

**EFFECT OF NITROGEN AND PHOSPHORUS ON THE GROWTH AND YIELD  
OF BRRI dhan57**

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OF BRR1 dhan57**

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**CERTIFICATE**

This is to certify that the thesis entitled '**Effect of Nitrogen and Phosphorus on the Growth and Yield of BRRI dhan57**' submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **Master of Science in Soil Science**, embodies the result of a piece of bonafide research work carried out by **Mahbubul Haque Imrul**, Registration number: **08-02876** 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.

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*DEDICATED TO  
MY  
BELOVED PARENTS*

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# **EFFECT OF NITROGEN AND PHOSPHORUS ON THE GROWTH AND YIELD OF BRRRI dhan57**

## **ABSTRACT**

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from July to November, 2014 to study the effect of nitrogen and phosphorus on the growth and yield of BRRRI dhan57. The experiment comprised of two factors- Factor A: Levels of nitrogen (4 levels); N<sub>0</sub>: 0 kg N ha<sup>-1</sup> i.e. control; N<sub>1</sub>: 90 kg N ha<sup>-1</sup>, N<sub>2</sub>: 120 kg N ha<sup>-1</sup>, N<sub>3</sub>: 150 kg N ha<sup>-1</sup>; Factors B: Levels of phosphorous (3 levels)- P<sub>0</sub>: 0 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> i.e. control, P<sub>1</sub>: 25 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> and P<sub>2</sub>: 35 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Data revealed that the tallest plant at 30, 60 DAT and at the time of harvest were found in case of treatments N<sub>2</sub> (120 kg N ha<sup>-1</sup>), P<sub>2</sub> (35 kg P ha<sup>-1</sup>) and treatment combination N<sub>2</sub>P<sub>2</sub> (120 kg N and 35 kg P ha<sup>-1</sup>), whereas, the treatments N<sub>0</sub>, P<sub>0</sub> and treatment combination N<sub>0</sub>P<sub>0</sub> (without N and P) showed the smallest plant height in each case, respectively. Side by side, the highest number of effective tillers hill<sup>-1</sup>, highest length of panicle and the maximum number of filled grains panicle<sup>-1</sup> were found in N<sub>2</sub>, P<sub>2</sub> treatments and N<sub>2</sub>P<sub>2</sub> treatment combination. The highest weight of 1000 grains (20.85 g), grain yield (4.95 t ha<sup>-1</sup>), straw yield (5.39 t ha<sup>-1</sup>), biological yield and (10.34 t ha<sup>-1</sup>) were found in the treatment combination N<sub>2</sub>P<sub>2</sub> and also found highest in each individuals N<sub>2</sub> and P<sub>2</sub> treatments. N, P, K, S and Zn concentration in case of grain and straw were found the highest in N<sub>2</sub>, P<sub>2</sub> treatments and N<sub>2</sub>P<sub>2</sub> treatment combination. The organic matter content (1.63%), total N (0.068%), available P (40.781 ppm), exchangeable K (0.184 me%) were found as the highest in the N<sub>2</sub>P<sub>2</sub> treatment combination and also found highest in each individual N<sub>2</sub> and P<sub>2</sub> treatment except the highest organic matter content (1.52%) in the P<sub>1</sub> treatment. Application of 120 kg N ha<sup>-1</sup> and 35 kg P<sub>2</sub>O<sub>5</sub> was more potential in regarding yield contributing characters and yield of BRRRI dhan57.

## TABLE OF CONTENTS

CHAPTER	TITLE	Page
	<b>ACKNOWLEDGEMENTS</b>	i
	<b>ABSTRACT</b>	ii
	<b>LIST OF CONTENTS</b>	iii-iv
	<b>LIST OF TABLES</b>	v
	<b>LIST OF FIGURES</b>	vi
	<b>LIST OF APPENDICES</b>	vi
<b>I</b>	<b>INTRODUCTION</b>	01-03
<b>II</b>	<b>REVIEW OF LITERATURE</b>	04-13
	2.1 Nitrogen fertilizer on yield contributing characters and yield of rice	04-08
	2.2 Phosphorus fertilizer on yield contributing characters and yield of rice	08-10
	2.3 Soil fertility and properties for application of fertilizers	11-13
<b>III</b>	<b>MATERIALS AND METHODS</b>	<b>14-25</b>
	3.1 Experimental site and soil	14
	3.2 Climate	14
	3.3 Planting material	14
	3.4 Initial soil sampling	16
	3.5 Treatment of the experiment	16
	3.6 Land preparation	16
	3.7 Experimental design and layout	16-17
	3.8 Fertilizer application	17
	3.9 Raising of seedlings	19
	3.10 Transplanting	19
	3.11 Intercultural operations	19
	3.12 Crop harvest	19

<b>CHAPTER</b>	<b>TITLE</b>	<b>Page</b>
	3.13 Collected data on yield components	20
	3.14 Chemical analysis of grain and straw samples	21-23
	3.15 Post harvest soil sampling	23
	3.16 Soil analysis	23-25
	3.17 Statistical analysis	25
<b>IV</b>	<b>RESULTS AND DISCUSSION</b>	<b>26-47</b>
	4.1 Yield contributing characters and yield of rice	26-38
	4.1.1 Plant height	26
	4.1.2 Number of effective tillers hill <sup>-1</sup>	28-29
	4.1.3 Number of non-effective tillers hill <sup>-1</sup>	30-31
	4.1.4 Number of total tillers hill <sup>-1</sup>	31-32
	4.1.5 Length of panicle	33
	4.1.6 Number of filled grains panicle <sup>-1</sup>	33-34
	4.1.7 Number of unfilled grains panicle <sup>-1</sup>	34
	4.1.8 Weight of 1000-grain	34-35
	4.1.9 Grain yield ha <sup>-1</sup>	35-36
	4.1.10 Straw yield ha <sup>-1</sup>	38
	4.1.11 Biological yield ha <sup>-1</sup>	38
	4.2 N, P, K, S and Zn concentration in grain and straw	39-43
	4.3 pH, organic matter, total N, available P and exchangeable K in post harvest soil	43-47
<b>V</b>	<b>SUMMARY AND CONCLUSION</b>	<b>48-51</b>
	<b>REFERENCES</b>	<b>52-60</b>
	<b>APPENDICES</b>	<b>61-64</b>



## LIST OF TABLES

TABLE	TITLE	PAGE
1.	The effect of different levels of nitrogen and phosphorous on plant height of BRR1 dhan57	27
2	Interaction effect of different levels of nitrogen and phosphorous on plant height of BRR1 dhan57	28
3	Effect of different levels of nitrogen and phosphorous on number of effective & non-effective tillers hill <sup>-1</sup> , filled & unfilled grains panicle <sup>-1</sup> and length of panicle of BRR1 dhan57	29
4	Interaction effect of different levels of nitrogen and phosphorous on number of effective & non-effective tillers hill <sup>-1</sup> , filled & unfilled grains panicle <sup>-1</sup> and length of panicle of BRR1 dhan57	30
5	Effect of different levels of nitrogen and phosphorous on weight of 1000-grains, grain, straw, biological yield and of BRR1 dhan57	36
6	Interaction effect of different levels of nitrogen and phosphorous on weight of 1000-grains, grain, straw, biological yield and harvest index of BRR1 dhan57	37
7	Effect of different levels of nitrogen and phosphorous on N, P, K, S and Zn concentrations in grain of BRR1 dhan57	39
8	Interaction effect of different levels of nitrogen and phosphorous on N, P, K, S and Zn concentrations in grain of BRR1 dhan57	40
9	Effect of different levels of nitrogen and phosphorous on N, P, K, S and Zn concentrations in straw of BRR1 dhan57	41
10	Interaction effect of different levels of nitrogen and phosphorous on N, P, K, S and Zn concentrations in straw of BRR1 dhan57	42
11	Effect of different levels of nitrogen and phosphorous on pH, organic matter, total N, available P and exchangeable K of post harvest soil	44
12	Interaction effect of different levels of nitrogen and phosphorous on pH, organic matter, total N, available P and exchangeable K of post harvest soil	45

## LIST OF FIGURES

FIGURE	TITLE	PAGE
1	Effect of nitrogen on the total tiller number hill <sup>-1</sup> of BRRIdhan57	31
2	Effect of phosphorus on the total tiller number hill <sup>-1</sup> of BRRIdhan57	32
3	Effect of phosphorus on the total tiller number hill <sup>-1</sup> of BRRIdhan57	32

## LIST OF APPENDICES

APPENDIX	TITLE	PAGE
I.	Monthly record of air temperature, relative humidity, rainfall, and sunshine (average) of the experimental site during the period from July to November 2013	61
II	Analysis of variance of the data on plant height of BRRIdhan57 as influenced by different levels of nitrogen and phosphorous	62
III	Analysis of variance of the data on effective, non-effective & total tillers plant <sup>-1</sup> , length of panicle, filled, unfilled and total grains of BRRIdhan57 as influenced by different levels of nitrogen and phosphorous	62
IV	Analysis of variance of the data on weight of 1000 grains, grain, straw & biological yield and harvest index of BRRIdhan57 as influenced by different levels of nitrogen and phosphorous	63
V	Analysis of variance of the data on N, P, K, S and Zn concentration in grain of BRRIdhan57 as influenced by different levels of nitrogen and phosphorous	63
VI	Analysis of variance of the data on N, P, K, S and Zn concentration in straw of BRRIdhan57 as influenced by different levels of nitrogen and phosphorous	64
VII	Analysis of variance of the data on pH, organic matter, total N, available P and exchangeable K of post-harvest soil of BRRIdhan57 as influenced by different levels of nitrogen and phosphorous	64

## CHAPTER I

### INTRODUCTION

Rice (*Oryza sativa L.*) belongs to cereal crops under Gramineae family. Nearly half of the population of the world use rice as their main food. Millions of people in Asia subsist entirely on rice and over 90% of the world's rice is grown and eaten in Asia (BBS, 2013). It plays a vital role in the economy of Bangladesh providing significant contribution to the GDP, employment generation and food availability. In Bangladesh, rice is the most extensively cultivated cereal crop. It provides about 75% of the calories and 55% of the protein in the average daily diet of the people of our country (Bhuiyan *et al.*, 2002). The climatic and edaphic conditions of Bangladesh are favorable for rice cultivation throughout the year. It provides nearly 48% of rural employment, about two-third of total calorie supply and about one-half of the total protein intakes of an average person in the country (BBS, 2013). About 75% of the total cropped area and over 80% of the total irrigated area is planted to rice. Thus, rice plays a vital role in the livelihood of the people of Bangladesh. Among the rice growing countries, Bangladesh occupies third position in rice area and fourth position in rice production (BRRI, 2012). But the average yield is quite low compared to that in other leading rice growing countries.

The second largest part of the total production of rice comes of Aman rice after Boro. Bangladesh earns about 31.6% of her gross domestic product (GDP) from agriculture (BBS, 2008) in which rice is the main crop. Agriculture in Bangladesh is characterized by intensive crop production with rice based cropping systems. Rice is grown in three seasons namely Aus (mid-March to mid-August), Aman (mid-June to November) and Boro (Mid December to mid-June). The largest part of the total production of rice comes from Aman rice. T. aman rice covers about 50.92% of the rice areas of Bangladesh of which modern T. aman varieties covers 60% (BBS, 2005). In ganges tidal floodplain Agro ecological zone-13 T. aman is

the main crop. Agro ecological condition of this area favours the large-scale cultivation of T. aman rice.

Nitrogen plays a key role in rice production and it is required in large amount. Nitrogen is the most important limiting nutrient in rice production and has heavy system losses when applied from inorganic sources in puddle field (Fillery *et al.* 1984). Nitrogen has a positive influence on the production of effective tiller per plant, yield and yield attributes (Jashim *et al.*, 1984, BRRI, 1990). It is necessary to find out the suitable rate of nitrogen fertilizer for efficient management and better yield of rice. A suitable combination of variety and rate of nitrogen is necessary for better yield (BRRI, 1990). Rice plant cannot produce higher grain yield without addition of fertilizer in the crop field (BRRI, 2011). Among the nutrients, nitrogen is the kingpin in rice farming (Alam *et al.*, 2012) for crop growth and development (Ahsan, 1996). However, only optimum dose of N applied can play a vital role on the growth and development of rice plant (Hasanuzzaman *et al.*, 2009). The absorption patterns of applied nitrogen vary with growth stages. About 52 to 60 % of total plant nitrogen in the high yielding plants has been absorbed by early panicle formation stage, and 70 to 80 % by heading stage; 20- 30 % nitrogen is absorbed during the ripening period (De Datta, 1981). So, it is necessary to improve the efficiency of applied nitrogenous fertilizer utilization by rice plant (Miah and Panaullah, 1999).

Phosphorus is also one of the important essential macro elements for the normal growth and development of plant. The phosphorus requirements for plant differ depending upon the nutrient content of the soil (Sahrawat *et al.*, 2001). Phosphorus shortage restricted the plant growth and remains immature and secondary mechanism of interference was the absorption of phosphorus from the soil through luxury consumption, increasing the tissue content without enhancing smooth biomass accumulation. It is a major component in ATP, the molecule that provides 'energy' to that plant for such processes as photosynthesis, protein synthesis, nutrient translocation, nutrient uptake and respiration (Li *et al.*, 2007). Phosphorus

application to rice increased P accumulation but did not consistently increase rice yields because flooding decreased soil P sorption and increased P diffusion. The optimum proportion of phosphorus fertilizer enhances the growth and development of a crop as well as ensured the availability of other essential nutrients for the plant.

Considering the above facts, the present research was under taken with the following objectives:

- To find out the appropriate doses of N and P regarding to proper growth and higher production of BRRI dhan57; and
- To select the suitable combination of N and P fertilizers concerning to growth and yield of BRRI dhan57.

## CHAPTER II

### REVIEW OF LITERATURE

Nitrogen and phosphorous fertilizer is the essential factor for sustainable soil fertility and crop productivity. Sole and combined use of nitrogen and phosphorus fertilizer stimulated plant growth, yield contributing characters and that leads to highest yield. Experimental information evidences that the use of nitrogen and phosphorus have an intimate effect on the yield and yield attributes of rice. The available relevant reviews that are related to the effect of nitrogen and phosphorus on the yield attributes, yield, nutrient concentration in grain & straw of rice and nutrient status of post-harvest soil are reviewed below-

#### **2.1 Nitrogen fertilizer on yield contributing characters and yield of rice**

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.

