INTEGRATED EFFECT OF ORGANIC MANURES AND NITROGEN ON YIELD CONTRIBUTING CHARACTERS AND YIELD OF RICE (BRRI dhan29)

BY

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CERTIFICATE

This is to certify that the thesis entitled **"Integrated Effect of Organic Manures and Nitrogen on Yield Contributing Characters and Yield of Rice (BRRI dhan29)"** 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 **Md. Sariful Islam**, Registration number: **09-03742** 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:
Dhaka, Bangladesh

Prof. Dr. Alok Kumar Paul
Department of Soil Science
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DEDICATED

TO

MY BELOVED PARENTS

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The Author

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ABSTRACT

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from January to April 2010 to study the integrated effect of organic manures and nitrogen on yield contributing characters and yield of rice (BRRI dhan29). The experiment consisted of 12 treatments. The treatments were T_1: Control condition (No chemical fertilizer, no organic manure); T_2: 100% recommended N (120 kg N ha^{-1}) + recommended P, K, S and Zn); T_3: 100 kg N from urea + 20 kg N substituted by vermicompost (VC) + P, K, S and Zn; T_4: 100 kg N from urea + 20 kg N substituted by cowdung (CD) + P, K, S and Zn; T_5: 80 kg N from urea + 40 kg N substituted by VC + P, K, S and Zn; T_6: 80 kg N from urea + 40 kg N substituted by CD + P, K, S and Zn; T_7: 60 kg N from urea + 60 kg N substituted by VC + P, K, S and Zn; T_8: 60 kg N from urea + 60 kg N substituted by CD + P, K, S and Zn; T_9: 100 kg N from urea + 20 kg N substituted equally by VC and CD + P, K, S and Zn; T_{10}: 80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn; T_{11}: 60 kg N from urea + 60 kg N substituted equally by VC and CD + P, K, S and Zn and T_{12}: 120 kg N substituted equally by VC and CD. Data on different growth parameter & yield, nutrient content in grain & straw, nutrient uptake by grain & straw and characteristics of post harvest soil was recorded. At 30, 50, 70, 90 DAT and harvest, the longest plant (23.96 cm, 31.29 cm, 44.23 cm, 66.84 cm and 88.87 cm) was recorded from T_{10} and at the same DAT the shortest plant (16.47 cm, 21.60 cm, 30.23 cm, 47.13 cm and 61.95 cm) was observed from T_1 as control condition. The highest grain yield (6.73 t ha^{-1}) was recorded from T_{10}, while the lowest (2.16 t ha^{-1}) from T_1. The highest straw yield (7.10 t ha^{-1}) was obtained from T_{10} and the lowest (4.33 t ha^{-1}) from T_1. The highest N uptake by grain (43.99 kg ha^{-1}) was recorded from T_{11} and the lowest (16.38 kg ha^{-1}) from T_1. The highest P uptake by grain (14.63 kg ha^{-1}) was observed from T_{11}, while the lowest (6.32 kg ha^{-1}) from T_1. The highest K uptake by grain (19.66 kg ha^{-1}) was found from T_{11}, whereas the lowest (7.72 kg ha^{-1}) was observed from T_1. The highest N uptake by straw (30.87 kg ha^{-1}) was recorded from T_6 and the lowest (21.85 kg ha^{-1}) from T_1. The highest P uptake by straw (4.72 kg ha^{-1}) was found from T_6, whereas the lowest (3.77 kg ha^{-1}) from T_1. The highest K uptake by straw (73.98 kg ha^{-1}) was recorded from T_6 and the lowest (50.76 kg ha^{-1}) from T_1. Applications of 80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn was the superior among the other treatments in consideration of yield contributing characters and yield of BRRI dhan29.

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CHAPTER I

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important food for the people of Bangladesh and it is the staple food for more than two billion people in Asia (Hien *et al.,* 2006). In Bangladesh, the geographical, climatic and edaphic conditions are favorable for year round rice cultivation. However, 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}) (FAO, 2009). The population of Bangladesh is increasing at an alarming rate and the cultivable land is reducing due to urbanization and industrialization resulting in more shortage of food. As it is not possible to have horizontal expansion of rice area, rice yield $unit^{-1}$ area should be increased to meet this ever-increasing demand of food in the country.

Among the production factors affecting crop yield, 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, optimum 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 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). Inadequate and improper applications 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 then 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. The long-term research of BARI revealed that the application of cowdung @ 5 t ha^{-1} $year^{-1}$ improved rice productivity as well as prevented the soil resources from degradation (Bhuiyan, 1994).

Organic manure can supply a good amount of plant nutrients which can contribute to crop yields. Thus, it is necessary to use fertilizer and manure in an integrated way in order to obtain sustainable crop yield without affecting soil fertility. 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 physicochemical 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. More recently, attention is focused on the global environmental problems; utilization of organic wastes, vermicompost and poultry manures as the most effective measure for the purpose. 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. Application of both chemical and organic fertilizers needs to be applied for the improvement of soil physical properties and supply of essential plant nutrients for higher yield. Under this circumstance the present research work has been taken with the following objectives:

a. To select a suitable combination of organic manures and nitrogenous fertilizer as a source of nitrogen for successful growth and yield of BRRI dhan29.

b. To evaluate the integrated effect of organic manure with the combination of chemical fertilizer on the growth and yield of BRRI dhan29.

c. To study the uptake pattern of NPKS by BRRI dhan29 rice from organic and inorganic combine treated plot.

CHAPTER II

REVIEW OF LITERATURE

Integrated use of organic manure and nitrogen fertilizer is the essential factor for sustainable soil fertility and crop productivity. Sole and combined use of cowdung, vermicompost, and inorganic fertilizer increase plant growth, yield contributing characters and yield because is the store house of plant nutrients. Experimental evidences that the use of cowdung, vermicompost, and nitrogen, phosphorus, potassium and sulphur have an intimate effect on the yield and yield attributes of rice. The available relevant reviews that are related to the effect of level of various organic manure and nitrogen fertilizer on the yield and yield attributes of rice are reviewed below-

2.1 Effect of cowdung

Rajput and Warsi (1991) conducted a field experiment and reported that rice yield was increased to 34.44 kg ha^{-1} with the application at FYM of 10 t ha^{-1}. Indulker and Malewar (1991) stated that application of 10 t ha^{-1} FYM alone produced grain yield of 2.19 t ha^{-1} and the untreated control gave 2.06 t ha^{-1}. Sharma and Mitra (1991) reported a significant increase in N, P and K uptake and also the nutritional status of soil with 5 t ha^{-1} of FYM of rice based cropping system.

Gurung and Sherchan (1993) reported that the application of cowdung with chemical fertilizers produced significantly higher grain yield than that of chemical fertilizers alone.

Kant and Kumar (1994) reported that the increasing rates of amendments with FYM increased the number of effective tillers $hill^{-1}$ significantly, number of grain $panicle^{-1}$, weight of 1000 grains also increased over the control. At the maximum level of FYM (30 t ha^{-1}) the increase of 48% tillers $hill^{-1}$, 14% number of grain per panicle and 4.5% weight of 1000 grains over the control were recorded. They also reported that higher rate of FYM (30 t ha^{-1}) resulted 22.00% increase in grain yield over the untreated plots.

Thakur and Patel (1998) conducted field experiments during *kharif* season to study the effect of split application of 60 or 80 kg N ha^{-1} on growth, yield and nitrogen uptake by rice with and without 5 t FYM ha^{-1} and proposed that both N rates increased yields attributes, yield, plant N content and N uptakes of rice compared with N or application of FYM alone. N rates and use of split doses had no effect. The highest grain yield (3.84 t ha^{-1}) was recorded with the application of 80 kg N ha^{-1} in three split doses with 5 t ha^{-1} FYM during both the years, 60 kg N in three split doses with 5 t ha^{-1} FYM gave seed grain 3.85 t ha^{-1}.

A field experiment was conducted by Gupta *et al.* (1999) on clay loam soil in 1993 in Jummu and Kasmir using rice cv. PC-19 as test crop with 0-100 kg P_2O_5 ha^{-1} and 0 or 10 t FYM. The crop also received a basal dressing of N, K and Zn. Grain yield was highest with 100 kg P_2O_5 + FYM (5.20 t ha^{-1}).

Mannan *et al.* (2000) reported that manuring with cowdung up to 10 t/ha in addition to recommended inorganic fertilizers with late N application improved grain and straw yields and quality of transplant aman rice over inorganic fertilizer alone.

Saitoh *et al.* (2001) conducted an experiment to evaluate the effect of organic fertilizers (cowdung and poultry manure) and pesticides on the growth and yield of rice and revealed that the yield of organic manure treated and pesticide free plots were 10% lower than that of chemical fertilizer and pesticide treated plot due to a decreased in the number of panicle. Yearly application of manure increased the total carbon and nitrogen content in soil.

2.2 Effect of compost

Anzai *et al.* (1989) found out the effect of successive application of rice straw compost on the growth and yield of rice with low and high soil nitrogen levels, respectively. The growth rice in the soil supplemented with rice straw compost was retarded initially and restored after the panicle formation stage. The yield was lower than that in the soil supplied with chemical fertilizer due to decrease in the percentage of ripened grains. Successive applications of 30 ton compost ha^{-1} produced more number of grain m^{-2} but a lower percentage of ripened grains and yield than that where chemical fertilizer was applied.

Vermicompost was tasted in pot experiment for its ability to replace a proportion of the urea fertilizer applied to rice. Compared with N fertilizer alone, supplying one-third or one-quarter of N as vermicompost increased plant height, grain yield and yield components of rice (Rini and Srivastava, 1997).

A study in typical clayey rice soil (Aeric Albaquept) of Bangladesh was conducted by Farid *et al.* (1998) incorporation of compost or rice straw and subsequent decomposition increased and maintained organic matter level at 2.5% that was higher than that in traditionally managed rice soil (<2%).

Application of composted coir pith improves the soil available K status and increase the uptake of K by grain and straw yield of rice. Application of 50 kg N with green leaf manure gave the highest grain and straw yield in both season, followed composted coir pith (Chittra and Janaki, 1999).

Composts from organic wastes, such as segregated waste, green botanical waste and food processing waste are becoming available in increasing quantities. These supply a complex mixture of nutrients in organic and mineral forms and are also used as soil condition to maintain and improve soil structure (HDRA, 1999).

Tamaki *et al.* (2002) observed that the correlation between growth and yield and duration of organic farming (compost mixed with straw) in comparison with conventional farming. In organic farming plant height of rice was shorter and short number $hill^{-1}$ was lesser than in conventional farming, but both of these values increased as the duration of organic farming increased. The maximum tiller number was smaller and panicle number was also smaller their in organic farming. However, both the panicle number and panicle length increased as the duration organic farming increased. The grain-straw ratio was higher in organic farming than the conventional farming. These results suggest that the growth and yield of rice increased with continuous organic farming and the yield increased with increase in panicle number $hill^{-1}$ and grain number $panicle^{-1}$.

Keeling *et al.* (2003) determined the green waste composts and provider with additional fertilizer and showed consistently that the response of wheat rape to compost and fertilizer applied together was greater than responses to the individual additives, but only when very stable compost was used. Experiments with 15 N labeled fertilizer showed that wheat was able to utilize the applied N more efficiently when cultivated in the stable compost.

Elsharaeay *et al.* (2003) found the effect of compost of the some plant residues i.e. rice straw and cotton stalk on some physical and chemical properties of the sandy soil. Application of cotton stalks or rice straw composts significantly improved the physical properties of the tasted soil, i.e., bulk density, hydraulic conductivity and moisture content namely field capacity, wilting point and available water, concerning the effect of compost application on the availability of N, P and K in the cultivated soil, rice straw was better than cotton stalks.

Aga *et al.* (2004) assessed the effect of compost on the growth and yield of rice. Plant growth characters such as plant height were highest with application of 15 t compost ha^{-1}. Grain yield increased significantly with the graded levels of compost application @ 10 t ha^{-1} but the response decreased with the increase of compost from 10 to 15 t ha^{-1}.

2.3 Effect of nitrogen fertilizer

Of the 16 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 is play pivotal role at yield and yield attributes of rice.

BRRI (1992) reported that both grain and straw yields of rice were increased significantly up to 80 kg N ha^{-1}. Application of nitrogen from 120 to 160 kg nitrogen ha^{-1} significantly reduced the yield which was assumed to be due to excessive vegetative growth follower by lodging after flowering.

Ahmed and Hossain (1992) observed that plant height of wheat were 7939, 82.3 and 84.4 cm with 45, 90 and 135 kg N ha^{-1}, respectively. Plant height increased with increasing nitrogen doses. Chandra *et al.* (1992) carried out an experiment during 1979-1980 at varanasi, Uttar Pradesh (India) and reported that plant height and dry matter increased with increasing the rate of N up to 120 kg ha^{-1}. Further increment of 3 kg N ha^{-1} decreased this parameter.

