SITE SPECIFIC MANAGEMENT OF NITROGEN FERTILIZER IN RICE FIELD (BRRI Dhan 29)

A Thesis

By

Md. Rezaul Karim
Examination Roll No: 1605033
Session: 2016-2017
Semester: January-June, 2017

MASTER OF SCIENCE (MS)

IN

SOIL SCIENCE

DEPARTMENT OF SOIL SCIENCE

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR

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November, 2017

DEDICATE
TO
MY BELOVED
PARENTS

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ABSTRACT

A field experiment was carried out at Soil Science research field, Hajee Mohammad Danesh Science and Technology University, Dinajpur, during the period from December, 2016 to April, 2017 to assess the effect of split application of nitrogen fertilizer on growth, yield of BRRI dhan 29. The experiment consisted of 5 nitrogen levels viz., T_0 (without fertilizer), Farmer's practice (225 kg ha^{-1}at 3 equal splits, 1/3 at 0 DAT (Day After Transplanting) + 1/3 at 30 DAT+ 1/3 at 70 DAT), T_1 (225 kg ha^{-1}, at 5 equal splits, 1/5 at 0 DAT+1/5 at 28 DAT+1/5 at 45 DAT+1/5 at 60 DAT+1/5 at 75 DAT) and T_2 (225 kg/ha, at 4 equal splits, 1/4 at 0 DAT +1/4 at 30 DAT + 1/4 at 50 DAT+1/4 at 70 DAT), T_3 (200 kg ha^{-1}, at 3 equal splits,1/3 at 0 DAT+1/3 at 30 DAT+1/3 at 70 DAT). Plant height, number of tiller $hill^{-1}$ were recorded at 35 DAT, 45 DAT, 55 DAT, 65 DAT, 75 DAT 85 DAT and also at maturity. At harvest, data on plant height, number of panicle $hill^{-1}$, length of panicle, number of filled grains $panicle^{-1}$, number of unfilled grains $panicle^{-1}$, 1000-grain weight, grain yield, straw yield, biological yield $hill^{-1}$, total N, available P, exchangeable K and also protein content were recorded in grain and straw. The effect of different split application of N fertilizer was found statistically significant on all parameters studied at 35 DAT, 45 DAT, 55 DAT, 65 DAT, 75 DAT, 85 DAT and also at maturity stage except the unfilled grain $panicle^{-1}$ and 1000-grain weight. At maturity the highest results of all parameters were found in T_1, but incase of unfilled grains $panicle^{-1}$ in FP was the highest. Number of panicles $hill^{-1}$ in FP and T_2 was statistically similar. The highest value of protein content was recorded in the treatment T_1, which statistically dissimilar to others. Lowest protein content in T_0. Protein content in FP,T_2 and T_3 was statistically similar. Unfilled grains $panicle^{-1}$ was similar in T_1 and T_2. 1000 grain weight was statistically similar in T_0, FP and T_2 but highest in T_1 and lowest in T_3. From the above results it was revealed that full dose of urea T1 (1/5 at 0 DAT+1/5 at 28 DAT+1/5 at 45 DAT+1/5 at 60 DAT+1/5 at 75 DAT) was more effective than the other split application. So the recommendation of this research was that 225 kg ha^{-1} of urea at 5 equal splits, 1/5 at 0 DAT+1/5 at 28 DAT+1/5 at 45 DAT+1/5 at 60 DAT+1/5 at 75 DAT should be applied for BRRI dhan 29 for better yield and this dose was also economically feasible.

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CHAPTER 1

INTRODUCTION

Bangladesh is an agricultural country. Rice (*Oryza sativa*) is the most important cereal crop of Bangladesh. Carbohydrate is the major source of energy for human being. Rice is the main source of carbohydrate for the people in Bangladesh and it is the staple food. The country earns about 15% of its gross domestic product (GDP) from agriculture and the average yield of rice in this country is around 7 t ha^{-1} (BBS, 2002). Though rice is the major food crop, yet the yield per hectare is very low compared to other major rice growing countries. It might be due to improper fertilizer application, management and use of traditional varieties.

Rice is the world's single most important food crop, being the primary food source for more than one third of the world's population and grown about 11% of the world's cultivated area (Russell, 1986). Bangladesh ranks fourth both in respect of area and production of rice among the rice producing countries following China, India and Indonesia (FAO, 1994).

Improved varieties and judicious application of fertilizer are of the most effective means for maximizing yield of rice. The fact is that rice plants require more nutrients to produce more yields. However, heavy application of nitrogen does not always contribute higher yield. Application of excessive nitrogen tends to cause damage of crop by inducing lodging and encourages grain shattering and the attack of insects and diseases (Bhardewaj *et al.*,1970).

There are three rice seasons in Bangladesh such as Aus, Aman and Boro (summer, autumn and spring/winter season). Among these, Aman rice holds the major share of the hecterage and total production in rice of the country, although BRRI dhan makes a vital contribution to the total food supply and hence, to the economy of Bangladesh. During 1993, BRRI dhan contributed 40% of total rice production. BRRI dhan was grown on 3.85 million hectare with the total production of 12.22 million tons in 2002-03 against the corresponding figures of 2.66 million hectare and 6.54 million tons in 1994-95 (BBS, 2003). Inadequate and improper application of nitrogen is now considered to be the major reasons for low yield of rice in Bangladesh. The use efficiency of applied N by the rice plant is very low. The submerged condition of wet land soils enhances N losses through leaching, surface runoff, and chemical fixation.

Nitrogenous fertilizer is a key input for increasing crop yield. Yield increase (70-80%) of field rice could be obtained by the application of nitrogen fertilizer (IFC, 1982). The introduction of high yielding varieties has greatly increased the prospect of getting higher yields but this may not be achieved until balanced fertilization is provided. The total area under rice cultivation will reduce gradually from 10.4 million hectares to 7.6 million hectares by the year 2030 (Karim, 1996).

Optimum dose of N fertilization plays a vital role in the growth and development of rice plant. Its growth is seriously hampered when lower dose of nitrogen is applied which drastically reduces yield. Further, excessive nitrogen fertilization encourages excessive vegetative growth that makes the plant susceptible to insects, pests and diseases, ultimately reduces yield. So, it is essential to find out the optimum rate of nitrogen application for efficient utilization of this element by the plants for better yield.

Therefore, site specific management of N fertilizer is essential because site specific management provide to a farmer to use right dose of N fertilizer in right growth stage of rice plant and also to know the soil N content. Site specific management approach was developed to increase mineral fertilizer use efficiency and achieve blanched plant nutrition because over application of N may decrease grain yield by increasing susceptibility to lodging (Chowdhury *et al.,* 1984). Research conducted in many Asian country including Northwest India (Livan *et al.,* 1986), has denoted limitations of current approach of fix rate, fixed time recommendation being made for large area.

Nitrogen has a positive influence on the production of effective tillers per plant, yield and yield attributes (Jashim *et al.*,1984 ; BRR1, 1990).

Nitrogen absorbed by the rice plant is rapidly converted into protein. Deficiency of nitrogen results in low content of chlorophyll. In rice leaves nitrogen content has two peaks. One occurring at the stage of cell volume increase, the other when the emerging shoot meets light and turns green. The second peak is due to protein synthesis induced by light and is associated with an increased volume of each chloroplast and accumulation of nitrogen in the chloroplast and at last it also induces increase in efficiency of photosynthesis (IRRI, 1964).

Application of proper N dose, can save money and also keep our environment sound. Because the excessive use of fertilizers, affects the soil and also the environment through the residual effect of fertilizers. Selection of the most appropriate doses of nitrogen is a major concern of economic viability of crop production and the impact in agriculture.

Therefore, the present study was undertaken to achieve the following objectives:

i) To find out proper dose of N fertilizer splitting for optimum growth, yield of BRRI dhan.
ii) To increase use efficiency of N fertilizer doses.
iii) To know the requirement of N fertilizer in various growth stage of rice.
iv) To increase yield of rice plant by maintaining a good soil health.

CHAPTER 2

REVIEW OF LITERATURE

N fertilizer is one of the major important elements, which generally influenced crop yields. With the advancement of science in the field of agriculture, investigators are continuously trying to get better utilization of nitrogen fertilizers by split application. Among the factors that are responsible for growth, yield and yield contributing characters of rice, split application of N fertilizers is very important. Especially for the production of modem BRRI dhan 29.

2.1 Performance of nitrogen fertilizers

Andreevska *et al.,* (2001) conducted a pot experiments to determine the effect of nitrogen fertilizer on the dry matter yield and the total nitrogen content in the roots, stems, leaves and panicles of rice (*Oryza sativa*) cultivars. The highest total nitrogen content during the heading flowering stage was recorded in the leaves.

Singh and Singh (1997) conducted a field experiment with N-fertilizer dwarf rice cultivar Jaja in 1987 in Uttar Pradesh, India. The cultivar was given 90 kg N ha^{-1} at urea super granules (USG) or 120 kg N ha^{-1} at large granular urea (LGU) of Neem cake coated urea (NCU), applied basally or in 2 equal splits (basally and at panicle initiation). Grain yield was not affected by N source but it was affected with higher 120 kg N and with split application.

The various nitrogenous fertilizers were applied at concentration of 60, 70, 80 and 100 kg N ha^{-1}. The highest grain and straw yields (4.63 and 7.80 tha^{-1} respectively) were obtained by using urea at 80 kg N ha^{-1}. Application of nitrogen from various sources increased grain yield from 14 to 45 % and straw yield from 19 to 73%. Among the various sources of nitrogen tested urea applied at 80 kg N ha^{-1} appeared to be the best with respect of yield of rice followed by ammonium sulpahte and calcium nitrate in the test condition.