BRRRI (1992) reported that both grain and straw yields of rice were increased significantly up to 80 kg N ha<sup>-1</sup>. Application of nitrogen from 120 to 160 kg nitrogen ha<sup>-1</sup> 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 79.39, 82.3 and 84.4 cm with 45, 90 and 135 kg N ha<sup>-1</sup>, respectively. Plant height increased with increasing nitrogen doses.

Awasthi and Bhan (1993) reported that increasing levels of nitrogen up to 60 kg ha<sup>-1</sup> 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<sup>-1</sup>.

Kumar *et al.* (1995) conducted a field experiment with four levels of nitrogen (0, 60, 120 and 180 kg N ha<sup>-1</sup>) and reported that productive tillers increased significantly with the increase of N doses from 0-120 kg N ha<sup>-1</sup>, but differences in productive tillers between 120 and 180 kg N ha<sup>-1</sup> and they were not statistically significant.

Effective tillers  $\text{m}^{-2}$  responded significantly to the application of N fertilizer (Behera, 1995). Effective tillers increased significantly with increase the level of N fertilizer up to  $80 \text{ kg N ha}^{-1}$ . Patel and Upadhyay (1993) conducted an experiment with 3 levels of N ( $90$ ,  $120$  and  $150 \text{ kg ha}^{-1}$ ) and reported that total and effective tillers  $\text{m}^{-2}$  increased significantly with increasing rates of N up to  $120 \text{ kg ha}^{-1}$ .

Andrade and Amorim (1996) observed that increasing level of applied N increased plant height, panicle  $\text{m}^{-2}$ , 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 ( $4.47 \text{ t ha}^{-1}$ ) when  $100 \text{ kg N ha}^{-1}$  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  $6.21 \text{ t ha}^{-1}$  were obtained from  $90 \text{ kg N ha}^{-1}$ , respectively.

Adhikary and Rhaman (1996) reported that rice grain yield  $\text{ha}^{-1}$  in various treatments of N showed significant effect. The highest yield was obtained from  $100 \text{ kg N ha}^{-1}$  ( $4.52 \text{ t ha}^{-1}$ ) followed by  $120 \text{ kg N ha}^{-1}$  ( $4.46 \text{ t ha}^{-1}$ ) and  $80 \text{ kg N ha}^{-1}$  ( $4.40 \text{ t ha}^{-1}$ ).

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 ( $120 \text{ kg ha}^{-1}$ ) of N application.

Dwivedi (1997) noticed that application of nitrogen significantly increased in growth, yield and yield components, grain yield, straw yield as well as harvest index with  $60 \text{ kg N ha}^{-1}$ . BRRI (1997) reported during *boro* and *transplantaman* to determined rice seed yield. The experiment was laid out with four nitrogen levels  $0$ ,  $50$ ,  $100$  and  $150 \text{ kg ha}^{-1}$  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 and observed that nitrogen and phosphorus fertilization significantly increased the number of fertile tiller  $\text{m}^{-2}$  and also that of grains

panicle<sup>-1</sup>, which in turn resulted in significant increase in grain yield. The application of 60 kg N ha<sup>-1</sup> 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<sup>-1</sup>). They observed that the varieties responded linearly to the applied N level up to 120 kg ha<sup>-1</sup>.

Kumar and Sharma (1999) conducted a field experiment with 4 levels of nitrogen (0, 40, 80 and 120 kg N ha<sup>-1</sup>) and observed that dry matter accumulation in rice increased from 0-40 kg N ha<sup>-1</sup> at 40 DAS, 0-120 kg N ha<sup>-1</sup> at 60 DAS, 0-80 kg ha<sup>-1</sup> 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<sup>-1</sup>) and reported that the amount of total dry matter was significantly greater at the N fertilizer rates of 100 and 150 kg nitrogen ha<sup>-1</sup>.

BRRRI (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<sup>-1</sup>. Castro and Sarker (2000) conducted field experiment to see the effects of N applications as basal (80, 60, and 45kg N ha<sup>-1</sup>) and top dressing (10, 30 and 45 kg ha<sup>-1</sup>) 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<sup>-1</sup> (basal) and 45 kg N ha<sup>-1</sup> (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<sup>-1</sup> gave maximum grain yield (2647 kg ha<sup>-1</sup>).

Pully *et al.* (2000) observed that increased yield associated with application of nitrogen stage, although booting stage nitrogen application had no effect on 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<sup>-1</sup> in the form of urea, 50% nitrogen was applied in four splits resulted in higher number of tillers, filled grains panicle<sup>-1</sup> and higher grain weight hill<sup>-1</sup>.

Munnujanet *al.* (2001) treated 4 levels of nitrogen fertilizer (0, 40, 80, and 160 kg ha<sup>-1</sup>) application at three levels each planting density (20, 40 and 80 hill m<sup>-1</sup>) and conducted that the highest grain yield (3.8 t ha<sup>-1</sup>) was obtained with 180 kg N ha<sup>-1</sup>, which was similar to the yield obtained at 80 kg N ha<sup>-1</sup> (3.81 t ha<sup>-1</sup>).

Sarkeret *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<sup>-1</sup>. 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 to determine the best split application of 150 kg N ha<sup>-1</sup> for rice cv. IR20. Data from the experiment revealed that 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<sup>-1</sup>) and straw (8649.6 kg ha<sup>-1</sup>) 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<sup>-2</sup>.

Duhan and Singh (2002) conducted a field experiment and 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<sup>-1</sup> than with lower level of nitrogen.

Mondal and Swamy (2003) found that application of N (120 kg ha<sup>-1</sup>) as urea in equal splits during transplanting, tillering, panicle initiation and flowering resulted in the highest number of panicle, number of grains panicle<sup>-1</sup>, 1000-grain weight, straw yield and harvest index. Shirameet *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<sup>-1</sup> one seedling hill<sup>-1</sup> showed significantly higher harvest index.

## **2.2 Phosphorus fertilizer on yield contributing characters and yield of rice**

Hassan *et al.* (1993) carried out an experiment and observed the yield response of Basmati 385 rice to 0, 33, 66 and 99 kg/haP. All treatments received 128-62-4.2 kg NKZn/ha. They observed that yield increased significantly up to 33 kg P/ha for all soil P test values, but significant response to the next higher dose was observed only when test values were less than or equal to 11 mg P/kg.

Subbaet *al.* (1995) reported that phosphorus applied @50 mg P/kg soil as SSP increased the grain and straw yields significantly. Chen and Fan (1997) conducted a field experiment at Rice Research Institute of Yunnan Agricultural University, Kunming on soils low in P and Zn using rice cultivars Xunza – 29, Hexi – 35 and Yungeng – 34 as test crop with 0, or 5 kg Zn/ha and 60, 150, or 200 kg P/ha and found that application of Zn and P significantly increased yield especially.

Ghosalet *al.* (1998) conducted a field experiment in Bihar on rice cv. Pankaj with 10–40 kg P/ha as triple super phosphate (TSP), highly reactive Morocco Rock Phosphate (HRMRP), Florida Rock Phosphate (FRP) and stated that yield increased with increasing P rates of four sources. They further proposed that grain yield was the highest with TSP followed by PAPR, HRMRP and FRP.

Sarkunanet *al.* (1998) conducted a pot experiment to find out the effect of P and S on yield of rice under flooded condition, on a P and S deficient sandy loam soil. They found increased yield with increasing level of P from 16.9 to 42.5 g/pot. Sulphur addition at 25 mg/kg resulted in 9% increase in grain yield. The treatment combination of 100 mg P and 10 mg S/kg soil gave significantly higher grain yield than other treatments.

Sahrawatet *al.* (2001) conducted a field experiment for six years (1993-1998) to determine the response of four promising upland rice cultivars with 0, 45, 90, 135, and 180 kg/ha as triple super phosphate (TSP). Only once used in 1993 and its residual value in 1994, 1995, 1996 and 1998 stated that grain yields of the rice cultivars were significantly increased by fertilizer P in 1993 and by the fertilizer P residues in the subsequent years although the magnitude of response decreased rapidly with time since the fertilizer was not applied.

Nair and Rajasree (2004) conducted a field experiment to assess comparative efficiency of super phosphate and PR (34/74) at different levels in the yield characters and composition of rice. The treatments were 30 and 45 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> in the form of superphosphate and PR (34/74) with and without organic matter (6 t ha<sup>-1</sup>), green manure (10 t ha<sup>-1</sup>) and iron pyrites (10% by weight). The results showed that high grade phosphate rock (M, 34/74) with organic manure performed well and were followed by PR (34/74) with iron pyrites and green manure. Thus, PR (34/74) performed well with organic matter, FeS<sub>2</sub> and green manure in deciding growth and yield of rice. Higher contents of N, P, K, Ca and Mg of grain and straw were obtained at higher levels of 45 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> treatment.

Moula (2005) conducted an experiment on T. aman rice with different phosphorus rates. He found that when four treatments (P<sub>0</sub>, 60 kg ha<sup>-1</sup> phosphate rock, 60 kg ha<sup>-1</sup> TSP and 210 kg ha<sup>-1</sup> phosphate rock) were applied, 210 kg phosphate rock (PR) showed better performance on yield contributing characters and nutrient content as well as nutrient uptake by rice over other treatments.

Das and Sinha (2006) conducted a field experiment on sandy loam soil during the kharif season to study the effects of the integrated use of organic manures and various rates of N (urea) on the growth and yield of rice cv. IR 68. Among the different sources of organic amendments, farmyard manure (FYM; 10 t ha<sup>-1</sup>) was superior, followed by the incorporation of wheat straw (5 t ha<sup>-1</sup>) along with the combined application of phosphates rock (40 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>) and N. Grain and straw yields were highest when FYM was applied with 90 kg N ha<sup>-1</sup>, although this treatment was comparable with combined application of wheat straw, phosphate rock and 90 kg N ha<sup>-1</sup>.

Li *et al.* (2007) conducted an experiment to evaluate the contributions of rice root morphology and phosphorus uptake kinetics to P uptake by rice from iron phosphates. The Fe-P treatment significantly decreased plant dry weight, P uptake per plant, and P concentration in plant dry matter of all cultivars in comparison with the control plants.

Dunn and Stevens (2008) conducted a field experiment to evaluate the effect of polymer coating of phosphate fertilizer on rice yield. Three rates of phosphate fertilizer, including polymer coated and non coated, were compared to an untreated check. Net return was calculated based on crop price and input costs. At the rate of 25 lb/acre P<sub>2</sub>O<sub>5</sub> rate the polymer coated treatments produced greater yields than equivalent non coated treatments.

Islam *et al.* (2010) conducted a field experiment with five phosphorus rates (0, 5, 10, 20 and 30 kg P ha<sup>-1</sup>) with four rice genotypes in Boro and T. Aman season. Phosphorus rates did not influence grain yield irrespective of varieties in T. aman season while in Boro season P response was observed among the P rates. Application of P @ 10 kg ha<sup>-1</sup> significantly increased the grain yield. But when P was applied @ 20 and 30 kg P ha<sup>-1</sup>, the grain yield difference was not significant. The optimum and economic rate of P for T. Aman was 20 kg P ha<sup>-1</sup> but in Boro rice the optimum and economic doses of P were 22 and 30 kg ha<sup>-1</sup>, respectively. Hybrid entries (EH<sub>1</sub> and EH<sub>2</sub>) used P more efficiently than inbred varieties. A negative P balance was observed up to 10 kg P ha<sup>-1</sup>.

Tang *et al.* (2011) conducted a field experiment on winter wheat (*Triticumaestivum* L.) and rice (*Oryza sativa* L.) crop rotations in Southwest China to investigate phosphorus (P) fertilizer utilization efficiency, including the partial factor productivity (PFP), agronomic efficiency (AE), internal efficiency (IE), partial P balance (PPB), recovery efficiency (RE) and the mass (input–output) balance. This study suggests that, in order to achieve higher crop yields, the P fertilizer utilization efficiency should be considered when making P fertilizer recommendations in wheat–rice cropping systems.

### 2.3 Soil fertility and properties for application of fertilizers

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<sup>-1</sup> 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<sup>-1</sup> from their initial values.

Meeluet *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. Medhiet *et al.* (1996) reported that incorporation of organic and inorganic sources of N increased soil solution NH<sub>4</sub>-N to a peak and then declined to very low levels.

Naharet *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.

Xuet *al.* (1997) observed that application of organic matters affect soil pH value as well as nutrient level.

Santhiet *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.

Hemalathaet *al.* (2000) revealed that green manure significantly increased the soil fertility status, organic carbon, available soil N, P and K at post-harvest soil. Zamanet *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 nitrogen and phosphorus fertilizer greatly influence the yield contributing characters and yield of rice. The properties of soils are also influenced by the inclusion of nitrogen and phosphorus fertilizer.

## CHAPTER III

### MATERIALS AND METHODS

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from July to November, 2013 to study the effect of nitrogen and phosphorus on the growth and yield of BRRI dhan57. 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 July to November 2013 have been presented in Appendix I.

#### **3.3 Planting material**

BRRI dhan57 was used as the test crop in this experiment. This variety was developed at the Bangladesh Rice Research Institute from the cross between Bashmoti (D) and BR5 in 1998. It is recommended for *Aman* season. Average plant height of the variety is around 125 cm at the ripening stage. The grains are long slender, fine and aromatic. It requires about 140 days completing its life cycle with an average grain yield of 3.5 t ha<sup>-1</sup> (BRRI, 2013).



**Table 1. Morphological characteristics of the experimental field**

<b>Morphology</b>	<b>Characteristics</b>
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)**

<b>Characteristics</b>	<b>Value</b>
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 <sup>-1</sup> )	0.12
Available P (mg kg <sup>-1</sup> )	19.85
Available S (mg kg <sup>-1</sup> )	14.40

### **3.4 Initial soil sampling**

Before land preparation, initial soil samples at 0-15 cm depth were collected from three 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.

### **3.5 Treatment of the experiment**

The experiment comprised of two factors

Factor A: Levels of nitrogen (4 levels)

- i)  $N_0$ : 0 kg N ha<sup>-1</sup> i.e. control
- ii)  $N_1$ : 90 kg N ha<sup>-1</sup>
- iii)  $N_2$ : 120 kg N ha<sup>-1</sup>
- iv)  $N_3$ : 150 kg N ha<sup>-1</sup>

Factors B: Levels of phosphorous (3 levels)

- i)  $P_0$ : 0 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> i.e. control
- ii)  $P_1$ : 25 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>
- iii)  $P_2$ : 35 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>

There were in total 12 (4×3) treatment combinations such as  $N_0P_0$ ,  $N_0P_1$ ,  $N_0P_2$ ,  $N_1P_0$ ,  $N_1P_1$ ,  $N_1P_2$ ,  $N_2P_0$ ,  $N_2P_1$ ,  $N_2P_2$ ,  $N_3P_0$ ,  $N_3P_1$  and  $N_3P_2$ .