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}.

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 productive tillers increased significantly with the increase of N doses from 0-120 kg N ha^{-1}, but differences in productive tillers between 120 and 180 kg N ha^{-1} were not significant.

Effective tillers m^{-2} responded significantly to the application of N fertilizer (Behera, 1995). Effective tillers increased significantly with increase the level of N fertilizer up to 80 kg N 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 rates of N up to 120 kg ha^{-1}.

Andrade and Amorim (1996) observed that increasing level of applied N increased plant height, panicle m^{-2}, grains $panicle^{-1}$ and grain yield significantly. Palm *et al.* (1996) conducted a field trial at Waraseoni in the 1989-90 rainy season and observed that yield of rice cv. R. 269 was the highest (4.47 t ha^{-1}) when 100 kg N ha^{-1} was applied 30% basally, 40% at tillering and 30% at panicle initiation stage.

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 rice grain yield ha^{-1} in various treatments of N showed significant effect. The highest yield was obtained from 100 kg N ha^{-1} (4.52 t ha^{-1}) followed by 120 kg N ha^{-1} (4.46 t ha^{-1}) and 80 kg N ha^{-1} (4.40 t ha^{-1}).

Verma and Achraya (1996) observed that LAI increased significantly at maximum tillering and flowering stages with increasing levels of nitrogen. BINA (1996) stated that the effect of different levels of nitrogen was significant only for number of tillers $hill^{-1}$, effective tillers $hill^{-1}$, straw yield and crop duration. The highest number of total and productive tillers $hill^{-1}$ was obtained from the highest level (120 kg ha^{-1}) of N application.

Dwibvedi (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) reported during *boro* and transplant *aman* to determined rice seed yield. 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.

Islam and Bhuiya (1997) studied the effect of nitrogen and phosphorus on the growth, yield and nutrient uptake of deep-water rice. They observed that nitrogen and phosphorus fertilization significantly increased the number of fertile tiller m^{-2} and also that of grains $panicle^{-1}$, which in turn resulted in significant increase in grain yield. The application of 60 kg N ha^{-1} alone gave 22% yield benefit over control.

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}.

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.

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}.

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 45kg 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 (2647 kg ha^{-1}).

Pully *et al.* (2000) observed that increased yield associated with application of nitrogen stage, although booting stage nitrogen application had no effect or shoot growth or nitrogen uptake. These preliminary results suggested a 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. Geethdevi *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}.

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 conducted that the highest grain yield (3.8 t ha^{-1}) was obtained with 180 kg N ha^{-1}, which was similar to the yield obtained at 80 kg N ha^{-1} (3.81 t ha^{-1}).

Sarker *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.

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 (6189.4 kg ha^{-1}) and straw (8649.6 kg ha^{-1}) yields, response ratio (23.40) and agronomic efficiency (41.26).

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 and at heading stages recorded significantly lower dry weight of weeds and increased crop growth viz. effective tillers m^{-2}.

Duhan and Singh (2002) reported 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 uptake were always higher with 120 kg ha^{-1} than with lower level of nitrogen.

Mondal and Swamy (2003) 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} one seedling hill^{-1} showed significantly higher harvest index.

2.4 Combined effect of nitrogen and organic fertilizer on the yield of rice

The concept of integrated nutrient management is the continuous improvement of soil productivity through appropriate use of fertilizers and organic manure including green manure. Considerable work has been done in India, China, Thailand, Philippines and other countries of the world with respect to the use of green manure (GM), poultry manure (PM) and farmyard manure (FYM) as alternative or supplementary sources of nutrients. In Bangladesh, only limited attempts have been made in this perspective.

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.

Miyazaki *et al.* (1986) found 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. Compost 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.

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 was studied (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.

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 (Meelu and Singh, 1991).

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. But these figures were 125 and 102% when Boro rice crop was fertilized with 100% chemical fertilizers + 5 t FYM ha^{-1} followed by Aman rice with only 100% chemical fertilizer.

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 with 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}.

Gupta (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.

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. There were six treatments cheek, 50, 100 and 200 t compost ha^{-1}, NPKS (75 kg N ha^{-1}, 20 kg P ha^{-1}, 45 kg K ha^{-1}, and 18 kg S ha^{-1}), PK (2 kg P, 45 kg K ha^{-1}), and three crops: rape, wheat and bearly. 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. However, the yield of 50 t ha^{-1} compost application was similar to that of 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.

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.

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.

Devi *et al.* (1997) conducted a field trail (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.

Goshal *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 only. 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.

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.

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.

Abedin Miah and Mosleahuddain (1999) conducted a long term fertility trail 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 NPKSZn treatment maintained its superiority both in T-Aman and Aus rice although the performance of NFYM was very close to NPKSZn treatment. In general, the response of T-Aman to S containing treatments showed a decreasing trend over the years. 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.

Singh and Singh (2000) reported that 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. Similar effect was observed in the number of tillers m^{-2} row length. The fresh and dry weight at rice samples from 100% urea application was 102.8 g and 22.1 g, respectively, in sludge-based Jamuna compost at 75 DAS. 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 on par with 100% urea application.

Yamagata (2000) a field experiment to determined 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.

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 at integrated treatments significant increase in plant height, number of effective panicle over the treatment having full nitrogen dose through urea.

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.

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.

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. The yield was comparable to the yield obtained from 40 t ha^{-1} of compost. This indicated that compost might be an appropriate substitute for manure and half of chemical fertilizer needed for soil.

Vijay and Singh (2006) was 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. However, the organic manure compost did not show marked variation among the other treatments.

2.5 Soil fertility and properties for integrated use of fertilizers and manure

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 (IRRI, 1979). 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).

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.

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%), available P (117.3%) and CEC (37.7%).

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.

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. More (1994) reported from 3-years study that application of 25 t ha^{-1} FYM + 20 t ha^{-1} press mud decreased the soil pH and increased organic matter content and available N, P and K in soil. 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.

Nahar *et al.* (1995) had 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.

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.

Nimbiar (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.

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.

Xu *et al.* (1997) observed that application of organic matters affect soil pH value as well as nutrient level. Ravankar *et al.* (1999) reported that organic carbon, total N and available P_2O_5, K_2O, S and Zn in the soil were higher in the plots where nutrients were applied through organics than the inorganic sources.

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.

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.

The literature review discussed above indicates that organic manure can supply a good amount of plant nutrients and thus can contribute to crop yields. 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 January to April 2010 to study the integrated effect of organic manures and nitrogen on yield contributing characters and yield of rice (BRRI dhan29). This chapter includes materials and methods that were used in conducting the experiment. The details are presented below under the following headings -

3.1 Experimental site and soil

The experiment was conducted in typical rice growing clay 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 January to May 2010 have been presented in Appendix I.

3.3 Planting material

BRRI dhan29 was used as the test crop in this experiment. This variety was developed at the Bangladesh Rice Research Institute from the cross between BG 90-2 and BR51-46-5 in 1994. It is recommended for *Boro* season. Average plant height of the variety is 90-95 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 5.5-6.0 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 (2.0-0.02 mm)	18.60
% Silt (0.02-0.002 mm)	45.40
% Clay (<0.002 mm)	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 (%)	0.686
Organic Matter (%)	1.187
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 15 January, 2010 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 Experimental design and layout

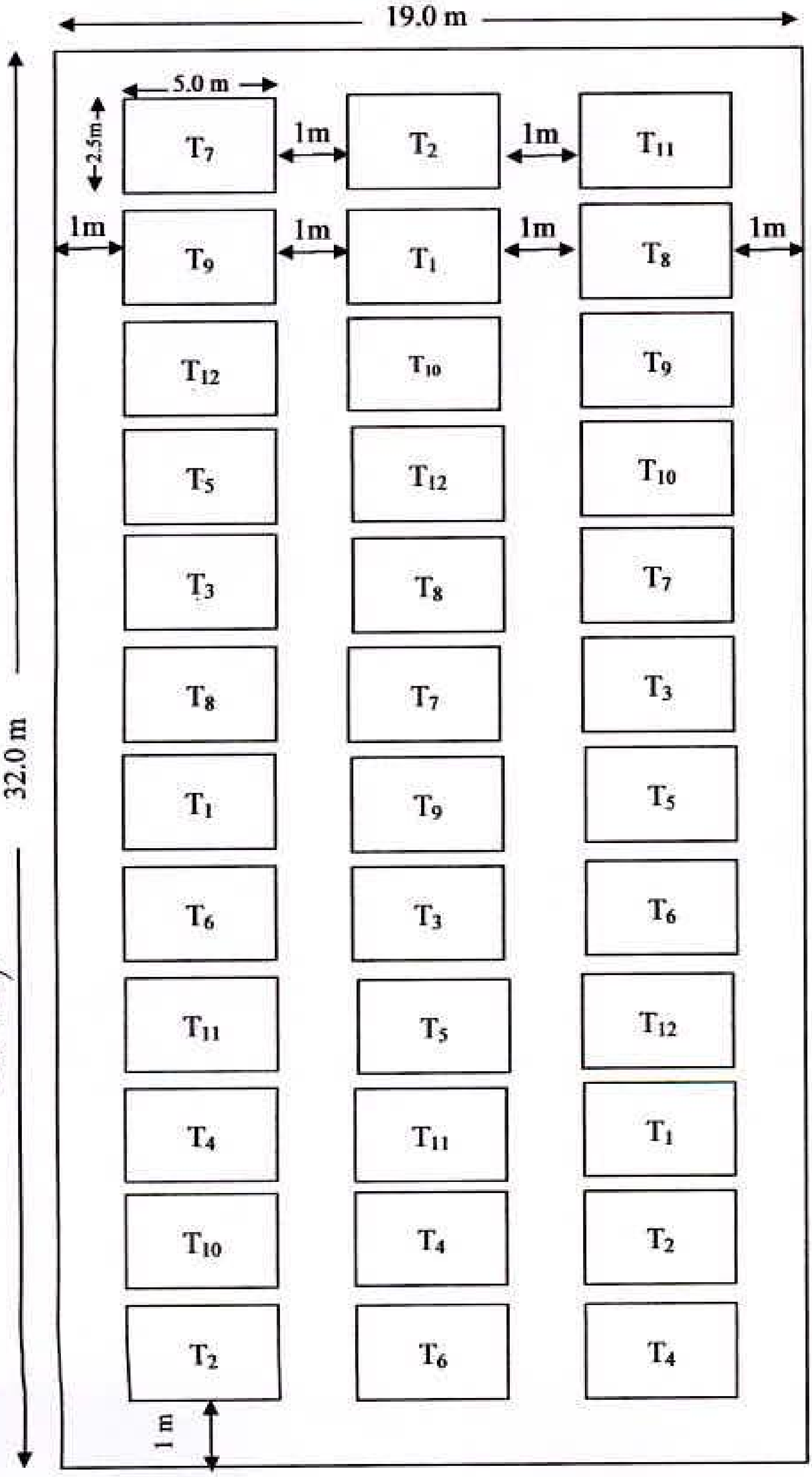
The experiment was laid out in a randomized complete block design (RCBD), where the experimental area was divided into three blocks representing the replications to reduce soil heterogenetic effects. Each block was divided into twelve unit plots as treatments with raised bunds around. Thus the total numbers of plots were 36. The unit plot size was 5 m × 2.5 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.

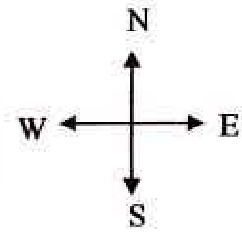
3.6 Initial soil sampling

Before land preparation, initial 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.

3.7 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.





