EFFECTS OF DIFFERENT DOSES OF UREA AS BALL PLACEMENT AND BROADCAST ON YIELD AND NUTRIENT CONTENT OF T. AMAN RICE (*Oryza sativa* L.)

BY

NAOWSHIN ZAHAN

Reg. No.: 05-01711

A Thesis
Submitted to the Department of Agricultural Chemistry
Sher-e-Bangla Agricultural University, Dhaka
In partial fulfillment of the requirements
for the degree
of

MASTER OF SCIENCE (MS)
IN

AGRICULTURAL CHEMISTRY
SEMESTER: JANUARY-JUNE 2011

APPROVED BY:

Md. Azizur Rahman Mazumder
Professor
Department of Agricultural Chemistry
SAU, Dhaka
Supervisor

Dr. Md. Abdur Razzaque
Professor
Department of Agricultural Chemistry
SAU, Dhaka
Co-Supervisor

Prof. Dr. Rokeya Begum
Chairman
Examination Committee

DEPARTMENT OF AGRICULTURAL CHEMISTRY
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

Memo No: SAU/AGCH/

CERTIFICATE

This is to certify that the thesis entitled "EFFECTS OF DIFFERENT DOSES OF UREA AS BALL PLACEMENT AND BROADCAST ON YIELD AND NUTRIENT CONTENT OF T. AMAN RICE (Oryza sativa L.)" submitted to the Department of Agricultural Chemistry, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of ***MASTER OF SCIENCE*** *in* ***AGRICULTURAL CHEMISTRY****, embodies the result of a piece of bona fide research work carried out by* ***NAOWSHIN ZAHAN****, Registration Number:* ***05-1711*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated: *June 2011*
Dhaka, Bangladesh

Md. Azizur Rahman Mazumder
Department of Agricultural Chemistry
Sher-e-Bangla Agricultural University
Dhaka-1207
Supervisor

DEDICATED

TO

MY BELOVED PARENTS

ACKNOWLEDGEMENTS

All praises are devoted to Almighty Allah, the omnipresent and omnipotent who is the supreme authority of this universe, and who has kindly enabled me to complete this research work and to submit the thesis for the degree of Master of Science (MS) in Agricultural Chemistry.

It is a privilege to express sincere gratitude and appreciation to my respected supervisor MD. Azizur Rahman Mazumder, Professor, Department of Agricultural Chemistry, Sher-e-Bangla Agricultural University, Dhaka for providing invaluable advice, Scholastic guidance, constant encouragement and motivation on my academic and research work during the whole period of study and for his constructive suggestions in preparing the manuscript of the thesis.

I gratefully express my deepest sense of respect to my co-supervisor Prof. Dr. Abdur Razzaque, Department of Agricultural Chemistry, Sher-e-Bangla Agricultural University, Dhaka for his valuable suggestions, relevant comments, keen interest and co-operation.

I express my sincere respect to other teachers of Department of Agricultural Chemistry, Sher-e-Bangla Agricultural University, Dhaka for their encouragement, visiting the experimental site, valuable advice to complete this research and preparing the thesis.

I would like to extend my grateful acknowledgement and sincere respect to all other respected teachers of the Department of Agricultural Chemistry, Sher-e-Bangla Agricultural University, Dhaka for their valuable suggestions and co-operation during the work.

I convey my honest thanks to all the staff members and laboratory assistants of the Department of Agricultural Chemistry and farm of Sher-e-Bangla Agricultural University, Dhaka for their help in conducting the experiment.

June, 2011 — *The Author*

SAU, Dhaka

ABSTRACT

The most important problem in achieving high yields in rice is how to increase the nitrogen (N) absorption at each growth stage. Modified forms of fertilizer application could reduce N losses and increase fertilizer use efficiency while cost of production is also reduced and yield is increased. In order to avoid losses and to use fertilizer nitrogen efficiently, it is necessary to develop better ways of predicting the optimum froms of N needed by the rice plants. A field experiment was conducted at Sher-e-Bangla Agricultural University (SAU) farm, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period of June to December, 2011 to study the effect of urea super granule on yield and nutrient content of T. aman rice. BRRI dhan 40 was used as the test crop in this experiment. The experiment was laid out in randomized complete block design (RCBD) with the replications. There were seven treatments viz., T_0 (control), T_1 (37.5 kg ha^{-1} urea as ball placement), T_2 (56.25 kg ha^{-1} urea as ball placement), T_3 (75 kg ha^{-1} urea as ball placement), T_4 (37.5 kg ha^{-1} urea as broadcast), T_5 (56.25 kg ha^{-1} urea as broadcast) and T_6 (75 kg ha^{-1} urea as broadcast). There was a positive impact of urea ball placement on yield, yield parameters and nutrient contents of T. aman rice variety BRRI dhan40 with increasing rate of urea. Due to the effect of urea super granule, maximum grain yield (7.04 t ha^{-1}) was observed in T_3 (75 kg ha^{-1} urea as ball placement) treatment. Plant height, number of filled and unfilled grain $panicle^{-1}$, effective and non-effective tiller $hill^{-1}$, panicle length, and straw yield was the highest in 75 kg ha^{-1} urea as ball placement and lowest in control treatment. The experimental result showed that application of 75 kg ha^{-1} urea super granule as ball placement produced the highest effects on all yield and yield parameters and nutrient content.

ABBREVIATIONS AND ACRONYMS

Full word	Abbreviation
And others (at elli)	*et al.*
Biologically controlled	
Urea super granule	BCUSG
Centimeter	cm
Cultivar	cv.
Cowdung	CD
Degree Celsius	°C
Degree of freedom	df
Dry matter	DM
Farm yard manure	FYM
Gram	g
Granular	G
Granular urea	GU
Hectare	ha
Hydrogen ion conc.	pH
Kilogram	kg
Least significant difference	LSD
Liter	L
Meter	m
Microgram	μg
Milligram	mg
Milliliter	mL
Millimeter	mm
Nanometer	nm
Prilled urea	PU
Square centimeter	cm^2
Square meter	m^2
Ton	t
Urea super granule	USG

LIST OF CONTENTS

CHAPTER	TITLE		Page No.
	ACKNOWLEDGEMENT		i
	ABSTRACT		ii
	ABBREVIATION AND ACRONYMS		iii
	LIST OF CONTENTS		iv-x
	LIST OF TABLES		viii
	LIST OF FIGURES		ix
	LIST OF APPENDIX		x
CHAPTER I	**INTRODUCTION**		**1-4**
CHAPTER II	**REVIEW OF LITERATURE**		**5-18**
CHAPTER III	**MATERIALS AND METHODS**		**19-36**
	3.1	Description of the experimental site	19
	3.1.1	Location of the experimental field	19
	3.1.2	Characteristics of the soil	19
	3.1.3	Climate	20
	3.1.4	Planting material	22
	3.1.5	Land preparation	22
	3.1.6	Experimental design and layout	23
	3.1.7	Fertilizers and manure application	23
	3.1.8	Treatments	25
	3.1.9	Urea super granule	26
	3.1.10	Raising of seedling	26
	3.1.11	Seedling transplanting	26
	3.1.12	Intercultural operation	27

CONTENTS (Contd.)

CHAPTER	TITLE	Page No.
	3.1.12.1Irrigation	27
	3.1.12.2 Weeding	27
	3.1.12.3 Insect and pest control	27
	3.1.13 Recording the data for plant height and tillers	27
	3.1.14 Crop harvest	28
	3.2 Yield component	29
	3.2.1Plant height	29
	3.2.2 Number of tiller hill^{-1}	29
	3.2.3 Effective tiller hill^{-1}	29
	3.2.4 Non-effective tiller hill^{-1}	29
	3.2.5 Total tiller	30
	3.2.6 Length of panicle	30
	3.2.7 Filled grains panicle^{-1}	30
	3.2.8Unfilled grains panicle^{-1}	30
	3.2.9 Total grain	30
	3.2.10 1000-grain weight	31
	3.2.11 Grain yield	31
	3.2.12 Straw yield	31
	3.3 Soil analysis	31
	3.3.1 Collection and preparation of soil samples	31
	3.3.2 Soil p^{H}	32
	3.3.3 Textural class	32
	3.3.4 Organic carbon and organic matter	32
	3.3.5 Total nitrogen	32
	3.3.6 Available phosphorus	32
	3.3.7 Exchangeable potassium	33

CONTENTS (Contd.)

CHAPTER	TITLE		Page No.
	3.4	Chemical analysis of plant sample	33
	3.4.1	Collection and Preparation of Plant sample	33
	3.4.2	Digestion of plant samples with Sulphuric acid for N estimation	33
	3.4.3	Digestion of plant samples with nitric acid and perchloric acid for P and K estimation	34
	3.4.4	Grain and straw analysis	34
	3.4.5	Determination of total nitrogen	34
	3.4.6	Determination of phosphorus	34
	3.4.7	Determination of potassium	35
	3.5	Statistical analysis	35
CHAPTER IV	**RESULTS AND DISCUSSION**		**36-78**
	4.1 Effects on yield and yield attributes of BRRI dhan40		36
	4.1.1	Plant height	36
	4.1.2	Number of effective tillerhill^{-1}	37
	4.1.3	Number of non-effective tillerhill^{-1}	37
	4.1.4	Length of Panicle	38
	4.1.5	Number of filled grainspanicle^{-1}	38
	4.1.6	Number of unfilled grains panicle^{-1}	39
	4.1.7	Weight of 1000 grain	39
	4.1.8	Grain yield	39
	4.1.9	Straw yield	40
	4.2	Effects on nutrient content of BRRI dhan40	46
	4.2.1	Nitrogen content in grain and straw	46
	4.2.2	Phosphorus content in grain and straw	48
	4.2.3	Potassium content in grain and straw	48

CONTENTS (Contd.)

CHAPTER	TITLE	Page No.
CHAPTER V	SUMMARY AND CONCLUSION	50-52
	REFERENCES	53-64
	APPENDICES	65-66

LIST OF TABLES

TABLE	TITLE	Page No.
3.1	Morphological, physical and mechanical characteristics of the soil of the experimental field soil	21
	a) Morphological characteristics of soil	20
	b) Physical characteristics of the soil	21
	c) Mechanical and chemical characteristics of soil	21
	d) pH and chemical composition of the soil	22
4.1	Effects of different doses of urea as ball placement and broadcast on N, P and K concentration in grain and straw of T-aman rice BRRI dhan40	47

LIST OF FIGURES

FIGURE	TITLE	Page No.
3.1	Layout of the experiment	24
4.1	Effect of different doses of urea as ball placement and broadcast on plant height of BRRI dhan40	41
4.2	Effect of different doses of urea as ball placement and broadcast on effective tillers hill^{-1} of BRRI dhan40	41
4.3	Effect of different doses of urea as ball placement and broadcast on non effective tillers hill^{-1} of BRRI dhan40	42
4.4	Effect of different doses of urea as ball placement and broadcast on panicle length of BRRI dhan40	42
4.5	Effect of different doses of urea as ball placement and broadcast on grains panicle^{-1}of BRRI dhan40	43
4.6	Effect of different doses of urea as ball placement and broadcast on unfilled grains panicle^{-1}of BRRI dhan40	43
4.7	Effect of different doses of urea as ball placement and broadcast on weight of 1000 grains of BRRI dhan40	44
4.8	Effect of different doses of urea as ball placement and broadcast on grain yield of BRRI dhan40	44
4.9	Effect of different doses of urea as ball placement and broadcast on straw yield of BRRI dhan40	45

LIST OF APPENDIX

APPENDIX	TITLE	Page No.
I	Monthly record of temperature, relative humidity rainfall and Sunshine hour during the period from July to November, 2011	65
I I	Effect of different doses of urea as ball placement and broadcast on yield contributing characters and yield of BRRI dhan40	66

CHAPTER I

INTRODUCTION

Rice is the staple food of about 135 million people of Bangladesh. It provides nearly 48% of rural employment, about two-third of total calorie supply and about one-half of the total protein intake of an average person in the country, rice sector contributes one-half of the agricultural GDP and one-sixth of the national income in Bangladesh. (BRRI, 2008). As of 2009 world food consumption of rice was 531,639 thousand metric tons of paddy equivalent (354,603 of milled equivalent), while Bangladesh consume 38.2 (million metric ton of paddy equivalent, FAO (2010).

Among three types of rice transplant aman covers about 43.34 percent of total rice area and it contributes to 38.26 percent of total rice production in the country (BBS, 2008). From websites or documents of the Library of Congress Country Studies 1988, In the mid-1980s, Bangladesh was the fourth largest rice producer in the world, but its productivity was low compared with other Asian countries, such as Malaysia and Indonesia. It is currently the world's sixth-largest producer. High yield varieties of seed, application of fertilizer, and irrigation have increased yields, although these inputs also raise the cost of production and chiefly benefit the richer cultivators. Rice is a major food staple and a mainstay for the rural population and their food security. It is mainly cultivated by small farmers in holdings of less than 1 hectare. Rice is also a wage commodity for workers in the cash crop or non-agricultural sectors. Rice is vital for the nutrition of much of the population in Bangladesh.

