EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON THE GROWTH AND YIELD OF *AMAN* RICE

A Thesis

By

MD. AHASANUL AZIZ

Student No. 1705216

MASTER OF SCIENCE

IN

CROP PHYSIOLOGY AND ECOLOGY

DEPARTMENT OF CROP PHYSIOLOGY AND ECOLOGY

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY

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Dedicated to

My

Beloved Parents

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ABSTRACT

An experiment was performed at Research Farm of Crop Physiology and Ecology Department, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh during T. *Aman* season (September to December) of 2018 to know the effect of integrated nutrient management on the growth and yield of rice. It was replicated in thrice with Randomized Complete Block Design (RCBD) and it was a single factor experiment. In this experiment, BRRI dhan51 used as planting materials that was imposed with eight integrated nutrient management treatments such as- T_1- No fertilizer, T_2-100% NPK, T_3- 50% NPK+ 4 ton cowdung ha^{-1}, T_4- 50% NPK+ 8 ton cowdung ha^{-1}, T_5- 50% NPK+ 12 ton cowdung ha^{-1}, T_6- 75% NPK+ 4 ton cowdung ha^{-1}, T_7- 75% NPK+ 8 ton cowdung ha^{-1} and T_8- 75% NPK+ 12 ton cowdung ha^{-1}). At 30, 50, 70 and 110 DAT, the tallest plant (60.85, 68.35, 80.35 and 95.69 cm) and greater number of leaves $hill^{-1}$(80.34, 75.51, 70.65 and 62.34 cm) was found in T_8 and the lowest was observed in T_1 in all aspects. The maximum total tillers $hill^{-1}$ (23.01), productive tillers $hill^{-1}$ (22.01), the longest panicle (29.67 cm), spiklets per panicle (242.09), grains per panicle (225.02), Thousand grain weight (31.35 g), grain yield (5.05 t ha^{-1}), straw yield (9.26 t ha^{-1}) and biological yield (14.31 t ha^{-1}) and minimum non-productive tillers $hill^{-1}$ (1.00) and sterile spiklets per panicle (12.07) were recorded in T_8 which is statistical similar with T_7 in most of the parameters. It is obvious that yield of rice can be increased substantially with the judicious application of organic manure and chemical fertilizers.

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CHAPTER I

INTRODUCTION

Rice belongs to the tribe *Oryzeae*, sub-family *Poacoideae* in the grass family *Poaceae* (syn. *Gramineae*). The genus *Oryza* is said to contain six species of which *Oryza sativa* L. is commercially the most important in world rice cultivation. About two millions of people are adding every year which will be 30 million over the next 20 years in Bangladesh. Thus, to meet up the food supply for this over population, Bangladesh needs 37.26 million tons of rice for the year 2020 (BRRI 2011). Rice covers about 75% of cropped area of Bangladesh with annual production of 34.71 million tons from 11.39 million hectares of land which contributes 15% of the country's GDP (BBS 2017). Rice is one of the most important cereal crops in the world followed by wheat and maize. It is indispensable in terms of importance as food crop because it provides more calories per hectare than any other crop. It is also use in the manufacture of wines and spirits, cosmetics and textile. The bran is a valuable poultry feed, and the oil extracted from it, is used as cooking oil, for soap manufacture, as carrier for insecticides and as anti-corrosive and rust resistant oil (Ndaeyo *et al*. 2008).

The rice production has to be enhanced to meet the food requirement of the growing population with good agronomic management practices with view of shrinking availability of land and water resources condition. Low yields may be attributed to various substantial factors but faulty nutrient management is an importance in reducing the overall productivity of rice (Mahmood and Walter 1990). On the other hand, cultivation of high yielding dwarf varieties responsive to fertilizer and irrigation in intensive cropping after green revolution with continuous and excess use of inorganic fertilizers has depleted the inherent soil fertility. The drawbacks associated with inorganic sources of plant nutrients are often overcome when they are used in judicious combinations with organic manures. Many of our problems on declining productivity (increasing cost, decreasing yield) can be traced to improper and inefficient use of nutrients. Improper nutrient management has resulted in nutrient imbalances in the soil with nutrients in excess while other nutrients depleted. Through this, farmers can increase agricultural productivity and safeguard the environment as they use fertilizer efficiently. The application of chemical fertilizers is costly and gradually lead to the environmental problems.

Depletion of soil fertility is a major constraint for higher crop production in Bangladesh. Most of the soil have organic matter content of below 1.5% on the other hand addition of organic matter is very low. Expenditure for inorganic fertilizer is high and thus, identifying appropriate and economically feasible approaches, which are environmentally friendly and healthy, is imperative.

Integrated nutrient management seems to be a suitable approach to achieve these goals. Integrated nutrient management (INM) aims to improve soil health and sustain high level of productivity and production (Prasad *et al*. 1995). Singh and Kumar (2014) reported increased yield and nutrient use efficiency in rice with organics.

Organic supply of nutrients at the peak period of absorption also provide micro nutrients and modify soil-physical behavior as well as increase the efficiency of applied nutrients (Pandey *et al*., 2007). Miah *et al*. (2006); Nambiar (1991) reviewed that integrated use of organic manure and chemical NPK fertilizers would be quite promising not only in providing greater stability in production, but also in maintaining higher soil fertility status. Organic matter takes an important role in maintaining soil fertility and productivity (Islam 2002; Mondal and Chettri 1998; Rahman and Parkinson 2007). The problem of nutrient deficiencies as well as nutrient mining caused by intensive cropping with HYV of rice and nutrient imbalance can be minimized by judicious application of nutrients through organic manures. Losses of soil organic matter can only be replenished in the short term by application of organic matter such as manures (Mahajan *et al*. 2008).

Organic residue recycling is becoming an important aspect of environmentally sound sustainable agriculture. Now-a-days, agriculture production based on organic applications is growing interest and the demands for the resulting products are increasing. Therefore, the effective use of organic materials in rice farming is also likely to be promoted. The application of organic materials is fundamentally important in that they supply various kinds of plant nutrients including micronutrients, improve soil physical and chemical properties and hence nutrient holding and buffering capacity and consequently enhance microbial activities (Suzuki 1997).

A suitable combination of organic and inorganic sources of nutrient is very necessary for suitable crop yield. When used in combination, interactions occur and the yield increase is always more than that from the use of equivalent quantities of these nutrient sources alone (Wickramasinghe and Wijewardena 2003). Nambiar (1991) views that use of organic manure and chemical fertilizers would be quite promising not only in providing greater stability in production, but also maintaining better soil fertility status. The long-term research of Bangladesh Rice Research Institute that the application of dung manure improve soil resource from degradation (Bhuiyan 1994). Organic manures have an important role in retaining nutrient from chemical fertilizers and releasing of nutrients slowly for next crop. The combined use of organic and inorganic fertilizers has been reported not only to meet the nutrients need of the crop but also has been fund to sustain large scale productivity goals (Yadav and Meena 2014). Crop fertilization refers to fertilizer application according to the crop demands, while soil fertilization is targeted to replenish its fertility level. So, the present investigation "integrated nutrient management on rice productivity.

The application of mineral fertilizer (Nitrogen, Phosphorus and Potassium inorganic fertilizers) as a sole soil fertility management method under intensive continuous cropping is also no longer feasible due to scarcity and high cost of the fertilizers (Akinrinde *et al*. 2005). Before 1980's, deficiency of NPK was a major problem of Bangladesh soil but thereafter along with NPK deficiencies of S and Zn are frequently reported (Haque and Jahiruddin 1994). The need for renewable forms of energy and reduced cost of fertilizing crops, have revived the use of organic manures worldwide (Ayeni 2012). However, sole use of organic manures as sources of soil improvement is hindered by its bulkiness, low nutrients quality and mineralization, cost of transportation and handling which constitute a constraint to its use by peasant farmers (Eifediyi *et al*. 2010) and (Ayeni 2012). Several researches have shown that proper use of NPK fertilizers increased the yield and improved the quality of rice significantly (Oikeh *et al*. 2008, Walker *et al*. 2008) and (Saidu *et al*. 2012).