Plot size: 5.0 m × 2.5 m

Plot spacing: 50 cm

Between replication: 1.0 m

T_1: Control condition (No chemical fertilizer, no organic manure)

T_2: 100% recommended N (120 kg N/ha) + recommended P, K, S and Zn)

T_3: 100 kg N from urea + 20 kg N substituted by vermicompost (VC) + P, K, S and Zn

T_4: 100 kg N from urea + 20 kg N substituted by cowdung (CD) + P, K, S and Zn

T_5: 80 kg N from urea + 40 kg N substituted by VC + P, K, S and Zn

T_6: 80 kg N from urea + 40 kg N substituted by CD + P, K, S and Zn

T_7: 60 kg N from urea + 60 kg N substituted by VC + P, K, S and Zn

T_8: 60 kg N from urea + 60 kg N substituted by CD + P, K, S and Zn

T_9: 100 kg N from urea + 20 kg N substituted equally by VC and CD + P, K, S and Zn

T_{10}: 80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn

T_{11}: 60 kg N from urea + 60 kg N substituted equally by VC and CD + P, K, S and Zn

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

Figure 1. Layout of the experimental plot

3.8 Treatments

Sole and integrated use of different types of organic manure (vermicompost and cowdung) and nitrogen fertilizer were used in the study. The experiment consisted of 12 treatments. The treatments were as follows:

T_1: Control condition (No chemical fertilizer, no organic manure)

T_2: 100% recommended N (120 kg N ha^{-1}) + recommended P, K, S and Zn)

T_3: 100 kg N from urea + 20 kg N substituted by vermicompost (VC) + P, K, S and Zn

T_4: 100 kg N from urea + 20 kg N substituted by cowdung (CD) + P, K, S and Zn

T_5: 80 kg N from urea + 40 kg N substituted by VC + P, K, S and Zn

T_6: 80 kg N from urea + 40 kg N substituted by CD + P, K, S and Zn

T_7: 60 kg N from urea + 60 kg N substituted by VC + P, K, S and Zn

T_8: 60 kg N from urea + 60 kg N substituted by CD + P, K, S and Zn

T_9: 100 kg N from urea + 20 kg N substituted equally by VC and CD + P, K, S and Zn

T_{10}: 80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn

T_{11}: 60 kg N from urea + 60 kg N substituted equally by VC and CD + P, K, S and Zn

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

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, cowdung and vermicompost were applied in the plot as per the treatments. Full amounts of TSP, MP, gypsum, zinc, cowdung and vermicompost were applied as basal dose before transplanting of rice seedlings. Urea were applied in 3 equal splits: one third was applied at 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).

3.10 Organic manure incorporation

Two different types of organic manure viz. cowdung and vermicompost were used. Cowdung and vermicompost were applied before four days of final land preparation. Chemical compositions of the manures used have been presented in Table 3.

Table 3. Chemical compositions of cowdung and vermicompost (dry basis)

Sources of organic manure	Nutrient content					
	C (%)	N (%)	P (%)	K (%)	S (%)	C:N
Cowdung	36	1.48	0.45	0.53	0.21	24
Vermicompost	48	1.90	1.20	0.80	0.32	25

3.11 Transplanting

Thirty days old seedlings of BRRI dhan29 were carefully uprooted from the seedling nursery and transplanted on 30 January, 2010 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 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 24 April, 2008. 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 30, 50, 70, 90 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 30, 50, 70 and 90 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 tiller $hill^{-1}$

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

3.14.4 In-effective tiller $hill^{-1}$

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

3.14.5 Total tiller hill^{-1}

The total number of tiller hill^{-1} was counted as the number of effective tiller hill^{-1} and non-effective tiller hill^{-1}. Data on total tiller 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 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 dried in an oven at 70 ^{0}C 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^{0}C and added 2.5 ml 30% H_2O_2 then heated was continued at 180^{0}C 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^{0}C. 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.

3.15.5 Determination of P, K and S from plant samples

3.15.5.1 Phosphorus

Phosphorus was digested from the plant sample (grain and straw) with 0.5 M $NaHCO_3$ solutions, pH 8.5 (Olsen *et al.*, 1954). Phosphorus in the digest was determined by using 1 ml for grain sample and 2 ml for straw sample from 100 ml 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).

3.15.5.2 Potassium

Five milli-liter of digest sample for the grain and 10 ml for the straw were taken and diluted 50 ml volume to make desired concentration so that the absorbance of sample were measured within the range of standard solutions. The absorbance was measured by atomic absorption flame photometer.

3.15.5.3 Sulphur

Sulphur content was determined from the digest of the plant samples (grain and straw) with $CaCl_2$ (0.15%) solution as described by (Page *et al.*, 1982). The digested 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 (Hunter, 1984).

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. These results have been shown in the Table 8. 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^{0}C and added 3 ml H_2O_2 and then heating at 360^{0}C 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 dhan29. 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 determine the integrated effect of organic manures and nitrogen on yield contributing characters and yield of rice (BRRI dhan29). 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 of BRRI dhan29 showed statistically significant variation due to the integrated effect of organic manures and nitrogen at 30, 50, 70, 90 DAT and harvest (Appendix II). At the different days after transplanting (DAT) the highest plant height (23.96 cm, 31.29 cm, 44.23 cm, 66.84 cm and 88.87 cm) was recorded from T_{10} (80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn) which was statistically similar (23.53 cm, 31.07 cm, 44.15 cm, 66.50 cm and 86.01 cm) with T_{11} (60 kg N from urea + 60 kg N substituted equally by VC and CD + P, K, S and Zn) at 30, 50, 70, 90 DAT and harvest, respectively. On the other hand, at the same DAT the lowest plant height (16.47 cm, 21.60 cm, 30.23 cm, 47.13 cm and 61.95 cm) was observed from T_1 as control condition which was closely followed (19.80 cm, 24.91 cm, 39.88 cm, 57.28 cm and 75.81 cm) by T_{12} as 120 kg N substituted equally by VC and CD (Table 4). From the data it was revealed that all the treatments produced significantly taller plants compared to the control treatment. Plant height was significantly influenced by the integrated effect of organic manures and nitrogen reported by Babu *et al.* (2001) earlier from an experiment. Similar results also reported by Rajani Rani *et al.* (2001), Singh *et al.* (1999), Hossain *et al.* (1997) and Sharma and Mitra (1991).

Table 4. Integrated effect of organic manures and nitrogen on plant height of BRRI dhan29

Treatment	Plant height (cm) at				
	30 DAT	50 DAT	70 DAT	90 DAT	at harvest
T_1	16.47 d	21.60 d	30.23 e	47.13 e	61.95 f
T_2	21.70 abc	28.38 abc	41.67 bcd	61.83 bc	82.17 cd
T_3	22.38 abc	29.05 ab	43.04 ab	63.68 abc	84.23 bc
T_4	22.93 ab	29.13 ab	43.33 ab	61.15 c	81.70 cd
T_5	21.73 abc	28.70 ab	42.22 abc	62.73 abc	83.97 bc
T_6	21.53 abc	29.63 ab	42.39 abc	64.10 abc	85.94 ab
T_7	22.87 ab	29.17 ab	43.38 ab	64.43 abc	85.33 abc
T_8	19.27 cd	26.20 bc	40.26 cd	60.75 cd	79.50 d
T_9	22.47 abc	29.53 ab	43.25 ab	65.33 ab	86.80 ab
T_{10}	23.96 a	31.29 a	44.23 a	66.84 a	88.87 a
T_{11}	23.53 a	31.07 a	44.15 a	66.50 a	86.01 ab
T_{12}	19.80 bc	24.91 cd	39.88 d	57.28 d	75.81 e
Significance level	0.01	0.01	0.01	0.01	0.01
$LSD_{(0.05)}$	3.047	3.420	2.092	3.684	3.340
CV(%)	8.35	7.16	5.98	6.52	8.41

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: Control condition (No chemical fertilizer, no organic manure)

T_2: 100% recommended N (120 kg N ha^{-1}) + recommended P, K, S and Zn)

T_3: 100 kg N from urea + 20 kg N substituted by vermicompost (VC) + P, K, S and Zn

T_4: 100 kg N from urea + 20 kg N substituted by cowdung (CD) + P, K, S and Zn

T_5: 80 kg N from urea + 40 kg N substituted by VC + P, K, S and Zn

T_6: 80 kg N from urea + 40 kg N substituted by CD + P, K, S and Zn

T_7: 60 kg N from urea + 60 kg N substituted by VC + P, K, S and Zn

T_8: 60 kg N from urea + 60 kg N substituted by CD + P, K, S and Zn

T_9: 100 kg N from urea + 20 kg N substituted equally by VC and CD + P, K, S and Zn

T_{10}: 80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn

T_{11}: 60 kg N from urea + 60 kg N substituted equally by VC and CD + P, K, S and Zn

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

4.1.2 Number of total tiller hill^{-1}

Number of total tiller hill^{-1} of BRRI dhan29 showed statistically significant variation due to the integrated effect of organic manures and nitrogen at 30, 50, 70 and 90 DAT (Appendix III). At the different days after transplanting (DAT) the maximum number of total tillers hill^{-1} (5.40, 11.17, 20.83 and 17.63) was observed from T_{10} (80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn) which was statistically identical (5.07, 10.87, 20.63 and 17.13) with T_{11} (60 kg N from urea + 60 kg N substituted equally by VC and CD + P, K, S and Zn) at 30, 50, 70 and 90 DAT, respectively (Table 5), again at the same DAT, the minimum number of total tillers hill^{-1} (2.60, 4.67, 10.30 and 7.27) was observed from T_1 as control condition which was closely followed (3.40, 7.27, 15.47 and 11 57) by T_{12} as 120 kg N substituted equally by VC and CD (Table 5). 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 of BRRI dhan29 due to the integrated effect of organic manures and nitrogen (Appendix IV). The maximum number of effective tillers per hill (13.43) was found from T_{10} (80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn) which was statistically identical (12.90, 12.37 and 12.47) with T_{11} (60 kg N from urea + 60 kg N substituted equally by VC and CD + P, K, S and Zn), T_9 (100 kg N from urea + 20 kg N substituted equally by VC and CD + P, K, S and Zn) and T_7 (60 kg N from urea + 60 kg N substituted by VC + P, K, S and Zn), respectively, whereas the minimum number of effective tillers hill^{-1} (5.90) was recorded from T_1 as control condition which was closely followed (9.23) by T_{12} as 120 kg N substituted equally by VC and CD (Table 6). BRRI dhan29 responded significantly better to chemical fertilizers when applied at the recommended doses than the manure. Chander and Pandey (1996) reported a significant increase in effective tillers hill^{-1} due to application of higher doses of nitrogen.

Table 5. Integrated effect of organic manures and nitrogen on number of total tillers $hill^{-1}$ of BRRI dhan29

Treatment	Number of total tillers $hill^{-1}$ at			
	30 DAT	50 DAT	70 DAT	90 DAT
T_1	2.60 f	4.67 d	10.30 f	7.27 e
T_2	4.20 cd	9.20 abc	17.20 cde	13.80 bcd
T_3	4.57 bc	10.33 a	18.67 abcd	15.20 ab
T_4	4.07 cde	9.67 ab	17.73 cde	13.83 bcd
T_5	4.10 cde	9.27 abc	16.57 de	13.50 bcd
T_6	4.57 bc	9.90 ab	18.13 bcd	14.83 abc
T_7	4.60 bc	9.73 ab	19.27 abc	15.10 ab
T_8	3.63 de	7.87 bc	16.43 de	12.13 cd
T_9	4.70 abc	9.90 ab	19.20 abc	15.30 ab
T_{10}	5.40 a	11.17a	20.83 a	17.63 a
T_{11}	5.07 ab	10.87 a	20.63 ab	17.13 a
T_{12}	3.40 e	7.27 c	15.47 e	11.57 d
Significance level	0.01	0.05	0.01	0.01
$LSD_{(0.05)}$	0.696	2.147	2.334	2.528
CV(%)	9.70	13.85	7.86	10.71

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: Control condition (No chemical fertilizer, no organic manure)

T_2: 100% recommended N (120 kg N ha^{-1}) + recommended P, K, S and Zn)

T_3: 100 kg N from urea + 20 kg N substituted by vermicompost (VC) + P, K, S and Zn

T_4: 100 kg N from urea + 20 kg N substituted by cowdung (CD) + P, K, S and Zn

T_5: 80 kg N from urea + 40 kg N substituted by VC + P, K, S and Zn

T_6: 80 kg N from urea + 40 kg N substituted by CD + P, K, S and Zn

T_7: 60 kg N from urea + 60 kg N substituted by VC + P, K, S and Zn

T_8: 60 kg N from urea + 60 kg N substituted by CD + P, K, S and Zn

T_9: 100 kg N from urea + 20 kg N substituted equally by VC and CD + P, K, S and Zn

T_{10}: 80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn

T_{11}: 60 kg N from urea + 60 kg N substituted equally by VC and CD + P, K, S and Zn

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

Table 6. Integrated effect of organic manures and nitrogen on yield contributing characters of BRRI dhan29

