha) was found from single seedling/hill. The interaction effect of forms of N-fertilizer and number of seedling/hill differed significantly for all the yield attributes, although the highest grain yield (7.0 t/ha) was produced from the treatment combination of Urea super granule (USG) × single seedling/hill followed by urea super granules × 2 seedling/hill (6.93 t/ha) and prilled urea × single seedling/hill (6.83 t/ha) interactions.

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LIST OF ABBREVIATIONS

%	=	Percent
@	=	At the rate
°C	=	Degree Centigrade
AEZ	=	Agro Ecological Zone
Anon.	=	Anonymous
ANOVA	=	Analysis of Variance
BARI	=	Bangladesh Agricultural Research Institute
BAU	=	Bangladesh Agricultural University
BBS	=	Bangladesh Bureau of Statistics
cv.	=	Cultivar (s)
DAI	=	Days After Inoculation
DMRT	=	Duncan's Multiple Range Test
e.g.	=	For example
et al.	=	And Others
etc.	=	Etcetera
FAO	=	Food and Agriculture Organization
g	=	Gram
hr	=	Hour (s)
i.e.	=	That is
IRRI	=	International Rice Research Institute
ISTA	=	International Seed Testing Association
kg	=	Kilogram
LSD	=	Least Significant Difference
no.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
T	=	Treatment
t/ha	=	Ton per Hectare
UNDP	=	United Nation Development Program
$^{w}/_{v}$	=	Weight per Volume
$^{w}/_{w}$	=	Weight per Weight
wt.	=	Weight
BCR	=	Benefit cost ratio
BE (%)	=	Biological efficiency (%)
Conc.	=	Concentration

CHAPTER 1

INTRODUCTON

Chapter 1
INTRODUCTION

Bangladesh is an agricultural country. She earns about 31.6% of her gross domestic product (GDP) from agriculture (BBS, 2008). Agriculture in Bangladesh is characterized by intensive crop production with rice based cropping systems. Rice is also the principal commodity of trade in our internal agricultural business. Although rice is our staple food, the average yield of rice in our country is around 2.45 t/ha which is less than the world average (3.1 t/ha) and frustratingly below the highest yield recorded (9.65 t/ha) in Australia (FAO, 2004).

Rice is grown in Bangladesh under diverse ecosystem, irrigated, rainfed and deep water conditions in three distinct seasons namely, Aus, Aman and Boro. The area and production of rice in Bangladesh are about 10.26 million hectares and 18.86 million metric tons respectively, where Boro covers the largest part of about 3.81 million hectares and the second highest production of about 6.1 million metric tons of rice. (BBS, 2007).

Horizontal expansion of rice area in Bangladesh is not possible due to limited land resources, as land availability for crop production has been declining day by day because of population pressure. So, the only avenue left is to increase the production of rice through vertical means. Although the soil and climate of Bangladesh are favorable for rice cultivation through out the year but per hectare yield of this crop is much below the potential yield level. The reasons are manifolds, some are varietals, some are technological and some are ecological.

Modern high yielding varieties require higher price of seeds, fertilizers, irrigation and pesticides. Our farmers are poor, so they can not always afford their costs. Hence, special attention should be given for increasing the yield per unit area by applying improved management practices. Among different management practices, use of appropriate number of seedling per unit area is one of them and recently there are alternative forms of urea, if these are used properly, could give more benefit than urea in respect of economic return.

Planting density in transplant rice culture constitutes the number of seedling/hill or hills per unit area. The number of tillers and their growth is greatly affected both qualitatively and quantitatively by number of seedling/hill. Optimum number of seedling/hill may enable the rice plant to grow properly both in its aerial and underground parts, by utilizing maximum radiant energy, nutrients, space and water and also could reduce seedling cost of farmers. All these factors can be efficiently utilized and ultimately they would lead to bumper crop production if proper care is taken. The excess or least number of seedling/hill may badly affect the normal physiological activities of the rice plant (excess number of seedling/hill may produce higher number of tiller/hill, resulting mutual shading and lodging and thus favor the production of more straw instead of grain). While the least number of seedling/hill may cause insufficient tiller growth thus keeping airspace and nutrients unutilized in soils and at the end, total panicles per unit area will be reduced resulting in poor yield.

Chowdhury *et al.* (1993) reported that number of seedling/hill is an important factor as it influences the plant population/unit area, availability of sunlight, competition for nutrients, photosynthesis and respiration which ultimately influence the yield and yield contributing characters of rice.

Nitrogen is the top most important nutrient and it is a key input for rice production in the rice growing countries as well in Bangladesh (Hasan, 2008). It affects the vegetative growth, development and yield of rice. Nitrogen use efficiency for rice crop largely ranges between 25 and 35% when it is applied as urea and seldom exceeds 50% (Singh and Yadav, 1985). The unique condition of wet land soil promotes nitrogen loss through NH_3 volatilization, denitrification, leaching and surface run-off. According to Crasswell and De Datta (1980) broadcast application of urea on the surface soil causes losses up to 50% but point placement of urea supergranules (USG) in 8-10 cm depth may result negligible loss. They also stated that urea supergranules placement provides a bonus of nitrogen to the soil and to the crop. Placement of urea supergranules in the root zone is the dhan most effective method for increasing the nitrogen use efficiency and rice yield (Prasad *et al.* 1982; Sharma, 1985).

Nitrogen losses are a problem in the cultivation of rice in Bangladesh during Boro season. So, the practical methods of more efficient use of nitrogenous fertilizer are needed. To minimize the losses of nitrogen, the slower release of nitrogenous fertilizers have been advocated with deep placement. Urea super granules (USG) is

a fertilizer that can be applied in the rice root zone at 8-10 cm depth of soil (reduced zone of rice soil), which can save 30% nitrogen than prilled urea, increase absorption rate, improve soil health and ultimately increase the yield (Savant *et al.*, 1991).

In view of above discussion, the present study was designed and conducted with the following objectives:

1. to determine the optimum number of seedling/hill for BRRI dhan 29
2. to observe the effects of prilled urea (PU), Urea super granule (USG), and foliar spray of urea on the yield of BRRI dhan 29, and
3. to find out the interaction, if any, between number of seedling/hill and forms of nitrogenous fertilizer on the yield of BRRI dhan 29 rice grown as Boro rice.

CHAPTER 2

REVIEW OF LITERATURE

Chapter 2
REVIEW OF LITERATURE

Growth and development of rice plants are greatly influenced by the environmental factors i.e., air, day length or photoperiod, temperature etc., variety used and agronomic practices like transplanting time, spacing, number of seedlings, depth of planting, especially the major nutrient i.e., N management and its forms, irrigation etc. Among the factors, which are responsible for the yield of rice, seedlings number per hill and forms of nitrogenous fertilizer are very important. Many research works on different aspects of rice cultivation have been done within and out side the country for the improvement of rice yield. Research works related to the forms of nitrogenous fertilizer and effect of seedling/hill on the growth, yield and yield components of boro rice have been reviewed in this chapter.

2.1 Effect of forms of nitrogenous fertilizer on plant characters

2.1.1 Plant height

Datta (1981) gave opinion that among the major nutrient elements, nitrogen was very much essential for growth, and yield content of rice, deficiency of which led to stunted growth with limited number of tillers which reduced grain yield.

Singh and Singh (1986) reported that plant height increases significantly with the increase in the level and forms of nitrogen from 27 to 87 kg N/ ha. Deep placement of urea super granules (USG) resulted in the highest plant height than prilled urea.

Vijaya and Subbaiah (1997) conducted an experiment with rice and was given fertilizer @ 90 kg N/ ha as prilled urea, large granular urea or urea super granules (USG) and 70 kg P2O5/ ha as single super phosphate or large di-ammonium

phosphate, both applied by broadcasting or placement methods. They showed that plant height, number of tillers, root length, number and weight of panicles, N and P uptake, dry matter and grain yield of rice increased with the increasing urea super granule size and were greater with the deep placement method of application both N and P compared with broadcasting.

2.1.2 Tillering pattern

Singh and Singh (1986) worked with different levels of nitrogen as urea super granules (USG), sulphur coated urea and prilled urea @ 27.54 and 87 kg /ha. They reported that number of tillers per square meter increased with increasing nitrogen fertilizer. The number of tillers per square meter was significantly greater in urea super granules than prilled urea in all levels of nitrogen. Jee and Mahapatra (1989) also observed that number of panicles per square meter were significantly higher @ 90 kg N/ ha 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 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. Deep placement of urea super granules gave 10.3% more grain yield than prilled urea or neem coated urea. The straw yield was also the highest with urea super granules.

Rama *et al.* (1989) mentioned that the number of panicles per square metre increased significantly when nitrogen level increased from 40 to 120 kg N/ ha as

different modified urea materials. Urea super granules (USG) produced significantly higher number of panicles per square meter and grains /panicle than split application of prilled urea.

2.1.3 Panicle length

Sen and Pandey (1990) reported that the application of urea super granules (USC) or prilled urea @ 38.32 kg N/ ha gave higher yield than broadcast prilled urea and there were no significant differences in panicle length.

Singh and Singh (1993) conducted an experiment on nitrogen levels. They showed that panicles per square meter, panicle length and grains/ panicle were increased due to application of 60 kg N/ ha.

Patel and Mishra (1994) carried out an experiment on rice cv. IR36 and was given 0, 30, 60 or 90 kg N/ ha as Moussorie rock phosphate-coated urea, neem cake-coated urea, gypsum coated urea, urea super granules (USG) or prilled urea. The coated materials as incorporated before transplanting and urea super granules as placed 5-10cm deep a week after transplanting and urea as applied in 3 split doses. They showed that N rate had no significant effect on panicle length, percent sterility and harvest index.

2.1.4 Grain/panicle and 1000-grain weight

Rama *et al.* (1989) carried out an experiment with different modified urea material at the rate of 27, 54, 87 kg N/ ha. They observed that spikelets/ panicle, % sterility and 1000-grain weight did not differ significantly due to different modified urea materials viz. Prilled urea, sulphur coated urea, urea super granules (USG).

Kamal *et al.* (1991) conducted a field experiment in Kharif seasons of 1985 and 1986 on rice cv. Joya with different forms of urea and level of nitrogen @ 29, 58, 87 kg N/ ha. They reported that total tiller varied significantly due to forms in 1985, but during 1996 there was no significant variation. Prilled urea was significantly inferior to the other forms. The highest number of tillers was produced in treatment where urea super granules (USG) was applied. 1000-grain weight was not significantly influence by the forms of urea. Among the three doses of nitrogen, total tiller was the highest when 87 kg N/ ha was applied. Productive tillers also followed a similar trend.

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 60 kg N hat 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 in 1987 and 4.94 t/ha in 1988.

Surendra *et al.* (1995) conducted an experiment during rainy season with nitrogen level @ 0, 40, 80, 120 kg /ha. They showed that urea super granules and urea dicyandiamide produced significantly more panicle /hill, filled grains/ panicle, panicle weight and grain yield than prilled urea @ 80 kg N/ ha

2.1.5 Grain and straw yield

Apparao (1983) pointed out that deep placement of 50 kg N/ ha as urea super granules (USG) gave significantly higher paddy yields compared with urea applied basally or in 3 split applications.

Sen *et al.* (1985) conducted an experiment under irrigated wetland conditions in the rainy season in 1982 and 1983. They reported that the placement of urea super granules (USG) at any time between 0 and 20 days after transplanting and in placement at 0, 5 and 10 days after transplanting gave similar yields. The average increase in yield from urea super granules placement compared with urea alone in 3 split dressing was about 46% in 1982 and 20% in 1983. All yield components were positively correlated with yield.

Balasubramaniyan and Rasasamy (1986) found that the application of N @ 75 kg/ ha on rice as (a) urea super granules (USG) (b) sulphur coated urea (SCU) (c) lac coated urea (LCU) (d) gypsum coated urea (e) 3 split application of prilled urea or (f) no nitrogen gave grain yields 4.84, 5.26, 4.44, 4.40, 4.34 mid 3.36 t/ha, respectively. N use efficiency was 65, 70, 59, 59 and 58 kg grain / kg N with (a), (b), (c), (d) and (c), respectively.

Nayak *et al.* (1986) carried out an experiment under rainfed low land conditions with the amount of 58 kg N hail as urea super granules (USG) placed in the root zone. They showed that USG was significantly superior to N as sulphur coated urea (SCU) or urea applying in split dressing, increasing panicle production /unit area and yields.

Reddy *et al.* (1986) reported that increasing N rates from 30 to 60 and 90 kg/ ha increased paddy yields of wetland rice from 2.89 to 3.77 and 4.39 t/ha, respectively. N as urea super granules (USG) placed in the root zone in soil gave significantly higher yields than N as neem cake coated urea (NCCU), urea dicyandiamide incorporated urea.

Patel and Desai (1987) carried out an experiment on rice applying N @ 58.87 or 116 kg/ ha as sulphur coated urea (SCU), urea super granules (USG) and masoorie-phosphorus-coated urea. They reported that the highest grain yield obtained with 87 and 116 kg N as sulphur coated. At 58 kg N/ ha as urea super granules placed at 10-12cm depth gave the highest yield (4.34 t/ha) and number of panicles per square metre.

Raju *et al.* (1987) conducted an experiment during Kharif with different sources of N fertilizers @ 0, 37.5, 75, 112.5 and 150 kg N/ ha. They reported that among all the sources of N, urea super granules (USG) recorded highest grain yield (5.41 t/ha) and proved significantly superior to rest of the sources. The increase in yield due to urea super granules over urea split application was to the tune of 14.7%. The rest of the N sources failed to exert any differential effect on yield.

Setty *et al.* (1987) evaluated different levels of modified urea on rice as urea super granules (USG) and sulphur coated urea (SCU). They observed that grain yield increased significantly with increase N rate up to 87 kg/ ha. Sulphur coated urea and urea super granules gave similar yields, which were significantly higher than urea in 2-3 split application. N use efficiency was greater with sulphur coated and urea super granules than urea.

Lal *et al.* (1988) evaluated the performance of urea super granules (USG), sulphur coated urea (SCU) and prilled urea in transplanted aman rice. Placement of N as urea super granules and broadcast incorporation of SCU were superior to prilled urea at 29, 58 and 87 kg N/ ha but not at 110 kg N/ ha. The sulphur-coated urea gave the highest response followed by urea super granules and both maintained superiority over prilled urea.

Singh and Singh (1988) pointed out that deep placed urea super granules (USG) proved superior in grain and straw yield, nitrogen uptake and nitrogen use efficiency to that of grilled urea.