The total production of rice in Bangladesh is not sufficient to feed her people. The urgent need of the crop sector of Bangladesh Agriculture at this moment is to produce more food to feed the country's ever growing population. To attain self-sufficiency in food, efforts must be made to enhance the yield per unit area and improve the quality of the produce. Targeting high yield with a higher cropping intensity is the most logical way to raise the total area from the total production from the limited land resource. The practice of intensive cropping with modern improved variety is a major endeavor of crop production in Bangladesh. This in turn causes a marked depletion of inherent reserves in soils Depleted soil fertility is a major constrains to higher crop production in Bangladesh. The increasing land use intensity has resulted in a greater exhaustion of nutrient in soils. The farmers of this country use on average 102 kg nutrients /ha annually (70 kg N+24 kg P+ 6kg K+ 2 kg S and Zn) while the crop removal is about 200 kg ha^{-1}(Islam *et al*., 1994.)

In Bangladesh most of the soil contains 1.5 percent organic matter while a good soil contains at least 2 percent organic matter.Application of different fertilizer influences the physical and chemical properties of soil. N is a key element which plays a vital role in vegetative growth, development of yield component and yield of rice (BRRI, 1990).

Nitrogen (N) is essential for rice, and usually it is the most yield-limiting nutrient in irrigated rice production around the world (Samonte *et al.*, 2006). Urea is the most widely used N fertilizer in the world because of its high solubility, high N content, low cost, and ease in handling and accounts for over 50% of all N applied. (Glibert *et al.*, 2006).In these areas, prilled urea (PU) conventionally applied by farmers is very inefficiently used by transplanted rice largely because of serious losses (up to 60% of applied N) via NH_3 volatilization, de-nitrification, leaching, and/or runoff. In order to minimize N loss, especially loss due to de-nitrification, historically the Japanese have used different ways of deep placing fertilizer N. In 1975, IFDC proposed use of super granules of urea (USG) in place of mudballs containing urea fertilizer to achieve the same agronomic benefits as achieved through the Japanese concept of deeppoint placement of fertilizer N in transplanted rice.The total nitrogen loss, measured in an open cuvette system, was about 38% with the surface application of urea super granules, whereas this loss was reduced to10% with deep placement of urea super granules. (Eriksen *et al.*, 1995). Urea Super Granule (USG) is one of the nitrogenous fertilizers that is now available in our country and the farmers are using it for Aman rice and banana cultivation (Nazrul *et al.*, 2007). The placement of urea super granule at 8-10 cm depth of soil can save 30 percent nitrogen than prilled urea, increases nutrient absorption, improves soil health and ultimately increases the yields. (Shingh *et al.*, 1993; Shingh and Shingh, 1986).

To minimize the adverse effects of ammonia volatilization, appropriate N management strategies should be considered. In addition to application of urea inhibitors, some other practical options, such as delaying the first urea application until two weeks after emergence, optimizing the timing and placement of urea, using slow-released N fertilizers splitting the application of urea into three or more doses, banding urea so that the granules are not placed too close to seeds rows, and deep placement of urea should be adopted. The scientists all over the world are fighting to increase fertilizer N use efficiency. With this, the present studies have been undertaken the study of urea super granule on the yield and nutrient content of T-aman rice with the following objectives:

I. To evaluate the efficiency of different doses of urea applied as ball placement and broadcast on yield contributing characters and yield of T-aman rice.

II. To find out the changes in nutrient status due to various doses of urea applied as ball placement and broadcast.

CHAPTER II

REVIEW OF LITERATURE

Nitrogen (N) fertilizer is one of the most important investments in a successful rice crop. The rice crop required large amounts of N for its growth and grain production. Generally urea is the most convenient N source for rice. Different forms of nitrogen fertilizer play an important role in wetland rice cultivation. The amount of N required and management of the N varies depending on variety, soil conditions, cultural practices, crop rotations, and other factors. Many experiments were conducted on rice with respect to forms of nitrogen fertilizers in the world especially on rice crop and a few were conducted in Bangladesh. Research work related to the effect of forms of nitrogen fertilizer as urea super granule on the growth, yield and yield component in transplant rice have been reviewed and discussed below-

Sarker *et al.* (2012) conducted an experiment in Sylhet under AEZ-20 (Eastern Surma-Kushiyara Floodplain) to find out the effect of Urea Super Granule (USG) on rice. There were five treatments viz. T_1: recommended nitrogen (N) dose as prilled urea (PU), T_2: recommended N dose as USG, T_3: 10% less than recommended dose of N as USG, T_4: 20% less than recommended dose of N as USG, and T_5: farmers practice (average of 20 farmers N dose used as PU) used in the experiment. Results revealed that yield of rice increased significantly due to application of USG over PU. The highest grain yield of rice 92.04 and 91.36 t ha^{-1} were obtained from the USG (recommended dose) which was statistically similar with USG 10% less than recommended dose (84.78 t ha-1) instead of traditional PU. The treatments T3and T4 were found more effective over PU, and N loss was also minimum than that of prilled urea where 10-20% N fertilizer could be saved by using USG instead of traditional PU.

Salem *et al.* (2011) conducted field experiments to study the effect of nitrogen fertilizer on seedling age Four nitrogen levels were used (0, 55, 110 and 165 kg N ha^{-1}) and three seedling age i.e. 20, 30 and 40 days from sowing. The results indicated that number of tillers hill^{-1}, days from sowing up to panicle initiation, heading dates, leaf area index, leaf area ratio, chlorophyll content,1000-grain weight, panicles length, agronomic efficiency, utilization efficiency and grain yield (t ha^{-1}) were increased by increasing nitrogen levels up to 165 kg N ha^{-1}. The 20 days seedling age recorded the highest values of each studied attributes.

Hasanuzzaman *et. al.* (2009) conducted a field experiment to find out the economic and effective method of urea application in rice crop. The different urea application treatments were (200 kg ha^{-1} at urea two equal splits, ½during final land preparation + ½ at 30 DAT), (200 kg ha^{-1} urea at three equal splits, 1/3 during final land preparation +1/3at 30 DAT + 1/3 at 55 DAT), Urea super granules (USG) @ 50 kg ha^{-1}, Urea super granules @ 75 kg ha^{-1}, 0.5% foliar spray @ 20 kg ha^{-1},1% foliar spray @ 40 kg ha^{-1}. Application of USG @ 75 kg ha^{-1} produced 22.03%. 5.88% more yield than granular urea application at 2 and 3 equal splits. Foliar spray of urea produced the lowest yield components and yield in this study.

Rahman *et al.* (2007) carried out an experiment during T. Aman season, to study the effect of different level of nitrogen on growth and yield of transplant aman rice. The experiment included four treatments viz. 0, 60, 80 and 100 kg N ha^{-1}. The highest number of effective tillers $hill^{-1}$ (9.20), maximum grains $panicle^{-1}$ (100.80) and highest grain yield (5.34 t ha^{-1}) were obtained with 80 kg N ha^{-1}. The highest straw yield (6.98 t ha^{-1}) was obtained at the highest nitrogen level (100 kg N ha^{-1}). The highest harvest index (44.50%) was observed at 80 kg N ha^{-1}. Results showed that 80 kg N ha^{-1} was optimum to produce maximum yield of transplant aman rice.

Manzoor *et al.* (2006) conducted a field experiment to find the appropriate level of nitrogen to get maximum paddy yield of rice. Effect of nine different nitrogen levels i.e. 0, 50, 75,100,125,150,175,200 and 225 kg ha^{-1} on paddy yield and yield components were studied in this experiment. Plant height, number of productive tillers $hill^{-1}$, panicle length, number of grains $panicle^{-1}$, 1000 grain weight and paddy yield showed increasing trend from 0 kg N ha^{-1} up to 175 kg Nha^{-1}. The yield parameters started declining at 200 kg N ha^{-1} level and above. Maximum paddy yield (4.24 t ha^{-1}) was obtained from 175 kg ha^{-1} nitrogen application treatment which also produced highest values of number of grains $panicle^{-1}$ (130.2) along with a maximum 1000 grain weight (22.92 gm). The plant height (139.8 cm) along with number of productive tillers $hill^{-1}$ (23.42) and panicle length (29.75 cm) was maximum at 225 kg N ha^{-1} level.

Mahtalat *et al.* (2005) carried out a field experiment at the experimental field of Agro technology Discipline, Khulna University, Khulna to study the effect of nitrogen on different characteristics of transplanted local aman rice variety, Jatai. The levels of nitrogen used in this study were 0, 20, 40, 60 and 80 kg ha^{-1}. Results of this study revealed that different agronomic characteristics varied significantly among the treatments. Higher N dose produced higher plant height. The highest effective tillerhill^{-1}, panicle length, filled grains panicle^{-1}, 1000-grain weight and grain yield was obtained with 40 kg N ha^{-1}. The highest and lowest biological yield was produced with 40 kg N $ha^{-1}$and 0-kg N ha^{-1} respectively.

Kenzowakimoto (2004) showed that the effect of application of controlled release nitrogen fertilizer (CRNF) on the different styles of paddy rice cultivation was investigated in southwestern Japan. Yield of transplanted rice grown by a single basal application of fertilizer consisting of 30% to 70% of sigmoid CRNF-100 was approximately equal to that grown by split application of ammonium sulfate under the same amount of nitrogen applied. In direct sowing cultivation under dry and flooded condition, rice yield was elevated by using nitrogen fertilizer consisting of 85% to 100% of CRNF. Approximately 30% of nitrogen applied was reduced in a single basal application with fertilizer consisting of 100% of CRNF nitrogen compared with that in split application with ammonium sulfate.

Rawluk, *et al.* (2001) reported that ammonia volatilization loss was decreased by 28–88% due to NBPT application with granular urea.

Ahmed *et al.* (2000) conducted a field experiment to study the effect of point placement of urea super granule (USG) and prilled urea as a source of N in transplant aman rice. USG and PU were applied @ 40, 80, 120, 160 kg N ha^{-1}. A controlled treatment (no N) was including in this experiment. USG was more effective than PU at all respective level of nitrogen in producing all yield components and in turn grain and straw yield. Placement of USG @ 160 kg N ha^{-1} produced highest grain yield (3.85 t ha^{-1}) which was statistically identical to that obtained from 120 N ha^{-1} as USG and significantly superior to that obtained from any other level and source of N.

Savant and Stangel (1998) reported that several farmer-managed field trials conducted in India demonstrate that USG–DAP management can make the fertilizer agronomically more efficient, economically more attractive with less risk, and reduce the loss of nutrients compared to the conventional use of PU and WSP fertilizers.

Islam and Black (1998) conducted a field experiment to the effect of urea super granule on aman rice in 72 Thanas of 31 Districts during the 1996-97. They reported that USG plots on an average produced higher yields than the prilled urea plots while applying 30-40 percent less urea in the form of USG.

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

Das and Shing (1994) reported that grain yield and N use efficiency by rice were greater for deep placed USG than USG broadcast and incorporate or three split applications of prilled urea. Mishra *et al.*,(1994) carried out a field experiment with rice cv. sita giving 0 or 80 kg urea, USG, and neem, lac, rock phosphate or karanj coated urea and showed that the highest grain yield was (33.39t ha^{-1}) obtained by urea in three split applications.

Das and Singh (1994) carried out a field experiment; it showed that wheat grain yield increased with increasing residual N rate and was highest after deep placement of 120 kg N as USG.

Subbaiah *et al.* (1994) reported that the highest grain yield (6.12 t ha^{-1}) was obtained with USG+DAP, 4.26 with PU+SSP and the lowest 2.89 ton $ha^{-1}$with the control. Grain yield, N use efficiency and apparent N recovery are consistently higher particularly during the boro season when N as USG is deep placed. The efficiency is further improved if whole is properly closed immediately after deep point placement of USG.

Patel and Mishra (1994) carried out an experiment on rice cv. IR36 applied with 0, 30, 60, or 90 kg N ha^{-1} as Mussorie rock phosphate coated urea, neem coated urea, gypsum coated urea, USG or prilled urea. The coated materials are incorporated before transplanting, USG are placed 5-10 cm deep a week after transplanting and urea was applied three split doses. They showed that N rate had no significant effect on panicle length, percent sterility and harvest index.

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

Bhale and Shalunke (1993) conducted a field trail to study the response of upland irrigated rice to nitrogen applied through urea and USG. They found that grain yield increase with up to120 kg urea and 100 kg USG. Shing *et al.*, (1993) reported that grain yield and N uptake increased with increased rate of N application and was the highest with deep placed USG.

Bhardwaj and Shing (1993) observed that placement of 84 kg N as USG produced a grain yield of 6.8 t ha^{-1} which was similar to placing 112 kg USG and significantly greater than other N sources and rates.

Sarker and Faroda (1993) reported that the grain yield of millet was the highest with BCUSG and the lowest with urea and in case of wheat, among N sources residual effects were in the order BCUSG> USG>BCU> urea.

Muneshwar *et al.* (1992) reported that the modified urea materials under different moisture regimes influence NH_3 volatilization loss and significantly less NH_3-N loss was observed for USG treatments than from surface applied urea.

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

Savant *et al.* (1991) observed that the broadcast application of urea on the surface soil causes loss up to 50% but point placement of USG in 10 cm depth can save 30% nitrogen as prilled urea, increase absorption rate, improve soil health and ultimately increase rice yield.