Use of organic manure especially cow dung and poultry droppings helps in improving physical condition of soil and serves as major contributor of plant nutrients (Bagayoko 2012). Many researchers have found the integrated soil nutrient management of combining organic wastes and mineral fertilizers, to be more feasible in maintaining soil nutrients status as well as crop production than single application of mineral or organic fertilizers. Cowdung can supply a good amount of plant nutrients which can contribute to crop yields. Rapid mineralization of soil organic matter occurs due to humid tropic climatic conditions of Bangladesh. Mineralization and immobilization are biochemical in nature that mediated by 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 and cowdung is well known organic manure in our country. Soil organic matter improves the physicochemical properties of the soil and ultimately promotes crop production. More recently, attention is focused on the global environmental problems; utilization of organic manures as the most effective measure for the purpose. Application of cowdung needs to be applied for the improvement of soil physical properties and supply of essential plant nutrients for higher yield, necessary for BRRI dhan-33 (Reganold *et al*. 1990).

Cow dung has long been recognized as perhaps the most desirable animal manures because of its high nutrient and organic matter content. Addition of cow dung increases the organic carbon content of degraded soil which may lead to the increasing activity of beneficial soil microorganisms as well as the fertility status of soil by increasing the availability of nutrients for the plants from soil. Cow dung significantly increased the growth and yield of plants (Sohel *et al.* 2016).

Issaka *et al*. (2014) also reported that application of 3.5 t/ha cow dung + half rate of mineral fertilizer gave similar effect as full rate of mineral fertilizer. In addition, organic matter slowly but continuously releases N as plant need it. N is the most limiting nutrient in irrigated rice systems, P and K deficiencies also reduce rice yield under continuous cultivation particularly in the inland valleys. Therefore the present research work was undertaken with following objectives

1. To develop a suitable dose of inorganic fertilizers and organic manure for the cultivation of *aman* rice.
2. To observe the effects of different levels of inorganic fertilizer and organic manure on the yield components and yield of *aman* rice.

CHAPTER II

REVIEW OF LITERATURE

The present research work entitled “effect of integrated nutrient management on growth and yield of rice (*Oryza sativa* L.)” included eight nutrient management treatments. A brief resume of work done on the effect of these factors on growth, yield, nutrient uptake and quality of rice in Bangladesh and abroad has been properly reviewed and presented in this chapter under various heads

2.1 Effect of integrated nutrient management

2.1.1 Growth and yield

Kumar *et al*. (2015) conducted two year consequtive experiment under North Eastern Hill region and reported that the application of 100% RDF +5 tonnes rice straw/ha produced significantly higher yield attributes and grain yield of 4.61 and 4.73 tonnes/ha among all of the different nutrient management practices.

The application of green leaf manuring (GLM) @ 6.25 t ha^{-1} + Azophosmet + 100 % NPK registered significantly the highest yield attributes in rice. The number of productive tillers m^{-2} was ranged from as low as 180 m^{-2} under Azophosmet application alone to as high as 416 m^{-2} with integrated application of GLM + Azophosmet + 100 % NPK. 150:50:50 kg ha^{-1}. The grain yield was increased, when GLM was integrated with 100 % NPK application (6030 kg ha^{-1}). The grain yield of rice was further increased, when Azophosmet was applied through seed and soil application along with GLM and 100 % NPK (6617 kg ha^{-1}). However, it was at par with application of FYM + Azophosmet + 100 % NPK. The same trend was also noticed in straw yield as mentioned by Jeyajothi and Durairaj (2015).

Mohanty *et al*. (2014) reported that integrated nutrient management i.e. 50% R.D.F. + 50% R.D.F. through organic sources (based on nitrogen requirement) registered the highest grain yield of 6.43 t ha^{-1} which was higher by 11.9 and 19.2% over recommended dose of fertilizer (RDF) and organic management (OM), respectively while studying the effect of different nutrient management practices on rice.

Tzudir and Ghosh (2014) conducted a field experiment in BCKV (kalyani, W.B) showed that the best result was obtained in rice crop with application of 75% N (Enrich Adhar) + 25% N (Urea) + P, K and consequently an increase in grain yield by 27.63%, 28.98% and 20.94% was observed over full NPK (60:30:30), 75% N (urea) + P, K and farmers' practice treated plots respectively. The corresponding increases in straw yields were 23.38, 24.4 and 17.73% respectively. Organic sources of plant nutrient also showed positive effect on other yield attributes such as panicle length (26.31 cm m^{-2}) tiller number (499.24) and filled grains per panicle (101.60).

The application of 100 % RDF (120:60:40 kg ha^{-1}) + 5 tons rice straw/ha recorded significantly higher yield attributes such as number of panicle m^{-2} (211.0), grain filling (88.1%), panicle length (25.60cm), panicle weight (4.42 g), number of grains/panicle (205.9), test weight (24.50g) and grain yield (4.73 ton / ha) of rice crop among the nutrient management practices in 2012 as reported by Kumar *et al.* (2013) through conducting an experiment in India.

Jagathjothi *et al.* (2012) mentioned that integrated nutrient management (INM) practice +2% urea phosphate spray at panicle initiation produced the highest plant height, dry matter production, number of tillers, yield attributes and yield of grain (5631 kg ha^{-1}) and straw (7647 kg ha^{-1}) the among the nutrient management treatments.

Dwivedi *et al.* (2012) observed that higher grain and straw yields of rice (37 and 60 q/ha) respectively was realized through integrated nutrient management (recommended practice) from different sources such as 80:40:30 NPK + 5 kg Zn + 5 t FYM +12 kg BGA + 3 Kg PSB.

A field experiment conducted by Acharya and Mondal (2010) on rice under West Bengal conditions confirmed that the highest productivity and quality of the crops in sequence and rice equivalent yield (32.4 t ha^{-1}) was observed with application of 75% recommended dose of fertilizer (RDF) along with 25% N through Neematex.

2.1.2 Nutrient uptake

Tzudir and Ghosh (2014) showed that the effect of different treatments on availability of soil nutrients also showed that application of integrated plant nutrients showed better results and application of 75% N (Enrich Adhar) + 25% N (urea) + P, K resulted in highest nitrogen percentage 0.0724 % available phosphorus and potassium 23.83 kg ha^{-1} and 175.27 kg ha^{-1} respectively, while the lowest was from sole application of NPK through inorganic nutrient sources.

Yadav and Saha (2014), concluded that the integration of nitrogen application @ 125 Kg ha^{-1} with application of pendimethalin @ 1 kg a.i. ha + 2 hand weeding at 20 and 40 DAS of rice resulted in significantly higher N & K uptake by grain (73.1 & 21.7 Kg ha^{-1} respectively). P uptake by straw (14.0 kg ha) and total N, P & K uptake by crop (116.1, 34.4 Kg ha^{-1} &, 48.8 Kg ha^{-1} respectively than weedy check plot which ultimately resulted in high grain yield (6.3 t ha^{-1}) this treatment also significantly reduced the density & dry weight of weeds and nutrient depletion by weeds.

Thirunavukkarasu and Vinoth (2014) while conducting experiment on rice, confirmed that nutrients uptake were recorded higher under application of vermicompost at the rate of 2.5 t ha^{-1} along with nitrogen addition based on leaf colour chart critical value less than 4.