### **3.6 Land preparation**

The land was first opened on 03 July, 2013 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 for seedling transplanting.

### **3.7 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 combinations with raised bunds around. Thus the total numbers of plots were 36. The unit plot size was 3.0 m × 1.5 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.

### 3.8 Fertilizer application

The fertilizers N, P, K, S, Zn and B in the form of urea, TSP, MOP, Gypsum, zinc sulphate and borax, respectively were applied. The one third amount of urea and entire amount of TSP, MOP, gypsum, zinc sulphate and borax were applied during the final preparation of land. Rest urea was applied in two equal installments at tillering and panicle initiation stages. The dose and method of application of fertilizers are presented in Table 3.

**Table 3. Dose and method of application of fertilizers in rice field**

Fertilizers	Dose (ha <sup>-1</sup> )	Application (%)		
		Basal	1 <sup>st</sup> installment	2 <sup>nd</sup> installment
Cowdung	5 ton	100	--	--
Urea	As per treatment	33.33	33.33	33.33
TSP	As per treatment	100	--	--
MOP	120 kg	100	--	--
Gypsum	30 kg	100	--	--
Zinc sulphate	2.0 kg	100		
Borax	10 kg	100	--	--

Source: BRRI, 2013 (AdunikDhanerChash)

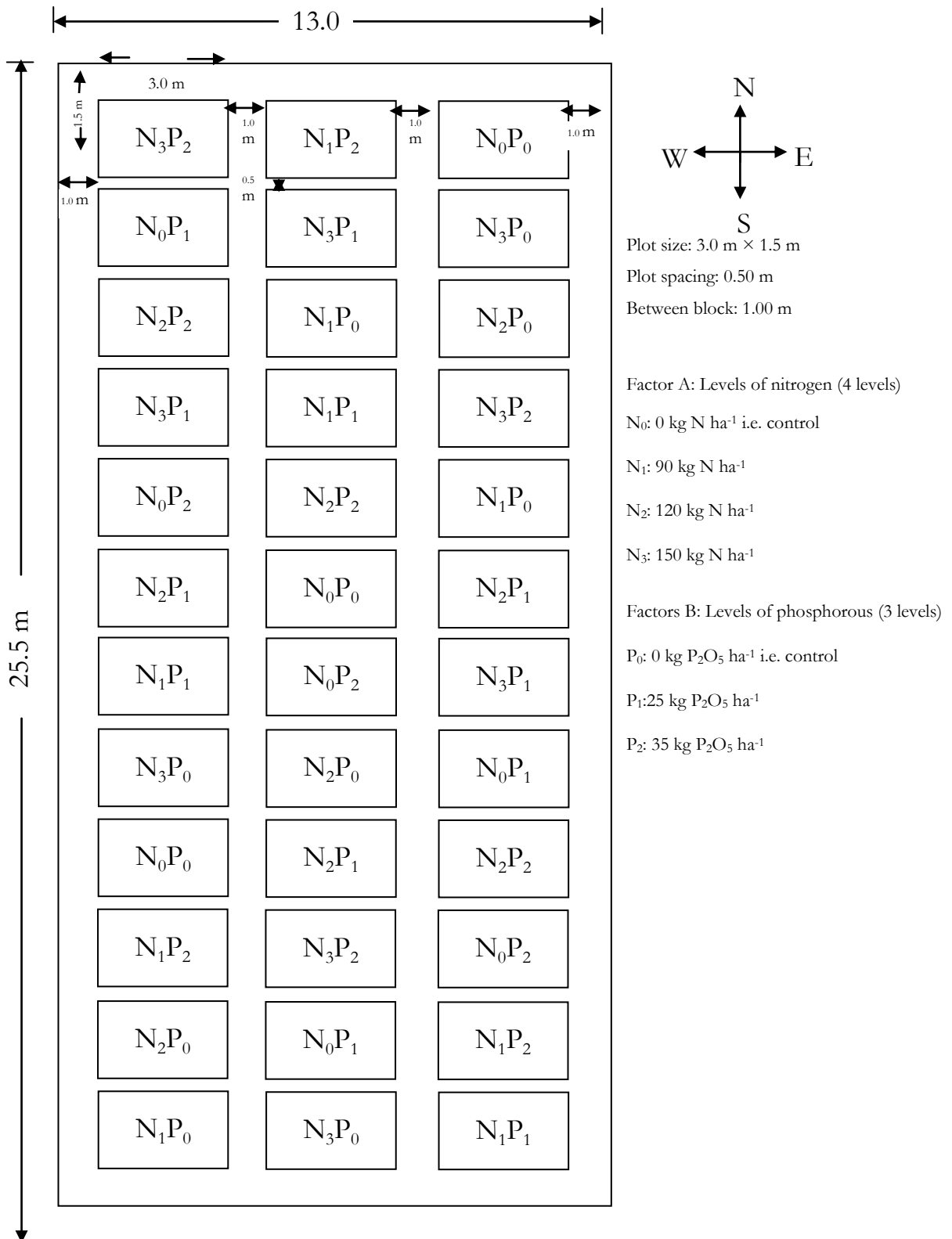


Figure 1. Layout of the experimental plot

### **3.9 Raising of seedlings**

The seedlings of rice were raised wet-bed methods. Seeds (95% germination) @ 50 kg ha<sup>-1</sup> were soaked and incubated for 48 hour and sown on a well-prepared seedbed. During seedling growing, no fertilizers were used. Proper water and pest management practices were followed whenever required.

### **3.10 Transplanting**

Thirty days old seedlings of BRR1 dhan29 were carefully uprooted from the seedling nursery and transplanted on 14 July, 2013 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.

### **3.11 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.

#### **3.11.1 Irrigation**

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

#### **3.11.2 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.

#### **3.11.3 Insect and pest control**

There was no infection of diseases in the field but leaf roller (*Chaphalocrosismedinalis*, Pyralidae, Lepidoptera) was observed in the field and used Malathion @ 1.12 L ha<sup>-1</sup>.

### **3.12 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.

### **3.13 Collected data on yield components**

#### **3.13.1 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.

#### **3.13.2 Effective tiller hill<sup>-1</sup>**

The total number of effective tiller hill<sup>-1</sup> was counted as the number of panicle bearing hill plant<sup>-1</sup>. Data on effective tiller hill<sup>-1</sup> were counted from 10 selected hills and average value was recorded.

#### **3.13.3 Non-effective tiller hill<sup>-1</sup>**

The total number of in-effective tiller hill<sup>-1</sup> was counted as the number of non-panicle bearing hill plant<sup>-1</sup>. Data on non effective tiller hill<sup>-1</sup> were counted from 10 selected hills and average value was recorded.

#### **3.13.4 Total tiller hill<sup>-1</sup>**

The total number of tiller hill<sup>-1</sup> was counted as the number of effective tiller hill<sup>-1</sup> and non-effective tiller hill<sup>-1</sup>. Data on total tiller hill<sup>-1</sup> were counted from 10 selected hills and average value was recorded.

#### **3.13.5 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.

#### **3.13.6 Filled grain panicle<sup>-1</sup>**

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<sup>-1</sup> was recorded.

#### **3.13.7 Unfilled grain panicle<sup>-1</sup>**

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<sup>-1</sup> was recorded.

### **3.13.8 Total grain panicle<sup>-1</sup>**

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<sup>-1</sup> was recorded.

### **3.13.9 Weight of 1000 seeds**

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

### **3.13.10 Grain yield**

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

### **3.13.11 Straw yield**

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

### **3.13.12 Biological yield**

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

$$\text{Biological yield} = \text{Grain yield} + \text{Straw yield}.$$

## **3.14 Chemical analysis of grain and straw samples**

### **3.14.1 Collection of grain and straw 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.

### **3.14.2 Preparation of samples**

The grain and straw samples were dried in an oven at 70 °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:

### **3.14.3 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 ( $K_2SO_4$ :  $CuSO_4 \cdot 5H_2O$ : Se in the ratio of 100: 10: 1), and 5 ml conc.  $H_2SO_4$  were added. The flasks were heating at  $120^\circ C$  and added 2.5 ml 30%  $H_2O_2$  then heated was continued at  $180^\circ C$  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  $H_2SO_4$ .

### **3.14.4 Digestion of samples with nitric-perchloric acid for P, K, S and Zn**

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  $200^\circ C$ . 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.

### **3.14.5 Determination of P, K, S and Zn from grain and straw samples**

#### **3.14.5.1 Phosphorus**

Phosphorus was digested from the plant sample (grain and straw) with 0.5 M  $NaHCO_3$  solutions, pH8.5 (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).

#### **3.14.5.2 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.



### **3.14.5.3 Sulphur**

Sulphur content was determined from the digest of the plant samples (grain and straw) with  $\text{CaCl}_2$  (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  $\text{K}_2\text{SO}_4$  in 6N HCl) and  $\text{BaCl}_2$  crystals. The intensity of turbidity was measured by spectrophotometer at 420 nm wavelengths (Hunter, 1984).

### **3.14.5.4 Zinc**

Zinc content was determined from the digest of the grain and straw samples (with  $\text{BaCl}_2$  solution as described by Page *et al.*, 1982). The digested Zn was determined by developing turbidity by adding  $\text{BaCl}_2$  seed solution. The intensity of turbidity was measured by spectrophotometer at 420 nm wavelengths (Hunter, 1984).

## **3.15 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.

## **3.16 Soil analysis**

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

### **3.16.1 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.

### **3.16.2 Organic matter**

Organic carbon in soil sample was determined by wet oxidation method. The underlying principle was used to oxidize the organic matter with an excess of 1N  $\text{K}_2\text{Cr}_2\text{O}_7$  in presence of conc.  $\text{H}_2\text{SO}_4$  and conc.  $\text{H}_3\text{PO}_4$  and to titrate the excess  $\text{K}_2\text{Cr}_2\text{O}_7$  solution with 1N  $\text{FeSO}_4$ . 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).

### 3.16.3 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 ( $K_2SO_4$ :  $CuSO_4 \cdot 5H_2O$ : Se in the ratio of 100:10:1), and 6 ml  $H_2SO_4$  were added. The flasks were swirled and heated  $200^{\circ}C$  and added 3 ml  $H_2O_2$  and then heating at  $360^{\circ}C$  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:

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

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

#### **3.16.4 Available phosphorus**

Available P was extracted from the soil with 0.5 M NaHCO<sub>3</sub> solutions, pH8.5 (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).

#### **3.16.5 Exchangeable potassium**

Exchangeable K was determined by 1N NH<sub>4</sub>OAc (pH 7) extraction methods and by using flame photometer and calibrated with a standard curve (Page *et al.*, 1982).

#### **3.17 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 BRR1 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 study the effect of nitrogen and phosphorus on the growth and yield of BRR I dhan57. The analyses of variance (ANOVA) of the data on different growth, yield parameters, yield nutrient concentration in grain and straw and nutrient status of post-harvest soil are presented in Appendix II-VII. The results have been presented and discussed with the help of tables and graphs and possible interpretations given under the following headings:

#### 4.1 Yield contributing characters and yield of rice

##### 4.1.1 Plant height

Statistically significant variation was recorded for plant height of BRR I dhan57 due to different levels of nitrogen at 30 and 60 days after transplanting (DAT) and at harvest (Appendix I and Table 1). Data revealed that at 30 and 60 DAT and harvest, the tallest plant (22.60, 80.81 and 115.66 cm, respectively) was recorded from N<sub>2</sub> (120 kg N ha<sup>-1</sup>) which were statistically similar (22.47, 80.09 and 112.44 cm, respectively) with N<sub>3</sub> (150 kg N ha<sup>-1</sup>) whereas the shortest plant (20.98, 61.08 and 82.09 cm, respectively) was found from N<sub>0</sub> i.e. control condition. It was revealed that with the increase of nitrogen fertilizer, plant height increased up to a certain level then decreases. 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. BRR I (1992) reported that application of nitrogen from 120 to 160 kg ha<sup>-1</sup> was assumed to be due to excessive vegetative growth followed by lodging after flowering. Andrade and Amorim (1996) observed that increasing level of N increased plant height. Patel and Upadhaya (1993) found that plant height of rice increased significantly with increasing rate of N up to 150 kg ha<sup>-1</sup>.

**Table 1. The effect of different levels of nitrogen and phosphorous on plant height of BRRRI dhan57**

Treatment	Plant height (cm)		
	30 DAT	60 DAT	Harvest
Levels of nitrogen			
<b>N<sub>0</sub></b>	20.98 c	61.08 c	82.09 c
<b>N<sub>1</sub></b>	21.76 b	72.43 b	94.31 b
<b>N<sub>2</sub></b>	22.60 a	80.81 a	115.66 a
<b>N<sub>3</sub></b>	22.47 a	80.09 a	112.44 a
<b>LSD<sub>(0.05)</sub></b>	0.688	0.285	5.416
<b>Significance level</b>	0.01	0.01	0.01
Levels of phosphorous			
<b>P<sub>0</sub></b>	18.85 b	59.67 c	80.97 c
<b>P<sub>1</sub></b>	22.13 a	71.90 ab	95.51 ab
<b>P<sub>2</sub></b>	22.37 a	78.12 a	111.64 a
<b>LSD<sub>(0.05)</sub></b>	0.596	0.247	4.690
<b>Significance level</b>	0.01	0.01	0.01
<b>CV(%)</b>	6.15	10.06	6.81

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

N<sub>0</sub>: 0 kg N ha<sup>-1</sup> (control)

N<sub>1</sub>: 90 kg N ha<sup>-1</sup>

N<sub>2</sub>: 120 kg N ha<sup>-1</sup>

N<sub>3</sub>: 150 kg N ha<sup>-1</sup>

P<sub>0</sub>: 0 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> (control)

P<sub>1</sub>: 25 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>

P<sub>2</sub>: 35 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>

Plant height of BRRRI dhan57 varied significantly for different levels of phosphorus at 30, 60 DAT and harvest (Appendix I and Table 1). At 30, 60 DAT and harvest, the tallest plant (22.37, 78.12 and 111.64 cm, respectively) were observed from P<sub>2</sub> (35 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>) which were statistically identical (22.13, 71.90 and 95.51 cm, respectively) with P<sub>1</sub> (25 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>). On the other hand, the shortest plant (18.85, 59.67 and 80.97 cm, respectively) were observed from P<sub>0</sub> (0 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>). It revealed that with the increase of application of phosphorus plant height showed increasing trend but after a certain level plant height increases very slowly.