Treatment	Number of effective tiller $hill^{-1}$	Number of in-effective tiller $hill^{-1}$	Length of panicle (cm)	Number of filled grain $plant^{-1}$	Number of unfilled grain $plant^{-1}$
T_1	5.90 f	4.33 a	15.28 e	52.63 g	13.53 a
T_2	11.03 cd	3.17 bcd	22.20 bcd	82.70 cde	8.33 ab
T_3	11.77 bcd	3.67 abc	23.05 abcd	84.80 bcd	7.27 b
T_4	10.37 de	3.00 bcde	22.87 abcd	81.40 de	7.93 ab
T_5	11.53 bcd	2.87 cde	22.67 abcd	84.77 bcd	8.50 ab
T_6	11.67 bcd	3.13 bcd	22.75 abcd	87.90 abc	8.17 ab
T_7	12.47 abc	3.33 bcd	22.52 abcd	88.33 abc	7.10 b
T_8	9.27 e	2.60 de	21.14 cd	78.93 ef	9.37 ab
T_9	12.37 abc	3.20 bcd	23.16 abc	88.57 abc	6.47 b
T_{10}	13.43 a	3.93 ab	24.50 a	91.40 a	6.07 b
T_{11}	12.90 ab	3.70 abc	23.66 ab	90.17 ab	7.30 b
T_{12}	9.23 e	2.20 e	21.06 d	73.70 f	9.40 ab
Significance level	0.01	0.01	0.01	0.01	0.01
$LSD_{(0.05)}$	1.504	0.840	1.806	5.248	5.276
CV(%)	8.08	15.22	4.83	7.77	10.15

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: Control condition (No chemical fertilizer, no organic manure)

T_2: 100% recommended N (120 kg N ha^{-1}) + recommended P, K, S and Zn)

T_3: 100 kg N from urea + 20 kg N substituted by vermicompost (VC) + P, K, S and Zn

T_4: 100 kg N from urea + 20 kg N substituted by cowdung (CD) + P, K, S and Zn

T_5: 80 kg N from urea + 40 kg N substituted by VC + P, K, S and Zn

T_6: 80 kg N from urea + 40 kg N substituted by CD + P, K, S and Zn

T_7: 60 kg N from urea + 60 kg N substituted by VC + P, K, S and Zn

T_8: 60 kg N from urea + 60 kg N substituted by CD + P, K, S and Zn

T_9: 100 kg N from urea + 20 kg N substituted equally by VC and CD + P, K, S and Zn

T_{10}: 80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn

T_{11}: 60 kg N from urea + 60 kg N substituted equally by VC and CD + P, K, S and Zn

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

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

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

Number of in-effective tillers hill^{-1} of BRRI dhan29 varied significantly due to the integrated effect of organic manures and nitrogen (Appendix IV). The maximum number of in-effective tillers hill^{-1} (4.33) was obtained from T_1 as control condition and the minimum number of in-effective tillers per hill^{-1} (2.20) was found from T_{12} as 120 kg N substituted equally by VC and CD (Table 6).

4.1.5 Total tillers hill^{-1}

Statistically significant variation was recorded for number of total tillers hill^{-1} of BRRI dhan29 due to the integrated effect of organic manures and nitrogen (Appendix IV). The maximum number of total tillers hill^{-1} (17.37) was observed from T_{10} (80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn) which was statistically identical (16.60, 15.80, 15.57 and 15.43) with T_{11} (60 kg N from urea + 60 kg N substituted equally by VC and CD + P, K, S and Zn), T_7 (60 kg N from urea + 60 kg N substituted by VC + P, K, S and Zn). On the other hand, the minimum (10.23) was obtained from T_1 (control condition) which was followed (11.43) by T_{12} as 120 kg N substituted equally by VC and CD (Figure 2).

4.1.6 Length of panicle

Length of panicle of BRRI dhan29 showed statistically significant variation due to integrated effect of organic manures and nitrogen (Appendix IV). The highest length of panicle (24.50 cm) was recorded from T_{10} (80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn) which was statistically identical (23.66 cm) with T_{11} (60 kg N from urea + 60 kg N substituted equally by VC and CD + P, K, S and Zn), while the lowest length of panicle (15.28 cm) was observed from T_1 as control condition which was followed (21.06 cm) by T_{12} as 120 kg N substituted equally by VC and CD (Table 6). BRRI dhan29 responded significantly better-combined application of 80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn. Haque (1999) and Azim (1996) noted a significant increase in panicle length due to the application of organic manure and chemical fertilizers. Babu *et al.* (2001); Ahmed and Rahman (1991) and Apostol (1989) also reported similar results.

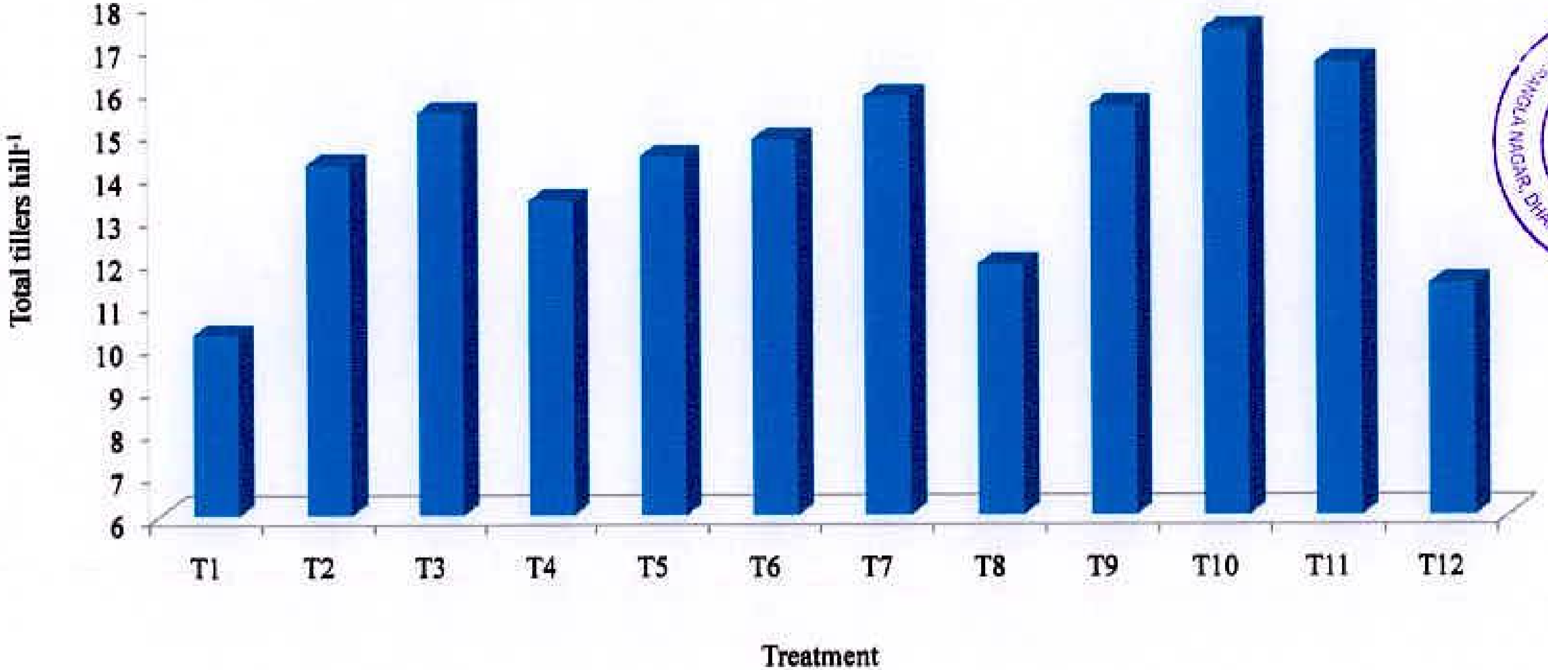


Figure 2. Integrated effect of organic manures and nitrogen on total tillers hill^{-1} of BRRI dhan29

4.1.7 Number of filled grain plant^{-1}

Due to the integrated effect of organic manures and nitrogen statistically significant variation was recorded for number of filled grain plant^{-1} of BRRI dhan29 (Appendix IV). The maximum number of filled grain plant^{-1} (91.40) was found from T_{10} (80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn) which was statistically identical (90.17, 88.57, 88.33 and 87.90) with T_{11} (60 kg N from urea + 60 kg N substituted equally by VC and CD + P, K, S and Zn), T_9 (100 kg N from urea + 20 kg N substituted equally by VC and CD + P, K, S and Zn) and T_7 (60 kg N from urea + 60 kg N substituted by VC + P, K, S and Zn) and T_6 (80 kg N from urea + 40 kg N substituted by CD + P, K, S and Zn), respectively. On the other hand, the minimum (52.63) was recorded from T_1 as control condition which was followed (73.70) by T_{12} as 120 kg N substituted equally by VC and CD (Table 6).

4.1.8 Number of unfilled grain plant^{-1}

Number of unfilled grain plant^{-1} of BRRI dhan29 showed statistically significant variation due to the integrated effect of organic manures and nitrogen (Appendix IV). The maximum number of unfilled grain plant^{-1} (13.53) was recorded from T_1 (control condition) which was statistically similar (9.40) with T_{12} (120 kg N substituted equally by VC and CD). On the other hand, the minimum number of unfilled grain plant^{-1} (6.07) was recorded from T_{10} as 80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn (Table 6).

4.1.9 Number of total grain plant^{-1}

A statistically significant variation was recorded for number of total grain plant^{-1} of BRRI dhan29 due to the integrated effect of organic manures and nitrogen (Appendix IV). The maximum number of total grain plant^{-1} (97.47) was found from T_{10} (80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn) and T_{11} (60 kg N from urea + 60 kg N substituted equally by VC and CD + P, K, S and Zn), whereas the minimum number of total grain plant^{-1} (66.17) was recorded from T_1 as control condition which was closely followed (83.10) by

T_{12} as 120 kg N substituted equally by VC and CD (Figure 3). Grains panicle^{-1} significantly increased due to the application of organic manures and chemical fertilizers (Razzaque, 1996). These results are also in agreement with Hoque (1999) and Azim (1996).

4.1.10 Weight of 1000 Seed

Weight of 1000 seeds of BRRI dhan29 showed statistically significant variation due to the integrated effect of organic manures and nitrogen (Appendix V). The highest weight of 1000 seeds (21.80 g) was found from T_{10} (80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn) which was statistically identical (21.50 g) with T_9 (100 kg N from urea + 20 kg N substituted equally by VC and CD + P, K, S and Zn) and T_{11} (60 kg N from urea + 60 kg N substituted equally by VC and CD + P, K, S and Zn) and T_9 (100 kg N from urea + 20 kg N substituted equally by VC and CD + P, K, S and Zn), while the minimum weight of 1000 seeds (15.50 g) from T_1 as control condition which was closely followed (19.83 g) by T_{12} as 120 kg N substituted equally by VC and CD (Figure 4). Abedin *et al.* (1999) reported that the combined application of organic manure and nitrogen increased the 1000-grain weight of rice.

4.1.11 Grain yield

Due to the integrated effect of organic manures and nitrogen grain yield of BRRI dhan29 showed statistically significant differences (Appendix V). The highest grain yield (6.73 t ha^{-1}) was obtained from T_{10} (80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn) which was statistically identical (6.46 t ha^{-1}) with T_{11} (60 kg N from urea + 60 kg N substituted equally by VC and CD + P, K, S and Zn), while the lowest grain yield (2.16 t ha^{-1}) was found from T_1 as control condition which was followed (4.03 t ha^{-1}) by T_{12} as 120 kg N substituted equally by VC and CD (Table 7). Devivedi and Thakur (2000) reported the grain yield was significantly increased due to application of organic manure and chemical fertilizers.