Singh *et al*. (2006), concluded that the integrated nutrient management treatments having bioorganic sources like FYM, green manure, crop residue and Azolla/Azotobacter enhanced nutrient availability which led to better nutrient uptake in rice.

Srinivasan and Angayarkanni (2008) revealed that the treatment combinations for chemical fertilizers were 5 levels of N (0, 50, 100, 150 and 200 kg ha^{-1}), 4 levels of P2O5 (0, 30, 60 and 90 Kg ha^{-1}) and 3 levels of K_2O (0, 40 and 80 kg ha^{-1}). Organic fertilizers FYM (0, 12.5 ha^{-1}), Azospirillum (0, 2 kg ha^{-1}) were also included into this study. At harvest, grain yield from each plot and from each strip was recorded. Plant samples were also collected, dried, powdered and analysed for N P and K contents and finally uptake were computed. The results indicated that the NPK uptake increased from Strip I to IV with the chemical fertilizers along with FYM+Azospirillum.

Lakshmi *et al*. (2014) revealed that the values of available micronutrient status, their uptake and humic substances were higher with integrated nutrient management practices, especially when vegetable market waste vermicompost was applied. With continuous chemical farming, there was a slight reduction in the soil micronutrient status, nutrient uptake and humic substances. Conjunctive application of organics along with inorganic exhibited higher seed yield of rabi green gram with high micronutrient uptake and soil humic substances over application of inorganic only.

A field experiment was conducted by Pyngrope *et al*. (2017) during Kharif whose reported that that the higher number of effective tillers hill^{-1} (18.59) observed in treatment T9 (120 kg Nitrogen ha^{-1}) and same treatment recorded significantly higher grain yield (5.34 t ha^{-1}) among all treatment combinations.

Higher growth and yield were observed in nitrogen fertilizer application@300 kg/ha mentioned by Youseftabar *et al*. (2012) through carried out a field trial at in rice research institute of Iran-departy of mazandaran (amol).

Gobi *et al*. (2008) concluded an experiment on rice to know the proper nitrogen level and reported that yield and yield components of rice significantly influenced by nitrogen level.

Iqbal *et al*. (2008) performed a field experiment at Faisalabad, Kala Shah Kaku and Gujranwala, Pakistan with nitrogen split application and found that paddy yield was also significantly increased with proper management of nitrogen application. They concluded that a greater than 5 t ha^{-1} paddy yield would be a reasonable commercial expectation for all the locations provided early transplanting of rice with better management of nitrogen could be established.

Zare *et al*. (2014) concluded that the nitrogen application@ 45 kg ha^{-1} produced the superior morphological, yield and yield components of rice by conducting a field experiment at the rice research institute (37°12″19′ N, 49°38″28′ E, 24.6 m a.s.l.) located in Rasht, Guilan province of Iran.

Khorshidi *et al*. (2011) the analysis of variance showed that the effect of nitrogen fertilizer and bacteria had no significant difference on 1000 seeds weight, number of clusters (m^2) and number of grains per panicle. The effect of fertilizers, bacteria *Azospirillum lipoferum* and *Pseudomonas flouresence* on rice yield showed that application of 100 kg of nitrogen with Pseudomonas and without Azospirillum had the highest yield of rice.

The application of nitrogen@ 40 kg ha^{-1} produced the maximum number of tillers (NT), plant mean height (PMH), dry matter of shoots (DMS), crop yield/mass of filled grains (MFG), content of N-DMS, agronomic efficiency of nitrogen (AE), mass of 100 filled grains (M100FG) and grain harvest index (GHI) as compare to others nitrogen levels as reported by Contreras *et al*. (2017).

An experiment was performed by Chaturvedi (2005) to determine the effect of different nitrogenous (N) fertilizers on growth, yield and quality of hybrid rice and they found that the nitrogen application at 55 kg ha^{-1} showed the maximum growth and yield contributing characters of rice.

Yoseftabar (2013) stated that highest panicle structure such as number of panicles (heads) spikeler density, panicle length, panicle curvature and the number of grains per panicle, grains $panicle^{-1}$, grain yield significantly increased with applying nitrogen@ 300 kg ha^{-1} among all treatment in Iran Islamic Azad University, Sari Branch, Sari, Iran.

Pramanik and Bera (2013) revealed that among of the nitrogen levels @ 200 kg ha^{-1} gave significant higher plant height, panicle initiation, number of tillers $hill^{-1}$, total chlorophyll content, panicle length and straw yield and nitrogen levels N150 kg ha^{-1} gave significant higher Number of effective tillers $hill^{-1}$, effective tiller index, panicle weight, filled grain $panicle^{-1}$, 1000 grain weight, grain yield, and harvest index as compared to N_0, N_{50}, N_{100} during both years.

To investigate the effect of nitrogen (N) application level on fiber-rich cultivar, Goami 2, an experiment was carried out by Jeon (2012) on a paddy soil at the rice experimental farm of the National Institute of Crop Science, Rural Development Administration (RDA) in Suwon, Korea. He mentioned that the test weight and grain and straw yield were significantly increased with the application of nitrogen@ 70 kg ha^{-1} among different N application levels (0, 50, 90, 110, 130 and 150 kg ha^{-1}).

An experiment was performed by Tayefe *et al*. (2014) during 2008 to 2009 to investigate the effect of nitrogen (N) fertilizer levels on yield and yield components of rice and they found that the total biomass (8386 kg ha^{-1}), grain yield (3662 kg ha^{-1}), plant height (127.9 cm), tillers m^{-2} (250.22), panicles m^{-2} (235.8) and total grain per panicle (103.8) reached the highest value at high nitrogen level (90 kg ha^{-1}) among 0, 30,60 kg N ha^{-1}.

Haque and Haque (2016) found that the assimilate remobilization varied from 109.21 to 232.93 gm-2 between the nitrogen levels where the maximum amount of remobilization was observed at 60 kg N ha^{-1}. The highest grain yield (5.36 t ha^{-1}) was found when the variety was fertilized with 60 kg N ha^{-1}.

Nitrogen application @120 kg ha^{-1} was significantly varied from all the parameters measured which include plant height number of tillers/hill, dry weight, length of panicle , number of filled grains panicle^{-1}, straw yield, biological yield, harvest index as compare to others treatment as mentioned by Malik *et al*. (2014) through conducting a field trail during rainy season.

An investigation was carried out by Saha *et al*. (2017) during kharif seasons of 2008 in rice crop with the different levels of nitrogen and various cultivars to find out the optimum dose of nitrogen under terai region of West Bengal, India. They reported that the among the nitrogen levels, maximum growth and yield contributing traits were recorded@ 90 kg ha^{-1}.

Lai *et al*. (2017) mentioned that the application of 120 kg N ha^{-1} was able to promote more plant growth and yield attributes than the other treatments, especially in plant height, leaf area, relative chlorophyll content and tiller number. Increased yield over the control treatment was found similar to 90 and 120 kg N ha^{-1} reducing fertilization up to 40% and resulted in 20% grain yield improvement compared to the control.

Maqsood *et al*. (2013) concluded nitrogen application at 100 kg N ha^{-1} provided a maximum paddy yield (4.39 and 4.67 t ha^{-1}) in both years. The rice kernel characteristics were also affected by culture methods and nitrogen levels. In addition, return variable cost in the transplanted rice increased by 22.27% over direct-seeded rice. Regarding quality, the amylose (24.35%) and protein (8.56%) contents were also higher in transplanted rice as compared to direct seeding at 100 kg N ha^{-1} application.