Interaction effect of different levels of nitrogen and phosphorus showed significant variation on plant height of BRRRI dhan57 at 30, 60 DAT and harvest (Appendix I and Table 2). At 30, 60 DAT and harvest, the tallest plant (28.77, 81.27 and 119.05 cm, respectively) were observed from N<sub>2</sub>P<sub>2</sub> (120 kg N ha<sup>-1</sup> and 35 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>) whereas, the shortest plant (18.13, 60.90 and 87.75 cm, respectively) were recorded at 30, 60 DAT and harvest, respectively from N<sub>0</sub>P<sub>0</sub> (0 kg N ha<sup>-1</sup> and 0 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>).

**Table 2. Interaction effect of different levels of nitrogen and phosphorous on plant height of BRR1 dhan57**

Treatmet	Plant height (cm)		
	30 DAT	60 DAT	Harvest
N <sub>0</sub> P <sub>0</sub>	18.13 f	60.90 e	87.75 i
N <sub>0</sub> P <sub>1</sub>	22.28 e	65.07 de	98.16 h
N <sub>0</sub> P <sub>2</sub>	22.12 e	64.77 de	99.93 g
N <sub>1</sub> P <sub>0</sub>	23.43 de	67.01 cde	102.29 f
N <sub>1</sub> P <sub>1</sub>	25.28 bcd	70.97 bcd	106.63 d
N <sub>1</sub> P <sub>2</sub>	25.62 bc	71.94 bcd	104.46 e
N <sub>2</sub> P <sub>0</sub>	22.26 e	65.62 de	96.99 h
N <sub>2</sub> P <sub>1</sub>	26.86 b	77.21 ab	114.20 b
N <sub>2</sub> P <sub>2</sub>	28.77 a	81.27 a	119.05 a
N <sub>3</sub> P <sub>0</sub>	23.82 cde	70.32 bcd	106.83 d
N <sub>3</sub> P <sub>1</sub>	26.12 b	76.25 ab	110.18 c
N <sub>3</sub> P <sub>2</sub>	25.32 bcd	73.57 bc	107.53 d
LSD <sub>(0.05)</sub>	1.913	6.934	1.191
Significance level	0.05	0.05	0.01
CV(%)	5.87	5.98	4.65

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

N<sub>0</sub>: 0 kg N ha<sup>-1</sup> (control), N<sub>1</sub>: 90 kg N ha<sup>-1</sup>, N<sub>2</sub>: 120 kg N ha<sup>-1</sup>, N<sub>3</sub>: 150 kg N ha<sup>-1</sup>

P<sub>0</sub>: 0 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> (control), P<sub>1</sub>: 25 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>, P<sub>2</sub>: 35 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>

#### 4.1.2 Number of effective tillers hill<sup>-1</sup>

Number of effective tillers hill<sup>-1</sup> of BRR1 dhan57 showed statistically significant variation due to different levels of nitrogen (Appendix III and Table 3). The maximum number of effective tillers hill<sup>-1</sup> (16.60) was found from N<sub>2</sub> which were statistically similar (16.47) with N<sub>3</sub>, while the minimum number of effective tillers hill<sup>-1</sup> (12.98) was recorded from N<sub>0</sub> i.e. control condition. BINA (1996) stated that the effect of different levels of nitrogen was significant for number of effective tillers hill<sup>-1</sup>.

Different levels of phosphorous varied significantly in terms of number of effective tillers hill<sup>-1</sup> of BRR1 dhan57 (Appendix III and Table 3). The maximum number of effective tillers hill<sup>-1</sup> (16.37) was obtained from P<sub>2</sub>, which were statistically identical (16.13) with P<sub>1</sub> and the minimum number of effective tillers hill<sup>-1</sup> (13.85) was observed from P<sub>0</sub> i.e. control condition.

**Table 3. Effect of different levels of nitrogen and phosphorous on number of effective & non-effective tillers hill<sup>-1</sup>, filled & unfilled grains panicle<sup>-1</sup> and length of panicle of BRR1 dhan57**

Treatment	Number of effective tiller hill <sup>-1</sup>	Length of panicle (cm)	Number of non effective tiller hill <sup>-1</sup>	Number of filled grain panicle <sup>-1</sup>	Number of unfilled grain panicle <sup>-1</sup>
Levels of nitrogen					
N <sub>0</sub>	12.98 c	20.57b	3.09 a	77.09 b	8.74 a
N <sub>1</sub>	15.76 b	22.11a	3.07 a	89.31 a	5.99 b
N <sub>2</sub>	16.60 a	23.05a	2.27 b	90.66 a	4.91 c
N <sub>3</sub>	16.47 a	22.68a	3.16 a	88.44 a	6.19 b
LSD <sub>(0.05)</sub>	0.688	1.133	0.285	5.416	0.376
Significance level	0.01	0.01	0.01	0.01	0.01
Levels of phosphorous					
P <sub>0</sub>	13.85b	19.76b	2.67 b	75.97 b	8.15 a
P <sub>1</sub>	16.13 a	22.84a	2.90 ab	90.51 a	5.44 c
P <sub>2</sub>	16.37 a	23.70a	3.12 a	92.64 a	5.78 b
LSD <sub>(0.05)</sub>	0.596	0.981	0.247	4.690	0.326
Significance level	0.01	0.01	0.01	0.01	0.01
CV(%)	6.15	5.49	10.06	6.81	5.96

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

N<sub>0</sub>: 0 kg N ha<sup>-1</sup> (control)

N<sub>1</sub>: 90 kg N ha<sup>-1</sup>

N<sub>2</sub>: 120 kg N ha<sup>-1</sup>

N<sub>3</sub>: 150 kg N ha<sup>-1</sup>

P<sub>0</sub>: 0 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> (control)

P<sub>1</sub>: 25 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>

P<sub>2</sub>: 35 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>

Interaction effect of different levels of nitrogen and phosphorus showed significant variation on number of effective tillers hill<sup>-1</sup> of BRR1 dhan57 (Appendix III and Table 4). The maximum number of effective tillers hill<sup>-1</sup> (17.87) was attained from N<sub>2</sub>P<sub>2</sub>, while the minimum number of effective tillers hill<sup>-1</sup> (12.27) was found from N<sub>0</sub>P<sub>0</sub> i.e. control condition.

**Table 4. Interaction effect of different levels of nitrogen and phosphorous on number of effective & non-effective tillers hill<sup>-1</sup>, filled & unfilled grains panicle<sup>-1</sup> and length of panicle of BRRI dhan57**

Treatment	Number of effective tiller hill <sup>-1</sup>	Length of panicle (cm)	Number of non effective tiller hill <sup>-1</sup>	Number of filled grain panicle <sup>-1</sup>	Number of unfilled grain panicle <sup>-1</sup>
N <sub>0</sub> P <sub>0</sub>	12.27 e	17.99 e	2.60 cde	67.83 e	9.77 a
N <sub>0</sub> P <sub>1</sub>	13.07 de	21.49 cd	2.93 bc	76.03 de	7.90 b
N <sub>0</sub> P <sub>2</sub>	13.60 cd	22.22 cd	3.73 a	87.40 bc	8.57 b
N <sub>1</sub> P <sub>0</sub>	14.47 c	21.06 d	2.93 bc	80.63 cd	8.17 b
N <sub>1</sub> P <sub>1</sub>	16.40 b	21.79 cd	3.27 ab	93.13 ab	4.70 def
N <sub>1</sub> P <sub>2</sub>	16.40 b	23.48 bc	3.00 bc	94.17 ab	5.10 de
N <sub>2</sub> P <sub>0</sub>	14.33cd	18.91 e	2.33 de	75.00 de	6.10 c
N <sub>2</sub> P <sub>1</sub>	17.60 ab	24.64 ab	2.33 de	99.73 a	4.40 ef
N <sub>2</sub> P <sub>2</sub>	17.87 a	25.59 a	2.13 e	97.23ab	4.23 f
N <sub>3</sub> P <sub>0</sub>	14.33 cd	21.09 d	2.80 bcd	80.43 cd	8.57 b
N <sub>3</sub> P <sub>1</sub>	17.47 ab	23.45 bc	3.07 bc	93.13 ab	4.77 def
N <sub>3</sub> P <sub>2</sub>	17.60 ab	23.51 bc	3.60 a	91.77 ab	5.23 d
LSD <sub>(0.05)</sub>	1.191	1.962	0.494	9.381	0.651
Significance level	0.05	0.05	0.01	0.05	0.05
CV(%)	6.15	5.49	10.06	6.81	5.96

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

N<sub>0</sub>: 0 kg N ha<sup>-1</sup> (control)

P<sub>0</sub>: 0 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> (control)

N<sub>1</sub>: 90 kg N ha<sup>-1</sup>

P<sub>1</sub>: 25 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>

N<sub>2</sub>: 120 kg N ha<sup>-1</sup>

P<sub>2</sub>: 35 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>

N<sub>3</sub>: 150 kg N ha<sup>-1</sup>

#### 4.1.3 Number of non-effective tillers hill<sup>-1</sup>

Statistically significant variation was recorded for number of non-effective tillers hill<sup>-1</sup> of BRRI dhan57 due to different levels of nitrogen (Appendix III and Table 3). The maximum number of non-effective tillers hill<sup>-1</sup> (3.16) was found from N<sub>3</sub> which were statistically similar (3.09 and 3.07) with N<sub>0</sub> and N<sub>1</sub>, while the minimum number of non-effective tillers hill<sup>-1</sup> (2.27) was recorded from N<sub>2</sub>.

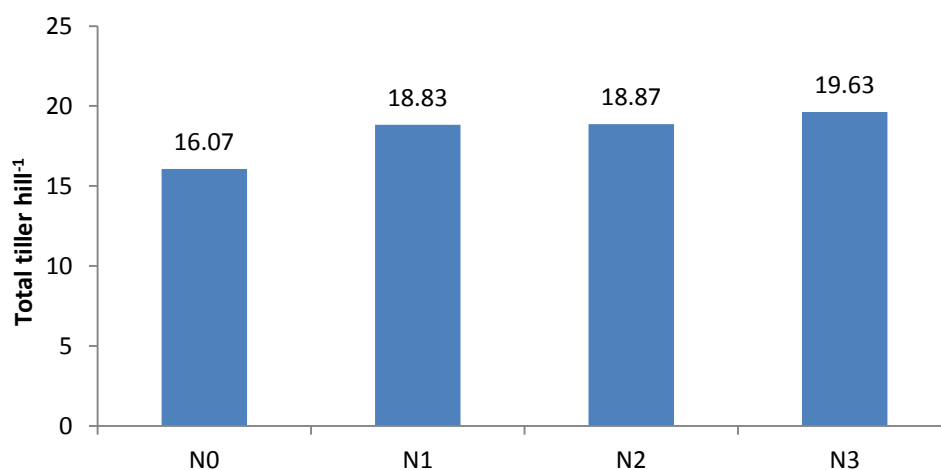
Number of non-effective tillers hill<sup>-1</sup> of BRRI dhan57 varied significantly for different levels of phosphorous (Appendix III and Table 3). The maximum number of non-effective tillers hill<sup>-1</sup> (3.12) was recorded from P<sub>2</sub>, which were statistically identical (2.90) with P<sub>1</sub>, whereas the minimum number of non-effective tillers hill<sup>-1</sup> (2.67) was found from P<sub>0</sub> i.e. control condition.



Interaction effect of different levels of nitrogen and phosphorus showed significant variation on number of non-effective tillers hill<sup>-1</sup> of BRR1 dhan57 (Appendix III and Table 4). The maximum number of non-effective tillers hill<sup>-1</sup> (3.73) was observed from N<sub>0</sub>P<sub>2</sub>, while the minimum number of non-effective tillers hill<sup>-1</sup> (2.13) was observed from N<sub>2</sub>P<sub>2</sub> i.e. control condition.

#### 4.1.4 Number of total tillers hill<sup>-1</sup>

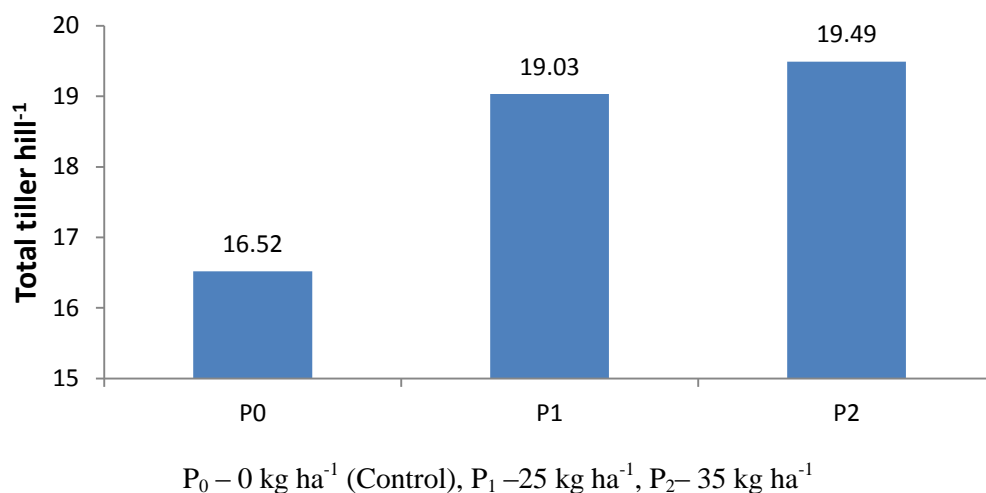
Different levels of nitrogen showed statistically significant variation in terms of number of total tillers hill<sup>-1</sup> of BRR1 dhan57 (Appendix III and Figure 1). The maximum number of total tillers hill<sup>-1</sup> (19.63) was attained from N<sub>3</sub> which were statistically similar (18.87 and 18.83) with N<sub>2</sub> and N<sub>1</sub>. On the other hand, the minimum number of total tillers hill<sup>-1</sup> (16.07) was observed from N<sub>0</sub> i.e. control condition. BINA (1996) stated that the effect of different levels of nitrogen was significant for number of tillers hill<sup>-1</sup>.