Narayanan and Thangamuthu (1991) carried out field experiment on rice cv. TKM9 and IR20 at combatore, Tamil Nadu in 1984-85, N was applied at 30, 60, or 90 kg ha^{-1} using USG placed at a depth of 10 cm in the main plot. They noted that maximum yields of grain and straw were obtained from 90 kg N ha^{-1}, while the lowest was under control treatment.

Schnier *et al.* (1990) reported that using 15N-labeled urea at IRRI showed that fertilizer N recovery with USG point placement was 65–96% while it was only 32–55% with the conventional PU broadcasting due to lower amount of ammonia volatilization loss.

BRRI (1990) reported that optimum dose of nitrogen fertilization plays a vital role in growth and development of rice plant. Its growth is seriously hampered when lower dose of nitrogen is applied which drastically reduces yield.

Nitrogen has a positive influence on the production of effective tillers plant^{-1}, yield and yield attributes.

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

Rama *et al.* (1989) mentioned that the number of panicles m^{-2} increased significantly when N level increased from 40-120 kg N ha^{-1} as different modified materials. USG produced significantly higher number of panicles m^{-2} and grains per panicle than split application of PU. Patra and Padhi (1989) stated that USG recorded the lowest number of tiller per hill, panicle per hill and shortest panicle.

Jee and Mahapatra (1989) also observed that number of panicles m^{-2} were significantly higher at 90kg N ha^{-1} as deep placed urea super granule than split application of urea.

Chakravorti *et al.* (1989) reported that applying 37.5, 75.0 and 112.5 kg N ha^{-1} as USG to rice gave rice yield of 3.85, 5.22, and 5.48 t ha^{-1} respectively compared with 3.10, 4.29 and 4.97 t respectively , with N as urea and 1.95 without N.

Morteza and Siavoshi (2011) study the effect of organic fertilizer on growth and yield components in rice, an experiment was carried out where chicken manure, cow manure and paddy rice were mixed together in 1:1:0.5 ratio to from organic fertilizer. The treatments of organic fertilizer were given in 5 levels (0.5, 1.0, 1.5, 2.0 and 2.5 t ha^{-1}). At one level organic fertilizer 1.5 ton ha^{-1} was mixed with inorganic fertilizers (N-50, P-25, K-25 kg ha^{-1}) and recommended dose of inorganic fertilizer-NPK (N=100, P=50, K=50 kg ha^{-1}) was used as check. The plants without treatments were served as control. Grain yield and its components were significantly increased in all the treatments over control. The maximum grain yield (4335.88 kg ha^{-1}) was noted in plants treated with 2 t ha^{-1} organic fertilizer and it was (4662.71 kg ha^{-1}).

Kapoor *et al.* (2008) showed that deep placement of USG-containing DAP and KCl performed better than broadcast application of urea (three splits), DAP, and KCl for rainfed rice in a Vertisol. Significantly higher grain yields and straw yields, total N, P, and K uptake, and N and P use efficiencies were observed with deep placement of N–P–K compared to broadcast of N–P–K. Furthermore, the amounts of N, P, and K in the floodwater in the deep-placement treatments were negligible—similar to floodwater N, P, and K contents without fertilizer application. Thus, urea based N–P–K compound fertilizers may be agronomical and economically feasible in super granule form by deep placement for flooded rice production.

HAO Hu-lin *et al.* (2007) conducted an pot experiment where effects of N fertilizer application on the concentrations of Fe, Mn, Cu and Zn in shoot of rice and the quality of brown rice were studied. In the treatments with N fertilizer application, the concentrations of Fe, Mn, Cu and Zn in most parts of rice shoot increased compared with control (no N fertilizer application).

Zaman *et al.,* (2000) reported that chemical properties like organic matter content , CEC, total N, exchangeable K, available P, and S, favorably influenced by the application of the organic source of nitrogen and potassium while the inorganic sources mostly did not show positive effect. Soil P^H decrease slightly compared to the initial status.

Santhi *et al.* (1999) observed that application of 100% NPK plus FYM decreased the bulk density and increase the water holding capacity of soil. The water holding capacity was increased due to the structural condition of the soil that was brought about mainly by the application of FYM in combination with NPK fertilizer.

Vijaya and Subbaiah (1997) conducted an experiment with rice cv. IET 1444 treated with fertilizer at 90 kg N ha^{-1} as prilled urea, large granular urea or urea super granules and 70 kg P_2O_5 ha^{-1} as single super phosphate or large di-ammonium phosphate, both applied by broadcasting or placement methods. They showed that plant height, no. of tillers, root length, no. and weight of panicles, N and P uptake dry matter and grain yield of rice increased with increasing urea super granule size and were greater with the deep placement of both N and P compared to their broadcasting application.

Mathew and Nair (1997) reported that cattle manure when applied alone or in combination with chemical fertilizer (NPK) increased the organic C content, total N, available P and K in rice soils. Sarker and Singh (1997) reported the organic fertilizer when applied alone or in combination with inorganic fertilizer increased the level of organic carbon in soil as well as the total P, N and K contents of soil.

Nambiar (1997) reported that integrated use of organic manure and chemical fertilizer would be quite promising no only in providing greater stability in production, but also in maintaining healthy soil fertility status. Intensive crop production system have witnessed serious problem associated with loss of soil fertility as a result of excessive soil mining of plant nutrients and consequently reduction of productivity.

Nahar *et al.* (1995) examined the soil condition after one crop cycle (rice wheat). Addition of organic matter during the rice crop doubled the organic carbon content compared to its original status. Total and available N contents were significantly improved by addition of organic matter, but had less impact on soil exchangeable cations.

Choudhury and Bhuiya (1994) reported that the relative performances of PU, ULG, USG, and Azollon in wetland rice culture were evaluated in BRRI.

Considering grain yield, USG was significantly superior to PU and azollon, whereas ULG had a slight edge over PU but was not statistically different. Total N uptake increased significantly in ULG- and USG-treated plots compared to the conventional PU-treated plots. Agronomic efficiency and apparent recovery of added N were considerably higher with USG and ULG compared to PU.

More (1994) reported from three years study that application of 20 t ha^{-1} FYM + 20 t ha^{-1} press mud decreased the soil p^{H} and increased organic matter content and available N, P and Kin soil. Medhi *et al.* (1996) reported that incorporation of organic of inorganic sources of N increased soil solution NH_4-N to a peak and then declined to very low levels.

Bhandari (1992) reported that an application of fertilizer or their combined use with organic manure increased the organic C status of soil. The NPK fertilizers at 100% level and their combined use with organic nitrogen sources also increased the available N and P by 5.22 kg and 0.83-3.8 kg ha^{-1} from their initial value.

Prasad and Kerketta (1991) conducted an experiment to assess the soil fertility, crop production and nutrient removal under different cropping sequences in the presences of recommended doses of fertilizers and cultural practices along with5 t ha^{-1} compost applied to the crops. There was overall increase in organic C, increase in total N (83.9%), available N (69.9%), available P (117.3%) and CEC (37.3%).

Bair (1990) stated that sustainable production of crop cannot be maintained by using chemical fertilizers only and similarly it is not possible to obtain higher crop yield by using organic manure alone. Sustainable crop production might be possible through the integrated use of organic manure and chemical fertilizer.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted in the farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. During the period from June to December, 2011 to study the effect of urea super granule on the yield and nutrient content of T-aman rice. This chapter includes materials and methods that were used in conducting the experiment. The details are presented below under the following headlines.

3.1 Description of the experimental site

3.1.1 Location of the experimental field

The experiment was at the Sher-e-Bangla Agricultural University farm, Sher-e-Bangla Nagar, Dhaka. Geographically, the experimental area is located at 24°75N N and 90°50N E longitude at the elevation of above 18 m the sea level.

3.1.2 Characteristics of the soil

The experimental soil is silt loam in texture belonging to the agro ecological zone of the Madhupur Tract (AEZ 28). The selected plot was fairly leveled land . The physical and chemical characteristics of the soil were determined at the Agricultural Chemistry Laboratory. Sher-e-Bangla Agricultural University, Dhaka. The characteristics of the soil are shown in Table 3.1.

3.1.3 Climate

The climate of experimental area is characterized by the high temperature, high humidity, and medium rain fall with occasional gusty winds. During the Kharif season (March-September) and scanty rainfall associated moderately low temperature in the rabi season (October-February). The weather information regarding temperature, rainfall, relative humidity and sunshine hours prevailed at the experimental site during the cropping season June to December 2011 have been presented in Appendix I.

Table 3.1. Morphological, physical and mechanical characteristics of the experimental field soil

a) Morphological characteristics of soil

Morphology	Characteristics
Locality	SAU farm, Dhaka
Agro-ecological zone	Madhupur Tract (AEZ 28)
General Soil Type	Deep Red Brown Terrace Soil
Parent Material	Madhupur Terrace
Topography	Fairly Level
Drainage	Well drained
Flood Level	Above flood level
Vegetation	Cropped with rice, pulse, mustard and other vegetation

b. Physical characteristics of the soil

Depth in cm	Description
0-15 cm	The soil is soft and feels floury. It appears cloddy but readily broken. When pulverized the soil is light brownish in color when pulverized. The soil is light brownish in color when wet, it shows finger print when pressed with thumb.

c. Mechanical and chemical characteristics of soil

Characteristics	Value
Mechanical fractions:	
% Sand (0.2-0.02mm)	22.24
% Silt (0.02-0.002mm)	56.71
% Clay (< 0.002mm)	20.78
Textural class	Silt loam

d. pH and chemical composition of the soil

Parameters	Content
pH (1: 2.5 soil-water)	6.2
CEC(c mol kg^{-1})	17.19
Organic carbon (%)	0.686
Organic matter (%)	1.18
Total N (%)	0.032
Exchangeable K(c mol kg^{-1})	0.12
Available P(mg kg^{-1})	19.89
Available S (mg kg^{-1})	14.38

3.1.4 Planting material

A high yielding variety of rice BRRI dhan40 was taken as the test crop in this experiment. The variety BRRI dhan40 was released by BRRI, Gazipur, in 2003. Average yield of BRRI dhan40 is about 4.5 t ha^{-1} (BRRI, 2004).

3.1.5 Land preparation

The land was first opened on July, 2011 by a tractor and prepared thoroughly by ploughing and cross ploughing with a power tiller followed by country plough. Laddering helped breaking the clods and leveling the land followed every ploughing. Before transplanting each unit of plot was cleaned by removing the weeds stubbles and crop residues. Finally each plot was prepared by cuddling. After uniformly leveling, the experimental plots were laid out according to the requirement of the treatments and statistical design.

3.1.6 Experimental design and layout:

The experiment was laid out in a randomized complete block design (RCBD) where the experimental area was divided into four blocks representing the replications to reduce soil heterogeneous effects. Each block was divided into seven unit plots as treatments with raised bunds around. Thus the total number of unit plot was 28 and size was 2 m × 2 m and ails separated plots from each other. The blocks were separated from one another by one-meter drain and plot to plot distance is 0.5 m. Treatments were randomly distributed within the blocks. The complete layout of the experiment has been presented in Figure 3.1.

3.1.7 Fertilizers and manure application

The fertilizers N, P, K, S and Zn in the form of urea , TSP, MOP, gypsum, and zinc sulphate, respectively were applied. Phosphorus, potassium, sulphur and zinc fertilizer were applied as per recommendation of BRRI. The amount of N, P, K, S and Zn was 112 kg ha^{-1}, 20 kg ha^{-1}, 45 kg ha^{-1}, 15 kg ha^{-1} and 2 kg ha^{-1} respectively (BRRI, 2005). The entire amount of TSP, MOP, gypsum and zinc sulphate were applied in two equal installments at tillering and panicle initiation stage. Urea was also applied in the plot as per the treatment of the experiment. In an addition well decomposed cow dung was mixed with the soil during final land preparation.