2.1.3 Soil quality

Das *et al*. (2007) concluded that sesbenia incorporation along with 100 kg N ha^{-1} improved wet soil NH4+-N, total N, available N P & K as organic C in the post-harvest soil. The results assume great importance considering integrating nutrient management, which in turn may prove highly beneficial in conserving fertility status of soil on a long term basis.

Dwivedi *et al*. (2012), observed that the increase in fertility level after harvesting of rice the soil has pH- 6.7, EC-0.22d sm^{-1}, organic carbon-0.63%, nitrogen-236 kg ha^{-1}, phosphorus-15-4 kg ha^{-1} potash-330 kg ha^{-1} and zinc- 0.710 ppm through integrated nutrient management (recommended practices) from different sources such as 80:40:30 NPK + 5 kg Zn + 5 t FYM +12 kg BGA + 3 KG PSB.

Nayak *et al*. (2012) showed that the application of NPK either through combination of inorganic and organics such as FYM or crop residue or green manure improved the soil organic carbon, particulate organic carbon, microbial biomass carbon concentration and their sequestration rate in rice-wheat cropping system.

Biswas *et al*. (2007) observed that the field experiment revealed that the most sensitive indicator, i.e. microbial biomass carbon (MBC), and soil organic carbon (SOC) responded positively to application of organics (farmyard manure *Leucaena leucocephala* and rice residues) in conjunction with inorganics to the soil. Both SOC and MBC contents were higher where higher amount of irrigation water was applied to both rice and wheat. Carbon and nitrogen mineralization studies also revealed that application of FYM and leucaena along with inorganic were better in terms of both carbon build-up and sustained release of nitrogen to the crops.

Acharya and Mondal (2010) field experiment was conducted between 2002-2004 at Mohanpur, West Bengal to study the effect of integrated nutrient management (INM) on nutrient uptake combined application of organic and inorganic sources of nutrients improved the nutrient uptake by the crops in sequence as compared to chemical fertilizer alone.

2.1.4 Economics

Mohanty *et al*. (2014), revealed that the rice crop with integrated nutrient management i. e. 50% R.D.F. + 50% R.D.F. through organic sources (based on nitrogen requirement) practices realized the highest gross return (Rs. 75586 ha^{-1}) and net return of (Rs. 40570 ha^{-1}); but the net return was at par with RDF (Rs. 40251 ha^{-1}). The return (Rs. 2.45 ha^{-1}) was the highest with R.D.F. followed by INM (Rs.2.16 ha^{-1}).

Dwivedi *et al*. (2012) while studing the performance of INM on economics of direct seeded rice in Rewa (M.P.) reported that the INM treatment (recommended practice: 80 +40 + 30 NPK + 5 Kg Zn + 5 Kg FYM + 12 Kg BGA + 3 Kg PSB ha^{-1}) register the highest B: C ratio 3: 1 and lowest B: C ratio 2.5 was observed in case of farmers practice.

Acharya and Mondal (2010) Field experiment was conducted during 2002-2004 at Mohanpur, West Bengal to study the effect of integrated nutrient management (INM) on rice. The highest net returns (Rs 1, 43,463 ha^{-1}) and net B:C ratios (2.92) were obtained when crops in sequence were fertilized with 75% RDF along with 25% N through FYM.

CHAPTER III

MATERIALS AND METHODS

Details of the methodology of the study followed during the research period are presented in this chapter.

3.1 Experimental location and duration

The experiment was carried at research farm of Crop Physiology and Ecology Department, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during August 2018 to December 2018. The Agro Ecological Zone (AEZ) of the area is the Old Himalayan Piedmont Plain (AEZ-1). The geographical position of the area is between 25º39′ N latitude and 88º41′ E longitude with an elevation of 37.58 meter above the sea level.

3.2 Climate and weather conditions

Dinajpur has a sub-tropical climate characterized with hot desiccating summer, cold winter and moderate annual rainfall. The mean meteorological data for cropping season recorded that is presented in Appendix II.

3.3 Soil of the experimental site

The experimental field was a medium high land belonging to the non-calcarious dark gray floodplain soil. The soil (Ranisankail Series) is sandy loam under the Order Inceptisol (Appendix II).

3.4 Brief description of cultivar used

Rice variety “BRRI dhan 51” was used as test crop in this experiment. This is a long duration variety of 140-145 days. The grains of the variety are thin. It has the potential to give 4.5-5.0 tons of grain yield ha^{-1}. It is moderately flood tolerant.

3.5. Experimental design, layout and treatments

The experiment was replicated thrice with Randomized Complete Block Design (RCBD). BRRI dhan51 was imposed eight integrated nutrient management treatments. The treatment were

Sl. No	**Treatment**	
1	T_1	No fertilizer
2	T_2	100% NPK (Recommended dose for rice)
3	T_3	50% NPK+ 4 ton cowdung ha^{-1}
4	T_4	50% NPK+ 8 ton cowdung ha^{-1}
5	T_5	50% NPK+ 12 ton cowdung ha^{-1}
6	T_6	75% NPK+ 4 ton cowdung ha^{-1}
7	T_7	75% NPK+ 8 ton cowdung ha^{-1}
8	T_8	75% NPK+ 12 ton cowdung ha^{-1})

The size of unit plot was 2.0 m × 2.5 m. The spacing between blocks and plots were 1 m and 50 cm, respectively. The total number of plots was 24 (treatment combinations: 8 × 3).

3.6. Procedure of the Experiment

3.6.1 Seed collection

Rice variety BBRI dhan 51 seeds was collected from Bangladesh Rice Research Institute (BRRI), Joydevpur, Gazipur.

3.6.2 Seed sprouting

Specific gravity method was used to determine the healthy seeds. About 24 hours requires for immersing the seed in water within a bucket. Then seeds was kept thickly in gunny bags after taken out of water. The seeds started sprouting after 48 hours and were sown after 72 hours of steeping.

3.6.3 Preparation of seedling nursery and seed sowing

Seedling were raised in a piece of high land of experimental farm, under Crop Physiology and Ecology Department, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur. Country plough and ladder were used for puddling and laddering. Then the sprouted seeds were sown in the nursery beds. For better growth of seedlings, weeds were removed and irrigation was provided as and when necessary.

3.6.4 Preparation of experimental land

The experimental plot was prepared by cross harrowing of the land followed by cross ploughing with cultivator. Each ploughing was followed by planking in order to pulverize the soil, weeds, root stubbles and other crop residues were removed and the field was leveled and pudlled under transplanting. The field was prepared by single ploughing without puddling and the seeds are directly sown into the field by the help of tyne under direct seeded rice.

3.6.5 Application of fertilizers and manures

The land was fertilized as per treatment specifications. Well decomposed cowdung was applied on 10 days before transplanting. Full dose of TSP, MP, gypsum and zinc sulphate were applied one day before transplanting where zinc sulphate was the main treatment. Nitrogen from urea was applied per treatments in three equal splits. The first split of urea was applied as top dressing after 20 days of transplanting. The second split of urea was applied after 35 days of transplanting and the third split of urea was applied after 55 days of transplanting.

3.6.6 The uprooting of seedlings

The irrigation was done in the nursery beds one day ahead of uprooting the seedlings. Twenty two days old seedlings were uprooted carefully without causing any mechanical injury to the root.

3.6.7 Planting technique

3.6.7.1 Transplanting

About twenty two old seedlings were transplanted on 09th August, 2018 in the well puddled plot. Three seedlings were transplanted by following spacing of 25 cm × 15 cm with 3 seedling per each hill.

3.6.8 Intercultural operations

The following intercultural operations were done for ensuring and maintaining normal growth of the crop:

3.6.8.1 Gap filling

Gap filling was done after one week of transplanting with seedlings in some hills died off and these were replaced.

