EFFECT OF DHAINCHA BIOMASS INCORPORATION ON THE GROWTH AND YIELD OF AMAN RICE AS A SUPPLEMENT OF NITROGENOUS FERTILIZER

BY

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REG. NO. : 10-04223

A Thesis
Submitted to the Faculty of Agriculture
Sher-e-Bangla Agricultural University, Dhaka
in partial fulfilment of the requirements
for the degree
of

MASTER OF SCIENCE (MS)
IN
SOIL SCIENCE

SEMESTER: JULY-DECEMBER, 2012

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CERTIFICATE

This is to certify that the thesis entitled **"Effect of Dhaincha Biomass Incorporation on the Growth and Yield of Aman Rice as a Supplement of Nitrogenous Fertilizer"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **Master of Science** in **Soil Science**, embodies the result of a piece of bonafide research work carried out by **Topan Kumar Roy**, Registration number: **10-04223** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:
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DEDICATED

TO

MY BELOVED PARENTS

ACKNOWLEDGEMENTS

All praises to the "Omnipotent Creator" for His never-ending blessing, the author deems it a great pleasure to express his profound thankfulness to his respected parents, who entiled much hardship inspiring for prosecuting his studies, receiving proper education.

The author likes to express his deepest sense of gratitude to his respected supervisor Dr. Alok Kumar Paul, Professor, Department of Soil Science, Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh for his scholastic guidance, support, encouragement and valuable suggestions and constructive criticism throughout the study period and gratuitous labor in conducting and successfully completing the research work and in the preparation of the manuscript writing.

The author also expresses his gratefulness to his respected Co-Supervisor Dr. Md. Asaduzzaman Khan, Professor, Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka for his scholastic guidance, helpful comments and constant inspiration, inestimatable help, valuable suggestions throughout the research work and in preparation of the thesis.

The author expresses his sincere gratitude towards the sincerity of the Chairman, Mst. Afrose Jahan, Professor, Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka for her valuable suggestions and cooperation during the study period. The author also expresses heartfelt thanks to all the teachers of the Department of Soil Science, SAU, for their valuable suggestions, instructions, cordial help and encouragement during the period of the study.

The author expresses his sincere appreciation to his brother, sisters, relatives, well wishers and friends for their inspiration, help and encouragement throughout the study period.

The Author

ABSTRACT

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from July to November 2011 to study the effect of *Dhaincha* biomass incorporation on the growth and yield of aman rice as a supplement of nitrogenous fertilizer. BRRI dhan40 was used as the test crop in this experiment. At 20, 40, 60, 80 DAT and harvest, the highest plant height (21.67 cm, 46.13 cm, 65.29 cm, 96.15 cm and 113.65 cm) was recorded from T_2 (100 kg N ha^{-1} (from urea) + 20 kg N ha^{-1} (from *Dhaincha*) [Land preparation]) whereas, at the same DAT the lowest plant height (14.00 cm, 36.76 cm, 54.94 cm, 80.10 cm and 91.19 cm) was observed from T_{12} (control). The maximum number of effective tillers per hill (12.33) was found from T_2 and the minimum number (6.13) was found from T_{12}. The highest length of panicle (22.96 cm) was recorded from T_3 (100 kg N ha^{-1} (from urea) + 10 kg N ha^{-1} (from *Dhaincha*) [Land preparation] + 10 kg N ha^{-1} (from *Dhaincha*) [top dressing]) and the lowest length (15.56 cm) was observed from T_{12}. The highest grain yield (5.17 t ha^{-1}) was obtained from T_2, while the lowest (2.48 t ha^{-1}) was found from T_{12}. The highest straw yield (5.89 t ha^{-1}) was obtained from T_2 and the lowest (3.72 t ha^{-1}) was found from T_{12}. The highest N concentration in grain (1.31%) was recorded from T_1 (120 kg N ha^{-1} (from urea), while the lowest grain (0.92%) was observed from T_{12}. The highest N uptake by grain (67.53 kg ha^{-1}) was recorded from T_1 and the lowest (22.69 kg ha^{-1}) was recorded from T_{12}. The highest organic matter in post harvest soil (1.30%) was recorded from T_3 and the lowest (1.05%) was observed from T_{12}. The highest total nitrogen in post harvest soil (0.053%) was recorded from T_2 and the lowest total nitrogen in post harvest soil (0.026%) was obtained from T_{12}. Application of 100 kg N ha^{-1} (from urea) + 20 kg N ha^{-1} (from *Dhaincha*) [Land preparation] was the superior among the other treatments in consideration of yield contributing characters and yield of BRRI dhan40.

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CHAPTER I

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food for more than two billion people in Asia and most extensively cultivated cereal crop as an important food for the people of Bangladesh (Hien *et al.*, 2006). The national average rice yield in Bangladesh (4.2 t ha^{-1}) is very low compared to those of other rice growing countries, like China (6.30 t ha^{-1}), Japan (6.60 t ha^{-1}) and Korea (6.30 t ha^{-1}). In Bangladesh, although, the geographical, climatic and edaphic conditions are favorable for year round rice cultivation (FAO, 2009). The cultivable land is reducing day by day due to urbanization and industrialization resulting in more shortage of food but the population of the country is increasing at an alarming rate. At present it is not possible to have horizontal expansion of rice area in our country but rice yield per unit area may be increased to meet this ever-increasing demand.

Nutrient is the single most important factor that plays a dominant role in yield increase if other production factors are not limiting. It is reported that chemical fertilizers today hold the key to success of production systems of Bangladesh agriculture being responsible for about 50% of the total crop production (BARC, 1997). Nutrient imbalance can be minimized by judicious application of different fertilizers. There is need to develop appropriate management technique to evaluate the performance and to assess the nutrient requirement for rice cultivation in the country. Among the fertilizers, nitrogen (N) is essential for vegetative growth but excess N may cause excessive vegetative growth, prolong the growth duration and delay crop maturity with reduction in grain yield. Many research works revealed a significant response of rice to N fertilizer in different soils (Hussain *et al.*, 1989). The efficient N management can increase crop yield and another way reduce production cost. An increase in the yield of rice by 70 to 80% may be obtained from proper application of N fertilizer (IFC, 1982). On the other hand, inadequate and improper application of N are now considered one of the major reasons for low yield of rice in Bangladesh. The utilization efficiency of applied N by the rice plant is very low.

The optimum dose of N fertilizer plays vital role for the growth and development of rice plant and its growth is seriously hampered when lower dose of N is applied, which drastically reduced yield. Further, excessive N fertilization encourages excessive vegetative growth which make the plant susceptible to insect pests and diseases which ultimately reduces yield. So, it is essential to find out the optimum rate of N application for efficient utilization of these elements by the plants for better yield. Depleted soil fertility is a major constrain to higher crop production in Bangladesh. The increasing land use intensity has resulted in a great exhaustion of nutrient in soils. The farmers of this country use on an average 102 kg nutrients ha^{-1} annually (70 kg N + 24 kg P + 6 kg 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 cultivated soils have less than 1.5% organic matter while a good agricultural soil should contain at least 2% organic matter (Ali, 1994). Moreover, this important component of soil is declining with time due to intensive cropping and use of higher dose of chemical fertilizers with little or no addition of organic manure in the farmer's field. In addition, rapid mineralization of soil organic matter occurs due to humid tropic climatic conditions of Bangladesh. Cycling of organic matter in soil is a pre–requisite for efficient cycling of nutrients. Unless due attention is paid to the improvement and maintenance of soil organic matter it may not be possible the goal to increase and sustained productivity of crop.

A suitable combination of organic and inorganic sources of nutrients is necessary for sustainable agriculture that can ensure quality food production. Nambiar (1991) views that integrated use of organic manure and chemical fertilizers would be quite promising not only in providing greater stability in production, but also in maintaining better soil fertility. Organic manure can supply a good amount of plant nutrients which can contribute to crop yields. Mineralization and immobilization are biochemical in nature and are mediated through the activities of microorganisms. The rate and extent of mineralization determines crop availability of nutrients. The transformation of N, P and S in soil depends on the quality and quantity of organic matter as well as soil fertility.

Soil organic matter improves the physiochemical properties of the soil and ultimately promotes crop production. Evidences from different AEZ of the country have shown a decrease in the content of organic matter by the range of 15 to 30% over the last 20 years (Miah, 1994). Therefore, it would not be wise to depend only on inherent potentials of soils for higher crop production. The application of different fertilizers and manures also positively correlated with soil porosity and enzymatic activity. Organic fertilizer enhances soil porosity by increasing regular and irregular pores and causes a priming effect of native soil organic matter. Dhaincha (*Sesbania aculeata*) is a green manure crop and subsequently add organic matter to the soil, improves the physical properties of soil in terms of aeration, porosity, water holding capacity and facilities penetration of rain water. It holds plant nutrients that would otherwise be lost by leaching. It is also able to add significant amount of nitrogen to the soil.

Under this circumstance the present research work has been taken with the following objectives:

a. To evaluate the effect of different levels of Dhaincha biomass as a supplement of inorganic N on yield and yield attributes of BRRI dhan 40.

b. To observe the effect of Dhaincha biomass on the physical and chemical properties of soil.

CHAPTER II

REVIEW OF LITERATURE

Among the 18 essential nutrient elements nitrogen is the major and primary elements for the growth and development and better yield of crops. Plants response best to nitrogen compared to other nutrient elements. Urea has been found to be very effective nitrogenous fertilizers. Nitrogen play pivotal role at yield and yield attributes of rice. Different green manure substitute different amount of nitrogen. Use of organic manure also the essential factor for sustainable soil fertility and crop productivity. Sole and combined use of inorganic fertilizer increase plant growth, yield contributing characters and yield because it is the store house of plant nutrients. Experimental evidences that the use of Dhaincha has an intimate effect on the yield and yield attributes of rice as a nitrogen supply green manure. The available relevant reviews that are related to the effect of level of various organic manure as a sole or combined application on the yield and yield attributes of rice are reviewed below under the following headings-

2.1 Effect of nitrogen fertilizer on rice

Mondal and Swamy (2003) conducted an experiment and found that application of N (120 kg ha^{-1}) as urea in equal splits during transplanting, tillering, panicle initiation and flowering resulted in the highest number of panicle, number of grains $panicle^{-1}$, 1000-grain weight, straw yield and harvest index. Shrirame *et al.* (2000) conducted an experiment during the kharif 1996 in Nagpur, Maharastra, India on rice cv. TNRH-10, TNRH-13 and TNRH-18 were grown at 1, 2, and 3 seedlings $hill^{-1}$ with N (120 kg ha^{-1}) as urea and found one seedling $hill^{-1}$ with N (120 kg ha^{-1}) as urea showed significantly higher harvest index.

Duhan and Singh (2002) stated that the rice yield and uptake of nutrients increased significantly with increasing N levels. Moreover, the application along with various green manures (GM) showed additive effect on the yield and uptake of micronutrients. Under all GM treatments, the yield and nutrient uptake were always higher with 120 kg ha^{-1} than with lower level of nitrogen.

Bayan and Kandasamy (2002) noticed that the application of recommended doses of nitrogen in four splits at 10 days after sowing active tillering, panicle initiation at heading stages recorded significantly lower dry weight of weeds and increased crop growth viz. effective tillers m^{-2}.

Angayarkanni and Ravichandran (2001) conducted a field experiment in Tamil Nadu, India from July to October 1997 to determine the best split application of 150 kg N ha^{-1} for rice cv. IR20. They found that applying 16.66% of the recommended N as basal, followed by 33.33% N at 10 DAT, 25% N at 20 DAT and 25% N at 40 DAT recorded the highest grain and straw yields.

Sarkar *et al.* (2001) obtained the nitrogen responses of a Japonica (Yumelvitachi) and an Indica (Takanari) rice variety with different nitrogen levels viz. 0, 40, 80, and 120 kg N ha^{-1}. They observed that application of nitrogen increased grain and straw yields significantly but harvest index was not increased significant.

Munnujan *et al.* (2001) treated 4 levels of nitrogen fertilizer (0, 40, 80, and 160 kg ha^{-1}) application at three levels each planting density (20, 40 and 80 hill m^{-1}) and concluded that the highest grain yield was obtained with 180 kg N ha^{-1}, which was similar to the yield obtained at 80 kg N ha^{-1}.

Pulley *et al.* (2000) observed that yield increase associated with application of nitrogen stage, although booting stage nitrogen application had no effect or shoot growth or nitrogen uptake. These preliminary results suggested single application of nitrogen is sufficient to maintain healthy rice growth, alleviating the need for additional N application after flooding. Rice may be responded to N applied as late as booting, but only when the rice is N limited and not severely N stressed. Geethadevi *et al.* (2000) found that 120 kg N ha^{-1} in the form of urea, 50% nitrogen was applied in four splits resulted in higher number of tillers, filled grains $panicle^{-1}$ and higher grain weight $hill^{-1}$.

BRRI (2000) reported that the grain yield was linearly increased with increasing nitrogen rates. Chopra and Chopra (2000) cited that seed yield increased linearly up to 80 kg N ha^{-1}. Castro and Sarker (2000) conducted field experiment to see the effects of N applications as basal (80, 60, and 45 kg N ha^{-1}) and top dressing (10, 30 and 45 kg ha^{-1}) on the yield and yield components of Japonica rice and obtained high effective tiller, percentage of ripened grains and high grain yields from 45 kg N ha^{-1} (basal) and 45 kg N ha^{-1} (top dressing). Singh *et al.* (2000) stated that each increment dose of N significantly increased grain and straw yields of rice over its preceding dose. Consequently the crop fertilized with 100 kg N ha^{-1} gave maximum grain yield.

Bellido *et al.* (2000) evaluate a field experiment with 4 levels of nitrogen (0, 50, 100 and 150 kg N ha^{-1}) and reported that the amount of total dry matter was significantly greater at the N fertilizer rates of 100 and 150 kg nitrogen ha^{-1}.

Kumar and Sharma (1999) conducted a field experiment with 4 levels of nitrogen (0, 40, 80 and 120 kg N ha^{-1}) and observed that dry matter accumulation in rice increased from 0-40 kg N ha^{-1} at 40 DAS, 0-120 kg N ha^{-1} at 60 DAS, 0-80 kg ha^{-1} at 80 DAS. Nitrogen application also hastened the growth and resulted in higher percentage of total dry matter accumulation in early stage of crop growth.

Singh *et al.* (1998) studied the performance of three hybrids KHR 1, Pro Agro 103 and MGR 1 using Jaya and Rasi as standard checks at four levels of N (0, 60, 120, and 180 kg ha^{-1}). They observed that the varieties responded linearly to the applied N level up to 120 kg ha^{-1}.

Dwivedi (1997) noticed that application of nitrogen significantly increased in growth, yield and yield components, grain yield, straw yield as well as harvest index with 60 kg N ha^{-1}. BRRI (1997) conducted experiment during *boro* and transplant *aman* season to determined rice seed yield and the experiment was laid out with four nitrogen levels 0, 50, 100 and 150 kg ha^{-1} and noted that seed yield increased gradually with the gradual increase of nitrogen.

Andrade and Amorim (1996) observed that increasing level of N increased plant height, panicle m^{-2}, grains $panicle^{-1}$ and grain yield. Palm *et al.* (1996) conducted a field trial at Waraseoni in the 1989-90 rainy season and observed that yield of rice was the highest when 100 kg N ha^{-1} was applied.

Khanda and Dixit (1996) reported that the increased levels of applied nitrogen significantly influenced the grain yields. They found that maximum grain and straw yields of 4.58 and 6.21 t ha^{-1} were obtained from 90 kg N ha^{-1}, respectively. Adhikary and Rhaman (1996) reported that the highest yield was obtained from 100 kg N ha^{-1} followed by 120 kg N ha^{-1} and 80 kg N ha^{-1}. Verma and Achraya (1996) observed that LAI increased significantly at maximum tillering and flowering stages with increasing levels of nitrogen.

Effective tillers m^{-2} responded significantly to N fertilizer (Behera, 1995). Effective tillers increased significantly with increase the level of N fertilizer up to 80 kg N ha^{-1}. Kumar *et al.* (1995) observed a field experiment with four levels of nitrogen (0, 60, 120 and 180 kg N ha^{-1}) and reported that effective tillers increased significantly with the increase of N doses from 0-120 kg N ha^{-1}.