N<sub>0</sub> – 0 kg ha<sup>-1</sup> (Control), N<sub>1</sub> –90 kg ha<sup>-1</sup>, N<sub>2</sub>– 120 kg ha<sup>-1</sup>, N<sub>3</sub>– 150 kg ha<sup>-1</sup>

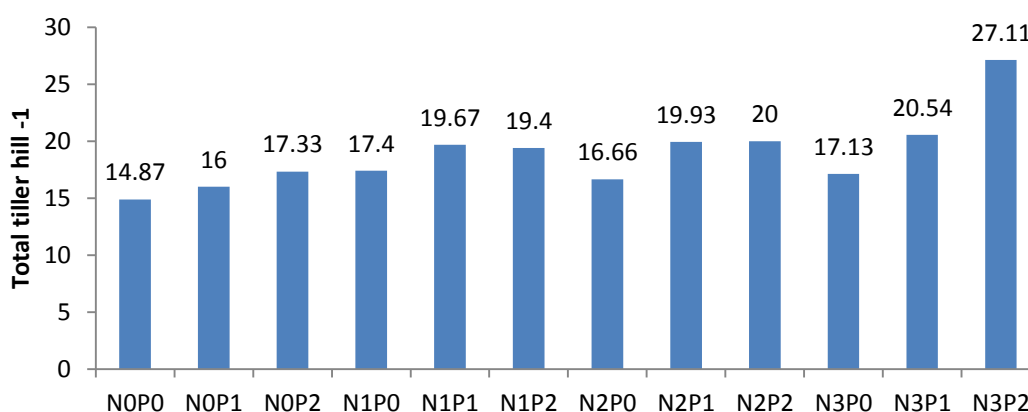
**Figure 1. Effect of nitrogen on the total tiller number hill<sup>-1</sup> of BRR1 dhan57**

Statistically significant variation was observed in terms of number of total tillers hill<sup>-1</sup> of BRR1 dhan57 varied significantly for different levels of phosphorous (Appendix III and Figure 2). The maximum number of total tillers hill<sup>-1</sup> (19.49) was observed from P<sub>2</sub>, which were statistically identical (19.03) with P<sub>1</sub> and the minimum number of total tillers hill<sup>-1</sup> (16.52) was found from P<sub>0</sub> i.e. control condition.



**Figure 2. Effect of phosphorus on the total tiller number hill<sup>-1</sup> of BRR1 dhan57**

Different levels of nitrogen and phosphorus showed significant variation due to their interaction effect of on number of total tillers hill<sup>-1</sup> of BRR1 dhan57 (Appendix III and Figure 3). The maximum number of total tillers hill<sup>-1</sup> (21.20) was obtained from N<sub>3</sub>P<sub>2</sub>, while the minimum number of total tillers hill<sup>-1</sup> (14.27) was found from N<sub>0</sub>P<sub>0</sub> i.e. control condition.



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

N<sub>0</sub>: 0 kg N ha<sup>-1</sup> (control)

N<sub>1</sub>: 90 kg N ha<sup>-1</sup>

N<sub>2</sub>: 120 kg N ha<sup>-1</sup>

N<sub>3</sub>: 150 kg N ha<sup>-1</sup>

P<sub>0</sub>: 0 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> (control)

P<sub>1</sub>: 25 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>

P<sub>2</sub>: 35 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>

**Figure 3. Effect of phosphorus on the total tiller number hill<sup>-1</sup> of BRR1 dhan57**

#### **4.1.5 Length of panicle**

Statistically significant variation was recorded for number length of panicle of BRR I dhan57 due to different levels of nitrogen (Appendix III and Table 3). The longest length of panicle (23.05 cm) was observed from N<sub>2</sub> which were statistically similar (22.11cm and 22.68 cm) with N<sub>1</sub> and N<sub>3</sub>, while the shortest length of panicle (20.57 cm) was found from N<sub>0</sub> i.e. control condition. Mondal and Swamy (2003) found that application of N (120 kg ha<sup>-1</sup>) as urea in equal splits during transplanting, tillering, panicle initiation and flowering resulted in the highest length of panicle.

Length of panicle of BRR I dhan57 varied significantly for different levels of phosphorous (Appendix III and Table 3). The longest length of panicle (23.70 cm) was observed from P<sub>2</sub>, which were statistically identical (22.84 cm) with P<sub>1</sub>, whereas the shortest length of panicle (19.76 cm) was recorded from P<sub>0</sub> i.e. control condition. Das and Sinha (2006) reported that 40 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> give the better performance in relation to length of panicle of rice.

Interaction effect of different levels of nitrogen and phosphorus showed significant variation on length of panicle of BRR I dhan57 (Appendix III and Table 4). The longest length of panicle (25.59 cm) was observed from N<sub>2</sub>P<sub>2</sub> and the shortest length of panicle (17.99 cm) from N<sub>0</sub>P<sub>0</sub> i.e. control condition.

#### **4.1.6 Number of filled grains panicle<sup>-1</sup>**

Statistically significant variation was recorded for number of filled grains panicle<sup>-1</sup> of BRR I dhan57 due to different levels of nitrogen (Appendix III and Table 3). The highest number of filled grains panicle<sup>-1</sup> (90.66) was recorded from N<sub>2</sub> which were statistically similar (89.31 and 88.44) with N<sub>1</sub> and N<sub>3</sub>. On the other hand, the lowest number of filled grains panicle<sup>-1</sup> (77.09) was observed from N<sub>0</sub> i.e. control condition.

Number of filled grains panicle<sup>-1</sup> of BRR I dhan57 varied significantly for different levels of phosphorous (Appendix III and Table 3). The highest number of filled grains panicle<sup>-1</sup> (92.64) was observed from P<sub>2</sub>, which were statistically identical (90.51) with P<sub>1</sub>, while the lowest number of filled grains panicle<sup>-1</sup> (75.97) was observed from P<sub>0</sub> i.e. control condition.

Interaction effect of different levels of nitrogen and phosphorus showed significant variation on number of filled grains panicle<sup>-1</sup> of BRRI dhan57 (Appendix III and Table 4). The highest number of filled grains panicle<sup>-1</sup> (99.73) was observed from N<sub>2</sub>P<sub>1</sub>, whereas the lowest number of filled grains panicle<sup>-1</sup> (67.83) was recorded from N<sub>0</sub>P<sub>0</sub> i.e. control condition.

#### **4.1.7 Number of unfilled grains panicle<sup>-1</sup>**

Statistically significant variation was recorded for number of unfilled grains panicle<sup>-1</sup> of BRRI dhan57 due to different levels of nitrogen (Appendix III and Table 3). The highest number of unfilled grains panicle<sup>-1</sup> (8.74) was observed from N<sub>0</sub> which were closely followed (6.19 and 5.99) by N<sub>3</sub> and N<sub>1</sub>, whereas the lowest number of unfilled grains panicle<sup>-1</sup> (4.91) from N<sub>2</sub> i.e. control condition.

Number of unfilled grains panicle<sup>-1</sup> of BRRI dhan57 varied significantly for different levels of phosphorous (Appendix III and Table 3). The highest number of unfilled grains panicle<sup>-1</sup> (8.15) was obtained from P<sub>0</sub>, which was followed (5.78) by P<sub>2</sub>, while the lowest number of unfilled grains panicle<sup>-1</sup> (5.44) from P<sub>1</sub>.

Interaction effect of different levels of nitrogen and phosphorus showed significant variation on number of unfilled grains panicle<sup>-1</sup> of BRRI dhan57 (Appendix III and Table 4). The highest number of unfilled grains panicle<sup>-1</sup> (9.77) was attained from N<sub>0</sub>P<sub>0</sub> and the lowest number (4.23) from N<sub>2</sub>P<sub>2</sub>.

#### **4.1.8 Weight of 1000-grain**

Statistically significant variation was recorded for weight of 1000- grains of BRRI dhan57 due to different levels of nitrogen (Appendix IV and Table 5). The highest weight of 1000-grains (19.43 g) was observed from N<sub>2</sub> which were statistically similar (19.33 g and 18.68 g) with N<sub>3</sub> and N<sub>1</sub>. On the other hand, the lowest weight of 1000-grains (17.31 g) was found from N<sub>0</sub> i.e. control condition. Mondal and Swamy (2003) found that application of N (120 kg ha<sup>-1</sup>) as urea in equal splits during transplanting, tillering, panicle initiation and flowering resulted in the highest 1000-grain weight.

Weight of 1000- grains of BRR1 dhan57 varied significantly for different levels of phosphorous (Appendix IV and Table 5). The highest weight of 1000- grains (19.63 g) was recorded from P<sub>2</sub>, which were statistically identical (18.95 g) with P<sub>1</sub>, while the lowest weight of 1000-grains (17.50 g) was found from P<sub>0</sub> i.e. control condition.

Interaction effect of different levels of nitrogen and phosphorus showed significant variation on weight of 1000- grains of BRR1 dhan57 (Appendix IV and Table 6). The highest number of unfilled grains panicle<sup>-1</sup> (20.85 g) was observed from N<sub>2</sub>P<sub>2</sub> and the lowest weight of- grains (16.75 g) was recorded from N<sub>0</sub>P<sub>0</sub> i.e. control condition.

#### **4.1.9 Grain yield ha<sup>-1</sup>**

Statistically significant variation was recorded for grain yield ha<sup>-1</sup> of BRR1 dhan57 due to different levels of nitrogen (Appendix IV and Table 5). The highest grain yield (4.56 t ha<sup>-1</sup>) was recorded from N<sub>2</sub> which were statistically similar (4.47 t ha<sup>-1</sup>) with N<sub>3</sub> and closely followed (4.15 t ha<sup>-1</sup>) by N<sub>1</sub>, whereas the lowest grain yield (3.15 t ha<sup>-1</sup>) was observed from N<sub>0</sub> i.e. control condition. Dwibvedi (1997) noticed that application of nitrogen significantly increased in grain yield, straw yield as well as harvest index with 60 kg N ha<sup>-1</sup>. Adhikary and Rhaman (1996) reported that the highest yield obtained from 100 kg N ha<sup>-1</sup> (4.52 t ha<sup>-1</sup>) followed by 120 kg N ha<sup>-1</sup> (4.46 t ha<sup>-1</sup>) and 80 kg N ha<sup>-1</sup> (4.40 t ha<sup>-1</sup>).

Grain yield ha<sup>-1</sup> of BRR1 dhan57 varied significantly for different levels of phosphorous (Appendix IV and Table 5). The highest grain yield (4.25 t ha<sup>-1</sup>) was observed from P<sub>2</sub>, which were statistically identical (4.18 t ha<sup>-1</sup>) with P<sub>1</sub> and the lowest grain yield (3.81 t ha<sup>-1</sup>) was observed from P<sub>0</sub> i.e. control condition. Islam *et al.* (2010) reported that application of P @ 10 kg ha<sup>-1</sup> significantly increased the grain yield but when P was applied @ 20 and 30 kg P ha<sup>-1</sup>, the grain yield difference was not significant.

**Table 5. Effect of different levels of nitrogen and phosphorous on weight of 1000-grains, grain, straw and biological yield of BRR1 dhan57**

Treatment	Weight of 1000 grains (g)	Grain yield (t ha <sup>-1</sup> )	Straw yield (t ha <sup>-1</sup> )	Biological yield (t ha <sup>-1</sup> )
<b>Levels of nitrogen</b>				
N <sub>0</sub>	17.31 b	3.15 c	3.56 c	6.71 c
N <sub>1</sub>	18.68 a	4.15 b	4.57 b	8.72 b
N <sub>2</sub>	19.43 a	4.56 a	4.98 a	9.54 a
N <sub>3</sub>	19.33 a	4.47 a	4.96 a	9.43 a
LSD <sub>(0.05)</sub>	0.989	0.243	0.235	0.421
Significance level	0.01	0.01	0.01	0.01
<b>Levels of phosphorous</b>				
P <sub>0</sub>	17.50 b	3.81 b	4.22 b	8.03 b
P <sub>1</sub>	18.95 a	4.18 a	4.64 a	8.82 a
P <sub>2</sub>	19.63 a	4.25 a	4.69 a	8.94 a
LSD <sub>(0.05)</sub>	0.856	0.211	0.204	0.364
Significance level	0.01	0.01	0.01	0.01
CV(%)	6.25	8.11	5.33	5.66

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

N<sub>0</sub>: 0 kg N ha<sup>-1</sup> (control)

N<sub>1</sub>: 90 kg N ha<sup>-1</sup>

N<sub>2</sub>: 120 kg N ha<sup>-1</sup>

N<sub>3</sub>: 150 kg N ha<sup>-1</sup>

P<sub>0</sub>: 0 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> (control)

P<sub>1</sub>: 25 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>

P<sub>2</sub>: 35 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>

Interaction effect of different levels of nitrogen and phosphorus showed significant variation on grain yield ha<sup>-1</sup> of BRR1 dhan57 (Appendix IV and Table 6). The highest grain yield (4.95 t ha<sup>-1</sup>) was observed from N<sub>2</sub>P<sub>2</sub>, whereas the lowest grain yield (3.07 t ha<sup>-1</sup>) was recorded from N<sub>0</sub>P<sub>0</sub> i.e. control condition.

**Table 6. Interaction effect of different levels of nitrogen and phosphorous on weight of 1000-grains, grain, straw, biological yield and harvest index of BRRIdhan57**

Treatment	Weight of 1000 grains (g)	Grain yield (t ha <sup>-1</sup> )	Straw yield (t ha <sup>-1</sup> )	Biological yield (t ha <sup>-1</sup> )
N <sub>0</sub> P <sub>0</sub>	16.75 e	3.07 e	3.43 e	6.50 f
N <sub>0</sub> P <sub>1</sub>	17.15 e	3.14 e	3.63 e	6.76 f
N <sub>0</sub> P <sub>2</sub>	18.07 cde	3.23 e	3.63 e	6.86 f
N <sub>1</sub> P <sub>0</sub>	17.95 de	3.96 cd	4.36 cd	8.31 de
N <sub>1</sub> P <sub>1</sub>	18.43 b-e	4.21 bcd	4.61 bcd	8.82 cde
N <sub>1</sub> P <sub>2</sub>	19.65 a-d	4.28 bcd	4.74 bc	9.03 cd
N <sub>2</sub> P <sub>0</sub>	17.13 e	3.86 d	4.22 d	8.08 e
N <sub>2</sub> P <sub>1</sub>	20.32 ab	4.87 a	5.33 a	10.20 ab
N <sub>2</sub> P <sub>2</sub>	20.85 a	4.95 a	5.39 a	10.34 a
N <sub>3</sub> P <sub>0</sub>	18.15 cde	4.37 bc	4.87 b	9.24 c
N <sub>3</sub> P <sub>1</sub>	19.88 abc	4.51 ab	5.00 ab	9.52 bc
N <sub>3</sub> P <sub>2</sub>	19.95 abc	4.52 ab	5.01 ab	9.53 bc
LSD <sub>(0.05)</sub>	1.713	0.422	0.408	0.728
Significance level	0.05	0.05	0.01	0.01
CV(%)	6.25	8.11	5.33	5.66

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

N<sub>0</sub>: 0 kg N ha<sup>-1</sup> (control)

N<sub>1</sub>: 90 kg N ha<sup>-1</sup>

N<sub>2</sub>: 120 kg N ha<sup>-1</sup>

N<sub>3</sub>: 150 kg N ha<sup>-1</sup>

P<sub>0</sub>: 0 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> (control)

P<sub>1</sub>: 25 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>

P<sub>2</sub>: 35 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>

#### 4.1.10 Straw yield ha<sup>-1</sup>

Statistically significant variation was recorded for straw yield ha<sup>-1</sup> of BRRRI dhan57 due to different levels of nitrogen (Appendix IV and Table 5). The highest straw yield (4.98 t ha<sup>-1</sup>) was observed from N<sub>2</sub> which were statistically similar (4.96 t ha<sup>-1</sup>) with N<sub>3</sub> and closely followed (4.57 t ha<sup>-1</sup>) by N<sub>1</sub>, while the lowest straw yield (3.56 t ha<sup>-1</sup>) was found from N<sub>0</sub> i.e. control condition. Mondal and Swamy (2003) found that application of N (120 kg ha<sup>-1</sup>) as urea in equal splits during transplanting, tillering, panicle initiation and flowering resulted in the highest straw yield.