3.6.8.2 Weeding

Weed infestation appeared to be a severe problem during the early stage of crop establishment. The plots were kept weed free up to 15, 30 and 50 days after transplanting of the seedling by hand pulling.

3.6.8.3 Irrigation and drainage

Proper irrigation was maintained as per necessary of crop for the better growth and development. The field was finally drained out before 15 days of harvest to enhance maturity.

3.6.8.4 Bund repairing

The bunds around the individual plots were repaired as and when necessary so that water along with nutrient elements did not move between plots.

3.6.8.5 Plant protection measures

No plant protection measure was taken as there is no remarkable infestation of insect and disease organisms was noticed in the field.

3.6.9 Harvesting

When more than 90% of grains matured fully, free from greenish tint and plants turned yellowish colour with dryness, crop was harvested in first week of December, 2018 with the help of sickle.. After sun drying, the produce of individual plot was bundled and weighed for total biological yield.

3.7 Collection of plant sample

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

3.8 Details of observations recorded

3.8.1 Crop growth parameters

3.8.1.1 Plant height

Height (cm) of the five tagged plants from five hills was measured from base of the plant to tip of the tallest leaf in each plot at different stages (- and at harvest) of growth. Thereafter, average height per plant was worked out for each plot.

3.8.1.2 Tiller number

The tiller number (m^{-2}) was counted at 30 DAS, 60 DAS, and 90 DAS and at harvest from randomly selected 0.25 m^{-2} areas at four locations in net plot area. The final value was computed and expressed in terms of mean value of four observations by completing the sum of the four observations.

3.8.2 Yield attributes and yield studies

3.8.2.1 Productive tillers hill^{-1}

The panicles which had at least one grain was considered as productive tillers. The number of productive tillers of 5 hills was recorded and expressed as effective tillers number m^{-2}.

3.8.2.2 Number of non-productive tillers hill^{-1}

The panicles which had no grain were recorded as non- productive tillers.

3.8.2.3 Panicle length

Randomly selected ten panicles were tagged plants and the length was measured (cm) from the neck node to the tip of the upper most panicle and average length was recorded.

3.8.2.4 Grains panicle^{-1}

The fertile grain per panicles were randomly selected from tagged plants of ten panicles from each plot were counted and averaged.

3.8.2.5 Sterile spiklets panicle^{-1}

The grain lacked any food material inside were considered as sterile spiklets and such grain present on each panicle was counted.

3.8.2.6 Thousand grain weight

One thousand cleaned dried seeds were counted randomly from each sample and weighed by using a digital electric balance at the stage the grain retained 14% moisture and the mean weight were expressed in gram.

3.8.2.7 Grain yield (t ha^{-1})

Grain yield was determined from the net plot area of each plot and expressed as t ha^{-1} and adjusted with 14% moisture basis. Grain moisture content was measured by using a digital moisture tester.

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

Straw yield was determined from the net plot area of each plot. After separating of grains, the sub-samples were oven dried to a constant weight and finally converted into t ha^{-1}.

3.9 Statistical analysis

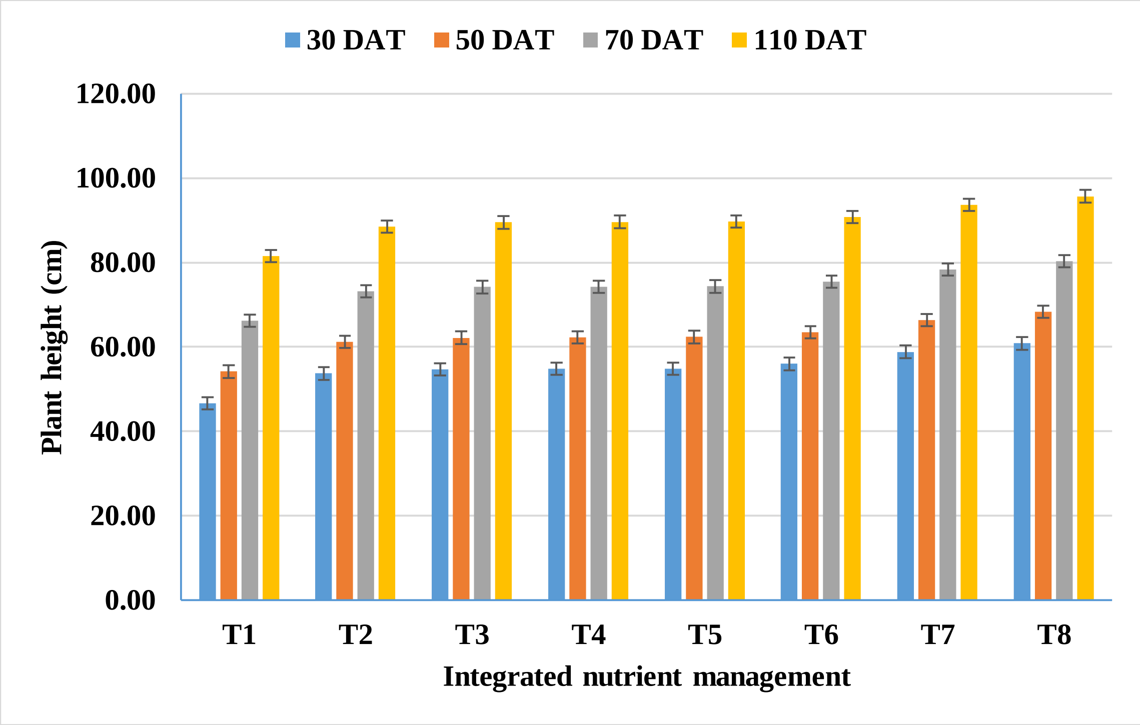
All the recorded and calculated data were statistically analyzed using the analysis of variance (ANOVA) technique by a computer using MSTATC statistical package programmed in accordance with the principles of Randomized Completely Block Design (RCBD). The Duncan's Multiple Range Test (DMRT) was used to compare the variations among the treatment means (Gomez and Gomez 1984).

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Plant height

Plant height was significantly influenced by the different integrated nutrient management treatments at various successive growth stages. Plant height increased significantly due to different treatments compared to control treatment. The highest plant (95.69 cm) was attained in treatment T_8 (75% NPK+12 ton cowdung ha^{-1}) and second highest plant (93.68 cm) was attained in treatment T_7 (75% NPK+8 ton cowdung ha^{-1}). The lowest plant height (81.52 cm) was observed in treatment T_1 (control) which was significantly lower from all other treatments (Fig. 1). This might be due to the fact that inorganic fertilization has quick, adequate and easy nutrient supplying capacity to the crop along with the added advantage of providing organic manures through green manuring which maintains the physical condition of soil besides supplying plant nutrients slowly but steadily improves crop growth like plant height Channabasavanna and Birandar (2001). This results is closely confirms the findings of Babu *et al*. (2001) who observed that the plant height was significantly influenced by the incorporation of organic manures with fertilizers.