Awasthi and Bhan (1993) reported that increasing levels of nitrogen up to 60 kg ha^{-1} influenced LAI and dry matter production of rice. Patel and Upadhaya (1993) found that plant height of rice increased significantly with increasing rate of N up to 150 kg ha^{-1}. Patel and Upadhyay (1993) conducted an experiment with 3 levels of N (90, 120 and 150 kg ha^{-1}) and reported that total and effective tillers m^{-2} increased significantly with increasing N up to 120 kg ha^{-1}.

Ahmed and Hossain (1992) observed that plant height were 79.4, 82.3 and 84.4 cm with 45, 90 and 135 kg N ha^{-1}, respectively. BRRI (1992) reported that both grain and straw yields of rice were increased significantly up to 80 kg N ha^{-1} and 120 to 160 kg nitrogen ha^{-1} and significantly reduced the yield which was assumed to be due to excessive vegetative growth follower by lodging after flowering.

2.2 Effect of biomass incorporation as a supplement of nutrients

Two field experiments were conducted by Phongpan and Mosier (2002) in a rice-fallow-rice cropping sequence during consecutive dry and wet seasons of 1997 on a clay soil to determine the fate and efficiency of broadcast urea in combination with three residue management practices (no residue, burned residue and untreated rice crop residue). During a 70 d follow period prior to flooding the soil for wet season rice, emissions of N_2O measured at weekly intervals from no residue, burned residue and residue treatments ranged from 25 to 128, 19 to 59 and 24 to 75 mg N m^{-2} ha^{-1}, respectively. Grain yield and N uptake were significantly increased by N application in the dry season but not significantly affected by residue treatments in either season.

Nelson (2002) also reasoned that subtracting the predicted amount of residue required to stay at or below T (calculated from the first set of analyses) from the amount of residue calculated from actual yield data would result in the amount of residue available for harvest. Some future hurdles to predict residue harvest potential from cropping systems include extending these results to all regions and soils, other crops, and extending the prediction to include more than just soil loss as a resource concern. To fully consider the soil quality impacts of residue removal, this method should also consider effects on soil organic matter, nutrients, biota, and future crop yield.

There is also sufficient quantity to support commercial production of biomass as a supplements of nutrients (DiPardo, 2000). However, removing crop residues for bio-energy use can have a negative effect on natural resource quality. Crop residues perform many positive functions for agricultural ecosystems including:

- Protecting soil from erosion, thereby maintaining water and air quality by reducing runoff and sediment (via reduced water-induced soil erosion) and air-borne particulates (through decreased wind erosion).
- Increasing or maintaining soil organic matter and nutrients, leading to improved soil and water quality
- Maintaining beneficial soil organisms and providing wildlife habitat; and

- Improving plant-available water and drought resistance, potentially increasing yields.

Gale and Cambardella (2000) reported that as a physical buffer, crop residues protect soil from the direct impacts of rain, wind and sunlight leading to improved soil structure, reduced soil temperature and evaporation, increased infiltration, and reduced runoff and erosion. While some studies suggest that plant roots contribute more carbon to soil than surface residues, crop residue contributes to soil organic matter and nutrient increases, water retention, and microbial and macroinvertebrate activity. These effects typically lead to improved plant growth and increased soil productivity and crop yield.

Glassner *et al*. (1999) reported that crop residues perform many positive functions for agricultural soils that reduce erosion and promote sustainable production. In many regions, cover crops are a viable alternative that offer soil protection and added organic matter. Green biomass, as with a cover crop, is considered to be 2.5 times more effective than crop residue in reducing wind erosion (in predictive models), especially if the residue is laying flat (McMaster and Wilhelm, 1997).

Paine *et al*. (1996) recommended growing these crops on marginal lands, such as highly erodible land, poorly drained soils or areas used for wastewater reclamation, which would avoid competition with food crops and increase the amount of arable land.

Karlen *et al*. (1994) found that 10 years of residue removal under no-till continuous corn in Wisconsin resulted in deleterious changes in many biological indicators of soil quality, including lower soil carbon, microbial activity, fungal biomass and earthworm populations compared with normal or double rates of residue return.

Lindstrom (1986) found increased runoff and soil loss with decreasing residue remaining on the soil surface under no-till, with the study results suggesting a 30% removal rate would not significantly increase soil loss in the systems modeled. Reduction in these properties and populations suggests loss of soil function, particularly reduced nutrient cycling, physical stability, and biodiversity.

Other conservation practices such as contour cropping or conservation tillage must be used to compensate for the loss of erosion protection and soil organic matter seen with residue removal (Lindstrom *et al.*, 1981; Larson, 1979).

To be sustainable, residue must only be removed when soil quality will not suffer as a result. In some regions the combination of crop, management practice, soil, and climate work together to produce more than is needed to maintain soil health. In this case, excess residues could potentially be used for conversion to biomass energy. However, for many other cropping, soil, and climate combinations (especially in warm regions), residue production is inadequate even for basic soil protection (Parr and Papendick, 1978).

2.3 Combined effect of nitrogen and organic fertilizer on rice

Vijay and Singh (2006) conducted a field experiment during kharif season of 2003 and 2004 at J.V. college, Baraut, Uttar Pradesh, India, to study the effect of organic manures and fertilizer treatments on growth, yield and yield attributes of rice (*Oryza sativa* cv. Pusa Bashmati). The manure treatment comprises compost. Fertilizer treatments included N at 0, 40, 80 and 120 kg ha^{-1}. Application of compost significantly improved the growth, yield and yield attributes of rice during the years of experimentation.

Davarynejad *et al.* (2004) conducted an experiment to investigate the effect of manure and municipal compost and their enrichment with chemical fertilizers on growth and yield of rice. Results showed that compost alone did not increase grain yield. However, when enriched with different levels of chemical fertilizer the highest amount of grain yield was produced.

Aal *et al.* (2003) measured then usefulness of supplementing different organic materials viz., water hyacinth compost (HC), town refuse compost (TR) to minimize consuming chemical fertilizers. The results showed that the application of organic materials either alone in combination with chemical fertilizer caused a substantial increase in total N, available P, K and micronutrients (Fe, Mn, Cu, Zn) as well as wheat yield (straw and grain). The importance of organic farming practices in desert sandy soils was emphasized to minimize chemical fertilizer consumption and to avoid environmental pollution.

Keeling *et al.* (2003) determined the green waste compost and provided with additional fertilizers and showed consistently that the response of rice rape to compost and fertilizer applied together than the response to the individual additives, but only very stable compost was used (>10 months processing). Experiments with 15 N-labeled fertilizer showed that rice was able to utilize the applied N-more efficiently when cultivated with the stable compost.

Rahman (2001) reported that in rice-rice cropping pattern, the highest grain yield of Boro rice was recorded in the soil test basis (STB) N P K S Zn fertilizers treatment while in T. Aman rice the 75% or 100% of N P K S Zn (STB) fertilizers plus GM with or without cow dung gave the highest or a comparable yield. The mean yearly N, P, K, S and Zn uptake by rice (Boro + T. Aman) increased with increasing supply of nutrients. Application of cow dung along with N P K S Zn (STB) resulted in markedly higher uptake of nutrients in Boro rice. In T. Aman rice, application of NPKS (STB) with GM and/or CD showed higher N, P, K, S, Zn uptake than that of NPKS (FRG) and NPK (FP) treatments. The total N content and the available N, P, K, S, and Zn status in soils increased slightly due to manuring. The whole results suggested that the integrated use of fertilizers with manure (viz. *Sesbania*, cow dung) could be an efficient practice for ensuring higher crop yields without degradation of soil fertility.

Rajni Rani *et al.* (2001) conducted a pot experiment in a glass house of Varanasi, Utter Pradesh, India during *kharif* season to assess the response of rice to different combinations of vermicompost (VC), poultry manure (PM) and nitrogen fertilizers. Results showed that integrated treatments significantly increase the plant height, number of effective panicle over the treatment having full nitrogen dose through urea.

Yamagata (2000) conducted a field experiment to determine the growth response of upland rice (*Oryza sativa* L.) and maize (*Zea mays*) to organic nitrogen by amending the soil with an inorganic N source (ammonium sulfate) and with an organic N source. N uptake was highest under the RBS treatment, but the inorganic N concentration in soil was lower when organic and inorganic N was applied together as compared to inorganic N alone. Upland rice also took up more N than maize in a pot experiment with RBS without differences in root spread.

Singh and Singh (2000) reported the effect of sewage sludge-based compost in the growth attributes and yield of rice during 1997, in Allhabad, Uttar Pradesh, India. The treatment were control, Jamuna compost at 2520 g ha^{-1} + urea at 986.60 g ha^{-1}, Jamuna compost at 5040 g ha^{-1} + urea at 657.33 g ha^{-1}, Jamuna compost at 7560 g ha^{-1} + urea at 328.60 g ha^{-1}, Jamuna compost at10083 g ha^{-1} + urea at 1315 g ha^{-1}. All the treatment equally received P and 2268.75 g ha^{-1} and potash at 403.33 g ha^{-1}. The plant height was highest at 100% urea application compared to 76.7 cm in Jamuna compost at 105 days after sowing. The highest grain yield of 44.58 q ha^{-1} was observed in 100% urea application, and it was the least in Jamuna compost (13.74 q ha^{-1}). However, application of Jamuna compost, alone with urea at 25 and 50%, showed and increase in growth and yield parameters of rice, which was as par with 100% urea application.

Abedin Miah and Mosleahuddain (1999) conducted a long term fertility trial in Sonatala silt-loam soil at Bangladesh Agricultural University farm, Mymensingh to evaluate the effects of continued fertilization and manureing on soil properties and yield of crops. Grain yield of rice increased due to N, P, K and S application but the rate of increase varied in different seasons. Residual S showed remarkable decrease in the yield in Aman season. The yield of Aman showed a decreasing trend over the years but the yield of Aus remained almost static. The availability of P, S and Zn increased in soil due to long continued application. P fertilization also improved the micronutrient status of soil. No considerable changes in K status were noted due to K application. Nutrient balance study showed a severe loss of most of the nutrients through soil degradation.

Liang-Yunjiang *et al.* (1999) observed that a mathematical model which analyzed the effect of application of organic and inorganic fertilizer on yields of rice growing on paddy soils was established. The model was used to study the effect of various factors on yields and to produce a strategy for optimization of management for high rice yields.

Singh *et al.* (1999) conducted field experiment during the rainy and winter seasons of 1990-91 to 1992-93 at Bari Bhag, Uttar Pradesh, India using recommended rates of N, P, K and Zn (120, 60, 40, 20 kg ha^{-1}) respectively, or 10 t/ha of FYM or rice straw 25 or 50% recommended rates (R.R) : N + RRP, K and Zn. Rice yield was the highest with FYM + S50 RRN, followed by the RRN, P, K and Zn.

Ghosal *et al.* (1998) in an experiment with rice found increased grain and dry matter yield when inorganic N fertilizer (50 kg N ha^{-1}) was applied alone or when a combination of organic (10 t FYM ha^{-1}) and inorganic N fertilizer (25 kg N ha^{-1}) were applied as compared with organic sources (20 t FYM ha^{-1}) alone.

Mondal and Chettri (1998) conducted field experiment during 1991-93 in West Bangal, India to study integrated nutrient management for high productivity and fertility building under a rice based cropping system with application of S as ammonium sulfate along with green manure in suit and farmyard manure to rice. The result showed maximum grain yields of rice (4.96 and 5.77 t ha^{-1}) in the wet and dry seasons, respectively.

Yadav (1998) conducted long-term fertilizer experiments on a rice-wheat cropping system at four locations in India. Long-term rice-wheat cropping system resulted in depletion of soil organic carbon and available N and P at two locations but increased in organic carbon, available N and K at the third location. The available P and K content of the soil also increased at the fourth location.

Devi *et al.* (1997) conducted a field trial (1987-93) to develop a system for integrated nutrient supply for a rice-rice cropping sequence. Application of 45:45:45 kg NPK ha^{-1} as mineral fertilizers and 45 kg N ha^{-1} as FYM in the *kharif* seasons followed by 90:45:45 kg mineral NPK ha^{-1} in the *rabi* seasons gave the highest yields in all years expect 1993 and application of half of the N in the *kharif* season or crop residues or green manure gave the highest yield.

Hossain *et al.* (1997) conducted a field experiment to evaluate the effect of integrated nutrient management on rice cropping in Old Brahmaputra Floodplain soil and found that the grain yield of BR 11 rice increased significantly due to the application of fertilizer alone or in combination with manures over control.

Singh *et al.* (1996) carried out a field experiment in India where irrigated rice was given 60, 80 or 120 kg N ha^{-1} per year as poultry manure, urea, poultry manure + urea respectively. In the first year, PM did not perform better than urea but in the fourth year, 120 g and 150 kg N as PM produced significantly higher grain yield than the same rate as urea. The PM help to sustain the grain yield of rice during the 3 years while the yield decreased with urea application.

Zhang *et al.* (1996) measured various crop response to a mixed municipal solid waste (refuse) bio-solids co-compost (named Nutrin plus) and examined the fate of certain metals associated with Nutri plus compost. The research results showed that the compost slightly increased heavy metal concentrations in the soil but did not cause any phytotoxicity to crops. Yield from 100 and 200 t ha^{-1} application was higher with compost than with NPKS treatment. The compost apparently was more beneficial in the year of application. The results suggest that Nutri plus compost application generated positive yield response in all three crops. Crop yield increased as the application rate increased.

Gupta *et al*. (1995) conducted field trial on different organic manure in India and reported that the application of field manure (10 t ha^{-1}) produced the highest grain yield (4.5 t ha^{-1}) followed by PM and FYM which produced yields of 4.1 and 3.9 t ha^{-1} of rice grain respectively. The increase in rice yield with organic manure was 34 to 55% higher over control and 5 to 22% higher over NPK fertilizers. Gupta *et al*. (1996) concluded that the rate of application of poultry manure could be reduced by 80 kg/ha of soil with the application of 1% poultry manure (PM). Organic C and available P contents of soil after harvest were increased with PM applications.

Miah (1994) stated that only the first crop following the application recovered one-fifth to one-half of the nutrient supplied by animal manure, reminder was held as humus to very slow decomposition, 2.4% element being released per annum. Islam (1995) found a significant yield increase with fertilizers and cowdung compared to fertilizer-N alone in T. Aman rice. In the following rice, the yields with fertilizer-N + residual of cowdung were higher than fertilizer-N alone. Flynn *et al*. (1995) studied the residual effect of broiler litter as a supplemental of mineral N and concluded that broiler litter applied in autumn at the rate of 9 t ha^{-1} reduced the mineral N from 44 kg to 22 kg ha^{-1}.

Ali (1994) carried out several experiments on integrated nutrient management at different places of Bangladesh. They reported that when Boro rice received total chemical fertilizers followed by Aman rice receiving the same, the combined yield increase over the control was 96 and 86% for grain and straw, respectively.

Meelu and Singh (1991) reported that besides chemical fertilizers, organic manure like poultry manure is another good source of nutrient of soil. Experiments on the use and agronomic efficiency of poultry manure showed that 4 t ha^{-1} poultry manure along with 60 kg N ha^{-1} as urea produced grain yield of rice similar to that with 120 kg N ha^{-1} as urea alone.

The effect of soil fertility and crop performance of different organic fertilizers (rice straw, farm yard manure, water hyacinth compost and tank silt) at different rates and in combination with N fertilizer studied by Sharma and Mittra (1991). Increasing the rates of FYM and water hyacinth compost application up to 15 t/ha increased rice yield but increasing the rate of rice straw beyond 5 t ha^{-1} did not.

Miyazaki *et al.* (1986) found from a field experiment with 0-30 t compost ha^{-1} + 0 or 80 kg N ha^{-1} for rice growing on a wet Andosol. Application of 10 and 30 t compost ha^{-1} increased soil ammonium N in the plough layer by 1 and 3 mg per 100 g dry soil, respectively. *Dhaincha* application increased soil N content, 60% of compost N remained in the soil and 50% of the N released by decomposition was taken up by the rice plants. Increased N uptake increased total DM yield and spikelet number. In cooler year, however, the percentage of ripened grains was lower with heavy application of compost than in warm years. Compost @ 20 t ha^{-1} gave a relatively stable high rice yield.