Sato *et al.,* (1996) reported that single application of total N fertilizer with controlled release coated urea on zero tillage rice culture (LP plot) was compared with a conventional application method using basal or top dressing ammonium sulphate (AT). Crop growth in LP plots was slightly lower than in AT-plots at the younger seedling stage, but plant height, tiller number and DM were all higher by the beginning of June. Soil N was reduced as a result of gentrification in AT-plots just after submergence and severe crop N deficiency was observed until the top dressing stage. Yield reduction in AT-plots seemed to be related to decrease in panicle numbers due to N deficiency during vegetative growth. N uptake in LP-plots was lower than in AT-plots during early growth but much higher after tillering and was 1.57 times that of AT-plots at maturity and recovers of controlled release coated urea for basal application.

Mahalle and Thorat (1995) conducted a field experiment on sandy loam soils during the Kharif (rainy) seasons of 1987-89 at Phondagat. Mahrathtra, rice cv. RTN-2 was given 29, 58, 87 or 116 kg N ha^{-1} a as urea or urea super granules (USG). Urea was given as a split application of 40% at maximum tillering and 20% at panicle initiation or incorporated at ploughing.

Saravanan and Manickam (1994) conducted a field experiment in 1989 at Madurai, Tamil Nadu. India. With rice cultivar ADT which was given 0-200 kg N ha^{-1} a as urea alone or with KCI. $CaS0_4$ or $ZnSO_4$. Grain yield increased with increasing N and was the highest and the lowest with + KCI as urea alone, respectively. N uptake followed the grain yield pattern.

Singh and Singh (1989) reported that rice 60 kg N ha^{-1} applied as urea super granules (USG) placed at 8-10 cm depth in centre of 4 hills in alternate rows, urea in 3 splits dressing or USG broad cast and incorporated in paddy field, produced grain yields of 4.79, 4.10 and 4.02 t ha^{-1}, respectively, compared with 2.92 t ha^{-1} without nitrogen fertilizer. Similar results were obtained with 90 and 120 kg N ha^{-1}, but the differences in yield between forms and methods of N applications were smaller Crops accumulated about 57% of the total DM and took up 72% of total N at the panicle initiation stage.

2.2 Plant height (cm)

Lawal and Lawal (2002) conducted an experiment on low land rice in Nigeria with nitrogen level 0, 40, 80 and 120 kg ha^{-1} and they suggested that higher doses of nitrogen application increased the plant height significantly increased rate of nitrogen fertilizer application under field condition.

Zhilin *et al.*, (1997) reported that by applying different levels of nitrogen on aromatic rice increased the plant height in Basmati 370. Sharma (1995) observed that plant height in rice increased significantly with the increase of nitrogen levels.

An experiment was conducted by Dahatonde (1992) during 1986-87, it was cited that N fertilizer significantly enhanced the plant height. Reddy *et al.*, (1990) reported a significant effect of nitrogen on plant height in rice. On the other hand Islam *et al.*, (1988) observed that N fertilizer did not affect significantly on the plant height. Akanda *et al.*, (1991) pointed out that split application of nitrogen had no significant effect on plant height.

Hussain and Sharma (1991) reported that application of nitrogen up to 40 kg ha^{-1} increased plant height. Change of N application from 80 kg and 120 kg N ha^{-1}, did not increase plant height. The highest plant height was obtained from 120 kg N ha^{-1} and lowest one from the control. Dahatonde (1992) observed that N fertilization significantly enhanced the plant height. Wagh and Throat (1988) observed that 30 + 30 + 10 + 10 kg N ha^{-1} a applied at 8 days after transplanting, maximum tillering, primordial initiation and flowering, respectively, produced the longest plant.

Reddy *et al.*, (1987) observed that 120 kg N ha^{-1} applied in three splits dressing after transplanting (50%), tillering (25%) and panicle emergence stage (25%) have higher increase in plant height than two equal splits at transplanting and tillering or in a single dressing at transplanting. Livan *et al.*, (1986) observed that plant height appeared to be higher at monitored at 35 and 42 days after sowing (DAT) in the high N level treatment (160 kg N ha^{-1} a) compared to the lower one (120 kg N ha^{-1}).

Akanda *et al.*, (1986) found that the tallest plants were produced when 80 kg N ha^{-1} a was applied in three splits (20 kg as basal, 40 kg at active tillering and 20 kg at maximum tillering). Latchanna and Yogeswara Rao (1977) concluded that N application in two splits at transplanting and tillering produced the longest plants.

2.3 Number of tillers hill^{-1}

Munnujan *et al.*, (2001) conducted a field experiment in 1993 with four nitrogen levels (0, 40, 80, 160 kg N ha^{-1}) and found that tillers hill^{-1} increased linearly with the increase of N fertilizer level. Hong *et al.*, (1999) reported positive correlation between N application, and number of tillers and effective tillers plant^{-1}. High N rates increased the length of the tillering period.

Ramamoorthy *et al.*, (1997) found that increasing N rate up to 200 kg significantly increased the number of productive tillers hill^{-1} in rice under field condition. Maske *et al.*, (1997) conducted an experiment on rice and found that number of tillers hill^{-1} increased significantly with increased nitrogen level in rice. Chander and Pandey (1996) reported that the application of 120 kg N significantly increased tiller compared with 60 kg N ha^{-1}

Idris and Matin (1990) found that maximum tillers hill^{-1} was produced by 140 kg N ha^{-1} which was statistically identical with 60, 80, 100 and 120 kg N ha^{-1}. The minimum tillers hill^{-1} was produced from the control. Shoo *et al.*, (1989) observed that nitrogen at transplanting or in two equal splits dressing at transplanting and tillering increased the total number of tillers hill^{-1}. Ile also found the highest number of effective tillers hill^{-1} with nitrogen applied in 2-3 splits dressing at tillering, panicle emergence and flowering.

Hussain *et al.*, (1989) stated that 150 kg N ha^{-1} in split application increased the number of total tillers hill^{-1}. Nitrogen application date had significant effect on tillers production of aman rice.

Wagh and Throat (1988) conducted an experiment with growth of rice (BR-24) with split application of nitrogen. Nitrogen at 30+30+10+10 kg ha^{-1} applied at 8 days after transplanting, maximum tillering, primordia initiation and flowering respectively, produced the highest number of effective tillers $hill^{-1}$.

Kamal *et al.,* (1988) observed that the highest rate of nitrogen fertilizer have maximum tillers $hill^{-1}$, which was significantly greater than any of the other treatments. Akanda *et al.,* (1986) reported that nitrogen application in three doses such as 20 kg as basal, 40 kg at active tillering and 20 kg at panicle initiation gave the highest number of panicle $hill^{-1}$.

Reddy *et al.,* (1985) conducted a pot trails with rice which was given. 120 kg N ha^{-1} in three splits dressing at transplanting (50%), tillering (25%) and panicle emergence stage (25%) gave higher number of total tillers $hill^{-1}$ than two equal splits dressing at transplanting and tillering or in a basal dressing at transplanting.

2.4 Panicle Length (cm)

Kamaru *et al.,* (1998) showed that long and highest number of panicles obtained from plants that received 100 kg N ha^{-1}. Azad *et al.,* (1995) observed that the panicle length increased significantly with increase in the levels of nitrogen from 0 to 75 kg ha^{-1}. Thakur (1991b) reported that total spikelets $panicle^{-1}$ was the highest when 40%, 30% and 30% nitrogen was applied as basal, at maximum tillering and at panicle initiation stages, respectively.

Idris and Matin (1990) found that the different rates of nitrogen application influenced panicle length, where longest panicle was found by the application of 60 kg ha^{-1} and shortest one from control (0 kg ha^{-1}). Sharma and Mittra (1989) noted the pronounced effect of N on yield attributes in rice. Plants receiving high N doses produced long and heavy panicles. Rafey *et al.,* (1989) showed that increasing N levels increased panicle length, number of grains $panicle^{-1}$ and 1000-grain weight significantly. Awan *et al.,* (1984) concluded that application of different levels of nitrogen on rice increased plant height, panicle length, 1000-grain weight and grain and straw yields significantly.

2.5 1000-grain weight

Mandal *et al.,* (2003) observed that, application of N (120 kg ha^{-1}) as urea in equal splits during transplanting, 1000-grain weight (22.57g). Kamaru *et at.,* (1998) conducted an experiment on rice with various rates of N fertilizer (25, 50 100 kg N ha^{-1}) including a zero level and observed that 1000-grain weight was not significantly different among the treatments.

Naseem *et al.,* (1995) conducted an experiment with 4 levels of nitrogen fertilizer and found that filled grains remained unchanged but 1000-grain weight reduced in control treatment.

Singh and Singh (1993) conducted an experiment on the method of seedling transplantation and nitrogen application in rice. They showed that application of 60 kg N had increased the 1000-grain weight. Thakur (1991) showed that increasing levels of nitrogen significantly increased panicles m^{-2} and grains panicle^{-1} up to 120 kg ha^{-1}, whereas, 1000-grain weight increased only up to 80 kg ha^{-1}.

Sadeque *et al.,* (1990) obtained the highest 1000-grain weight (24.93g) by the application of 50 kg N ha^{-1} than higher doses i.e. 100 and 200 kg N ha^{-1}. Mondal *et al.,* (1987) observed that increasing N levels from 40 to 160 kg ha^{-1} significantly increased the 1000-grain weight.