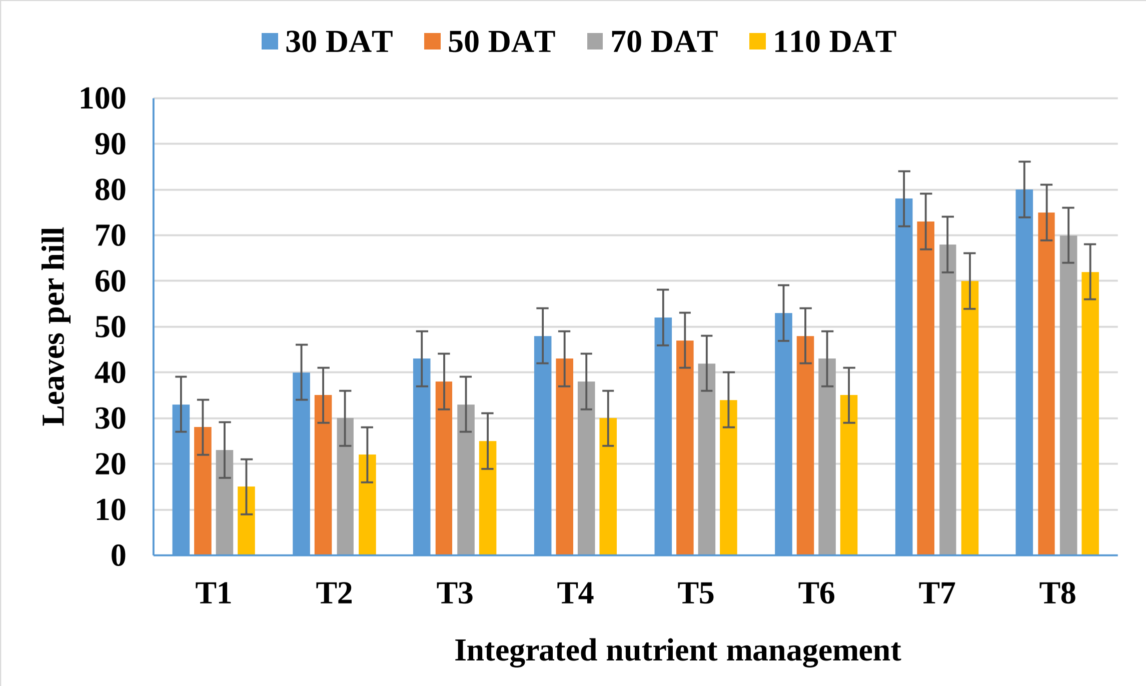


T_1- No fertilizer, T_2-100% NPK, T_3- 50% NPK+ 4 ton cowdung ha^{-1}, T_4- 50% NPK+ 8 ton cowdung ha^{-1}, T_5- 50% NPK+ 12 ton cowdung ha^{-1}, T_6- 75% NPK+ 4 ton cowdung ha^{-1}, T_7- 75% NPK+ 8 ton cowdung ha^{-1} and T_8- 75% NPK+ 12 ton cowdung ha^{-1}

Fig. 1: Plant height of rice as influenced by integrated nutrient management

4.2 Leaves per hill

Integrated nutrient management significantly influenced the plant height of rice at various successive growth stages (Fig. 1). The application of T_8 (75% NPK+12 ton cowdung ha^{-1}) and T_1 (control) produced the maximum and minimum leaves per hill, respectively among all treatments at 110 DAT as well as all growth stages. Higher leaves per hill was attained in T_8 which is statistically similar with T_7 (75% NPK+8 ton cowdung ha^{-1}). Leaves per hill influenced by integrated nutrient application through improving physical condition of soil besides supplying plant nutrients slowly but steadily improves crop growth as mentioned by Channabasavanna and Birandar (2001) and Vennila (2007).



T_1- No fertilizer, T_2-100% NPK, T_3- 50% NPK+ 4 ton cowdung ha^{-1}, T_4- 50% NPK+ 8 ton cowdung ha^{-1}, T_5- 50% NPK+ 12 ton cowdung ha^{-1}, T_6- 75% NPK+ 4 ton cowdung ha^{-1}, T_7- 75% NPK+ 8 ton cowdung ha^{-1} and T_8- 75% NPK+ 12 ton cowdung ha^{-1}

Fig. 2: Leaves $hill^{-1}$ of rice as influenced by integrated nutrient management

4.3 Number of total tillers $hill^{-1}$:

Different levels of nutrient showed significant variation for number of total tillers $hill^{-1}$ of BRRI dhan 51 (Table 1). Maximum (23.01) number of total tillers $hill^{-1}$ was found from T_8 whereas minimum from T_0 (17.05). Kant and Kumar (1994) reported that maximum level of FYM (30 t ha^{-1}) the increase of 48% tillers $hill^{-1}$. The effect due to nutrient management on number of tillers per meter square was also found to be significant and exhibits increasing trend at progressive growth stages. Inorganic fertilization along with green manuring can supply adequate nutrients and maintain proper soil physical condition for crop growth. That's why 100% inorganic fertilization together with green manuring played a significant role in increasing number of tillers per unit area. This result proves the findings of Jeyajothi and Durairaj (2015).

4.4 Productive tillers hill^{-1}

The number of productive tillers hill^{-1} was also significantly influenced by the different treatments. The application of 75% NPK+12 ton cowdung ha^{-1}(T_8) produced the highest number of productive tillers hill^{-1} (22.01) which is statistical nearly similar with T_7 (75% NPK+8 ton cowdung ha^{-1}) while the lowest (11.01) was recorded in control condition among all treatments (Table 1). The number of effective tillers hill^{-1} in the treatments T_4 and T_5 were statistically similar. Significantly higher number of effective tillers per meter square was recorded under treatment S_4 (100% inorganic + green manuring) compared to other sub plot treatments. This is due to adequate nutrients quickly as compare to organic substitution of chemical fertilization to the crop. Moreover, extra advantage is derived from green manuring being organic sources in S_4 plots. This result is also supported by the findings of Saha and Bharti (2010). Rahman *et al*. (2009) observed that the effect of poultry manure on effective tillers hill^{-1} were more prominent than cow dung, it was more so when chemical fertilizers were used in combination. Azim *et al*. (1999) and Chaturvedi (2005) also reported beneficial effects of manures in combination with chemical fertilizers on effective tillers hill-^{1}.

4.5 Non-productive tillers hill^{-1}

Results in Table 04 indicated that number of non-productive tillers hill^{-1} was significantly influenced by the different treatments over control (Table 1). Application of chemical fertilizers (NPK) along with the cow dung varied the number of non-productive tillers hill^{-1} 1 to 6.04. The lowest (1.00) number of non-productive tillers hill^{-1} in rice was recorded in T_8 which is statistically similar with T_7 while highest (6.04) was observed in T_1 among all treatments. Ali *et al*. (2003) reported that the increasing rates of amendments of chemical fertilizers with FYM decreased the number of non-productive tillers hill^{-1} significantly and at the maximum level of FYM (30 t ha^{-1}). Number of productive tillers hill^{-1} of BRRI dhan33 varied significantly for different levels of cowdung.

4.6 Panicle length

Integrated nutrient management significantly influenced the panicle length of rice (Table 02). All the treatments produced higher panicle length over control treatment (T_1). Panicle length varied from 16.35 to 29.67cm. The highest panicle length (29.67cm) was observed in (75% NPK+12 ton cowdung ha^{-1}) T_8 which was higher than that all of the treatment and T_8 and was statistically close identical to the result of treatment T_7 (75% NPK+8 ton cowdung ha^{-1}). The lowest panicle length (16.35cm) was observed in the treatment T_1 (control). The result further showed that panicle length increase was directly influenced by the increased dose of organic manure in combination with chemical fertilizers and poultry manure on increased panicle length than cow dung. Adequate fertilization with added advantages of green manuring is known to have beneficial effect on yield attribute like panicle length of the crop. Similar results are also reported by Ahemed and Rahman (1991) and Kumar and Singh (2006) reported that the combined application of organic matter and chemical fertilizers increased panicle length of rice.