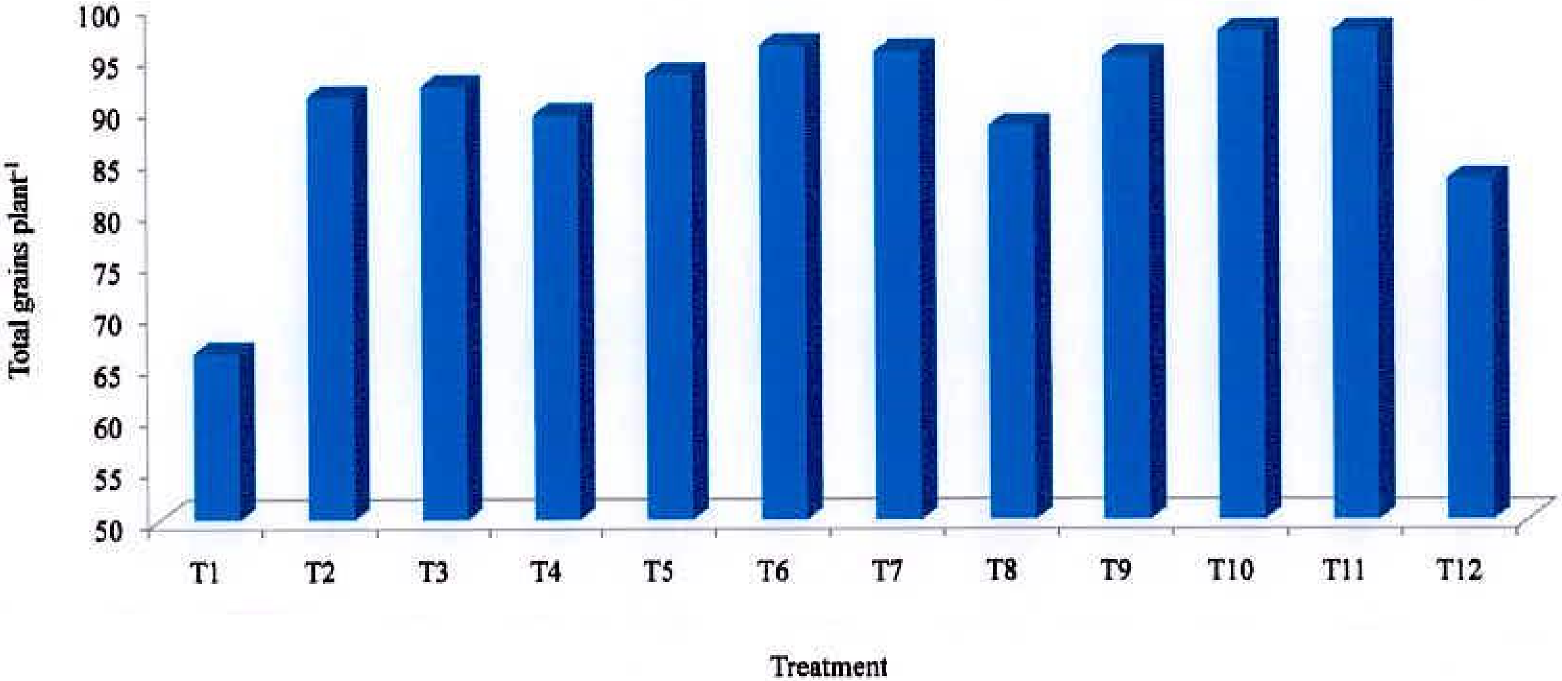


Figure 3. Integrated effect of organic manures and nitrogen on total grains plant^{-1} of BRRI dhan29

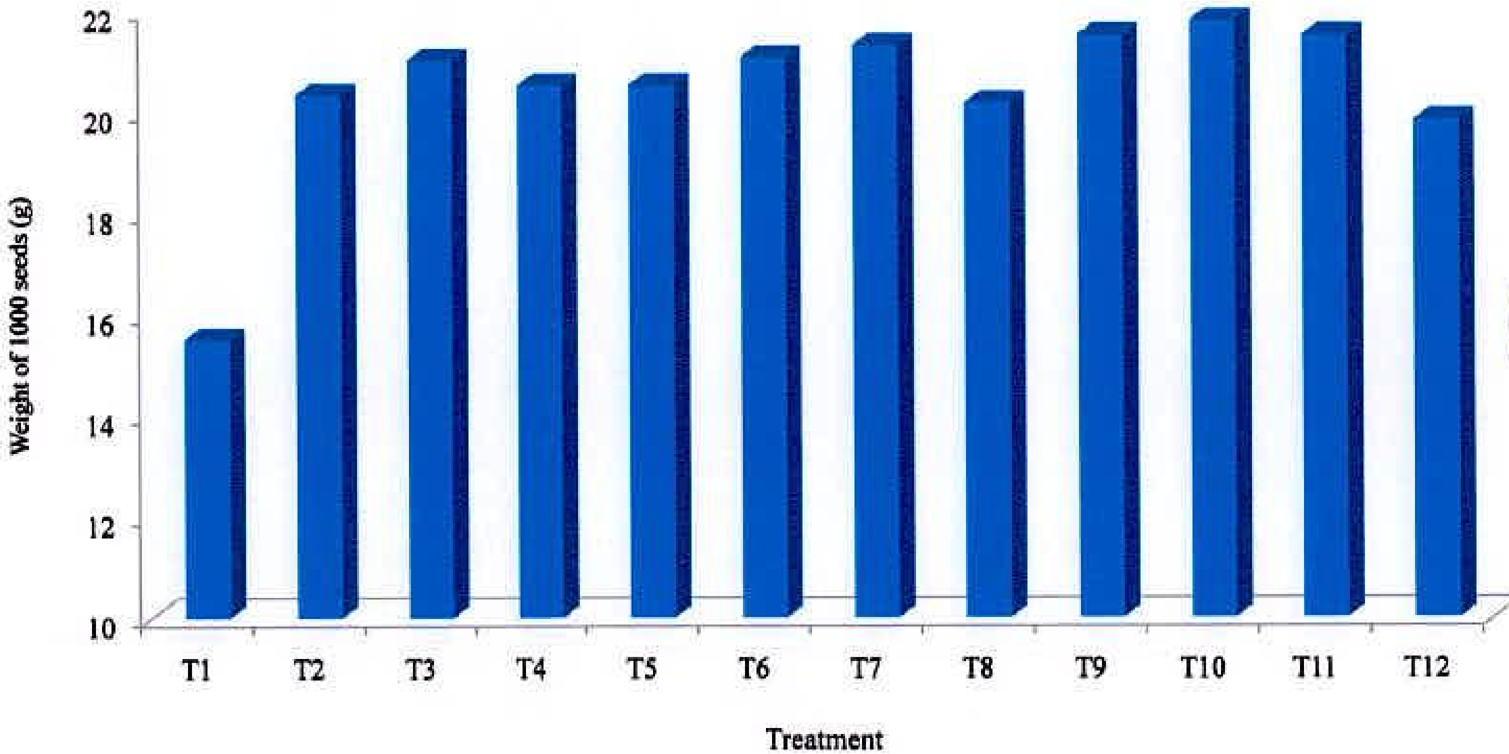


Figure 4. Integrated effect of organic manures and nitrogen on weight of 1000 seeds of BRRI dhan29

Table 7. Integrated effect of organic manures and nitrogen on yield of BRRI dhan29

Treatment	Grain yield ($t\ ha^{-1}$)	Straw yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest index (%)
T_1	2.16 g	4.33 e	6.49 e	33.26 d
T_2	5.00 def	6.04 bcd	11.04 bcd	45.29 bc
T_3	5.67 bcd	6.46 abc	12.13 ab	46.54 ab
T_4	4.26 ef	5.56 cd	9.81 cd	43.29 c
T_5	5.10 cde	6.11 abcd	11.21 bc	45.45 bc
T_6	5.79 abcd	6.93 ab	12.72 ab	45.72 abc
T_7	6.03 abcd	6.69 ab	12.72 ab	47.33 ab
T_8	4.45 ef	5.16 de	9.61 cd	46.22 abc
T_9	6.06 abc	6.78 ab	12.84 ab	47.17 ab
T_{10}	6.73 a	7.10 a	13.83 a	48.67 a
T_{11}	6.46 ab	7.05 a	13.52 a	47.78 ab
T_{12}	4.03 f	5.24 de	9.28 d	43.51 c
Significance level	0.01	0.01	0.01	0.01
$LSD_{(0.05)}$	0.934	0.882	1.714	2.670
CV(%)	10.72	8.50	8.99	5.50

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: Control condition (No chemical fertilizer, no organic manure)

T_2: 100% recommended N (120 kg N ha^{-1}) + recommended P, K, S and Zn)

T_3: 100 kg N from urea + 20 kg N substituted by vermicompost (VC) + P, K, S and Zn

T_4: 100 kg N from urea + 20 kg N substituted by cowdung (CD) + P, K, S and Zn

T_5: 80 kg N from urea + 40 kg N substituted by VC + P, K, S and Zn

T_6: 80 kg N from urea + 40 kg N substituted by CD + P, K, S and Zn

T_7: 60 kg N from urea + 60 kg N substituted by VC + P, K, S and Zn

T_8: 60 kg N from urea + 60 kg N substituted by CD + P, K, S and Zn

T_9: 100 kg N from urea + 20 kg N substituted equally by VC and CD + P, K, S and Zn

T_{10}: 80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn

T_{11}: 60 kg N from urea + 60 kg N substituted equally by VC and CD + P, K, S and Zn

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

4.1.12 Straw yield

Straw yield of BRRI dhan29 varied significantly due to the integrated effect of organic manures and nitrogen (Appendix V). The highest straw yield (7.10 t ha^{-1}) was obtained from T_{10} (80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn) which was statistically identical (7.05 t ha^{-1}) with T_{11} (60 kg N from urea + 60 kg N substituted equally by VC and CD + P, K, S and Zn). On the other hand, the lowest straw yield (4.33 t ha^{-1}) was found from T_1 as control condition which was followed (5.24 t ha^{-1}) by T_{12} as 120 kg N substituted equally by VC and CD (Table 7). 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) and Khan (1998). It is clear that organic manure in combination with nitrogen encouraged vegetative growth of plants and thereby increasing straw yield.

4.1.13 Biological yield

Biological yield of BRRI dhan29 showed statistically significant variation due to the integrated effect of organic manures and nitrogen (Appendix V). The highest biological yield (13.83 t ha^{-1}) was recorded from T_{10} (80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn) which was statistically identical (13.52 t ha^{-1}) with T_{11} (60 kg N from urea + 60 kg N substituted equally by VC and CD + P, K, S and Zn). On the other hand, the lowest biological yield (6.49 t ha^{-1}) was obtained from T_1 which was followed (9.28 t ha^{-1}) by T_{12} as 120 kg N substituted equally by VC and CD (Table 7).

4.1.14 Harvest index

Harvest index of BRRI dhan29 showed significant variation due to the integrated effect of organic manures and nitrogen (Appendix V). The highest harvest index (48.67%) was found from T_{10} (80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn) which was statistically identical (47.78%) with T_{11} (60 kg N from urea + 60 kg N substituted equally by VC and CD + P, K, S and Zn) and the lowest (33.26%) from T_1 as control condition (Table 7).

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 of BRRI dhan29 due to the integrated effect of organic manures and nitrogen (Appendix VI). The lowest N concentration in grain (0.566%) was recorded from T_{10} as 80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn and the highest N concentration in grain (0.759%) was observed from T_1 control condition which was statistically identical (0.717%) with T_{12} (120 kg N substituted equally by VC and CD), while (Table 8).

4.2.2 P concentration in grain

P concentration in grain of BRRI dhan29 showed statistically significant variation due to the integrated effect of organic manures and nitrogen (Appendix VI). The lowest P concentration in grain (0.201%) was recorded from T_{10} (80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn); whereas the highest P concentration in grain (0.293%) was found from T_1 as control condition which was statistically similar (0.284%) with T_{12} as 120 kg N substituted equally by VC and CD (Table 8). An increase in P contents both in rice grain and straw due to the application of poultry manure and chemical fertilizers was reported by many investigators (Razzaque, 1996; Azim, 1999 and Hoque, 1999).

4.2.3 K concentration in grain

K concentration in grain of BRRI dhan29 differs significantly due to the integrated effect of organic manures and nitrogen (Appendix VI). The lowest K concentration in grain (0.265%) was obtained from T_{10} (80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn) again, the highest K concentration in grain (0.358%) was observed from T_1 as control condition which was statistically similar (0.344%) by T_{12} as 120 kg N substituted equally by VC and CD (Table 8). Singh *et al.* (2001) also revealed that Potassium content in grain and straw were increased due to combined application of organic manure and chemical fertilizers.

Table 8. Integrated effect of organic manures and nitrogen on N, P, K and S concentrations in grain of BRRI dhan29

Treatment	Concentration (%) in grain			
	N	P	K	S
T_1	0.759 a	0.293 a	0.358 a	0.126 ab
T_2	0.682 bc	0.255 b	0.315 cde	0.109 bcd
T_3	0.639 c	0.235 cd	0.296 f	0.098 d
T_4	0.700 b	0.265 b	0.326 bc	0.111 abcd
T_5	0.688 bc	0.262 b	0.315 cde	0.109 bcd
T_6	0.668 bc	0.250 bc	0.322 cd	0.108 bcd
T_7	0.637 c	0.237 cd	0.304 def	0.106 cd
T_8	0.700 b	0.285 a	0.331 bc	0.118 abc
T_9	0.657 bc	0.215 ef	0.301 ef	0.104 cd
T_{10}	0.566 d	0.201 f	0.265 g	0.075 e
T_{11}	0.681 bc	0.227 de	0.304 def	0.108 bcd
T_{12}	0.717 ab	0.284 a	0.344 ab	0.129 a
Significance level	0.01	0.01	0.01	0.01
$LSD_{(0.05)}$	0.054	0.017	0.017	0.017
CV(%)	7.08	6.29	8.47	6.93

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: Control condition (No chemical fertilizer, no organic manure)

T_2: 100% recommended N (120 kg N ha^{-1}) + recommended P, K, S and Zn)

T_3: 100 kg N from urea + 20 kg N substituted by vermicompost (VC) + P, K, S and Zn

T_4: 100 kg N from urea + 20 kg N substituted by cowdung (CD) + P, K, S and Zn

T_5: 80 kg N from urea + 40 kg N substituted by VC + P, K, S and Zn

T_6: 80 kg N from urea + 40 kg N substituted by CD + P, K, S and Zn

T_7: 60 kg N from urea + 60 kg N substituted by VC + P, K, S and Zn

T_8: 60 kg N from urea + 60 kg N substituted by CD + P, K, S and Zn

T_9: 100 kg N from urea + 20 kg N substituted equally by VC and CD + P, K, S and Zn

T_{10}: 80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn

T_{11}: 60 kg N from urea + 60 kg N substituted equally by VC and CD + P, K, S and Zn

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

4.2.4 S concentration in grain

Due to the integrated effect of organic manures and nitrogen S concentration in grain of BRRI dhan29 showed statistically significant differences (Appendix VI). The lowest S concentration in grain (0.075%) was recorded from T_{10} (80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn), while the highest S concentration in grain (0.129%) was recorded from T_{12} as 120 kg N substituted equally by VC and CD (Table 8).