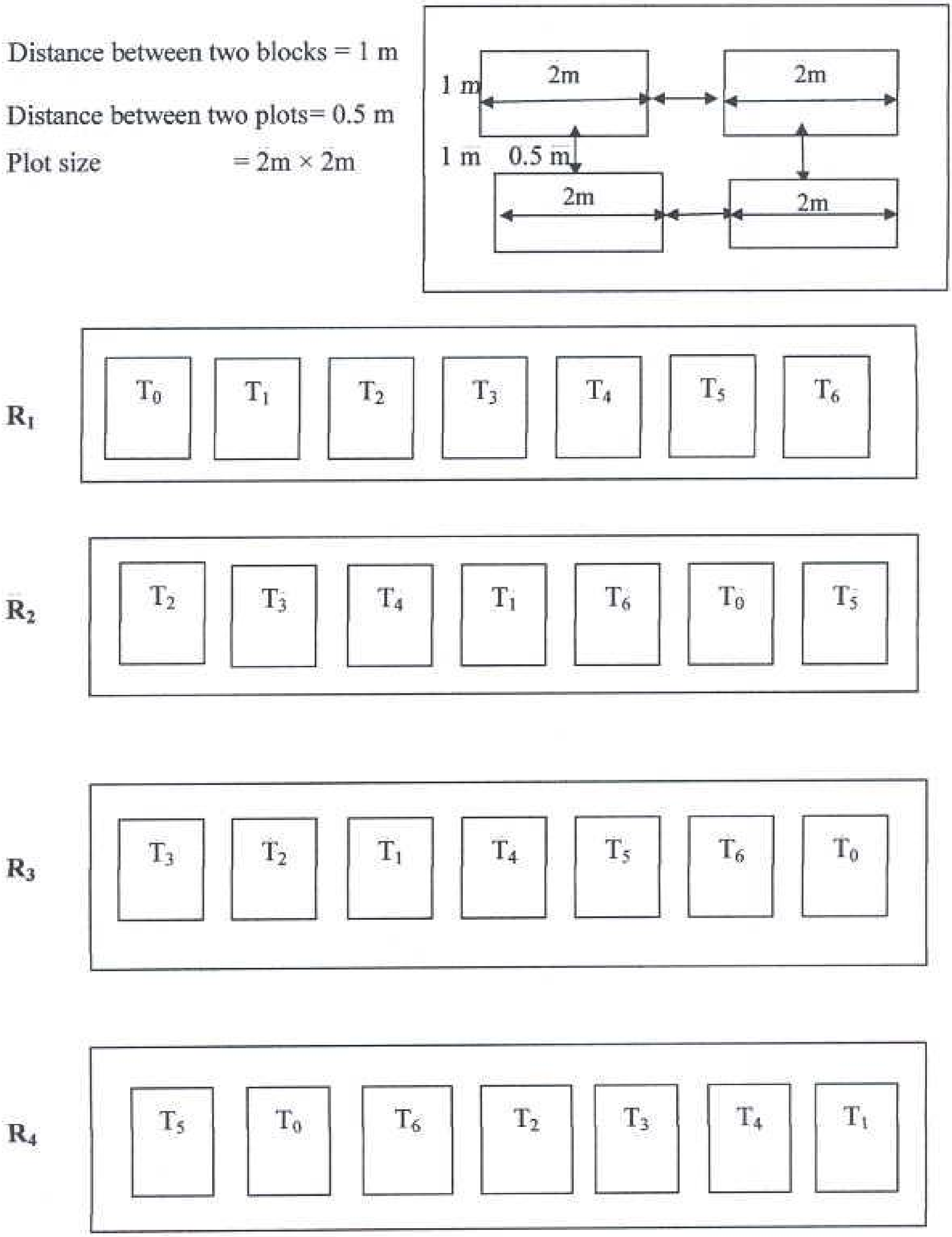

Figure 3.1 Layout of the experiment

3.1.8 Treatments

Urea was ball placed as urea super granule while prilled urea was used for broadcast in the study. The experiment consisted of 7 treatments. The treatments were as followed:

T_0: Control

T_1: 37.5 kg ha^{-1} urea used as urea ball placement

T_2: 56.25 kg ha^{-1} urea used as urea ball placement

T_3: 75 kg ha^{-1} urea used as urea ball placement

T_4: 37.5 kg ha^{-1} urea used as broadcast

T_5: 56.25 kg ha^{-1} used urea as broadcast

T_6: 75 kg ha^{-1} urea used as broadcast

Urea super granule (USG) was applied at 10 days after transplanting (DAT), in the middle of four hills as 9-10 cm apart from the seedling base and at 7-8 cm depth in soil. In this experiment in case of T_1 and T_4 only 50 % of recommended dose (37.5 kg ha^{-1}) used as ball placement and prilled respectively and remaining half was not used. For T_2 and T_5 treatment 75% of recommended dose (56.25 kg ha^{-1}) was applied as ball placement and prilled respectively and remaining 25% is not applied in the plot. In case of T_3 and T_6 full of the recommended dose (75 kg ha^{-1}) was applied in the experimental plot as ball placement and broadcast respectively.

3.1.9 Urea super granule

Today urea fertilizer is manufactured as granule and urea prilled may be applied in the field as a form of urea super granule (USG). Granules are larger, harder, and more resistant to moisture. As a result, granulated urea has become a more suitable material for fertilizer blends. Urea super granule is a modified size of urea that contains 46% of nitrogen Urea super granule would be applied as per recommendation at 7-10 days after transplanting in 8-10 cm soil depth (BRRI, 2004).

3.1.10 Raising of seedling

The seedlings of rice were raised in wet seed bed methods. Seeds (95% germinated) were soaked and incubated for 48 hours and sown on a well prepared seed bed. During seedling growth, no fertilizers were used. Proper water and pest management practices were followed whenever required.

3.1.11 Seedling transplanting

Forty days old seedlings of BRRI dhan40 were carefully uprooted from the seedling nursery and transplanted on 5 August 2011 in well puddled plot. Three seedlings hill^{-1} were used following a spacing of 25 cm × 15 cm. After one week of transplanting, all plots were checked. If seedlings in some hills died off, then these were replaced by gap filling with the seedlings from the same source.

3.1.12 Intercultural operation

Intercultural operations were done to ensure normal growth of the crop. Plant protection measures were followed as and when necessary. The following intercultural operations were done.

3.1.12.1 Irrigation

There was sufficient rainfall during the whole growing period. The necessary irrigations were provided optimum level to the plots and about 5-6 cm water layer were maintained in the pot until the crop attained maturity.

3.1.12.2 Weeding

The plots were infested with some common weeds which were recommended by uprooting them from the field, two weeding at 20 and 30 DAT was done during the growing period of rice crop.

3.1.12.3 Insect and pest control

There was no infestation of diseases in the field but insect leaf roller *(Chaphalocrosis mendinalis*, Pyralidae, Lepidoptera) was observed in the field and Malathion @ 1.12 L ha^{-1} was used.

3.1.13 Recording the data for plant height and tillers

At 120 DAT (days after transplanting), plant height and tillers $hill^{-1}$ were recorded from ten selected hills per plot and the average of plant height and tillers $hill^{-1}$ was calculated

3.1.14 Crop harvest

The crop was harvested at full maturity when 80% of the grains were turned into golden yellow in color on 9 December 2011. The crop was cut at the ground level and plot wise crop was bundled separately and brought to the threshing floor. Grains were sun dried and moisture content of 14% was adjusted to estimate in grain yield. Sun dried weights of both grain and straw were duly recorded for each plot. The following data were collected and recorded:

1. Plant height (cm)
2. Effective tillers hill^{-1} (no.)
3. Non-effective tillers hill^{-1} (no.)
4. Panicle length (cm)
5. Filled grains panicle^{-1} (no.)
6. Unfilled grains panicle^{-1} (no.)
7. 1000 grain weight (g)
8. Grain yield (t ha^{-1})
9. Straw yield (t ha^{-1})

3.2 Yield components

3.2.1 Plant height

The plant height (cm) was recorded at harvest. Data was recorded as the average of 10 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the panicle.

3.2.2 Number of tillers

The number of tiller hill^{-1} was recorded at harvest by counting total tillers. Data were recorded as the average of 10 hills selected at random from the inner rows of each plot.

3.2.3 Effective tillers hill^{-1}

The number of effective tillers hill^{-1} was counted as the number of panicle bearing plant hill^{-1}. Data on effective tillers hill^{-1} were counted from 10 selected hills and average value was recorded.

3.2.4 Non-effective tiller hill^{-1}

The non-effective tillers hill^{-1} was counted as the number of non-panicle bearing plant hill^{-1}. Data on non-effective tillers hill^{-1} were counted from 10 selected hills and average value was recorded.

3.2.5 Total tiller

The total number of tillers $hill^{-1}$ was counted as the number of effective tillers $hill^{-1}$ and non-effective tillers $hill^{-1}$. Data on total tillers $hill^{-1}$ were counted from 10 selected hills and average value was recorded.

3.2.6 Length of panicle

The length of panicle was measured with a meter scale from 10 selected plants and the average value was recorded as per plot.

3.2.7 Filled grains $panicle^{-1}$

The filled grain of each of the effective tiller for the individual plant and consequently those of all the selected ten plants were counted, the average of which gave the number of filled grain number per panicle.

3.2.8 Unfilled grains $panicle^{-1}$

The number of unfilled grain was counted from the randomly selected hill $plant^{-1}$, the average of which gave the number of unfilled grain.

3.2.9 Total grain

The total of grain $panicle^{-1}$ was collected randomly from 10 selected plants of a plotcounting by adding filled and unfilled grain and then average number of grain $panicle^{-1}$ was recorded.

3.2.10 1000-grain weight

The thousand grains were counted randomly from cleaned harvested grain of each plot and then weighed in grams and recorded.

3.2.11 Grain yield

Grains obtained from each unit plot were sun dried and weighted carefully. The dry weights of grains of central 1 m^{-2}area was recorded of the respective unit plot and finally converted to t ha^{-1}.

3.2.12 Straw yield

Straw obtained from each unit plot were sun dried and weighted carefully. The dry weight of straw of central 1 m^2 area was recorded of the respective unit plot and finally converted to t ha^{-1}.

3.3 Soil analysis

3.3.1 Collection and preparation of soil samples

The soil samples were collected at a depth of 0-15 cm from the experimental plots prior to addition of fertilizers. The pre planting soil samples were drawn by means of an auger from ten different random spots covering the whole experimental plot and were mixed thoroughly to make a composite sample. From the collected soil samples the stones, gravels, rabbles, plant roots, leaves etc were picked up, removed and sieved through a 10 mesh sieve. The soil samples were kept in a clean plastic container for physical and chemical analyses.

3.3.2 Soil pH

Soil pH was measured with the help of a glass electrode pH meter, the soil water ratio being maintained at 1:2.5 as described by Jackson (1973).

3.3.3 Textural class

Mechanical analysis of soil was done by hydrometer method as described by Piper (1966) and the textural class was determined by fitting the value for sand, silt and clay to the textural triangle following USDA system.

3.3.4 Organic carbon and organic matter

Walkely and Blacks (1965) wet oxidation method was followed to determine the percentage of organic carbon as outlined by Jackson (1973).

3.3.5 Total nitrogen

Total nitrogen content of the soil sample was determined by macro kjeldahl method by digestion with concentrated H_2SO_4 and digestion catalyst mixture (K_2SO_4: $CuSO_4.5H_2O$: Se= 10 : 1 : 0.1) and then distilled with 40% NaOH, the ammonia distilled with over was absorbed in boric acid in presence of mixed indicator (0.066 g methyl red + 0.99 g bromocresol green [$C_{21}H_{14}O_5Br_4S$] + 100 ml 95% methanol) and titrated against 0.01N H_2SO_4 (PCARR, 1980).

3.3.6 Available phosphorus

Available phosphorus was extracted from the soil with 0.5M $NaHCO_3$ at a pH of 8.5. The phosphorus in the extract was then determined by developing the blue color by $SnCl_2$

which formed phosphomolybdate complex and the color intensity was measured colorimetrically at 660 nm wavelength (Olsen *et al.*, 1954) with the help of a spectrophotometer .

3.3.7 Exchangeable potassium

Soil samples were extracted with 1N ammonium acetate (1N NH_4OAC, pH 7.0) and then exchangeable potassium content in the extract was determined by using flame photometer (Black, 1965).

3.4 Chemical analysis of plant sample

3.4.1 Collection and preparation of plant samples

Grain and straw samples were collected after threshing and dried in an oven at 65^0 C for 72 hours. The plant samples were finely ground by using a Wiley-Mill with a 60- mesh sieve. The samples were stored in a plastic vial for analysis of K, P and S.

3.4.2 Digestion of plant samples with sulphuric acid for N estimation

An amount of 1 g oven dry, ground sample was taken in a 250 ml conical flask and 0.1 g catalyst mixture (K_2SO_4: $CuSO_4.5H_2O$: Se = 100:10:1). Two (2) ml 30% H_2O_2 and 15 ml conc. H_2SO_4 were added. The flask was swirled and allowed to stand for about 10 minutes followed by heating at 200°C. Heating was continued until the digest was clear and colorless. After cooling, the contents were taken into a 100 ml volumetric flask and the volume was made with distilled water. This digestion was used for N determination.

3.4.3 Digestion of plant samples with nitric acid and perchloric acid for P and K estimation

Exactly 1g of finely ground grain and straw materials were taken into a 250 mL conical flask and 15 ml of di-acid mixture (HNO_3 : $HClO_4$ = 2:1) was added to it. Then it was placed on an electric hot plate for heating at 180-200°C until the solid particles disappeared and white fumes were evolved from the flask. Then, it was cooled at room temperature, washed with distilled water and filtered into 100 ml volumetric flasks through Whatman No. 42 filter paper making the volume up to the mark with distilled water following wet oxidation method as described by Jackson (1973). This digestion was used for determination of P and K.

3.4.4 Grain and straw analysis

The grain and straw samples were chemically analyzed for the following parameters:

3.4.5 Determination of total nitrogen

The total nitrogen content of the plant samples was determined by macro Kjeldhal method as described by Page *et al.* (1982).

3.4.6 Determination of phosphorus

Phosphorus in the plant sample digest was determined by using 10 ml sample of grain and straw samples from 100 ml extract and diluted to 100 ml was then determined by developing blue color with reduction of phosphomolybdate complex and the color intensity were measured calorimetrically at 660 nm wavelength and readings were calibrated with the standard P curve (Page *et al.* 1982).