Bharat and Srivastava (1989) conducted a field experiment in Kharif season on rice cv. Java was given @ 0, 29, 58, 87 or 116 kg N/ ha as prilled urea or urea super granules (USG). They obtained grain yield 2.14 and 2.68 t/ha, respectively. N uptake in grain and straw increased with the N application rate and was higher with urea super granules.

Chauhan and Mishra (I989) found that application of N @ 20, 80 and 112 kg/ ha as urea super granules (USG) gave grain yield 4.08, 4.86 and 5.17 t/ha and as prilled urea gave 3.95, 3.72 and 4.33 t/ha, respectively. Deep placement of urea super granules proved superior to prilled urea.

Das (1989) reported that the dry matter yield, concentration of NH_4^+ N content in soil, N uptake and grain and straw yield of rice were higher with application of urea super granules (USG).

Chalam *et al.* (1989) reported that the application of N a 37.5, 75.0 or 112.5 kg/ ha as urea super granules (USG) or prilled urea gave paddy yields of 3.I5-3.53, 4.06-4.32 and 3.66-3.75 t/ha compared with 2.20 t/ha without nitrogen. Yields, N uptake and N recovery percentage were higher with N as urea super granules than prilled urea.

Ameta and Singh (1990) observed that increasing fertilizer N .application from 30 to 120 kg/ ha increased rice grain yield linearly from 3.52 to 5.36 t/ha. Coating urea with neem cake powder (20% by weight) at transplanting, tillering and

panicle initiation stages produced grain yield of 4.87 t/ha compared to 4.39 t/ha from applying all N as basal dressing. Placement of 75 kg urea super granules (USG) at 8-10cm soil depth, 7 days after transplanting produced similar grain yield as application of 90 kg plain urea.

Singh *et al.* (1991) studied the effect of sources and level of N on the yield, yield attributes and N uptake of rice and reported that yield, yield attributes and N uptake were affected significantly due to sources and levels of N. Deep placement of urea super granules showed the highest grain yield 2.59 t/ha followed by 2.43, 2.32 and 2.15 t/ha with sulphur coated urea, mussoorie rock phosphate-coated urea and prilled urea, respectively.

Johnkutty and Mathew (1992) conducted an experiment with different forms of nitrogen on rice cv. Jyothy dluring rainy season and reported that 84 kg N/ ha as urea supergranules (USG) gave higher yield than urea.

Singh *et al.* (1993) pointed out that application of 30 or 60 kg N/ ha as prilled urea or urea super granules (USG) gave the highest grain yield and N uptake increased with the rate of N application and were highest with deep placed urea super granules. N use efficiency was the highest with 30 kg N ha' from deep placed urea super granules.

Das and Singh (1994) pointed out grain yield of rice cv. RTH-2 during Kharif season was greater for deep placed urea super granules (USG) than urea super granules for broadcast and incorporated or three split applications of prilled urea.

Quayum and Prasad (1994) conducted field trials during Kharif season involving 5 rates of N (0, 35.5, 75, 112.5 and 120 kg/ ha) and six different source of nitrogen with rice cv. Sita and found that application up to 112.5 kg/ ha increased grain yield (4.37 t/ha) and straw yield (5.49 t/ha). They also reported that N applied as urea super granules (USG) gave the best yield and yield attributes and concluded that slow release fertilizer were effective for rain fed lowland rice.

Bastia and Sarkar (1995) conducted a field trial in Kharif season with rice cv.Jagnnath was given 80 kg N/ ha as prilled urea, urea super granules (USG), large granules and lac-coated urea observed that grain yield and N content were the highest 4.07 t and 1.43%, respectively with urea super granules (USG), and the lowest 2.66 t/ha and 1.31%, respectively with prilled urea.

Dwivedi and Bajpai (1995) conducted a field experiment during rainy season on rice cv. Ruchi was given 0-90 kg N/ ha as different forms of urea and showed that grain yield was the highest with urea super granules (USG) and the lowest with urea spray.

Talukder (2000) conducted an experiment at the experimental field of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh to evaluate the effect of four levels of seedlings/hill — 1, 2, 3 and 4 and two forms of N-fertilizer pilled urea and urea super granules (USG) @ 80 kg N had. Number of seedlings/hill was assigned in the main plots and forms of N-fertilizer in the sub plots in a split-plot design with 3 replications. Effect of number of seedlings/hill was significant in respect of all the yield attributes and growth characters except culm length, panicle length, percentage of filled grain and 1000-grain weight. Significantly higher grain

yields were obtained from single seedling/hill (5.71 t/ha) and two seedlings/hill (5.56 t/ha). The highest straw yield (8.19 t/ha) was obtained from four seedlings/hill and the lowest (7.25 t/ha) from single seedling/hill. Forms of N-fertilizer significantly influenced all the growth characters and yield attributes except panicle length, No. of total spikelets/panicle, percentage of filled grain, 1000-grain weigh and harvest index. Deep placement of USG have significantly higher grain (5.20 t/ha) and straw yield (8.14 t/ha) over the split application of prilled urea which produced lower grain (4.90 t/ha) and straw yields (7.37 t/ha). The interaction effect of number of seedlings/hill and forms of N-fertilizer did not differ significantly for all the growth characters and yield attributes, although the highest grain yield (5.94 t/ha) was produced from the treatment combination of single seedling/hill×USG.

Jalloh Mohamed Alpha *et al.* (2009) in a pot experiment studied the influence of four nitrogen (N) fertilizer forms [Urea; calcium nitrate, $Ca(NO_3)_2$; ammonium sulfate, $(NH_4)_2SO_4$; and organic N] on growth, photosynthesis, and yield of rice under two cadmium (Cd) levels (0 and 100 mg Cd/kg soil). Cadmium addition significantly reduced photosynthetic rate, and the reduction varied with N fertilizer form, with ammonium ($NH4^+$)-N and urea treated plants having more reduction. Nitrogen form had a distinct effect on SPAD value, and the effect was also dependent on Cd level and growth stage. Cadmium-stress significantly reduced flag leaf area, but for the second leaf, only the plants supplied with organic N showed the reduction. There was a significant difference in plant height among four N forms, with NH4+- and nitrate (NO_3-)-treated plants having the highest and lowest height, respectively. Cadmium stress caused significant reduction in grains per panicle and total plant weight, and the reduction varied with N form, with

organic N treatment showing more reduction. There were significant differences among N forms in N and Cd concentrations of the plants subjected to Cd stress, with $NH4^+$-N treated plants having highest N and lowest Cd concentrations and NO3--treated plants having lowest N and highest Cd uptake. The results showed that the inhibition of Cd stress on growth and yield formation of rice is closely related to N fertilizer form.

Alam (2002) conducted an experiment at the agronomy field laboratory, BAU, Mymensing during the boro season with three varieties and four level of USG. He observed that 1000-grain weight was not influenced by level of USG. He also found increased plant height with the increase of level of USG/4 hill.

Jaiswal and Singh (2001) conducted a field experiment on comparative efficiency of urea super granules and prilled urea, both at 60 and 120 kg/ha 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) and deep placement of USG increased N use efficiency (31.7%) compared to conventional method urea application.

Miah *et al.*, (2004) observed that the values of the parameters measured were higher with application of urea super granules compared to application of urea. Patel and Desai (1987) found that rate of 58 kg N/ha as urea super granules placed at 10-12 cm depth gave the highest yield (4.34 t/ha) compared to any other rate.

2.2 Effects of number of seedling per hill on plant characters

Number of seedlings/hill is an important factor for the improvement of yield of transplanted rice. It affects plant population per unit area. Optimum number of seedlings/hill depends upon different factors such as season, variety, time of planting, spacing and type of soil. Available literatures which are related to the number of seedlings/hill are briefly reviewed in this section.

2.2.1 Plant height, panicle length, tiller and grain yield

Pataniswamy and Gomez (1976) reported that in the dry season of 1970, rice cv. IR 22 grown with 1, 2 or 3 seedling/hill, 3 seedling/hill gave the lowest plant height. The tiller number/hill increased with increasing number of seedling/hill.

Mohammad *et al.* (1987) reported that when rice cv. Basmati 370 was grown at 2 seedlings/hill and at 6, 11, 25 or 44 hills/square meter, then the number of tillers/hill, the number of panicle bearing tillers/hill and 1000- grain weight decreased with increasing planting density but plant height, number of grains per square meter and grain yield remained unaffected.

Singh *et al.* (1987) conducted an experiment with seed rate in nursery and seedlings/hill on the yield and yield components of transplanted aman rice. They found that the increasing sowing rates decreased number of panicle/hill and grain/panicle and the number of seedlings/hill had no significant effect.

Shah *et al.* (1991) reported from a field trial in 1987 with rice cv. K39 grown at 15cm x 15cm or 10cm x 10cm planting spacing and 3, 4, 5 or 6 seedlings/ hill. Number of panicles/ plant and spikelets/ panicle, 1000-grain weight, grain yield,

straw yield and harvest index were unaffected by the treatments. Plant height and number of grain /panicle increased with decrease in seedling number /hill. Plant height and harvest index were greater with 15cm x 15cm spacing and tiller number /square metre and straw yield were highest at 10cm x 10cm spacing. The highest grain yield of 2.70 t/ ha was obtained from 6 seedlings /hill with 15cm x 15cm spacing.

An experiment conducted by BRRI (1995) to study the effect of seedling number and spacing for transplanting on the panicle production and yield of local variety Kumragoir with 25cm × 15cin, 25cm × 30cm and 25cm × 45cm spacing with 1, 3, 6 and 9 seedlings/ hill. The results revealed that panicle production and grain yield differed significantly with spacing but not with seedling number/hill.

Rahman (2003) stated that plant height did not effected by different level of USG. He also found that different levels of US did not have any significant effect on 1000– grain weight.

2.2.2 Effective panicle, number of grain, 1000- grain weight

Shah *et al.* (1991) reported that rice cv. K39 was grown at 15cm × 15cm or 10cm × 10cm plant spacing and 3, 4, 5 or 6 seedlings/hill. Number of panicles/plant and spikelets/panicle, 1000-grain weight, grain yield, straw yield and harvest index were unaffected by the treatments. Plant height and number of grain/panicle increased with decrease in seedling number/hill. Plant height and harvest index were the greatest with 15cm × 15cm spacing and tiller number per square meter and straw yield were the highest at 10cm × 10cm spacing. The highest grain yield of 2.70 t/ha was obtained from 6 seedlings/hill at 15cm x 15cm apart.

Karim *et al.* (1992) found from an experiment where Basmati 385 and breeding line 4048 were grown at 118560, 160550 and 197600 plants/ha in two cropping seasons, 1000-grain weight, cooked .grain length, total milling recovery and head rice recovery decreased with increasing plant density.

2.2.3 Grain yield

Insignificant yields were obtained by planting 1 to 4 seedlings/hill at different spacing although yield was the highest at 20cm x 20cm spacing by planting 1 seedlings/hill (Shahi and Gill, 1976).

Kang and Choi (1978) reported that in rice cultivar Tongil grown with 1, 3, 5 or 7 seedlings/hill, increased the number of seedlings/hill shortened the growth duration and increased the ripened grain ratio but the effect was not significant in crops grown in the early season. Increasing the number of seedlings/hill increased grain yields in Tongil, especially in late season crops, but not in cv. Milyang 15. For the early, 3-4 seedlings/hill and for the late 5-6 seedlings/hill produced maximum yield.

Relwani (1982) while investigating the effect of spacing, number of seedlings/hill and levels of nitrogen on paddy found that 6 seedlings/hill yielded significantly higher than 4 seedlings the latter i.e., 4 seedlings/hill was found significantly superior to 2 seedlings/hill.

Pillai *et al.* (1972) reported that 2 or 3 seedlings/hill at 15cm x 10cm spacing produced the highest paddy yield.

Reddy and Ghosh (1984) conducted an experiment with seedling and hill density on the performance of rice under intermediate deep-water condition. They showed

that transplanting with 6-8 seedlings/hill at 20-25 hills per square meter gave grain yields as high as with 3 seedlings/hill as 50 hills per square meter.

Ramasamy *et al.* (1987) investigated 50, 66 or 80 hills per square meter with 2, 4, 6 or 8 seedlings/hill. The results showed that spacing at 80 hills gave the highest grain yield of 4.0 t/ha. Yield decreased with more than 2 seedlings/hill

Pande *et al.* (1987) found that 4 rice cultivars transplanted at 1, 2, 3 or 4 seedlings/hill gave average paddy yields of 3.78, 5.09, 5.00 and 4.94 t/ha respectively.

Ahmed (1987) in trials with rice hybrid HY-103, observed that spacing increasing from 4" x 4" to 8" x 8" increased grain yield/hill but decreased grain yield per unit area. At all spacing, maximum grain yield was obtained by planting 3 seedlings/hill.

Islam (1989) conducted an experiment to determine the number of seedlings/hill for transplanted aman cv. Nizersail, Tilokchachari and Badshabog. The results revealed that 2-3 seedlings/hill were as good as 3-4 seedlings/hill with respect to grain yield.

Das *et al.* (1989) observed that 5 seedlings/hill of rice cv. Parijat gave the highest yields when transplanted at 2-5 seedlings/hill.

BRRI (1990) studied to find out the optimum plant population required for a satisfactory grain yield of rice both at Joydebpur and Habigonj at the combination of different plant spacing, with 2-3 and 5-6 seedlings/hill produced the highest grain yield of 6.57 t had at Joydebpur. A similar trend was also observed at Habigonj but significantly the highest grain yield was obtained using 5-6

seedlings/hill in a 30cm x 10cm spacing. Increase in seedling number from 2-3 to 5-6 seedlings/hill produced a higher grain yield in most cases.

BRRI (1991) conducted an experiment at the station of Barisal to study the effect of seedling number (2, 3, 4 and 5 seedlings/hill) on the yield and yield components of BR3, BR9 and BR14. The results showed that there was no significant effect of seedling numbers on the yield of BR3 and BR14. Planting 4-5 seedlings/hill gave significantly higher yield of BR9 than 2-3 seedlings/hill although such differences were not apparent in yield components.

In another experiment with modem rice cv. BR22, BR23 and Nizersail (BRRI, 1992) reported that transplanted at mid-September with 16, 20, 47, 33, 44 and 66 hills per square meter using 2-4 seedlings/hill, grain yield increased with the increment in plant population density irrespective of varieties.

Singh and Singh. (1992) conducted an experiment with 2, 4 or 6 seedlings/hill to study their effect on the yield and yield components of rice cv. Madhukar and found that for all factors 4 seedlings/hill were better for grain yield.

Prasad *et al.* (1992) conducted an experiment with 4 and 5 seedlings/hill to study their effect on the yield and yield components of rice cv. Sarjoo-52 and found that for all factors 4 seedlings/hill were better for grain yield.