Maskina *et al.* (1986) studied the effect of N application on wetland rice in a loamy sand soil amended with cattle manure (60 kg N ha^{-1}) or PM (80 kg N ha^{-1}). The absence of urea N: PM increases the rice grain yield by 98%, which was 2.6 times higher than cattle manure (37%). Rice yield increased linearly with N rates whether or not the soil was amended with organic manure. Urea N equivalent to cattle and PM varied from 21 to 53 kg ha^{-1} and 50 to 123 kg ha^{-1} respectively. Apparent recovery of N from poultry manure ranged from 38 to 82% compared with 51 to 69% from urea and 20 to 25% from cattle manure and pig manure.

2.4 Soil properties for integrated use of fertilizers and organic manure

Hemalatha *et al.* (2000) revealed that green manure significantly increased the soil fertility status, organic carbon, available soil N, P and K at post harvest soil. Zaman *et al.* (2000) reported that chemical properties like organic matter content CEC, total N, exchangeable K, available P and S were favorably influenced by the application of organic sources of nitrogen and potassium while the organic sources mostly did not show positive effect. Soil pH decreased slightly compared to the initial status.

Santhi *et al.* (1999) observed that application of 100% NPK plus FYM decreased the bulk density and increased the water holding capacity of soil. The decreased in bulk density in FYM treated plots might be ascribed to better aggregation. The water holding capacity was increased due to the improvement in structural condition of soil that was brought about mainly by the application of FYM in combination with NPK fertilizers.

Xu *et al.* (1997) observed that application of organic matters affect soil pH value as well as nutrient level. 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 that organic fertilizers when applied alone or in combination with inorganic fertilizers increase the level of organic carbon in soil as well as the total N, P and K contents of soil.

Nambiar (1997) views that integrated use of organic manure and chemical fertilizers would be quite promising not only in providing greater stability in production, but also in maintaining healthy soil fertility status. Intensive crop production systems have witnessed serious problems associated with loss of soil fertility as a result of excessive soil mining of plant nutrients and consequently reduction in productivity. Application of external source of plant nutrients is a key element in optimal management of soil organic matter, crop residues and manure for ensuring the bio-availability, the cycling and the balance of nutrients in the soil plant systems.

Palm *et al.* (1996) stated that organic materials influence nutrient availability nutrients added through mineralization – immobilization pattern as energy sources for microbial activities and as precursors to soil organic matter and by reducing P sorption of the soil.

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 C content compared to its original status. Total and available N contents were also significantly improved by addition of organic matter, but had less impact on soil exchangeable cations.

Meelu *et al.* (1992) reported that organic C and total N increased significantly when *Sesbania* and *Crotolaria* were applied in the preceded rice crop for two wet seasons. Medhi *et al.* (1996) reported that incorporation of organic and inorganic sources of N increased soil solution NH_4-N to a peak and then declined to very low levels.

Bhandari *et al.* (1992) reported that an application of fertilizers 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 N also increased the available N and P by 5.22 kg and 0.8-3.8 kg ha^{-1} from their initial values.

Prasad and Kerketta (1991) conducted an experiment to assess the soil fertility, crop production and nutrient removal for cropping sequences in the presence of recommended doses of fertilizers and cultural practices along with 5 t ha^{-1} compost applied to the crops. There was an overall increase in organic C, increase in total N (83.9%), available N (69.9%) and available P (117.3%).

Bair (1990) stated that sustainable production of crop can not 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 fertilizers.

IRRI (1979) reported that organic materials are widely used to maintain soil fertility and improve soil properties in intensive cropping systems especially in traditional agriculture. Total N, exch. K and available P in soil increased by green manuring. The application of FYM increased organic C, total N, available P, Exchangeable K and CEC than GM. Application of NPK at 100-150% based on the initial soil test showed appreciable improvement in available soil N, P, and K. Organic C content was highest under FYM treatment. Depletion of P was highest under 100% treatment and K under 100% N and P treatment (Singh and Nambiar, 1984).

The literature review discussed above indicates that different organic manure can supply a good amount of plant nutrients and thus can contribute to crop yields. Dhaincha as a green manure improve the soil properties of soil in terms of aeration, porosity, water holding capacity and facilities for water penetration. The properties of soils are also influenced by the inclusion of organic manure and crop residues in the soil fertility management system either directly or through residual action. The integrated approach by using the organic and inorganic sources of nutrients helps improve the efficiency of nutrients.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from July to November 2011 to study the effect of Dhaincha biomass incorporation on the growth and yield of aman rice as a supplement of nitrogenous fertilizer. The details are presented below under the following headings -

3.1 Experimental site and soil

The experiment was conducted in typical rice growing silty loam soil at the Sher-e-Bangla Agricultural University Farm, Dhaka. The morphological, physical and chemical characteristics of the soil are shown in the Table 1 and 2.

3.2 Climate

The climate of the experimental area is characterized by high temperature, high humidity and medium rainfall with occasional gusty winds during the *kharif* season (March-September) and a scanty rainfall associated with 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 July to November 2011 have been presented in Appendix I.

3.3 Planting material

BRRI dhan40 was used as the test crop in this experiment. This variety was developed at the Bangladesh Rice Research Institute and it is recommended for *Aman* season. Average plant height of the variety is 110 cm at the ripening stage. The grains are medium fine and white. It requires about 155-160 days completing its life cycle with an average grain yield of 4.5 t/ha (BRRI, 2011).

Table 1. Morphological characteristics of the experimental field

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

(FAO and UNDP, 1988)

Table 2. Initial physical and chemical characteristics of the soil (0-15 cm depth)

Characteristics	Value
Mechanical fractions:	
% Sand	18.60
% Silt	45.40
% Clay	36.00
Textural class	Silty Loam
Consistency	Granular and friable when dry
pH (1: 2.5 soil- water)	5.8
CEC (cmol/kg)	17.9
Organic C (%)	0.69
Organic Matter (%)	1.19
Total N (%)	0.06
Exchangeable K (mol kg^{-1})	0.12
Available P (mg kg^{-1})	19.85
Available S (mg kg^{-1})	14.40

3.4 Land preparation

The land was first opened on 20 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 puddling.

3.5 Treatments

Different level of nitrogen from urea and Dhancha during land preparation and top dressing were used as a treatment. 100 kg green Dhaincha were used for 1.0 kg N. The experiment consisted of 12 treatments. The treatments were as follows:

T_1: 120 kg N ha^{-1} (from urea)

T_2: 100 kg N ha^{-1} (from urea) + 20 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_3: 100 kg N ha^{-1} (from urea) + 10 kg N ha^{-1} (from Dhaincha) [Land preparation] + 10 kg N ha^{-1} (from Dhaincha) [top dressing]

T_4: 80 kg N ha^{-1} (from urea) + 40 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_5: 80 kg N ha^{-1} (from urea) + 20 kg N ha^{-1} (from Dhaincha) [Land preparation] + 20 kg N ha^{-1} (from Dhaincha) [top dressing]

T_6: 60 kg N ha^{-1} (from urea) + 60 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_7: 60 kg N ha^{-1} (from urea) + 30 kg N ha^{-1} (from Dhaincha) [Land preparation] + 30 kg N ha^{-1} (from Dhaincha) [top dressing]

T_8: 50 kg N ha^{-1} (from urea) + 70 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_9: 50 kg N ha^{-1} (from urea) + 35 kg N ha^{-1} (from Dhaincha) [Land preparation] + 35 kg N ha^{-1} (from Dhaincha) [top dressing]

T_{10}: 120 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_{11}: 60 kg N ha^{-1} (from Dhaincha) [Land preparation] + 60 kg N ha^{-1} (from Dhaincha) [top dressing]

T_{12}: Control condition (No nitrogen, no Dhaincha)

3.6 Experimental design and layout

The experiment was laid out in a randomized complete block design (RCBD) with three replications, where the experimental area was divided into three blocks representing the replications to reduce soil heterogenetic effects. Each block was divided into twelve unit plots as treatments with raised bunds around. Thus the total numbers of plots were 36. The unit plot size was 3.0 m × 2.0 m and was separated from each other by 0.5 m ails. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m respectively. The layout of the experiment is shown in Figure 1.

3.7 Initial soil sampling

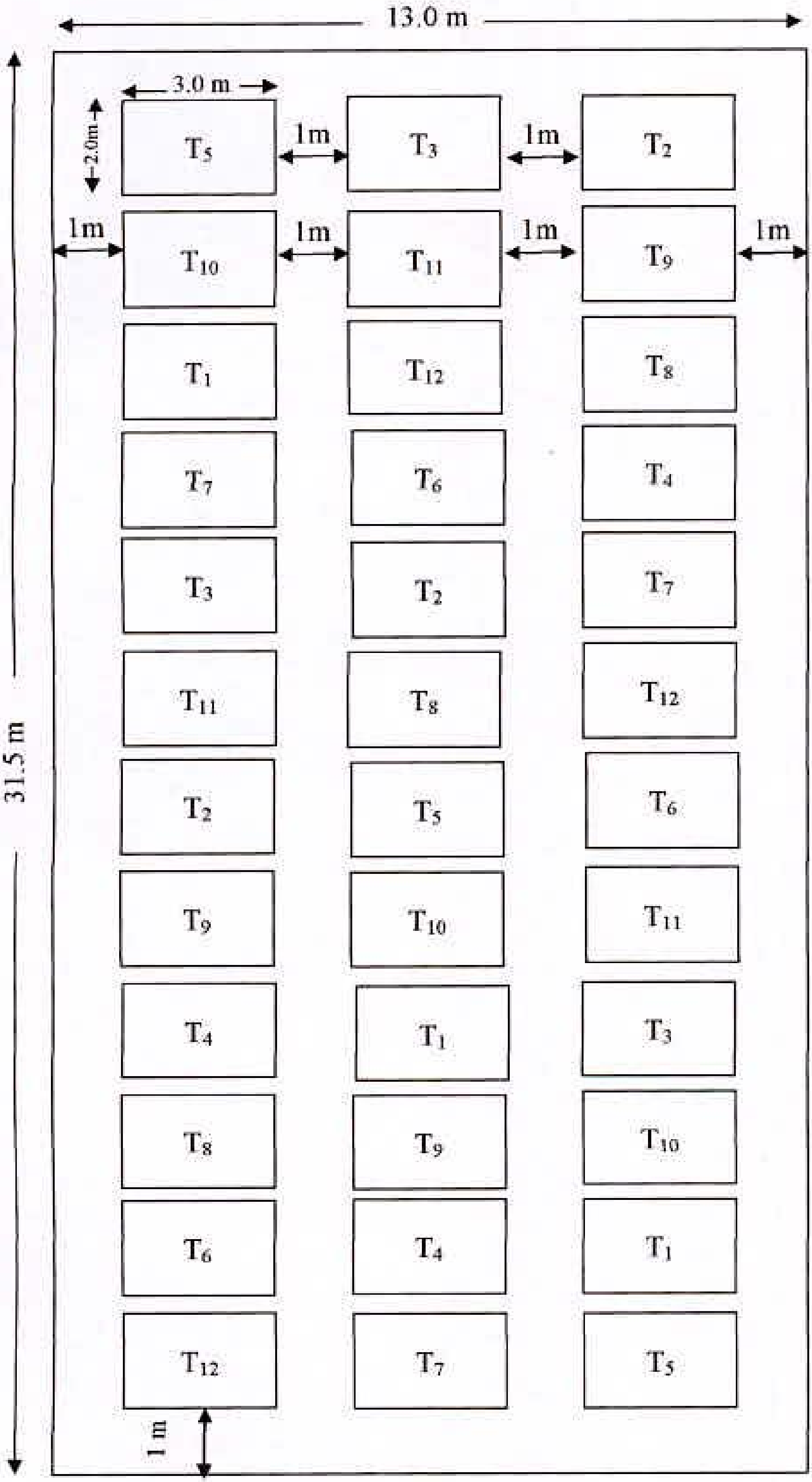
Before land preparation, initial 3 soil samples at 0-15 cm depth were collected from different spots of the experimental field. The composite soil sample were air-dried, crushed and passed through a 2 mm (10 meshes) sieve. After sieving, the soil samples were kept in a plastic container for physical and chemical analysis.

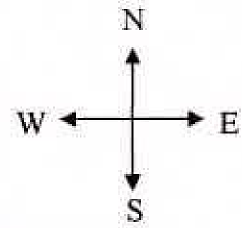
3.8 Raising of seedlings

The seedlings of rice were raised wet-bed methods. Seeds (95% germination) @ 5 kg ha^{-1} were soaked and incubated for 48 hour and sown on a well-prepared seedbed. During seedling growing, no fertilizers were used. Proper water and pest management practices were followed whenever required.

3.9 Fertilizer application

The amounts of P, K, S and Zn fertilizers were applied @ 130 g, 120 g, 70 g and 10 g $plot^{-1}$ and urea, Dhaincha were applied in the plot as per the treatments. Full amounts of TSP, MP, gypsum, zinc were applied as basal dose at final land preparation. Three urea doses were applied in equal splits: one third was applied as basal before transplanting, one third at active tillering stage (30 DAT) and the remaining one third was applied at 5 days before panicle initiation stage (55 DAT).





Plot size: 3.0 m × 2.0 m

Plot spacing: 50 cm

Between replication: 1.0 m

T_1: 120 kg N ha^{-1} (from urea)

T_2: 100 kg N ha^{-1} (from urea) + 20 kg N ha^{-1} (from Dhancha) [Land preparation]

T_3: 100 kg N ha^{-1} (from urea) + 10 kg N ha^{-1} (from Dhancha) [Land preparation] + 10 kg N ha^{-1} (from Dhancha) [top dressing]

T_4: 80 kg N ha^{-1} (from urea) + 40 kg N ha^{-1} (from Dhancha) [Land preparation]

T_5: 80 kg N ha^{-1} (from urea) + 20 kg N ha^{-1} (from Dhancha) [Land preparation] + 20 kg N ha^{-1} (from Dhancha) [top dressing]

T_6: 60 kg N ha^{-1} (from urea) + 60 kg N ha^{-1} (from Dhancha) [Land preparation]

T_7: 60 kg N ha^{-1} (from urea) + 30 kg N ha^{-1} (from Dhancha) [Land preparation] + 30 kg N ha^{-1} (from Dhancha) [top dressing]

T_8: 50 kg N ha^{-1} (from urea) + 70 kg N ha^{-1} (from Dhancha) [Land preparation]

T_9: 50 kg N ha^{-1} (from urea) + 35 kg N ha^{-1} (from Dhancha) [Land preparation] + 35 kg N ha^{-1} (from Dhancha) [top dressing]

T_{10}:120 kg N ha^{-1} (from Dhancha) [Land preparation]

T_{11}: 60 kg N ha^{-1} (from Dhancha) [Land preparation] + 60 kg N ha^{-1} (from Dhancha) [top dressing]

T_{12}:Control condition (No nitrogen, no Dhancha)

Figure 1. Layout of the experimental plot

3.10 Organic manure incorporation

Dhaincha as a organic manure were used. Dhaincha were applied before four days of final land preparation and panicle initiation stage as top dressing. 100 kg green Dhaincha were used for 1.0 kg N.

3.11 Transplanting

Thirty days old seedlings of BRRI dhan40 were carefully uprooted from the seedling nursery and transplanted on 5 August, 2011 in well puddled plot. Two seedlings per hill were used following a spacing of 20 cm × 20 cm. After one week of transplanting all plots were checked for any missing hill, which was filled up with extra seedlings whenever required.

3.12 Intercultural operations

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.

3.12.1 Irrigation

Necessary irrigations were provided to the plots as and when required during the growing period of rice crop.

3.12.2 Weeding

The plots were infested with some common weeds, which were removed by uprooting them from the field three times during the period of the cropping season.