4.7 Number of grains panicle^{-1}

Number of grains panicle^{-1}in BRRI dhan51 was significantly influenced by combined application of cow dung and NPK (Table 1). The highest number of grains panicle^{-1} (242.09) was observed in the treatment T_8 which was closely statistically identical to the results of treatments T_6 and T_7. The lowest number of grains panicle^{-1} (205.08) was observed in the treatment T_1 (control). Likewise, potassium is osmotically active component in plant cell contributing to cell turgor and enhancing the cell capacity to retain water which has direct bearing on size of the cell (Priyanka *et al*. 2013). It helped in the development of reproductive organs and filling of storages tissues with photosynthates. All result into more number of grains per panicle of the crop. The results are in agreement with Dissanayake *et al*. (2014).

Table 1: Effect of integrated nutrient management on the yield contributing characters of rice

Treatments	Total tillers hill^{-1}	Productive tillers hill^{-1}	Non-productive tillers hill^{-1}	Panicle length (cm)	Grains panicle^{-1}
T_1	17.05bc	11.01c	6.04a	16.35d	205.08c
T_2	18.32bc	14.28c	4.04b	19.65cd	223.55ab
T_3	16.13c	13.03c	3.13ab	20.45bcd	205.95c
T_4	18.67bc	15.07bc	3.60ab	22.43abcd	214.16bc
T_5	19.01abc	16.01bc	3.01ab	22.54abcd	229.16bc
T_6	19.23abc	17.04abc	2.19ab	24.81abc	221.85abc
T_7	21.54ab	20.07ab	1.47c	27.91ab	230.83ab
T_8	23.01a	22.01a	1.00c	29.67a	242.09a
LSD	4.35**	5.52**	1.85**	7.44**	15.68**
CV (%)	12.99	13.97	20.25	12.95	8.71

The values with same letters(s) in a column are not significantly different as per DMRT, T_1- No fertilizer, T_2-100% NPK, T_3- 50% NPK+ 4 ton cowdung ha^{-1}, T_4- 50% NPK+ 8 ton cowdung ha^{-1}, T_5- 50% NPK+ 12 ton cowdung ha^{-1}, T_6- 75% NPK+ 4 ton cowdung ha^{-1}, T_7- 75% NPK+ 8 ton cowdung ha^{-1} and T_8- 75% NPK+ 12 ton cowdung ha^{-1}

4.8 Grains panicle^{-1}

The number of grains panicle^{-1} was significantly affected due to application of different organic and inorganic nutrient (Table 2). The highest (225.02) and lowest (170.05) number of grains panicle^{-1} was found in the application of 75% NPK+12 ton cowdung ha^{-1}(T_8) that is nearly similar with T_7 and control (T_1), respectively among all treatments. Umanah *et al*. (2003) and Usman *et al*. (2003) reported that organic manure increased the fertile grains per panicle. A similar finding was also claimed by Satyanarayana *et al*. (2002).

4.9 Sterile spiklets panicle^{-1}

The application of integrated nutrient progressively increased the sterile spiklets panicle^{-1} of BRRI dhan 51. Sterile spiklets panicle^{-1} of rice ranged from 12.07 to 35.04 (Table 2) due to application of chemical fertilizers along with the cow dung. The highest sterile spiklets panicle^{-1} of rice (35.04) was found in control treatment T_1. The second highest sterile spiklets panicle^{-1} of rice (28.07) was statistically similar with the results of treatment T_4. Minimum number of sterile spiklets panicle^{-1} of rice was found in treatment T_8 (12.07). Significantly lower number of sterile spiklets panicle^{-1} (7.39) was observed in *aman* rice genotypes due to integrated nutrient management (cowdung and zinc sulphate) as mentioned by Khatun *et al*. (2018).

4.10 Thousand grain weight

The 1000-grain weight of BRRI dhan51 was significantly influenced by the different treatments (Table 2). The highest 1000-grain weight (31.35 g) was observed in the treatment T_8 which was statistically identical to those observed in the treatments T_7. The lowest 1000-grain weight (23.33 g) was observed in treatment T_1 (control). Basically, test weight or 1000-grain weight is a genetically character of the crop. That's why it might not have been influenced by any of the main and sup plot treatments. The results of this investigation also get support from the work of Yadav and Saha (2014). Rahman *et al*. (2009) reported that application of chemical fertilizers with farmyard manure or in alternate wetting and drying condition increased N, P, & K uptake by rice plants, increased 1000 grain weight and grain yield of rice.

4.11 Grain yield

Integration of organic and inorganic nutrient significantly influenced the grain yield of *aman* rice (cv. BRRI dhan 51). The grain yields of rice varied from 2.57 to 5.05 t ha^{-1} due to different treatments. Higher grain yield over control was observed by all the treatments (Table 2). The highest grain yield of 5.05 t ha^{-1} showing 96.49 % increase over control was obtained in the treatment T_8 (75% NPK+12 ton cowdung ha^{-1}) that statistically similar with the treatment T_7 (75% NPK+8 ton cowdung ha^{-1}). The lowest grain yield of 2.05 t ha^{-1} was observed in control treatment T_1. The treatments can be ranked in the order of $T_8>T_7>T_6>T_5>T_4>T_3>T_2>T_1$ in term of grain yields. The results clearly indicated that organic sources of nutrient gave significantly higher grain yield over chemical fertilizer. The study revealed that integrated use of cow dung with chemical fertilizers reduced fertilizer use without any remarkable yield decline. Haque *et al*. (2001) and Rajni *et al*. (2001) reported that application of cow dung, poultry manure and water hyacinth in combination with chemical fertilizers increased grain yield of BRRI dhan29. Rahman *et al*. (2009) and Singh *et al*. (2006) reported that the application of organic manure and chemical fertilizers increased the grain and straw yields of rice. The yield ascribing character was maximum under this S_4 treatment resulting higher grain yield. This result is in close agreement with those reported earlier by (Mohanty *et al*. 2014).

Table 2: Yield and yield contributing traits of rice as influenced by integrated nutrient management

Treatments	Grains panicle^{-1}	Sterile spiklets panicle^{-1}	1000-grain weight(g)	Grain yield (tha^{-1})
T_1	170.05e	35.03a	23.33e	2.57b
T_2	195.12cd	28.43ab	25.11c	3.73ab
T_3	180.52de	25.43b	24.18d	3.93ab
T_4	187.07cde	27.09ab	26.44c	4.03ab
T_5	201.09bc	28.07ab	27.03c	4.34ab
T_6	200.18bc	21.67bc	26.22c	4.39ab
T_7	215.42ab	15.41cd	28.17ab	4.78a
T_8	225.02a	12.07d	31.35a	5.05a
LSD	17.21**	8.07**	*	1.73**
CV(%)	3.52	13.93	10.56	16.89

The values with same letters(s) in a column are not significantly different as per DMRT, T_1- No fertilizer, T_2-100% NPK, T_3- 50% NPK+ 4 ton cowdung ha^{-1}, T_4- 50% NPK+ 8 ton cowdung ha^{-1}, T_5- 50% NPK+ 12 ton cowdung ha^{-1}, T_6- 75% NPK+ 4 ton cowdung ha^{-1}, T_7- 75% NPK+ 8 ton cowdung ha^{-1} and T_8- 75% NPK+ 12 ton cowdung ha^{-1}

4.12 Straw yield

Like other parameters, the straw yield of *aman* rice (cv. BRRI dhan51) responded significantly to the combined application of organic and chemical fertilizers (Table 3). The application of 75% NPK+12 ton cowdung ha^{-1} and control produced the highest (9.26 t ha^{-1}) and lowest straw (2.65 t ha^{-1}) yield among all treatments. In producing straw yield, the treatments may be ranked in order of T_8>T7>T_6>T_5>T_4>T_3>T_2>T_1. This may be due to the fact that all growth parameter and yield contributing characters were maximum under nutrient management offered higher straw yield of rice. This statement is also supported by Sowmya *et al*. (2012). The results showed that the application of cow dung with chemical fertilizers induced higher straw yield of BRRI dhan29. This finding is assembled to the work of Khan (1998) and Reddy *et al*. (2004) who found significant effects of manures and fertilizers on straw yield. Rajput and Warsi (1992) and Singh *et al*. (2001) also reported that the application of organic manure and chemical fertilizers increased straw yield.