3.4.7 Determination of potassium

Exactly 5ml of digest sample for the grain and 10 ml for the straw were taken and diluted 100 ml volume to make desire concentration so that the emission radiation of sample was measured within the range of standard solutions. The content of K was measured by flame photometer.

3.5 Statistical analysis

The data obtained for different parameters were analyzed to find out the significant difference of different treatments on yield and yield contributing characters of BRRI dhan40 using MSTAT-C software. The mean value of all the parameters was calculated and analysis of variance was performed by the F-test. The significant difference among the treatments was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

This chapter contains results of the experiment and the follow-up discussion. For convenience, the whole chapter has been divided into two sections:

a) Agronomic characteristics

b) Nutrient contents

The experiment was conducted to find out the effect of different doses of urea as ball placement and broadcast on the yield and nutrient content of T-aman rice e.g. plant height, effective and non-effective tillers hill^{-1}, panicle length, number of filled and unfilled grains panicle^{-1} and 1000-grain weight while the chemical analyses of rice grain and straw include nitrogen, phosphorus, potassium etc. as influenced by different levels of urea as ball placement and prilled. The results of the whole experiment are shown in Appendix II, Tables 4.1 and Figures 4.1-4.9 which have been discussed under the following sub sections. The results have been discussed and possible interpretations under these following headings:

4.1 Effects of different doses of urea as ball placement and broadcast on yield and yield attributes of BRRI dhan40

4.1.1 Plant height

Growth of rice plant was greatly influenced by different methods of application of urea fertilizer. In this study plant height was significantly affected by urea at all of growth stage. Maximum plant height of BRRI dhan40 showed statistically significant variation due to the application of urea. However, the tallest plant (80.17 cm) was achieved from T_3 (75 kg ha^{-1} as ball placement) and it was statistically similar to T_6, T_2 and T_5 treatments and the shortest plant (59.88cm) grew from T_0 as control treatment (Appendix II and Figure 4.1). From the data it was revealed that all the treatments produced significantly taller plants compared to the control treatment. Application of urea super granule at higher rate facilitated higher vegetative growth over T_4 and T_5; hence T_3 showed maximum plant height. This result was supported by Islam *et al.* (2009).

4.1.2 Number of effective tiller

At harvest number of effective tillers $hill^{-1}$ of rice plant was also significantly affected by different urea treatments in BRRI dhan40. The maximum number of effective tiller $hill^{-1}$ (13.00) was observed from T_3 (75 kg ha^{-1} urea as super granule) which was statistically similar with T_6 and T_2 treatments and minimum number of tiller $hill^{-1}$was observed in T_0as control condition (Appendix II and Figure 4.2). Adequate of nitrogen as USG probably favored the development of plant which led to increased number of productive tiller per hill. Shing and Shing (1986) also reported the similar findings from their experiment.

4.1.3 Number of non-effective tillers

Application of different treatments of urea showed statistically significant variation to the number of non-effective tillers $hill^{-1}$ of BRRI dhan40. The maximum number of non-effective tillers $hill^{-1}$ (4.30) was obtained from T_3 (75 kg ha^{-1} as ball placement).On the other hand, the maximum number of non-effective tillers $hill^{-1}$(2.23) was recorded from T_4, which was statistically identical with T_1 treatment (Appendix II and Figure 4.3).

4.1.4 Length of panicle

A statistically significant variation recorded due to the application of urea as USG prilled urea on length of panicle of BRRI dhan40. The longest panicle (24.58cm) was found from T_3 (75 kg ha^{-1} as ball placement) followed by T_6 (23.57 cm), T_2 (23.31 cm), T_5 (22.74 cm) and T_1 (22.88 cm) treatments (Appendix II). On the other contrary, the shortest panicle (18.05 cm) was obtained from T_0 as control condition which was closely followed by T_4 (Figure 4.4). Sarder *et al.* (1988); Rajagopalan and Palanisamy (1985) and Talukder (1973) also recorded similar results with the application of urea super granule. Jee and Mahapatra (1989) also observed that length of panicle m^{-2}were significantly higher @ 90 kg N ha^{-1} as deep place urea super granules (USG) than split application of urea.

4.1.5 Number of filled grains

Number of filled grains per panicle significantly varied due to the application of different dose of as USG and prilled urea. The maximum number of filled grains per panicle (90.96) was observed from T_3 (75 kg ha^{-1} as ball placement) followed by T_6 (88.56), T_2 (87.90) and T_5 (85.66). On other contrary, the lowest (53.29) was obtained from T_0 as control condition (Appendix II and Figure 4.5). Results reveled that application of urea super granule exerted considerable positive effect on the number of filled grain per panicle. USG increased the number of grain per panicle that was also observed by Rama *et al.* (1989) and Kaper *et al.* (1996).

4.1.6 Number of unfilled grains

A statistically significant variation was found on number of unfilled grains panicle^{-1} due to the application of urea as USG and prilled urea on BRRI dhan40. The maximum number of unfilled grains per panicle (13.94) was observed from T_0 which was closely followed by T_4 and T_1 treatments but the minimum number of unfilled grain (8.19) was observed by T_3 (Appendix II and Figure 4.6).

4.1.7 Weight of 1000-grain

A statistically non-significant difference was recorded due to the application of urea as USG and prilled urea for weight of 1000 grains weight of BRRI dhan40. Though the highest weight of 1000 grains (21.77 g) was recorded from T_3 (75 kg ha^{-1} as ball placement) which was almost similar with T_6 (21.38 g) and T_2 (21.02 g), T_1 (20.60 g) and T_5 (20.45 g) while, the lowest was found from T_0 as control condition which was closely followed by T_4 (Appendix II and Figure 4.7).

4.1.8 Grain yield

Grain yield (t ha^{-1}) of BRRI dhan40 was significantly affected by application of ureaas USG and prilled urea. The highest grain yield (7.04 t ha^{-1})was observed from T_3 (75 kg ha^{-1} as ball placement) followed by T_2 (6.68 t ha^{-1}),T_6 (6.57 t ha^{-1}).On other contrary, the lowest yield (2.71 t ha^{-1}) was obtained from T_0 as control condition which was closely followed by T_4 (4.42 t ha^{-1}) (Appendix II and Figure 4.8). USG as a source of N on grain yield of rice has been observed by Sarker and Batista (1991); Shing and Shing, (1986); Pandey and Tiwari, (1996); Vijay and Subbaiah (1997). Bhardwaj and Singh (1993) observed that placement of 84kg N ha^{-1} as USG produced a grain yield of 6.8 t ha^{-1} which was similar to placing 112 kg USG and significantly greater than other nitrogen sources rates.

4.1.9 Straw yield

The application of different forms of urea (USG and prilled) showed a significant variation in straw yield of BRRI dhan40. The highest amount (7.94t ha^{-1}) straw was observed from T_3 (75 kg ha^{-1} as ball placement) which was statistically similar with T_6followed by T_5 (7.30 t ha^{-1}), and T_2 (7.22 t ha^{-1}). On other contrary, the lowest straw yield (5.27 t ha^{-1}) was obtained from T_0 as control condition which was closely related to T_4 (Appendix II and Figure 4.9).

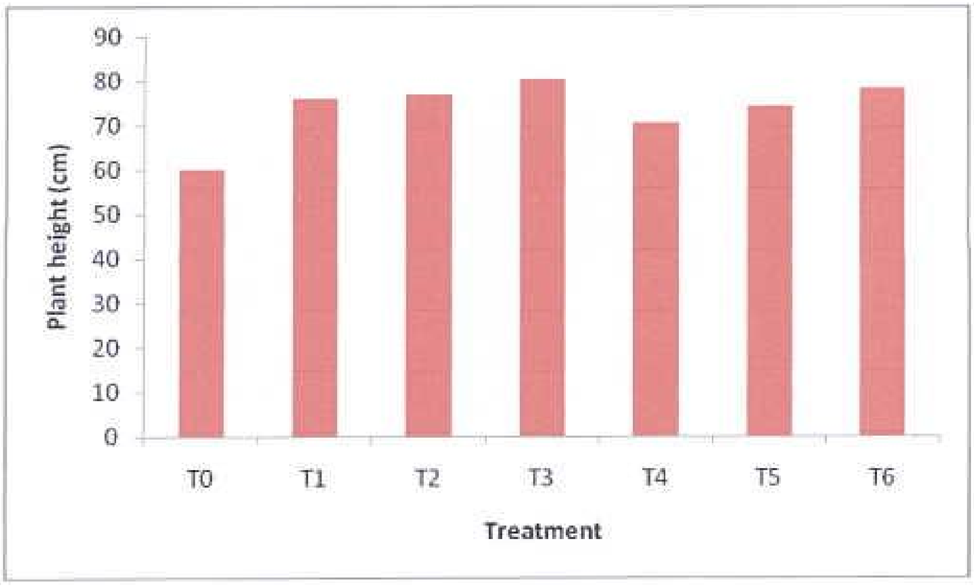

Figure 4.1 Effect of different doses of urea as ball placement and broadcast on plant height of BRRI dhan40

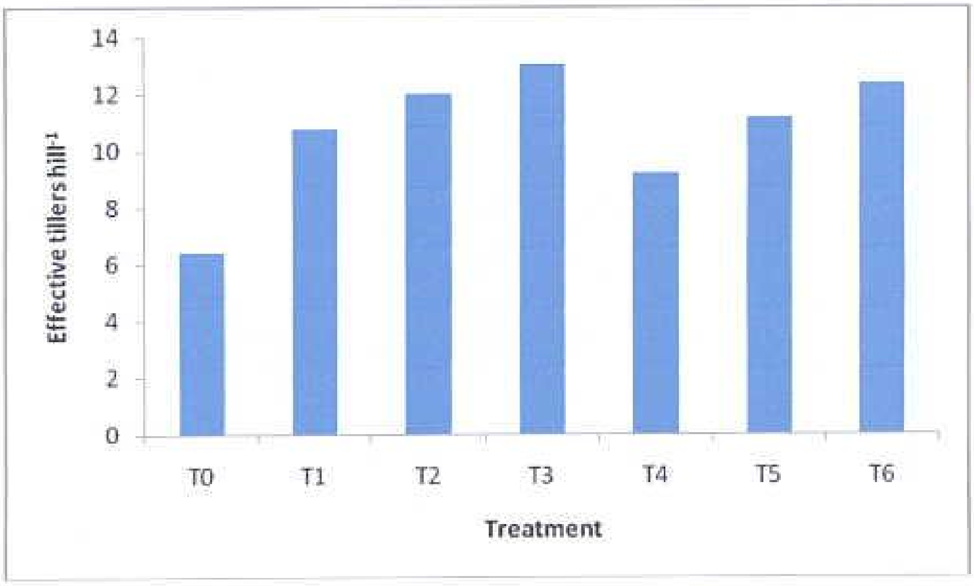

Figure 4.2 Effect of different doses of urea as ball placement and broadcast on effective tillers hill^{-1} of BRRI dhan40

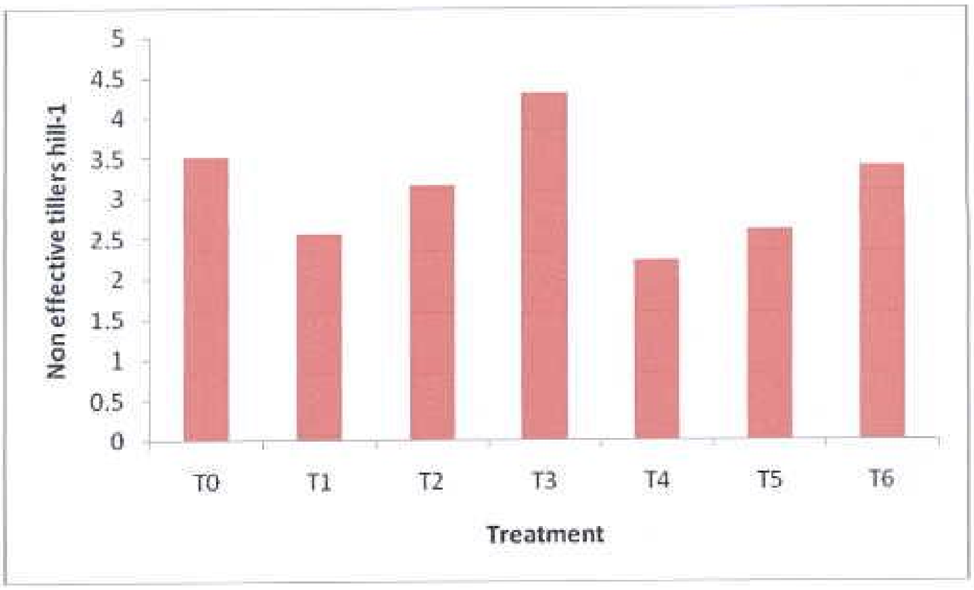

Figure 4.3 Effect of different doses of urea as ball placement and broadcast on non effective tillers hill^{-1} of BRRI dhan40