4.2.5 N concentration in straw

Statistically significant variation was recorded for N concentration in straw of BRRI dhan29 due to the integrated effect of organic manures and nitrogen (Appendix VII). The lowest N concentration in straw (0.332%) was found from T_{10} (80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn) and the highest N concentration in straw (0.506%) was obtained from T_1 as control condition which was closely followed (0.501%) by T_{12} as 120 kg N substituted equally by VC and CD (Table 9).

4.2.6 P concentration in straw

P concentration in straw of BRRI dhan29 showed statistically significant variation due to the integrated effect of organic manures and nitrogen (Appendix VII). The lowest P concentration in straw (0.051%) was found from T_{10} (80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn), whereas the highest (0.087%) from T_1 as control condition which was statistically identical (0.084%) with T_{12} as 120 kg N substituted equally by VC and CD (Table 9).

4.2.7 K concentration in straw

Due to the integrated effect of organic manures and nitrogen K concentration in straw of BRRI dhan29 varied significantly (Appendix VII). The lowest K concentration in straw (0.778%) was recorded from T_{10} (80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn), again the highest (1.175%) was found from T_1 which was statistically identical (1.149%) by T_{12} as 120 kg N substituted equally by VC and CD (Table 9).

Table 9. Integrated effect of organic manures and nitrogen on N, P, K and S concentrations in straw of BRRI dhan29

Treatment	Concentration (%) in straw			
	N	P	K	S
T_1	0.506 a	0.087 a	1.175 a	0.098 a
T_2	0.442 c	0.073 abc	1.084 abc	0.083 ab
T_3	0.404 d	0.064 cd	0.969 c	0.074 bc
T_4	0.470 b	0.078 abc	1.140 ab	0.087 ab
T_5	0.444 c	0.074 abc	1.137 ab	0.088 ab
T_6	0.446 c	0.068 bcd	1.070 abc	0.079 ab
T_7	0.409 d	0.067 bcd	1.030 bc	0.076 bc
T_8	0.489 a	0.078 abc	1.154 ab	0.089 ab
T_9	0.401 d	0.064 cd	0.991 c	0.073 bc
T_{10}	0.332 e	0.051 d	0.778 d	0.058 c
T_{11}	0.413 d	0.065 bcd	1.043 abc	0.076 bc
T_{12}	0.501 a	0.084 ab	1.149 ab	0.091 ab
Significance level	0.01	0.01	0.01	0.01
$LSD_{(0.05)}$	0.017	0.017	0.120	0.017
CV(%)	5.93	8.24	6.52	5.58

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: Control condition (No chemical fertilizer, no organic manure)

T_2: 100% recommended N (120 kg N ha^{-1}) + recommended P, K, S and Zn)

T_3: 100 kg N from urea + 20 kg N substituted by vermicompost (VC) + P, K, S and Zn

T_4: 100 kg N from urea + 20 kg N substituted by cowdung (CD) + P, K, S and Zn

T_5: 80 kg N from urea + 40 kg N substituted by VC + P, K, S and Zn

T_6: 80 kg N from urea + 40 kg N substituted by CD + P, K, S and Zn

T_7: 60 kg N from urea + 60 kg N substituted by VC + P, K, S and Zn

T_8: 60 kg N from urea + 60 kg N substituted by CD + P, K, S and Zn

T_9: 100 kg N from urea + 20 kg N substituted equally by VC and CD + P, K, S and Zn

T_{10}: 80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn

T_{11}: 60 kg N from urea + 60 kg N substituted equally by VC and CD + P, K, S and Zn

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

4.2.8 S concentration in straw

S concentration in straw of BRRI dhan29 showed statistically significant variation due to the integrated effect of organic manures and nitrogen (Appendix VII). The lowest S concentration in straw (0.058%) was obtained from T_{10} (80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn), whereas the highest S concentration in straw (0.098%) was found from T_1 as control condition which was closely followed (0.091%) by T_{12} as 120 kg N substituted equally by VC and CD (Table 9).

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 of BRRI dhan29 due to the integrated effect of organic manures and nitrogen (Appendix VIII). The highest N uptake by grain (43.99 kg ha^{-1}) was recorded from T_{11} (60 kg N from urea + 60 kg N substituted equally by VC and CD + P, K, S and Zn). On the other hand, the lowest N uptake by grain (16.38 kg ha^{-1}) was recorded from T_1 as control condition which was followed (28.91 kg ha^{-1}) by T_{12} as 120 kg N substituted equally by VC and CD (Table 10). Sengar *et al.* (2000) reported that the N uptake by rice grain and straw increased significantly with the combined application of organic manure and chemical fertilizers. Rahman (2001); Duhan *et al.* (2002); Azim (1999) and Hoque (1999) also reported similar results.

4.3.2 P uptake by grain

P uptake by grain of BRRI dhan29 showed statistically significant variation due to the integrated effect of organic manures and nitrogen (Appendix VIII). The highest P uptake by grain (14.63 kg ha^{-1}) was observed from T_{11} (60 kg N from urea + 60 kg N substituted equally by VC and CD + P, K, S and Zn), while the lowest P uptake by grain (6.32 kg ha^{-1}) was observed from T_1 as control condition which was followed (11.46 kg ha^{-1}) by T_{12} as 120 kg N substituted equally by VC and CD (Table 10). Sengar *et al.* (2000) observed that the highest P uptake by rice grain was recorded with the combined application of organic manure and phosphatic fertilizers.

Table 10. Integrated effect of organic manures and nitrogen on N, P, K and S uptake by grain of BRRI dhan29

Treatment	Uptake by grain (kg ha^{-1})			
	N	P	K	S
T_1	16.38 e	6.32 c	7.72 g	2.72 e
T_2	34.10 bcd	12.76 ab	15.77 def	5.44 bcd
T_3	35.75 bc	13.11 ab	16.48 bcde	5.39 bcd
T_4	29.78 cd	11.25 b	13.86 f	4.73 d
T_5	35.10 bcd	13.36 ab	16.02 cdef	5.58 bcd
T_6	38.70 ab	14.45 a	18.68 ab	6.30 abc
T_7	38.44 ab	14.38 a	18.35 abc	6.42 ab
T_8	31.14 cd	12.67 ab	14.70 ef	5.23 cd
T_9	39.88 ab	13.00 ab	18.23 abcd	6.31 abc
T_{10}	38.13 ab	13.51 ab	17.87 abcd	5.05 d
T_{11}	43.99 a	14.63 a	19.66 a	6.96 a
T_{12}	28.91 d	11.46 b	13.87 f	5.19 d
Significance level	0.01	0.01	0.01	0.01
$LSD_{(0.05)}$	5.899	2.197	2.272	0.977
CV(%)	10.19	10.32	8.42	10.59

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: Control condition (No chemical fertilizer, no organic manure)

T_2: 100% recommended N (120 kg N ha^{-1}) + recommended P, K, S and Zn)

T_3: 100 kg N from urea + 20 kg N substituted by vermicompost (VC) + P, K, S and Zn

T_4: 100 kg N from urea + 20 kg N substituted by cowdung (CD) + P, K, S and Zn

T_5: 80 kg N from urea + 40 kg N substituted by VC + P, K, S and Zn

T_6: 80 kg N from urea + 40 kg N substituted by CD + P, K, S and Zn

T_7: 60 kg N from urea + 60 kg N substituted by VC + P, K, S and Zn

T_8: 60 kg N from urea + 60 kg N substituted by CD + P, K, S and Zn

T_9: 100 kg N from urea + 20 kg N substituted equally by VC and CD + P, K, S and Zn

T_{10}: 80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn

T_{11}: 60 kg N from urea + 60 kg N substituted equally by VC and CD + P, K, S and Zn

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

4.3.3 K uptake by grain

Due to the integrated effect of organic manures and nitrogen K uptake by grain of BRRI dhan29 showed statistically significant differences (Appendix VIII). The highest K uptake by grain (19.66 kg ha^{-1}) was found from T_{11} (60 kg N from urea + 60 kg N substituted equally by VC and CD + P, K, S and Zn), whereas the lowest K uptake by grain (7.72 kg ha^{-1}) was observed from T_1 as control condition which was followed (13.87 kg ha^{-1}) by T_{12} as 120 kg N substituted equally by VC and CD (Table 10). Sengar *et al.* (2000) 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), Cassman (1995), Azim (1996) and Hoque (1999).

4.3.4 S uptake by grain

S uptake by grain of BRRI dhan29 showed statistically significant variation due to the integrated effect of organic manures and nitrogen (Appendix VIII). The highest S uptake by grain (6.96 kg ha^{-1}) was obtained from T_{11} (60 kg N from urea + 60 kg N substituted equally by VC and CD + P, K, S and Zn), the lowest S uptake by grain (2.72 kg ha^{-1}) was observed from T_1 as control condition which was closely followed (5.19 kg ha^{-1}) by T_{12} as 120 kg N substituted equally by VC and CD (Table 10). Poongothai *et al.* (1999) observed that application of sulphur enhanced significantly S uptake by rice. 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 Sengar *et al.* (2000) and Rahman (2001).

4.3.5 N uptake by straw

N uptake by straw of BRRI dhan29 showed statistically significant variation due to the integrated effect of organic manures and nitrogen (Appendix IX). The highest N uptake by straw (30.87 kg ha^{-1}) was recorded from T_6 (80 kg N from urea + 40 kg N substituted by CD + P, K, S and Zn) and the lowest N uptake by straw (21.85 kg ha^{-1}) was observed from T_1 as control condition (Table 11).

Table 11. Integrated effect of organic manures and nitrogen on N, P, K and S uptake by straw of BRRI dhan29

Treatment	Uptake by straw (kg ha^{-1})			
	N	P	K	S
T_1	21.85 d	3.77 bc	50.76 d	4.24 cd
T_2	26.69 bc	4.39 abc	65.48 abc	5.04 ab
T_3	25.82 bc	4.07 abc	61.80 bc	4.69 abcd
T_4	26.10 bc	4.31 abc	63.38 abc	4.82 abcd
T_5	27.19 abc	4.53 ab	69.54 ab	5.37 ab
T_6	30.87 a	4.72 a	73.98 a	5.48 a
T_7	27.38 abc	4.51 ab	68.92 ab	5.06 ab
T_8	25.22 bcd	4.00 abc	59.55 bcd	4.59 bcd
T_9	27.19 abc	4.34 abc	67.24 ab	4.95 abc
T_{10}	23.72 cd	3.65 a	55.21 cd	4.12 d
T_{11}	29.07 ab	4.55 ab	73.51 a	5.38 ab
T_{12}	26.28 bc	4.40 abc	60.38 bcd	4.77 abcd
Significance level	0.01	0.05	0.01	0.01
$LSD_{(0.05)}$	3.541	0.694	9.893	0.694
CV(%)	7.90	9.60	9.11	8.41

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: Control condition (No chemical fertilizer, no organic manure)

T_2: 100% recommended N (120 kg N ha^{-1}) + recommended P, K, S and Zn)

T_3: 100 kg N from urea + 20 kg N substituted by vermicompost (VC) + P, K, S and Zn

T_4: 100 kg N from urea + 20 kg N substituted by cowdung (CD) + P, K, S and Zn

T_5: 80 kg N from urea + 40 kg N substituted by VC + P, K, S and Zn

T_6: 80 kg N from urea + 40 kg N substituted by CD + P, K, S and Zn

T_7: 60 kg N from urea + 60 kg N substituted by VC + P, K, S and Zn

T_8: 60 kg N from urea + 60 kg N substituted by CD + P, K, S and Zn

T_9: 100 kg N from urea + 20 kg N substituted equally by VC and CD + P, K, S and Zn

T_{10}: 80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn

T_{11}: 60 kg N from urea + 60 kg N substituted equally by VC and CD + P, K, S and Zn

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

4.3.6 P uptake by straw

Statistically significant variation was recorded for P uptake by straw of BRRI dhan29 due to the integrated effect of organic manures and nitrogen (Appendix IX). The highest P uptake by straw (4.72 kg ha^{-1}) was found from T_6 (80 kg N from urea + 40 kg N substituted by CD + P, K, S and Zn) which was statistically identical (3.65 kg ha^{-1}) with T_{10} (80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn), whereas the lowest P uptake by straw (3.77 kg ha^{-1}) was observed from T_1 as control condition (Table 11).