3.12.3 Insect and pest control

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

3.13 Crop harvest

The crop was harvested at full maturity when 80-90% of the grains were turned into straw colored on 25 November, 2011. The crop was cut at the ground level and plot wise crop was bundled separately and brought to the threshing floor.

3.14 Collected data on yield components

3.14.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of 20, 40, 60, 80 days and at harvesting stage. Data were 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.

3.14.2 Number of tillers hill^{-1}

The number of tillers hill^{-1} was recorded at the time of 20, 40, 60 and 80 days by counting total tillers. Data were recorded as the average of 10 hills selected at random from the inner rows of each plot.

3.14.3 Effective tillers hill^{-1}

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

3.14.4 In-effective tillers hill^{-1}

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

3.14.5 Total tillers hill^{-1}

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.

3.14.6 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 plant.

3.14.7 Filled grain panicle^{-1}

The total numbers of filled grain was collected randomly from selected 10 plants of a plot on the basis of grain in the spikelet and then average numbers of filled grain panicle^{-1} was recorded.

3.14.8 Unfilled grain panicle^{-1}

The total numbers of unfilled grain was collected randomly from selected 10 plants of a plot on the basis of not grain in the spikelet and then average numbers of unfilled grain panicle^{-1} was recorded.

3.14.9 Total grain panicle^{-1}

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

3.14.10 Weight of 1000 seeds

One thousand seeds were counted randomly from the total cleaned harvested seeds and then weighed in grams and recorded.

3.14.11 Grain yield

Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains of central 1 m^2 area and five sample plants were added to the respective unit plot yield to record the final grain yield plot^{-1} and finally converted to t ha^{-1}.

3.14.12 Straw yield

Straw obtained from each unit plot were sun-dried and weighed carefully. The dry weight of straw of central 1 m^2 area and five sample plants were added to the respective unit plot yield to record the final straw yield $plot^{-1}$ and finally converted to t/ha.

3.14.13 Biological yield

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

Biological yield = Grain yield + Straw yield.

3.14.14 Harvest index

Harvest index was calculated from the grain and straw yield of rice for each plot and expressed in percentage.

$$HI = \frac{\text{Economic yield (grain weight)}}{\text{Biological yield (Total dry weight)}} \times 100$$

3.15 Chemical analysis of plant samples

3.15.1 Collection of grain and plant samples

Grain and straw samples were collected after threshing. The samples were finely ground by using a Wiley-Mill with stainless contact points to pass through a 60-mesh sieve. The samples were stored in plastic vial for analyses of N, P, K and S.

3.15.2 Preparation of plant samples

The plant samples were at first sun dried and then oven at 70^0C for 72 hours and then ground by a grinding machine to pass through a 20-mesh sieve. The grain and straw samples were analyzed for determination of N, P, K and S concentrations. The methods were as follows:

3.15.3 Digestion of plant samples with sulphuric acid for N

For the determination of nitrogen an amount of 0.2 g oven dry, ground sample were taken in a micro kjeldahl flask. 1.1 g catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se in the ratio of 100: 10: 1), and 5 ml conc. H_2SO_4 were added. The flasks were heating at 120^0C and added 2.5 ml 30% H_2O_2 then heated was continued at 180^0C until the digests became clear and colorless. After cooling, the content was taken into a 100 ml volumetric flask and the volume was made up to the mark with de-ionized water. A reagent blank was prepared in a similar manner. Nitrogen in the digest was estimated by distilling the digest with 10 N NaOH followed by titration of the distillate trapped in H_3BO_3 indicator solution with 0.01N H_2SO_4.

3.15.4 Digestion of plant samples with nitric-perchloric acid for P, K and S

A sub sample weighing 0.5 g was transferred into a dry, clean 100 ml digestion vessel. Ten ml of di-acid (HNO_3: $HClO_4$ in the ratio 2:1) mixture was added to the flask. After leaving for a while, the flasks were heated at a temperature slowly raised to 200^0C. Heating were stopped when the dense white fumes of $HClO_4$ occurred. The content of the flask were boiled until they were became clean and colorless. After cooling, the content was taken into a 100 ml volumetric flask and the volume was made up to the mark with de-ionized water. P, K and S were determined from this digest.

3.16 Nutrient uptake

After chemical analysis of straw and grain samples the nutrient contents were calculated and from the value of nutrient contents, nutrient uptakes were also calculated by following formula:

Nutrient uptake = Nutrient content (%) × Yield (kg ha^{-1})/100

3.17 Post harvest soil sampling

After harvest of crop soil samples were collected from each plot at a depth of 0 to 15 cm. Soil samples of each plot was air-dried, crushed and passed through a two mm (10 meshes) sieve. The soil samples were kept in plastic container to determine the physical and chemical properties of soil.

3.18 Soil analysis

Soil samples were analyzed for both physical and chemical characteristics viz. organic matter, pH, total N and available P, K, and S contents. The soil samples were analyzed by the following standard methods as follows:

3.18.1 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 Page *et al.*, 1982.

3.18.2 Organic matter

Organic carbon in soil sample was determined by wet oxidation method of Walkley and Black (1935). The underlying principle was used to oxidize the organic matter with an excess of 1N $K_2Cr_20_7$ in presence of conc. H_2SO_4 and conc. H_3PO_4 and to titrate the excess $K_2Cr_20_7$ solution with 1N $FeSO_4$. To obtain the content of organic matter was calculated by multiplying the percent organic carbon by 1.73 (Van Bemmelen factor) and the results were expressed in percentage (Page *et al.*, 1982).

3.18.3 Total nitrogen

Total N content of soil were determined followed by the Micro Kjeldahl method. One gram of oven dry ground soil sample was taken into micro kjeldahl flask to which 1.1 gm catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se in the ratio of 100:10:1), and 6 ml H_2SO_4 were added. The flasks were swirled and heated 200^0C and added 3 ml H_2O_2 and then heating at 360^0C was continued until the digest was clear and colorless. After cooling, the content was taken into 100 ml volumetric flask and the volume was made up to the mark with distilled water. A reagent blank was prepared in a similar manner. These digests were used for nitrogen determination (Page *et al.*, 1982).

Then 20 ml digest solution was transferred into the distillation flask, Then 10 ml of H_3BO_3 indicator solution was taken into a 250 ml conical flask which is marked to indicate a volume of 50 ml and placed the flask under the condenser outlet of the distillation apparatus so that the delivery end dipped in the acid. Add sufficient amount of 10N-NaOH solutions in the container connecting with distillation apparatus. Water runs through the condenser of distillation apparatus was checked. Operating switch of the distillation apparatus collected the distillate. The conical flask was removed by washing the delivery outlet of the distillation apparatus with distilled water. Finally the distillates were titrated with standard 0.01 N H_2SO_4 until the color changes from green to pink. The amount of N was calculated using the following formula:

$$\% N = (T\text{-}B) \times N \times 0.014 \times 100/S$$

Where,

T = Sample titration (ml) value of standard H_2SO_4

B = Blank titration (ml) value of standard H_2SO_4

N = Strength of H_2SO_4

S = Sample weight in gram

3.18.4 Available phosphorus

Available P was extracted from the soil with 0.5 M $NaHCO_3$ solutions, pH 8.5 (Olsen *et al.*, 1954). Phosphorus in the extract was then determined by developing blue color with reduction of phosphomolybdate complex and the color intensity were measured colorimetrically at 660 nm wavelength and readings were calibrated with the standard P curve (Page *et al.*, 1982).

3.18.5 Exchangeable potassium

Exchangeable K was determined by 1N NH_4OAc (pH 7) extraction methods and by using flame photometer and calibrated with a standard curve (Page *et al.*, 1982).

3.18.6 Available sulphur

Available S content was determined by extracting the soil with $CaCl_2$ (0.15%) solution as described by (Page *et al.*, 1982). The extractable S was determined by developing turbidity by adding acid seed solution (20 ppm S as K_2SO_4 in 6N HCl) and $BaCl_2$ crystals. The intensity of turbidity was measured by spectrophotometer at 420 nm wavelengths.

3.19 Statistical analysis

The data obtained for different parameters were statistically analyzed to find out the significant difference of different treatments on yield contributing characters, yield and soil properties of BRRI dhan40. The mean values of all the characters were calculated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the treatment means was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to study the effect of *Dhaincha* biomass incorporation on the growth and yield of aman rice as a supplement of nitrogenous fertilizer. Data on different growth parameter & yield, nutrient content in grain & straw, nutrient uptake by grain & straw and characteristics of post harvest soil was recorded. The analyses of variance (ANOVA) of the data on different parameters are presented in Appendix II-X. The results have been presented and possible interpretations given under the following headings:

4.1 Yield contributing characters and yield of rice

4.1.1 Plant height

Plant height showed statistically significant variation at 20, 40, 60, 80 days after transplanting (DAT) and harvest due to the effect of *Dhaincha* biomass incorporation as a supplement of nitrogenous fertilizer (Appendix II). At 20, 40, 60, 80 DAT and harvest, the highest plant height (21.67 cm, 46.13 cm, 65.29 cm, 96.15 cm and 113.65 cm) was recorded from T_2 (100 kg N ha^{-1} (from urea) + 20 kg N ha^{-1} (from Dhaincha) [Land preparation]) whereas, at the same DAT the lowest plant height (14.00 cm, 36.76 cm, 54.94 cm, 80.10 cm and 91.19 cm) was observed from T_{12} as control condition (Table 3). From the data it was revealed that all the treatments produced significantly taller plants compared to the control condition. Plant height was significantly influenced by the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer. Miyazaki *et al.* (1986) reported that Dhaincha application increased soil N content, 60% of compost N remained in the soil and 50% of the N released by decomposition was taken up by the rice plants that helps for longest plant. Similar results also reported by Rajani Rani *et al.* (2001), Singh *et al.* (1999), Hossain *et al.* (1997) and Sharma and Mitra (1991) and they reported that different organic manure significantly influenced plant height of rice.

Table 3. Effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer on plant height of BRRI dhan40

Treatment	Plant height (cm) at				
	20 DAT	40 DAT	60 DAT	80 DAT	at harvest
T_1	21.32 ab	45.03 a	65.10 a	95.63 a	112.46 a
T_2	21.67 a	46.13 a	65.29 a	96.15 a	113.65 a
T_3	20.94 ab	45.07 a	64.83 a	95.37 a	110.98 a
T_4	20.20 ab	43.13 ab	63.67 a	90.92 a	106.47 a
T_5	20.27 ab	44.63 ab	63.77 a	92.10 a	108.73 a
T_6	19.93 ab	43.83 ab	63.86 a	94.80 a	111.57 a
T_7	20.47 ab	45.80 a	64.53 a	95.90 a	111.75 a
T_8	18.80 bc	43.90 ab	62.86 a	93.56 a	110.84 a
T_9	19.53 ab	43.53 ab	62.81a	91.88 a	107.91 a
T_{10}	16.60 c	40.22 bc	59.86 ab	89.46 a	103.40 a
T_{11}	19.34 ab	42.90 ab	62.27 a	91.63 a	106.98 a
T_{12}	14.00 d	36.76 c	54.94 b	80.10 b	91.19 b
Significance level	0.01	0.01	0.05	0.01	0.01
$LSD_{(0.05)}$	2.456	4.133	5.179	6.762	10.10
CV(%)	7.47	5.62	4.87	4.33	5.52

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

T_1: 120 kg N ha^{-1} (from urea)

T_2: 100 kg N ha^{-1} (from urea) + 20 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_3: 100 kg N ha^{-1} (from urea) + 10 kg N ha^{-1} (from Dhaincha) [Land preparation] + 10 kg N ha^{-1} (from Dhaincha) [top dressing]

T_4: 80 kg N ha^{-1} (from urea) + 40 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_5: 80 kg N ha^{-1} (from urea) + 20 kg N ha^{-1} (from Dhaincha) [Land preparation] + 20 kg N ha^{-1} (from Dhaincha) [top dressing]

T_6: 60 kg N ha^{-1} (from urea) + 60 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_7: 60 kg N ha^{-1} (from urea) + 30 kg N ha^{-1} (from Dhaincha) [Land preparation] + 30 kg N ha^{-1} (from Dhaincha) [top dressing]

T_8: 50 kg N ha^{-1} (from urea) + 70 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_9: 50 kg N ha^{-1} (from urea) + 35 kg N ha^{-1} (from Dhaincha) [Land preparation] + 35 kg N ha^{-1} (from Dhaincha) [top dressing]

T_{10}: 120 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_{11}: 60 kg N ha^{-1} (from Dhaincha) [Land preparation] + 60 kg N ha^{-1} (from Dhaincha) [top dressing]

T_{12}: Control condition (No nitrogen, no Dhaincha)

4.1.2 Number of total tiller hill^{-1}

Statistically significant variation was recorded for number of total tiller hill^{-1} due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer at 20, 40, 60 and 80 DAT (Appendix III). At 20 and 80 DAT, the maximum number of total tillers hill^{-1} (5.17 and 20.30) was found from T_3 (100 kg N ha^{-1} (from urea) + 10 kg N ha^{-1} (from Dhaincha) [Land preparation] + 10 kg N ha^{-1} (from Dhaincha) [top dressing]) and at 40 and 60 DAT the maximum number of total tillers hill^{-1} (11.27 and 16.87) was observed from T_2 (100 kg N ha^{-1} (from urea) + 20 kg N ha^{-1} (from Dhaincha) [Land preparation]), again at 20, 40, 60 and 80 DAT, the minimum number of total tillers hill^{-1} (2.93, 5.23, 8.60 and 11.93) was observed from T_{12} as control condition (Table 4). It was revealed that all the treatments produced significantly maximum number of tiller compared to the control treatment.

4.1.3 Number of effective tillers hill^{-1}

A statistically significant variation was recorded for number of effective tillers per hill due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer (Appendix IV). The maximum number of effective tillers per hill (12.33) was found from T_2 (100 kg N ha^{-1} (from urea) + 20 kg N ha^{-1} (from Dhaincha) [Land preparation]) which was statistically identical (12.17, 12.00, 11.33, 11.20 and 11.13) with T_3 (100 kg N ha^{-1} (from urea) + 10 kg N ha^{-1} (from Dhaincha) [Land preparation] + 10 kg N ha^{-1} (from Dhaincha) [top dressing]), T_1 (120 kg N ha^{-1} (from urea), T_6 (60 kg N ha^{-1} (from urea) + 60 kg N ha^{-1} (from Dhaincha) [Land preparation]) T_7 (60 kg N ha^{-1} (from urea) + 30 kg N ha^{-1} (from Dhaincha) [Land preparation] + 30 kg N ha^{-1} (from Dhaincha) [top dressing]) and T_8 (60 50 kg N ha^{-1} (from urea) + 70 kg N ha^{-1} (from Dhaincha) [Land preparation]), respectively and closely followed (10.33 and 10.32) by T_5 (80 kg N ha^{-1} (from urea) + 20 kg N ha^{-1} (from Dhaincha) [Land preparation] + 20 kg N ha^{-1} (from Dhaincha) [top dressing]) and T_9 (50 kg N ha^{-1} (from urea) + 35 kg N ha^{-1} (from Dhaincha) [Land preparation] + 35 kg N ha^{-1} (from Dhaincha) [top dressing]). On the other hand, the minimum number of effective tillers hill^{-1} (6.13) was found from T_{12} as control which was followed (8.33, 9.13 and 10.07) by T_{10} (120 kg N ha^{-1} (from Dhaincha) [Land preparation]), T_4 (80 kg N ha^{-1} (from

Table 4. Effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer on number of total tillers hill^{-1} of BRRI dhan40

Treatment	Number of total tillers hill^{-1} at			
	20 DAT	40 DAT	60 DAT	80 DAT
T_1	5.07 ab	10.77 a	16.73 a	19.93 ab
T_2	4.90 a-d	11.27 a	16.87 a	20.27 a
T_3	5.17 a	10.67 a	16.43 a	20.30 a
T_4	3.93 ef	8.93 ab	13.23 b	17.43 a-c
T_5	4.10 ef	9.83 ab	14.00 ab	17.30 a-c
T_6	4.50 a-e	9.30 ab	14.50 ab	18.70 a-c
T_7	4.93 a-c	10.27 a	16.50 a	20.00 a
T_8	4.33 b-e	9.47 ab	13.90 ab	16.93 bc
T_9	4.17 d-f	9.23 ab	13.23 b	17.30 a-c
T_{10}	3.47 fg	7.53 b	11.60 b	15.77 c
T_{11}	4.20 c-f	9.10 ab	13.83 ab	17.43 a-c
T_{12}	2.93 g	5.23 c	8.60 c	11.93 d
Significance level	0.01	0.01	0.01	0.01
$LSD_{(0.05)}$	0.679	2.186	2.707	2.665
CV(%)	9.32	13.88	11.32	8.85

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

T_1: 120 kg N ha^{-1} (from urea)

T_2: 100 kg N ha^{-1} (from urea) + 20 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_3: 100 kg N ha^{-1} (from urea) + 10 kg N ha^{-1} (from Dhaincha) [Land preparation] + 10 kg N ha^{-1} (from Dhaincha) [top dressing]

T_4: 80 kg N ha^{-1} (from urea) + 40 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_5: 80 kg N ha^{-1} (from urea) + 20 kg N ha^{-1} (from Dhaincha) [Land preparation] + 20 kg N ha^{-1} (from Dhaincha) [top dressing]

T_6: 60 kg N ha^{-1} (from urea) + 60 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_7: 60 kg N ha^{-1} (from urea) + 30 kg N ha^{-1} (from Dhaincha) [Land preparation] + 30 kg N ha^{-1} (from Dhaincha) [top dressing]

T_8: 50 kg N ha^{-1} (from urea) + 70 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_9: 50 kg N ha^{-1} (from urea) + 35 kg N ha^{-1} (from Dhaincha) [Land preparation] + 35 kg N ha^{-1} (from Dhaincha) [top dressing]

T_{10}: 120 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_{11}: 60 kg N ha^{-1} (from Dhaincha) [Land preparation] + 60 kg N ha^{-1} (from Dhaincha) [top dressing]

T_{12}: Control condition (No nitrogen, no Dhaincha)

urea) + 40 kg N ha^{-1} (from Dhaincha) [Land preparation]) and T_{11} (60 kg N ha^{-1} (from Dhaincha) [Land preparation] + 60 kg N ha^{-1} (from Dhaincha) [top dressing]) (Figure 2). BRRI dhan40 responded significantly better to effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer.