At the Bangladesh Agricultural University Farm, Mymensingh, Akanda *et al.,* (1986) stated that the weight of 1000 grains was the highest when 80 kg N ha^{-1} a was applied in three splits such at 20 kg ha^{-1} as basal, 40 kg ha^{-1} at active tillering and 20 kg ha^{-1} at panicle initiation stages.

2.6 Total dry matter (TDM)

Munnujan *et al.,* (2001) found that dry matter per hill increased almost linearly with the increase in N level, but its effect was more conspicuous after the heading stage. Krishnan *et al.,* (1998) conducted a field experiment in 1994-95 in Orissa on rice cultivars and were given 30, 60, 90, 120 or 150 kg N ha^{-1}. Nitrogen rate affected shoot growth and the partitioning of dry matter at different developmental stages, partitioning of dry matter to leaves and stems peaked during vegetative and panicle initiation stages, respectively.

Kumar *et al.,* (1996) observed that increasing level of N increased the dry matter yield significantly up to 160 kg N ha^{-1} at 30 DAT. The dry matter yield was higher when urea was applied before puddling and one week of submergence period. Chudhury *et al.,* (1995) found that the dry matter yield increased due to nitrogen application at active tillering and panicle initiation stages. At active tillering stage dry matter yield increased significantly up to 60 kg N ha^{-1} of applied. While at panicle initiation stage, the effect of nitrogen fertilization on dry matter yield was significant up to 120 kg N ha^{-1}.

Dubey and Khan (1993) observed that increase in dry matter with N level from 0 to 90 kg had. Ingram *et al.,* (1991) showed that the dry matter assimilation, tillering and LAI inquired when fertilizers were placed in deep the late grown crop. Chauhand and Mishra (1989) conducted field experiment at Pantnagar in India in the wet seasons of 1983 and 1984 with rice cv. Jaya applying 40, 80 or 120 kg N ha^{-1} in five different forms of urea. They reported that USG point placement one week after transplanting gave the highest dry matter yield and pilled urea gave the lowest grain yield, whole deep placed USG gave the highest grain yields of 4.08, 4.86 and 5.17 t ha^{-1} at the rate of 40, 80 and 120 kg N had, respectively in 1983 while the corresponding yields of 1984 were 4.05, 4.75 and 5.39 t ha^{-1} respectively.

Rao *et al.,* (1986) reported that urea super granules placed at 8-10 cm in between the hills, gave paddy yields of 4.33, 4.37, 4.96 and 5.45 t ha^{-1} respectively the urea super granules were most effective in increasing dry matter production, N uptake and recovery. Rambabu, *et al.,* (1983) evaluated different forms and methods of application of N-fertilizer to rice under flooded condition. They stated that placement of N as urea super granules in root zone at transplanting were the most effective increasing dry matter production in rice.

2.7 Number of grains panicle^{-1}

A field study was conducted by Mazid *et al.,* (1998) with 0, 60, 80 and 100 kg N ha^{-1}. They reported that number of grains panicle^{-1} increased with N up to 60 or 80 kg ha^{-1} depending on tillage system. Nazim *et al.,* (1995) described that rice crop was strongly influenced by urea application. Applying urea at 46 kg N ha^{-1} decreased unfilled grains panicle^{-1} and on the other hand, increased filled grains panicle^{-1}.

Kalita and Sharma (1992) observed an increased number (78.9) of filled grains panicle^{-1} with increasing levels of nitrogen fertilizer. The nitrogen rates 60 kg/ha was significantly superior to other levels. Hussain and Sharma (1991) stated that application of nitrogen increased grain number panicle^{-1} up to 80 kg N ha^{-1} Nitrogen application at the rate of 120 kg ha^{-1} did not significantly affect the number of grains panicle^{-1}. The highest number of grains panicle^{-1} was produced by the application of 80 kg N ha^{-1} and the lowest one was produced at the control.

Kim *et al.,* (1990) observed that high dose of nitrogen gave increased number of panicles and spikelet panicle^{-1}. Maskina and Sing (1987) reported that N fertilizer application at the rate of 90, 120 and 150 kg N ha^{-1} influenced grains panicle^{-1} in rice.

Islam *et al.,* (1996) reported that grain yield was increased with increasing basal top dressing of nitrogen. Vaiyapuri *et al.,* (1995) stated that application of 100 kg N ha^{-1} in three splits 25% basal + 50% tillering stage + 25% panicle initiation gave the highest yield (5.88 t ha^{-1}). Hossain *et al.,* (1995) conducted an experiment on rice and found that nitrogen application up to 120 kg N increased the grain yield of rice. The increase in yield with 40, 80 and 120 kg N ha^{-1} was 24, 33 and 34%, respectively over the control. Nitrogen rates of 80 and 120 kg N ha^{-1} had significantly higher grain yield than 0 and 40 kg N.

Chowdhury *et al.,* (1994) reported that Basmati rice gave the highest grain yield when fertilized with 124 kg N ha^{-1} in three equal splits dressing at transplanting, 20-25 days after transplanting and 40 or 45 days after transplanting. Patel *et al.,* (1994) reported that N as urea applied in two splits dressing at tillering and panicle initiation stages was more effective in terms of yield than a single dressing or two other split dressing.

Avasthe *et al.,* (1993) observed that the highest grain yield of 5.46 t ha^{-1} was obtained when nitrogen was applied in two equal splits at transplanting and 7 days before panicle initiation or half of the nitrogen at late tittering + 1/4 of nitrogen each at panicle initiation. Mongia (1992) reported that grain yield was the highest with 60 kg N ha^{-1} a applied in three splits (50% basal + 25% at flowering + 25% at the flag leaf stage).

Tantwi *et al.,* (1991) stated that split application of nitrogen markedly increased yield, with the highest yield obtained from the triple splits. Split application resulted in greater number of panicles, heavier grains and more grains/panicle. Bhuyian *et al.,* (1990) observed that rice yield increased by 11-38 percent with three time split application and by 5-29 percent with two time application. Raju and Reddy (1989) reported that rice yield was higher with nitrogen applied in three split dressing (25% as basal + 50% at tittering stage + 25% at panicle initiation) than when it was applied in two split dressing or in a single dressing.

Wagh and Thorat (1988) conducted an experiment and observed that the number of panicles m^{-2}, grain and straw yield were significantly higher when nitrogen was applied in four splits with 50% at eight days after transplanting, 30% at tillering and 10% each at primordia initiation and flowering stages of the crop. Salam *et al.,* (1988) reported that straw yield was the highest when nitrogen fertilizer was applied in splits including tillering stage.

Khader *et al.,* (1987) applied 60, 90 and 120 kg N ha^{-1} and obtained paddy yields of 5.67, 5.19 and 5.16 t ha^{-1}, respectively. Ninety kg N ha^{-1} as urea applied 15 DAT or as urea applied in 2 splits dressing or in a single dressing at transplanting gave yields of 5.47, 5.19 and 4.16 t ha^{-1}, respectively. Paturade and Rahate (1986) reported that significant increase in grain yield of rice was obtained due to nitrogen application in the split doses of 0 kg N ha^{-1} at transplanting, 20 kg N ha^{-1} at panicle initiation and 20 kg N ha^{-1} at heading stage. He also reported that straw yield was found the highest in same splitting.

Reddy *et al.,* (1985) observed that 120 kg N ha^{-1} a applied in three splits dressing at transplanting (50%), tittering (25%) and panicle emergence stage (25%) gave significant increase in plant height than when in two equal splits dressing at transplanting and tillering or in a single dressing at transplanting or tittering. Subramanian and Venkataramana (1980) observed that rice cv. BR 20 grown with 90 kg N ha^{-1} applied either at transplanting or three split dressing (50%) at transplanting and reminder top dressing or foliar sprays in two equal split dressing at the tittering and panicle initiation stage gave paddy yield of 4.40, 4.51 and 4.66 t ha^{-1} respectively.

Yousuf *et at.,* (1979) showed that 60 kg N ha^{-1} a applied by point placement one week after transplanting and 15+30 kg N ha^{-1} broadcast at rapid tillering and one week before panicle initiation gave high yield BRRI (1978) reported that grain yield in Mala increased with nitrogen application and that split application was better than single application. Application of nitrogen in three equal splits on 25, 50 and 75 DAT increased yield to 5.32 t ha^{-1}.

2.8 Harvest Index (HI)

Janaki and Thiyagrajan (2002) conducted a field experiment at Wimbatore, Tamil Nadu, India, 1998 and 1999 to study the effect of planting density and N treatments or rice. Nitrogen fertilizer was applied in splits at 7 days after transplanting (DAT), active tittering stage, panicle initiation and at 10 days after panicle initiation. The higher yield in 1998 was attributed to higher N partitioning to grains and harvest index recorded for that year.

Dwivedi (1997) conducted a field experiment on rice with 4 levels of nitrogen (0, 30, 60 and 90 kg ha^{-1}) and found the highest growth, yield attributes, grain and straw yields and harvest index with 60 and 90 kg ha^{-1}. Sharma and Malik (1993) conducted a field experiment where two N levels (120 and 150 kg ha^{-1}) were applied. They found that higher N level decreased the harvest index.

Prasad (1981) found that high N rates tended to increase biological yield and decrease harvest index and observed that the increasing rates of N application from 100 to 200 kg N ha^{-1} increased the biological yield but decreased harvest index.

