STUDIES ON RESPONSE OF NITROGEN LEVELS ON GROWTH, YIELD AND N USE EFFICIENCY OF DIFFERENT RICE CULTIVARS IN *VERTISOL*

M.Sc. (Ag.) THESIS

by

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INDIRA GANDHI KRISHI VISHWAVIDYALAYA
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Thesis

Submitted to the

Indira Gandhi Krishi Vishwavidyalaya, Raipur

by

SUKRITI

IN PARTIAL FULFILMENT OF THEREQUIREMENTS FOR THEDEGREE OF

Master of Science
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Roll No. 20131417322 I.D. No. 120118216

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CERTIFICATE - I

This is to certify that the thesis **"Studies on response of nitrogen levels on growth, yield and N use efficiency of different rice cultivars in *Vertisol*"** submitted in partial fulfillment of the degree of **Master of Science in Agriculture** of the Indira Gandhi Krishi Vishwayidyalaya, Raipur, is a record of the bonafide research work carried out by **Sukriti** under my guidance and supervision. The subject of the thesis has been approved by student's Advisory Committee and Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma or certificate course. All the assistance and help received during the course of the investigations have been duly acknowledged.

Date: 05.12.2020

Chairman

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

Chairman (Dr. Anurag) _____

Member (Dr. L.K.Srivastava) _____ 05/12/2020

Member (Dr. H.L. Sonboir) _____

Member (Dr. R.R. Saxena) _____

CERTIFICATE- II

This is to certify that the thesis entitled **"Studies on response of nitrogen levels on growth, yield and N use efficiency of different rice cultivars in *Vertisol*"** submitted by **Sukriti** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur, in partial fulfillment of the requirements for the degree of Master of science in Agriculture in the Department of Soil Science and Agricultural Chemistry has been approved by the external evaluator and Student's Advisory Committee after oral examination, ***under the chairmanship of Head of the Department.***

Date 05/03/2021

Signature of Head of the Department

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Major Advisor _____

Faculty Dean _____

Approved/ Not approved

Director of Instruction _____

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Sukriti

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Date:

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LIST OF ABBREVIATIONS

Abbreviations	Description	Abbreviations	Description
%	Percent	m^{-2}	Per metre square
@	At the rate	No.	number
a.i.	Active ingredient	NS	Non-significant
B:C	Benefit cost ratio	d.f.	Degree of freedom
CD	Critical difference	etc.	Etcetera
Day^{-1}	Per day	q	Quintal
t ha^{-1}	Ton per hectare	Rs	Rupees
^oC	Degree Celsius	SEm+	Standard error of mean
DAS	Days after sowing	Rs ha^{-1}	Rupees per hectare
et al.	And other/ co-worker	viz.	For example
Fig	Figure	N	Nitrogen
ha	Hectare	P	Phosphorus
ha^{-1}	Per hectare	K	Potassium
HI	Harvest index	S	Significant
hr	Hours	G	Grain
i.e.	That is	FYM	Farm yard manure
kg	Kilogram	OC	Organic corbon
kmph	Kilometre per hour	mm	millimetre
cm	Centimeter	m	Metre
cm^2	Centimetre square	L	Litre
max.	Maximum	min.	minimum
g	Gram		

THESIS ABSTRACT

a) Title of the Thesis"	"Studies on response of nitrogen levels on growth, yield and N use efficiency of different rice cultivars in *Vertisol*".
b) Full Name of the Student:	Sukriti
c) Major Subject	Soil Science and Agricultural Chemistry
d) Name and Address of the Major Advisor	Dr. Anurag Professor College of Agriculture, Raipur (C.G.)
e) Degree to be awarded	Master of Science in Agriculture "(Soil Science and Agricultural Chemistry)"

"Signature of the Student"

"Signature of Major Advisor"

Date: 09/12/2020

"Signature of Head of the Department

ABSTRACT

The present investigation entitled **"Studies on response of nitrogen levels on growth, yield and N use efficiency of different rice cultivars in *Vertisol*"** was conducted during *kharif* season of 2019 at the research cum instructional farm of Indira Gandhi krishiVishwavidyalaya, Raipur, Chhattisgarh. Field experiment was laid down in split-plot design and treatments allocated randomly nitrogen levels (N0, N50 and N100 kg ha^{-1} in main plots and in sub plots 10 rice cultivars Viz; CNN-1,CNN-2, CNN-3,CNN-4, CNN-5, RASI, MTU-1010, BCV-1, VARDHAN, TI93 and replicated thrice. Soil and plant samples were collected yield and yield attributing characteristics of rice crop and analyzed various physico chemical properties of soil.

The experimental soil was clayey in texture with pH (7.3), EC (0.42 ds m^{-1}), OC (0.49 %), available N (144 kg ha^{-1}), available P (13.26 kg ha^{-1}) and available K (372kg ha^{-1}). Results of field experiment shown that yield and yield contributing characters of different rice varieties were significantly impacted by levels of applied nitrogen, grain and straw yield ranged from 29.99 to 54.09 q ha^{-1}& 40.31 to 61.14 q ha^{-1} from control (N_0) to applied 100 kg N ha^{-1} respectively. Among the different rice varieties BCV-1 produced highest grain and straw yield (54.86 and 66.75 q ha^{-1}) and lowest (44.89 and 35.39 q ha^{-1})was found under TI93 cultivar respectively.

The number of tillers m^{-2}, number of panicles m^{-2}, grains $panicle^{-1}$, and test weight" were found highest in rice variety BCV-1(404.56, 292.22, 211.78, 25.95) followed by VARDHAN (398.44, 281.67, 201.67, 24.67) under applied 100 kg N ha^{-1} and lowest found under cultivar TI93 (365.56, 215.56, 149.33, 16.64), respectively. Nitrogen, Phosphorus & Potassium content in grain and straw of rice cultivars were found non-significant with levels of applied nitrogen.

Nitrogen levels showed significant effect on N, P and K uptake by rice cultivars. The highest nitrogen, phosphorus and potassium uptake (kg ha^{-1}) was recorded by rice cultivar BCV-1, (92.29, 16.72 & 119.85 kg ha^{-1}) and the lowest found under cultivar TI93 (45.44, 8.14, 71.40 kg ha^{-1}) under 100 kg of applied N ha^{-1}.Incresed nutrient uptake due to higher nutrient availability which resulted in higher dry mass production and yield parameters of rice crop.

The overall efficiency of nitrogen uptake (%), agronomic efficiency of N (kg grain kg^{-1} N) and physiological efficiency (kg biomass kg^{-1} N uptake) decreased with increasing levels of applied nitrogen from 50 to 100 kg N ha^{-1}. Among the rice cultivars, highest NUE (%) 42.14 was recorded by MTU-1010 and the lowest 22.96 by CNN-2 respectively. Highest agronomic N use efficiency 25.61 kg grain kg^{-1} N and lowest 15.26 kg grain kg^{-1} N were obtained by rice cultivars CNN-3 and TI93, respectively. Highest physiological efficiency 121.09 and lowest 65.72 kg biomass kg^{-1}N uptake were recorded by rice cultivars CNN-2 and MTU-1010 respectively.

In post harvest analysed soil samples after rice crop,soil pH, EC and organic carbon were not significantly influenced with levels of applied nitrogen,

whereas the available nitrogen, phosphorus and potassium in soil increased significantly over control. The highest available N (201 kg ha^{-1}), available P (15.13 kg ha^{-1}) and available K (487.68 kg ha^{-1}) were observed under 100 kg N ha^{-1} level of applied nitrogen. Different cultivars of rice did not show any significant effect with respect to changes in pH, EC and organic carbon, available nitrogen, phosphorus and potassium in soil.

As per the above findings, 100 kg N ha^{-1} level of applied nitrogen performed best yield and growth parameters of rice cultivars and among different rice cultivars, BCV-1 produced maximum yield followed by VARDHAN, MTU-1010, CNN-1 and CNN5.

शोध सारांश

अ)	शोध का शीर्षक	:	"नाइट्रोजन स्तर केप्रयोग का विश्नि धान किस्मों के वृद्धि, उत्पादन एवं नाइट्रोजन उपयोग दक्षताका वर्टिसोल पर आधारित अध्ययन"
ब)	छात्र का पूरा नाम	:	सुकृति
स)	मुख्य विषय	:	मृदा विज्ञान एवं कृषि रसायन
द)	मुख्य सलाहकार का नाम एवं पता	:	डॉ. अनुराग प्राध्यापक कृषि महाविद्यालय, रायपुर (छ.ग.)
इ)	उपाधि का नाम	:	स्नातकोत्तर (कृषि), "मृदा विज्ञान एवं कृषि रसायन"

छात्र के हस्ताक्षर

मुख्य सलाहकार के हस्ताक्षर

दिनॉकः 09/12/2020

विभागाध्यक्ष के हस्ताक्षर

सरांश

वर्तमान शोध अध्ययन**"नाइट्रोजन स्तर के प्रयोग का विश्नि धान किस्मों के वृद्धि, उत्पादन एवं नाइट्रोजन उपयोग दक्षता का वर्टिसोल पर आधारित अध्ययन"**शीर्षक से इंदिरा गाँधी कृषि विश्वविद्यालय; (IGKV) रायपुर; (C.G.).के अनुसंधान और निर्देशात्मक प्रक्षेत्र में 2019 खरीफ सीजन के दौरान आयोजित किया गया था। स्प्लिट–प्लॉट डिजाइन में प्रयोग को निर्धारित किया गया था और उपचारों में अव्यवस्थित ढंग से आवंटित किया गया था, मुख्य भूखंडों में नाइट्रोजन के स्तर ;(N0, N50 और N100 किलोग्राम नाइट्रोजन/हेक्टेयर)और 10 धान की किस्में CNN-1, CNN-2, CNN-3, CNN-4, CNN-5, RASI, MTU-1010, BCV-1, VARDHAN, TI93 को तीन प्रतिकृति के साथ उप भूखंडों में षामिल है। मिट्टी और पौधों के नमूनों को एकत्र किया गया और धान की फसल और मिट्टी के विभिन्न भौतिक रासायनिक गुणों के कारण उपज और उपज वर्णित गुणों का विश्लेषण किया गया।

प्रयोग स्थल की मिट्टी पीएच (7.3), विद्युत चालकता (0.42 ds m^{-1}), जैविक कार्बन (0.49 %), उपलब्ध नाइट्रोजन (144 किलोग्राम/हेक्टेयर), उपलब्ध फास्फोरस (13.26 किलोग्राम/हेक्टेयर) और उपलब्ध पोटैशियम 372 (किलोग्राम/हेक्टेयर) प्राप्त हुए। क्षेत्र प्रयोग के परिणामों से पता चला है कि विभिन्न धान किस्मों के मापदंडों के कारण उपज और उपज वर्णित गुण,नाइट्रोजन के स्तर से काफी प्रभावित थे, अनाज और पुआल की उपज 29.99 से 54.09 (क्विंटल/ह0) और 40.31 से 61.14 (क्विंटल/ह0) क्रमशः नियंत्रण (N0) से 100 किग्रा0नाइट्रोजन/हे0 लागू करने के लिए तक थी। विभिन्न धान किस्मों में बीसीवी–1 (54.86 और 66.75 क्विंटल/ह0) में सबसे अधिक अनाज और पुआल की पैदावार हुई और सबसे कम क्रमशः टीआई93 किस्म (35.38 और 44.89 क्विंटल/ह0) के तहत पाया गया।