4.1.4 Number of in-effective tillers hill^{-1}

Number of in-effective tillers hill^{-1} varied significantly due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer (Appendix IV). The maximum number of in-effective tillers hill^{-1} (3.70) was obtained from T_1 and the minimum number of in-effective tillers per hill^{-1} (2.17) was found from T_{10} (Table 5).

4.1.5 Total tillers hill^{-1}

Statistically significant variation was recorded for number of total tillers hill^{-1} due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer (Appendix IV). The maximum number of total tillers hill^{-1} (15.80) was observed from T_2 which was statistically identical (15.70, 14.53, 14.20 and 13.73) with T_1, T_3, T_7, T_6 and T_8 and closely followed (13.25 and 13.17) by T_9 and T_5. On the other hand, the minimum number of total tillers hill^{-1} (9.67) was obtained from T_{12} (control condition) which was followed (10.50) by T_{10} (Table 5).

4.1.6 Length of panicle

Length of panicle showed statistically significant variation due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer (Appendix IV). The highest length of panicle (22.96 cm) was recorded from T_3 which was statistically identical with other treatments except T_{12} and T_{10}. The lowest length of panicle (15.56 cm) was observed from T_{12} as control condition which was followed (19.64 cm) by T_{10} (Figure 3). Haque (1999) and Azim (1996) noted a significant increase in panicle length due to the application of organic manure and chemical fertilizers. Ahmed and Rahman (1991) and Apostol (1989) also reported similar results from their earlier experiments.

Table 5. Effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer on yield contributing characters of BRRI dhan40

Treatment	Number of in-effective tiller $hill^{-1}$	Number of total tiller $hill^{-1}$	Number of unfilled grain $plant^{-1}$	Number of total grain $plant^{-1}$
T_1	3.70 a	15.70 a	6.07 de	90.20 ab
T_2	3.47 a-c	15.80 a	6.67 c-e	92.10 a
T_3	3.53 ab	15.70 a	5.70 e	92.20 a
T_4	2.70 c-e	11.83 cd	8.20 bc	84.63 ab
T_5	2.83 b-e	13.17 bc	7.47 b-e	86.80 ab
T_6	2.87 b-e	14.20 ab	6.43 c-e	89.80 ab
T_7	3.33 a-d	14.53 ab	7.20 b-e	92.53 a
T_8	2.60 de	13.73 a-c	8.10 bc	90.80 ab
T_9	2.94 a-e	13.25 bc	7.87 b-d	86.22 ab
T_{10}	2.17 e	10.50 de	9.07 b	83.13 b
T_{11}	3.10 a-d	13.17 bc	8.00 b-d	85.60 ab
T_{12}	3.53 ab	9.67 e	12.00 a	68.00 c
Significance level	0.01	0.01	0.01	0.01
$LSD_{(0.05)}$	0.712	1.982	1.760	6.853
CV(%)	13.72	8.71	13.45	4.66

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

T_1: 120 kg N ha^{-1} (from urea)

T_2: 100 kg N ha^{-1} (from urea) + 20 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_3: 100 kg N ha^{-1} (from urea) + 10 kg N ha^{-1} (from Dhaincha) [Land preparation] + 10 kg N ha^{-1} (from Dhaincha) [top dressing]

T_4: 80 kg N ha^{-1} (from urea) + 40 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_5: 80 kg N ha^{-1} (from urea) + 20 kg N ha^{-1} (from Dhaincha) [Land preparation] + 20 kg N ha^{-1} (from Dhaincha) [top dressing]

T_6: 60 kg N ha^{-1} (from urea) + 60 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_7: 60 kg N ha^{-1} (from urea) + 30 kg N ha^{-1} (from Dhaincha) [Land preparation] + 30 kg N ha^{-1} (from Dhaincha) [top dressing]

T_8: 50 kg N ha^{-1} (from urea) + 70 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_9: 50 kg N ha^{-1} (from urea) + 35 kg N ha^{-1} (from Dhaincha) [Land preparation] + 35 kg N ha^{-1} (from Dhaincha) [top dressing]

T_{10}: 120 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_{11}: 60 kg N ha^{-1} (from Dhaincha) [Land preparation] + 60 kg N ha^{-1} (from Dhaincha) [top dressing]

T_{12}: *Control condition (No nitrogen, no Dhaincha)*

T_{12}: 120 kg N substituted equally by VC and CD

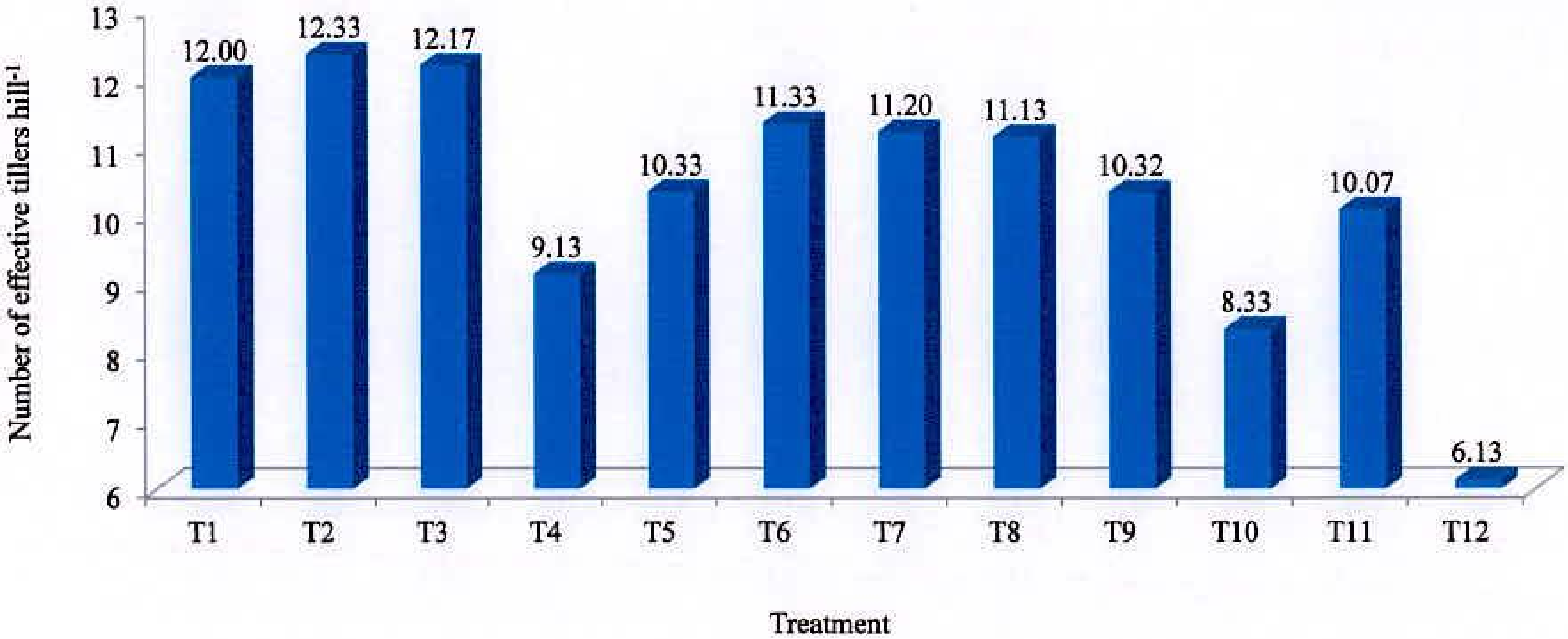


Figure 2. Effect of *Dhaincha* biomass incorporation as a supplement of nitrogenous fertilizer on number of effective tillers hill^{-1}

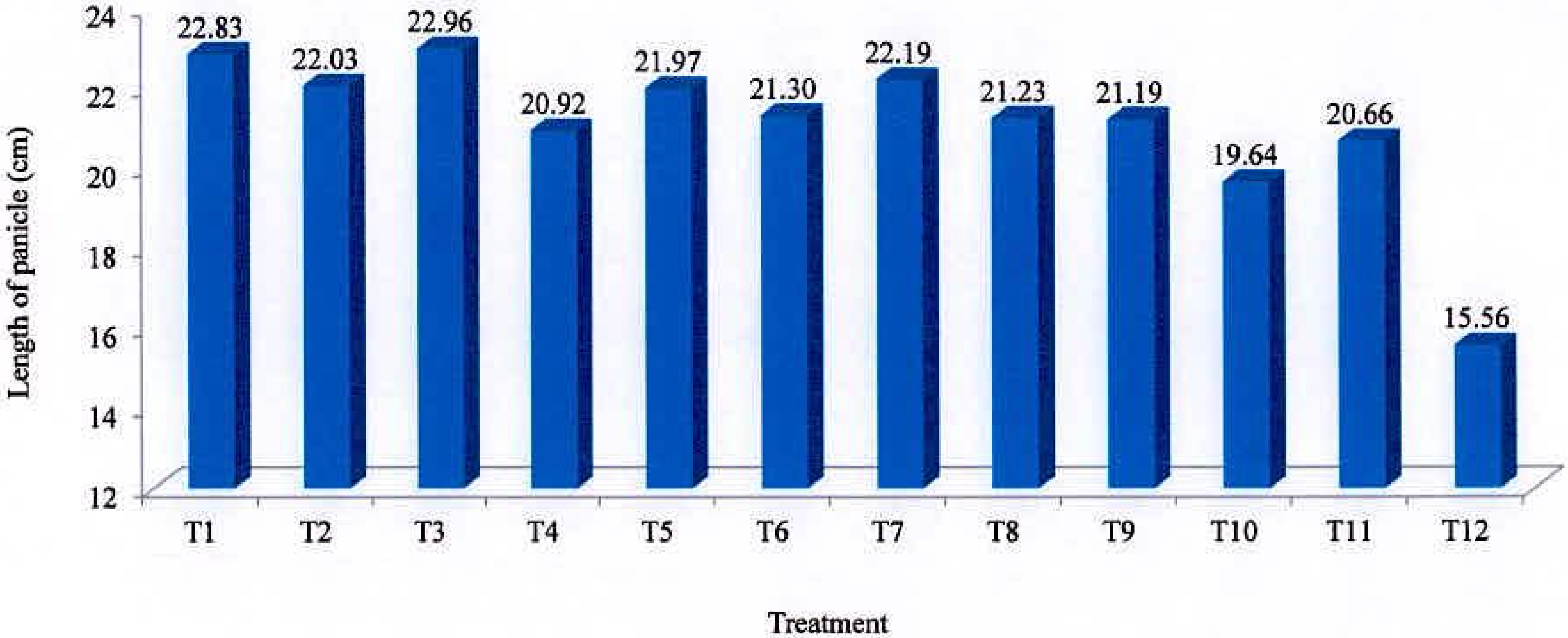


Figure 3. Effect of *Dhaincha* biomass incorporation as a supplement of nitrogenous fertilizer on length of panicle

4.1.7 Number of filled grain plant^{-1}

Due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer statistically significant variation was recorded for number of filled grain plant^{-1} (Appendix IV). The maximum number of filled grain plant^{-1} (86.50) was found from T_3 which was statistically identical with all other treatments except T_{12}, T_{10} and T_4 and closely followed (76.43) by T_4 while, the minimum number (56.00) was recorded from T_{12} as control condition which was followed (74.07) by T_{10} (Figure 4).

4.1.8 Number of unfilled grain plant^{-1}

Number of unfilled grain plant^{-1} showed statistically significant variation due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer (Appendix IV). The maximum number of unfilled grain plant^{-1} (12.00) was recorded from T_{12} as control condition which was closely followed (9.07) by T_{10}. On the other hand, the minimum number of unfilled grain plant^{-1} (5.70) was recorded from T_3 which was followed (6.07) by T_1 (Table 5).

4.1.9 Number of total grain plant^{-1}

A statistically significant variation was recorded for number of total grain plant^{-1} due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer (Appendix IV). The maximum number of total grain plant^{-1} (92.53) was found from T_7 which was statistically similar with other treatments except T_{12} and T_{10}, whereas the minimum number of total grain plant^{-1} (68.00) was recorded from T_{12} as control condition which was closely followed (83.13) by T_{10} (Table 5). Grains panicle^{-1} significantly increased due to the effect of *Dhaincha* biomass incorporation as a supplement of nitrogenous fertilizer. These results are also in agreement with Haque (1999) and Azim (1996).