Straw yield ha<sup>-1</sup> of BRRRI dhan57 varied significantly for different levels of phosphorous (Appendix IV and Table 5). The highest straw yield (4.69 t ha<sup>-1</sup>) was found from P<sub>2</sub>, which were statistically identical (4.64 t ha<sup>-1</sup>) with P<sub>1</sub> and the lowest straw yield (4.22 t ha<sup>-1</sup>) was recorded from P<sub>0</sub> i.e. control condition.

Interaction effect of different levels of nitrogen and phosphorus showed significant variation on straw yield ha<sup>-1</sup> of BRRRI dhan57 (Appendix IV and Table 6). The highest straw yield (5.39 t ha<sup>-1</sup>) was obtained from N<sub>2</sub>P<sub>2</sub>, whereas the lowest straw yield (3.43 t ha<sup>-1</sup>) was recorded from N<sub>0</sub>P<sub>0</sub> i.e. control condition.

#### 4.1.11 Biological yield ha<sup>-1</sup>

Statistically significant variation was recorded for biological yield ha<sup>-1</sup> of BRRRI dhan57 due to different levels of nitrogen (Appendix IV and Table 5). The highest biological yield (9.54 t ha<sup>-1</sup>) was found from N<sub>2</sub> which were statistically similar (9.43 t ha<sup>-1</sup>) with N<sub>3</sub> and closely followed (8.72 t ha<sup>-1</sup>) by N<sub>1</sub>. On the other hand, the lowest biological yield (6.71 t ha<sup>-1</sup>) from N<sub>0</sub> i.e. control condition.

Biological yield ha<sup>-1</sup> of BRRRI dhan57 varied significantly for different levels of phosphorous (Appendix IV and Table 5). The highest biological yield (8.94 t ha<sup>-1</sup>) was recorded from P<sub>2</sub>, which were statistically identical (8.82 t ha<sup>-1</sup>) with P<sub>1</sub>, while the lowest biological yield (8.03 t ha<sup>-1</sup>) was found from P<sub>0</sub> i.e. control condition.

Interaction effect of different levels of nitrogen and phosphorus showed significant variation on biological yield ha<sup>-1</sup> of BRRRI dhan57 (Appendix IV and Table 6). The highest biological yield (10.34 t ha<sup>-1</sup>) was observed from N<sub>2</sub>P<sub>2</sub>, whereas the lowest biological yield (6.50 t ha<sup>-1</sup>) from N<sub>0</sub>P<sub>0</sub> i.e. control condition.



## 4.2 N, P, K, S and Zn concentration in grain and straw

### 4.2.1 N, P, K, S and Zn concentration in grain

Statistically significant variation was recorded for N, P, K, S and Zn concentration in grain due to different levels of nitrogen (Appendix V and Table 7). The highest N, P, K, S and Zn concentration in grain (0.753%, 0.297%, 0.374%, 0.166% and 0.0205%, respectively) was obtained from N<sub>2</sub>, again the lowest N, P, K, S and Zn concentration in grain (0.494%, 0.240%, 0.247%, 0.107% and 0.0158%, respectively) was observed from N<sub>0</sub> i.e. control condition.

N, P, K, S and Zn concentration in grain varied significantly for different levels of phosphorous (Appendix V and Table 7). The highest N, P, K, S and Zn concentration in grain (0.710%, 0.292%, 0.350%, 0.155% and 0.0196%, respectively) was found from P<sub>2</sub>, whereas the lowest N, P, K, S and Zn concentration in grain (0.612%, 0.239%, 0.285%, 0.125% and 0.0172%, respectively) from P<sub>0</sub>.

**Table 7. Effect of different levels of nitrogen and phosphorous on N, P, K, S and Zn concentrations in grain of BRR1 dhan57**

Treatment	Concentration (%) in grain				
	N	P	K	S	Zn
<b>Levels of nitrogen</b>					
N <sub>0</sub>	0.494 c	0.240 c	0.247 c	0.107 c	0.0158 b
N <sub>1</sub>	0.675 b	0.263 bc	0.315 b	0.138 b	0.0183 ab
N <sub>2</sub>	0.753 a	0.297 a	0.374 a	0.166 a	0.0205 a
N <sub>3</sub>	0.726 a	0.282 ab	0.360 a	0.159 a	0.0200 a
LSD <sub>(0.05)</sub>	0.031	0.031	0.031	0.010	0.003
Significance level	0.01	0.01	0.01	0.01	0.01
<b>Levels of phosphorous</b>					
P <sub>0</sub>	0.612 c	0.239 b	0.285 b	0.125 b	0.0172
P <sub>1</sub>	0.664 b	0.281 a	0.336 a	0.148 a	0.0191
P <sub>2</sub>	0.710 a	0.292 a	0.350 a	0.155 a	0.0196
LSD <sub>(0.05)</sub>	0.027	0.027	0.027	0.008	--
Significance level	0.01	0.01	0.01	0.01	NS
CV(%)	4.79	9.08	10.29	10.47	6.17

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

N<sub>0</sub>: 0 kg N ha<sup>-1</sup> (control)

N<sub>1</sub>: 90 kg N ha<sup>-1</sup>

N<sub>2</sub>: 120 kg N ha<sup>-1</sup>

N<sub>3</sub>: 150 kg N ha<sup>-1</sup>

P<sub>0</sub>: 0 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> (control)

P<sub>1</sub>: 25 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>

P<sub>2</sub>: 35 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>

Interaction effect of different levels of nitrogen and phosphorus showed significant variation on N, P, K, S and Zn concentration in grain (Appendix V and Table 8). The highest N, P, K, S and Zn concentration in grain (0.814%, 0.340%, 0.428%, 0.184% and 0.0226%, respectively) was observed from N<sub>2</sub>P<sub>2</sub> and the lowest N, P, K, S and Zn concentration in grain (0.461%, 0.224%, 0.233%, 0.100% and 0.0153%, respectively) was recorded from N<sub>0</sub>P<sub>0</sub> i.e. control condition.

**Table 8. Interaction effect of different levels of nitrogen and phosphorous on N, P, K, S and Zn concentrations in grain of BRRI dhan57**

Treatment	Concentration (%) in grain				
	N	P	K	S	Zn
N <sub>0</sub> P <sub>0</sub>	0.461 f	0.224 d	0.233 f	0.100 f	0.0153 c
N <sub>0</sub> P <sub>1</sub>	0.495 ef	0.243 cd	0.247 f	0.106 ef	0.0157 c
N <sub>0</sub> P <sub>2</sub>	0.526 e	0.253 cd	0.262 f	0.114 ef	0.0163 bc
N <sub>1</sub> P <sub>0</sub>	0.623 d	0.254 cd	0.285 def	0.124 de	0.0172 abc
N <sub>1</sub> P <sub>1</sub>	0.672 cd	0.256 cd	0.321 cde	0.141 cd	0.0185 abc
N <sub>1</sub> P <sub>2</sub>	0.730 bc	0.279 bcd	0.338 cde	0.149 bc	0.0192 abc
N <sub>2</sub> P <sub>0</sub>	0.673 cd	0.227 d	0.281 ef	0.122 e	0.0170 abc
N <sub>2</sub> P <sub>1</sub>	0.772 ab	0.325 ab	0.413 ab	0.184 a	0.0220 ab
N <sub>2</sub> P <sub>2</sub>	0.814 a	0.340 a	0.428 a	0.191 a	0.0226 a
N <sub>3</sub> P <sub>0</sub>	0.690 c	0.252 cd	0.343 cd	0.151 bc	0.0194 abc
N <sub>3</sub> P <sub>1</sub>	0.718 bc	0.298 abc	0.364 bc	0.161 b	0.0201 abc
N <sub>3</sub> P <sub>2</sub>	0.769 ab	0.297 abc	0.372 bc	0.165 b	0.0205 abc
LSD <sub>(0.05)</sub>	0.054	0.054	0.054	0.017	0.005
Significance level	0.05	0.05	0.05	0.05	0.05
CV(%)	4.79	9.08	10.29	10.47	6.17

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

N<sub>0</sub>: 0 kg N ha<sup>-1</sup> (control)

N<sub>1</sub>: 90 kg N ha<sup>-1</sup>

N<sub>2</sub>: 120 kg N ha<sup>-1</sup>

N<sub>3</sub>: 150 kg N ha<sup>-1</sup>

P<sub>0</sub>: 0 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> (control)

P<sub>1</sub>: 25 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>

P<sub>2</sub>: 35 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>

#### 4.2.2 N, P, K, S and Zn concentration in straw

Statistically significant variation was recorded for N, P, K, S and Zn concentration in straw due to different levels of nitrogen (Appendix VI and Table 9). The highest N, P, K, S and Zn concentration in straw (0.485%, 0.074%, 1.23%, 0.078% and 0.0171%, respectively) was found from N<sub>2</sub>, while the lowest N, P, K, S and Zn concentration in straw (0.410%, 0.055%, 1.01%, 0.067% and 0.0140%, respectively) was recorded from N<sub>0</sub> i.e. control condition.

**Table 9. Effect of different levels of nitrogen and phosphorous on N, P, K, S and Zn concentrations in straw of BRRI dhan57**

Treatment	Concentration (%) in straw				
	N	P	K	S	Zn
<b>Levels of nitrogen</b>					
N <sub>0</sub>	0.410 d	0.055 b	1.01 b	0.067 b	0.0140 c
N <sub>1</sub>	0.438 c	0.065 a	1.19 a	0.073 ab	0.0158 b
N <sub>2</sub>	0.485 a	0.074 a	1.23 a	0.078 a	0.0171 a
N <sub>3</sub>	0.472 b	0.072 a	1.20 a	0.076 ab	0.0167 ab
LSD <sub>(0.05)</sub>	0.010	0.010	0.054	0.010	0.001
Significance level	0.01	0.01	0.01	0.01	0.01
<b>Levels of phosphorous</b>					
P <sub>0</sub>	0.412 c	0.054 b	1.05 b	0.066 b	0.0148 b
P <sub>1</sub>	0.462 b	0.072 a	1.19 a	0.077 a	0.0160 a
P <sub>2</sub>	0.480 a	0.073 a	1.23 a	0.078 a	0.0169 a
LSD <sub>(0.05)</sub>	0.008	0.008	0.046	0.008	0.001
Significance level	0.01	0.01	0.01	0.01	0.01
CV(%)	4.67	12.92	4.77	7.67	8.23

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

N<sub>0</sub>: 0 kg N ha<sup>-1</sup> (control)

N<sub>1</sub>: 90 kg N ha<sup>-1</sup>

N<sub>2</sub>: 120 kg N ha<sup>-1</sup>

N<sub>3</sub>: 150 kg N ha<sup>-1</sup>

P<sub>0</sub>: 0 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> (control)

P<sub>1</sub>: 25 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>

P<sub>2</sub>: 35 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>

N, P, K, S and Zn concentration in straw varied significantly for different levels of phosphorous (Appendix VI and Table 9). The highest N, P, K, S and Zn concentration in straw (0.480%, 0.073%, 1.23%, 0.078% and 0.0169%, respectively) was found from P<sub>2</sub> and the lowest N, P, K, S and Zn concentration in straw (0.412%, 0.054%, 1.05%, 0.066% and 0.0148%, respectively) from P<sub>0</sub> i.e. control condition.

**Table 10. Interaction effect of different levels of nitrogen and phosphorous on N, P, K, S and Zn concentrations in straw of BRR1 dhan57**

Treatment	Concentration (%) in straw				
	N	P	K	S	Zn
N <sub>0</sub> P <sub>0</sub>	0.396 g	0.046 ef	0.99 g	0.058 b	0.0129 e
N <sub>0</sub> P <sub>1</sub>	0.407 g	0.059 def	1.00 g	0.068 ab	0.0140 de
N <sub>0</sub> P <sub>2</sub>	0.428 ef	0.058 def	1.03 fg	0.074 ab	0.0151 cd
N <sub>1</sub> P <sub>0</sub>	0.411 fg	0.063 c-f	1.11 ef	0.074 ab	0.0161 c
N <sub>1</sub> P <sub>1</sub>	0.437 e	0.063c-f	1.21 cd	0.071 ab	0.0152 cd
N <sub>1</sub> P <sub>2</sub>	0.465 d	0.068 bcd	1.26 bc	0.074 ab	0.0161 c
N <sub>2</sub> P <sub>0</sub>	0.397 g	0.045 f	0.95 g	0.062 b	0.0139 de
N <sub>2</sub> P <sub>1</sub>	0.519 b	0.085 ab	1.32 ab	0.086 a	0.0180 ab
N <sub>2</sub> P <sub>2</sub>	0.538 a	0.092 a	1.41 a	0.087 a	0.0194 a
N <sub>3</sub> P <sub>0</sub>	0.442 e	0.064 cde	1.16 de	0.071 ab	0.0162 c
N <sub>3</sub> P <sub>1</sub>	0.484 c	0.079 abc	1.24 bcd	0.083 a	0.0169 bc
N <sub>3</sub> P <sub>2</sub>	0.489 c	0.072 bcd	1.22 cd	0.075 ab	0.0169 bc
LSD <sub>(0.05)</sub>	0.017	0.017	0.093	0.017	0.002
Significance level	0.01	0.01	0.01	0.01	0.05
CV(%)	4.67	12.92	4.77	7.67	8.23

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

N<sub>0</sub>: 0 kg N ha<sup>-1</sup> (control)

N<sub>1</sub>: 90 kg N ha<sup>-1</sup>

N<sub>2</sub>: 120 kg N ha<sup>-1</sup>

N<sub>3</sub>: 150 kg N ha<sup>-1</sup>

P<sub>0</sub>: 0 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> (control)

P<sub>1</sub>: 25 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>

P<sub>2</sub>: 35 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>

Interaction effect of different levels of nitrogen and phosphorus showed significant variation on N, P, K, S and Zn concentration in straw (Appendix VI and Table 10). The highest N, P, K, S and Zn concentration in straw (0.538%, 0.092%, 1.41%, 0.087% and 0.0194%, respectively) was recorded from N<sub>2</sub>P<sub>2</sub>, while the lowest N, P, K, S and Zn concentration in straw (0.396%, 0.045%, 0.99%, 0.058% and 0.0129%, respectively) was found from N<sub>0</sub>P<sub>0</sub> i.e. control condition.