धान की किस्मबीसीवी–1 (404.56, 292.22, 211.78, 25.95) उसके बाद वर्धन (398.44, 281.67, 201.67, 24.67) में टिलर की संख्या/मिटर^2, पैनिकल्स की संख्या/मिटर^2, अनाज/पैनिकल, और 1000 दानो का वजन लागू 100 किग्रा0नाइट्रोजन/हे0 के तहत अधिक पाए गए और सबसे कम टीआई93 (365.56, 215.56, 149.33, 16.64) में क्रमशः है। धान की खेती के अनाज और पुआल में नाइट्रोजन, फास्फोरस और पोटैशियम सामग्री को लागू नाइट्रोजन के स्तर के साथ गैर–महत्वपूर्ण पाया गया।

नाइट्रोजन, फास्फोरस और पोटैशियम के अनुप्रयोग ने धानमें महत्वपूर्ण प्रभाव दिखाया। धान की किस्मों बीसीवी–1, (92.29, 16.72, 119.85 किग्रा/ह0) और टीआई93(45.44, 8.14, 71.40 किग्रा/ह0) के साथ उच्चतम और निम्नतम एन, पी और केअवशोषण (किग्रा/ह0) देखे गए। 100 किग्रा0नाइट्रोजन/हे0 उपचार के तहत, चावल की फसल के बेहतर विकास और पैदावार मापदंडों के कारण वृद्धि हुई, जिसके परिणामस्वरूप फसल का अधिक सूखा उत्पादन हुआ।

धान की किस्में से नाइट्रोजन, फास्फोरस और पोटैशियम अवशोषण पर नाइट्रोजन के स्तर ने महत्वपूर्ण प्रभाव दिखाया। धान की किस्म बीसीवी–1,(92.29, 16.72 और 119.85 किग्रा/ह0) द्वारा उच्चतम नाइट्रोजन, फास्फोरस और पोटेशियम अवशोषण (किग्रा/ह0) और सबसे कम टीआई93(45.44, 8.14, 71.40 किग्रा है), लागू 100 किलोग्राम नाइट्रोजन/ह0 के तहत पाए गए। उच्च पोषक तत्व की उपलब्धता के कारण पोषक तत्वों की अवशोषण मात्रा बढ़ जाती है, जिसके परिणामस्वरूप धान की फसल का शुष्क उत्पादन और उपज मापदंड अधिक होता है।

संपूर्ण नाइट्रोजन का उपयोग दक्षता (%),कृषि नाइट्रोजन उपयोग दक्षता (किग्रा अनाज/किग्रा नाइट्रोजन) और शारीरिक दक्षता (किग्रा बायोमास/किग्रा नाइट्रोजन अवशोषण) 50 से 100 किग्रा0नाइट्रोजन/हे0 में बढ़ते नाइट्रोजन स्तर के साथ कम हो गया। धान की किस्म में सबसे ज्यादा नाइट्रोजन उपयोग दक्षता (%), एमटीयू-1010 (42.14 %) और क्रमशः सीएनएन–2 (22.96 %) सबसे कम दर्ज किया गया। धान की किस्म सीएनएन–3 (25.61 किग्रा0 अनाज/किग्रा0 नाइट्रोजन) और टीआई93 (15.26 किग्रा0 अनाज/किग्रा0 नाइट्रोजन) द्वारा सबसे अधिक और सबसे कम कृषि नाइट्रोजन उपयोग दक्षता पाए गए। धान की किस सीएनएन–2 (121.09) और एमटीयू-1010 (65.72) द्वारा सबसे अधिक और सबसे कम शारीरिक दक्षता (किग्रा बायोमास/ किग्रा नाइट्रोजन अवशोषण) पाए गए।

धान की फसल के कटाई बाद के मिट्टी के नमूनों का विश्लेषण किया गया, मृदा पीएच, ईसी और कार्बनिक कार्बन लागू नाइट्रोजन के स्तर से काफी प्रभावित नहीं थे, जबकि मिट्टी में उपलब्ध नाइट्रोजन, फास्फोरस और पोटेशियम नियंत्रण पर काफी बढ़ गए। उपलब्ध नाइट्रोजन (201 किग्रा/हे0), उपलब्ध फास्फोरस (15.13 किग्रा/हे0) और उपलब्ध पोटेशियम (487.68 किग्रा/हे0) का उच्चतम मूल्य लागू नाइट्रोजन के 100 किग्रा0नाइट्रोजन/हे0 स्तर के तहत देखा गया। मिट्टी में पीएच, ईसी और कार्बनिक कार्बन, उपलब्ध नाइट्रोजन, फास्फोरस और पोटेशियम पर विभिन्न धान की किस्मों का कोई महत्वपूर्ण प्रभाव नहीं देखा गया था

उपरोक्त निष्कर्षों के अनुसार, लागू नाइट्रोजन के स्तर 100 किग्रा0नाइट्रोजन/हे0 का धान की किस्मों पर सर्वोत्तम उपज और वृद्धि के मापदंडों का प्रदर्शन किया और विभिन्न धान की किस्मों के बीच, बीसीवी–1 का अधिकतम उपज प्राप्त हुआ, उसके बाद वर्धमान, एमटीयू–1010, सीएनएन–1 और सीएनएन–5।

CHAPTER -I

INTRODUCTION

Rice is the most important and widely grown food crop known as "National Grain" due to its use as the primary staple food in about 100 countries worldwide. In over a hundred nations, rice is grown and is the primary food for half of the world 's population. Rice supplies 32-59 percent of the dietary energy and 25-44 percent of the dietary protein in 39 nations. India has the largest rice area in Asia, 43.77 million ha, representing 29.4 percent of the global rice area, and a production record of 116.42 million tonnes during 2018-19 (Annual report, Department of Agriculture, Co-operation & Farmers Welfare, 2018-19) and accounted for providing 70% of people direct jobs in rural areas. The productivity of rice in India is still low as compared to other major rice producing countries. Rice occupies an area of.3.7 mha, in Chhattisgarh with 834.67million tonnes of production and an average productivity of 2177kgha^{-1} (Department of Agriculture, Raipur, 2018-19).

Over the past few decades, rice production has increased, mainly because of the introduction of high yielding varieties, the increase in irrigated areas, and the use of chemical fertilizers. However, the rate of increase in rice yields is stagnant and sustainable technologies are necessary for moving the yield ceiling upwards. Nitrogen (N) is the primary input and main plant nutrient for increasing crop production and the most yield-limiting nutrient in rice (*Oryza sativa* L.) cropping system worldwide.The role of chemical fertilizer is well known for maximizing the yield levels of different crops and cropping systems. The effectiveness of nitrogen and phosphorus fertilizers in rice is rarely greater than 40 and 20 per cent, respectively due to losses of nutrients in various forms from soil system. Applied nitrogen through urea not efficiently used by rice crops and large quantities of added nitrogen are lost from rice fields (Mikkelsen *et al.,* 1978).

Nitrogen (N) is the critical nutrient for the development of rice and its absorption is influenced by the varieties of rice, the climate, soil conditions, crop rotation, etc. During the vegetative stage, rice plants need N to encourage tillering and growth, which in turn determines the potential number of panicles. Nitrogen

contributes to the development of spikelets during the early stage of panicle formation and, during the late stage of panicle formation, contributes to sink size. Nitrogen also plays a role in grain filling, improving photosynthetic ability and facilitating the accumulation of carbohydrates in culms and leaf sheaths (Mae, 1997, Artacho *et al*., 2009).In varietal improvement plays an important role in rising yields of rice. Increases in rice production rely on the availability of high yielding varieties (Wahab *et al*., 1998). Varieties vary in their productivity-impact performance. (Harbir *et al.*,1998) stated that, compared to short-term cultivars, in India, medium-duration rice cultivars gave maximum value to grain yield and its components. Rice hybrids over inbred varieties have a mean yield advantage of 10-15 percent increased growth rates (Abdalla *et al*., 2012). The productivity of crop plant nitrogen usage can be expressed rather simply as the nitrogen yield per unit of usable nitrogen and affected mainly by two processes , efficiency of absorption to extract N from the soil and the efficiency of utilization to pass nitrogen to the grain mainly present as protein. (Sachiko *et al.*, 2009)

N use efficiency (NUE), defined as the ratio of grain yield to supplied N, is a key parameter for evaluating a crop cultivar and consists of the efficiency of N uptake and N physiological use efficiency (De Macale and Velk, 2004). N uptake efficiency is the accumulation of N relative to its source, while N physiological use efficiency represents grain yield relative to the accumulation of nitrogen (Moll et al., 1982).Although it is difficult to calculate the amount of N available from soil and fertilizer, grain yields can be used to determine the NUE, and high NUE cultivars can be identified in the same experimental conditions by their ability to produce higher grain yields than others (Ladha *et al*., 1998). As PNN in rice could improve the growth and increase grain yield, theoretically it should increase NUE, but this relationship still has to be varied, (Duan *et al*., 2007).

The quality of the nitrogen used is only 30 percent to 50 percent, and even less than that percentage in certain cases. The efficient use of nitrogen is recognized as an effective production factor for rice, but it has always been a problem to increase the rice plant's utilization rate and increase the productivity of absorbed nitrogen for grain production. Since nitrogen fertilizer is expensive and its use varies from variety to variety, it is necessary to determine the physiology

and performance of varieties. (Haque *et al.*, 2016).A decrease in NUE crops with increasing N fertilization has been observed (Fageria *et al*., 2001).

In view of the above facts the present experiment entitled, **"Studies on response of nitrogen levels on growth, yield and N use efficiency of different rice cultivars in *Vertisol*"** was carried out with the following objectives.

Objectives:

- To study the effect of applied nitrogen levels on yield and yield attributing characters of rice cultivars.
- Estimation of N,P, K content, uptake and N use efficiency of rice cultivars under varied nitrogen levels.

CHAPTER –II

REVIEW OF LITERATURE

In this chapter, an attempt has been made to review available literature on topic entitled **"Studies on response of nitrogen levels on growth, yield and N use efficiency of different rice cultivars in *Vertisol*"**carried out by various researchers in India and abroad and discussed under the following heads:

2.1 Effect of nitrogen levels on yield and attributing characters

2.2 Effect of nitrogen levels on nutrient content, uptake and nitrogen utilization efficiency

2.1 Effect of nitrogen levels on yield and attributing characters

Shivay *et al.* (2003), studied the effect of planting geometry and N levels on the growth, yield characteristics and yield of the 'PRH 10' fragrant hybrid rice variety. They stated the features of yield,yields and nitrogen-use effectiveness were not affected by planting geometry. However, each enhance in the level of N the unit led to a significant increase on yield and yield attributing characteristics of rice yield and reported the highest grain yield (65.5 q ha-1) with maximum level of applied N @ 75 $kgha^{-1}$, and subsequently lowest with the highest in applied fertilizer N levels.

Singh and Singh(2003)reported that increasing nitrogen levels application significantly increased the number of effective tillers $hill^{-1}$, length of panicle, weight of panicle, straw,grain yields and uptake of nitrogen of rice crop and observed the significant decline in agronomic nitrogen use efficiency.