Chowdhury *et al.* (1993) carried out an experiment with 2, 4 and 6 seedlings/hill to study their effect on yield and yield components of rice cv. BR23 and Pajam during the aman season. They reported that 6 seedlings/hill gave the highest grain yield and straw yield.

Rao and Reddy (1993) conducted a field experiment with rice cv. Rasi in the Kharif (Monsoon) season with 33, 44, 50, 67 or 200 hills per square meter with 1, 2, 4, 8 or 10 seedlings/hill. They reported that grain yield increased with decreasing spacing from 22-200 hills per square meter, with 1 seedlings/hill; when 10 seedlings/hill were planted yield decreased at the widest spacing.

Banik *et al.* (1997) conducted in a field experiment in 1993-I995 in Bihar with 30-, 40-, 50-, or 60-day-old rice cv. Pankaj and Patnation seedlings were transplanted at 2, 4, 6 or 8 seedlings/hill. There was no significant variation in yield between the cultivars. Mean grain yield was highest (4.74 t/ha) from pots transplanted with 40-day-old seedlings, yield was highest with 4 seedlings/hill (4.22 t/ha).

Srivastava and Tripathi (1998) found in a field experiment in 1995 in Madhya Pradesh of India, rice cv. Hybrid 6201 and R 320-300 were grown at 20cm x 15cm or 15cm x 10cm spacing at 1, 2 or 3 seedlings/hill. cv. R 320-300 grown at 15cm x 10cm spacing at 2 seedlings/hill produced the highest grain yield of 7.59 t/ha.

Khan and Shafi (1956) conducted an experiment with 4 different spacing and 1, 2 and 3 seedlings/hill to study their effects on the yield and yield components of transplant aman rice and found that straw yield-increased with an increase in number of plants per unit area and an inc a increase in the number of seedlings/hill did not influence yield appreciably.

In an experiment Mian and Gaffer (1970) studied the effect of number of seedlings/hill on grain and straw yield and concluded that increasing the number of seedlings/hill increased grain yield. Straw yield was also higher when the number of seedlings/hill increased from 1 to 4.

Karim *et al.* (1987) observed that highest grain and straw yields were 2.75 and 4.6 t/ha, respectively produced by 4 seedlings/hill while 1 seedlings/hill yielded lowest.

Sarker *et al.* (1988) reported that grain and the straw yields increased significantly with 5cm hill spacing mainly duet higher number of hills and ultimately higher number of panicle/ ha.

Islam *et al.* (1994) stated that closer spacing of 20cm x 15cm with 6 seedlings/hill produced 61% and 44% higher grain and straw yield, respectively over 40cm x 30cm spacing with 10 seedlings/hill.

From the above reviews it is cleared that N-sources and number of seedling per hill have profound influence on the yield and yield contributing characters of rice. Thus there may have enough scope investigating the effect of N-sources and number of seedling/hill in favour of yield improvement of boro rice cv. BRRI Dhan29

CHAPTER 3

MATERIALS AND METHODS

Chapter 3
MATERIALS AND METHODS

The experiment was conducted at the experimental field of the Sher-e-Bangla Agricultural University (SAU), during the period from November 2007 to April 2008. This chapter deals with a brief description of the site, soil, land preparation, layout, design, intercultural operations, data recording and procedure of statistical analysis etc.

3.1 Description of experimental site

3.1.1. Location and sits

The experimental field is located at agronomical farm of SAU. The experimental area belongs to Modhupur Tract (Agro-Ecological Zone 28). The land area was situated at 23°41' N latitude and 90°22' E longitude at an altitude of 8.6 meter above the sea level.

3.1.2 Soil

The soil of the experimental field belongs to the general soil type, shallow red brown terrace soil under tejgaon series. Top soils were clay loam in texture, olive gray with common fine medium distinct dark yellowish brown mottles and pH 5.47-5.63. The experimental area was flat having available irrigation and drainage system. The land was above flood level and sufficient sunshine was available during the experimental period.

3.1.3 Climate

The experimental area was under the sub-tropical climate that is characterized by high temperature, high humidity and heavy rainfall with occasional gusty winds in kharif season (April-September) and less rainfall associated with moderately low temperature during the Rabi season (November-March). The weather data during the period of the experimental site has shown in Appendix I

3.2.1 Planting material

BRRI dhan 29, a high yielding variety of boro rice developed by the Bangladesh Rice Research Institute (BRRI), has been used as planting material. The cultivar BRRI dhan 29 matures in 145-150 days. It attains a plant height of about 115-120 cm. The cultivar gives an average yield of 6.5-7.5 t/ha.

3.2.2 Experimental treatment

The treatments included in the experiment are as follows:

Factor A. Forms of Nitrogenous fertilizer –3 (Main Plot)

i. U_1 = Prilled Urea (PU)
ii. U_2 = Urea super granules (USG)
iii. U_3 = Foliar spray of Urea

Factor B. Number of seedlings/hill – 4 (Sub plot)

i. S_1 = One seedling
ii. S_2 = Two seedlings
iii. S_3 = Four seedlings
iv. S_4 = Six seedlings

3.3 Experimental design and layout

The experiment was laid out in Split-plot design with three replications. Each replication was divided into three main plots and each main plot was divided into four sub plots where nitrogen sources were assigned in the main plot and the number of seedling in the subplot. The total numbers of unit plots were 36. The sub plot size was 4.0m x 3.0m. The differences between plot to plot and replication to replication were 1 m and 1.5 m, respectively. The layout of the experimental plot has been shown in appendix II.

3.4 Raising of seedlings

Seeds of BRRI dhan 29 were collected from BRRI, Gazipur. The seedlings were raised in the wet nursery bed. The seeds were sprouted by soaking for 48 hours. The sprouted seeds were sown uniformly in the well-prepared nursery bed on 10 November, 2007.

3.5 Land preparation

The experimental field was opened with a tractor drawn rotary plough and later on, the land was ploughed and cross-ploughed three times by country plough followed by laddering to obtain the desirable tilth. The corners of the land were spaded. All kinds of weeds and stubbles were removed from the field and the land was made ready. Whole experimental land was divided into sub plots. Finally basal doses of PKSZn fertilizers were applied in sub plots and the plots were made ready by thorough spading and leveling before transplantation.

3.6 Fertilizer application

At the time of first ploughing cow dung at the rate of 10 t/ha was applied. The plots were fertilized with 120, 80, 120, 55 and 10 kg/ha N, P_2O_5, K_2O, S and Zn applied in the form of urea, triple super phosphate (TSP), muriate of potash (MP), gypsum and zinc sulphate, respectively. All the fertilizer except urea was incorporated with the soil one day before transplanting as basal.

3.6.1 Split application of prilled urea

Prilled urea was applied 280 kg urea ha^{-1} in three splits . The first split was applied on 10 days after transplanting (DAT), the second split as top dressing at active tillering stage on 30 DAT and the third split at panicle initiation stage on 50 DAT.

3.6.2 Placement of urea super granules

Urea super granules were placed 5-8cm depth at root zone on 7 DAT in the centre of four hills in alternate rows.

3.6.3 Foliar application of urea

After 7 DAT and maximum tillering stage and before emerging of the panicle nitrogen was applied in the form of foliar spray 800 liter/ha of water @ 20 kg N/ha. The total volume was allowed for half an hour to dissolve the urea completely. The suspension was filtered through cloth that no dust remained in the solution and to ensure easy passing through nozzle of sprayer (Ali *et al.* 1996).

3.7 Uprooting and transplanting of seedlings

Thirty five day old seedlings were uprooted from the nursery carefully and transplanted in the plots on 15 December, 2007. The spacing was 25cm × 15cm between the rows and hills, respectively.

3.8 Intercultural operations

The following intercultural operations were done for ensuring the normal growth of the crop.

3.8.1 Gap filling

Within one week of transplantation, dead seedlings were replaced by planting new healthy seedlings, which were kept at the side of each plot and were transplanted in the plot carefully.

3.8.2 Weed control

During plant growth stage three hand weedings were done. First weeding was done at 20 days after transplantation followed by second weeding after 15 days of first weeding and third weeding after 15 days of second weeding.

3.8.3 Irrigation and drainage

Irrigation water was applied keeping a standing water about 2-3cm during the whole growing period except a drying period about one week after 40 DAT. Water was drained out when 80% panicles were golden yellow.

3.8.4 Plant protection measure

During the growing period some plants were infested by rice stem borer (*Scirpophaga incertulus*) which were successfully controlled by applying Diazinon 60 EC @ 20 mL per 10 Liter of water for spraying in 5 decimal of land Beside this no prominent infestation of insect-pests and diseases were observed in the field.

3.9 General observation

Regular observation was made to identify the growth stages in the crops so that nitrogenous fertilizer as urea could be top dressed in relation to these stages. The urea supergranules applied plot looks greener through out the growing period up to maturity. But incase of prilled urea, a little bit pale green or yellowish was observed at the time of next urea application. When urea was applied it turned into green colour again within 6-7 days.

3.10 Detecting the panicle initiation stage

With experience it was felt that identifying the panicle initiation stage should need to follow some special technique rather than mere field observations. Therefore, arrangements were made accordingly. The method of detecting the panicle initiation stage involved the selection, dissection and inspection of the rice stems starting from maximum tillering stage on wards. A number of tillers from the middle of the border hills of the unit plot were cut of at the base of the plant. The leaf sheaths were carefully pealed off and the upper most nodes were identified.

The stem was dissected length-wise. The operation was done for several tillers at the same time when a small growth at the top of upper most nodes was noted like a dome. This was the beginning of panicle initiation stage when 10% of the sampled plants showed panicle initiation, the stage was confirmed.

3.11 Harvest and post harvest operation

The crop was harvested on 1 April 2008 at maturity. The grains were threshed, cleaned and sun dried to record grain yield/plot. Straws were also sun dried and weighed plot wise.

3.12 Sampling and data collection

Data collection from the experiment on different growth stages was done under the following heads as per experimental requirements.

3.12.1 Data collection on crop characters after harvest

Five hills from each plot were selected at random prior to harvesting and were labeled with tags for recording morphological and yield attributes. From the harvested five hills the following data were taken:

1. Plant height at harvest (cm)
2. Number of effective tiller/hill
3. Number of in-effective tiller/hill
4. Panicle length (cm)
5. Number of fertile spikelet/panicle
6. Number of sterile spikelet/panicle
7. Number of grain/plant
8. Thousand grain weight (g)
9. Grain yield (t/ha)
10. Straw yield (t/ha)
11. Biological yield (t/ha)
12. Harvest index (%)

3.12.2 Data collection procedure

The procedures of data collection are given below:

Plant height (cm)

Plant heights of the pre-selected 10 hills were taken by measuring the distance from base of the plant to the tip of the flag leaf after heading. The collected data were finally averaged.

Tiller/hill: Number of effective and non-effective tiller were counted from 10 preselected hills.

Panicle length (cm): All the panicles of ten hills were included in panicle length measurement. Panicle length was recorded from the basal nodes of the rachis to the apex of each panicle.

Filled grain and unfilled grain/panicle: Number of filled grain and unfilled grain were counted from each of ten hills. Lack any food materials inside the spikelets were denoted as unfilled grains.

Filled grain percentage: Number of filled grain and unfilled grain/panicle constitutes total spikelets. From these data percentage filled grains were calculated by using the following formula

$$\text{Percentage filled grain} = \frac{\text{Number of filled spikelet/panicle}}{\text{No. of total spikelet/panicle}} \times 100$$

Where, No. of total spikelet/panicle = No. of filled grain/panicle + No. of unfilled spikelet/panicle.

Thousand grain weight: One thousand grains were randomly collected from each plot and were sun dried and weighed by an electronic balance. Then the moisture content was determined by a moisture meter and the final weight was adjusted at 14% moisture level.

Grain yield (t/ha): Three square meter (m^2) area were harvested at random from undisturbed area of each plot. The grains were threshed, cleaned, dried and then weighed The moisture content of grain and straw were determined plot wise by a moisture meter. Then they were adjusted to 14% level of moisture by using the following formula.

$$\text{Moisture (\%)} = \frac{\text{Fresh weight - Oven dry weight}}{\text{Fresh weight}} \times 100$$

$$\text{So, adjusted yield at 14\% moisture content} = \frac{100 - \%MC}{86} \times W$$

Where, MC = percent moisture content of the grain, W = Fresh weight of grain.

Then the yield of 25 hills was converted in per unit basis.

Straw yield (t/ha): After threshing the grain the straw of the 3 m^2 area were properly sun dried and were adjusted to 14% level of moisture and the values were expressed per unit basis.

Biological yield: Grain yield and straw yields are altogether regarded as biological yield. The biological yield was calculated with the following formula

Biological yield = Grain yield + Straw yield.

Harvest index: Harvest index was calculated from the grain yield and straw yield by using the following formula.

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

3.13. Statistical Analysis

The data were compiled and tabulated in proper form and were subjected to statistical analysis. Analysis of variance was done following the computer package MSTAT-C program. The mean differences among the treatments were adjusted by Duncan's Multiple Range Test at 5% and 1% level of significance (Gomez and Gomez, 1984).

CHAPTER 4

RESULTS AND DISCUSSION

Chapter 4

RESULTS AND DISCUSSION

This chapter comprises of presentation and discussion of the results obtained from the study to see the effect of forms of nitrogenous fertilizer and number of seedling/hill on the yield of BRRI dhan 29. The analyses of variances are given in appendices. Effects of different treatments on yield attributes and yield are presented in Tables 1 through 3, Figures 1 through 13 and Appendices 3.

4.1 Plant height

4.1.1 Effect of nitrogen

Forms of nitrogenous fertilizer had significant influence on plant height. (Figure 1 and Appendix 3). The tallest plant (83.7 cm) was obtained from prilled urea whereas foliar spray of urea produced the shortest one (75.3 cm). These results are similar to Singh and Singh (1986) who reported that plant height increased significantly with the increase in the level of N-fertilizer from 27 to 87 kg N/ ha. The authors also showed that deep placement of Urea resulted in the highest plant height compared to other forms of urea.