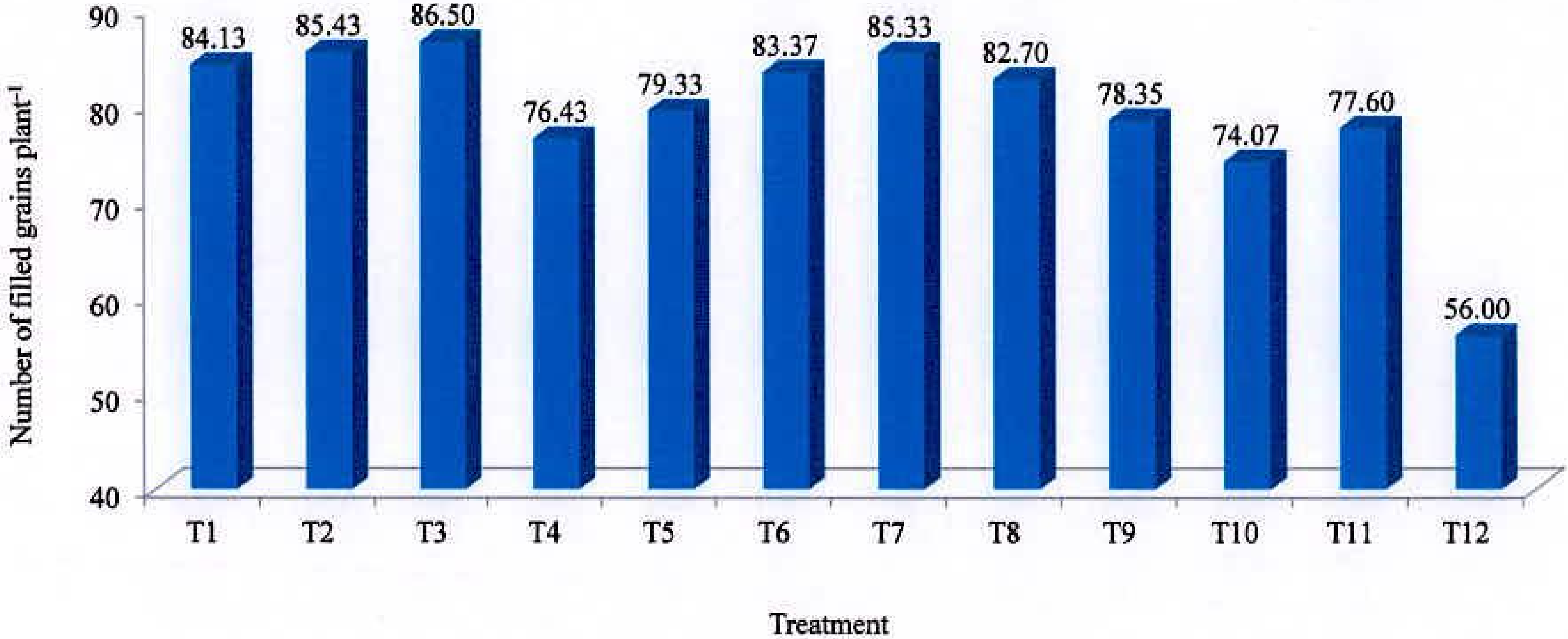


Figure 4. Effect of *Dhaincha* biomass incorporation as a supplement of nitrogenous fertilizer on number of filled grains $plant^{-1}$

4.1.10 Weight of 1000 Seed

Weight of 1000 seeds showed statistically significant variation due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer (Appendix V). The highest weight of 1000 seeds (21.47 g) was found from T_3 which was statistically identical with other treatments except T_{12} and the minimum weight of 1000 seeds (17.77 g) was obtained from T_{12} as control condition (Table 6). It was revealed that the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer increased the 1000-grain weight of rice.

4.1.11 Grain yield

Due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer grain yield showed statistically significant differences (Appendix V). The highest grain yield (5.17 t ha^{-1}) was obtained from T_2 which was statistically identical (5.14, 5.11, 4.93, 4.90 and 4.83 t ha^{-1}) with T_1, T_3, T_8, T_7 and T_6, while the lowest grain yield (2.48 t ha^{-1}) was found from T_{12} as control condition which statistically similar (3.37 t ha^{-1}) with T_{10} (Table 6). Miyazaki *et al*. (1986) reported the grain yield was significantly increased due to application of organic manure and chemical fertilizers.

4.1.12 Straw yield

Straw yield varied significantly due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer (Appendix V). The highest straw yield (5.89 t ha^{-1}) was obtained from T_2 which was statistically identical (5.85, 5.71, 5.77, 5.61 and 5.48 t ha^{-1}) with T_3, T_1, T_8, T_6 and T_7. On the other hand, the lowest straw yield (3.72 t ha^{-1}) was found from T_{12} as control condition which was statistically identical (3.99 t ha^{-1}) with T_{10} (Table 6). Ahmed and Rahman (1991) reported that the application of organic manure and chemical fertilizers increased the straw yields of rice. These findings are well corroborated with the work of Islam (1997). It is clear that organic manure in combination with nitrogen encouraged vegetative growth of plants and thereby increasing straw yield.

Table 6. Effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer on yield of BRRI dhan40

Treatment	Weight of 1000 seeds (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
T_1	21.21 a	5.14 a	5.71 a-c	47.14 a
T_2	21.13 a	5.17 a	5.89 a	46.67 a
T_3	21.47 a	5.11 a	5.85 a	46.64 a
T_4	20.03 a	3.39 de	4.35 ef	43.72 a
T_5	20.30 a	3.90 cd	4.85 de	44.57 a
T_6	21.00 a	4.83 a-c	5.61 a-c	46.25 a
T_7	21.10 a	4.90 ab	5.48 a-d	47.07 a
T_8	20.53 a	4.93 ab	5.77 ab	46.06 a
T_9	20.16 a	4.12 b-d	5.07 b-e	44.85 a
T_{10}	19.73 a	3.37 de	3.99 f	45.62 a
T_{11}	19.98 a	3.98 b-d	4.98 c-e	44.40 a
T_{12}	17.77 b	2.48 e	3.72 f	39.86 b
Significance level	0.05	0.01	0.01	0.01
$LSD_{(0.05)}$	1.858	0.875	0.682	3.456
CV(%)	5.39	12.07	7.88	4.51

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

T_1: 120 kg N ha^{-1} (from urea)

T_2: 100 kg N ha^{-1} (from urea) + 20 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_3: 100 kg N ha^{-1} (from urea) + 10 kg N ha^{-1} (from Dhaincha) [Land preparation] + 10 kg N ha^{-1} (from Dhaincha) [top dressing]

T_4: 80 kg N ha^{-1} (from urea) + 40 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_5: 80 kg N ha^{-1} (from urea) + 20 kg N ha^{-1} (from Dhaincha) [Land preparation] + 20 kg N ha^{-1} (from Dhaincha) [top dressing]

T_6: 60 kg N ha^{-1} (from urea) + 60 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_7: 60 kg N ha^{-1} (from urea) + 30 kg N ha^{-1} (from Dhaincha) [Land preparation] + 30 kg N ha^{-1} (from Dhaincha) [top dressing]

T_8: 50 kg N ha^{-1} (from urea) + 70 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_9: 50 kg N ha^{-1} (from urea) + 35 kg N ha^{-1} (from Dhaincha) [Land preparation] + 35 kg N ha^{-1} (from Dhaincha) [top dressing]

T_{10}: 120 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_{11}: 60 kg N ha^{-1} (from Dhaincha) [Land preparation] + 60 kg N ha^{-1} (from Dhaincha) [top dressing]

T_{12}: Control condition (No nitrogen, no Dhaincha)

4.1.13 Biological yield

Biological yield showed statistically significant variation due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer (Appendix V). The highest biological yield (11.06 t ha^{-1}) was recorded from T_2 which was statistically identical (10.96, 10.84, 10.70, 10.44 and 10.44 t ha^{-1}) with T_3, T_1, T_8, T_6 and T_7. On the other hand, the lowest biological yield (6.21 t ha^{-1}) was obtained from T_{12} which was similar (7.36 t ha^{-1}) to T_{10} (Figure 5).

4.1.14 Harvest index

Harvest index showed significant variation due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer (Appendix V). The highest harvest index (47.14%) was found from T_1 which was statistically identical with other treatment except T_{12} as control condition and the lowest harvest index (39.86%) was recorded for this treatment (Table 6).

4.2 NPKS concentration in grain and straw

4.2.1 N concentration in grain

Statistically significant variation was recorded for N concentration in grain due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer (Appendix VI). The highest N concentration in grain (1.31%) was recorded from T_1 which was similar (1.28%) to T_2, while the lowest N concentration in grain (0.92%) was observed from T_{12} control condition (Table 7).

4.2.2 P concentration in grain

P concentration in grain showed statistically significant variation due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer (Appendix VI). The highest P concentration in grain (0.294%) was recorded from T_2 which was statistically identical (0.278%) with T_1, whereas the lowest P concentration in grain (0.205%) was found from T_{12} as control condition which was statistically similar (0.215% and 0.218%) with T_{11} and T_{10} (Table 7).

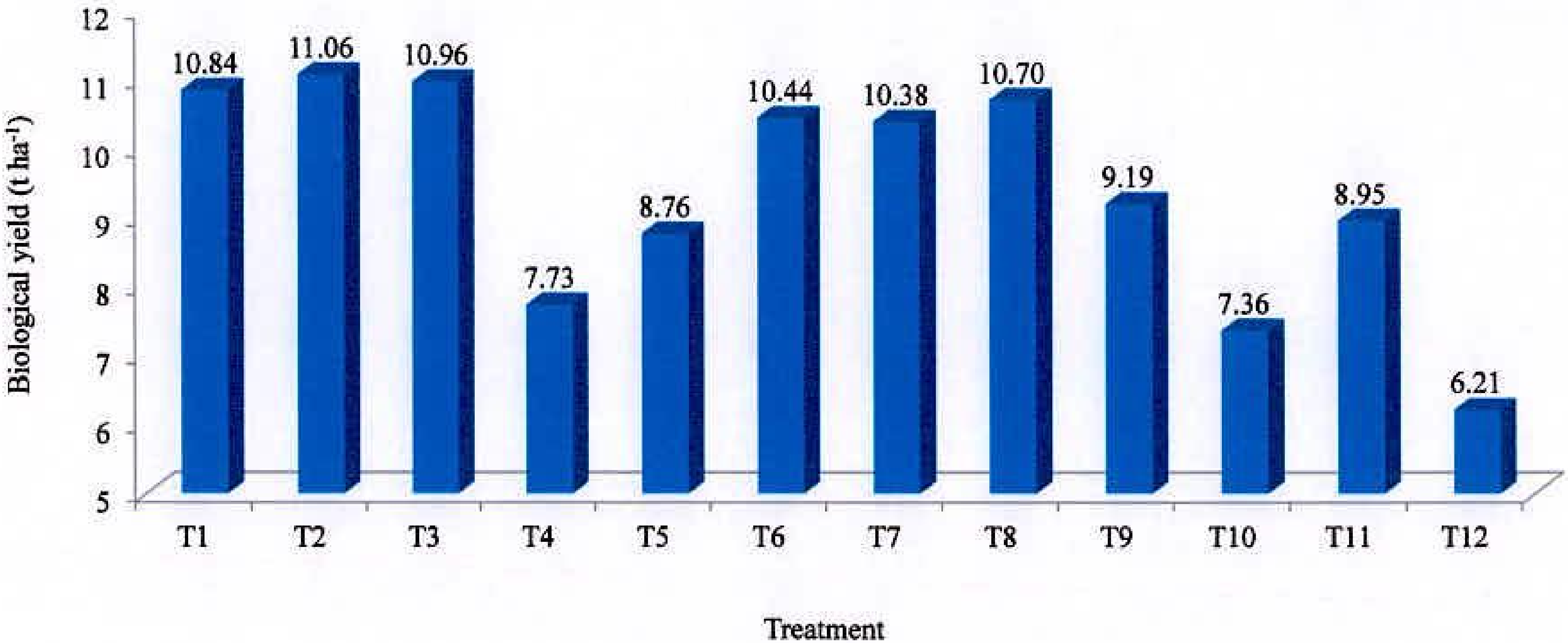


Figure 5. Effect of *Dhaincha* biomass incorporation as a supplement of nitrogenous fertilizer on biological yield ha^{-1}

Table 7. Effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer on N, P, K and S concentrations in grain of BRRI dhan40

Treatment	Concentration (%) in grain			
	N	P	K	S
T_1	1.31 a	0.278 ab	0.692 a	0.120 ab
T_2	1.28 a	0.294 a	0.686 a	0.127 a
T_3	1.20 b	0.276 b	0.628 b	0.115 ab
T_4	1.19 b	0.262 bc	0.615 b-d	0.106 bc
T_5	1.18 b	0.252 c	0.616 b-d	0.109 ab
T_6	1.17 b	0.251 c	0.621 bc	0.114 ab
T_7	1.18 b	0.255 c	0.616 b-d	0.109 ab
T_8	1.17 b	0.247 cd	0.611 b-d	0.107 b
T_9	1.15 b	0.232 de	0.604 cd	0.106 bc
T_{10}	0.95 c	0.218 ef	0.577 e	0.088 cd
T_{11}	1.14 b	0.215 ef	0.601 d	0.104 bc
T_{12}	0.92 c	0.205 f	0.575 e	0.083 d
Significance level	0.01	0.01	0.01	0.01
$LSD_{(0.05)}$	0.054	0.017	0.017	0.017
CV(%)	4.25	6.56	3.33	7.95

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

T_1: 120 kg N ha^{-1} (from urea)

T_2: 100 kg N ha^{-1} (from urea) + 20 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_3: 100 kg N ha^{-1} (from urea) + 10 kg N ha^{-1} (from Dhaincha) [Land preparation] + 10 kg N ha^{-1} (from Dhaincha) [top dressing]

T_4: 80 kg N ha^{-1} (from urea) + 40 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_5: 80 kg N ha^{-1} (from urea) + 20 kg N ha^{-1} (from Dhaincha) [Land preparation] + 20 kg N ha^{-1} (from Dhaincha) [top dressing]

T_6: 60 kg N ha^{-1} (from urea) + 60 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_7: 60 kg N ha^{-1} (from urea) + 30 kg N ha^{-1} (from Dhaincha) [Land preparation] + 30 kg N ha^{-1} (from Dhaincha) [top dressing]

T_8: 50 kg N ha^{-1} (from urea) + 70 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_9: 50 kg N ha^{-1} (from urea) + 35 kg N ha^{-1} (from Dhaincha) [Land preparation] + 35 kg N ha^{-1} (from Dhaincha) [top dressing]

T_{10}: 120 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_{11}: 60 kg N ha^{-1} (from Dhaincha) [Land preparation] + 60 kg N ha^{-1} (from Dhaincha) [top dressing]

T_{12}: Control condition (No nitrogen, no Dhaincha)

4.2.3 K concentration in grain

K concentration in grain differs significantly due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer (Appendix VI). The highest K concentration in grain (0.692%) was obtained from T_1 which was statistically identical (0.686%) with T_2 and the lowest K concentration in grain (0.575%) was observed from T_{12} as control condition which was statistically similar (0.577%) by T_{10} (Table 7). Singh *et al.* (2001) also revealed that Potassium content in grain were increased due to combined application of organic manure and chemical fertilizers.

4.2.4 S concentration in grain

Due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer S concentration in grain showed statistically significant differences (Appendix VI). The highest S concentration in grain (0.127%) was recorded from T_2, while the lowest S concentration in grain (0.083%) was recorded from T_{12} as control condition (Table 7).

4.2.5 N concentration in straw

Statistically significant variation was recorded for N concentration in straw due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer (Appendix VII). The highest N concentration in straw (1.103%) was found from T_1 which was closely followed (1.083% and 1.068%) with T_3 and T_2, while the lowest N concentration in straw (0.720%) was obtained from T_{12} as control condition which was statistically identical (0.839%) by T_{10} (Table 8).

4.2.6 P concentration in straw

P concentration in straw showed statistically significant variation due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer (Appendix VII). The highest P concentration in straw (0.083%) was found from T_1 which was statistically similar with other treatments except T_{12}, T_{10} and T_{11}, whereas the lowest (0.055%) from T_{12} as control condition which was statistically identical (0.057%) with T_{10} (Table 8).