Manzoor *et al*. (2006) conducted experiment to find out the most suitable nitrogen amount to achieve the highest rice yield of the Super Basmati rice variety. This experiment examined the effect of nine various N levels, i.e. 0, 50, 75,100,125,150,175,200 and 225 $kgha^{-1}$, on rice yield and yield parameters. Height of the plant , number of productive tillers $hill^{-1}$, length of the panicles, number of grains $panicle^{-1}$, The 1000 grains weight and yield of paddy showed an growing pattern from 0 kg N ha^{-1} to 175 kg N ha^{-1}. The yield parameters began to decrease at 200 kg N ha^{-1}level and above, including rice yield, number of grains

panicle^{-1} and test weight. Total rice yield (4.24 t ha^{-1}) was obtained from treatment with 175 kg N ha^{-1} of nitrogen application, which also provided the highest number of grains panicle^{-1} (130.2) along with a highest weight of 1000 grains (22.92g). The overall plant height (139.8 cm) was 225 kg N ha^{-1}, along with the number of active tillers hill^{-1} (23.42) and panicle length (29.75 cm).

Bharadwaj *et al*. (2007) conducted experiments to evaluate the effect of fifteen fertilizer dose combinations in two rice varieties (one hybrid and one inbred) on the yield. They reported that the yield of grain and straw was substantially higher in the PSD-1 hybrid rice cultivar compared to the Saket-4 inbred cultivar. And the greater grain yield (5.5 t ha^{-1}) registered in hybrid rice cultivar PSD-1 with T13 treatment (N 200 P 34.4 K 66.6 Zn 10 kg ha^{-1}) while the inbred cultivar Saket-4 recorded the highest yield with T9 treatment (N 150 P 34.4 K 66.6 Zn 10 kg ha^{-1}).

Zaidi *et al*. (2007) conducted an experiment to assess the impact of doses of applied N, viz. 0, 50, 100 and 150 Kg N ha^{-1} on yield of hybrid rice cultivars (PHB-71, KRH-2, NDRH-2).They found application of N, resulted significant greater in grain yield, straw yield, paniclesm^{-2} and weight of panicle with every enhance in N levels up to 150 kg Nha^{-1}.

Gautam *et al.* (2008) conducted experiment with three varieties (PRH-10, Pusa Sugandh-3 and Pusa Basmati-1), and three N levels (0, 80 and 160 kg N ha^{-1}). They noted that the most of the yield attributing parameters, the substantially greater yield of grain, PRH-10 over Pusa Sugandh-3 and Pusa Basmati-1 was caused by substantial developed.The 160 kg N ha^{-1} application reported 23.7 and 26.1 percent more grain yield over no nitrogen application, while 6.4 and 6.1 percent more than 80 kg N ha^{-1} were reported.

Hossain *et al*. (2008) assessed the effect of different levels of nitrogen on the output of four gynotypes of rice, during the transplanted aman (monsoon) season. BRRI dhan38, Kalizira, Badshabhog, and Tulsimala were included in the aromatic rice varieties, while nitrogen was added at 30, 60, 90 and 120 kg ha^{-1}. The output of various varieties was distinct. Due to range, all the yield attributing parameters differed significantly. The maximum number of grains panicle^{-1} was produced (135.90) by Kalizira.BRRI dhan 38 gave the maximum grain yield (4.00

t ha^{-1}) among the varieties. The aromatic rice varieties were also significantly affected by distinct nitrogen rates. All components of the yield were substantially increased to 90 kg N ha^{-1}. The higher grain yield (3.62 t ha^{-1}) of 60 kg N ha^{-1} was nevertheless observed. In addition, the plant characteristics and yield parameters of aromatic rice were influenced by the combination of varieties and nitrogen values, which ultimately affected the yield, and the BRRI dhan 38 variety was found to be more sensitive to nitrogen in combination to produce better yields.

Maksoud *et al*.(2008)studied the effect of N fertilization levels and splits on the growth and yield of three cultivars of rice viz; Giza 178, Sakha 103 and Sakha 104. Two nitrogen fertilizer levels 40 and 60 kg were split and applied at two, three, and four equal doses. The reported that the rice cultivars differed in their growth, grain yield and yield components and found rice cultivar Sakha 103 was the superior followed by Sakha 104. Increasing nitrogen fertilization levels from 40 to 60 kg N/fad increased the most yield components which led to significant enhance in grain yield/fad and also rice grain quality was improved significantly with increasing nitrogen fertilizer level and N splitting showed significant increase on yield and yield attributes.

Banerjee *et al*. (2011) studied the response planting geometry and different applied nitrogen levels on hybrid rice and significant yield increases and different yield contributing characteristics were recorded, viz. Number of successful tillers m^{-2}, panicle length, $panicle^{-1}$ filled grains and 1000 grain weight, with an increase in nitrogen concentrations from 50 to 150 kg ha^{-1}.

Metwally *et al*. (2011) conducted a field experiment at the Rice Research and Training Center, Sakha, Kafer El-Sheikh, Egypt during the 2008 and 2009 growing seasons and the studied nitrogen response was 0, 50, 100, 150, 200, 250, 300, 350, and 400 kg N ha^{-1} on the yield, uptake and N use efficiency of Egyptian hybrid rice 1'H1'. The grain yield was substantially increased by nitrogen fertilization and the highest grain yield was obtained by applying 200 kg N ha^{-1}. Parameters of yield have also been substantially affected by N treatments.

Abdalla *et al.* (2012) conducted two field experiments (RRTC)-Sakha, kafr-El Sheikh, Governorate, Egypt in (2010) and (2011) seasonal forecasting of some rice varieties (Sakha 106, Sakha 105, GZ 7565, GZ 9075 and GZ 9362) under

different N levels [0, 55, 111, 165 and 220 (Kg ha^{-1}) and the leaf area index, chlorophyll content, tillers number m^{-2} test weight, number of grains $panicle^{-1}$, panicle length (cm) and grain yield (t ha^{-1}).The highest value of applied nitrogen was found to be @ 220 kg N ha^{-1} for the rice cultivar Sakha 106, whereas 0 Nwith GZ.9362 reported the minimum value for all the characteristics under study.

Sharma *et al*. (2012) conducted a field experiment at Research Farm of College of Agriculture,Kaul (Kaithal) HAU,Hissar during *kharif* season of 2010 on clay loam alkaline soil, with four rice cultivars (CSR-30, HKR03-408, Pusa Basmati-1 and Pusa Basmati-1121) and six nitrogen levels and reported highest grain yield of cultivar Pusa basmati-1121 than all other cultivars and observed increasing nitrogen and phosphorus levels significantly increased yield and all the crop growth characters viz. plant height, tillers m^{-2}, dry matter accumulation and found maximum @ 90 kg ha^{-1} of applied nitrogen.

Srilatha *et al.* (2013) studied the production capacity of rice varieties at different nitrogen levels, during the seasons, the 2007 and 2008 *kharif* and the 2007 and 2008 *rabi* seasons at Jagtial. The results showed that the JGL-1798, JGL-11470 and JGL-3855 varieties were equally superior in terms of straw and grain yields during *Kharif* 2007.Varieties JGL-11470 and JGL-3855 showed significantly higher grain and straw yields than other varieties evaluated during *kharif* 2008. During *rabi* 2007-08, variety JGL-3855 reported significantly higher grain yield and uptake of nitrogen over other varieties. In response to applied nitrogen, up to 100 % RDN (100 kg N ha^{-1}), during *kharif* 2008 and up to 150 % RDN (180 kg N ha^{-1}) were observed during the *rabi* seasons of 2007-08 and 2008-09, respectively.

Islam *et al.*(2014) studied the effect of N fertilizer application and variety on the growth and yield of the Aman rice transplant. In the experiment, four varieties were used. BRRI dhan33, BRRI dhan34, BRRI dhan39 and BRRI dhan46, respectively, as well as four N levels. 1pellet (0.9 g) of USG/4 hills of 2 adjacent rows (30 kg N ha^{-1}) was applied to 10 DAT and 2pellets of USG (0.9 g each) were applied to 10 DAT and 2 pellets of USG (0.9 g each) were applied to 10 DAT and 2 pellets of USG (0.9 g each) were applied to 10 DAT and the other two adjacent rows (60 kg N ha^{-1}) at 45 DAT/4 hills. The results of the experiment

showed that there was a significant effect on the yield and yield characteristics of the Aman rice transplant on the variety and levels of application of nitrogen. Two USG/4 hill pellets supplying 60 kg N ha^{-1} were observed at maturity in the tallest plant (122.60 cm) and the highest number of total $hill^{-1}$ tillers (12.72), respectively. BRRI dhan34 was used to obtain the highest number of tillers $hill^{-1}$ (10.08), while the lowest number (9.88) was obtained from BRRI dhan34. BRRI dhan46, BRRI dhan46 (4.56 t ha^{-1}). The highest grain yield and BRRI dhan34 yielded the lowest yield (3.27 t ha^{-1}). The interaction shows that the maximum grain yield (5.61 t ha^{-1}) was obtained with two USG pellets (0.9 g each) applied at 10 DAT and 45 DAT respectively from the BRRI dhan46 treatment combination.

Jisan *et al*. (2014) reported that the yield production of certain transplant varieties was reported to be affected by different levels of N for aman rice. Four varieties were included in the test i.e. BRRI dhan49, BRRI dhan52, BRRI dhan56, BRRI dhan57 respectively, and four phases of N viz. 0, 46, 60 and 75 kg ha^{-1}, respectively. The yield attributing parameters and yield of aman rice transplants were significantly affected by variety, N levels and their relationship. The tallest plant developed by BRRI dhan52 was (117.20 cm), the maximum number of effective tillers $hill^{-1}$ (11.28), grain $panicle^{-1}$ (121.5) and test weight (23.65 g) among the varieties, while the minimum values of these parameters were provided by BRRI dhan57. The maximum yield of grain (5.69 t ha^{-1}) was obtained from BRRI dhan52, followed by BRRI dhan49 (5.15 t ha^{-1}) and the minimum was obtained from BRRI dhan57575 (4.25 t ha^{-1}).In the case of N, 75 kg N ha^{-1} were obtained from the longest plant (111.70 cm), the maximum total number of $tillershill^{-1}$(12.34), grains $panicle^{-1}$ (133.6), test weight (24.55 g) and grain yield (5.64 tha^{-1}) and the lowest values were obtained from the monitor. For all the parameters studied, BRRI dhan52 fertilized with 75 kg Nha^{-1} showed the better results.

Malik *et al.*(2014)evaluated response of different nitrogen levels to the growth and yield characteristics of various cultivars Basmati Rice (*Oryza Sativa* L.) Haryana Basmati-1, Basmati-370 and Pusa basmati-1 varieties at three various fertility levels: 100, 120 and 140 at the Allahabad Institute of Agriculture for Crop

Research Farm (Deemed University).They reported that at nitrogen level -120, Pusa Basmati-1 differs significantly from all measured parameters including plant height number of tillers hill^{-1}, dry weight, panicle length , number of filled grains panicle^{-1}, straw yield, biological yield, harvest index, benefit cost ratio and grain yield of 4.66 t ha^{-1} at nitrogen level-120, 3.10 t ha^{-1}atN level -120 were highest and lowest in Pusa basmati-1 and Basmati-370 respectively.