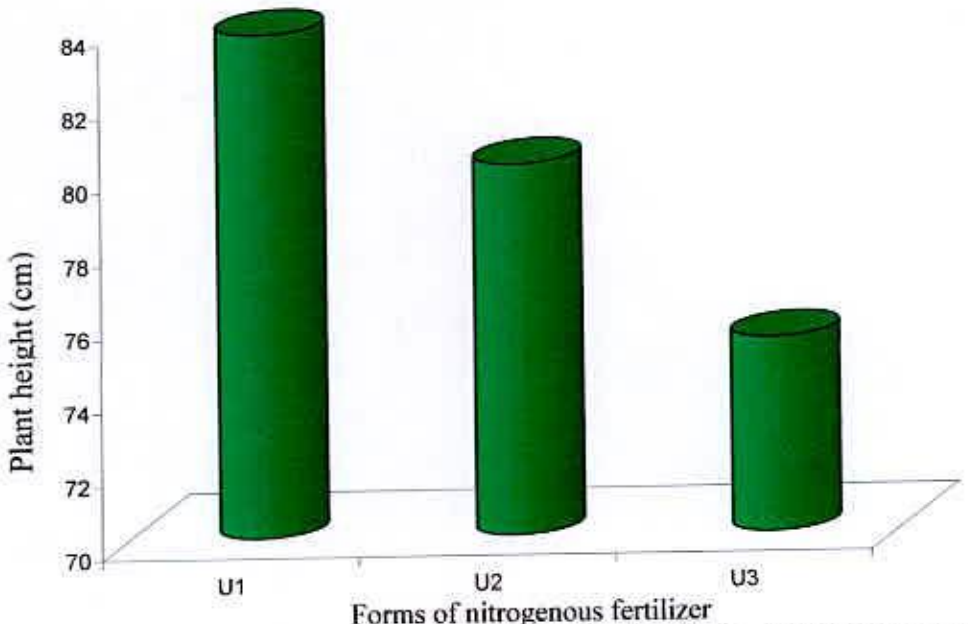
4.1.2 Effect of seedling /hill

Plant height was significantly influenced by the number of seedling/hill (Appendix 3). The tallest plant (84.7 cm) was obtained from 1 seedling/hill and the plant heights were decreased when the number of seedling/hill increased

from 1 to 6 (Figure 2). These results are in agreement with the findings of Shah *et al.* (1991) who reported that plant height increased with decrease in seedling number/hill.

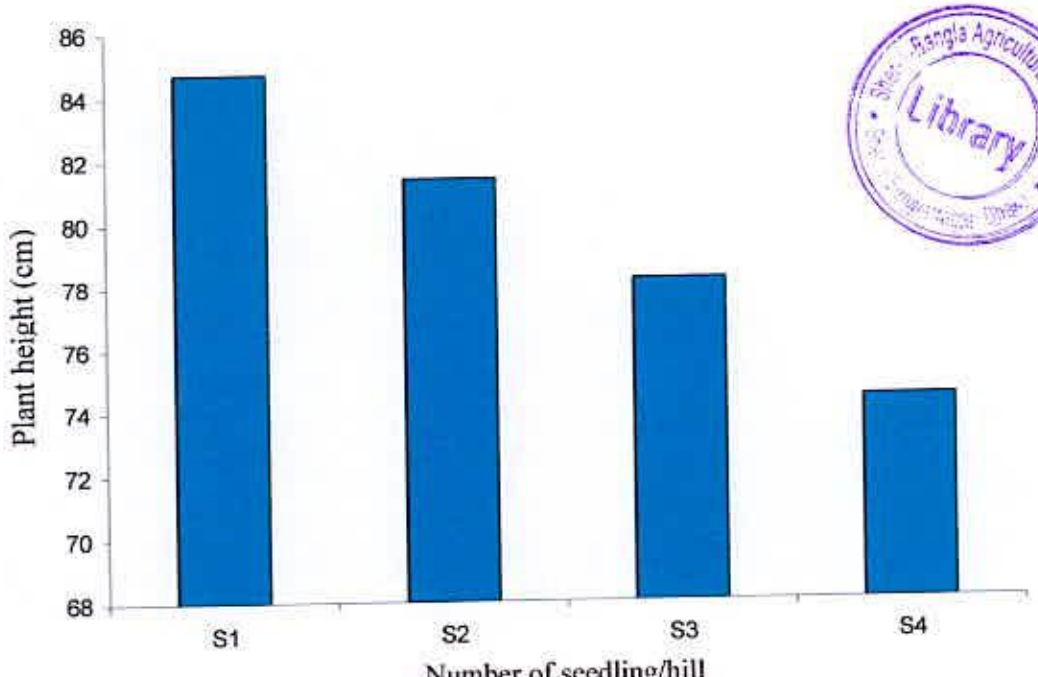
4.1.3 Interaction effect of nitrogen and seedling/hill

Plant height differ significantly due to interaction between number of seedling/hill and forms of N-fertilizer (Table 1 and Appendix 3). The plant height (86.33 cm) was obtained from the treatment combination of Urea super granules × 1 seedling/hill followed by the treatment combination of prilled urea × 1 seedling/hill (86.12 cm) (Table 1). The shortest plant (70.33 cm) was obtained from the treatment combination foliar spray of urea × 6 seedling/hill.



U_1= Prilled urea (PU), U_2= Urea super granules (USG), U_3= Foliar spray of urea

Figure 1. Effect of forms of nitrogenous fertilizer on plant height of Boro rice cv. BRRI dhan 29



S_1= 1 Seedling/hill; S_2= 2 Seedling/hill; S_3= 4 Seedling/hill; S_4= 6 Seedling/hill

Figure 2. Effect of number of seedling/hill on plant height of Boro rice cv. BRRI dhan 29

4.2 Number of effective tiller /hill

4.2.1 Effect of nitrogen

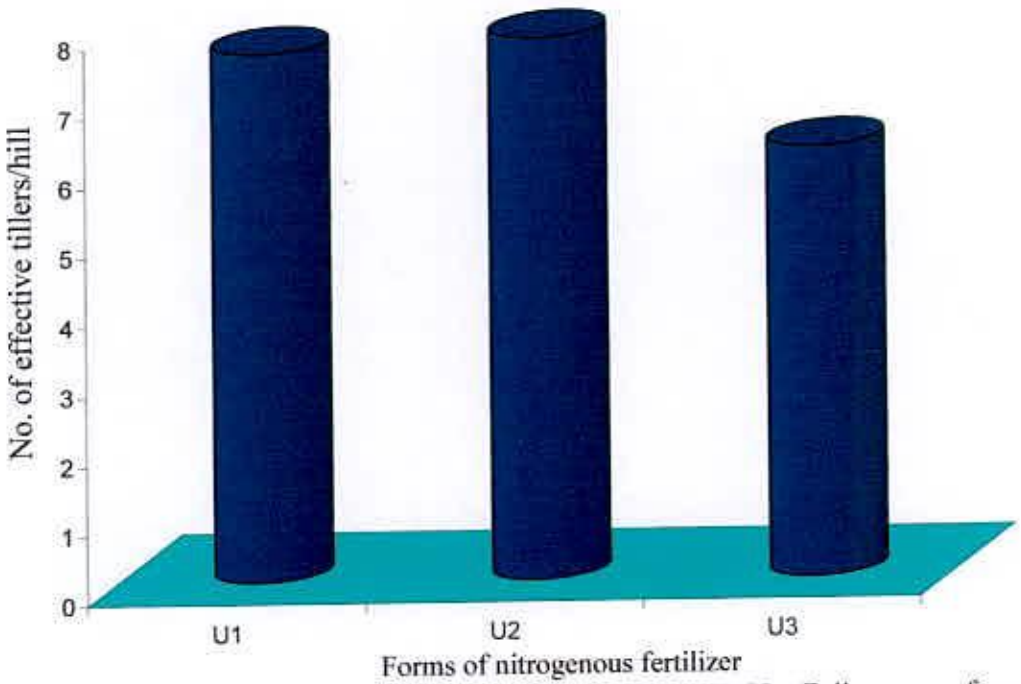
Results of the study revealed that forms of N-fertilizer showed significant influence on the number of effective tiller /hill (Appendix 3). Significantly highest number of effective tiller /hill (7.8 cm) was produced due to application of Urea super granules and the lower (6.2 cm) was recorded with foliar application of urea (Figure 3). The results obtained for effective tiller /hill are similar to Jee and Mahapatra (1989) who mentioned that number of panicles per sq. meter was significantly higher with 90 kg N/ha in the forms of urea super granules in deep placement method than split application of urea.

4.2.2 Effect of seedling/hill

Number of effective tiller /hill at harvest was significantly influenced by number of seedling/hill (Appendix 3). Significantly higher number of effective tiller /hill (7.7 cm) was observed by 2 seedling/hill followed by 1 seedling/hill (7.6 cm) and the lowest (6.5 cm) was recorded with 6 seedling/hill (Figure 4).

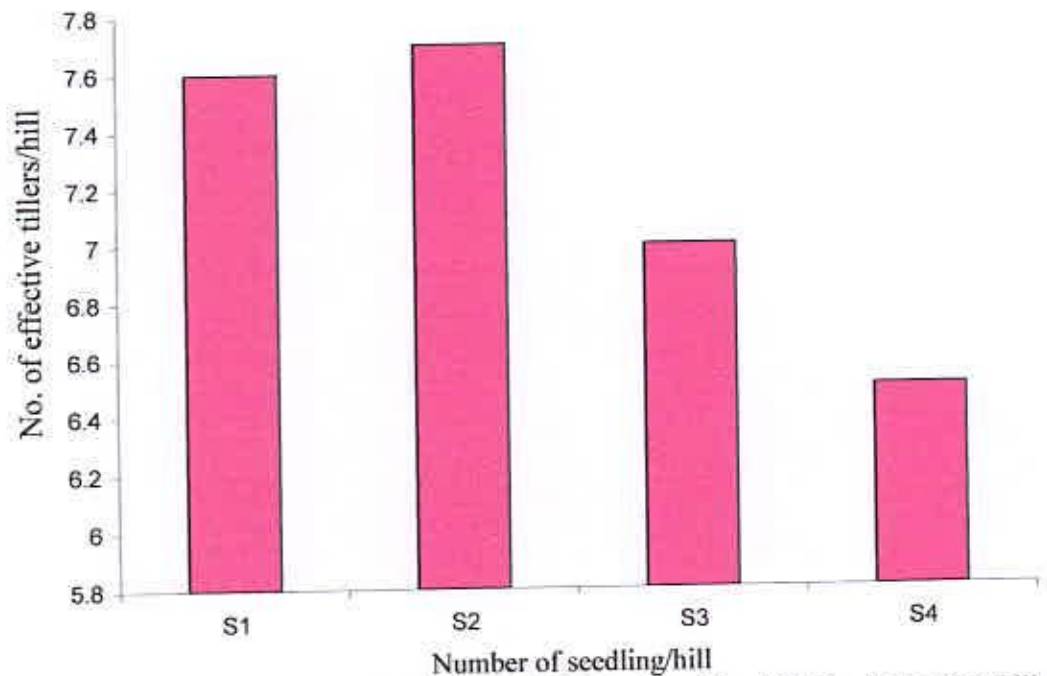
4.2.3 Interaction effect of nitrogen and seedling/hill

Interaction effect between number of forms of N-fertilizer and seedling/hill also have significant influence on number of effective tiller/hill (Table 1). Results showed that numerically higher number of effective tiller/hill (8.50) was produced by the treatment combination of Urea super granules × 2 seedling/hill and the lowest number of effective tiller /hill (5.70) was obtained by the treatment combination of foliar spray of urea × 6 seedling/hill followed by the treatment combination of foliar spray of urea × 4 seedling/hill (5.90) (Table 1).



U_1= Prilled urea (PU), U_2= Urea super granules (USG), U_3= Foliar spray of urea

Figure 3. Effect of forms of nitrogenous fertilizer on number of effective tiller/hill of Boro rice cv. BRRI dhan 29



S_1= 1 Seedling/hill; S_2= 2 Seedling/hill; S_3= 4 Seedling/hill; S_4= 6 Seedling/hill

Figure 4. Effect of number of seedling/hill on number of effective tiller/hill of Boro rice cv. BRRI dhan 29

4.3 Number of ineffective tiller/hill

4.3.1 Effect of nitrogen

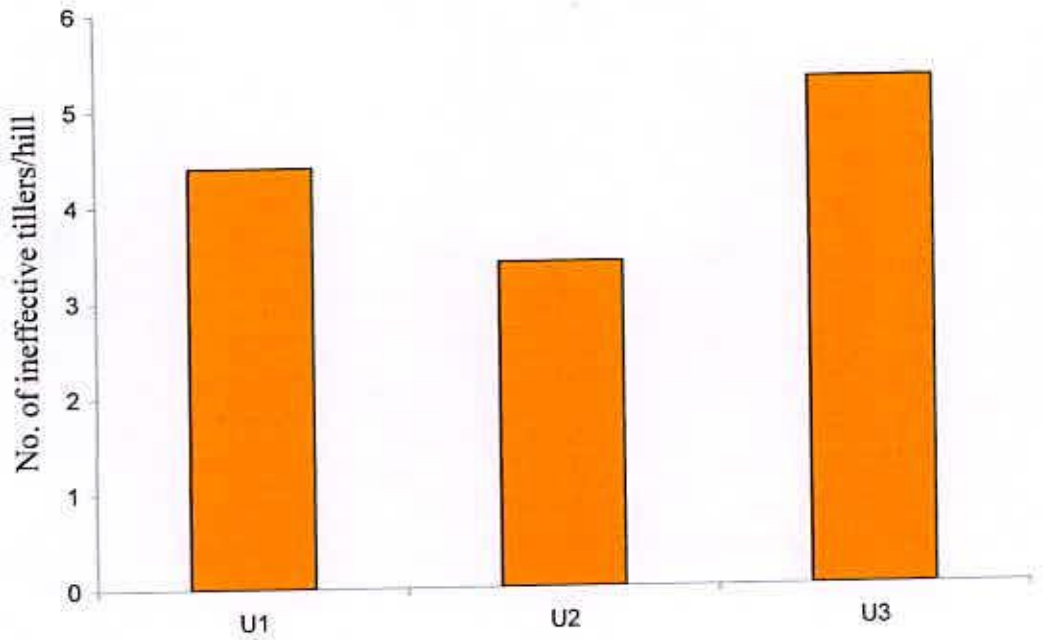
Results of the study revealed that forms of N-fertilizer showed significant influence on the number of ineffective tiller/hill (Figure 5 and Appendix 3). Significantly lowest number of ineffective tiller/hill (3.4) was produced due to application of Urea super granules and the highest (5.3) was recorded with foliar application of urea (Figure 5) followed by prilled urea (4.4). The results obtained for ineffective tiller /hill are similar to Jee and Mahapatra (1989) who mentioned that number of panicles per meter was significantly higher with 90 kg N/ ha deep placement of urea super granules than split application of urea.