4.3.7 K uptake by straw

K uptake by straw of BRRI dhan29 showed statistically significant variation due to the integrated effect of organic manures and nitrogen (Appendix IX). The highest K uptake by straw (73.98 kg ha^{-1}) was recorded from T_6 (80 kg N from urea + 40 kg N substituted by CD + P, K, S and Zn) which was statistically identical (73.51 kg ha^{-1}) with T_{11} (60 kg N from urea + 60 kg N substituted equally by VC and CD + P, K, S and Zn). On the other hand, the lowest K uptake by straw (50.76 kg ha^{-1}) was found from T_1 as control condition (Table 11).

4.3.8 S uptake by straw

S uptake by straw of BRRI dhan29 showed statistically significant variation due to the integrated effect of organic manures and nitrogen (Appendix IX). The highest S uptake by straw (5.48 kg ha^{-1}) was observed from T_6 (80 kg N from urea + 40 kg N substituted by CD + P, K, S and Zn), while the lowest S uptake by straw (4.12 kg ha^{-1}) was observed from T_{10} as 80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn (Table 11).

4.4 pH, organic matter and NPKS in post harvest soil

4.4.1 pH

Statistically significant variation was recorded for pH in post harvest soil due to the integrated effect of organic manures and nitrogen in BRRI dhan29 (Appendix X). The highest pH of post harvest soil (6.47) was found from T_{12} as 120 kg N substituted equally by VC and CD and the lowest pH in post harvest soil (5.67) was recorded from T_7 as 60 kg N from urea + 60 kg N substituted by VC + P, K, S and Zn (Figure 5). 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), Khan (1998) and Swarup and Singh (1994).

4.4.2 Organic matter

Organic matter in post harvest soil showed statistically significant differences due to the integrated effect of organic manures and nitrogen in BRRI dhan29 (Appendix X). The highest organic matter in post harvest soil (1.533%) was recorded from T_9 (100 kg N from urea + 20 kg N substituted equally by VC and CD + P, K, S and Zn) and the lowest organic matter in post harvest soil (1.110%) was observed from T_7 as 60 kg N from urea + 60 kg N substituted by VC + P, K, S and Zn (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 Haque *et al.* (2001); Mathew and Nair (1997); Azim (1999) and Hoque (1999).

4.4.3 Total Nitrogen

Total nitrogen in post harvest soil showed statistically significant differences due to the integrated effect of organic manures and nitrogen in BRRI dhan29 (Appendix X). The highest total nitrogen in post harvest soil (0.054%) was recorded from T_1 control condition which was statistically identical (0.053%) with T_{12} as 120 kg N substituted equally by VC and CD. On the other hand, the lowest total nitrogen in post harvest soil (0.024%) was obtained from T_{10} as 80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn (Table 12). Several workers reported that organic manure had a positive influenced on total and available N content of soil. Similar were also observed by Razzaque (1996) and Azim (1999).

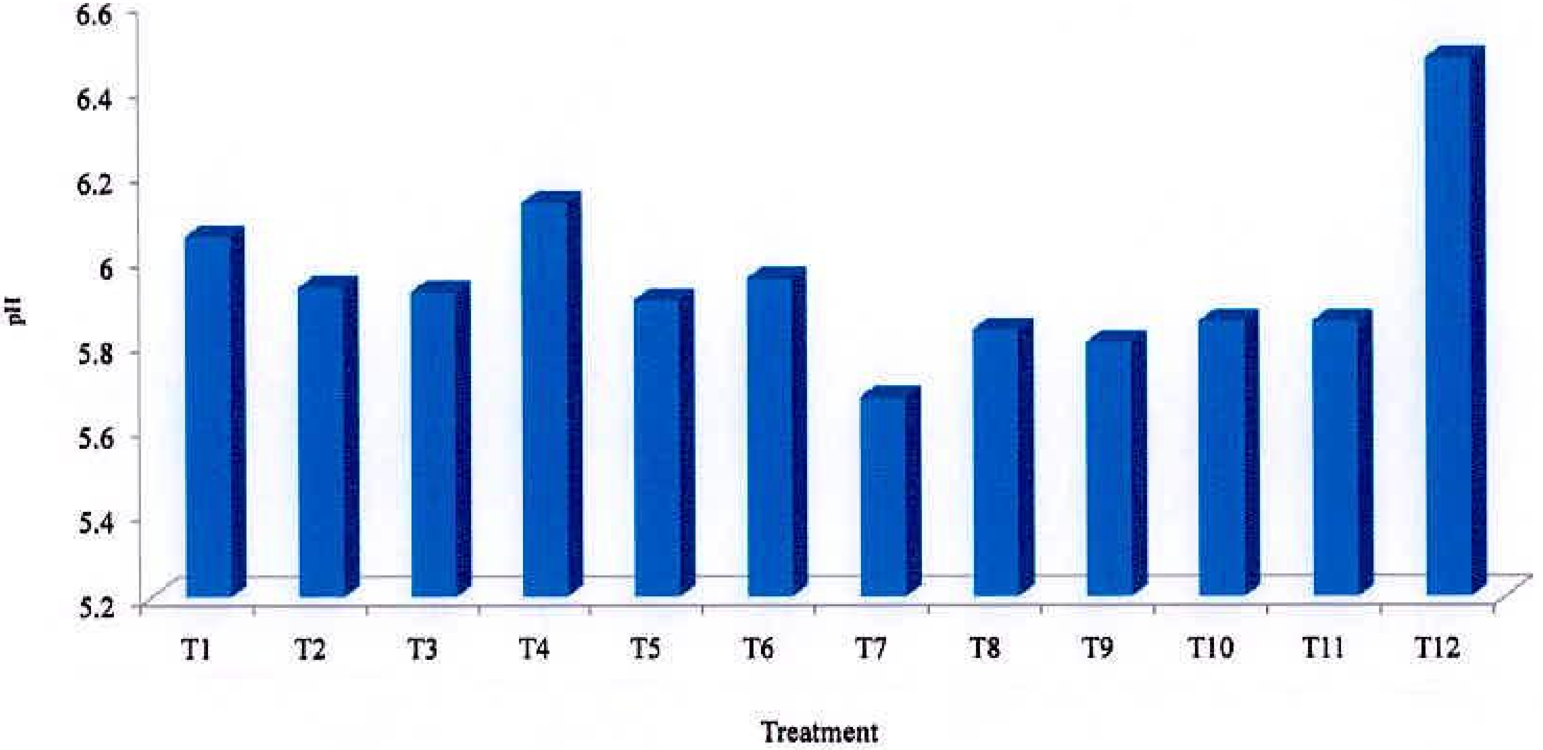


Figure 5. Integrated effect of organic manures and nitrogen on pH in post harvest soil

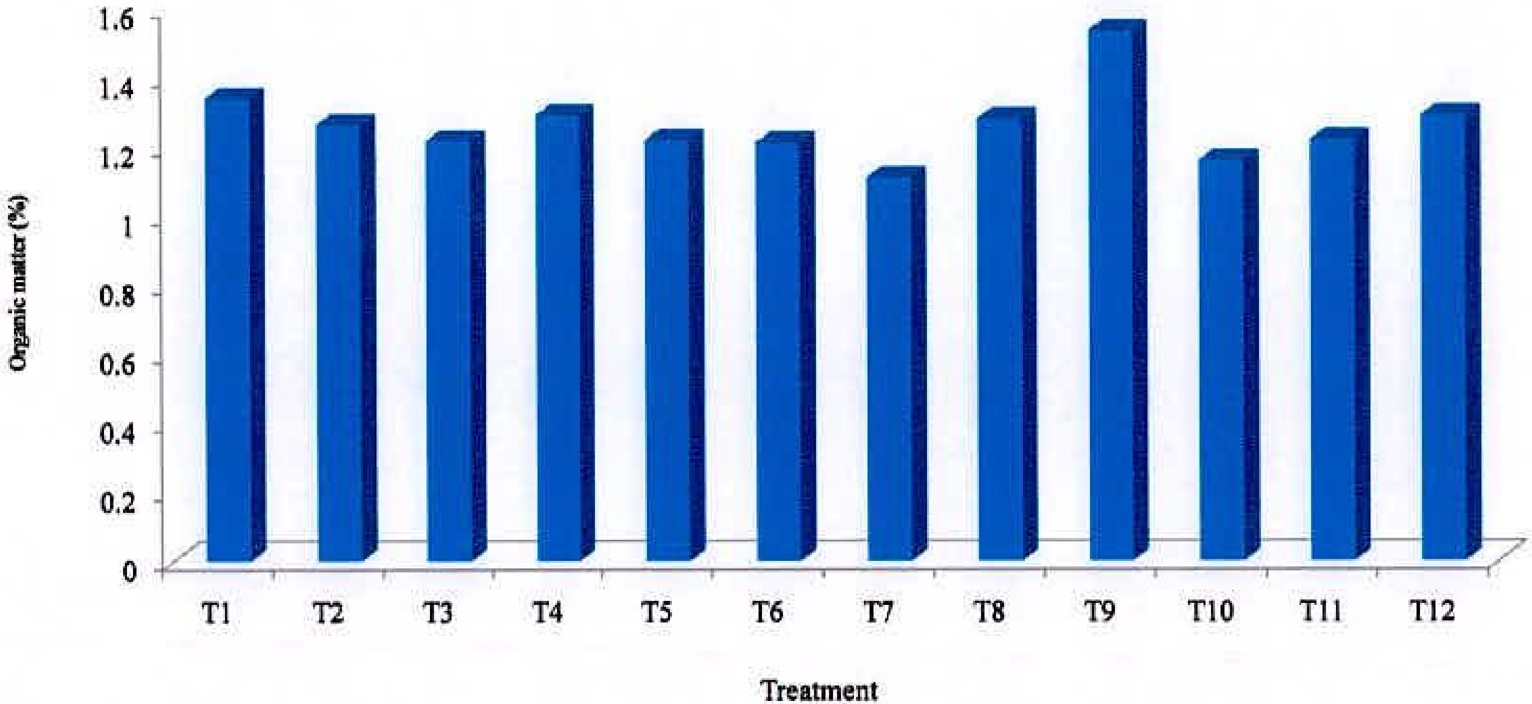


Figure 6. Integrated effect of organic manures and nitrogen on organic matter content in post harvest soil

Table 12. Integrated effect of organic manures and nitrogen on the nutrient content of post harvest soil

Treatment	Total N (%)	Available P (ppm)	Exchangeable K (me %)	Available S (ppm)
T_1	0.054 a	25.53 ab	0.166 a	20.69 a
T_2	0.044 ab	23.57 abcd	0.146 bcd	17.79 bcd
T_3	0.036 abc	22.03 cde	0.129 d	15.84 d
T_4	0.050 ab	24.98 abc	0.156 ab	18.93 ab
T_5	0.046 ab	24.05 abcd	0.154 ab	18.00 bcd
T_6	0.040 abc	23.66 abcd	0.141 bcd	17.44 bcd
T_7	0.038 abc	22.48 bcd	0.132 cd	16.30 cd
T_8	0.048 ab	23.89 abcd	0.151 abc	18.89 abc
T_9	0.032 bc	21.09 de	0.128 d	16.05 d
T_{10}	0.024 c	19.42 e	0.103 e	12.45 e
T_{11}	0.041 abc	23.26 abcd	0.135 cd	17.43 bcd
T_{12}	0.053 a	25.58 a	0.158 ab	19.86 ab
Significance level	0.01	0.01	0.01	0.01
$LSD_{(0.05)}$	0.017	2.674	0.017	2.316
CV(%)	9.95	6.78	5.74	7.83

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: Control condition (No chemical fertilizer, no organic manure)

T_2: 100% recommended N (120 kg N ha^{-1}) + recommended P, K, S and Zn)

T_3: 100 kg N from urea + 20 kg N substituted by vermicompost (VC) + P, K, S and Zn

T_4: 100 kg N from urea + 20 kg N substituted by cowdung (CD) + P, K, S and Zn

T_5: 80 kg N from urea + 40 kg N substituted by VC + P, K, S and Zn

T_6: 80 kg N from urea + 40 kg N substituted by CD + P, K, S and Zn

T_7: 60 kg N from urea + 60 kg N substituted by VC + P, K, S and Zn

T_8: 60 kg N from urea + 60 kg N substituted by CD + P, K, S and Zn

T_9: 100 kg N from urea + 20 kg N substituted equally by VC and CD + P, K, S and Zn

T_{10}: 80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn

T_{11}: 60 kg N from urea + 60 kg N substituted equally by VC and CD + P, K, S and Zn

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

4.4.4 Available phosphorus

Available phosphorus in post harvest soil showed statistically significant differences due to the integrated effect of organic manures and nitrogen in BRRI dhan29 (Appendix X). The highest available phosphorus in post harvest soil (25.58 ppm) was recorded from T_{12} (120 kg N substituted equally by VC and CD) which was statistically identical (25.53 ppm) with T_1 control condition, again the lowest available phosphorus in post harvest soil (19.42 ppm) was found from T_{10} as 80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn (Table 12). Similar results were also found by Zhang *et al.* (1996); Mathew and Nair (1997); Hoque (1999) and Azim (1999).