Sharma *et al*. (2014) conducted a field experiment to study the effect of N levels on yield parameters of basmati rice cultivars at farm of basmati export development foundation (BEDF) during *kharif* 2012-13. They reported significant positive effect of applied nitrogen and was equally superior in terms of tillers hill^{-1}, grains panicle^{-1} , grain and straw yield. They recorded highest number of panicle m^{-2} with 160 kg N ha^{-1} however differences in filled grains panicle^{-1} and yield between 160 kg N ha^{-1} (44.68 q ha^{-1}) and 120 kg N ha^{-1} (43.53 q ha^{-1}) were statistically at par. Among varieties maximum values of yield (43.89 q ha^{-1}) and yield attributing traits was registered with Pusa Sugandha-5.

Khatri *et al*. (2015) conducted a field experiment during the year 2013-14 for response of various nitrogen levels viz. 0, 60, 80, 100 and 120 N kg ha^{-1}on rice genotypes viz. Madhyamdhan, IR-87707-446-BBB, UPLRI-5, IR-83383-B-B-1293 and IET-16775 under rainfed condition at National Rice Research Program, Hardinath, Dhanusha. They reported significant effect of applied levels of N on grain yield of rice in both years and observed genotypes only during 2013-14. The interaction effect of genotype and N levels was found non-significant in both years.Among tested rice cultivars Madhyamdhan recorded highest grain yield 4.09 t ha^{-1} and 3.45 t ha^{-1} during years 2013-14 and 2014-15 and produced the maximum grain yield of 4.63 t ha^{-1} of applied N @ 100 kg ha^{-1}.

Shukla *et al*.(2015) studied the performance of rice varieties and relation to N level under irrigated conditions at the, JNKVV, Rewa M.P. during *kharif* season, comprising three levels of nitrogen (40, 80 and 120 kg ha^{-1}) on rice varieties viz; Aditaya, Dantensavari, IET 21288, Jaldidhan, Varalu, IET 21296, and IET 21278. They found that 120 kg N ha^{-1} significantly higher to 40 kg N and produced highest grain yield (49.88 q ha^{-1}), straw yield (93.10 q ha^{-1}). Among

different rice varieties, Dantensavari with applied 120 N kgha^{-1}produced highest grain yield (58.39 q ha^{-1}), followed by IET 21278 (56.78 q ha^{-1}) .

Chowdhury *et al*. (2016)studied that the effect of N levels and variety on the yield output of fine aromatic rice. Three varieties were used in the experiment, viz. Kalizira, Binadhan-13 and dhan34 BRRI, and six nitrogen levels, viz. USG 1.8 g 4 hills^{-1} (55 kg ha^{-1}) and USG 2.7 g 4 hills^{-1} (80 kg Nha^{-1}) . 0, 30, 60, 90 kg N ha^{-1}. The yield of aromatic rice was significantly affected by variety, nitrogen level and their interaction. Binadhan-13 yielded the maximum yield of grain (3.33 tha^{-1}), followed by BRRI dhan34 (3.16 tha^{-1}) and Kalizira yielded the minimum yield of grain (2.11 tha^{-1}). In the case of N, when fertilized with USG 1.8 g 4 hills^{-1}, the tallest plant (140.3 cm), the maximum number of successful tillers hill^{-1} (11.40), grains panicle^{-1} (152.8) and grain yield (3.32 t ha^{-1}) were found and the minimum values were found at 0 kg N ha^{-1}.Consequently, Binadhan-13 fertilized with USG 1.8 g 4 hills^{-1} (55 kg N ha^{-1}) appeared to be the promising grain yield practice.

Djaman *et al*. (2016)evaluated the effect of N levels (0, 60, 90, 120 and 150 kg ha^{-1}) with P (26 kg P ha^{-1}); or P-K (26 kg P ha^{-1} and 50 kg K ha^{-1}) with the aromatic rice varieties Pusa Basmati, Sahel 329, Sahel 177 and Sahel 328 and the non-aromatic rice varieties Sahel 108 in the 2012 hot and dry season and in the 2012 rainy season in Ndiaye and Fanaye (Senegal).Rice yields across genotypes ranged from 3.3 to 8.6 Mg ha^{-1} under N-P fertilizer and from 3.5 to 8.8 Mg ha^{-1} under N-P-K fertilizer at Ndiaye, they recorded. At Fanaye, the yield of rice under N-P fertilizer ranged from 3.7 to 8.6 Mg ha^{-1}and under N-P - K fertilizer from 3 to 10.3 Mg ha^{-1}. Among the aromatic rice varieties, Sahel 177 obtained the maximum grain yield. The optimal dose of nitrogen varies with the genotype and position of rice.

Haque *et al.* (2016) conducted a field experiment during 2014 with applied levels of nitrogen 0, 20, 40, 60, 80 and 100 kg ha^{-1} for new rice variety (BUdhan 1). They reported that growth of the new rice variety favored at maximum levels of applied N although it flattened at 80 and 100 kg N ha^{-1} and the highest yield of grain (5.36 t·ha^{-1}) registered with fertilized 60 kg N ha^{-1} and concluded that

application of the intermediate level of N was economical and environmentally-friendly for the cultivation of new rice variety.

Kumar *et al*. (2017) conduced a field experiment in the Shiwalik foothills area of the North-Western Himalayas under aerobic conditions, with sixteen treatment combinations including varieties of rice, viz. V1: PR-115, V2: DRRH-3, V3: PAC-837 and V3: PR-121 and stages of fertility, i.e. F1: power (N0P0K0) ,F2: N, P_2O_5, K_2O 90: 45: 22.5 kg ha^{-1}, F3: N, P2O5, K2O 120:60:30 kg ha^{-1}, F4: N, P2O5, K2O 150: 75: 37.5 kg ha^{-1}. They reported that among the different varieties, PAC-837 reported the maximum grain yield of 45.65 q ha^{-1} and 59.98 q ha^{-1} straw yield, plant height and number of tillers m^{-2} at all stages of development. All attributes of yield, viz. In various varieties, the number of effective tillers m^{-2}, the number of seeds $panicle^{-1}$, test weight, spikelet sterility and grain yield, straw yield and harvest index varied significantly and were registered at the maximum level with DRRH-3 in PAC-837 except for grain yield and effective tillers m^{-2}.

Rajesh *et al*. (2017) conducted a field experiment and studied the response of rice varieties to morpho-physiological and yields under two-nitrogen levels 120 $kgha^{-1}$ [N120], 60 kg N ha^{-1} [N60], as key treatments and twenty-six sub-treatment genotypes of rice varieties. They reported that the 120 kg N ha^{-1} dose applied registered significantly higher morpho-physiological parameter values, such as the number of tillers/hill.SCMR values, photosynthetic rate and also resulted in the higher number of panicles/hill, number of filled grains $hill^{-1}$, percentage of filled grain, test weight and grain yield, while spikelet sterility and number of $hill^{-1}$ unfilled grains found highest. Among the genotypes, MTU-1001 reported the highest grain yield of 5021 kg ha^{-1} at 60 kg N ha^{-1} applied @ level

Saha *et al*. (2017)carried out an experiment with three levels of nitrogen: 30, 60 and 90 kg ha^{-1}on rice cultivars namely, V1= MTU7029, V2= ANNADA, V3= KHANDAGIRI, V4= SATABDI and V5= GS-3during *kharif* seasons of 2008 under terai region of West Bengal. They reported that among the cultivars, maximum grain yield (3.56) was produced by V1 (MTU-7029) followed by Khandagiri (3.45) Annada (3.38) and GS-3 (3.11). Cultivars MTU-7029 produced higher (4.72) straw yield which was statistically at par with Khandagiri (4.58) and

Annada (4.56). Cultivars MTU-7029 registered highest values (42.67) of harvest index which was followed by Khandagiri (42.00) and Annada (41.33).90 kg dose of applied N ha^{-1}produced maximum number of tillers (255.20, 280.06, 244.64 and 214.10 at 20 DAT, 40 DAT, 60 DAT and at harvest respectively. 1000 grain weight was higher (28.32) in MTU-7029 and found non significant with Annada and Khandagiri.

2.2Effect of nitrogen levels on nutrient content, uptake and nitrogen utilization efficiency

Shivay *et al.* (2003) conducted a field experiment to study the impact of planting geometry and levels of nitrogen on growth and N-use efficiencies of scented hybrid rice 'PRH 10' during the rainy *kharif* season (July-October) of 2000 and 2001 at IARI, New Delhi. N-use efficiency (NUE), apparent recovery (percent), N efficiency ratio (NER) and physiological efficiency (PEIN) were reported to be significantly higher at low N levels and decreased significantly, with N levels increasing.

Kumar *et al.*(2004) studied to the effect of N levels and sources on the concentration and absorption of nitrogen, the high yielding variety Pusa 834 and the hybrid rice PRH3. N concentrations remained lower in hybrid PRH 3 than in Pusa 834, but N absorption was significantly higher in hybrid PRH 3. N fertilization by rice increased both nitrogen concentration and nitrogen uptake. Nitrogen uptake was greater in Pusa 834 at 30 days after transplantation (DAT), but substantially greater in Pusa 834 than in Pusa 834 at 60 DAT and hybrid PRH 3 at harvest. In both Pusa 834 and hybrid PRH 3, the use of neem oil blended urea (PNGU) and neem coated urea (NCU) enhanced nitrogen concentration and rice uptake. For rice, the use of neem coated / mixed urea is recommended.

Zaidi *et al*. (2007) studied the effect of N levels viz. 0, 50, 100 and 150 Kg Nha^{-1} on N utilization efficiency (NUE) of hybrid rice cultivars PHB-71, KRH-2, NDRH-2, and inbred check NDR-359. They observed that application of nitrogen significantly increased nitrogen uptake with every increase in levels of N up to 150 kg N ha^{-1}while agronomical efficiency (AE) was higher with 100Kg Nha^{-1} and physiological efficiency (PE) with 50Kg Nha^{-1} and among rice cultivars the highest N uptake, agronomical efficiency and physiological efficiency

was obtained with cultivar PHB-71 followed by NDRH-2 and minimum under NDR-359 respectively, any variation in doses caused significant reduction in AE and PE.

Artacho *et al*. (2009) carried out field experiments in the major rice growing area of Chile in two sites with applied six nitrogen levels i.e.,0, 50, 100, 150, 200, and 300 kg N ha^{-1}on uptake of nitrogen, and efficiency of N use in rice cultivar 'Diamante'.They reported that nitrogen use efficiency decreased with N fertilization for biomass and production of grain, and yield of grain per unit of grain N whereas agronomic N use efficiency and N harvest index were not affected. They found that cultivar 'Diamante' would correspond to a higher nitrogen use efficiency genotype for grain yield.

Mahajan *et al*. (2010) conducted field experiment and evaluated levels of nitrogen (0, 20, and 60 kg N ha^{-1}) for greater productivity and NUE of modern aromatic rice varieties. They reported that the highest mean N-fertilizer response at 40 kg $ha^{-1}$of applied nitrogen dose as compared to other N levels and observed that across all genotypes further enhance in nitrogen level had no effect on crop response to fertilizer. Among cultivars, interaction effect between N levels and varieties, 'Punjab Mehak 1' rice cultivar responded significantly up to 60 kg N ha^{-1} due to more NUE and maximum uptake of nitrogen as compared to 'Pusa 1121' and 'Punjab Basmati 2'. They concluded that cultivars differences in NUE existed in aromatic rice gynotypes; therefore, NUE of different cultivars could be a useful tool to adopt the appropriate cultural practices for achieving N response exploration.