4.3.2 Effect of seedling /hill

Number of ineffective tiller/hill at harvest was significantly influenced by number of seedling/hill (Figure 6 and Appendix 3). Significantly lower number of ineffective tiller/hill (3.5) was observed by 1 seedling/hill and the highest (5.4) was recorded with 6 seedling/hill followed by 4 seedling/hill (4.8)

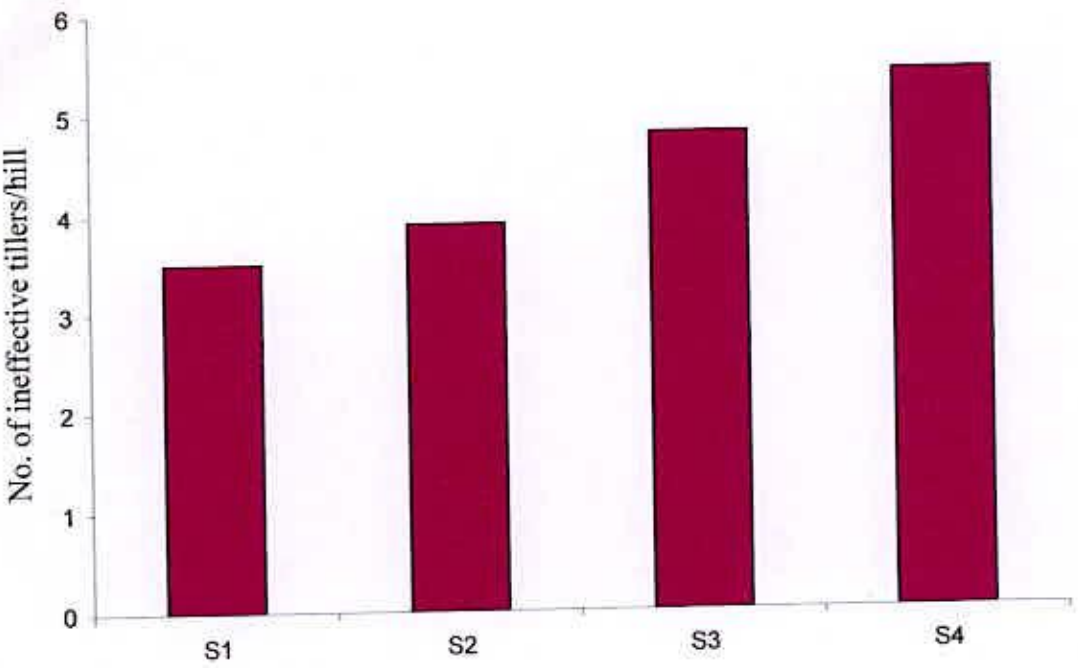
4.3.3 Interaction effect of nitrogen and seedling /hill

Interaction effect between number of forms of N-fertilizer and seedling/hill significantly influence the number of ineffective tiller/hill (Table 1). Results showed that higher number of ineffective tiller/hill was produced by the treatment combination of foliar spray of urea × 6 seedling/hill (6.10) followed by foliar spray of urea × 4 seedling/hill (5.63) and prilled urea × 6 seedling/hill (5.60). The lowest number (2.17) of ineffective tiller/hill was obtained by the treatment combination of Urea super granules × 1 seedling/hill. The rest of the treatments differed significantly in terms of forms of Nitrogenous fertilizer and number of seedling/ hill.



U_1= Prilled urea (PU), U_2= Urea super granules (USG), U_3= Foliar spray of urea

Figure 5. Effect of forms of nitrogenous fertilizer on number of ineffective tiller/hill of Boro rice cv BRRI dhan 29



S_1= 1 Seedling/hill; S_2= 2 Seedling/hill; S_3= 4 Seedling/hill; S_4= 6 Seedling/hill

Figure 6. Effect of number of seedling/hill on number of ineffective tiller/hill of Boro rice cv. BRRI dhan 29

4.4 Length of panicle

4.4.1 Effect of nitrogen

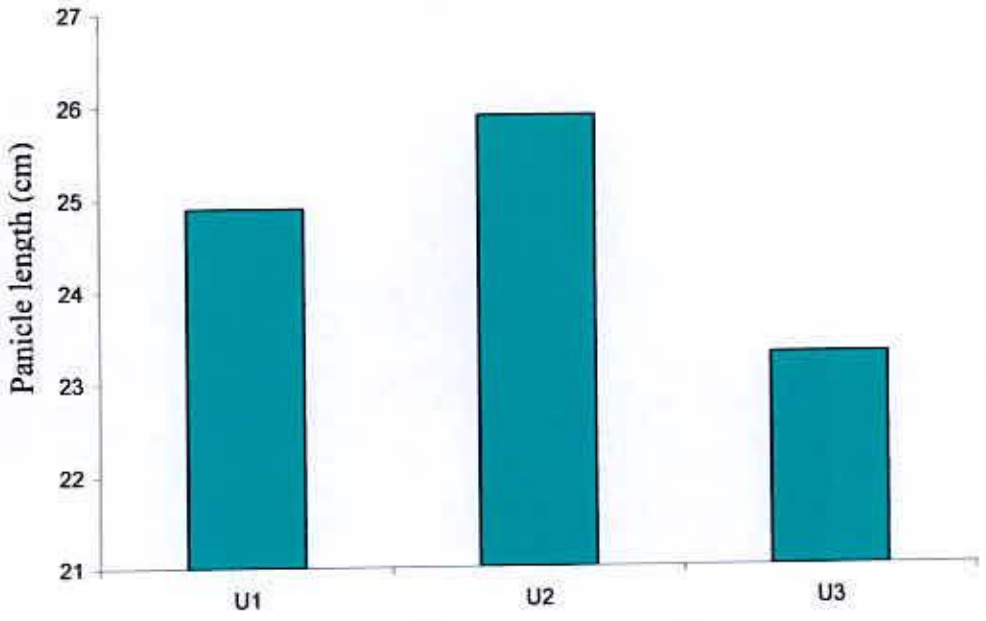
Results of the experiment indicated that panicle length show significant variation due to forms of N-fertilizer whether it was pellet urea or granular urea or foliar spraying form of urea (Figure 7). The highest length of panicle was obtained from (25.9cm) from Urea super granules application. The results were contradictory with the findings of Sen and Pandey (1990) who found that there were no significant differences in panicle length due to application of urea super granule (USG) or prilled urea @ 38.32 kg N/ha.

4.4.2 Effect of seedling /hill

Results of the study revealed that number of seedling/hill had significant effect on panicle length (Appendix 3). The highest panicle length (25.9cm) was observed with 2 seedling/hill and the lowest panicle length (23.30cm) was produced by 6 seedling/hill (Figure 8). The result of the present study was conformed with the result of Talukder (2000).

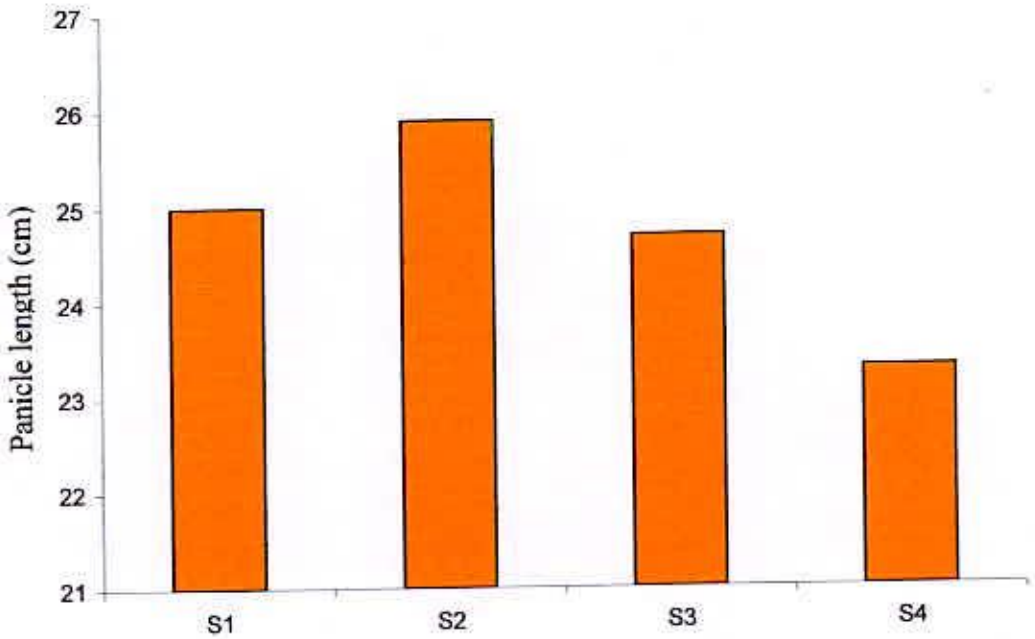
4.4.3 Interaction effect of nitrogen and seedling/hill

Interaction effect between number of seedling/hill and forms of N-fertilizer showed significant differences on panicle length (Table 1). The longest panicle (27.73cm) was recorded in the treatment combination of Urea super granules × 1 seedling/hill and the shortest panicle (22.42 cm) was produced in the treatment combination of foliar spray of urea × 1 seedling/hill (Table 1). The rest of the treatments differed significantly in terms of forms of Nitrogenous fertilizer and number of seedling/ hill combination treatments.



U_1= Prilled urea (PU), U_2= Urea super granules (USG), U_3= Foliar spray of urea

Figure 7. Effect of forms of nitrogenous fertilizer on panicle length (cm) of Boro rice cv. BRRI dhan 29



S_1= 1 Seedling/hill; S_2= 2 Seedling/hill; S_3= 4 Seedling/hill; S_4= 6 Seedling/hill

Figure 8. Effect of number of seedling/hill on panicle length (cm) of Boro rice cv. BRRI dhan 29

4.5 Number of filled grain/panicle

4.5.1 Effect of nitrogen

Forms of N-fertilizer had significant influence on the number of filled grain/panicle (Figure 9 and Appendix 3). Results presented in Figure 9 showed that higher number of filled grain/panicle (116.8) was observed by Urea super granules compared to prilled urea (110.4) and foliar application of urea (93.9). Similar result were obtained by Rama *et al.* (1989) who reported that the number of filled grain/ panicle was significantly higher with 40, 80 or 121 kg N/ha applied as Urea super granule (USG) than split application of urea.

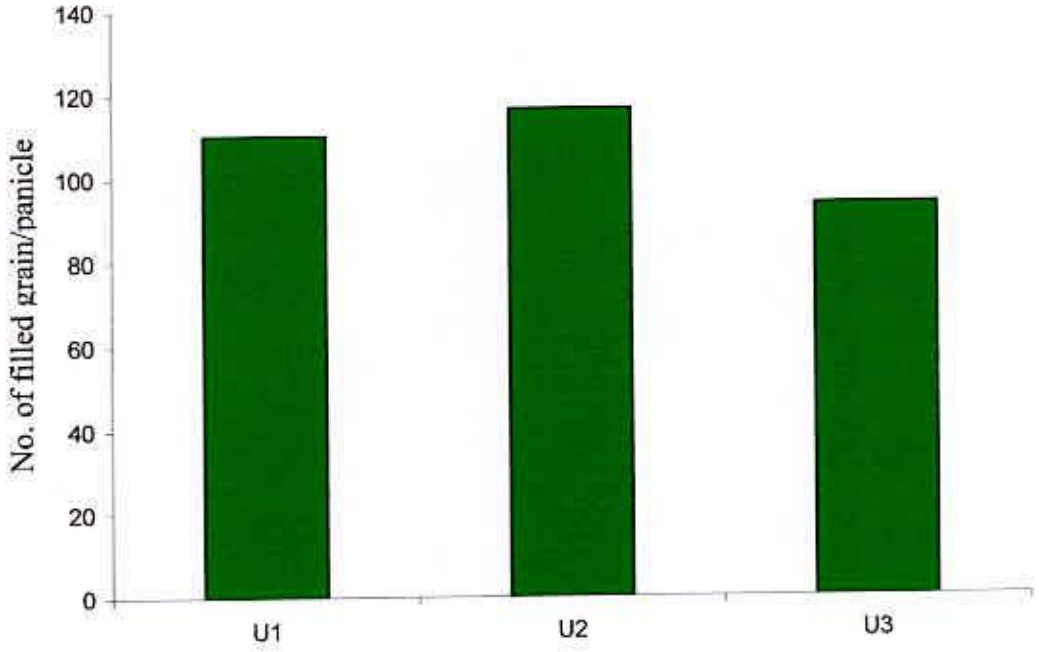
4.5.2 Effect of seedling /hill

Number of seedling/hill had a significant effect on number of filled grain/panicle (Appendix 3). The number of filled grain/panicle was found to increase due to the decrease in seedling/hill (Figure 10). It was observed that the highest number of filled grain/panicle (112.2) was produced when 1 seedling was transplanted/hill followed by 2 seedling was transplanted/hill (111.8) and the lowest number of fertile grain/ panicle (99.9) was produced when 6 seedling were transplanted/hill. The results are in conformity with that of Shah *et al.* (1991) who reported that grain/panicle increased with decrease in seedling number/ hill.

4.5.3 Interaction effect of nitrogen and seedling /hill

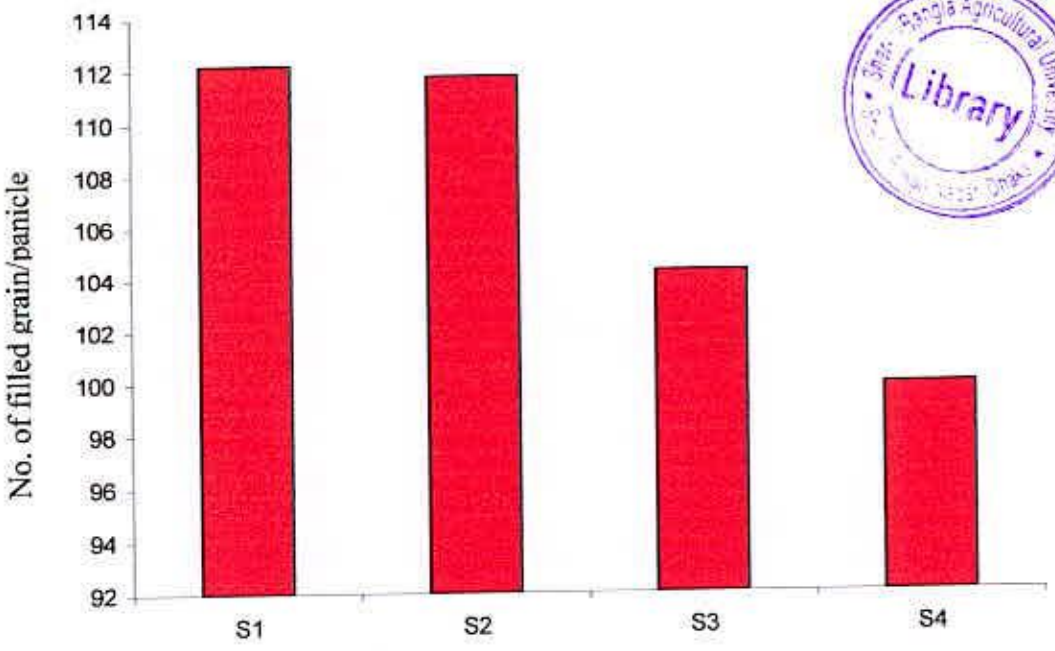
Filled grain/panicle differed significantly by the interaction between number of seedling/hill and forms of N-fertilizer (Table 1). Significantly the highest number of filled grain/panicle (122.7) was found in the treatment combination of Urea super granules × 2 seedling/hill followed by the treatment combination of Urea super granules × 1 seedling/hill and the lowest (89.00) was observed from the combination of foliar spray of urea × 6 seedling/hill (Table 1). The rest of the treatments differed significantly in terms of Nitrogenous fertilizer

and number of seedling/ hill.