CHAPTER 3

MATERIALS AND METHODS

This chapter deals with the experimental aspect of the research work. The materials used and methods followed in this experiment have presented in this episode. This contains brief descriptions of experimental site, soil climate, crop, treatments, experimental design, land preparation transplanting of seedling, intercultural operation, data recording, collection and preparation of soil and plant samples and for method for the chemical as well as statistical analysis.

3.1 Experimental site and soil

The experiment was set up at the Soil Science research field of HSTU Dinajpur during the boro season December, 2016 to May of 2017. The experimental site at 24° N latitude and 90.25° E longitudes with an elevation of 34 meter from the sea level. It belongs to the AEZ of old Himalayan Piedmont Plain. The soil is Ranisankail sandy loam, a member of the hyperthermic aeric haplaquept under the inceptisol having only few horizons, developed under aquic moisture regime and variable temperature conditions. The general characteristics of the soil are presented in below table.

3.2 Climate

The experimental site is situated in the sub tropical climatic zone, characterized by the heavy rainfall May to September and scanty rainfall during the rest time. At the growing period of the crop total rainfall was 85 mm Details of the meteorological data in respect of temperature, rainfall, relative humidity and total sunshine hours during the growing period of the experimental site.

Table 3.1 Morphological, Physical and Chemical characteristics of the experimental soil.

A. Morphological Characteristics

Morphology	**Characteristics**
Location	Research field, HSTU, Dinajpur
AEZ	Old Himalayan Piedmont Plain (AEZ 1)
General soil type	Non-calcareous brown floodplain soil
Parent material	Piedmont alluvium
Soil series	Ranishankail
Drainage	Moderately well drained
Flood level	Above flood level
Tropography	High land

B. Physical Characteristics

Characteristics		Value
Particle size (%)		
	Sand	60.0
	Silt	27.0
	Clay	13.0
Textural class		Sandy loam

C. Chemical characteristics

D.

Characteristics	Content	Interpretation
pH	6.60	Moderately acidic
Organic matter (%)	1.22	Low
CEC (me/100g soil)	5.60	Low
Total N (%)	0.07	Very low
Available P (ppm)	25.75	Medium
Exchangeable K (me/100g soil)	0.25	Medium low
Exchangeable Ca (me/100g soil)	1.21	Very low
Exchangeable Mg (me/100g soil)	0.39	Low

Available S (ppm)	43.47	Very high

3.3 Plant material

BRRI dhan 29, a modern variety of rice, was used as test crop and was released by Bangladesh Rice Research Institute, Gazipur. Its life duration is 135-150 days and yield is about 7.5 t ha^{-1}. It is suitable for growing in Boro season.

3.4 Land Preparation

The land was prepared thoroughly by ploughing and cross sloughing with a power tiller. Every ploughing was followed by laddering to have a good tilth. Weeds and stubbles of the previous crop were collected and removed from the experimental plot before final ploughing, pudling and leveling.

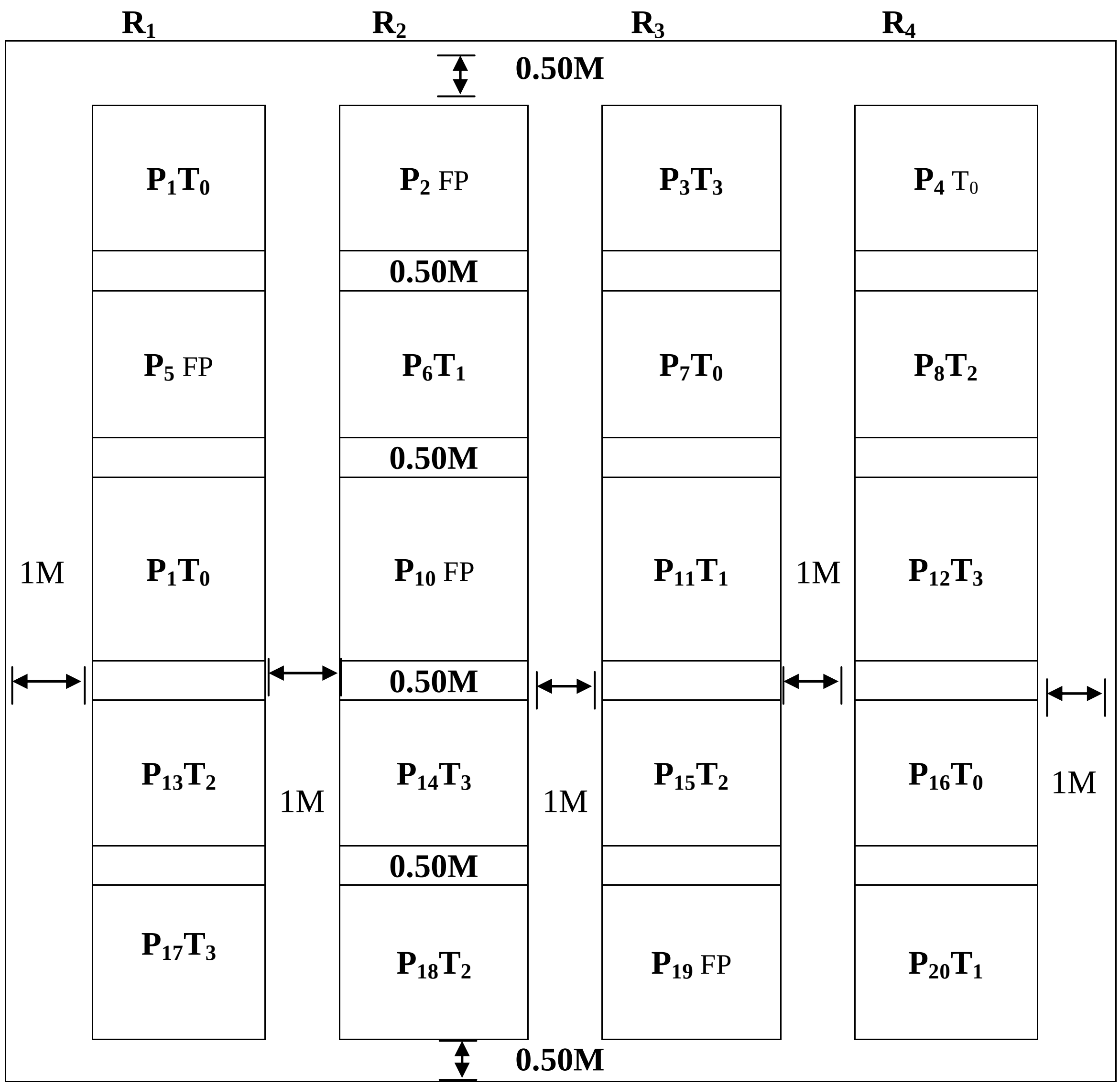
3.5 Treatments

There were 5 treatments of N at different level at different time applied. The treatments combinations for the experiment as follows:

Treatment code	Treatment description
T_o	Without N fertilizer
FP	Farmer's practice (225 kg N ha^{-1} at 50%, 25%, 25% doses of N at 0, 35, 70 DAT respectively)

T_1 (Recommended dose)	225 kg N ha^{-1} at 5 equal splitting doses at 0, 28, 45, 60, 75 DAT
T_2	225 kg N ha^{-1} at 4 equal splitting doses at 0, 30, 50, 70 DAT
T_3	200 kg N ha^{-1} at 3 equal splitting doses at 0, 35, 70 DAT

3.6 Experimental Design



Here,
P= Plot

Number of Treatments = 5

Number of Replications= 4

Total Number of plot = 20

Net Size of each plot= (2m × 2.5m) = 5 m^2

Distance between two adjacent plots = 0.5

Distance between two adjacent blocks = 1m

Figure: Layout of the experiment with necessary information

3.7 Application of manures and fertilizers

The full doses of cow dung and Triple super phosphate (TSP), Murate of potass (MOP) were added during final land preparation.

3.8 Transplanting of seedling

Thirty five days old seedling were uprooted carefully from the seedbed in the morning and transplanted on 7th January 2017 in the main plot. Plant spacing was maintained 20cm × 25 cm. seedling was transplanted in the field at a rate of three seedling hill^{-1}.

3.9 Intercultural operation

Intensive care was taken during the growing period to ensure adequate growth and development of the crop which are given below:

3.9.1 Weeding

Three hand weeding were done at 20, 35 and 60 days after transplanting (DAT) of the seedling.

3.9.2 Irrigation

The plots were irrigated from deep tube-well as per needed during the growing period of the crop.

3.9.3 Insect and pest control

There was no pest and disease in the field during the experimental period and hence no control measures were adopted.

3.9.4 Harvesting and post- harvest process

The crop was at full maturity on 23 May 2017. The yield of the grain and straw per plot were recorded after threshing, winnowing and drying.

3.10 Collection of plant sample

Ten hills were randomly selected from each plot at maturity to record the yield contributing characters. Grain and straw samples were kept for chemical analysis.

3.11 Data recorded during harvest

The following parameter was recorded during harvest:

i. Plant height (cm)
ii. Number of tillers hill^{-1}
iii. Number of effective tillers hill^{-1}
iv. Panicle length (cm)
v. Number of grains panicle^{-1}
vi. Number of filled grains panicle^{-1}
vii. Weight of 1000 grains
viii. Grain yield (t ha^{-1})
ix. Straw yield (t ha^{-1})
x. Biological yield (t ha^{-1})

3.12 Procedures of data collection

The data were recorded on yield and yield components of rice. The yield and yield components were; plant height, number of tillers hill^{-1}, number of effective tillers hill^{-1}, panicle length, number of grains panicle^{-1}, and number of filled grains panicle^{-1}, 1000 grain weight, grain yield, straw yield and biological yield.