Metwally *et al*. (2011) conducted a field experiment, to evaluate the response of Egyptian hybrid rice 1 'H1' to different levels of applied nitrogen 0, 50, 100, 150, 200, 250, 300, 350, and 400 kg Nha^{-1}. They reported that enhance the N level to 200 kg N ha^{-1}improved the efficiency of N usage. In addition, increasing the levels of N decreased the efficiency of nitrogen usage.

Iqbal *et al*. (2014) observed response of different doses of nitrogen application viz.,0, 40, 80, 120 and 160 kg ha^{-1},on rice cultivars BRRI dhan49, BR7870-5*(Nils)-2-HR2 and BRRI hybrid dhan4at Bangladesh Rice Research Institute (BRRI)research field, Regional Station (R/S), Comilla. They reported that

all the tested genotypes of both seasons were highly responsive to different levels of nitrogen and BRRI dhan49 showed highest grain N uptake (81.67 kg ha^{-1}) at 80 kg N ha^{-1} in T.Aman season. In Boro season highest N uptake (111.33 kg ha^{-1}) was found in case of BRRI hybrid dhan2 at 160 kg N ha^{-1} level and was at par with 120 kg N ha^{-1} level. They calculated optimum N doses 73, 101, 90, 103, 106 and 125 kg ha^{-1} for BRRI dhan49, BR7870-5*(Nils)-2-HR2, BRRI hybrid dhan4, BRRI dhan45, BRRI dhan50 and BRRI hybrid dhan2 respectively.

Haque *et al*. (2016) studied the response of applied nitrogen levels @ 20, 40, 60, 80 and 100 kg $Nha^{-1}$for new rice variety (BUdhan 1)at Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh. They reported that application of 60 kg N ha^{-1} resulted the maximum efficiency of nitrogen use (344.50 kg grain kg^{-1} N applied) of the variety and found intermediate level of applied N fertilizer environment and economical-friendly for the cultivation of new rice variety.

Sampath *et al*. (2017) conducted a field experiment, during the 2014-15 *Kharif* seasons, evaluated the uptake of nutrient of rice varieties, as affected by the combination of plant densities and fertilizers under late sown conditions on a sandy clay loam soil. They reported that among the varieties, MTU 1010 performed superior to Pradyumna and Rajendra in nutrient uptake and recorded highest yield at fertility levels of 195-86-90, N, P_2O_5 and K_2O, respectively.

Gewaily *et al*. (2018) conducted a field experiments during the growing seasons of 2016 and 2017,to evatuate the effectiveness of various N fertilizer rates on N use efficiency of some newly released Sakha 108 rice varieties and some promising GZ9399-4-1-1-3-2-2, GZ10101-5-1-1-1, GZ10154-3-1-1-1 of nitrogen application doses. @ 55, 110, 165 and 220 kg N ha^{-1}. They found that the agronomical efficiency (AE), varied significantly for rice varieties studied and ranged from 3.63 to 32.9 and from 2.72 to 34.12 kg of grain yields provided per kg of applied N in 2016 and 2017 respectively, and GZ9399 reported the maximum AE values for the nitrogen fertilizer dose @165 kg N ha^{-1} seasons among rice cultivars in both.

CHAPTER – III
MATERIALS AND METHODS

The present study entitled**"Studies on response of nitrogen levels on growth, yield and N use efficiency of different rice cultivars in *Vertisol*"**.was under taken during *kharif* season of the year, 2019 at the Research cum Instructional Farm, IGKV, Raipur. The details of experiment with prevailing weather conditions, materials used and procedures adopted during the course of investigation are briefly presented in following sub heads:

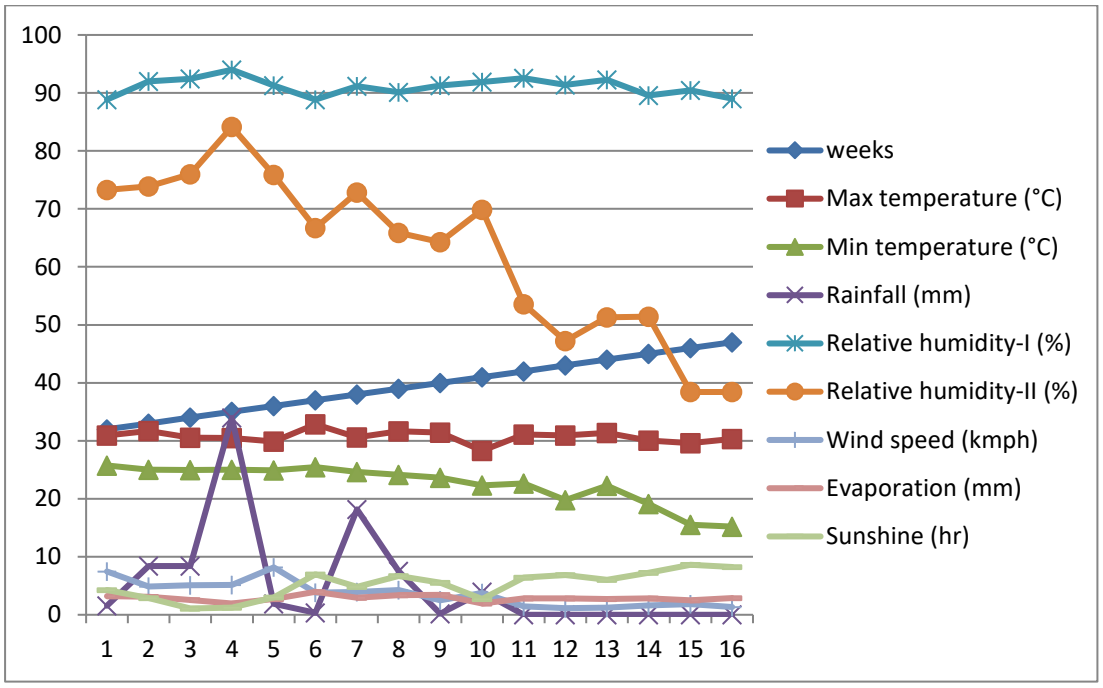
3.1 Geographical situation

The experimental site is situated in plains of Chhattisgarh at Eastern part of Raipur and located between 20˚4˚ North latitude and 81˚39˚ East longitudes with an altitude of 293 m above mean sea level.

3.2 Climatic and weather

The general climate of this region is dry humid, sub humid, and 1200-1400 mm of rainfall is received annually in the region, of which about 88% is received during the rainy season (June to September). The pattern of rainfall varies considerably from year to year during the rainy season.The temperature reaches as high as 48 °C during the summer months and decreases to 5 °C during December to January. Below are the weekly averages of meteorological observations during the investigation period reported at the Indira Gandhi Agricultural University Agro-meteorological Observatory, Raipur.

Fig: 3.1 Weekly meteorological data during the crop growth period during*Kharif*2019



3.3 Soil of experimental site

To analyze soil of experimental area surface soil samples (0-15 cm) were collected with the help of auger and representative samples after air dried, grounded and passed through 2 mm sieve analyzed for various physico-chemical properties.

The initial physico-chemical properties of soil employed for analysis are presented in table 3.1. Soil contains 20 % sand, 35 % silt, and 45% clay and characterized clayey in texture. Hence soil of experimental field was designated in order *Vertisols*, as texturally clay and locally known as *"kanhar"*. In chemical analysis, soil was neutral in reaction (pH 7.3) and normal in case of EC (0.42 dsm^{-1}) available N,P and K status of soil was 144, 13.26 and 372 kg ha^{-1} respectively , which showed low to medium status of macronutrient in soil and available micronutrient Fe, Zn, cu and Mn were 6.0 , 1.01, 3.08 and 8.42 ppm respectively.

Table 3.1: Initial soil physico-chemical properties

S.No.	Properties	Values	Method of estimation
1	pH (1:2.5)	7.3	Glass electrode pH meter (Piper,1967)
2	EC (dS m^{-1})	0.42	Solubridge conductivity method (Black, 1965).
3	Organic carbon (%)	0.49	Rapid titration method (Walkley and Black, 1934).
4	Textural class	Clayey	International pipette method (Black,1965)
5	Available N (kg ha^{-1})	194	Alkaline permanganate method (Subbiah and Asija, 1956).
6	Available P (kg ha^{-1})	13.26	Sodium bicarbonate method (Olsen *etal*., 1954)
7	Available K (kg ha^{-1})	372	Ammonium acetate method (Hanway and Heidel, 1952)
8	Available Zn (mg kg^{-1})	1.01	DTPA extraction method (1978) by Lindsay and Norvel
9	Available Fe (mg kg^{-1})	6.0	DTPA extraction method (1978) by Lindsay and Norvel
10	Available Mn (mg kg^{-1})	8.42	DTPA extraction method (1978) by Lindsay and Norvel
11	Available Cu (mg kg^{-1})	3.08	DTPA extraction method (1978) by Lindsay and Norvel

Table 3.2:Experimental details and layout plan

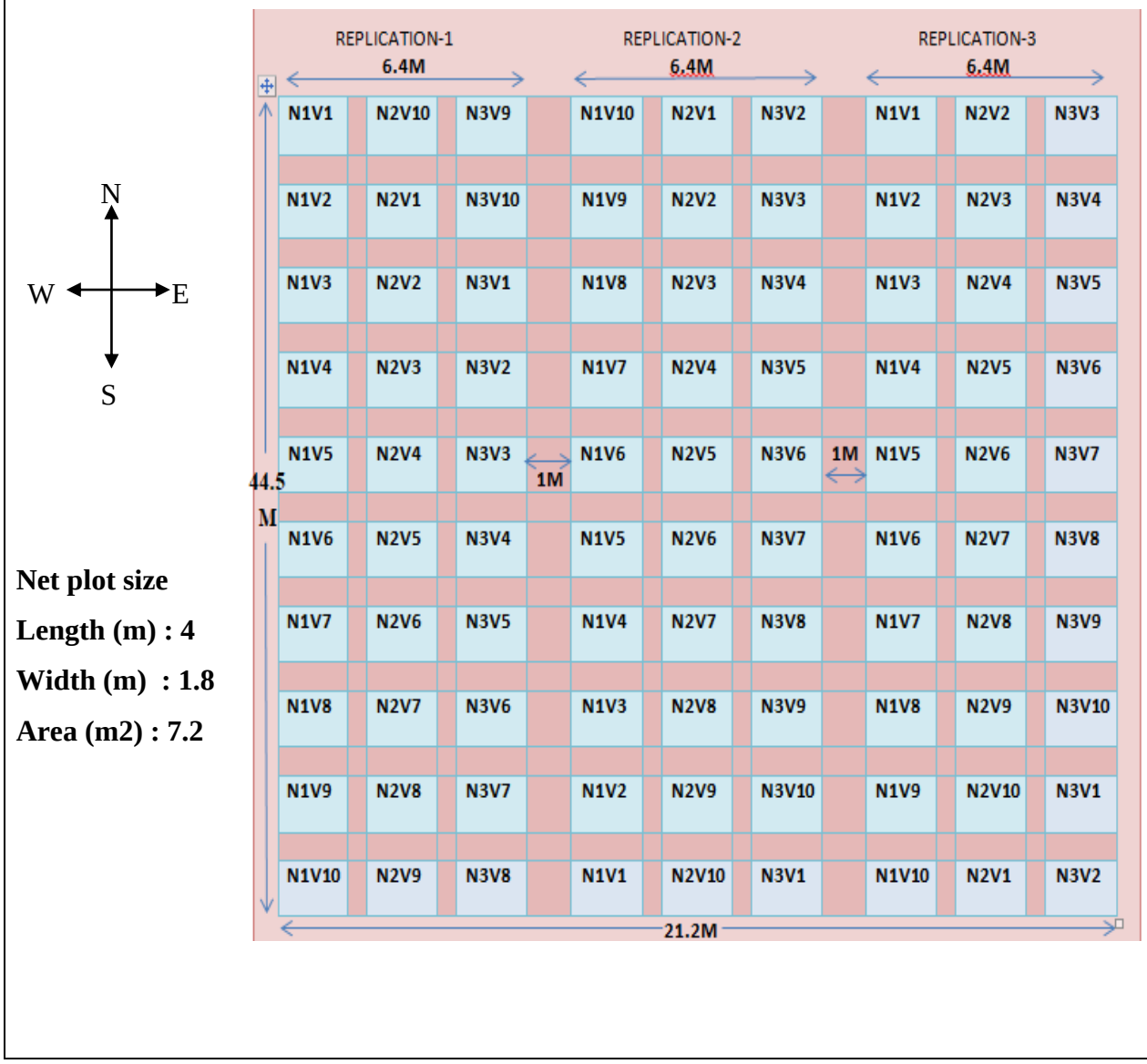
Location	Research Farm, I.G.K.V. Raipur (C.G.)
Season	*Kharif 2019*
Crop	Rice
Kind of trial	Field experiment
Design	Split plot design
Replication	3
Treatment details	
Main plots (A)	**Levels of nitrogen - 3** N0, N50, and N100 % i.e. Control, N@ 50 and N@100kg ha^{-1} dose of nitrogen through urea
Sub plots (B)	**Rice genotypes - 10** V1-CNN-1,V2-CNN-2,V3-CNN-3,V4-CNN-4,V5-CNN-5,V6-RASI,V7-MTU-1010,V8-BCV-1,V9-VARDHAN, V10-TI93
RDF (100:60:40 N:P:K (kg ha^{-1})	P & K @ 60 and @40 kg ha^{-1} was applied commonly in each plots , respectively.