U_1= Prilled urea (PU), U_2= Urea super granules (USG), U_3= Foliar spray of urea

Figure 9. Effect of forms of nitrogenous fertilizer on number of filled grain/panicle of Boro rice cv.BRRI dhan 29



S_1= 1 Seedling/hill; S_2= 2 Seedling/hill; S_3= 4 Seedling/hill; S_4= 6 Seedling/hill

Figure 10. Effect of number of seedling/hill on number of filled grain/panicle of Boro rice cv.BRRI dhan 29

4.6 Number of sterile grain/ panicle

4.6.1 Effect of nitrogen

Forms of N-fertilizer had significant influence on the number of sterile grain/ panicle (Appendix 3). Results presented in figure 11 showed that higher number of sterile grain/panicle (23.0) was observed by foliar spray of urea compared to other forms of urea application. The lowest sterile grain/panicle (13.7) was observed by Urea super granules followed by prilled urea. Similar result were obtained by Rama *et al.* (1989) who reported that the number of sterile grain/ panicle was significantly higher with 40, 80 or 121 kg N/ ha applied as USG than split application of urea.

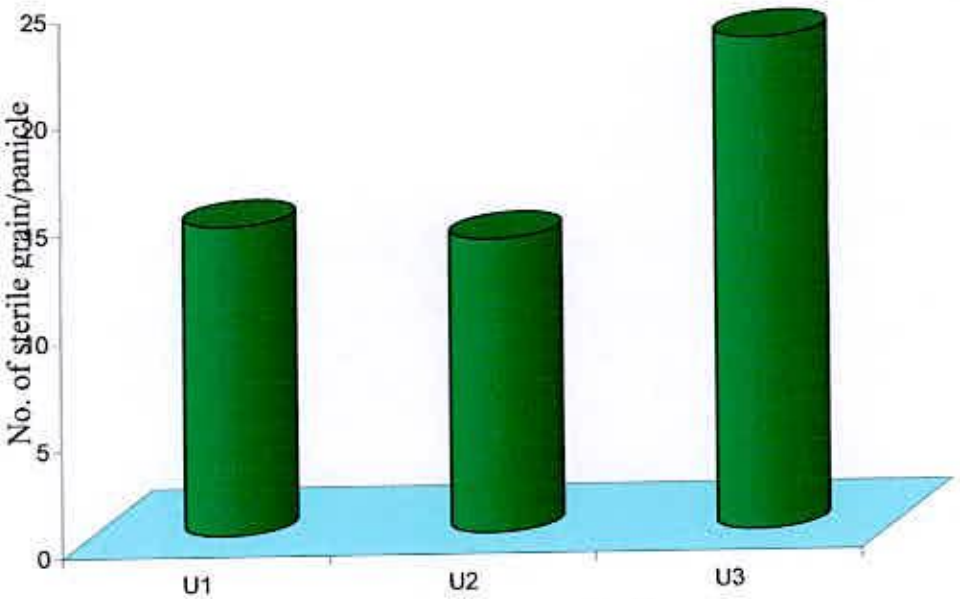
4.6.2 Effect of seedling/hill

Number of seedling/hill had a significant effect on number of sterile grain/panicle (Appendix 3). The number of sterile grain/ panicle was found to increase due to the increase in seedling/hill (Figure 12). It was observed that the highest number of sterile grain/panicle (19.4) was produced when 6 seedling was transplanted/hill followed by 4 seedling/hill (18.7) and the lowest number of grain/ panicle (14.4) was produced when 1 seedling was transplanted/hill followed by 2 seedling/hill (15.6). The results are in conformity with that of Shah *et al.* (1991) who reported that sterile grain/ panicle decreased with decrease in seedling number/ hill.

4.6.3 Interaction effect of nitrogen and seedling/hill

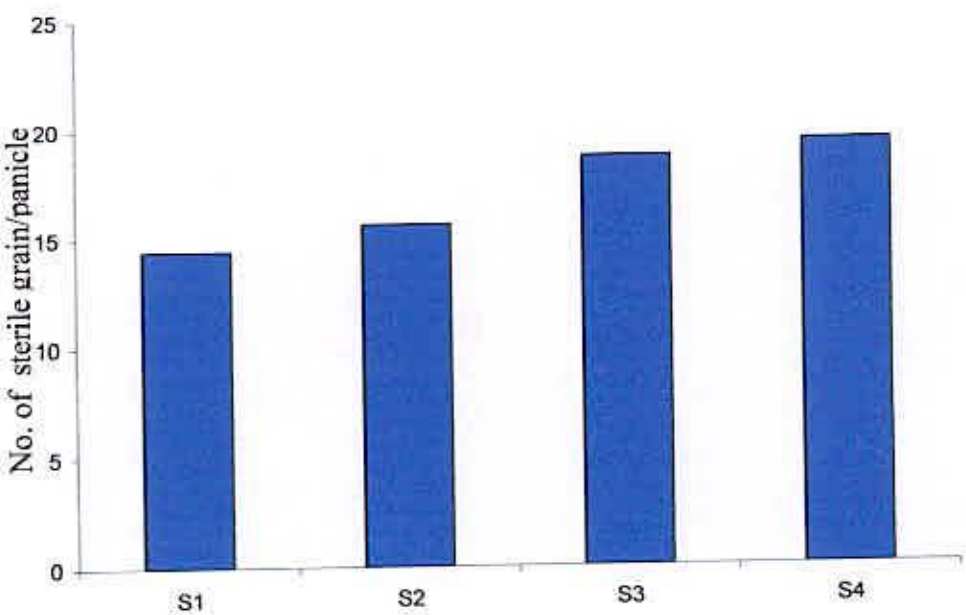
Sterile grain/panicle differed significantly by the interaction between forms of N-fertilizer and number of seedling/hill (Table 1). Significantly the lowest number of sterile grain/panicle (10.67) was found in the treatment combination of Urea super granules × 1 seedling/hill followed by the treatment combination of prilled urea × 2 seedling/hill and the highest (25.67) was observed from the combination of foliar spray of urea × 6 seedling/hill followed by the treatment combination of foliar spray of urea × 4 seedling/hill (Table 1). The rest of the

treatments differed significantly in terms of Nitrogenous fertilizer and number of seedling/hill combination treatments.



U_1= Prilled urea (PU), U_2= Urea super granules (USG), U_3= Foliar spray of urea

Figure 11. Effect of forms of nitrogenous fertilizer on number of sterile grain/ panicle of Boro rice cv.BRRI dhan 29



S_1= 1 Seedling/hill; S_2= 2 Seedling/hill; S_3= 4 Seedling/hill; S_4= 6 Seedling/hill

Figure 12. Effect of number of seedling/hill on number of sterile grain/ panicle of Boro rice cv.BRRI dhan 29

Table 1. Interaction effect of forms of nitrogenous fertilizer and number of seedling/hill on plant characters and number of filled grain/panicle and sterile grains/panicle of Boro rice cv.BRRI dhan 29

Treatments	Plant height (cm)	Effective tiller/hill (no.)	In-effective tiller/hill (no.)	Length of panicle (cm)	Filled grains/panicle (no.)	Sterile spikelet/panicle (no.)
U_1x S_1	86.12 a	7.90 c	3.50 ef	24.73 e	117.3 b	13.00 f
U_1x S_2	84.11 b	8.13 b	3.60 ef	26.27 c	116.7 b	12.00 fg
U_1x S_3	83.84 b	7.67 d	5.07 bc	25.17 d	106.0 e	16.67 d
U_1x S_4	80.66 d	6.70 f	5.60 ab	23.40 g	101.7 f	16.00 de
U_2x S_1	86.33 a	8.23 b	2.17 g	27.73 a	121.7 a	10.67 g
U_2x S_2	83.00 bc	8.50 a	3.30 f	27.20 b	122.7 a	12.33 f
U_2x S_3	78.67 e	7.53 d	3.77 def	25.28 d	114.0 c	15.00 e
U_2x S_4	72.26 f	7.10 e	4.37 cde	23.52 g	109.0 d	16.67 d
U_3x S_1	81.67 cd	6.73 f	4.72 bcd	22.42 i	97.67 g	19.67 c
U_3x S_2	77.00 e	6.40 g	4.83 bc	24.33 f	96.00 g	22.33 b
U_3x S_3	72.00 fg	5.90 h	5.63 ab	23.55 g	93.00 h	24.33 a
U_3x S_4	70.33 g	5.70 h	6.10 a	22.85 h	89.00 i	25.67 a
LSD	1.84	0.230	0.912	0.309	2.426	1.530
Level of significance	0.01	0.01	0.05	0.01	0.01	0.05

In column the figures having common letters do not differ significantly where as figures having dissimilar letters at 5% and 1% level of significance according to DMRT

U_1= Prilled urea (PU), U_2= Urea super granules (USG), U_3= Foliar spray of urea

S_1= 1 Seedling/hill; S_2= 2 Seedling/hill; S_3= 4 Seedling/hill; S_4= 6 Seedling/hill

NS=Not significant, DAT=Days after transplanting

4.7 Number of total grains/panicle

4.7.1 Effect of nitrogen

Forms of N-fertilizer had significant influence on the number of total grains/panicle (Table 2). Results presented in Table 2 showed that higher grains/panicle (130.5) was observed by the application of urea super granule but the lowest was obtained in foliar application of urea (116.9). The result of the present study matched with the study of Hasan (2008) who also found lower number of grains/panicle with foliar spray of urea.

4.7.2 Effect of seedling/hill

Number of total grains/panicle was significantly affected by the number of seedling/hill (Table 2). It was observed that the highest number of total grains/panicle (127.3) was produced when 2 seedling were transplanted/hill and the lowest number of total grains/panicle (119.3) was produced when 6 seedling were transplanted/hill (Table 2). Talukder (2000) also found similar result that the number of grains/panicle gradually reduced if the number of seedling/hill increased gradually.

4.7.3 Interaction effect of nitrogen and seedling/hill

Number of total grains/panicle differed significantly by the interaction between forms of N-fertilizer and number of seedling/hill (Table 3). The highest number of grains/panicle (135.0) was observed in the treatment combination of urea super granule × 2 seedling/hill and the lowest number of grains/panicle (114.7)

was obtained from the treatment combination of foliar spray of urea × 6 seedling/hill. Hasan (2008) also found similar types of result.

4.8 Weight of 1000-grains

4.8.1 Effect of nitrogen

Weight of 1000-grains differs significantly due to forms of N-fertilizer (Table 2). Significantly the highest 1000-grain weight (29.1 g) was found with urea super granule application while lowest 1000-grain weight (26.5 g) was found with foliar spray of urea. The result confirms with the findings of Hasan (2008).

4.8.2 Effect of seedling/hill

Weight of 1000-grains was significantly affected due to number of seedling/hill (Table 2). The highest 1000-grain weight (29.6 g) was found with 1 seedling/hill followed by 2 seedling/hill (29.5 g) and the lowest 1000-grain weight (25.0 g) was found with 6 seedling/hill. The result matches with the result of Talukder (2000).

4.8.3 Interaction effect of nitrogen and seedling/hill

Interaction of forms of N-fertilizer and number of seedling/hill exerted significant effect on 1000-grain weight (Table 3). The highest 1000-grain weight (29.7g) was observed in the treatment combination of urea super granule × 1 seedling/hill while the lowest 1000-grain weight (20.1 g) was

found with granular application urea × 6 seedling/hill. Talukder (2000) in his study found the similar result.

4.9 Grain yield (t/ha)

4.9.1 Effect of nitrogen

Grain yield was significantly affected by the forms of N-fertilizer (Table 2). Significantly the highest grain yield (6.4 t/ha) was observed by application of urea super granule than other forms of nitrogen application. However, foliar application of urea showed the lowest yield (5.0 t/ha). Placement of nitrogen @ 80 kg N/ha through urea super granule in the present experiment produced the highest number of panicles/hill, total spikelets/panicle, filled grain/ panicle which ultimately gave higher grain yield than other application of urea. Similar results were also reported by Raju *et al.* 1987, Nayak *et al.*, 1986; Reddy *et al.*, 1986; Setty *et al.*, 1987; Singh and Singh, 1988 and Pandey and Tiwari, 1996. They observed that among the sources of N, urea super granules produced the highest grain yield and proved significantly superior to other sources.