### **4.3 pH, organic matter, total N, available P and exchangeable K in post-harvest soil**

#### **4.3.1 pH**

Statistically significant variation was recorded for pH in post-harvest soil due to different levels of nitrogen (Appendix VII and Table 11). The highest pH (7.04) was observed from N<sub>2</sub> which were statistically similar (6.95 and 6.93) with N<sub>3</sub> and N<sub>1</sub>, whereas the lowest pH (6.69) was found from N<sub>0</sub> i.e. control condition.

pH varied significantly for different levels of phosphorus (Appendix VII and Table 11). The highest pH (7.06) was recorded from P<sub>2</sub>, which were statistically identical (7.02) with P<sub>1</sub> and the lowest pH (6.62) from P<sub>0</sub> i.e. control condition.

Interaction effect of different levels of nitrogen and phosphorus showed significant variation on pH (Appendix VII and Table 12). The highest pH (7.35) was observed from N<sub>2</sub>P<sub>2</sub>, whereas the lowest pH (6.53) from N<sub>0</sub>P<sub>0</sub>.

#### **4.3.2 Organic matter**

Statistically significant variation was recorded for organic matter in post-harvest soil due to different levels of nitrogen (Appendix VII and Table 11). The highest organic matter (1.51%) was found from N<sub>2</sub> which were statistically similar (1.49% and 1.41%) with N<sub>3</sub> and N<sub>1</sub>. On the other hand, the lowest organic matter (1.35%) was recorded from N<sub>0</sub> i.e. control condition.

**Table 11. Effect of different levels of nitrogen and phosphorous on pH, organic matter, total N, available P and exchangeable K of post-harvest soil**

Treatment	pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (me %)
<b>Levels of nitrogen</b>					
N <sub>0</sub>	6.69 b	1.35 b	0.014 c	23.171 c	0.131 c
N <sub>1</sub>	6.93 a	1.41 ab	0.043 b	26.321 b	0.154 b
N <sub>2</sub>	7.04 a	1.51 a	0.054 a	31.501a	0.166 a
N <sub>3</sub>	6.95 a	1.49 a	0.051 ab	28.111 b	0.164 ab
LSD <sub>(0.05)</sub>	0.183	0.120	0.010	2.978	0.010
Significance level	0.01	0.05	0.01	0.01	0.01
<b>Levels of phosphorous</b>					
P <sub>0</sub>	6.62 b	1.32 b	0.033 b	15.651 b	0.139 b
P <sub>1</sub>	7.02 a	1.52 a	0.044 a	32.701 a	0.157 a
P <sub>2</sub>	7.06 a	1.48 a	0.046 a	33.481 a	0.165 a
LSD <sub>(0.05)</sub>	0.183	0.104	0.008	2.579	0.008
Significance level	0.01	0.01	0.01	0.01	0.01
CV(%)	4.73	8.53	15.56	11.17	6.45

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

N<sub>0</sub>: 0 kg N ha<sup>-1</sup> (control)

N<sub>1</sub>: 90 kg N ha<sup>-1</sup>

N<sub>2</sub>: 120 kg N ha<sup>-1</sup>

N<sub>3</sub>: 150 kg N ha<sup>-1</sup>

P<sub>0</sub>: 0 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> (control)

P<sub>1</sub>: 25 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>

P<sub>2</sub>: 35 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>

**Table 12. Interaction effect of different levels of nitrogen and phosphorous on pH, organic matter, total N, available P and exchangeable K of post-harvest soil**

Treatment	pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (me %)
N <sub>0</sub> P <sub>0</sub>	6.56 e	1.33 d	0.009 e	15.031 d	0.124 f
N <sub>0</sub> P <sub>1</sub>	6.76 b-e	1.36 cd	0.018 de	26.601 c	0.129 ef
N <sub>0</sub> P <sub>2</sub>	6.74c-e	1.35 cd	0.017 de	27.871 bc	0.139 def
N <sub>1</sub> P <sub>0</sub>	6.73 c-e	1.30 d	0.040 c	15.001 d	0.145 de
N <sub>1</sub> P <sub>1</sub>	7.03 a-d	1.50 a-d	0.044 bc	31.731 bc	0.152 bcd
N <sub>1</sub> P <sub>2</sub>	7.05 a-c	1.45 a-d	0.047 bc	32.231 b	0.165 abc
N <sub>2</sub> P <sub>0</sub>	6.53 e	1.27 d	0.034 cd	14.401 d	0.136 def
N <sub>2</sub> P <sub>1</sub>	7.23 a	1.62 ab	0.060 ab	39.321 a	0.178 a
N <sub>2</sub> P <sub>2</sub>	7.35 a	1.63 a	0.068 a	40.781 a	0.184 a
N <sub>3</sub> P <sub>0</sub>	6.69 de	1.39 bcd	0.049 bc	18.171 d	0.151 cd
N <sub>3</sub> P <sub>1</sub>	7.07 abc	1.59 abc	0.053 abc	33.141 b	0.170 ab
N <sub>3</sub> P <sub>2</sub>	7.10 ab	1.50 a-d	0.050 bc	33.041 b	0.171 ab
LSD <sub>(0.05)</sub>	0.317	0.207	0.017	5.159	0.017
Significance level	0.05	0.05	0.01	0.01	0.05
CV(%)	4.73	8.53	15.56	11.17	6.45

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

N<sub>0</sub>: 0 kg N ha<sup>-1</sup> (control)

N<sub>1</sub>: 90 kg N ha<sup>-1</sup>

N<sub>2</sub>: 120 kg N ha<sup>-1</sup>

N<sub>3</sub>: 150 kg N ha<sup>-1</sup>

P<sub>0</sub>: 0 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> (control)

P<sub>1</sub>: 25 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>

P<sub>2</sub>: 35 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>

Organic matter varied significantly for different levels of phosphorous (Appendix VII and Table 11). The highest organic matter (1.52%) was observed from P<sub>1</sub>, which were statistically identical (1.48%) with P<sub>2</sub>, whereas the lowest organic matter (1.32%) was found from P<sub>0</sub> i.e. control condition.

Interaction effect of different levels of nitrogen and phosphorus showed significant variation on organic matter (Appendix VII and Table 12). The highest organic matter (1.63%) was observed from N<sub>2</sub>P<sub>2</sub>, while the lowest organic matter (1.33%) was recorded from N<sub>0</sub>P<sub>0</sub> i.e. control condition.

### **4.3.3 Total nitrogen**

Statistically significant variation was recorded for total nitrogen in post-harvest soil due to different levels of nitrogen (Appendix VII and Table 11). The highest total nitrogen (0.053%) was found from N<sub>2</sub> which were statistically similar (0.054%) with N<sub>3</sub> and closely followed (0.051%) by N<sub>1</sub>, whereas the lowest total nitrogen (0.014%) was observed from N<sub>0</sub> i.e. control condition.

Total nitrogen varied significantly for different levels of phosphorous (Appendix VII and Table 11). The highest total nitrogen (0.046%) was observed from P<sub>2</sub>, which were statistically identical (0.044%) with P<sub>1</sub>, while the lowest total nitrogen (0.033%) was observed from P<sub>0</sub> i.e. control condition.

Interaction effect of different levels of nitrogen and phosphorus showed significant variation on total nitrogen (Appendix VII and Table 12). The highest total nitrogen (0.068%) was observed from N<sub>2</sub>P<sub>2</sub>, whereas the lowest total nitrogen (0.018%) was recorded from N<sub>0</sub>P<sub>0</sub> i.e. control condition.

### **4.3.4 Available P**

Statistically significant variation was recorded for available P in post-harvest soil due to different levels of nitrogen (Appendix VII and Table 11). The highest available P (31.51 ppm) was recorded from N<sub>2</sub>. On the other hand, the lowest available P (23.171 ppm) from N<sub>0</sub> i.e. control condition.

Total nitrogen varied significantly for different levels of phosphorous (Appendix VII and Table 11). The highest available P (33.481 ppm) was obtained from P<sub>2</sub>, which were statistically identical (32.701 ppm) with P<sub>1</sub>, while the lowest available P (15.651 ppm) was found from P<sub>0</sub> i.e. control condition.



Interaction effect of different levels of nitrogen and phosphorus showed significant variation on available P (Appendix VII and Table 12). The highest available P (40.781 ppm) was recorded from N<sub>2</sub>P<sub>2</sub>, whereas the lowest available P (14.401 ppm) was recorded from N<sub>0</sub>P<sub>0</sub> i.e. control condition.

#### **4.3.5 Exchangeable K**

Statistically significant variation was recorded for exchangeable K in post-harvest soil due to different levels of nitrogen (Appendix VII and Table 11). The highest exchangeable K (0.166 me%) was found from N<sub>2</sub> which were statistically similar (0.164 me%) with N<sub>3</sub>, while the lowest exchangeable K (0.131 me%) was recorded from N<sub>0</sub> i.e. control condition.

Total nitrogen varied significantly for different levels of phosphorous (Appendix VII and Table 11). The highest exchangeable K (0.165 me%) was found from P<sub>2</sub>, which were statistically identical (0.157 me%) with P<sub>1</sub>, again the lowest exchangeable K (0.139%) was obtained from P<sub>0</sub> i.e. control condition.

Interaction effect of different levels of nitrogen and phosphorus showed significant variation on exchangeable K (Appendix VII and Table 12). The highest exchangeable K (0.184 me%) was found from N<sub>2</sub>P<sub>2</sub> and the lowest exchangeable K (0.124 me%) was observed from N<sub>0</sub>P<sub>0</sub> i.e. control condition.

## CHAPTER V

### SUMMARY AND CONCLUSION

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during July to November, 2013 to study the effect of nitrogen and phosphorus on the growth and yield of BRR1 dhan57. The experiment comprised of two factors- Factor A: Levels of nitrogen (4 levels); N<sub>0</sub>: 0 kg N ha<sup>-1</sup> i.e. control; N<sub>1</sub>: 90 kg N ha<sup>-1</sup>, N<sub>2</sub>: 120 kg N ha<sup>-1</sup>, N<sub>3</sub>: 150 kg N ha<sup>-1</sup>; Factors B: Levels of phosphorous (3 levels)- P<sub>0</sub>: 0 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> i.e. control, P<sub>1</sub>: 25 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> and P<sub>2</sub>: 35 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>. The experiment was laid out in a randomized complete block design (RCBD) with three replications.

Data revealed that at 30, 60 DAT and harvest, the tallest plant (22.60, 80.81 and 115.66 cm, respectively) was recorded from N<sub>2</sub>, whereas the shortest plant (20.98, 61.08 and 82.09 cm, respectively) was found from N<sub>0</sub>. The maximum number of effective tillers hill<sup>-1</sup> (16.60) was found from N<sub>2</sub>, while the minimum number of effective tillers hill<sup>-1</sup> (12.98) was recorded from N<sub>0</sub> treatment. The maximum number of non-effective tillers hill<sup>-1</sup> (3.16) was found from N<sub>3</sub>, while the minimum number of non-effective tillers hill<sup>-1</sup> (2.27) was recorded from N<sub>2</sub> treatment. The maximum number of total tillers hill<sup>-1</sup> (19.63) was attained from N<sub>3</sub> and the minimum number of total tillers hill<sup>-1</sup> (16.07) was observed from N<sub>0</sub>. The longest length of panicle (23.05 cm) was observed from N<sub>2</sub>, while the shortest length of panicle (20.57 cm) was found with N<sub>0</sub>. The highest number of filled grains panicle<sup>-1</sup> (90.66) was recorded from N<sub>2</sub> and the lowest number of filled grains panicle<sup>-1</sup> (77.09) was observed from N<sub>0</sub>. The highest number of unfilled grains panicle<sup>-1</sup> (8.74) was observed from N<sub>0</sub>, whereas the lowest number of unfilled grains panicle<sup>-1</sup> (4.91) with N<sub>2</sub>. The highest number of total grains panicle<sup>-1</sup> (95.57) was recorded from N<sub>2</sub>, while the lowest number of total grains panicle<sup>-1</sup> (85.83) from N<sub>0</sub>. The highest weight of 1000-grains (19.43 g) was observed from N<sub>2</sub> and the lowest weight of 1000-grains (17.31 g) was found from N<sub>0</sub>. The highest grain yield (4.56 t ha<sup>-1</sup>) was recorded from N<sub>2</sub>, whereas the lowest grain yield (3.15 t ha<sup>-1</sup>) was observed from N<sub>0</sub>. The highest straw yield (4.98 t ha<sup>-1</sup>) was observed from N<sub>2</sub>, while the lowest straw yield (3.56 t ha<sup>-1</sup>) was found from N<sub>0</sub>. The highest biological yield (9.54 t ha<sup>-1</sup>) was found from N<sub>2</sub> and the lowest biological yield (6.71 t ha<sup>-1</sup>) from N<sub>0</sub>.

The highest N, P, K, S and Zn concentration in grain (0.753%, 0.297%, 0.374%, 0.166% and 0.0205%, respectively) was obtained from N<sub>2</sub>, again the lowest (0.494%, 0.240%, 0.247%, 0.107% and 0.0158%, respectively) was observed from N<sub>0</sub>. The highest N, P, K, S and Zn concentration in straw (0.485%, 0.074%, 1.23%, 0.078% and 0.0171%, respectively) was found from N<sub>2</sub>, while the lowest (0.410%, 0.055%, 1.01%, 0.0687% and 0.0140%, respectively) was recorded from N<sub>0</sub>. The highest pH (7.04) was observed from N<sub>2</sub>, whereas the lowest pH (6.69) was found from N<sub>0</sub>. The highest organic matter (1.51%) was found from N<sub>2</sub> and the lowest organic matter (1.35%) was recorded from N<sub>0</sub>. The highest total nitrogen (0.054%) was found from N<sub>2</sub>, whereas the lowest total nitrogen (0.014%) was observed from N<sub>0</sub>. The highest available P (31.501 ppm) was recorded from N<sub>2</sub> and the lowest available P (23.171 ppm) was observed from N<sub>0</sub>. The highest exchangeable K (0.166 me%) was found from N<sub>2</sub>, while the lowest exchangeable K (0.131 me%) was recorded from N<sub>0</sub> treatment.