Field preparation was done by tractor driven implements. The ploughing was done by cultivator finally the field puddled by tractor drawn puddler and leveled to created soft condition essential for transplanting of rice.

3.4 Layout plan

Field experiment was laid out with three main plots(N levels) treatments and subplots treatments (10 rice genotypes) allocated randomly comprising total 90 plots in three replications. These treatment combinations were arranged in a proper layout following the split-plot experimental design and depicted in Fig 3.2

Fig 3.2 Layout of experiment



Net plot size

Length (m) : 4

Width (m) : 1.8

Area (m2) : 7.2

Table 3.3: Calendar of operations during *kharif* 2019

S.No.	Field operations	Date
1	Initial soil sample collection	07-08-2019
2	Land preparation and leveling	10-08-2019
3	Field layout	11-08-2019
4	Date of transplanting	14-08-2019
5	1st urea application	14-08-2019
6	2nd urea application	15-09-2019
7	3rd urea application	13-10-2019
8	1st hand weeding	14-09-2019
9	2nd hand weeding	20-10-2019
10	Date of harvesting	26-11-2019
11	Soil sample collection after harvest	29-11-2019

3.5 Transplanting

Transplanting is the most important cultivation aspect, so while transplanting the seedling utmost care was taken without disturbing the root system and was done on dated 14-08-2019using 25 days old seedlings at the density of 1-2 seedlings $hill^{-1}$ at 20 x 10 cm spacing and at the normal depth of 3-4 cm.

3.6Treatment application

N, P and K were applied through urea,single super phosphate and muriate of potash . At the time of transplanting whole amount of P @ 60 kg P_2O_5 kg ha^{-1} and K @ 40 kg ha^{-1} K_2O were applied uniformly to all plots. According to lay out of field experiment ,treatments of main plots i.e. nitrogen levels, N0 (Control) N50 & N100 kg N ha^{-1}) were applied in three equal splits except to control plots at transplanting, active tillering and panicle initiation stages and sub plots treatments ie. 10 rice cultivars randomized and transplanted in field.

3.7 Harvesting and Threshing

Harvesting was achieved when the crop entered the maturity stage, which is visually measured when more than 95 percent of the spikelet's were transformed into golden colour. With the aid of sickle, harvesting was conducted through

manual labour. The harvested produce was left on the plot for sun-drying for around four days. The product was weighed plot-wise after exposure to sun-drying in the field.

Threshing, with the aid of a thresher, was performed by manual workers. Winnowing was done to distinguish the grain from the chaffy grains and straw with the aid of the natural wind fan, after which the clean grains were weighed.

3.8Field observations

3.8.1 Number of tillers m^{-2}

The total number of tillers m^{-2} was counted and used for statistical analysis by averaging the data observations from each plot.

3.8.2 Number of panicles m^{-2}

The total number of panicles m^{-2} was counted and used for statistical analysis by averaging the data observations from each plot.

3.8.3 Number of grains $panicle^{-1}$

Ten plants have been picked at random and grains have been removed and counted. The mean value was measured and noted as the amount of grains $plant^{-1}$.

3.8.4 Test weight (g)

Grain samples were taken from each treatment produce and 1000 grains were counted and dried for 48 hours in the oven at 60 ^{o}C. They were weighed after drying, and the mean weight of 1000 grains was noted as the test weight.

3.8.5 Grain and straw yield (q ha^{-1})

Every treatment's sun-dried produce was tied in bundles and weighed to assess the production of dry matter (grains+straw). The grains obtained from each plots following threshing and winnowing was weighed and noted. The weight of the straw was obtained by subtracting the grain weight from the overall bundle weight.

3.9Soil analysis

3.9.1 Soil pH

Piper (1967) described soil pH by glass electrode pH meter in 1:2.5 soil wat er suspensions

3.9.2 Electrical conductivity

The pH determined soil sample was allowed to settle for 24 hours. The conductivity meter described by Black (1965) determined the electrical conductivity of the supernatant liquid.

3.9.3 Organic carbon

Organic carbon was determined by Walkley and Black (1934) rapid titration method.

3.9.4 Available nitrogen in soil

The available nitrogen in soil was determined by alkaline potassium permanganate method as described by Subbiah and Asija (1956).

3.9.5 Available phosphorus

Available soil P was extracted by 0.5 N $NaHCO_3$ and ascorbic acid for slightly a cidic, neutral and alkaline soils was used to determine phosphorus in the extract (Olsen, et al., 1954).

3.9.6 Available potassium

Soil potassium was extracted using neutral normal ammonium acetate and determined as described by the flame photometer (Hanway and Heidel, 1952).

3.10 Plant analysis

Plant samples of rice collected at harvest time were dried in an oven at 55^0C for 24 hours and were grinded and analyzed for N, P &K content in grain and straw samples.

3.10.1 Nitrogen content

Grain and straw sample nitrogen content analysis was performed by taking 0.25 gm. uniformly prepared digestion tube sample. 1gm salt mixture (K_2SO_4 and $CuSO_4.5H_2O$) was applied to the tube at a ratio of 9:1 to 10 ml. 0.5 ml of concentrated H2SO4 acid was added to the digestion block and the material was digested at 400 ºC before the material became colorless. Then the nitrogen in digested material was distilled by automatic KEL plus system.

3.10.2 Phosphorus and Potassium

Digestion:

In the digestion tube, 1 gram of grain and straw samples were taken and 10 ml was added. Di-acid mixture (concentrated HNO_3&, $HClO_4$ in 9:4 ratio). The substance was digested in KEL plus digestion block at 250 ºC until the content became colorless. It was moved to 100 ml of volumetric flask. by repeatedly washing with distilled water, the volumetric flask made up the volume up to the level. For the estimation of P and K content analysis, this digested material was used for following P & K contents as given below:

Phosphorus:

Phosphorus content in plant was estimated by vanadomolybdo- phosphoric acid yellow color complex as described by Jackson (1967). 10 ml of an aliquot was taken in that 10 ml of vanado – molebdate yellow reagent was added and volume was made up to 50 ml. After half an hour color intensity was measured with the help of spectrophotometer at 420nm.

Potassium:

Method to determine the Potassium content was described by chapman and Pratt (1961) an aliquot of 5 ml was taken and made up to volume of 25 ml in volumetric flask and estimated by flame photometer

3.11 Nitrogen uptake efficiency: - It was calculated by using the following formula

$$\text{NUE (\%)} = \frac{\text{Uptake from treated plot} - \text{Uptake from controled plot}}{\text{Total nitrogen applied}} \times 100$$

3.12 Agronomic N use efficiency(kg grain kg N^{-1})

$$\text{AE} = \frac{\text{Yield (kg ha}^{-1}\text{) in fertilized treatment - Yield (kg ha}^{-1}\text{) in unfertilized treatment}}{\text{Nitrogen applied (kg ha}^{-1}\text{)}}$$

3.13 Physiological efficiency (kg biomass kg^{-1} N uptake)

$$PE = \frac{\text{Yield (kg ha}^{-1}\text{) in fertilized treatment} - \text{Yield (kg ha}^{-1}\text{) in unfertilized treatment}}{\text{Nitrogen uptake fertilized treatment (kg ha}^{-1}\text{)} - \text{Nitrogen uptake unfertilized treatment (kg ha}^{-1}\text{)}}$$

3.14 Statistical analysis

The data generated from the field and laboratory studies were subjected to statistical analysis using the technique of analysis of variance for split plot design for the interpretation of results as described by Gomez and Gomez (1984).

CHAPTER -IV

RESULT AND DISCUSSION

The experimental results obtained on various aspects from present investigation entitled **"Studies on response of nitrogen levels on growth, yield and N use efficiency of different rice cultivars in *Vertisol*"** during *Kharif* season, 2019 at Research Cum Instructional Farm, IGKV, Raipur are presented through appropriate tables and graphs and briefly discussed under the following heads:

4.1 Effect of nitrogen levels on yield contributing characters of the different rice cultivars.

4.2 Effect of nitrogen levels on grain and straw yields of the different rice cultivars

4.3 Effect of nitrogen levels on nutrients content,(N, P & K) by the different rice cultivars

4.4 Effect of nitrogen levels on nutrients uptake,(N, P & K) by the different rice cultivars

4.5 effect of nitrogen levels on nitrogen uptake, agronomic N use and physiological efficiency of the different rice cultivars

4.6 Effect of nitrogen levels on physico-chemical properties of soil after harvest of the different rice cultivars

4.1 Effect of nitrogen levels on yield contributing characters of the different rice cultivars

The data relating yield attributing characteristict viz, number of tillers m^{-2}, number of panicles m^{-2}, grains $panicle^{-1}$ and test weight of rice cultivars as affected by different nitrogen levels are presented in Table 4.1 and is being discussed below.

4.1.1 Number of tillers m^{-2}

The data on the number of tillers are showed in Table 4.1, as well as graphically illustrated in Fig.4.1(a). The data show that the number of tillers m^{-2} and the overall number of tillers is significantly affected by rising levels of applied nitrogen (399.53 m-2), was recorded at highest level of applied nitrogen @ 100

kg N ha^{-1} and lowest tillers (365.5 m^{-2}) found under control (N_0).This might be due to the maximum uptake of nitrogen applied and the greater availability of soil nutrients.