Plant height (cm)

Plant height was measured from the ground level of a plant to the top of a panicle. Plants of ten hills measured and averaged from each plot.

Number of tillers hill^{-1}

Ten hills were taken at random from each plot and the total number of tillers hill^{-1} was calculated.

Number of effective tillers hill^{-1}

The tillers having at least 25% spikelet of a normal panicle were considered as effective tillers.

Panicle length (cm)

Measurement was taken from the basal node of the raches to the apex of each panicle. Each observation was an average of 10 hills.

Number of grains panicle^{-1}

Presence of any food material in any spikelet was considered as a grain and total number of such grain present on each panicle was counted physically.

Number of filled grain panicle^{-1}

10 panicles were taken at random from each plot and the filled grain panicle were counted and averaged.

Weight of 1000 grains

1000 grains were randomly selected from sample of each plot and dried in an oven and adjusting at 14% moisture content and weighted by an electric balance.

Grain yield (t ha^{-1})

Grains obtained from each unit plot were sun dried and weighed carefully. The dry weights of grains of 10 sample plants were added to the respective unit plot to record the total grain yield per plot. The grain yield was finally converted to kg per hectare.

Straw yield (t ha^{-1})

Straw obtained from each unit plot including the straw of ten sample plants were dried in the sun and weighed to record the final straw yield per plot and then converted to kg ha^{-1}.

Biological yield (t ha^{-1})

Biological yield was calculated by using the following formula:

Biological yield (t ha^{-1}) = Grain yield (t ha^{-1}) + straw yield (t ha^{-1})

3.13 Analysis of soil sample

Soil sample for chemical properties were analyzed in the laboratory of the Department on Soil Science, HSTU, Dinalpur and Soil resource development Institute (SRDI), Local laboratory, Mrittika vabon, Nashipur, Dinajpur. The soil chemical properties under the study were texture, pH, organic matter, total N available P and exchangeable K contents.

3.13.1. Collection and preparation of soil sample

Initial soil sample

The initial soil sample was collected before land preparation from the plough depth layer (0-15cm). 10 samples were taken by means of an auger from 10 locations covering the whole experimental plot and mixed thoroughly to make a composite sample. The composite sample was air dried, grounded and sieved thorough a 20-mesh and sieve and stored in a plastic bag foe physical and chemical analysis.

Post harvest soil samples

After harvesting the crop the crop, ten soil samples were collected from each plot at 0-15 cm depth. The soil were air dried, grounded sieved thorough a 20-mesh sieve. Prepared soil sample were stored in plastic bags for chemical analysis only.

3.13.2 Particle size analysis

It was done by the hydrometer method and textural class was determined by plotting the result for % sand, % silt and % clay in the marshall's triangular coordinating following USDA system.

3.13.3 Soil pH

The soil pH was measured with a glass electrode pH meter using soil water suspension of 1:2.5 as described by Jackson (1962).

3.13.4. Organic matter content (OM)

This was estimated following the method developed by Walkley and black (1935).The principle under laying the method is to oxidize the organic matter with the excess of 1N $K_2Cr_2O_7$ solution in presence of concentrated H_2SO_4 and to titrate the remaining un-reacted $Cr_2O_7^{-2}$ solution with N $FeSO_4$. Finally, the organic carbon contents were then calculated by multiplying the % organic carbon the Van- Bemmelen factor. 1.724.

3.13.5 Digestion and determination of total N from soil samples

One g of oven dry ground soil sample was taken in a micro-kjeldahl flask .1.1 g catalyst mixture (K_2SO_4 :$CuSO_4.5H_2O$:Se=100:10:1), 3 ml 30% H_2O_2 and 5 ml conc. H_2SO_4 were added into the flasks .The flasks were swirled and allowed to stand for about 10 minutes. Then heating at 380°C was continued until the digest was clear and colorless. After cooling the contents were taken into volumetric flasks and volumes were made up to the mark with distilled water. A reagent blank was prepared in the similar manner. These digests were used for N determination.

After completion of digestion, 40% NaOH was added with the digests for the distillation. The evolved was trapped in 4% H_3BO_3 solution and 5 drops of the mixed indicator of bromocressol green ($C_{12}H_{14}O_5Br_4S$) and methyl red ($C_{10}H_{10}N_3O_3$) solution. Finally the distillates were titrated with the standard 0.01 N H_2SO_4 until the color changed from green to pink.

3.13.6 Available phosphorus (P)

This was extracted from the soil by shaking with 0.5m $NaHCO_3$ at the pH 8.5 following Olsen *et al.*, (1954). The phosphorus in the extract was determined with 1.0 N NH_4OAc (pH 7) extractive reagent. Then P was determined directly with a flame emission spectrophotometer.

3.13.7 Available sulphur (S)

Available sulpher was determined by extracting the soil sample with $CaCl_2$ solution (o.15%). The available S content in the extract was estimated turbid metrically with spectrophotometer at 420 nm wave length.

3.14 Chemical analysis of plant samples

Preparation of plant samples

Both the grain and straw samples were dried in an oven at 60°C for 24 hours and then grounded by a grinding mill. The prepared sample were then put in paper bags and kept in desiccators until analysis.

Digestion and determination of total N from plant samples

For the determination of N 0.1 g oven dry ground plant samples (both grain and straw) as taken in a micro-kjeldahl flask. 1.1 g catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se=100:10:1), 3 ml 30 ml 30% H_2O_2 and 5 ml conc. H_2SO_4 were added into the flasks. The flasks were swirled and allowed to stand for ten minutes. Then heating was continued until the digest was clear and colorless. After cooling, the content was taken until 100 ml volumetric flasks and the volumes were made up to the mark with distilled water. A reagent blank was prepared in the same way. These digests were used for N determination.

Digestion of plant samples for P and K determination

Plant samples of 0.5 g were transferred into dry clean 100 ml Kjeldahl flasks. 10 ml of di-acid mixture (HNO_3: $HClO_4$=2:1) were added into the flasks. After leaving for a while, the flasks were heated slowly up to 200°C. The content of the flasks were boiled until they became sufficiently clear and colorless. After cooling, the digest were transferred into 50 ml volumetric flasks and the volumes were made up to the mark with distilled water. The digests were used for the determinations of P, K and S.

3.15 Determination of N, P and K from plant samples

Nitrogen (N)

N content in the digest was determined by the same method as described in case of soil analyses.

Phosphorus (P)

P was determined following the procedure of soil analyses using one ml digest for grain samples and 2 ml digests for straw samples from 50 ml extract.

Potassium (K)

Five ml digest samples for grain and 2 ml for straw were taken diluted to 50 ml volume to make desired conc. So that the absorbance's of sample could be measured within the range of standard solutions. The absorbance were finally measured by an automic absorption flame photometer.

3.16 Nutrient uptake

Nutrient uptake was calculated by using the formula stated below:

Nutrient uptake (kg ha^{-1}) = {yield (kg ha^{-1}) × nutrient}/100

3.17 Statistical analyses

All the collected data were analyzed for ANOVA using the randomized complete block design (RCBD) with the help of the computer package program SPSS. The differences among the treatment means were evaluated by the Duncan's New Multiple Range Test (DMRT) as outlined by Gomez and Gomez, 1984.

CHAPTER 4

RESULTS AND DISCUSSION

Results obtained from the present study, regarding the effect of split application of nitrogen fertilizer on growth, yield and yield contributing characters of BRRI dhan 29 have been presented and discussed in this chapter.

The effects of N fertilizer split application on different plant characters and performance of treatments also discussed here. The effects of N fertilizer split application on crop characters have been shown in Table 1, 2, 3, 4, 5 and 6.

4.1 Effect of N fertilizer split application on morpho- pysiological characters

4.1.1 Plant height (cm)

The effect of N fertilizer split application on plant height was significant at 35, 45, 55, 65, 75, 85 DAT and also in maturity. The plant height ranged from 25.5 cm to 35.5 cm at 35 DAT, tallest plant was found in FP and lowest plant was found in T_0. Plant height in T_1, T_2, T_3 was found statistically similar at 35 DAT. The plant height ranged from 32 cm to 45.5 cm at 45 DAT, tallest plant was found in FP and lowest plant was found in T_0. Plant height in T_1, FP was found statistically similar at 45 DAT. The plant height ranged from 45.5 cm to 55.5 cm at 55 DAT, tallest plant was found in FP and lowest plant was found in T_0. Plant height in T_1, T_2 and FP was found statistically similar at 55 DAT. The plant height ranged from 54.5 cm to 65.5 cm at 65 DAT, tallest plant was found in T_1 and lowest plant found in T_0. Plant height in T_2, T_3 was found statistically similar at 65 DAT. The plant height ranged from 59.05 cm to 70.5 cm at 75 DAT, tallest plant was found in T_1 and lowest plant found in T_0. Plant height in T_1, T_2, FP was found statistically similar at 75 DAT. The plant height ranged from 73.5 cm to 83.5 cm at 85 DAT, tallest plant was found in T_1 and lowest plant was found in T_0. Plant height in T_1, FP was statistically similar at 85 DAT. The plant height was ranged 86 cm to 95.5 cm at maturity, tallest plant was found in T_1 and lowest plant was found in T_0. Plant height in T_1, FP was found statistically similar at maturity. However, this result supported by Akanda *et al.,* (1986).If we observed table1 we see that in early stage, FP treatment show better height then others due to using more N fertilizer.