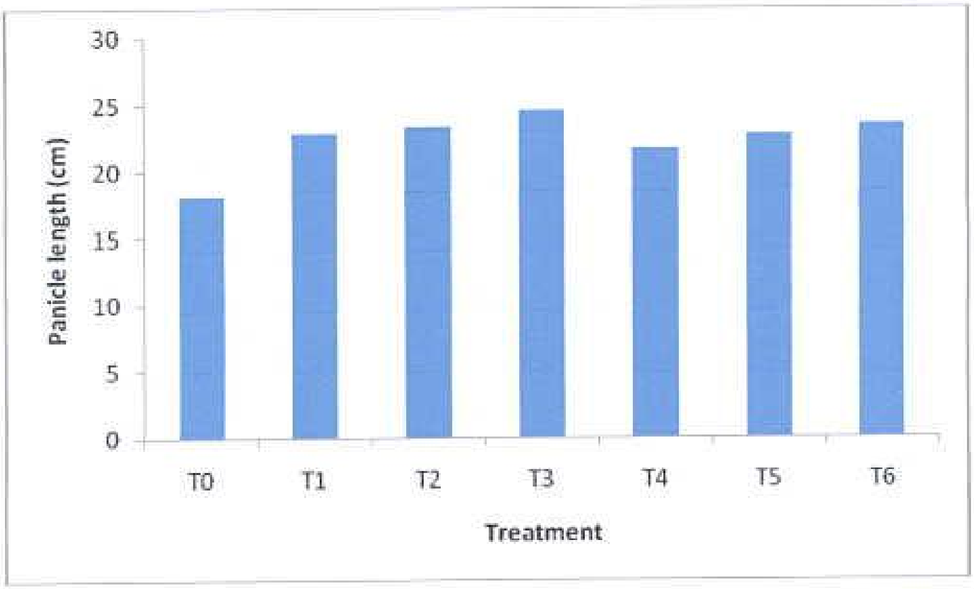

Figure 4.4 Effect of different doses of urea as ball placement and broadcast on panicle length of BRRI dhan40

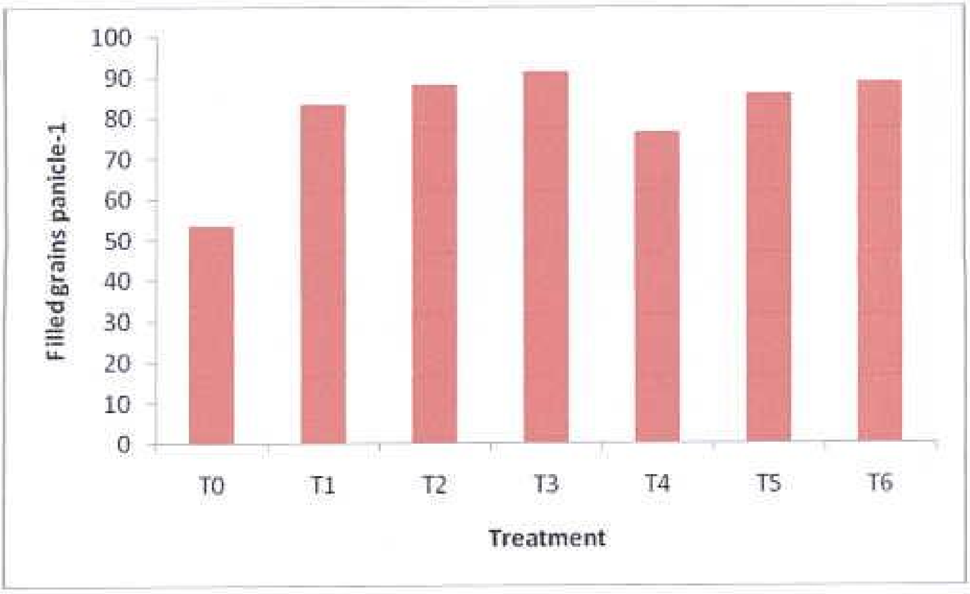

Figure 4.5 Effect of different doses of urea as ball placement and broadcast on filled grains panicle^{-1} of BRRI dhan40

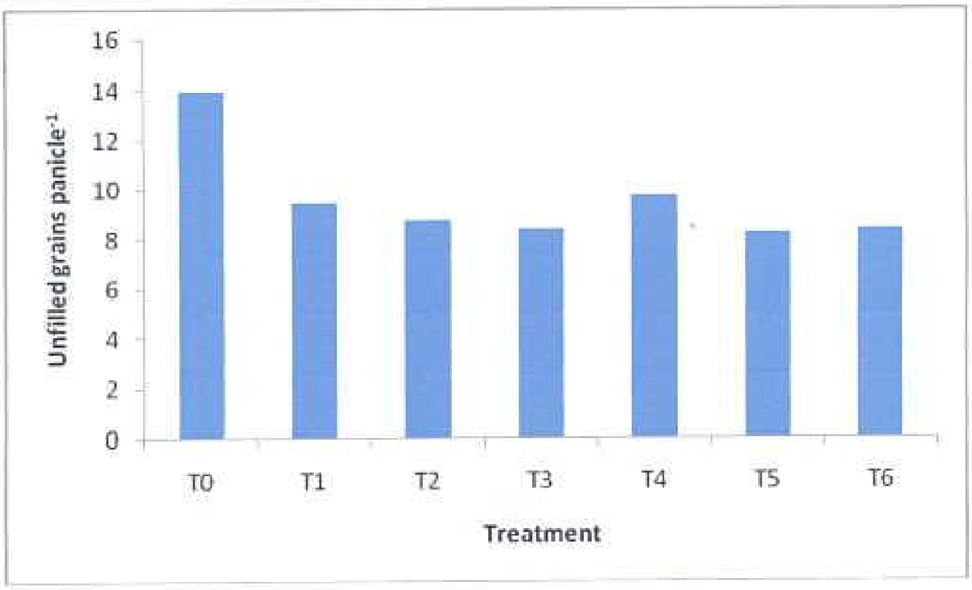

Figure 4.6 Effect of different doses of urea as ball placement and broadcast on unfilled grains panicle^{-1} of BRRI dhan40

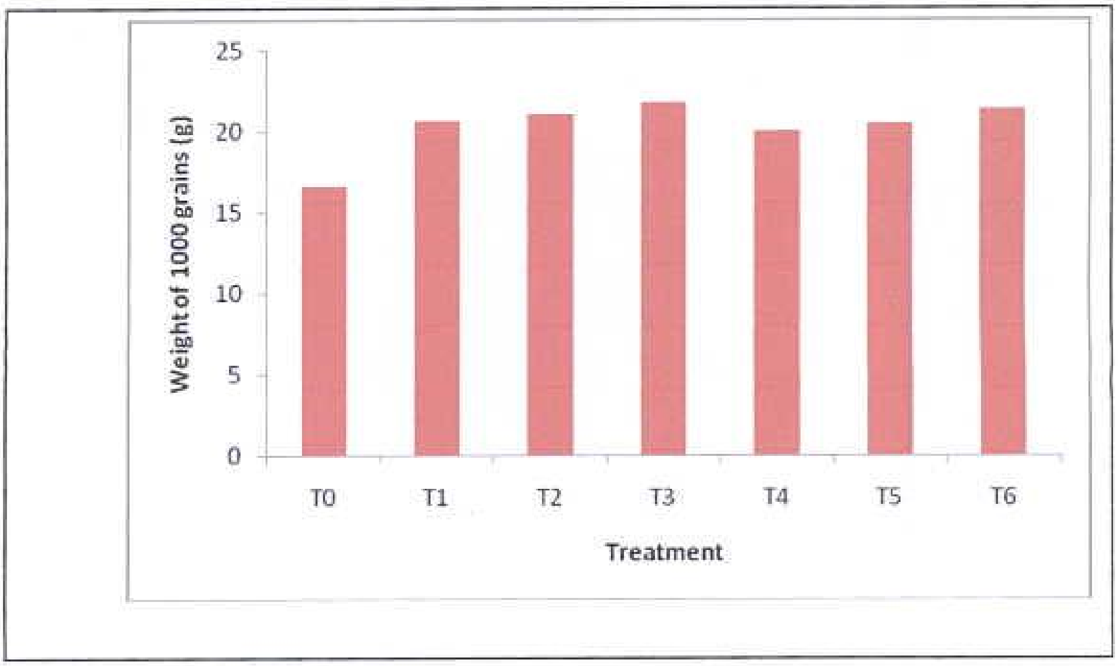

Figure 4.7 Effect of different doses of urea as ball placement and broadcast on weight of 1000 grains of BRRI dhan40

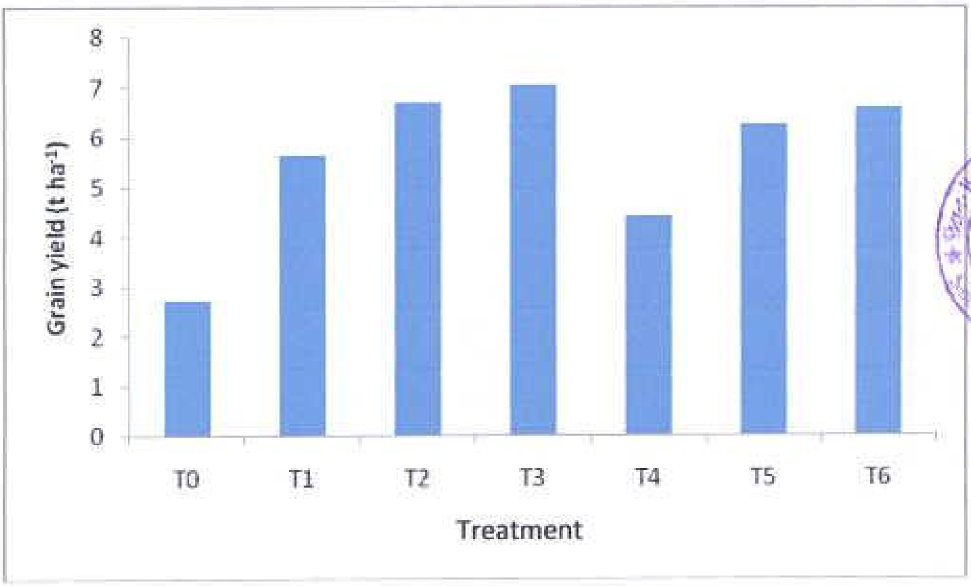

Figure 4.8 Effect of different doses of urea as ball placement and broadcast on grain yield of BRRI dhan40

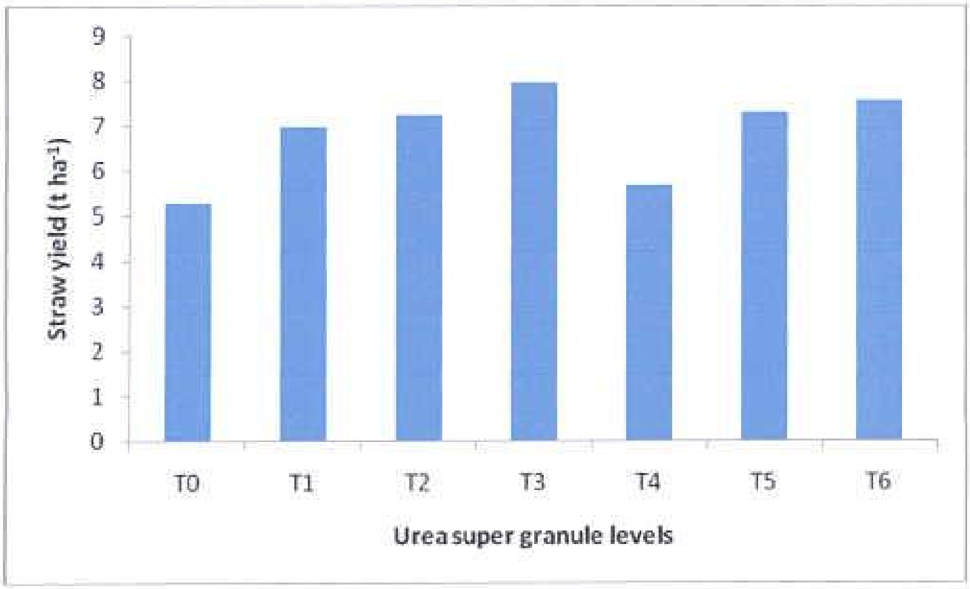

Figure 4.9 Effect of different doses of urea as ball placement and broadcast on straw yield of BRRI dhan40

4.2 Effects of different doses of urea as ball placement and broadcast on nutrient content of BRRI dhan40

4.2.1 Nitrogen content in grain and straw

Nitrogen concentration in grain showed a statistically non-significant difference due to the application of urea as USG and prilled urea. But the highest N concentration in grain (0.731%) was observed from T_3 (75 kg ha^{-1} as ball placement) which was almost similar with T_6 (0.705%). On the other contrary, the lowest N concentration in grain (0.601%) was found from T_0 which was closely followed (0.634%) by T_4 (Table 4.1). Application of urea super granule increased the N content in grain. A significant increase in N content in rice grain and straw due to the application of 100 kg N per hector from urea super granule has been supported by Ram Babu *et al.* (1983).