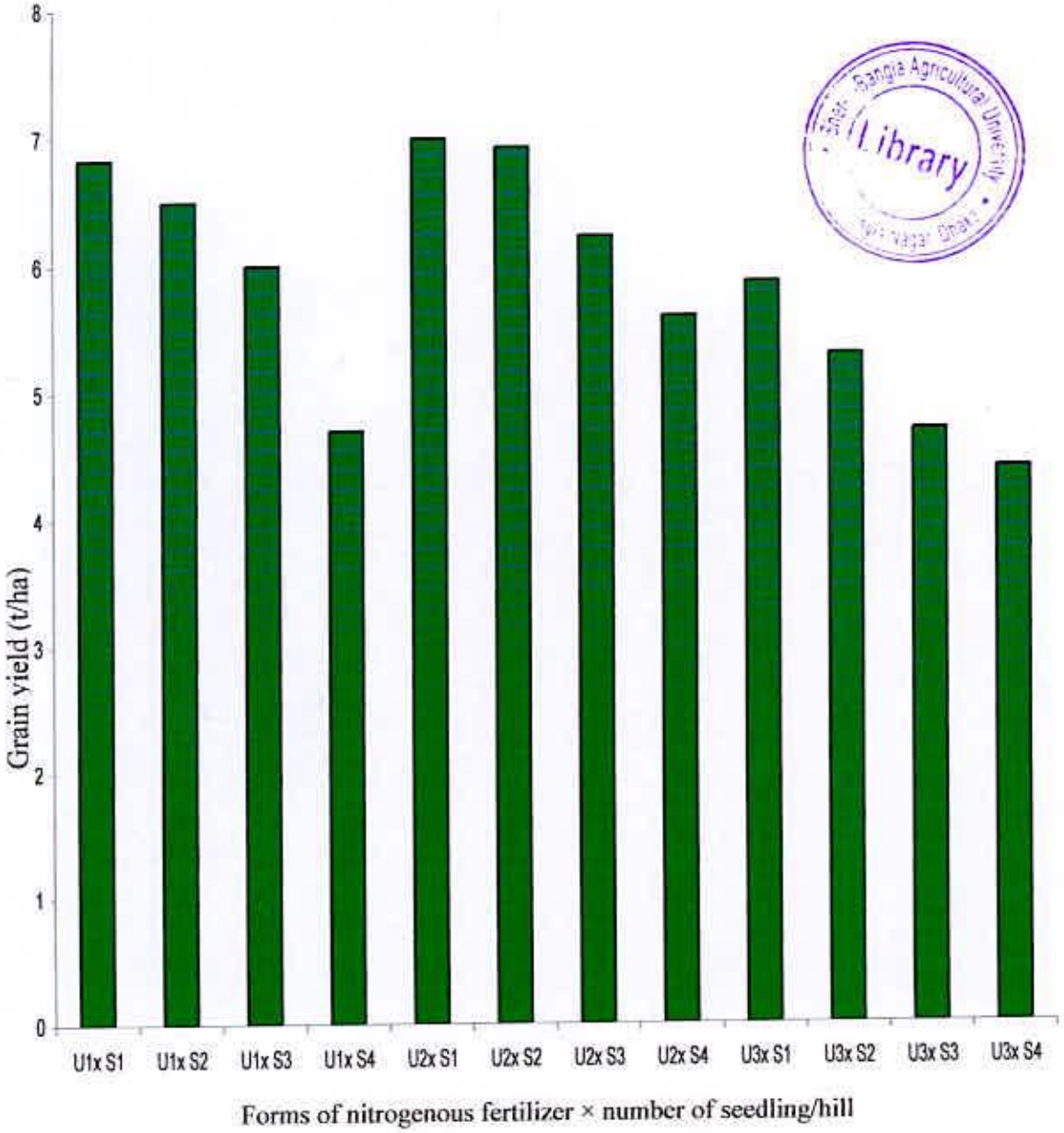
4.9.2 Effect of seedling/hill

Grain yield was significantly affected by the number of seedling/hill (Table 2). Data revealed that the highest grain yield (6.6 t/ ha) was observed by 1 seedling/hill followed by 2 seedling/hill (6.4 t/ha). More than 2 seedling/hill produced significantly lower yields. The results are more or less similar to the findings of Shahi and Gill (1976) who reported that yield was the highest in

20cm x 20cm spacing by planting 1 seedling/hill. However, Pillai *et al.* (1972) reported that 2 or 3 seedling/hill at 15cm x 10cm spacing produces the highest paddy yield. The present results also confirmed that with 1 seedling/hill produced highest yield with the spacing of 25cm x 15cm. Ramasamy *et al.* (1987) reported that yield decreased with more than 2 seedling/hill, which was similar to the findings of present study.

4.9.3 Interaction effect of nitrogen and seedling/hill

Grain yield was significantly affected by the interaction between forms N-fertilizer and number of seedling/hill (Figure 13). The highest grain yield (7.00 t/ha) was found by the treatment combination of urea super granule × 1 seedling/hill followed by treatment combination of urea super granule × 2 seedling/hill (6.93 t/ha) and treatment combination of prilled urea × 1 seedling/hill (6.83t/ha). It could be observed from the figure 13 that grain yield decreased when more than 2 seedling/hill was transplanted but the yield of urea super granule (USG) receiving plots were yet produced higher than those with urea treated plots. The lowest grain yield was recorded from treatment combination of foliar spray of urea × 6 seedling/hill (4.40 t/ha). The present result keeps in with the study of Hasan (2008) and Talukder (2000).



U_1= Prilled urea (PU), U_2= Urea super granules (USG), U_3= Foliar spray of urea
S_1= 1 Seedling/hill; S_2= 2 Seedling/hill; S_3= 4 Seedling/hill; S_4= 6 Seedling/hill

Figure 13. Interaction effect of forms of nitrogenous fertilizer and number of seedling/hill on grain yield of Boro rice cv.BRRI dhan 29

4.10 Straw yield (t/ha)

4.10.1 Effect of nitrogen

The effect of forms of nitrogenous fertilizer was significant in respect of straw yield (Table 2). Data revealed that straw yield was highest (6.7 t/ ha) in prilled urea than other treated plots of urea. The result was contradictory with the findings of Mohanty *et al.* (1989) that urea super granules in rice gave significantly higher straw yield than split application of urea.

4.10.2 Effect of seedling/hill

Straw yield was significantly influenced by the number of seedling/hill (Table 2). Maximum straw yield (7.5 t/ha) was observed from 6 seedling/hill and minimum (6.7 t/ ha) from 1 seedling/hill. 6 seedling/hill produced the higher number of total tiller/hill resulting in the production of more straw than grain. In the case of 1 seedling/hill, lower numbers of total tiller /hill were produced and as a result straw yield was also lower. These results are in agreement with the findings of Mian and Gaffer (1970) who reported that straw yield increased with the increasing number of seedling/hill from 1 to 4. Karim *et al.* (1987) also reported that 4 seedling/hill produced higher straw than 1 seedling/hill.

4.10.3 Interaction effect of nitrogen and seedling/hill

Straw yield was affected significantly by the interaction between number of seedling/hill and forms of nitrogenous fertilizer (Table 3). It was observed that the highest straw yield (7.50 t/ ha) was obtained from the treatment combination of prilled urea × 6 seedling/hill and the lowest straw (6.25 t/ ha) yield were recorded from foliar urea application × 1 seedling/hill.

4.11 Biological yield

4.11.1 Effect of nitrogen

Biological yield was significantly influenced by the forms of N-fertilizer (Table 2). Results revealed that significantly the highest biological yield (12.9 t/ha) was produced by deep placement of urea super granule whereas foliar spray of urea produced the lowest one (10.8 t/ha). Hasan (2008) also found similar result in Aman season.

4.11.2 Effect of seedling/hill

Number of seedling/hill had significant effect on the biological yield (Table 2). Maximum biological yield (13.4 t/ha) was observed from 2 seedling/hill followed by 1 seedling/hill (13.3 t/ha) and minimum (13.1 t/ha) with 4 and 6 seedling/hill. Talukder (2000) also found similar result.

4.11.3 Interaction effect of nitrogen and seedling/hill

The interaction effect of the number of seedling/hill and forms of nitrogenous fertilizer also differed significantly in terms of biological yield. The highest biological yield (14.03 t/ha) was obtained from the treatment combination of urea super granule × 1 seedling/hill. The lowest amount of (10.93 t/ha) was from the treatment combination of foliar spray of urea × 6 seedling/hill. This result is more or less similar with the result of Talukder (2000).

4.12 Harvest index (%)

4.12.1 Effect of nitrogen

Forms of nitrogenous fertilizer had significant effect on harvest index (Table 2). The higher harvest index (49.61%) was observed by deep placement of urea super granule than that of other application of urea (Table 2). The lowest harvest index was found in foliar spray of urea (46.29%).

4.12.2 Effect of seedling/hill

Harvest index was significantly influenced by the number of seedling/hill (Table 2). Maximum harvest index (49.62%) was obtained from 1 seedling/hill followed by 2 seedling/hill (47.73%). On the other hand, minimum harvest index (42.75%) was obtained from 6 seedling/hill (Table 2).

4.12.3 Interaction effect of nitrogen and seedling/hill

Harvest index (HI) of Boro rice cv. BRRI dhan29 was significantly influenced by the interaction between forms of nitrogenous fertilizer and number of seedling/hill (Table 3). Results indicated that the highest harvest index (50.00%) was observed in the treatment combination of urea super granule × 1 seedling/hill and the lowest harvest index (40.26%) was obtained in the treatment combination of foliar spray of urea × 6 seedling/hill.

Table 2. Effect of forms of nitrogenous fertilizer and number of seedling/hill no total number of grain/panicle, weight of thousand grain (g), grain yield (t/ha), straw yield (t/ha), biological yield (t/ha) and harvest Index (%) of Boro rice cv. BRRI dhan 29

Treatments	Grain/panicle (no.)	Weight of thousand seed (g)	Grain yield (t/ha)	Straw yield (t/ha)	Biological Yield (t/ha)	Harvest Index (%)
Urea						
U_1	124.8 b	28.9 a	6.0 b	6.7 a	12.7 b	47.24 ab
U_2	130.5 a	29.1 a	6.4 a	6.5 b	12.9 a	49.61 a
U_3	116.9 c	26.5 b	5.0 c	5.8 c	10.8 c	46.29 b
LSD	3.071	2.060	0.206	0.192	0.349	2.505
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01
Seedling/hill						
S_1	126.7 a	29.6 a	6.6 a	6.7 d	13.3 a	49.62 a
S_2	127.3 a	29.5 a	6.4 a	7 c	13.4 a	47.73 b
S_3	123.0 b	27.4 b	5.9 c	7.2 b	13.1 b	45.04 c
S_4	119.3 c	25.0 c	5.6 d	7.5 a	13.1 b	42.75 d
LSD	3.071	2.060	0.206	0.913	0.349	0.989
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01

In column the figures having common letters do not differ significantly where as figures having dissimilar letters at 5% and 1% level of significance according to DMRT

U_1= Prilled urea (PU), U_2= Urea super granules (USG), U_3= Foliar spray of urea

S_1= 1 Seedling/hill; S_2= 2 Seedling/hill; S_3= 4 Seedling/hill; S_4= 6 Seedling/hill

NS=Not significant, DAT=Days after transplanting

Table 3. Interaction effect of forms of nitrogenous fertilizer and number of seedling/hill on total number of grain/panicle, weight of thousand grain (g), straw yield (t/ha), biological yield (t/ha) and harvest Index (%) of Boro rice cv. BRRI dhan29

Treatments	Grain/panicle (no.)	Weight of thousand grain (g)	Straw yield (t/ha)	Biological Yield (t/ha)	Harvest Index (%)
U_1x S_1	130.3 bc	29.17 a	7.10 b	13.93 ab	49.03 ab
U_1x S_2	128.7 c	27.5 ab	7.20 b	13.70 b	47.45 bc
U_1x S_3	122.7 e	23.5 bc	7.40 a	13.40 bc	44.78 d
U_1x S_4	117.7 f	21.5 c	7.50 a	12.20 d	38.52 g
U_2x S_1	132.3 b	29.7 a	7.00 bc	14.00 a	50.00 a
U_2x S_2	135.0 a	29.5 a	7.10 b	14.03 a	49.39 ab
U_2x S_3	129.0 c	24.5 b	7.20 b	13.43 bc	46.39 c
U_2x S_4	125.7 d	21.5 c	7.40 a	13.00 c	43.08 e
U_3x S_1	117.3 f	23.5 bc	6.25 d	12.12 d	48.43 b
U_3x S_2	118.3 f	20.5 d	6.30 cd	11.60 e	45.69 cd
U_3x S_3	117.3 f	20.4 d	6.40 cd	11.10 f	42.34 ef
U_3x S_4	114.7 g	20.1 d	6.53 c	10.93 g	40.26 f
LSD	2.498	2.060	0.193	0.349	0.989
Level of significance	0.01	0.01	0.01	0.01	0.05

In column the figures having common letters do not differ significantly where as figures having dissimilar letters at 5% and 1% level of significance according to DMRT

U_1= Prilled urea (PU), U_2= Urea super granules (USG), U_3= Foliar spray of urea

S_1= 1 Seedling/hill; S_2= 2 Seedling/hill; S_3= 4 Seedling/hill; S_4= 6 Seedling/hill

NS=Not significant, DAT=Days after transplanting

CHAPTER 5

SUMMARY AND CONCLUSION

Chapter 5
SUMMARY AND CONCLUSION

The present piece of work was conducted at the experimental farm of Sher-e-Bangla Agricultural University (SAU) during the period from November 2007 to April, 2008 to find out the effect of forms of nitrogenous fertilizer and number of seedling/ hill on the yield of Boro rice cv. BRRI dhan29. The experiment consisted of (A) three forms of nitrogenous fertilizer viz. foliar urea spray and urea granules and urea pellet at recommended dose and (B) four levels of seedling/hill viz. 1, 2, 4 and 6 seedling/hill. The experiment was laid out in a split plot design with three replications.

The plots were fertilized with PKSZn in the form of triple super phosphate (TSP), muriate of potash (MP), gypsum and zinc oxide, respectively one day before transplanting. Urea was top dressed in three equal splits on 10, 30 and 50 days after transplanting (DAT). Urea pellet (46% N) weighing l g each were placed 5-8cm depth at 10 DAT in the centre of four hills in alternate rows at a rate of two granules to supply 80 kg N/ha. All the relevant data were recorded and analyzed statistically and the mean differences were adjusted by Duncan's New Multiple Range Test

Forms of nitrogenous fertilizer had significant influence on plant height. The tallest plant (83.7 cm) was obtained from prilled urea whereas foliar spray of urea produced the shortest one (75.3 cm). Plant height was significantly influenced by the number of seedling/hill. The tallest plant (84.7 cm) was obtained from 1 seedling/hill and the plant heights were decreased when the number of seedling/hill increased from 1 to 6. Plant height differs significantly due to interaction between number of seedling/hill and forms of N-fertilizer. The plant height (86.33 cm) was obtained from the treatment combination of

Urea super granules × 1 seedling/hill followed by the treatment combination of prilled urea × 1 seedling/hill (86.12 cm). The shortest plant (70.33 cm) was obtained from the treatment combination foliar spray of urea × 6 seedling/hill.