4.1.2. Number of tillers hill^{-1}

The effect of N fertilizer split application on tiller number hill^{-1} was significant at 35, 45, 55, 65, 75, 85 DAT and also in maturity. The tiller number hill^{-1} ranged from 3.4 to 5.5 at 35 DAT, highest tiller number hill^{-1} was found in FP and lowest tiller number hill^{-1} was found in T_0. Tiller number hill^{-1} in T_1, T_2 was found statistically similar, and T_0,T_3 was also found statistically similar at 35 DAT. The tiller number hill^{-1} ranged from 5.5 to 8 at 45 DAT, highest tiller number hill^{-1} was found in T_1 and lowest tiller number hill^{-1} was found in T_0. Tillers number hill^{-1} in T_1, FP was found statistically similar at 45 DAT. The tiller number hill^{-1} ranged from 9 to 12.5 at 55 DAT, highest tiller number hill^{-1} was found in T_1 and lowest plant was found in T_0. Tiller number hill^{-1} in T_1, T_2, and FP was found statistically similar at 55 DAT. The tiller number hill^{-1} ranged from 7.5 to 15.5 at 65 DAT, highest tiller number hill^{-1} was found in T_1 and lowest tiller number hill^{-1} found in T_0. Tiller number hill^{-1} in FP, T_2 was found statistically similar and T_0,T_3 was also found statistically similar at 65 DAT. The tiller number hill^{-1}ranged from 8 to 17 at 75 DAT, highest tiller number hill^{-1} was found in T_1 and lowest tiller number hill^{-1} found in T_0. Tiller number hill^{-1} in T_2, FP was found statistically similar at 75 DAT. Tiller number hill^{-1} ranged from 10.5 to 19.5 at 85 DAT, highest tiller number hill^{-1} was found in T_1 and lowest tiller number hill^{-1} found in T_0. Tiller number hill^{-1} in was statistically superior then others treatments at 85 DAT. The tiller number hill^{-1}was ranged 10 to 16.5 at maturity, highest tiller number hill^{-1} was found in T_1 and lowest tiller number hill^{-1} found in T_0. Tiller number hill^{-1} in T_2, FP was found statistically similar at maturity. Similar result was also reported by Bhuyian *et al.,* (1990).

Table 1. Effect of N fertilizer split application on Plant height of BRRI dhan 29 at different stages

Treatments	Plant height at 35 DAT	Plant height 45 DAT	Plant height at 55 DAT	Plant height at 65 DAT	Plant height at 75 DAT	Plant height at 85 DAT	Plant height at Maturity Stage
T_0	25.05b	31.9b	44.9b	54.1c	59.1c	72.6b	82.0b
FP	35.2a	45.8a	55.2a	57.9bc	65.1ab	82.2a	93.0a
T_1	33.0bc	43.0a	55.4a	65.0 a	70.0a	83.0a	95.0a
T_2	31.6c	42 ab	53.5a	61.0b	78.5a	81.0ab	92.5ab
T_3	32.3bc	40.5bc	51.b	59.5b	66.b	78.0c	87.5b
F value	**3.35**	**7.8**	**5.38**	**8.77**	**7.16**	**4.56**	**14.96**
P value	**0.03**	**0.001**	**0.004**	**0.001**	**0.001**	**0.009**	**0.01**
SE	**1.94**	**1.84**	**1.88**	**1.39**	**1.59**	**2.008**	**1.3**

Figures having common letters in the same column do not differ significantly at 5% level as per SPSS

Where,

T_0= (without fertilizer),

FP = (225 kg ha^{-1} at 3 equal splits, 1/3 at 0 DAT + ½ of remaining at 30 DAT+ least ½ at 70 DAT),

T_1 = (225 kg ha^{-1}, at 5 equal splits, 1/5 at 0 DAT+1/5 at 28 DAT+1/5 at 45 DAT+1/5 at 60 DAT+1/5 at 75 DAT)

T_2 = (225 kg ha^{-1}, at 4 equal splits, 1/4 at 0 DAT +1/4 at 30 DAT + 1/4 at 50 DAT+1/4 at 70 DAT)

T_3= (200 kg ha^{-1}, at 3 equal splits, 1/3 at 0 DAT+1/3 at 30 DAT+1/3 at 70 DAT).

Table 2. Effect of split application of N fertilizer on No. of tiller of BRRI dhan 29 at different stages

Treatments	Tiller hill^{-1} at 35 DAT	Tiller hill^{-1} at 45 DAT	Tiller hill^{-1} at 55 DAT	Tiller hill^{-1} at 65 DAT	Tiller hill^{-1} at 75 DAT	Tiller hill^{-1} at 85 DAT	Tiller hill^{-1} at Maturity Stage
T_0	3.40c	5.40c	5.80c	7.20c	7.60c	10.20d	9.00c
FP	5.20a	7.80a	11.60a	11.80b	12.80b	15.60b	14.00ab
T_1	4.40bc	8.00a	12.40a	15.00a	17.00a	19.60a	16.00a
T_2	4.20bc	7.40ab	11.80a	14.00b	16.00b	17.80ab	15.00ab
T_3	3.80c	6.20bc	10.00b	13.00ab	14.20ab	13.40c	13.00b
F value	**3.59**	**4.47**	**27.58**	**24.52**	**23.89**	15.30	13.40
P value	**0.02**	**0.01**	**0.00**	**0.00**	**0.00**	**16.39**	**14.60**
SE	**0.35**	**0.49**	**0.48**	**0.61**	**0.49**	**0.00**	**0.00**

Figures having common letters in the same column do not differ significantly at 5% level as per SPSS

Where,

T_0= (without fertilizer),

FP = (225 kg ha^{-1} at 3 equal splits, 1/3 at 0 DAT + ½ of remaining at 30 DAT+ least ½ at 70 DAT),

T_1 = (225 kg ha^{-1}, at 5 equal splits, 1/5 at 0 DAT+1/5 at 28 DAT+1/5 at 45 DAT+1/5 at 60 DAT+1/5 at 75 DAT)

T_2 = (225 kg ha^{-1}, at 4 equal splits, 1/4 at 0 DAT +1/4 at 30 DAT + 1/4 at 50 DAT+1/4 at 70 DAT)

T_3= (200 kg ha^{-1}, at 3 equal splits, 1/3 at 0 DAT+1/3 at 30 DAT+1/3 at 70 DAT).

4.2.1 Number of spikelet hill^{-1}

Split application of N fertilizer showed the insignificant influence of the number of spikelet hill^{-1}. The highest number of spikelet hill^{-1} (12.66) was produced at maturity when nitrogen was applied in 5 equal splits. The lowest number of panicles hill^{-1} (10.56) was produced without nitrogen application. Results indicated that T_1 was more efficient than others but all the treatments are statistically insignificant. Probable reason of the result might be the availability of nitrogen throughout the growth period of rice plants. This result also supported by Nazim *et al.,* (1995).

4.2.2 Length of panicle (cm)

Length of panicle was significantly influenced by N fertilizer split application (Table-3). The highest panicle length (29.23 cm) was obtained from T_1. The lowest panicle length was (25.49 cm) obtained from T_0. Panicle length of FP and T_2 was statistically similar. These results were in agreement with the findings of Reddy *et al.,* (1987).

4.2.3Number of filled grains panicle^{-1}

Number of filled grains panicle^{-1} was statistically significant due to split application of N fertilizer. The highest number of filled grains panicle (138.03) was recorded from 5 equal split applications. The lowest (126.43) was found in T_0. Number of filled grain was statistically similar in T_1 and T_2 and also Number of filled grain was statistically similar in FP and T_o .This trend of results supported earlier findings of Akanda *et al.,* (1986) and Reddy *et al.,* (1987).

4.2.4 Number of unfilled grains panicle^{-1}

The influence of N fertilizer split application on the number of unfilled grains panicle^{-1} was statistically insignificant. The highest number of unfilled grains panicle^{-1} (14.49) was found in FP. The lowest number of unfilled grains panicle^{-1} (11.91) was found in T_0. Results indicated all the treatments were statistically insignificant .This result also supported by Fernandez *et al.,* (2000).

4.2.5 1000-grain weight (g)

N fertilizer split application on 1000-grain weight was not significant. The highest 1000-grain weight (24.44g) was obtained from T_1. The lowest number of 1000-grain weight (23g) was found in T_3. Similar result was reported by Hari *et al.,* (1996).

Table 3. Effect of N fertilizer split application on different growth parameter of BRRI dhan 29

Treatment	Plant height	Tiller hill^{-1}	Non effective tiller number	Panicle length (cm)	Spikelet panicle^{-1}	Filled grain panicle^{-1}	Unfilled grain panicle^{-1}	1000 grain weight (g)
T_O	82.00b	9.00c	1.00c	25.00c	10.72a	124.00c	10.57a	23.00a
FP	93.00a	14.00ab	2.00bc	27.29b	11.86a	130.20bc	14.00a	23.10a
T_1	95.80a	16.00a	3.00a	29.72a	10.86a	137.58b	11.57a	23.50a
T_2	93.40a	15.00ab	2.00b	28.72a	11.86a	135.70b	11.26a	23.00a
T_3	86.20b	13.00b	1.00c	26.86b	10.72a	130.80bc	12.00a	22.85a
F value	**14.96**	**14.60**	**11.66**	**29.69**	**1.94**	**5.11**	**0.43**	**0.76**
P value	**0.01**	**0.00**	**0.00**	**0.00**	**0.13**	**0.005**	**0.79**	**0.56**
SE	**1.30**	**0.71**	**0.31**	**0.32**	**0.43**	**2.05**	**1.95**	**0.32**

Figures having common letters in the same column do not differ significantly at 5% level as per SPSS.