The nitrogen concentration in straw also showed a statistically non-significant difference due to the application of urea as USG and prilled urea. Though the highest N concentration in straw (0.503%) was observed from T_3 (75 kg ha^{-1} as ball placement) which was closely followed by T_6 (0.471%) and T_2 (0.452%). On the other contrary, the lowest N concentration in straw (0.376%) was found from T_0 which was closely followed (0.403%) by T_4 (Table 4.1). The application of urea super granule increased the N content in straw. A significant increase in N content in rice straw due to the application of fertilizers has been reported by Azim, (1999).

Table 4.1 : Effects of different doses of urea as ball placement and broadcast on N, P and K concentration in grain and straw of T-aman rice BRRI dhan40

Treatment	Concentration (%) in grain			Concentration (%) in straw		
	N	P	K	N	P	K
T_0	0.601	0.207	0.286	0.376	0.064	0.918 d
T_1	0.653	0.245	0.330	0.425	0.072	1.11 b
T_2	0.668	0.263	0.339	0.452	0.075	1.16 a
T_3	0.731	0.292	0.365	0.503	0.084	1.17 a
T_4	0.634	0.220	0.323	0.403	0.068	1.02 c
T_5	0.623	0.243	0.335	0.428	0.072	1.05 c
T_6	0.705	0.263	0.351	0.471	0.082	1.17 a
$LSD_{(0.05)}$	0.33	0.42	0.36	0.34	0.39	0.04
Level of significance	NS	NS	NS	NS	NS	0.01
CV(%)	2.67%	5.20%	4.17%	3.37%	6.98%	3.48%

T_0 : Control, T_1 : 37.5 kg ha^{-1} urea as ball placement, T_2 : 56.25 kg ha^{-1} urea as ball placement, T_3 : 75 kg ha^{-1} urea as ball placement, T_4 : 37.5 kg ha^{-1} urea as broadcast, T_5 : 56.25 kg ha^{-1} urea as broadcast, T_6 : 75 kg ha^{-1} urea as broadcast

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability; NS: Not significant

4.2.2 Phosphorus content in grain and straw

Application of urea as USG and prilled forms showed a statistically non-significant variation in the P concentration in grain. The highest P concentration in grain (0.292%) was recorded from T_3 (75 kg ha^{-1} as ball placement) which was almost identical with T_6 (0.263%). On the other hand, the lowest P concentration in grain (0.207%) was recorded from T_0 which was closely followed by T_4 (0.220%) (Table 4.1). An increase in P content in rice grain due to the application of chemical fertilizers was reported by many investigators (Razzaque, 1996; Azim, 1999).

Statistically non-significant variation was observed due to the application of urea as USG and prilled forms for P concentration in straw. The highest P concentration in straw was recorded from T_3 (0.084%) which was almost similar with T_6 (0.082%). On the other hand the lowest P concentration in straw (0.064%) was recorded from T_0 which was closely followed (0.068%) by T_4 (Table 4.1).

4.2.3 Potassium content in grain and straw

A statistically non-significant variation was obtained due to the application of urea as USG and prilled in terms of K concentration in grain. The highest K concentration in grain (0.365%) was observed from T_3 (75 kg ha^{-1} as ball placement) which was almost identical with T_6 (0.360%). While, the lowest 0.286%) was recorded from T_0 which was closely followed by T_4 (0.323%) (Table 4.1).

Due to the application of urea as USG and prilled urea a statistically significant variation was recorded for K concentration in straw. The highest K concentration (1.17 %) in straw was found from T_3 (75 kg ha^{-1} as ball placement) followed by T_2 (1.16 %) which was statistically identical with T_2 (1.16%). Again the lowest K concentration in straw (0.918%) was recorded from T_0 which was closely followed by T_4 (1.02 %) (Table 4.1).

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from July to December, 2011 to study the effect of urea super granule on the yield on the quality of T-aman rice. BRRI dhan40 was used as the test crop in this experiment.

The soil at the experiment field belongs to the agro-ecological zone of Madhupur tract (AEZ- 28). The experiment consisted of 7 treatments. Such as- T_0 : Control, T_1 : 37.5 kg ha^{-1} urea as ball placement, T_2 : 56.25 kg ha^{-1} urea as ball placement, T_3 : 75 kg ha^{-1} urea as ball placement, T_4 : 37.5 kg ha^{-1} urea as broadcast, T_5 : 56.25 kg ha^{-1} urea as broadcast, T_6 : 75 kg ha^{-1} urea as broadcast.

The experiment was laid out in the Randomized Completely Block Design (RCBD) with 4 replications. The size of unit plot was (2 m x 2 m) and the number of total plots was 28. The experimental plot was fertilized with urea, TSP, MOP and zinc sulphate one day prior to transplanting during the final land preparation. Urea was applied in three splits. The intercultural operations such as irrigation, weeding, ail repairing and application of insecticides were done as and when needed.

The pre-planting soil samples were collected from 10 spots of the experimental plot at a depth of 0-15 cm and chemically analyzed. After the crop had been harvested from each unit plot at maturity, the yield and yield contributing characters were recorded. Nitrogen, phosphorus and potassium contents of rice grain and straw were studied. The collected and calculated data were analyzed statistically.

At harvest the tallest plant (80.17 cm) was obtained from T_3 whereas, at the same time the shortest plant (59.88 cm) was observed from T_0. At harvest the highest of effective tillers per hill (13.00) was found from T_3 hand, the lowest (6.8) was observed from T_0. The highest non-effective tillers^{-1} hill (4.30), the longest panicle (24.58cm), maximum number of filled grains panicle^{-1} (90.96), maximum number of unfilled grains panicle^{-1} (13.94), highest weight of 1000 seeds (21.77 g), the highest grain (7.04 t/ha) and straw yield (7.94 t/ha), were obtained from the treatment T_3 (75 kg ha^{-1} urea as ball placement). The lowest of these parameters were observed in case of control T_0 (no use of fertilizer N).

The highest N concentration in grain and straw (0.731% and 0.503% respectively), the highest P concentration in grain and straw (0.292% and 0.084% respectively) and the highest K concentration in grain and straw (0.365% and 1.17% respectively) were observed from T_3 (75 kg ha^{-1} as ball placement). The lowest of these attributes were found in the control treatment.

From the above discussion it can be concluded that 75 kg ha^{-1} urea as USG was found superior to yield contributing characters and the yield compared to other treatments.

Considering the situation of the present experiment, the following recommendation and suggestion may be made:

1. Ball placement of urea super granule @ 75 kg ha^{-1} may be used instead of prilled urea at farmer's level.

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

REFERENCES

Ahmed, M.H., M.A. Kader, and M. P. Anwar. (2000). Evaluation of urea super granule as source of nitrogen in Transplant Aman Rice. *Pakistan Journal of Biological Science*,2(**5**):735-737.

Ahmed, M., Islam, M. and Paul, S.K. (2005). Efect of Nitrogen on Yield and Other Plant Characters of Local T. Aman Rice, Var. Jatai. *Res. J. Agric. & Biol. Sci.* **1**(2): 158-161.

Azim,S. M. A.(1999). Effect of sulphur, zinc and boron supplied from manure and fertilizers on BRRI 29. M.S. Thesis, Dept. Soil Sci., BAU, Mymensingh.

Bair, W. (1990). Characterization of the environment for sustainable agriculture in semi-aridtropic.InProc.:Sustainable Agriculture: Issue. Perspective and prospect in semiarid tropics.Sigh.R.D.Ed,Hydrabad India. *Indian Soc.Agron.***1**:90-128.

"Bangladesh: A Country Study:Rice". Library of Congress, Washington, D.C.. September 1988. Retrieved March 21, 2009.

BBS (Bangladesh Bureau of Statistics). (2008).Statistical Year book of Bangladesh. Stat. Dvi., Ministry of planning .Govt. Peoples Republic of Bangladesh, Dhaka.

Bhale, V. M. and Salunke, V.D. (1993) Response of upland irrigated rice yo nitrogen applied through urea and urea super granules, *Mysore J.Agril.Sci.***27**(1):1-4.

Bhandari, A.L., Sood, A., Sharma, K. N. and Rana, D. S. (1992).Integrated nutrient management in rice wheat system. *J.Indian Soc. Soil Sci.***40**:742-747.

Bhardwaj, A. K. and Shing, Y. (1993). Increasing nitrogen use efficiency through modified urea materials in flooded rice in mollisols. *Annals agril. Res.***14**(4):448-451.

Black, C.A. (1965). *Methods of Soil Analysis.* Part I and II. American Society Agronomy Inc. Pub. Madison, Wisconsin, USA.

BRRI (Bangladesh rice Research Institute). (2004). Adhunik dhaner Chas. Bangladesh Rice Research Ins.Joydeppur, Gazipur.pp.32-39.

BRRI(Bangladesh Rice Research Institute(2008)Bangladesh Rice Knowledge Bank. Bangladesh Rice Research Ins. JoydebpurGazipur.

BRRI (Bangladesh Rice Research Institute),(1990). Nitrogen response of promising variety. Annual Rep.Bangladesh Rice Res. Inst., Joydebpur, Gazipur. p: 95.

Cao, Z.H., De Datta, S.K., and Fillery, I.R.P. (1984) Effect of placement methods on floodwater properties and recovery of applied nitrogen (15N-labeled urea) in wetland rice. *Soil Sci. Soc. Am. J.*, 48: 196–203.

Chakravorti, S.P., Chalam, A.B. and Mohanty, S. K. (1989). Comprative efficiency of prilled urea and urea super granule for wetland rice. *J. Indian Soc. Soil. Sci.***37** (1):209-214.

Chauhan,P. P. and Mishra, R. C (1989). Effect of nitrogen on dry matter and nutrient accumulation pattern in wheat (*Triticum aestivum*) under different showing. *Indian J. Agron.* **12**(1):123-141.

Choudhury, A.T.M.A. and Bhuiyan, N.I. (1994) Effects of rates and methods of nitrogen application on the grain yield nitrogen uptake of wetland rice. *Pakistan J. Sci. Ind. Res.*, **37**: 104–107.

Das S. and Singh, T. A. (1994). Residual effect of urea super granules application in rice (*Oriza sativa*) wheat (*Triticum aestivum*) cropping system. *Indian J Agron.* **39**(4): 604-605.

Das, S. and Singh, T. A. (1994). Nitrogen use efficiency by rice and flood water parameters as affected by fertilizer placement techniques. *J. Indian Spl Sci.* **42**(1):46-50.

Eriksen, A.B., Kjeldby, M. and Nilsen, S. (1995). The effect of intermittent flooding on the growth and yield of wetland rice and nitrogen loss mechanism with surface applied and deep placed urea. *Indian Journal Agron.* **30**(1):12-15.

FAO (Food and Agriculture Organization). (2010). Food Balance Sheets. Commodity Balance. Crops Primary Equivalent. FAO, Rome. Pp. 472-475.

FAO (Food and Agriculture Organization). (2006). "Food Balance Sheets. FAO Statistical series, Rome. Vol.54 pp.76-77.

Glibert, P.M., Harrison J., Heil C. and Seitzinger S.(2006) "Escalating worldwide use of urea a global change contributing to coastal eutrophication," Biogeochemistry, vol. 77, no. 3, pp. 441–463.

Gomez,K.A. and Gomez A.A.(1984). Statistical Procedures for Agricultural Research. John Wilely and Sons. New York pp.182.

HAO Hu-lin, W.YZhang, Y. Xiao-e, F. Ying and W.U. Yong. (2007) Effects of Nitrogen Fertilizer Levels on Fe, Mn, Cu and Zn Concentrations in Shoot and Grain Quality. in Rice. *Chinese Journal of Rice Science*, **21**(4): 411-416.

Hasanuzzaman, M., Nahar, K., Alam, M.M., Hossain M.Z. and Islam, M.R. (2009). Response of Transplanted Rice to Different Application Methods of Urea Fertilizer. *International Journal of Sustainable Agriculture* **1**(1):1-5.

Islam, M.S., M. Hasanuzzaman, M. Rokonuzzaman and K. Nahar. (2009). Effect of application of nitrogen fertilizer on morpho-physiological parameters of rice genotypes. *Intl. J. Plant Prod.***3** (1) :51-62.

Islam,M.M.and Blank, R.P.(1998). Urea super granule technology-impact and action on plant for 1988-89.paper presented at the National Workshop on urea super granule (USG) Technology, held at BARC, Dhaka, Bangladesh.

Islam. M. S. Amin, M.S. and Anwar, M.N.(1994). Integrated Soil Fertility management in Bangladesh. Paper presented at the workshop on Integrated Nutrient

Management for Sustainable Agriculture held at Soil Resour. Dev. Inst., Dhaka in June 26-28,1994.

IFDC. (2007). Bangladesh will dramatically expand technology that doubles efficiency of urea fertilizer use. IFDC Rep. **32**(4):1–2–5.

IFDC. (1975). Deep placement of urea super granule to achieve agronomic benefit. IFDC Rep. **12**(2).32-40.

Jashim, C., Ahmed, U. and Ahmed, K.U. 1984. Response of rice varieties to applied N in saline soils. Int. Rice Res. News.**9**(5), 22.

Jackson, M.L. (1973). Soil Chemical Analysis. Prentice-Hall of India Pvt. Ltd., New Delhi, India. pp.41-196.