Among rice cultivars, number of tillers m^{-2} presented in Table 4.1and also illustrated graphically in Fig. 4.1 (b), showed that significantly and the highest number of tillers m^{-2} (404.56 m^{-2}) was found inBCV-1 followed by (398.44 m^{-2}) in VARDHAN, and the lowest (365.56m^{-2})recorded under cultivar TI93. This might be due to transportation of photosynthates from source to sink.

The interaction effect of nitrogen and cultivars added on the number of tillers m^{-2} was found to be non-significantly. The rise in the number of tillers with growing doses of nitrogen may be attributed to the luxurious availability of N for development and growth. These results are in corroborative with the findings of Rahman *et al*. (2007), Shukla *et al*. (2015), Rajesh *et al*. (2017), and Saha *et al*. (2017).

4.1.2 Number of panicles m^{-2}

The data on the number of panicles are showed in Table 4.1 as well as graphically illustrated in Fig. 4.1(a). The finding showed that the amount of nitrogen added greatly affected the number of panicles m^{-2}. Maximum panicles m^{-2} (283.50 m^{-2}) was registered at application @ 100 kg N ha^{-1}, which was statistically equal to treatment @ 50 kg N ha^{-1} and the lowest panicles m^{-2} (236.23 m^{-2}) was reported under the control plot (N0). This may be due to the maximum absorption of applied nitrogen and greater availability of nutrients from the soil.

The number of panicles differed significantly presented in Table 4.1 and also illustrated graphically in Fig. 4.1 (b). In all rice cultivars and ranged from (215.56 to 292.22 m^{-2}). The maximum number of panicles was recorded with BCV-1 (292.22m^{-2}) followed by VARDHAN (281.67m^{-2}) and the lowest under variety TI93 (215.56m^{-2}).Better production and transport of photosynthates from source to sink can be due to the synergistic response of nitrogen to enhancement in the total number of panicles from different rice cultivars.

The interaction effect of applied nitrogen on rice cultivars for production of number of panicles m^{-2} was found to be differed non-significantly. Maximum numbers of panicles m^{-2} was recorded in N3V8 (287.86 m^{-2}) and the minimum

number of panicles m^{-2} was recorded in N1V10 treatment combinations (225.89 m^{-2}). These results are in corroborative with the findings of Singh *et al*. (2007), Sharma *et al*. (2014) and Saha *et al*. (2017).

4.1.3 Grains panicle^{-1}

The data on number of grains panicle^{-1} is presented in Table 4.1and also illustrated graphically in Fig. 4.1 (a). The findings revealed that this yield attribute was influenced significantly with levels of applied nitrogen and was ranged from (171.37 to 188.53). The maximum number of grains panicle^{-1}(188.53)was found under applied N @ 100 kg ha^{-1} which was statistically at par with applied N @ 50 kg ha^{-1}(181.27 grains panicle^{-1}) and the lowest (171.37)recorded in control (N0).This was possibly due to higher nitrogen absorption and greater soil nutrient availability.

Among rice cultivars, number of grains panicle^{-1} presented in Table 4.1and also illustrated graphically in Fig. 4.1 (b). In all rice cultivars and ranged from (149.33 to 211.78) and the V8 (BCV-1) variety recorded the highest grainspanicle^{-1} (211.78) followed by VARDHAN (201.67) and the lowest registered under V10 (TI93). The synergistic response of nitrogen on enhancement in grains panicles^{-1}of different rice cultivars may be attributed better production and transportation of photosynthates from source to sink.

The interaction effect of nitrogen with rice cultivars for production of number of grains panicle^{-1} was found to be differed non-significantly. Maximum numbers of grainspanicle^{-1} was recorded in N3V8 (200.15) and the minimum number of grains panicle^{-1} was recorded in N1V10 treatment combinations (160.35). These results are in corroborative with the findings of Singh *et al*. (2007), Sharma *et al*. (2014), Shukla *et al*. (2015),Rajesh *et al*. (2017), and Saha *et al*. (2017).

4.1.4 Test weight (g)

The data on test weight are presented in Table 4.1 and also illustrated graphically in Fig. 4.1 (a). The results showed significant effect of applied nitrogen levels on test weight and was ranged from (19.93 to 21.47g). The maximum grain weight (21.47g) was recorded under applied N @ 100 kg ha^{-1} which and the lowest (19.93g)obtained under control N0. This was probably due to

the maximum uptake of nitrogen applied and the greater availability of soil nutrients.

Among rice cultivars,presented in Table 4.1 and also illustrated graphically in Fig. 4.1 (b). V8 (BCV-1) variety recorded the highest test weight (25.95g)followed by VARDHAN (24.67g) and the lowest (16.64g)registered under V10 (TI93). This might be due to higher conservation of light energy into chemical energy and its subsequent translocation from source to sink.

The interaction effect of nitrogen and rice cultivars on test weight was also found to be differed non-significantly. This might be due to the fact that test weight is a very stable varietal character and does not vary much among the nitrogen level. The results are inconformity with the findings of Tunio *et al*. (2002), Singh *et al*. (2007), Saha *et al*. (2017), and Gewaily *et al*. (2018).

Table 4.1: Effect of nitrogen levels on yield contributing characters of the different rice cultivars

Treatments	Number of tillers m^{-2}	Number of panicles m^{-2}	Number of grains $panicle^{-1}$	Test weight (g)
Nitrogen levels				
N0	365.50	236.23	171.37	19.93
N50	395.83	259.50	181.27	20.13
N100	399.53	283.50	188.53	21.47
SEm±	**3.91**	**3.93**	**0.96**	**0.35**
CD (p=0.05)	**15.37**	**15.45**	**3.80**	**1.38**
Cultivars				
CNN-1	390.44	261.67	196.67	18.38
CNN-2	388.56	257.78	171.67	22.09
CNN-3	377.11	253.22	167.33	17.94
CNN-4	385.44	255.78	168.89	18.53
CNN-5	389.44	258.89	187.44	19.58
RASI	372.67	250.78	151.78	21.04
MTU-1010	397.33	269.89	197.33	20.29
BCV-1	404.56	292.22	211.78	25.95
VARDHAN	398.44	281.67	201.67	24.67
TI93	365.56	215.56	149.33	16.64
SEm±	**6.97**	**7.27**	**2.31**	**0.63**
CD (p=0.05)	**19.78**	**20.61**	**6.57**	**1.79**
Interaction	**NS**	**NS**	**NS**	**NS**

Fig 4.1 (a): effect of N levels on yield contributing characters of the different rice cultivars

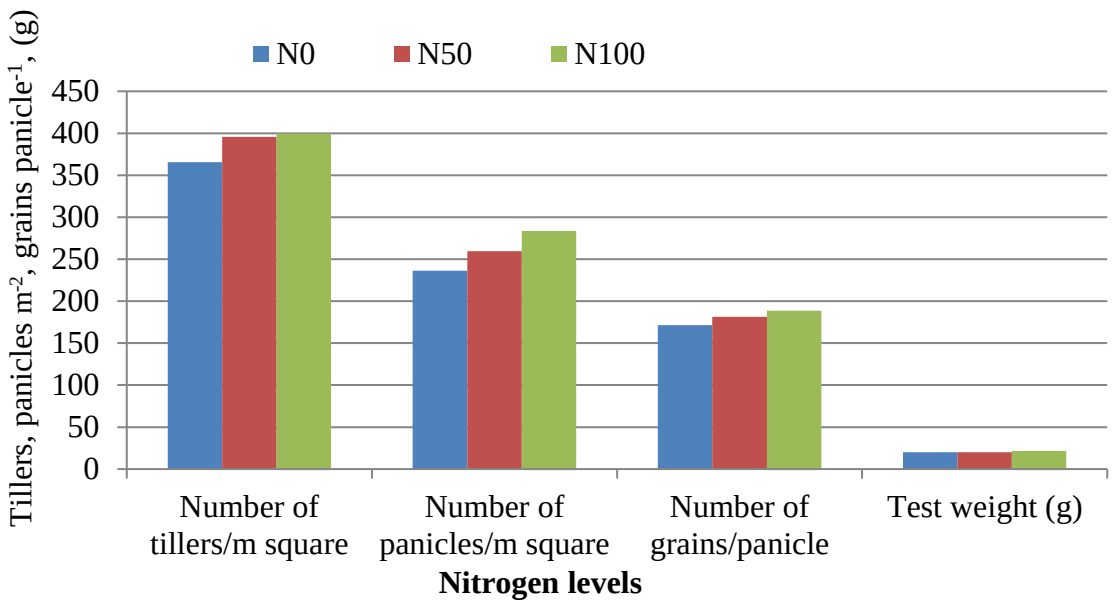
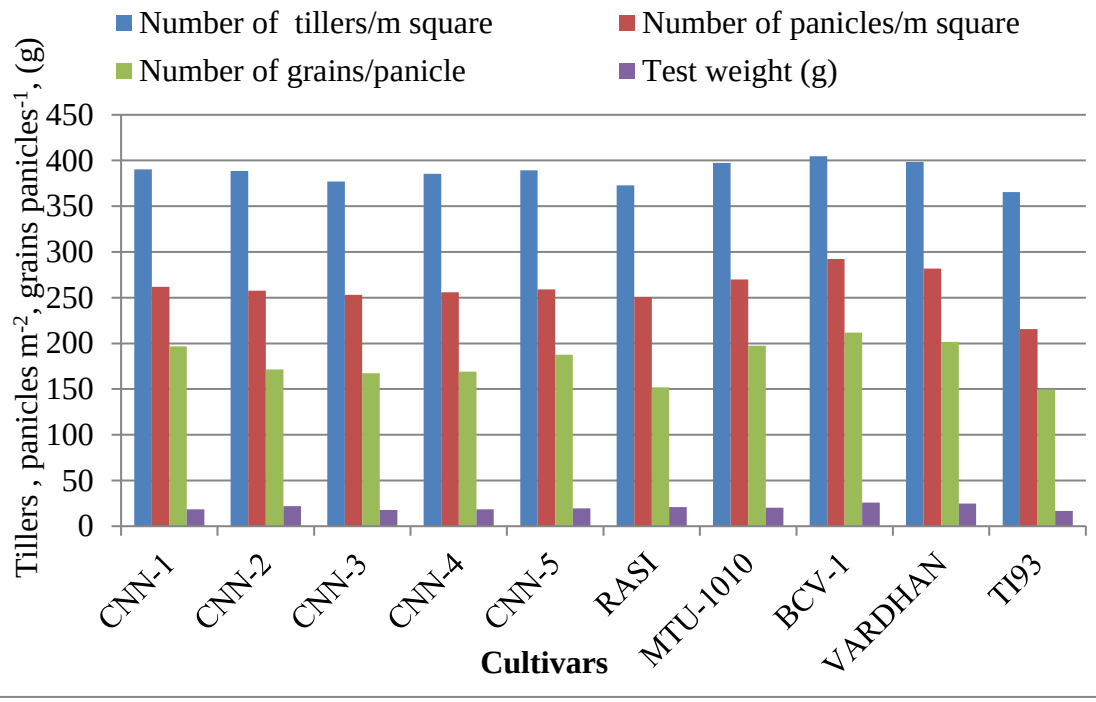


Fig 4.1 (b): effect of different cultivars of rice on yield contributing characters



4.2 Effect of N levels on grain and straw yields of the rice cultivars

4.2.1 Grain yield (q ha^{-1})

The results on yield of grain is recorded at harvest and showed in Table 4.2 and also illustrated graphically in Fig. 4.2 (a). The datashows that grain yield of all rice cultivars increased significantly with levels of applied nitrogen over control.The higher grain yield (54.09 q ha^{-1})was recorded under applied N @100 kg ha^{-1}, which was statistically at par with @ 50 kg N ha^{-1}(48.13q ha^{-1}) and the lowest (29.99 q ha^{-1}) was obtained under control (N0). This might be due to robust and increased growth of plants and also due to continuous and synchronize supply of nutrients throughout the growth stage of rice

The data showed in Table 4.2 and also illustrated graphically in Fig. 4.2 (b). Indicated that the all varieties proved significantly superior with respect to grain yield production and was ranged from (35.39 to 54.86q ha^{-1}). Among rice cultivars BCV-1 produced the maximum yield of grain (54.86 q ha^{-1}) and at par with VARDHAN (50.17 q ha^{-1}),and followed by MTU-1010, CNN-1, CNN-5 (46.58, 45.55, 45.15 q ha^{-1}), respectively and lowest obtained in cultivar TI93. The highest grain yield of BCV-1 might be due to with higher nitrogen responsive genetic traits and increased production of photosynthesis and translocation of nutrients by rice crop.