Table 8. Effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer on N, P, K and S concentrations in straw of BRRI dhan40

Treatment	Concentration (%) in straw			
	N	P	K	S
T_1	1.103 a	0.083 a	2.439 ab	0.350 a
T_2	1.068 b	0.081 ab	2.526 a	0.339 a
T_3	1.083 b	0.077 ab	2.499 ab	0.287 b
T_4	1.044 c	0.074 a-c	2.474 ab	0.288 b
T_5	1.040 c	0.071 a-c	2.322 a-c	0.281 b
T_6	1.043 c	0.071 a-c	2.352 a-c	0.282 b
T_7	1.041 c	0.072 a-c	2.365 a-c	0.283 b
T_8	1.031 c	0.067 a-c	2.352 a-c	0.278 b
T_9	1.008 d	0.066 a-c	2.279 b-d	0.276 b
T_{10}	0.839 e	0.057 c	2.076 de	0.218 c
T_{11}	1.001 d	0.063 bc	2.183 cd	0.273 b
T_{12}	0.720 e	0.055 c	1.965 e	0.210 c
Significance level	0.01	0.01	0.01	0.01
$LSD_{(0.05)}$	0.017	0.017	0.201	0.017
CV(%)	5.85	7.67	5.19	4.46

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

T_1: 120 kg N ha^{-1} (from urea)

T_2: 100 kg N ha^{-1} (from urea) + 20 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_3: 100 kg N ha^{-1} (from urea) + 10 kg N ha^{-1} (from Dhaincha) [Land preparation] + 10 kg N ha^{-1} (from Dhaincha) [top dressing]

T_4: 80 kg N ha^{-1} (from urea) + 40 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_5: 80 kg N ha^{-1} (from urea) + 20 kg N ha^{-1} (from Dhaincha) [Land preparation] + 20 kg N ha^{-1} (from Dhaincha) [top dressing]

T_6: 60 kg N ha^{-1} (from urea) + 60 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_7: 60 kg N ha^{-1} (from urea) + 30 kg N ha^{-1} (from Dhaincha) [Land preparation] + 30 kg N ha^{-1} (from Dhaincha) [top dressing]

T_8: 50 kg N ha^{-1} (from urea) + 70 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_9: 50 kg N ha^{-1} (from urea) + 35 kg N ha^{-1} (from Dhaincha) [Land preparation] + 35 kg N ha^{-1} (from Dhaincha) [top dressing]

T_{10}: 120 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_{11}: 60 kg N ha^{-1} (from Dhaincha) [Land preparation] + 60 kg N ha^{-1} (from Dhaincha) [top dressing]

T_{12}: Control condition (No nitrogen, no Dhaincha)

4.2.7 K concentration in straw

Due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer K concentration in straw varied significantly (Appendix VII). The highest K concentration in straw (2.526%) was recorded from T_2 which was statistically similar with other treatments except T_{12}, T_{10} and T_{11}, again the lowest (1.965%) was found from T_{12} which was statistically identical (2.076%) with T_{10} (Table 8).

4.2.8 S concentration in straw

S concentration in straw showed statistically significant variation due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer (Appendix VII). The highest S concentration in straw (0.350%) was obtained from T_1 which was statistically similar (0.339%) with T_2, whereas the lowest S concentration in straw (0.210%) was found from T_{12} as control condition which was statistically similar (0.218) to T_{10} (Table 8).

4.3 NPKS uptake by grain and straw

4.3.1 N uptake by grain

Statistically significant variation was recorded for N uptake by grain for the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer (Appendix VIII). The highest N uptake by grain (67.53 kg ha^{-1}) was recorded from T_1. On the other hand, the lowest N uptake by grain (22.69 kg ha^{-1}) was recorded from T_{12} as control condition which was similar (32.09 kg ha^{-1}) to T_{10} (Table 9). Rahman (2001) reported that the N uptake by rice grain increased significantly with the combined application of organic manure and chemical fertilizers. Duhan and Singh (2002); Azim (1996) and Haque (1999) also reported similar results.

Table 9. Effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer on N, P, K and S uptake by grain of BRRI dhan40

Treatment	Uptake by grain (kg ha^{-1})			
	N	P	K	S
T_1	67.53 a	14.28 ab	35.50 a	6.18 a
T_2	65.98 a	15.21 a	35.46 a	6.56 a
T_3	61.25 a	14.12 ab	32.08 a	5.88 a
T_4	40.26 de	8.88 d	20.79 c	3.60 c
T_5	45.92 cd	9.82 cd	24.05 bc	4.25 bc
T_6	56.66 a-c	12.09 bc	30.01 ab	5.52 ab
T_7	57.55 ab	12.45 a-c	30.14 ab	5.32 ab
T_8	57.61 ab	12.17 bc	30.07 ab	5.30 ab
T_9	47.55 b-d	9.58 cd	24.91 bc	4.37 bc
T_{10}	32.09 ef	7.47 de	19.58 cd	3.03 cd
T_{11}	45.31 d	8.55 d	23.90 bc	4.14 bc
T_{12}	22.69 f	5.09 e	14.25 d	2.03 d
Significance level	0.01	0.01	0.01	0.01
$LSD_{(0.05)}$	10.35	2.648	5.718	1.247
CV(%)	12.22	14.47	12.63	15.72

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

T_1: 120 kg N ha^{-1} (from urea)

T_2: 100 kg N ha^{-1} (from urea) + 20 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_3: 100 kg N ha^{-1} (from urea) + 10 kg N ha^{-1} (from Dhaincha) [Land preparation] + 10 kg N ha^{-1} (from Dhaincha) [top dressing]

T_4: 80 kg N ha^{-1} (from urea) + 40 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_5: 80 kg N ha^{-1} (from urea) + 20 kg N ha^{-1} (from Dhaincha) [Land preparation] + 20 kg N ha^{-1} (from Dhaincha) [top dressing]

T_6: 60 kg N ha^{-1} (from urea) + 60 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_7: 60 kg N ha^{-1} (from urea) + 30 kg N ha^{-1} (from Dhaincha) [Land preparation] + 30 kg N ha^{-1} (from Dhaincha) [top dressing]

T_8: 50 kg N ha^{-1} (from urea) + 70 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_9: 50 kg N ha^{-1} (from urea) + 35 kg N ha^{-1} (from Dhaincha) [Land preparation] + 35 kg N ha^{-1} (from Dhaincha) [top dressing]

T_{10}: 120 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_{11}: 60 kg N ha^{-1} (from Dhaincha) [Land preparation] + 60 kg N ha^{-1} (from Dhaincha) [top dressing]

T_{12}: Control condition (No nitrogen, no Dhaincha)

4.3.2 P uptake by grain

P uptake by grain showed statistically significant variation due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer (Appendix VIII). The highest P uptake by grain (15.21 kg ha^{-1}) was observed from T_2 which was statistically similar (14.28, 14.12 and 12.45 kg ha^{-1}) with T_1, T_3 and T_7, while the lowest P uptake by grain (5.09 kg ha^{-1}) was observed from T_{12} as control condition which was statistically similar (7.47 kg ha^{-1}) by T_{10} (Table 9). Rahman (2001) observed that the highest P uptake by rice grain was recorded with the combined application of organic manure and phosphatic fertilizers.

4.3.3 K uptake by grain

Due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer K uptake by grain showed statistically significant differences (Appendix VIII). The highest K uptake by grain (35.50 kg ha^{-1}) was found from T_1 which was similar (35.46 kg ha^{-1}) to T_2, whereas the lowest K uptake by grain (14.25 kg ha^{-1}) was observed from T_{12} (Table 9). Rahman (2001) reported that application of chemical fertilizer and organic manure significantly increased the K uptake by rice. Similar results were also found by Sharma and Mitra (1991), Azim (1996) and Haque (1999).

4.3.4 S uptake by grain

S uptake by grain showed statistically significant variation due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer (Appendix VIII). The highest S uptake by grain (6.56 kg ha^{-1}) was obtained from T_2, the lowest S uptake by grain (2.03 kg ha^{-1}) was observed from T_{12} as control condition which was similar (3.03 kg ha^{-1}) to T_{10} (Table 9). Azim (1999) and Hoque (1999) recorded the higher uptake of S with the application of manure and fertilizers either alone or in combinations. Similar results were also reported by Rahman (2001).

4.3.5 N uptake by straw

N uptake by straw showed statistically significant variation due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer (Appendix IX). The highest N uptake by straw (63.33 kg ha^{-1}) was recorded from T_3 which was statistically similar (63.05 and 62.90 kg ha^{-1}) with T_2 and T_1 and the lowest N uptake by straw (26.81 kg ha^{-1}) was observed from T_{12} as control condition (Table 10).

4.3.6 P uptake by straw

Statistically significant variation was recorded for P uptake by straw due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer (Appendix IX). The highest P uptake by straw (4.80 kg ha^{-1}) was found from T_2 which was statistically identical (4.76 and 4.50 kg ha^{-1}) with T_1 and T_3, whereas the lowest P uptake by straw (2.03 kg ha^{-1}) was observed from T_{12} as control condition which was statistically identical (2.31 kg ha^{-1}) with T_{10} (Table 10).

4.3.7 K uptake by straw

K uptake by straw showed statistically significant variation due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer (Appendix IX). The highest K uptake by straw (148.46 kg ha^{-1}) was recorded from T_2 which was statistically identical (146.12 and 139.03 kg ha^{-1}) with T_3 and T_1. On the other hand, the lowest K uptake by straw (72.16 kg ha^{-1}) was found from T_{12} as control condition which was similar (83.00 k ha^{-1}) to T_{10} (Table 10).

4.3.8 S uptake by straw

S uptake by straw showed statistically significant variation due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer (Appendix IX). The highest S uptake by straw (20.01 kg ha^{-1}) was observed from T_2, while the lowest S uptake by straw (7.83 kg ha^{-1}) was observed from T_{12} (Table 10).

Table 10. Effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer on N, P, K and S uptake by straw of BRRI dhan40

Treatment	Uptake by straw (kg ha^{-1})			
	N	P	K	S
T_1	62.90 a	4.76 a	139.03 a-c	19.95 a
T_2	63.06 a	4.80 a	148.46 a	20.01 a
T_3	63.33 a	4.50 ab	146.12 ab	16.78 b
T_4	45.41 d	3.22 cd	107.57 e	12.52 e
T_5	50.47 b-d	3.46 cd	112.71 e	13.65 de
T_6	58.53 ab	3.96 bc	131.78 bc	15.84 b-d
T_7	57.04 a-c	3.96 bc	129.27 cd	15.51 b-d
T_8	59.54 a	3.84 b-d	135.90 a-c	16.02 bc
T_9	51.12 b-d	3.35 cd	115.55 de	13.99 c-e
T_{10}	33.49 e	2.31 e	83.00 f	8.70 f
T_{11}	49.82 cd	3.12 d	108.63 e	13.59 de
T_{12}	26.81 e	2.03 e	72.16 f	7.83 f
Significance level	0.01	0.01	0.01	0.01
$LSD_{(0.05)}$	7.709	0.704	14.49	2.145
CV(%)	8.79	11.53	7.18	8.72

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

T_1: 120 kg N ha^{-1} (from urea)

T_2: 100 kg N ha^{-1} (from urea) + 20 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_3: 100 kg N ha^{-1} (from urea) + 10 kg N ha^{-1} (from Dhaincha) [Land preparation] + 10 kg N ha^{-1} (from Dhaincha) [top dressing]

T_4: 80 kg N ha^{-1} (from urea) + 40 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_5: 80 kg N ha^{-1} (from urea) + 20 kg N ha^{-1} (from Dhaincha) [Land preparation] + 20 kg N ha^{-1} (from Dhaincha) [top dressing]

T_6: 60 kg N ha^{-1} (from urea) + 60 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_7: 60 kg N ha^{-1} (from urea) + 30 kg N ha^{-1} (from Dhaincha) [Land preparation] + 30 kg N ha^{-1} (from Dhaincha) [top dressing]

T_8: 50 kg N ha^{-1} (from urea) + 70 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_9: 50 kg N ha^{-1} (from urea) + 35 kg N ha^{-1} (from Dhaincha) [Land preparation] + 35 kg N ha^{-1} (from Dhaincha) [top dressing]

T_{10}: 120 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_{11}: 60 kg N ha^{-1} (from Dhaincha) [Land preparation] + 60 kg N ha^{-1} (from Dhaincha) [top dressing]

T_{12}: Control condition (No nitrogen, no Dhaincha)

4.4 pH, organic matter and NPKS in post harvest soil

4.4.1 pH

No significant variation was recorded for pH in post harvest soil due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer (Appendix X). The highest pH of post harvest soil (6.28) was found from T_2 and the lowest pH in post harvest soil (5.70) was recorded from T_9 (Table 11). Bharadwaj and Tyagi (1994) reported that the soil pH reduce due to the application of FYM plus pressmud. Similar results were also observed by Islam (1997).

4.4.2 Organic matter

Organic matter in post harvest soil showed statistically significant differences due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer (Appendix X). The highest organic matter in post harvest soil (1.30%) was recorded from T_3 and the lowest organic matter in post harvest soil (1.05%) was observed from T_{12} (Figure 6). Zhang *et al.* (1996) showed that the combined application of organic manure and chemical fertilizers increased organic matter content in soil. Organic carbon also increased due to application of organic manure as reported by Mathew and Nair (1997); Azim (1996) and Haque (1999).

4.4.3 Total Nitrogen

Total nitrogen in post harvest soil showed statistically significant differences due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer (Appendix X). The highest total nitrogen in post harvest soil (0.053%) was recorded from T_2 which was statistically identical with other treatment except T_{12}, T_{11} and T_{10}. On the other hand, the lowest total nitrogen in post harvest soil (0.026%) was obtained from T_{12} (Table 11). Several workers reported that organic manure had a positive influenced on total and available N content of soil. Similar were also observed by Azim (1996).

Table 11. Effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer on the nutrient content of post harvest soil

Treatment	pH	Total N (%)	Available P (ppm)	Exchangeable K (me %)	Available S (ppm)
T_1	6.12	0.051 ab	24.20 a	0.155 ab	19.51 ab
T_2	6.28	0.053 a	25.37 a	0.163 a	20.66 a
T_3	6.00	0.050 ab	24.95 a	0.152 ab	18.90 ab
T_4	5.90	0.047 ab	24.05 a	0.153 ab	18.00 a-c
T_5	5.95	0.042 a-c	23.34 ab	0.142 bc	17.55 bc
T_6	5.95	0.041 a-c	22.69 a-d	0.147 a-c	16.81 b-d
T_7	5.94	0.044 a-c	23.51 ab	0.146 a-c	17.55 bc
T_8	5.85	0.040 a-c	24.58 a	0.138 bc	18.07 a-c
T_9	5.70	0.041 a-c	23.12 a-c	0.133 cd	16.95 b-d
T_{10}	5.85	0.031 bc	20.53 cd	0.117 de	14.26 de
T_{11}	5.73	0.032 bc	21.09 b-d	0.128 c-e	15.70 c-e
T_{12}	5.93	0.026 c	20.17 d	0.110 e	13.98 e
Significance level	NS	0.01	0.01	0.01	0.01
$LSD_{(0.05)}$	--	0.017	2.414	0.017	2.576
CV(%)	5.66	9.25	6.16	6.76	8.78

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

T_1: 120 kg N ha^{-1} (from urea)

T_2: 100 kg N ha^{-1} (from urea) + 20 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_3: 100 kg N ha^{-1} (from urea) + 10 kg N ha^{-1} (from Dhaincha) [Land preparation] + 10 kg N ha^{-1} (from Dhaincha) [top dressing]

T_4: 80 kg N ha^{-1} (from urea) + 40 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_5: 80 kg N ha^{-1} (from urea) + 20 kg N ha^{-1} (from Dhaincha) [Land preparation] + 20 kg N ha^{-1} (from Dhaincha) [top dressing]

T_6: 60 kg N ha^{-1} (from urea) + 60 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_7: 60 kg N ha^{-1} (from urea) + 30 kg N ha^{-1} (from Dhaincha) [Land preparation] + 30 kg N ha^{-1} (from Dhaincha) [top dressing]

T_8: 50 kg N ha^{-1} (from urea) + 70 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_9: 50 kg N ha^{-1} (from urea) + 35 kg N ha^{-1} (from Dhaincha) [Land preparation] + 35 kg N ha^{-1} (from Dhaincha) [top dressing]

T_{10}: 120 kg N ha^{-1} (from Dhaincha) [Land preparation]

T_{11}: 60 kg N ha^{-1} (from Dhaincha) [Land preparation] + 60 kg N ha^{-1} (from Dhaincha) [top dressing]

T_{12}: Control condition (No nitrogen, no Dhaincha)