Jee, L. P. and Mahapatra, Y.K.(1989). Effect of rates, time and method of nitrogen application of rice.*Indian J. Agron.***33**(4):422-432.

Kapoor,V., Singh, U., Patel, S. K., Magre, H., Shrivastsva, L. K., Mishra, V. N., Das, R. O.,Samadhiya, V. K., Sanabria, J., and Diamond, R. (2008). Rice growth, grain yield, and floodwater dynamics as affected by nutrient placement and rate. *Agron.* J. 100, 526–536.

Kapre, M. M., Bisen,C. R. and Johar, M.S.(1996). Effect of sloe released N-fertilizer on rice under low land conditions crop Res. (hisar).**11**(2):17-23.

Kenzowakimoto (2004). Utilization Advantages of Controlled Release Nitrogen Fertilizer on Paddy Rice Cultivation. Japan Agricultural Research Query. **38** (1), 15 – 20.

Mahtalat, A., Islam, M.M. and Paul,S.K. (2005). Effect of Nitrogen on Yield and Other Plant Characters of Local T. Aman Rice. *Res. J. Agric. & Biol. Sci.* ***1***(2): 158-161.

Manzoor, Z., Awan T.H., Zahid M.A. and Faiz F.A. (2006). Response of rice crop (super Basmati) to different nitrogen levels. *J. Anim. Pl. Sci.* **16**(1-2).

Mathew, T. and Nair, S.S (1997). Physical and chemical properties of rice soils as influenced by organic and inorganic sources of nutrients. Indian J. Agril. Res. **31**(4): 257-261.

Medhi, B. D. and Barthakur, S. N. (1996).Effect of organic and inorganic source of N on the nutrient in soil and soil solution and growth of rice. *J Indian Soc. Soil Sci.* **44**(2):263-266.

More, S.D.(1994).Effect of farm waste and organic manure on soil properties, nutrient availability and yield of wheat rice sequence grown on sodicversitol.*Indian J.Soc.SoilSci.***42**(2):333-335.

Morteza, S.(2011). Effect of Organic Fertilizer on Growth and Yield Components in Rice. *J.l of Agricultural Sci.***3**(3) :125-128.

Muneshwar S, P. N. Takkar, Vi Ben, M. R Chaudhary, P. S. Sidhu, N. S. Pashricha and M. S. Bajwa. (1992). Proceedings of International Symposium on Nutrient Management for Sustained Productivity. **2**:7-8.

Nahar,K.,Haider, J. and Karim,A.J.M.S.(1995). Residual effect of organic manure and influence on nitrogen on soil properties and performance of wheat. *Annals Bangladesh Agric.*5(2:)73-78.

Nambiar, K. K. M (1997). Soil health and organic matter-changing scenario. Proc. NAD Sci. India special issue. pp: 141-160.

Narayan, A.M. and Thangamuthu, G.S. (1991). Effect of nitrogen management and nursery on grain and straw yield of rice. *Madras Agric. J.* **78**(9-12):310-312.

Nazrul, M.I., Rahman, M.A., Choudhury, D.A. and Quayyum, M.A. (2007). Effect of urea super granule naprilled urea in performance of banana. *Bangladesh J. Agril. Res.*, **32**(1): 145-149.

Olsen, S.R., Col, C.V., Watnable, F.S. and Dean L.A. (1954). Estimation of available phosphorus in soil by extraction with sodium bicarbonate U.S. Dept.Agric.Cire. pp. 929.

Page,A.L.,Miller,R.H. and Keeny,D.R.(1982).Methods of soil analysis. Part 2 of 2nd ed. Ani. Soc. Agron. Inc. Madi., Wis., USA. Research Division, Los Banos. Philippines. Pp. 11-72.

Pandey, A. And Tiwary, K. L. (1996). Effect of prilled urea, modified urea, and coated urea on transplanted rice. *Adv. Agric. Reas*. India. **5**:43-88.

Patel, S.R. and Mishra, V.N. (1994).Effect of different forms of urea and level of nitrogen on the yield and nutrient uptake of rice. *Advn. Pl. Sci.* **7**(2):29.

Patra, S. K. and Padhi, A. K. (1989). Response of rice to sources, method and levels of N. Intl. *Rice Res. News.* **14**(6):19-19.

PCARR (Philippine Council for Agricultural Resources and Research). (1980). Standard Methods of Analysis for Soil, Tissue, Water and Fertilizer. Farmresearch system.

Piper, C.S. (1966). Soil and Plant Analysis. Adelaide Univ. Hassel Press, Australia.

Prasad, N.K. and Kerkeyta, R. (1991).Soil fertility as influenced by different cropping sequences. *Indian Agric.Sci.* **61**:16-19.

Quayum, A. and Prasad, K. (1994). Performance of modified urea materials in rainfed lowland rice. *J. Res.* **6** (02):131-134.

Rahman, M. H., Ali, M. H., Ali, M. M. and Khatun, M. M. (2007). Effect of Different Level of Nitrogen on Growth and Yield of Transplant Aman Rice cv BRRI dhan32. *Int. J. Sustain*. Crop Prod. 2(1): 28-34.

Rama, S., Reddy, G. and Reddy, K.(1989).Effect of levels and sources of nitrogen on rice. *Indian J. Agro.* **34**(3):364-366.

Rambabu, P., Pillai, K. G. and Reddy, S. N.(1983). Effect of modified urea materials and their methods of application on dry matter production, grain yield and nitrogen uptake in rice. *Oryza*.**20**(2/3):86-90.

Rawluk, C.D.L., Grant, C.A., and Racz, G.J. (2001) Ammonia volatilization from soils fertilized with urea and varying rates of urease inhibitor NBPT. *Canadian J. Soil Sci.*, 81: 239–246.

Razzaque, M. M. A.(1996). Comparative study on the effect of rice straw, FYM and fertilizer N on the growth and yield of BR 11 rice. MS. Thesis, Dept. Soil Sci. BAU. Mymensingh.

Reddy ,G.R.S.,Reddy,G.B.Ramaiah,N.V.and Reddy, G.V. (1991). Effect of different level of nitrogen and from of urea on growth and yield of wetland rice. *Indian J. Agron.* **31**(2):195-197.

Salem, A.K.M., ElKhoby W.M., Khalifa A.B.A. and Ceesay M, (2011).Effect of Nitrogen Fertilizer and Seedling Age on Inbred and Hybrid Rice Varieties. *American-Eurasian J. Agric. & Environ. Sci.,* **11** (5): 640-646.

Samonte, S. O. P. B., L. T. Wilson, J. C. Medley, S. R. M. Pinson, A. M. Mc- Clung, and J. S. Lales.(2006). Nitrogen utilization efficiency: relationships with grain yield, grain protein, and yield-related traits in rice. *Agronomy Journal* 98: 168–176.

Santhi, F., Velusamy, M.S., Murugappan,V.M. and Selvi, D. (1999). Effect of inorganic fertilizer and fertilizer manure combination of soil physic-chemical properties and dynamics of microbial biomass in an inceptisol. *J. Indian Soc. Soil Sci.***47**(3):479-482.

Sarder, N. A., Shamusddin, A. M. and Khan, N.H. (1988). Yield and yield component of wetland rice under various sources and levels of nitrogen. *Philippine J. Crop Sci.***13**(3):155-158.

Sarker, M. M. R., Shaheb, M. R. and Nazrul, M. I. (2012). Urea Super Granule: A Good Source of Nitrogen on Growth Yield and Profitability of rice. *J. Environ. Sci. & Natural Resources.* **5**(1): 295-299.

Sarker,S. and Singh, S.R. (1997). Integrated nutrient management in relation to soil fertility and yield sustainability under dry land farming. *Indian J. Agric. Sci.* **67**(9):431-433.

Sarker, Aand A. S Faroda, (1993). Modified from if urea pearl millet-wheat sequence under subtropical conditions. *Tropical Agric,* **70**(3): 1 79-281.

Sarker, R. K. and Batista, D. (1991). Relative efficiency of slow release N-carries in rainfed low land rice. *Indian Agriculturist.***35**(1):39-44.

Savant,. K., and Stangel, P. J. (1998). Urea briquettes containing diammoniumphosphate: A potential NP fertilizer for transplanted rice. *Fertil. Res.* 51: 85–94.

Savant N. K., S. S. dhane and S. Talashilkar, (1991). Fertilizer News. International Fertilizer Development Center, Muscle Sholas, Alabama and 1.S.A. **36**(3): 19-25.

Schnier, H.F., Dingkuhn, M., De Datta, S.K., Marqueses, E.P., and Faronilo, J.E.(1990). Nitrogen-15 balance in transplanted and direct-seeded flooded rice as affected by different methods of urea application. *J. Biol.&Fertil. Soils*., 10: 89–96.

Singh, B. K. and Singh, R. P.(1986).Effect of modified urea materials on rainfed low land transplanted rice and there residual effect on succeeding wheat crop. *Indian J. Agron.* **31**(2):198-200.

Singh, G., Singh, O.P., Yadav, R.A., Singh, R. S. and Singh, B. B. (1993). Effect of sources and levels of nitrogen on grain yield, yield attributes, N uptake,recovery and response by in deep water conditions(100cm).*Crop Res.*(Hisar).**6**(2):21-25.

Subbaiah S.V., Kumar, R. M. and Pillai, K. G. (1994). Relative performance of granular fertilizers in irrigated rice. *Indian J. Agril. Sci.* **64** (4) 255-256.

Talukder, M. N. I.(1973). Effect of N on the yield and other characteristics of three verities of rice IR-8-288-3, IRATOM-24, IRATOM-38. M.Sc.(Ag.) Thesis. Dept. Agron. Bangladesh Agril. Univ. Mymensingh.p. 96.

Vijaya, D. and Subbaiah, S.V. (1997). Effects of methods of application of granular forms of fertilizer on growth, nutrient uptake and yield of paddy. *Ann. Agril. Res.*,18(3):361-364.

Walkley, A. and Black, C.A. (1965). Determination of organic carbon. Cited from Soil and plant Analysis. Adelaide Univ. Press. Australia .

Zaman, S., Hasem, M. A., Miah, M. H. Mallik, S. A. and Shamsuddoha, A. T. M. (2000). Effect of organic and inorganic sources of nitrogen and potassium on physical and chemical properties of soil under rice cropping. *Bangladesh J. Agril. Sci.***27**(1):71-76.

APPENDICES

Appendix I. Monthly records of Air temperature, Relative humidity and Rainfall of the experiment site during the period from July to November, 2011.

Month	* Air temperature (° C)		*Relative humidity (%)	*Rainfall (mm)
	Maximum	Minimum		
July	31.4	19.6	54	11
August	33.2	21.1	61	88
September	34.1	20.2	78	102
October	35.3	24.6	79	134
November	36.4	25.2	82	165

*Monthly Average

Source : Bangladesh Metrological Department (climate and weather division) Agargaon, Dhaka- 1212.

Appendix II. Effect of different doses of urea as ball placement and broadcast on yield contributing characters and yield of BRRI dhan40

Treatment	Plant height (cm)	Effective tillers $hill^{-1}$ (No.)	Non-effective tillers $hill^{-1}$ (No.)	Panicle length (cm)	Filled grains $panicle^{-1}$ (No.)	Unfilled grains $panicle^{-1}$ (No.)	Weight of 1000 grains (g)	Grain yield ($t\ ha^{-1}$)	Straw yield ($t\ ha^{-1}$)
T_0	59.88 e	6.38 e	3.50 b	18.05 d	53.29 f	13.94 a	16.58	2.71 f	5.27 d
T_1	76.05 bc	10.74 c	2.56 c d	22.88 b	83.20 d	9.47 b	20.60	5.65 d	6.97 c
T_2	76.90 a-c	12.01 a	3.16 b	23.31 b	87.90 b c	8.73 b	21.02	6.68 b	7.22 b c
T_3	80.17 a	13.00 a	4.30 a	24.58 a	90.96 a	8.39 b	21.77	7.04 a	7.94 a
T_4	70.69 d	9.19 d	2.23 d	21.73 c	76.07 e	9.76 b	20	4.42 e	5.66 d
T_5	74.37 c	11.15 b	2.60 c	22.74 b	85.66 c	8.23 b	20.45	6.25 c	7.30 d c
T_6	78.25 bc	12.34 a	3.39 b	23.57 b	88.56 ab	8.38 b	21.38	6.57 b	7.55 a b
$LSD_{(0.05)}$	3.36	1.04	0.33	0.95	2.46	1.56	2.58	0.289	0.450
Level of significance	0.05	0.05	0.05	0.05	0.05	0.05	NS	0.05	0.05
CV(%)	3.07	6.58	7.19	2.86	2.05	11.04	3.58	3.46	4.44

T_0 : Control, T_1 : 37.5 kg ha^{-1} urea as ball placement, T_2 : 56.25 kg ha^{-1} urea as ball placement, T_3 : 75 kg ha^{-1} urea as ball placement, T_4 : 37.5 kg ha^{-1} urea as broadcast, T_5 : 56.25 kg ha^{-1} urea as broadcast, T_6 : 75 kg ha^{-1} urea as broadcast

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability; NS: Not significant