At 30, 60 DAT and harvest, the tallest plant (22.37, 78.12 and 111.64 cm, respectively) were observed from P<sub>2</sub> and the shortest plant (18.85, 59.67 and 80.97 cm, respectively) were observed from P<sub>0</sub>. The maximum number of effective tillers hill<sup>-1</sup> (16.37) was obtained from P<sub>2</sub>, and the minimum number of effective tillers hill<sup>-1</sup> (13.85) was observed from P<sub>0</sub>. The maximum number of non-effective tillers hill<sup>-1</sup> (3.12) was recorded from P<sub>2</sub>, whereas the minimum number of non-effective tillers hill<sup>-1</sup> (2.67) was found from P<sub>0</sub>. The maximum number of total tillers hill<sup>-1</sup> (19.49) was observed from P<sub>2</sub>, and the minimum number of total tillers hill<sup>-1</sup> (16.52) was found from P<sub>0</sub>. The longest length of panicle (23.70 cm) was observed from P<sub>2</sub>, whereas the shortest length of panicle (19.76 cm) was recorded from P<sub>0</sub>. The highest number of filled grains panicle<sup>-1</sup> (92.64) was observed from P<sub>2</sub>, while the lowest number of filled grains panicle<sup>-1</sup> (75.97) was observed from P<sub>0</sub>. The highest number of unfilled grains panicle<sup>-1</sup> (8.15) was obtained from P<sub>0</sub>, while the lowest number of unfilled grains panicle<sup>-1</sup> (5.44) was found from P<sub>1</sub>. The highest number of total grains panicle<sup>-1</sup> (98.42) was observed from P<sub>2</sub>, whereas the lowest number of total grains panicle<sup>-1</sup> (84.12) was observed from P<sub>0</sub>. The highest weight of 1000- grains (19.13 g) was recorded from P<sub>2</sub>, while the lowest weight of 1000-grains (17.50 g) was found from P<sub>0</sub>. The highest grain yield (4.25 t ha<sup>-1</sup>) was observed from P<sub>2</sub>, and the lowest grain yield (3.81 t ha<sup>-1</sup>) was observed from P<sub>0</sub>. The highest straw yield (4.69 t ha<sup>-1</sup>) was found from P<sub>2</sub> and the lowest straw yield (4.22 t ha<sup>-1</sup>) was recorded from P<sub>0</sub>. The highest biological yield

(8.94 t ha<sup>-1</sup>) was recorded from P<sub>2</sub>, while the lowest biological yield (8.03 t ha<sup>-1</sup>) was found from P<sub>0</sub>.

The highest N, P, K, S and Zn concentration in grain (0.710%, 0.292%, 0.350%, 0.155% and 0.0196%, respectively) was found from P<sub>2</sub>, whereas the lowest (0.612%, 0.239%, 0.285%, 0.125% and 0.0172%, respectively) was attained from P<sub>0</sub>. The highest N, P, K, S and Zn concentration in straw (0.480%, 0.073%, 1.23%, 0.078% and 0.0169%, respectively) was found from P<sub>2</sub> and the lowest (0.412%, 0.054%, 1.05%, 0.066% and 0.0148%, respectively) was obtained from P<sub>0</sub>. The highest pH (7.06) was recorded from P<sub>2</sub>, and the lowest pH (6.62) was found from P<sub>0</sub>. The highest organic matter (1.52%) was observed from P<sub>1</sub>, whereas the lowest organic matter (1.32%) was found from P<sub>0</sub>. The highest total nitrogen (0.046%) was observed from P<sub>2</sub>, while the lowest total nitrogen (0.033%) was observed from P<sub>0</sub>. The highest available P (33.481 ppm) was obtained from P<sub>2</sub>, while the lowest available P (15.651 ppm) was found from P<sub>0</sub>. The highest exchangeable K (0.165 me%) was found from P<sub>2</sub>, again the lowest exchangeable K (0.139%) was obtained from P<sub>0</sub>.

At 30, 60 DAT and harvest, the tallest plant (28.77, 81.27 and 119.05 cm, respectively) were observed from N<sub>2</sub>P<sub>2</sub> whereas, the shortest plant (18.13, 60.90 and 87.75 cm, respectively) were recorded from N<sub>0</sub>P<sub>0</sub>. The maximum number of effective tillers hill<sup>-1</sup> (17.87) was attained from N<sub>2</sub>P<sub>2</sub>, while the minimum number of effective tillers hill<sup>-1</sup> (12.27) was found from N<sub>0</sub>P<sub>0</sub> i.e. control condition. The maximum number of non-effective tillers hill<sup>-1</sup> (3.73) was observed from N<sub>0</sub>P<sub>2</sub>, while the minimum number of non-effective tillers hill<sup>-1</sup> (2.13) was observed from N<sub>2</sub>P<sub>2</sub>. The maximum number of total tillers hill<sup>-1</sup> (21.20) was obtained from N<sub>3</sub>P<sub>2</sub>, while the minimum number of total tillers hill<sup>-1</sup> (14.87) was found from N<sub>0</sub>P<sub>0</sub>. The longest length of panicle (25.59 cm) was observed from N<sub>2</sub>P<sub>2</sub> and the shortest length of panicle (17.99 cm) from N<sub>0</sub>P<sub>0</sub> i.e. control condition. The highest number of filled grains panicle<sup>-1</sup> (99.73) was observed from N<sub>2</sub>P<sub>1</sub>, whereas the lowest number of filled grains panicle<sup>-1</sup> (67.83) was recorded from N<sub>0</sub>P<sub>0</sub>. The highest number of unfilled grains panicle<sup>-1</sup> (9.77) was attained from N<sub>0</sub>P<sub>0</sub> and the lowest number of unfilled grains panicle<sup>-1</sup> (4.23) was recorded from N<sub>2</sub>P<sub>2</sub>. The highest number of total grains panicle<sup>-1</sup> (104.13) was observed from N<sub>2</sub>P<sub>1</sub>, while the lowest number of total grains panicle<sup>-1</sup> (77.60) was recorded from N<sub>0</sub>P<sub>0</sub>. The maximum weight of 1000 grains (20.85 g) was observed from N<sub>2</sub>P<sub>2</sub> and the lowest weight of- grains (16.75 g) was recorded from

$N_0P_0$ . The highest grain yield ( $4.95 \text{ t ha}^{-1}$ ) was observed from  $N_2P_2$ , whereas the lowest grain yield ( $3.07 \text{ t ha}^{-1}$ ) was recorded from  $N_0P_0$ . The highest straw yield ( $5.39 \text{ t ha}^{-1}$ ) was obtained from  $N_2P_2$ , whereas the lowest straw yield ( $3.43 \text{ t ha}^{-1}$ ) was recorded from  $N_0P_0$ . The highest biological yield ( $10.34 \text{ t ha}^{-1}$ ) was observed from  $N_2P_2$ , whereas the lowest biological yield ( $6.50 \text{ t ha}^{-1}$ ) from  $N_0P_0$ .

The highest N, P, K, S and Zn concentration in grain (0.814%, 0.340%, 0.428%, 0.191% and 0.0226%, respectively) was observed from  $N_2P_2$  and the lowest N (0.461%, 0.224%, 0.233%, 0.100% and 0.0153%, respectively) was recorded from  $N_0P_0$ . The highest N, P, K, S and Zn concentration in straw (0.538%, 0.092%, 1.41%, 0.087% and 0.0194%, respectively) was recorded from  $N_2P_2$ , while the lowest (0.396%, 0.046%, 0.99%, 0.058% and 0.0129%, respectively) was found from  $N_0P_0$ . The highest pH (7.35) was observed from  $N_2P_2$ , whereas the lowest pH (6.53) was obtained from  $N_0P_0$ . The highest organic matter (1.63%) was observed from  $N_2P_2$ , while the lowest organic matter (1.27%) was recorded from  $N_0P_0$ . The highest total nitrogen (0.068%) was observed from  $N_2P_2$ , whereas the lowest total nitrogen (0.009%) was recorded from  $N_0P_0$ . The highest available P (40.78 ppm) was recorded from  $N_2P_2$ , whereas the lowest available P (14.03 ppm) was recorded from  $N_0P_0$ . The highest exchangeable K (0.184 me%) was found from  $N_2P_2$  and the lowest exchangeable K (0.124 me%) from  $N_0P_0$ .

### **Conclusion**

It was revealed that application of  $120 \text{ kg N ha}^{-1}$  &  $35 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$  was more potential in regarding yield and yield contributing characters of BRRI dhan57.

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

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional compliance and other performances.
2. More experiments may be carried out with other organic, inorganic and also micro nutrients.

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## APPENDICES

**Appendix I. Monthly record of air temperature, relative humidity, rainfall, and sunshine (average) of the experimental site during the period from July to November 2013**

Month (2013)	Air temperature (°c)		Relative humidity (%)	Rainfall (mm)	Sunshine (hr)
	Maximum	Minimum			
July	36.0	24.6	83	563	3.1
August	36.0	23.6	81	319	4.0
September	34.8	24.4	81	279	4.4
October	26.5	19.4	81	22	6.9
November	25.8	16.0	78	00	6.8

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

**Appendix II. Analysis of variance of the data on plant height of BRRIdhan57 as influenced by different levels of nitrogen and phosphorous**

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm) at				
		30 DAT	45 DAT	60 DAT	75 DAT	Harvest
Replication	2	0.875	2.140	1.049	4.826	0.595
Levels of nitrogen (A)	3	46.532**	160.313**	222.221**	161.817**	389.041**
Levels of phosphorus (B)	2	46.306**	130.149**	178.774**	240.724**	328.217**
Interaction (A×B)	6	4.078*	13.158*	27.489*	50.437*	76.078*
Error	22	1.276	4.351	10.220	16.770	33.576

\*\* : Significant at 0.01 level of probability:

\* : Significant at 0.05 level of probability

**Appendix III. Analysis of variance of the data on effective, non-effective & total tillers plant<sup>-1</sup>, length of panicle, filled, unfilled and total grains of BRRIdhan57 as influenced by different levels of nitrogen and phosphorous**

Source of variation	Degrees of freedom	Mean square						
		Effective tiller hill <sup>-1</sup>	Non-effective tiller hill <sup>-1</sup>	Total tiller hill <sup>-1</sup>	Length of panicle (cm)	Number of filled grains panicle <sup>-1</sup>	Number of unfilled grains panicle <sup>-1</sup>	Number of total grains panicle <sup>-1</sup>
Replication	2	0.003	0.014	0.004	0.948	10.672	0.023	11.591
Levels of nitrogen (A)	3	25.684**	1.589**	21.966**	10.783*	352.375**	23.740**	197.387**
Levels of phosphorus (B)	2	23.203**	0.608**	30.674**	51.530*	987.093**	26.106**	700.892**
Interaction (A×B)	6	1.251*	0.347*	2.223*	4.467*	78.248*	1.152**	68.356*
Error	22	0.495	0.085	0.677	1.343	30.690	0.148	31.079

\*\* : Significant at 0.01 level of probability:

\* : Significant at 0.05 level of probability



**Appendix IV. Analysis of variance of the data on weight of 1000 grains, grain, straw & biological yield and harvest index of BRRIdhan57 as influenced by different levels of nitrogen and phosphorous**

Source of variation	Degrees of freedom	Mean square			
		Weight of 1000 grains (g)	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)
Replication	2	0.014	0.000	0.033	0.035
Levels of nitrogen (A)	3	8.491**	3.762**	4.002**	15.516**
Levels of phosphorus (B)	2	14.239**	0.651**	0.806**	2.904**
Interaction (A×B)	6	2.556*	0.194*	0.221**	0.827*
Error	22	1.023	0.062	0.058	0.185

\*\* : Significant at 0.01 level of probability:

\* : Significant at 0.05 level of probability

**Appendix V. Analysis of variance of the data on N, P, K, S and Zn concentration in grain of BRRIdhan57 as influenced by different levels of nitrogen and phosphorous**

Source of variation	Degrees of freedom	Mean square				
		Nutrient concentration in grain (%)				
		N	P	K	S	Zn
Replication	2	0.0001	0.0001	0.0001	0.0001	0.0001
Levels of nitrogen (A)	3	0.122**	0.005**	0.029**	0.006**	0.0001**
Levels of phosphorus (B)	2	0.029**	0.009**	0.014**	0.003**	0.0001**
Interaction (A×B)	6	0.003**	0.002**	0.003**	0.001**	0.0001**
Error	22	0.001	0.001	0.001	0.000	0.00001

\*\* : Significant at 0.01 level of probability:

\* : Significant at 0.05 level of probability

**Appendix VI. Analysis of variance of the data on N, P, K, S and Zn concentration in straw of BRRIdhan57 as influenced by different levels of nitrogen and phosphorous**

Source of variation	Degrees of freedom	Mean square				
		Nutrient concentration in straw (%)				
		N	P	K	S	Zn
Replication	2	0.0001	0.0001	0.003	0.0001	0.0001
Levels of nitrogen (A)	3	0.010**	0.001**	0.090**	0.0001**	0.0001**
Levels of phosphorus (B)	2	0.015**	0.001**	0.104**	0.001**	0.0001**
Interaction (A×B)	6	0.002**	0.0001**	0.032**	0.0001**	0.0001**
Error	22	0.0001	0.0001	0.003	0.0001	0.00001

\*\* : Significant at 0.01 level of probability:

\* : Significant at 0.05 level of probability

**Appendix VII. Analysis of variance of the data on pH, organic matter, total N, available P and exchangeable K of post-harvest soil of BRRIdhan57 as influenced by different levels of nitrogen and phosphorous**

Source of variation	Degrees of freedom	Mean square				
		pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (me %)
Replication	2	0.017	0.005	0.0001	5.066	0.0001
Levels of nitrogen (A)	3	0.205	0.049	0.003**	109.092**	0.002**
Levels of phosphorus (B)	2	0.296	0.128	0.001**	1218.149**	0.002**
Interaction (A×B)	6	0.093	0.050	0.0001**	34.215**	0.000**
Error	22	0.335	0.115	0.0001	9.282	0.000

\*\* : Significant at 0.01 level of probability:

\* : Significant at 0.05 level of probability