Where,

T_0= (without fertilizer),

FP = (225 kg ha^{-1} at 3 equal splits, 1/3 at 0 DAT + ½ of remaining at 30 DAT+ least ½ at 70 DAT),

T_1 = (225 kg ha^{-1}, at 5 equal splits, 1/5 at 0 DAT+1/5 at 28 DAT+1/5 at 45 DAT+1/5 at 60 DAT+1/5 at 75 DAT)

T_2 = (225 kg ha^{-1}, at 4 equal splits, 1/4 at 0 DAT +1/4 at 30 DAT + 1/4 at 50 DAT+1/4 at 70 DAT)

T_3= (200 kg ha^{-1}, at 3 equal splits,1/3 at 0 DAT+1/3 at 30 DAT+1/3 at 70 DAT).

4.2.6 Grain yield (t ha$^{-1)}$

The effect of N fertilizer split application on grain yield t ha^{-1} was statistically significant. The highest grain yield (8.7 t ha^{-1}) was produced when urea was applied in 5 equal splits application. The lowest grain yield 5.12 t ha^{-1} was produced in T_0. It was revealed that the highest grain yield was produced T_1 due to higher number of panicles hill^{-1} and grains panicle^{-1} and lowest in T_0 due to lower number of panicles hill^{-1} and grains panicle^{-1} and it was statistically found that T_1 showed more efficient result then other treatments. Similar result was reported by (Carrers *et al.*,).

4.2.7 Straw yield (t ha^{-1})

The influence of N fertilizer split application on straw yield was statistically significant. The highest straw yield (12.11 t ha^{-1}) was produced in 5 equal splits application. The lowest straw yield (7.07 t ha^{-1}) was produced when urea was not applied .It was observed that straw yield was increased with split application of N fertilizer and statistically found that T_1 showed more superior result then other treatments. These results were in agreement with the findings of Khush *et al.,* (1991).

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

The influence of N fertilizer split application on biological yield was statistically significant. The highest biological yield (20.76 t ha^{-1}) was produced in T_1. The lowest biological yield 12.236 t ha^{-1} was produced when urea was not applied. Statistically found that T_1 showed more superior result then other treatments due to split application of N fertilizer. Hussain *et al.,* (1989) observed that biological yield was increased with split application of N fertilizer.

Table 4. Effect of N fertilizer split application on Grain yield (t ha^{-1}), Straw yield (t ha^{-1}) Biological yield (t ha^{-1}) of BRRI dhan 29

Treatments	**Grain yield (** t ha^{-1})	**Straw yield (** t ha^{-1}**)**	**Biological yield (** t ha^{-1}**)**
T_0	5.15e	7.21e	12.23e
FP	6.99c	9.72c	16.72c
T_1	8.55a	11.97a	20.52a
T_2	7.98b	11.16b	19.14b
T_3	6.60d	9.24d	15.84d
F value	**666.55**	**545.14**	**600.98**
P value	**0.00**	**0.00**	**0.00**
SE	**0.04**	**0.05**	**0.12**

Figures having common letters in the same column do not differ significantly at 5% level as per SPSS.

Where,

T_0= (without fertilizer),

FP = (225 kg ha^{-1} at 3 equal splits, 1/3 at 0 DAT + ½ of remaining at 30 DAT+ least ½ at 70 DAT),

T_1 = (225 kg ha^{-1}, at 5 equal splits, 1/5 at 0 DAT+1/5 at 28 DAT+1/5 at 45 DAT+1/5 at 60 DAT+1/5 at 75 DAT)

T_2 = (225 kg ha^{-1}, at 4 equal splits, 1/4 at 0 DAT +1/4 at 30 DAT + 1/4 at 50 DAT+1/4 at 70 DAT)

T_3= (200 kg ha^{-1}, at 3 equal splits,1/3 at 0 DAT+1/3 at 30 DAT+1/3 at 70 DAT).

4.3 Nutrient content in rice grain and straw

Both grain and straw sample were analyzed for the determination of N, P, K content. The result are presented in the table 5 and discussed under the following headings.

4.3.1 Nitrogen (N)

The N content in rice grain was significantly influenced by the application of splitting N fertilizers which ranges from 1.10 to 1.43%. The highest nitrogen content 1.43 in rice grain was observed in the treatment T_1 due to application of 5 equal N fertilizer splitting doses. The lowest N content was observed in rice grain in T_0. Statistically found that T_1 showed more superior result then other treatments, so use of N fertilizer splitting doses increases the N content in rice markedly.

In rice straw, the N content varied significantly due to different treatments (table 5) ranged from 0.40 to 0.45%. Table 5 showed that all the treatments had significant effect on N content over T_0 and N content in T_1 , FP was statistically similar and T_0,T_3,T_2 was also statistically similar among the treatments, the highest N content in straw (0.45%) was recorded in T_1 in which 5 splits application of N was applied. The control treatment T_0 had the lowest N content .An increasing tendency of N content both in grain and straw was sited from the treatments having reduced recommended doses of fertilizers along with where 5 splits application of N was applied. From the table, it also revealed that the N content was comparatively higher in grain than that of straw. A significant increase in N content in rice grain and straw due to application of splits N had also been reported by many investigators (Verma ,1991; Jeong *et al.*, 1996 and Azim *et al.*, 1999).

4.3.2 Phosphorus (P)

The P contents in grain and straw of BRRI dhan 29 were significantly influenced by different treatments under the study of table 5. In case of grain P content varied from 0.16 to 0.24. The highest value was recorded in the treatment T_1 where 5 splits application of N was applied. The T_0 had the lowest P content observed from the table 5. It was observed that FP, T3 and T_2 statistically similar.

In rice straw, the P content varied significantly due to different treatments (table 5) from 0.12 to 0.20%. Table 5 showed that all the treatments had significant effect on P content over T_0. T_1,T_2 , FP, statistically similar among the treatments .The highest P content in straw (0.20%) was recorded in T_1 treatment in which 5 splits application of N was applied. The treatment T_0 had the lowest P content. An increasing tendency of P content both in grain and straw was sited due to split application of N fertilizer, it also revealed that the P content was comparatively higher in grain than that of straw. Gupta *et al.,* (1995) stated that the concentrations of P in rice tissue at different stages were increased with the application of P and splits doses of N.

4.3.3. Potassium (K)

K contents in grain and straw were governed profoundly by the different treatments used under the study table 5. In case of grain K content varied from 0.16 to 0.29%. The highest value was recorded in the treatment T_1 where 5 splits application of N was applied. The T_0 had the lowest K content. From the table, it was clear that the treatment T_1 was statistically suparior from others treatment. But K content in FP, T_2 and T_3 was statistically similar.

In rice straw, the K content varied significantly due to different treatments (table 5) from 0.89 to 1.23%. Table 5 showed that all the treatments had significant effect on K content over T_0 but the influence of T_1 on the straw K content was statistically superior among the treatments .The highest K content in straw (1.23%) was recorded in T_1 treatment in which 5 splits application of N was applied. The T_0 had the lowest K content. But K content in FP, T_0 was statistically similar. An increasing tendency of K content both in grain and straw was noted where 5 splits application of N was applied, from the table, it also revealed that the K content was comparatively higher in grain than that of straw. *Bhale et al.,* (1996) stated that the beneficial effect of K increase in rice at different stages with the application of K and splits doses of N.

4.3.4 Percent of Protein

The Protein contents in grain of BRRI dhan 29 were significantly influenced by different treatments under the study table 5. In case of grain Protein content varied from 7.12 to 8.93%. The highest value was recorded in the treatment T_1 where 5 splits application of N was applied. Which statistically superior to others. Protein content in FP, T_2 and T_3 was statistically similar. The treatment T_0 had the lowest protein content, observed from the table. This result also supported by Amon *et al.,* (1949).

Table 5. Effect of split application of N fertilizer on N, P, K content both grain and straw of BRRI dhan 29

Treatments	Percent of Nitrogen		Percent of protein	Phosphorus		Potassium	
	Grain t ha^{-1}	Straw t ha^{-1}	Grain t ha^{-1}	Grain t ha^{-1}	Straw t ha^{-1}	Grain t ha^{-1}	Straw t ha^{-1}
T_0	1.10c	0.40b	7.12c	0.16c	0.12d	0.16c	1.14b
FP	1.34b	0.44a	8.36b	0.23a	0.18b	0.24b	1.18b
T_1	1.43a	0.44a	8.93a	0.24a	0.20a	0.29a	1.23a
T_2	1.18e	0.41b	8.12b	0.23a	0.16c	0.23b	1.17bc
T_3	1.14d	0.42a	7.38b	0.18b	0.14c	0.23b	0.89c
F Value	**88.94**	**8.09**	**1.34**	**20.34**	**26.41**	**26.23**	**123.5**
P Value	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
SE	**0.041**	**0.005**	**0.090**	**0.006**	**0.004**	**0.003**	**0.776**

Figures having common letters in the same column do not differ significantly at 5% level as per SPSS

Where,

T_0= (without fertilizer),

FP = (225 kg ha^{-1} at 3 equal splits, 1/3 at 0 DAT + ½ of remaining at 30 DAT+ least ½ at 70 DAT),

T_1 = (225 kg ha^{-1}, at 5 equal splits, 1/5 at 0 DAT+1/5 at 28 DAT+1/5 at 45 DAT+1/5 at 60 DAT+1/5 at 75 DAT)

T_2 = (225 kg ha^{-1}, at 4 equal splits, 1/4 at 0 DAT +1/4 at 30 DAT + 1/4 at 50 DAT+1/4 at 70 DAT)

T_3= (200 kg ha^{-1}, at 3 equal splits, 1/3 at 0 DAT+1/3 at 30 DAT+1/3 at 70 DAT).