4.4.5 Exchangeable potassium

Due to the integrated effect of organic manures and nitrogen in BRRI dhan29 exchangeable potassium in post harvest soil showed statistically significant differences (Appendix X). The highest exchangeable potassium in post harvest soil (0.166 me%) was recorded from T_1 control condition which was statistically identical (0.158 me%) with T_{12} as 120 kg N substituted equally by VC and CD. On the other hand, the lowest exchangeable potassium in post harvest soil (0.103 me%) was observed from T_{10} as 80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn (Table 12).

4.4.6 Available sulphur

Available sulphur in post harvest soil showed statistically significant differences due to the integrated effect of organic manures and nitrogen in BRRI dhan29 (Appendix X). The highest available sulphur in post harvest soil (20.69 ppm) was obtained from T_1 control condition which was statistically identical (19.86 ppm) with T_{12} as 120 kg N substituted equally by VC and CD, while the lowest available sulphur in post harvest soil (12.45 ppm) was observed from T_{10} as 80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn (Table 12). Shahidduzaman (1997) also found that the application of organic manure increase available S content in soil compared to application of chemicals fertilizers. Similar results were obtained by Hoque (1999) and Azim (1999).

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from January to April 2010 to study the integrated effect of organic manures and nitrogen on yield contributing characters and yield of rice (BRRI dhan29). Sole and integrated use of different types of organic manure (vermicompost and cowdung) and nitrogen fertilizer were used in the study. The experiment consisted of 12 treatments. The treatments will be; T_1: Control condition (No chemical fertilizer, no organic manure); T_2: 100% recommended N (120 kg N ha^{-1}) + recommended P, K, S and Zn); T_3: 100 kg N from urea + 20 kg N substituted by vermicompost (VC) + P, K, S and Zn; T_4: 100 kg N from urea + 20 kg N substituted by cowdung (CD) + P, K, S and Zn; T_5: 80 kg N from urea + 40 kg N substituted by VC + P, K, S and Zn; T_6: 80 kg N from urea + 40 kg N substituted by CD + P, K, S and Zn; T_7: 60 kg N from urea + 60 kg N substituted by VC + P, K, S and Zn; T_8: 60 kg N from urea + 60 kg N substituted by CD + P, K, S and Zn; T_9: 100 kg N from urea + 20 kg N substituted equally by VC and CD + P, K, S and Zn; T_{10}: 80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn; T_{11}: 60 kg N from urea + 60 kg N substituted equally by VC and CD + P, K, S and Zn and T_{12}: 120 kg N substituted equally by VC and CD. Data on different growth parameter & yield, nutrient content in grain & straw, nutrient uptake by grain & straw and characteristics of post harvest soil was recorded.

At 30, 50, 70, 90 DAT and harvest, the highest plant height (23.96 cm, 31.29 cm, 44.23 cm, 66.84 cm and 88.87 cm) was recorded from T_{10} and at the same DAT the lowest plant height (16.47 cm, 21.60 cm, 30.23 cm, 47.13 cm and 61.95 cm) was observed from T_1 as control condition. At 30, 50, 70 and 90 DAT, the maximum number of total tillers $hill^{-1}$ (5.40, 11.17, 20.83 and 17.63) was observed from T_1, again at the same DAT, the minimum number (2.60, 4.67, 10.30 and 7.27) was observed from T_1.

The maximum number of effective tillers per hill (13.43) was found from T_{10}, whereas the minimum number (5.90) was recorded from T_1. The maximum number of in-effective tillers $hill^{-1}$ (4.33) was obtained from T_1 and the minimum number (2.20) was found from T_{12}. The maximum number of total tillers $hill^{-1}$ (17.37) was observed from T_{10} and the minimum (10.23) was obtained from T_1. The highest length of panicle (24.50 cm) was recorded from T_{10}, while the lowest length (15.28 cm) was observed from T_1. The maximum number of filled grain $plant^{-1}$ (91.40) was found from T_{10} and the minimum (52.63) was recorded from T_1. The maximum number of unfilled grain $plant^{-1}$ (13.53) was recorded from T_1 and the minimum number (6.07) was recorded from T_{10}. The maximum number of total grain $plant^{-1}$ (97.47) was found from T_{10}, whereas the minimum number (66.17) was recorded from T_1.

The highest weight of 1000 seeds (21.80 g) was found from T_{10}, while the minimum weight (15.50 g) was observed from T_1. The highest grain yield (6.73 t ha^{-1}) was obtained from T_{10}, while the lowest (2.16 t ha^{-1}) was found from T_1. The highest straw yield (7.10 t ha^{-1}) was obtained from T_{10} and the lowest (4.33 t ha^{-1}) was found from T_1. The highest biological yield (13.83 t ha^{-1}) was recorded from T_{10} and the lowest (6.49 t ha^{-1}) was obtained from T_1. The highest harvest index (48.67%) was found from T_{10} and the lowest (33.26%) from T_1.

The highest N uptake by grain (43.99 kg ha^{-1}) was recorded from T_{11} and the lowest (16.38 kg ha^{-1}) was recorded from T_1. The highest P uptake by grain (14.63 kg ha^{-1}) was observed from T_{11}, while the lowest (6.32 kg ha^{-1}) was observed from. The highest K uptake by grain (19.66 kg ha^{-1}) was found from T_{11}, whereas the lowest (7.72 kg ha^{-1}) was observed from T_1. The highest S uptake by grain (6.96 kg ha^{-1}) was obtained from T_{11} and the lowest (2.72 kg ha^{-1}) was observed from T_1. The highest N uptake by straw (30.87 kg ha^{-1}) was recorded from T_6 and the lowest (21.85 kg ha^{-1}) was observed from T_1. The highest P uptake by straw (4.72 kg ha^{-1}) was found from T_6, whereas the lowest (3.77 kg ha^{-1}) was observed from T_1. The highest K uptake by straw (73.98 kg ha^{-1}) was recorded from T_6 and the lowest (50.76 kg ha^{-1}) was found from T_1. The highest S uptake by straw (5.48

kg ha^{-1}) was observed from T_6 while the lowest (4.12 kg ha^{-1}) was observed from T_{10}. The highest pH of post harvest soil (6.47) was found from T_{12} and the lowest (5.67) was recorded from T_7. The highest organic matter in post harvest soil (1.533%) was recorded from T_9 and the lowest (1.110%) was observed from T_7. The highest total nitrogen in post harvest soil (0.054%) was recorded from T_1 and the lowest (0.024%) was obtained from T_{10}. The highest available phosphorus in post harvest soil (25.58 ppm) was recorded from T_{12}, again the lowest (19.42 ppm) was found from T_{10}. The highest exchangeable potassium in post harvest soil (0.166 me%) was recorded from T_1 and the lowest (0.103 me%) was observed from T_{10}. The highest available sulphur in post harvest soil (20.69 ppm) was obtained from T_1 while the lowest (12.45 ppm) was observed from T_{10}.

Applications of 80 kg N from urea + 40 kg N substituted equally by VC and CD + P, K, S and Zn was the superior among the other treatments in consideration of yield contributing characters and yield of BRRI dhan29.

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 organic manure and doses of chemical fertilizer may be used for further study, and
3. Other combination of organic manures and chemicals fertilizer may be used for further study to specify the specific combination.

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APPENDIXCES

Appendix I. Monthly record of air temperature, rainfall, relative humidity, soil temperature and Sunshine of the experimental site during the period from January to April 2010

Month (2010)	*Air temperature (°c)		*Relative humidity (%)	*Rain fall (mm) (total)	*Sunshine (hr)
	Maximum	Minimum			
January	24.5	12.4	68	00	5.7
February	27.1	16.7	67	30	6.7
March	31.4	19.6	54	11	8.2
April	33.6	23.6	69	163	6.4

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

Appendix II. Analysis of variance of the data on plant height of boro rice BRRI dhan29 as influenced by integrated effect of organic manures and nitrogen

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm) at				
		30 DAT	50 DAT	70 DAT	90 DAT	at harvest
Replication	2	0.410	0.060	0.101	2.758	0.118
Treatment	11	13.386**	22.585**	43.478**	85.550**	155.036**
Error	22	71.203	4.079	1.526	4.733	3.890

**: Significant at 0.01 level of probability

Appendix III. Analysis of variance of the data on number of total tiller per hill of boro rice BRRI dhan29 as influenced by integrated effect of organic manures and nitrogen

Source of variation	Degrees of freedom	Number of total tiller per hill at			
		30 DAT	50 DAT	70 DAT	90 DAT
Replication	2	0.017	0.028	0.017	0.026
Treatment	11	1.745**	9.670*	23.677**	22.656**
Error	22	0.169	1.607	1.900	2.229

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

Appendix IV. Analysis of variance of the data on yield contributing characters of boro rice BRRI dhan29 as influenced by integrated effect of organic manures and nitrogen

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	0.087	0.002	0.067	0.157	5.406	0.183	3.659
Treatment	11	12.928**	1.031**	14.08**	16.445**	335.453**	11.395**	228.08**
Error	22	0.789	0.246	1.490	1.138	9.605	0.707	7.293

**: Significant at 0.01 level of probability

Appendix V. Analysis of variance of the data on yield contributing characters and yield of boro rice BRRI dhan29 as influenced by integrated effect of organic manures and nitrogen

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	0.119	0.020	0.080	0.181	0.240
Treatment	11	8.303**	4.917**	2.341**	13.858**	48.823**
Error	22	0.363	0.304	0.271	1.025	2.487

**: Significant at 0.01 level of probability

Appendix VI. Analysis of variance of the data on N, P, K and S concentrations in grain of boro rice BRRI dhan29 as influenced by integrated effect of organic manures and nitrogen

Source of variation	Degrees of freedom	Mean square			
		Concentration (%) in grain			
		N	P	K	S
Replication	2	0.001	0.0001	0.0001	0.0001
Treatment	11	0.007**	0.003**	0.002**	0.001**
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 boro rice BRRI dhan29 as influenced by integrated effect of organic manures and nitrogen

Source of variation	Degrees of freedom				
		Concentration (%) in straw			
		N	P	K	S
Replication	2	0.0001	0.0001	0.001	0.0001
Treatment	11	0.007**	0.0001**	0.037**	0.0001**
Error	22	0.0001	0.0001	0.005	0.0001

**: Significant at 0.01 level of probability

Appendix VIII. Analysis of variance of the data N, P, K and S uptake by grain of boro rice BRRI dhan29 as influenced by integrated effect of organic manures and nitrogen

Source of variation	Degrees of freedom	Mean square			
		Uptake by grain (kg/ha)			
		N	P	K	S
Replication	2	1.367	0.450	0.376	0.162
Treatment	11	152.54**	15.047**	31.116**	3.536**
Error	22	12.136	1.684	1.801	0.333

**: Significant at 0.01 level of probability

Appendix IX. Analysis of variance of the data N, P, K and S uptake by straw of boro rice BRRI dhan29 as influenced by integrated effect of organic manures and nitrogen

Source of variation	Degrees of freedom	Mean square			
		Uptake by straw (kg/ha)			
		N	P	K	S
Replication	2	2.317	0.127	5.352	0.078
Treatment	11	16.146**	0.328*	149.435**	0.556**
Error	22	4.372	0.168	34.135	0.168

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

Appendix X. Analysis of variance of the data on the post harvest soil of boro rice BRRI dhan29 as influenced by integrated effect of organic manures and nitrogen

Source of variation	Degrees of freedom	Mean square					
		pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (me %)	Available S (ppm)
Replication	2	0.015	0.010	0.0001	0.196	0.0001	0.765
Treatment	11	0.123**	0.034**	0.0001**	9.904**	0.001**	14.078**
Error	22	0.030	0.011	0.0001	2.493	0.0001	1.871

**: Significant at 0.01 level of probability