Results of the study revealed that forms of N-fertilizer showed significant influence on the number of effective tiller /hill. Significantly highest number of effective tiller /hill (7.8 cm) was produced due to application of Urea super granules and the lower (6.2 cm) was recorded with foliar application of urea. Number of effective tiller /hill at harvest was significantly influenced by number of seedling/hill. Significantly higher number of effective tiller /hill (7.7 cm) was observed by 2 seedling/hill followed by 1 seedling/hill (7.6 cm) and the lowest (6.5 cm) was recorded with 6 seedling/hill. Interaction effect between number of forms of N-fertilizer and seedling/hill also has significant influence on number of effective tiller /hill. Results showed that numerically higher number of effective tiller/hill (8.50) was produced by the treatment combination of Urea super granules × 2 seedling/hill and the lowest number of effective tiller /hill (5.70) was obtained by the treatment combination of foliar spray of urea × 6 seedling/hill followed by the treatment combination of foliar spray of urea × 4 seedling/hill (5.90).

Results of the study revealed that forms of N-fertilizer showed significant influence on the number of ineffective tiller/hill. Significantly lowest number of ineffective tiller/hill (3.4) was produced due to application of Urea super granules and the highest (5.3) was recorded with foliar application of urea followed by prilled urea (4.4). Number of ineffective tiller/hill at harvest was significantly influenced by number of seedling/hill. Significantly lower number

of ineffective tiller/hill (3.5) was observed by 1 seedling/hill and the highest (5.4) was recorded with 6 seedling/hill followed by 4 seedling/hill (4.8). Interaction effect between number of forms of N-fertilizer and seedling/hill significantly influence the number of ineffective tiller/hill. Results showed that higher number of ineffective tiller/hill was produced by the treatment combination of foliar spray of urea × 6 seedling/hill (6.10) followed by foliar spray of urea × 4 seedling/hill (5.63) and prilled urea × 6 seedling/hill (5.60). The lowest number (2.17) of ineffective tiller/hill was obtained by the treatment combination of Urea super granules × 1 seedling/hill.

Results of the experiment indicated that panicle length show significant variation due to forms of N-fertilizer whether it was pellet urea or granular urea or foliar spraying form of urea. The highest length of panicle was obtained from (25.9cm) from Urea super granules application. Results of the study revealed that number of seedling/hill had significant effect on panicle length. The highest panicle length (25.9cm) was observed with 2 seedling/hill and the lowest panicle length (23.30cm) was produced by 6 seedling/hill. Interaction effect between number of seedling/hill and forms of N-fertilizer showed significant differences on panicle length. The longest panicle (27.73cm) was recorded in the treatment combination of Urea super granules × 1 seedling/hill and the shortest panicle (22.42 cm) was produced in the treatment combination of foliar spray of urea × 1 seedling/hill.

Forms of N-fertilizer had significant influence on the number of filled grain/panicle. Results presented that higher number of filled grain/panicle (116.8) was observed by Urea super granules compared to prilled urea (110.4)

and foliar application of urea (93.9). Number of seedling/hill had a significant effect on number of filled grain/panicle. The number of filled grain/panicle was found to increase due to the decrease in seedling/hill. It was observed that the highest number of filled grain/panicle (112.2) was produced when 1 seedling was transplanted/hill and the lowest number of fertile grain/ panicle (99.9) was produced when 6 seedling were transplanted/hill. Filled grain/panicle differed significantly by the interaction between number of seedling/hill and forms of N-fertilizer. Significantly the highest number of filled grain/panicle (122.7) was found in the treatment combination of Urea super granules × 2 seedling/hill followed by the treatment combination of Urea super granules × 1 seedling/hill and the lowest (89.00) was observed from the combination of foliar spray of urea × 6 seedling/hill. The rest of the treatments differed significantly in terms of nitrogenous fertilizer and number of seedling/ hill.

Forms of N-fertilizer had significant influence on the number of sterile grain/ panicle. Results showed that higher number of sterile grain/panicle (23.0) was observed by foliar spray of urea compared to other forms of urea application. The lowest sterile grain/panicle (13.7) was observed by Urea super granules followed by prilled urea. Number of seedling/hill had a significant effect on number of sterile grain/panicle. The number of sterile grain/ panicle was found to increase due to the increase in seedling/hill. It was observed that the highest number of sterile grain/panicle (19.4) was produced when 6 seedling was transplanted/hill followed by 4 seedling/hill (18.7) and the lowest number of grain/ panicle (14.4) was produced when 1 seedling was transplanted/hill followed by 2 seedling/hill (15.6). Sterile grain/panicle differed significantly by the interaction between forms of N-fertilizer and number of seedling/hill.

Significantly the lowest number of sterile grain/panicle (10.67) was found in the treatment combination of Urea super granules × 1 seedling/hill followed by the treatment combination of prilled urea × 2 seedling/hill and the highest (25.67) was observed from the combination of foliar spray of urea × 6 seedling/hill followed by the treatment combination of foliar spray of urea × 4 seedling/hill. The rest of the treatments differed significantly in terms of nitrogenous fertilizer and number of seedling/hill combination treatments.

Forms of N-fertilizer had significant influence on the number of total grains/panicle. Results presented that higher grains/panicle (130.5) was observed by the application of urea super granule but the lowest was obtained in foliar application of urea (116.9). Number of total grains/panicle was significantly affected by the number of seedling/hill. It was observed that the highest number of total grains/panicle (127.3) was produced when 2 seedling were transplanted/hill and the lowest number of total grains/panicle (119.3) was produced when 6 seedling were transplanted/hill. Number of total grains/panicle differed significantly by the interaction between forms of N-fertilizer and number of seedling/hill. The highest number of grains/panicle (135.0) was observed in the treatment combination of urea super granule × 2 seedling/hill and the lowest number of grains/panicle (114.7) was obtained from the treatment combination of foliar spray of urea × 6 seedling/hill.

Weight of 1000-grains differs significantly due to forms of N-fertilizer Significantly the highest 1000-grain weight (29.1 g) was found with urea super granule application while lowest 1000-grain weight (26.5 g) was found with foliar spray of urea. Weight of 1000-grains was significantly affected due to

number of seedling/hill. The highest 1000-grain weight (29.6 g) was found with 1 seedling/hill and the lowest 1000-grain weight (25.0 g) was found with 6 seedling/hill. Interaction of forms of N-fertilizer and number of seedling/hill exerted significant effect on 1000-grain weight. The highest 1000-grain weight (29.7 g) was observed in the treatment combination of urea super granule × 1 seedling/hill while the lowest 1000-grain weight (20.1 g) was found with foliar application urea × 6 seedling/hill.

Grain yield was significantly affected by the forms of N-fertilizer. Significantly the highest grain yield (6.4 t/ha) was observed by application of urea super granule than other forms of nitrogen application. However, foliar application of urea show lowest yield (5.0 t/ha). Grain yield was significantly affected by the number of seedling/hill. Data revealed that the highest grain yield (6.6 t/ ha) was observed by 1 seedling/hill followed by 2 seedling/hill (6.4 t/ha). More than 2 seedling/hill produced significantly lower yields. Grain yield was significantly affected by the interaction between forms N-fertilizer and number of seedling/hill. The highest grain yield (7.00 t/ha) was found by the treatment combination of urea super granule × 1 seedling/hill followed by treatment combination of urea super granule × 2 seedling/hill (6.93 t/ha) and treatment combination of prilled urea × 1 seedling/hill (6.83t/ha). The lowest grain yield was found from treatment combination of foliar spray of urea × 6 seedling/hill (4.40 t/ha).

The effect of forms of nitrogenous fertilizer was significant in respect of straw yield Data revealed that straw yield was highest (6.7 t/ ha) in prilled urea treated plots than other treated plots of urea. Straw yield was significantly

influenced by the number of seedling/hill. Maximum straw yield (7.5 t/ha) was observed from 6 seedling/hill and minimum (6.7 t/ ha) from 1 seedling/hill. It was observed that the highest straw yield (7.50 t/ ha) was obtained from the treatment combination of prilled urea × 6 seedling/hill and the lowest straw (6.25 t/ ha) yield were recorded from foliar urea application × 1 seedling/hill.

Biological yield was significantly influenced by the forms of N-fertilizer. Results revealed that significantly the highest biological yield (12.9 t/ha) was produced by deep placement of urea super granule whereas foliar spray of urea produced the lowest one (10.8 t/ha). Number of seedling/hill had significant effect on the biological yield. Maximum biological yield (13.4 t/ha) was observed from 2 seedling/hill and minimum (13.1 t/ha) with 4 and 6 seedling/hill. The interaction effect of the number of seedling/hill and forms of nitrogenous fertilizer also differed significantly in terms of biological yield. The highest biological yield (14.03 t/ha) was obtained from the treatment combination of urea super granule × 1 seedling/hill. The lowest amount of (10.93 t/ha) was from the treatment combination of foliar spray of urea × 6 seedling/hill.

Forms of nitrogenous fertilizer had significant effect on harvest index. The higher harvest index (49.61%) was observed by deep placement of urea super granule than that of other application of urea. The lowest harvest index was found in foliar spray of urea (46.29%). Harvest index was significantly influenced by the number of seedling/hill. Maximum harvest index (49.62%) was obtained from 1 seedling/hill. On the other hand, minimum harvest index (42.75%) was obtained from 6 seedling/hill. Harvest index (HI) of Boro rice

cv. BRRI dhan29 was significantly influenced by the interaction between forms of nitrogenous fertilizer and number of seedling/hill. Results indicated that the highest harvest index (50.00%) was observed in the treatment combination of urea super granule × 1 seedling/hill and the lowest harvest index (40.26%) was obtained in the treatment combination of foliar spray of urea × 6 seedling/hill.

It appeared from the result that fertilization with N in the form of urea super granule as deep placement and 1 or 2 seedling per hill as the promising practice in terms of increasing yield of Boro rice cv. BRRI dhan 29.

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APPENDICES

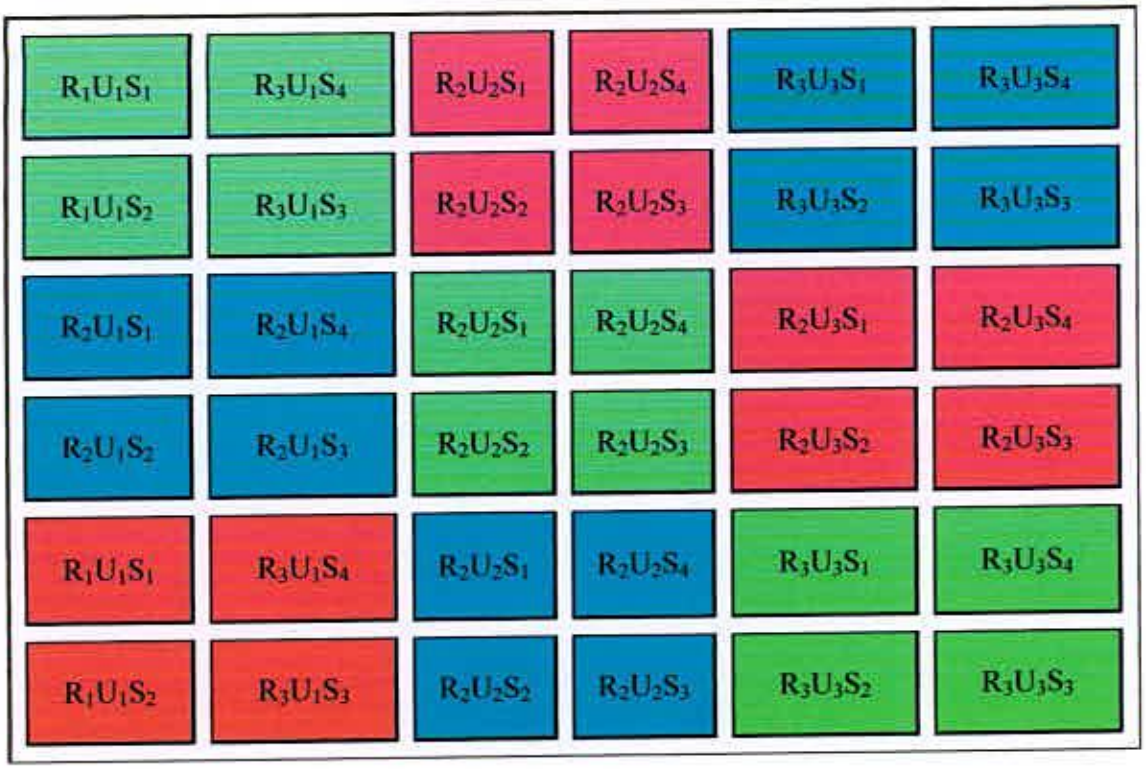
APPENDICES

Appendix 1. Monthly average temperature, relative humidity and rainfall of the experimental site

Month	Temperature (°C)			Relative humidity (%)	Rain fall (mm)
	Minimum	Maximum	Average		
Nov'07	19.9	29.0	24.45	77	111
Dec'07	15.0	25.8	20.4	69	0
Jan'08	12.4	24.5	18.45	68	0
Feb'08	16.7	27.1	21.9	68	30
Mar'08	19.6	31.4	25.5	54	11
Apr'08	23.6	33.6	28.6	69	163

Source: Bangladesh Meteorological Directorate, Bangladesh

Appendix 2. Layout of the experimental field



Appendix 3. Effect of forms of nitrogenous fertilizer and number of seedling/hill on plant characters and number of filled grain/panicle and sterile grain/panicle of Boro rice cv.BRRI dhan 29

Treatments	Plant height (cm)	Effective tiller/hill (no.)	In-effective tiller/hill (no.)	Length of panicle (cm)	Filled grains/panicle (no.)	Sterile spikelet/panicle (no.)
Urea						
U_1	83.7 a	7.6 b	4.4 ab	24.9 b	110.4 b	14.4 b
U_2	80.1 b	7.8 a	3.4 b	25.9 a	116.8 a	13.7 b
U_3	75.3 c	6.2 c	5.3 a	23.3 c	93.9 c	23.0 a
LSD	1.844	0.320	1.246	0.309	2.426	2.079
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01
Seedling/hill						
S_1	84.7 a	7.6 a	3.5 c	25.0 b	112.2 a	14.4 b
S_2	81.4 b	7.7 a	3.9 bc	25.9 a	111.8 a	15.6 b
S_3	78.2 c	7 b	4.8 ab	24.7 b	104.3 b	18.7 a
S_4	74.4 d	6.5 c	5.4 a	23.3 c	99.9 c	19.4 a
LSD	1.884	0.230	1.246	0.309	2.426	2.079
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01

In column the figures having common letters do not differ significantly where as figures having dissimilar letters at 5% and 1% level of significance according to DMRT

U_1= Prilled urea (PU), U_2= Urea super granules (USG), U_3= Foliar spray of urea

S_1= 1 Seedling/hill; S_2= 2 Seedling/hill; S_3= 4 Seedling/hill; S_4= 6 Seedling/hill

NS=Not significant, DAT=Days after transplanting