4.13 Biological yield

Biological yield of BRRI dhan51 varied significantly to different levels of nutrients. Biological yield of rice ranged from 5.22 to 14.31 t ha^{-1}. The maximum biological yield (14.31 t ha^{-1}) was found in T_8 which was statistically identical to the result of treatment T_7 and minimum was observed from T_1 (5.22 t ha^{-1}) among all treatments (Table 3). It was also observed that the crop sown with S_4 treatment produced significantly higher straw yield, although, this treatment was found to be statistically at par with 100% inorganic fertilization over the other treatments due to having higher values of growth parameters and yields attributes. This finding is also in close agreement with findings Mohanty *et al*. (2014). Similar results were observed by Farid *et al*. (2011).

Table 3: Straw yield and biological yield as influenced by integrated nutrient management

Treatments	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})
T_1	2.65e	5.22d
T_2	4.59d	8.32c
T_3	5.23cd	9.16bc
T_4	5.36cd	9.39bc
T_5	6.01bc	10.35bc
T_6	6.1bc	10.49bc
T_7	7.12b	11.9ab
T_8	9.26a	14.31a
LSD	1.33**	2.69**
CV (%)	9.28	11.02

The values with same letters(s) in a column are not significantly different as per DMRT, T_1- No fertilizer, T_2-100% NPK, T_3- 50% NPK+ 4 ton cowdung ha^{-1}, T_4- 50% NPK+ 8 ton cowdung ha^{-1}, T_5- 50% NPK+ 12 ton cowdung ha^{-1}, T_6- 75% NPK+ 4 ton cowdung ha^{-1}, T_7- 75% NPK+ 8 ton cowdung ha^{-1} and T_8- 75% NPK+ 12 ton cowdung ha^{-1}

CHAPTER V

SUMMARY AND CONCLUSION

To evaluate the effect of integrated nutrient management on the growth, yield attributes, yield of rice cv. BRRI dhan51, the present experiment was conducted at the Research Field of the Department of Crop Physiology and Ecology, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh during T. *Aman* season (September to December) of 2018. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications and single factor. BRRI dhan 51 was imposed eight integrated nutrient management treatments (T_1- No fertilizer, T_2-100% NPK, T_3- 50% NPK+ 4 ton cowdung ha^{-1}, T_4- 50% NPK+ 8 ton cowdung ha^{-1}, T_5- 50% NPK+ 12 ton cowdung ha^{-1}, T_6- 75% NPK+ 4 ton cowdung ha^{-1}, T_7- 75% NPK+ 8 ton cowdung ha^{-1} and T_8- 75% NPK+ 12 ton cowdung ha^{-1}) in this experiment. The size of unit plot was 2.0 m × 1.5 m. The spacing between blocks and plots were 50 cm and 25 cm, respectively. The total number of plots was 24 (treatment combinations: 8 × 3). Cowdung and recommended doses of urea, TSP, MoP and gypsum were applied as per treatments. The TSP, MoP and gypsum were applied to the plots as basal during final land preparation. Urea was applied in three equal splits. Twenty two day old seedlings were transplanted in the experimental plot. Intercultural operations like gap filling, weeding, irrigation and drainage were done as and when required to normal crop growth. Five hills were randomly selected for measuring plant height and tiller production well as yield contributing characters during harvesting. Grain and straw yields were recorded and the grain yield was expressed on 14 % moisture basis while the straw yields on sundry basis. All the data were statistically analyzed by MSTATE-C package program and the mean differences were adjudged by Duncan's New Multiple Range Test (DMRT).

The results of the experiment are summarized below:

- The application of 75% NPK+ 12 ton cowdung ha^{-1} (T_8) significantly influenced the plant height of rice at different stages of crop growth. The maximum plant height of rice was recorded under T_8 which is turn were significantly similar T_7 (75% NPK+ 8 ton cowdung ha^{-1}) among all treatments.
- The maximum value in response of total tillers $hill^{-1}$, productive tillers $hill^{-1}$ achieving by the application of 75% NPK+ 12 ton cowdung ha^{-1} (T_8) which is also showed close statistical similar with T_7 (75% NPK+ 8 ton cowdung ha^{-1}).
- Among all treatments, the minimum non-productive tillers $hill^{-1}$ and sterile spiklets were recorded in T_8 (75% NPK+ 12 ton cowdung ha^{-1}).
- 75% NPK+ 12 ton cowdung ha^{-1} (T_8) produced the maximum panicle length which is significantly similar with T_7 (75% NPK+ 8 ton cowdung ha^{-1}) from rest of the treatments.
- Maximum number of grains per panicle and fertile grains per panicle of rice were produced by the application of 75% NPK+ 12 ton cowdung ha^{-1} (T_8) among all treatment.

- In respect of test weight of rice, (T_8) achieved higher value among all treatments.
- Among all integrated nutrient management treatments, maximum grain yield, straw yield and biological yield were recorded in the application of 75% NPK+ 12 ton cowdung ha^{-1} (T_8).

Conclusion

From the above discussion it is clear that integrated nutrient management have a significant influence on growth and productivity in rice. Further, yield and yield traits gradually increased with imposing different nutrients. The application of 75% NPK+ 12 ton cowdung ha^{-1} (T_8) produced the highest growth, yield and yield traits, but in most of the cases it was statistically similar with T_7 (75% NPK+ 8 ton cowdung ha^{-1}). Accordingly, it might be summarized that BRRI dhan51 could be cultivated by application of 75% NPK+ 8 ton cowdung ha^{-1} to boost the yield of rice as well as to maintain and improve soil health for achieving the optimum economic benefit.

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APPENDICES

Appendix I. Characteristics of soil of the experimental site

General characters	Description	
Location	Research field of Crop Physiology and Ecology, HSTU, Dinajpur.	
AEZ	Old Himalayan Piedmont Plain (AEZ-1)	
General Soil type	Non-Calcareous Brown Floodplain Soil	
Parent material	Piedmont alluvium	
Soil series	Ranishankail	
Drainage	Moderately well drained	
Flood level	Above flood level	
Topography	High land	
Physical characteristics	**Value**	
Bulk density (g cm-3)	0.86-1.07	
Particle size (%)		
Sand (2-0.02mm)	60.0	
Silt (0.02-0.002mm)	27.0	
Clay (< 0.002mm)	13.0	
Textural class	Sandy loam	
Chemical characteristics	**Content**	**Interpretation**
pH	5.40-5.50	Moderately acidic
Organic carbon (%)	0.69	Low
Organic matter (%)	1.19	Low
CEC (meq/100g soil)	5.60	Low
Total N (%)	0.07	Very low
Available P (ppm)	16.75	Medium
hangeable K (meq/100g soil)	0.17	Medium low

Source: Analysis of initial soil samples was done in SRDI, Dinajpur, Bangladesh.

Appendix II: Weather data for growing season of *aman* rice, August to December, 2018

Month	Relative humidity (%)	Temperature		Total rainfall (mm)
		Minimum (^oC)	Maximum (^oC)	
August	78.23	23.34	32.29	17.93
September	80.13	26.17	33.59	14.80
October	70	13.20	28.10	5.20
November	81	16.10	30.0	0.00
December	85	12.10	26.4	7.00

Source: Wheat Research Centre, Dinajpur.