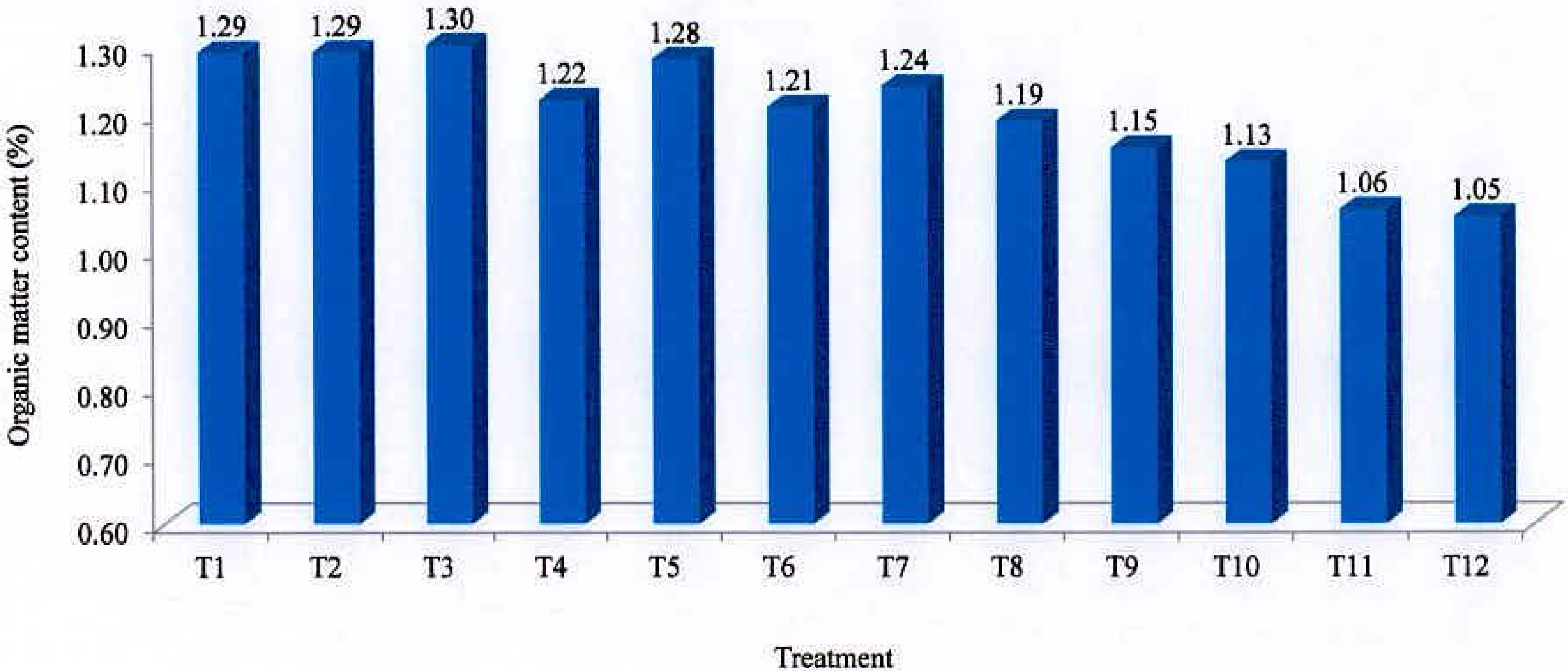


Figure 6. Effect of *Dhaincha* biomass incorporation as a supplement of nitrogenous fertilizer on organic matter content in post harvest soil

4.4.4 Available phosphorus

Available phosphorus in post harvest soil showed statistically significant differences due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer (Appendix X). The highest available phosphorus in post harvest soil (25.37 ppm) was recorded from T_2 which was statistically identical with other treatment except T_{12}, T_{11} and T_{10}, again the lowest available phosphorus in post harvest soil (20.17 ppm) was found from T_{12} (Table 11). Similar results were also found by Zhang *et al.* (1996); Mathew and Nair (1997); Haque (1999) and Azim (1996).

4.4.5 Exchangeable potassium

Due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer exchangeable potassium in post harvest soil showed statistically significant differences (Appendix X). The highest exchangeable potassium in post harvest soil (0.163 me%) was recorded from T_2 and the lowest exchangeable potassium in post harvest soil (0.110 me%) was observed from T_{12} (Table 11).

4.4.6 Available sulphur

Available sulphur in post harvest soil showed statistically significant differences due to the effect of Dhaincha biomass incorporation as a supplement of nitrogenous fertilizer (Appendix X). The highest available sulphur in post harvest soil (20.66 ppm) was obtained from T_2 which was statistically identical (19.51, 18.90, 18.07 and 18.00 ppm) with T_1, T_3, T_8 and T_4, while the lowest available sulphur in post harvest soil (13.98 ppm) was observed from T_{12} (Table 11). Similar results were obtained by Haque (1999) and Azim (1996).

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 November 2011 to study the effect of *Dhaincha* biomass incorporation on the growth and yield of aman rice as a supplement of nitrogenous fertilizer. BRRI dhan40 was used as the test crop in this experiment. Different level of nitrogen from urea and *Dhaincha* during land preparation and top dressing were used as a treatment. 100 kg green *Dhaincha* were used for 1.0 kg N. The experiment consisted of 12 treatments.

At 20, 40, 60, 80 DAT and harvest, the highest plant height (21.67 cm, 46.13 cm, 65.29 cm, 96.15 cm and 113.65 cm) was recorded from T_2 whereas, at the same DAT the lowest plant height (14.00 cm, 36.76 cm, 54.94 cm, 80.10 cm and 91.19 cm) was observed from T_{12} as control condition. At 20 and 80 DAT, the maximum number of total tillers hill^{-1} (5.17 and 20.30) was found from T_3 and at 40 and 60 DAT the maximum number of total tillers hill^{-1} (11.27 and 16.87) was observed from T_2, again at 20, 40, 60 and 80 DAT, the minimum number of total tillers hill^{-1} (2.93, 5.23, 8.60 and 11.93) was observed from T_{12}. The maximum number of effective tillers per hill (12.33) was found from T_2 (100 kg N ha^{-1} and the minimum number of effective tillers hill^{-1} (6.13) was found from T_{12}. The maximum number of in-effective tillers hill^{-1} (3.70) was obtained from T_1 and the minimum number of in-effective tillers per hill^{-1} (2.17) was found from T_{10}. The maximum number of total tillers hill^{-1} (15.80) was observed from T_2 and the minimum number of total tillers (9.67) was obtained from T_{12}. The highest length of panicle (22.96 cm) was recorded from T_3 and the lowest length of panicle (15.56 cm) was observed from T_{12}. The maximum number of filled grain plant^{-1} (86.50) was found from T_3 while, the minimum number (56.00) was recorded from T_{12}. The maximum number of unfilled grain plant^{-1} (12.00) was recorded from T_{12} and the minimum number of unfilled grain plant^{-1} (5.70) was recorded from T_3. The maximum number of total grain plant^{-1} (92.53) was found from T_7, whereas the minimum number of total grain plant^{-1} (68.00) was recorded from T_{12}. The highest weight of 1000 seeds (21.47 g) was found from T_3 and the minimum weight of 1000 seeds (17.77 g) was obtained from T_{12}. The highest grain yield (5.17 t ha^{-1}) was obtained from T_2, while the lowest grain yield (2.48 t ha^{-1}) was found from T_{12}. The highest straw yield (5.89 t ha^{-1}) was obtained from T_2 and the lowest straw yield (3.72 t ha^{-1}) was found from T_{12}. The highest biological yield (11.06 t ha^{-1}) was recorded from T_2 and the lowest biological yield (6.21 t ha^{-1}) was obtained from T_{12}. The highest harvest index (47.14%) was found from T_1 and the lowest harvest index (39.86%) was recorded for T_{12}.

The highest N concentration in grain (1.31%) was recorded from T_1, while the lowest N concentration in grain (0.92%) was observed from T_{12}. The highest P concentration in grain (0.294%) was recorded from T_2, whereas the lowest P concentration in grain (0.205%) was found from T_{12} as control condition. The highest K concentration in grain (0.692%) was obtained from T_1 again and the lowest K concentration in grain (0.575%) was observed from T_{12}. The highest S concentration in grain (0.127%) was recorded from T_2, while the lowest S concentration in grain (0.083%) was recorded from T_{12}. The highest N concentration in straw (1.103%) was found from T_2, while the lowest N concentration in straw (0.720%) was obtained from T_{12}. The highest P concentration in straw (0.083%) was found from T_1, whereas the lowest (0.055%) from T_{12}. The highest K concentration in straw (2.526%) was recorded from T_2, again the lowest (1.965%) was found from T_{12}. The highest S concentration in straw (0.350%) was obtained from T_1, whereas the lowest S concentration in straw (0.210%) was found from T_{12}.

The highest N uptake by grain (67.53 kg ha^{-1}) was recorded from T_1 and the lowest N uptake by grain (22.69 kg ha^{-1}) was recorded from T_{12}. The highest P uptake by grain (15.21 kg ha^{-1}) was observed from T_2, while the lowest P uptake by grain (5.09 kg ha^{-1}) was observed from T_{12}. The highest K uptake by grain (35.50 kg ha^{-1}) was found from T_1, whereas the lowest K uptake by grain (14.25

kg ha^{-1}) was observed from T_{12}. The highest S uptake by grain (6.56 kg ha^{-1}) was obtained from T_2, the lowest S uptake by grain (2.03 kg ha^{-1}) was observed from T_{12}. The highest N uptake by straw (63.33 kg ha^{-1}) was recorded from T_3 and the lowest N uptake by straw (26.81 kg ha^{-1}) was observed from T_{12}. The highest P uptake by straw (4.80 kg ha^{-1}) was found from T_2, whereas the lowest P uptake by straw (2.03 kg ha^{-1}) was observed from T_{12}. The highest K uptake by straw (148.46 kg ha^{-1}) was recorded from T_2 and the lowest K uptake by straw (72.16 kg ha^{-1}) was found from T_{12}. The highest S uptake by straw (20.01 kg ha^{-1}) was observed from T_2, while the lowest S uptake by straw (7.83 kg ha^{-1}) was observed from T_{12}.

The highest pH of post harvest soil (6.28) was found from T_2 and the lowest pH in post harvest soil (5.70) was recorded from T_9. The highest organic matter in post harvest soil (1.30%) was recorded from T_3 and the lowest organic matter in post harvest soil (1.05%) was observed from T_{12}. The highest total nitrogen in post harvest soil (0.053%) was recorded from T_2 and the lowest total nitrogen in post harvest soil (0.026%) was obtained from T_{12}. The highest available phosphorus in post harvest soil (25.37 ppm) was recorded from T_2, again the lowest available phosphorus in post harvest soil (20.17 ppm) was found from T_{12}. The highest exchangeable potassium in post harvest soil (0.163 me%) was recorded from T_2 and the lowest exchangeable potassium in post harvest soil (0.110 me%) was observed from T_{12}. The highest available sulphur in post harvest soil (20.66 ppm) was obtained from T_2, while the lowest available sulphur in post harvest soil (13.98 ppm) was observed from T_{12}.

Application of 100 kg N ha^{-1} (from urea) + 20 kg N ha^{-1} (from *Dhaincha*) [Land preparation] was the superior among the other treatments in consideration of yield contributing characters and yield of BRRI dhan40.

Considering the results of the present experiment, further studies in the following areas may be suggested:

1. Such study is needed to be repeated in different agro-ecological zones (AEZ) of Bangladesh for the evaluation of regional adaptability,
2. Other green manures and doses of inorganic fertilizer may be used for further study, and
3. Other combination of other green manures and inorganic fertilizer may be used for further study to specify the specific combination.

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APPENDICES

Appendix I. Monthly record of air temperature, rainfall, relative humidity, soil temperature and Sunshine of the experimental site during the period from July to November 2011

Month (2011)	*Air temperature (°c)		*Relative humidity (%)	*Rain fall (mm) (total)	*Sunshine (hr)
	Maximum	Minimum			
July	35.4	22.5	80	577	4.2
August	36.0	24.6	83	563	3.1
September	36.0	23.6	81	319	4.0
October	34.8	24.4	81	279	4.4
November	34.8	18.0	77	227	5.8

* Monthly average,
Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka - 1212

Appendix II. Analysis of variance of the data on plant height of rice as influenced by *Dhaincha* biomass incorporation as a supplement of nitrogenous fertilizer

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm) at				
		20 DAT	40 DAT	60 DAT	80 DAT	at harvest
Replication	2	1.232	1.119	0.962	0.354	9.286
Treatment	11	14.018**	20.506**	25.130*	58.770**	109.959**
Error	22	2.104	5.957	9.356	15.947	35.557

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

Appendix III. Analysis of variance of the data on number of total tiller per hill of as influenced by *Dhaincha* biomass incorporation as a supplement of nitrogenous fertilizer

Source of variation	Degrees of freedom	Number of total tiller per hill at			
		20 DAT	40 DAT	60 DAT	80 DAT
Replication	2	0.085	0.493	1.166	0.800
Treatment	11	1.337**	7.901**	17.073**	17.474**
Error	22	0.161	1.667	2.477	2.556

**: Significant at 0.01 level of probability;

Appendix IV. Analysis of variance of the data on yield contributing characters of rice as influenced by *Dhaincha* biomass incorporation as a supplement of nitrogenous fertilizer

Source of variation	Degrees of freedom	Mean square						
		Effective tiller /hill	Non-effective tiller/hill	Total tiller/ hill	Length of panicle (cm)	Number of filled grain/ plant	Number of unfilled grain/ Plant	Number of total grain/ plant
Replication	2	0.675	0.082	1.157	1.131	20.243	0.916	12.791
Treatment	11	9.726**	0.639**	11.807**	11.535**	207.04**	8.323**	136.37**
Error	22	0.993	0.177	1.370	1.747	23.703	1.080	16.377

**: Significant at 0.01 level of probability

Appendix V. Analysis of variance of the data on yield contributing characters and yield of rice as influenced by *Dhaincha* biomass incorporation as a supplement of nitrogenous fertilizer

Source of variation	Degrees of freedom	Mean square				
		Weight of 1000 Seed (g)	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
Replication	2	0.426	0.251	0.177	0.791	2.428
Treatment	11	2.986*	2.295**	1.686**	7.844**	12.367**
Error	22	1.204	0.267	0.162	0.706	4.166

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

Appendix VI. Analysis of variance of the data on N, P, K and S concentrations in grain of rice as influenced by *Dhaincha* biomass incorporation as a supplement of nitrogenous fertilizer

Source of variation	Degrees of freedom	Mean square			
		Concentration (%) in grain			
		N	P	K	S
Replication	2	0.001	0.000	0.000	0.000
Treatment	11	0.006**	0.002**	0.001**	0.000**
Error	22	0.001	0.0001	0.0001	0.0001

**: Significant at 0.01 level of probability

Appendix VII. Analysis of variance of the data on N, P, K and S concentrations in straw of rice as influenced by *Dhaincha* biomass incorporation as a supplement of nitrogenous fertilizer

Source of variation	Degrees of freedom				
		Concentration (%) in straw			
		N	P	K	S
Replication	2	0.000	0.001	0.003	0.000
Treatment	11	0.006**	0.001**	0.031**	0.001**
Error	22	0.001	0.0001	0.005	0.000

**: Significant at 0.01 level of probability

Appendix VIII. Analysis of variance of the data N, P, K and S uptake by grain of rice as influenced by *Dhaincha* biomass incorporation as a supplement of nitrogenous fertilizer

Source of variation	Degrees of freedom	Mean square			
		Uptake by grain (kg/ha)			
		N	P	K	S
Replication	2	4.123	0.787	25.333	0.325
Treatment	11	158.620**	28.306**	155.929**	5.510**
Error	22	16.477	2.445	24.564	0.542

**: Significant at 0.01 level of probability

Appendix IX. Analysis of variance of the data N, P, K and S uptake by straw of rice as influenced by *Dhaincha* biomass incorporation as a supplement of nitrogenous fertilizer

Source of variation	Degrees of freedom	Mean square			
		Uptake by straw (kg/ha)			
		N	P	K	S
Replication	2	3.650	0.083	0.112	0.112
Treatment	11	80.719**	2.321**	2.893**	2.893**
Error	22	4.446	0.173	0.175	0.175

**: Significant at 0.01 level of probability;

Appendix X. Analysis of variance of the data on the post harvest soil of rice as influenced by *Dhaincha* biomass incorporation as a supplement of nitrogenous fertilizer

Source of variation	Degrees of freedom	Mean square					
		pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (me %)	Available S (ppm)
Replication	2	0.005	0.006	0.001	0.655	0.0001	2.370
Treatment	11	0.074	0.023**	0.001**	8.853**	0.001**	11.755**
Error	22	0.047	0.003	0.0001	2.033	0.0001	2.314

**: Significant at 0.01 level of probability