4.4 Effects of N fertilizer splitting doses on soil properties

The data presented in the table 6 and showed that the split application of N fertilizer when applied in soil it effect soil post-harvest properties. The soil pH organic matter content, total N. available P, exchangeable K have been discussed under the following sub-site.

4.4.1 Soil pH

Effects of N fertilizer splitting doses on soil pH of post-harvest soils are presented in table 6. In all the treatment, the soil pH slightly decreased compared to the initial pH value of 6.60, as the value of the post-harvest soil ranged from 6.44 to 6.59, highest value 6.59 was observed in the treatment T_2 and the lowest value 6.44 was found in the treatment T_0. Where soil pH in T_0 and T_3 is statistically similar and soil pH in FP and T_1 was statistically similar. Ram *et al.,* (2000) was reported that the application of chemical fertilizers decreased the soil pH.

4.4.2 Organic matter content (OM)

Table 6 revealed that the organic matter contents of the post-harvest soil ranged from 1.12 to 1.37%. The OM content of the initial soil was 1.22. It was observed that the OM content of the soils slightly decreased due to application of fertilizers while the results tended to increase in the soil treated with N fertilizer. The increasing OM content might be due addition biomass like cow dung with split application of N fertilizer, the highest value 1.37 was observed in the treatment T_1 and the lowest value was found 1.12 in the treatment T_0, OM content in T_2 and T_3 was statistically similar. Zhang *et al.,* (1996) reported that the combined application of cow dung and split application of N fertilizers increased the OM content in post-harvest soils.

4.4.3 Total N

The total N content of the post-harvest soils varied considerably by different treatments compared at Table 6. It revealed that the total N contents of the post-harvest soil ranged from 0.05 to 0.12 %. The total N content of the initial soil was 0.07. It was observed that the N content of the soils slightly increased due to application of N fertilizers except T_0.. The causes of increasing of N content due addition of split application of N fertilizer, the highest value 0.12 was observed in the treatment T_2 and the lowest value (0.05) was found in the treatment T_0. The result indicated that the application of splitting doses of N fertilizer in 4 equal splits was increasing the effect on the total N content of the post-harvest soil. N content in $T_{1,}$ FP T_3 was statistically similar. Mathew and Nair (1997) observed that the application of cow dung and split application of N fertilizers increase the total N content in post-harvest soil in rice field.

4.4.4 Available phosphorus (P)

The Available phosphorus content of the post-harvest soils varied considerably by different treatments compared at Table 6 and it revealed that the available P of the post-harvest soil ranged from (25.03 to 32.73) ppm. The available P of the initial soil was 27.20 ppm. It was observed that the available P of the soils slightly increased (except $T_{0)}$ due to split application of N fertilizers .The reason of increasing available P due to addition more N fertilizer. The highest value 32.73 ppm was observed in the treatment T_1 and the lowest was observed 25.03 in the treatment T_0 and P content in FP and T_3 was found statistically similar. The result indicated that the application of 5 equal N fertilizer splitting doses was increase the effect of the available P of the post-harvest soil. Gupta *et al.,* (1995) observed that P content in post-harvest soil was increased by split application of N fertilizer.

4.4.5 Exchangeable potassium (K)

The Exchangeable potassium content of the post-harvest soils influenced by different treatments compared at Table 6 and it revealed that the exchangeable K of the post-harvest soil ranged from (0.14 to 0.21) me/100 g soil. The exchangeable K of the initial soil was found 0.25 me/100 g soil. It was observed that the exchangeable K of the soils slightly decreased after harvesting. The highest value (0.21me/100 g soil) was observed in the T_1 and the lowest value (0.14me/100 g soil) was observed in the T_0 and K content in T_0 and T_3 was found statistically similar. The result indicated that the 5 equal split application of N fertilizer was increase effect of exchangeable K of the post-harvest soil. Mathew and Nair (1997) reported same result.

Table. 6 Effect of N fertilizer split application on pH, Organic Matter, Total N, Available P and Exchangeable K content of BRRI dhan 29

Treatments	**pH**	**Organic Matter**	**Total N**	**Available P (ppm)**	**Exchangeable** K (me./100g soil)
T_0	6.44c	1.12d	0.05c	25.03d	0.14c
FP	6.48b	1.21c	0.08b	28.50c	0.15bc
T_1	6.50b	1.37a	0.08b	30.21b	0.21a
T_2	6.59a	1.29b	0.12a	32.73a	0.17b
T_3	6.46c	1.30b	0.08b	28.00c	0.14c
F Value	**108.38**	**22.32**	**2.3**	**128.83**	**21.67**
P Value	**0.00**	**0.00**	**0.10**	**0.00**	**0.00**
SE	**0.005**	**0.0148**	**0.004**	**0.1632**	**0.0232**

Figures having common letters in the same column do not differ significantly at 5% level as per SPSS

Where,

T_0= (without fertilizer),

FP = (225 kg ha^{-1} at 3 equal splits, 1/3 at 0 DAT + ½ of remaining at 30 DAT+ least ½ at 70 DAT),

T_1 = (225 kg ha^{-1}, at 5 equal splits, 1/5 at 0 DAT+1/5 at 28 DAT+1/5 at 45 DAT+1/5 at 60 DAT+1/5 at 75 DAT)

T_2 = (225 kg ha^{-1}, at 4 equal splits, 1/4 at 0 DAT +1/4 at 30 DAT + 1/4 at 50 DAT+1/4 at 70 DAT)

T_3= (200 kg ha^{-1}, at 3 equal splits, 1/3 at 0 DAT+1/3 at 30 DAT+1/3 at 70 DAT).

CHAPTER 5

SUMMARY AND CONCLUSION

A field experiment was carried out at Soil Science research field, Hajee Mohammad Danesh Science and Technology University, Dinajpur, during the period from December, 2016 to April, 2017 to assess the effect of split application of nitrogen fertilizer on growth, yield of BRRI dhan 29. Optimum dose of nitrogen fertilization plays a vital role for growth and development of rice plant. Its growth is seriously affected when lower dose of nitrogen is applied which drastically reduces rice yield. On the other hand, excessive nitrogen application encourages excessive vegetative growth which makes the plant susceptible to insects, pests and diseases infestation, elongated internode, causes lodging, ultimately reduce rice yield. So, it is essential to find out the optimum doses of nitrogen application for efficient utilization of this element by the plants for better yield.

Thus , the experiment consisted of 5 nitrogen levels viz., T_0 (Without N fertilizer), FP (225 kg ha^{-1} urea at 3 equal splits, 1/3 at 0 DAT + 1/3 at 30 DAT+ l/3 at 70 DAT), T_1 (225 kg ha^{-1}, full doze of urea at 5 equal splits, 1/5 at 0 DAT+1/5 at 28 DAT+1/5 at 45 DAT+1/5 at 60 DAT+1/5 at 75 DAT) and T_2 (225 kg ha^{-1}, full doze of urea at 4 equal splits, 1/4 at 0 DAT +1/4 at 30 DAT + 1/4 at 50 DAT+1/4 at 70 DAT), T_3 (200 kg ha^{-1}, full doses of urea at 3 equal splits,1/3 at 0 DAT+1/3 at 30 DAT+1/3 at 70 DAT).

The effect of different split application of N fertilizer was found statistically significant on all parameters studied at 35, 45, 55, 65, 75, and 85 DAT and also at maturity stage except the unfilled grain $panicle^{-1}$ and 1000-grain weight. At early stage, growth rate was higher in FP compare to others treatments because initially higher doses of N fertilizer was applied in FP but later stage growth rate was higher in T_1 and T_2 due to intensive application of N fertilizer but growth rate of FP is reduce due to long interval of N application. At maturity, the highest results of all parameters were found in T_1, but unfilled grains $panicle^{-1}$ was highest in FP. The highest value of protein content was recorded in the treatment T_1, which statistically superior than those of others treatments. Lowest protein content was found in T_0. Protein content in FP, T_2 and T_3 was statistically similar. Harvest index was highest in T_1. At maturity, the minimum values of all parameters were found in T_0 and unfilled grains $panicle^{-1}$ was found similar in T_1 and T_2. 1000g grain weight was found similar in T_0, FP and T_2 but highest was found in T_1 and lowest was found in T_3.

From the above results and discussion it was revealed that full dose of urea (225 kg ha^{-1}, at 5 equal splits, 1/5 at 0 DAT+1/5 at 28 DAT+1/5 at 45 DAT+1/5 at 60 DAT+1/5 at 75 DAT) was more effective than the other splits application.

By applying proper dose of N fertilizer we can save money and can also keep our environment sound and healthy. Because the excessive use of N fertilizers affects the soil and also the environment through the residual effect of fertilizer. Selection of the most appropriate doses of nitrogen fertilization is a major concern of economic viability of crop production and the impact of agriculture. Further research may be taken for N fertilizer split application.

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