The interaction effect of nitrogen and rice cultivars for grain yield was obtained to be non-significantly. Maximum grain yield was recorded in N3V8 (54.47 q ha^{-1}) and the minimum yield of grain was recorded in N1V10 treatment combinations (32.68. q ha^{-1}). These results are in line with the findings of Subbiah *et al*. (2001), Rajesh *et al*. (2017), Saha *et al.* (2017) and Gewaily *et al.* (2018).

4.2.2 Straw yield (q ha^{-1})

The results on straw yield is recorded at harvest and showed in Table 4.2 and also illustrated graphically in Fig. 4.2 (a). The datareveals that straw yield of all rice cultivars increased significantly with levels of applied N over control.The highest straw yield 61.14 q ha^{-1})was founded under applied @100 kg N ha^{-1}, which was statistically at par with @ 50 kg N ha^{-1}(57.60 q ha^{-1}), and the lowest obtained(40.31 q ha^{-1})under control (N0). Application of @ 100 kg nitrogen level

this may be due to increased availability of nutrients which improved the soil properties.

The data showed in (Table 4.2) and also illustrated graphically in Fig. 4.2 (b), indicated that the all varieties proved significantly superior with respect to straw yield production and was ranged from 44.89 to 66.76 q ha^{-1}. Among rice cultivars BCV-1 produced the maximum straw yield (66.76 q ha^{-1}) and at par with VARDHAN (58.67 q ha^{-1}), and followed by MTU-1010, CNN-1, CNN-5 (54.88, 53.29, 53.09 q ha^{-1}) respectively, and lowest obtained in cultivar TI93. The highest straw yield of BCV-1 might be due to with higher nitrogen responsive genetic traits and increased production of photosynthesis and translocation of nutrients by rice crop.

The interaction effect of N×V for straw yield was found to be differed non-significantly. Maximum straw yield was recorded in N3V8 (63.95q ha^{-1}) and the minimum straw yield was founded in N1V10 treatment combinations (42.60 q ha^{-1}). These results are in conformity with the findings of Mhaskar *et al*. (2005), Rajesh *et al*. (2017) and Saha *et al*. (2017).

Table 4.2: Effect of nitrogen levels on grain and straw yields (q ha^{-1}) of rice cultivars

Treatments	Grain yields (q ha^{-1})	Straw yields (q ha^{-1})
Nitrogen levels		
N0	29.99	40.31
N50	48.13	57.60
N100	54.09	61.14
SEm±	**0.78**	**0.77**
CD (p=0.05)	**3.06**	**3.05**
Cultivars		
CNN-1	45.55	53.29
CNN-2	43.36	52.48
CNN-3	39.20	48.25
CNN-4	42.72	49.70
CNN-5	45.15	53.09
RASI	37.74	48.13
MTU-1010	46.58	54.88
BCV-1	54.86	66.76
VARDHAN	50.17	58.67
TI93	35.39	44.89
SEm±	**1.04**	**1.58**
CD (p=0.05)	**2.96**	**4.47**
Interaction	**NS**	**NS**

Fig. 4.2: (a) Effect of nitrogen levels on grain and straw yields of rice cultivars

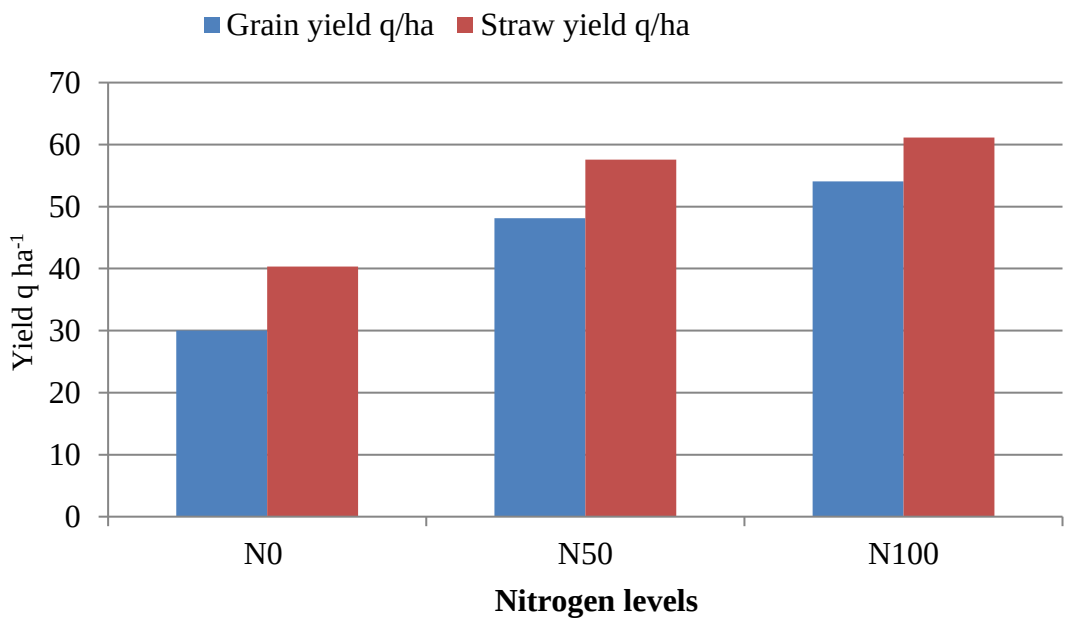
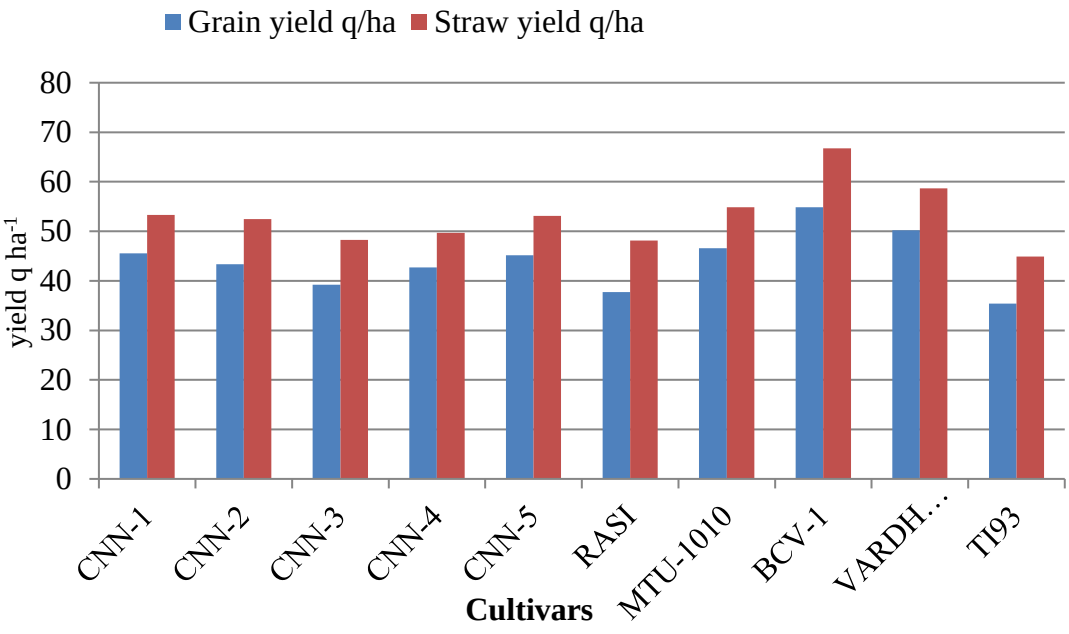


Fig. 4.2: (b) Effect of different cultivars of rice on grain and straw yields



4.3 Effect of nitrogen levels on N, P & K content (%) of the different rice cultivars

4.3.1 Nitrogen (%)

Grain and straw samples were analyzed for nitrogen content (%) is presented in Table 4.3.Nitrogen content was differed non-significantly with applied nitrogen doses though higher nitrogen content obtained at highest doses of applied N @ 100 kg ha^{-1}(1.14 and 0.33 %) grain and straw and ranged in different rice cultivars from (0.98 % to 1.12 %) and (0.21% to 0.43 %) in grain and straw respectively. Similar results were also reported by Sharma *et al*. (2012) and Bora *et al*.(2018). The interaction effect of nitrogen and rice cultivars for N content of grain and straw were found to be non-significantly.

4.3.2 Phosphorus (%)

Grain and straw samples were analyzed for P content (%) is presented in Table 4.3.The P content (%) was differed non-significantly on different nitrogen levels. Higher P content of nitrogen levels, P (0.21 and 0.06%,) in grain and straw was associated with @ 100 kg N ha^{-1}, respectively, and lowest in control plot. And ranged in different rice cultivars from (0.18 % to 0.23 %) and (0.04 % to 0.06 %) in grain and straw respectively. Similar results were also reported by Sharma *et al*.(2012) and Bora *et al*.(2018). The interaction effect of nitrogen and rice cultivars for P content of grain and straw were found to be non-significantly.

4.3.3 Potassium (%)

Grain and straw samples were analyzed for potassium content (%) is presented in Table 4.3.The potassium content (%) was differed non-significantly on different nitrogen levels. Higher potassium content of nitrogen levels, K (0.26 and 1.53%,) in grain and straw was associated with @ 100 kg N ha^{-1}, respectively, and lowest in control plot. And ranged in different rice cultivars from (0.24 % to 0.28 %) and (1.40% to 1.57 %) in grain and straw, respectively. Similar results were also reported by Sharma *et al*.(2012) and Bora *et al.* (2018). The interaction effect of nitrogen and rice cultivars for potassium content of grain and straw were found to be non-significantly.

Table 4.3: Effect of nitrogen levels on N, P, and K content (%) the different rice cultivars

Treatment	N content (%)		P content (%)		K content (%)	
N levels	**Grain**	**Straw**	**Grain**	**Straw**	**Grain**	**Straw**
N0	1.02	0.26	0.19	0.05	0.25	1.47
N50	1.04	0.31	0.20	0.05	0.25	1.52
N100	1.14	0.33	0.21	0.06	0.26	1.53
SEm±	**0.032**	**0.034**	**0.02**	**0.00**	**0.01**	**0.02**
CD (p=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Cultivars						
CNN-1	1.09	0.31	0.21	0.06	0.25	1.53
CNN-2	1.06	0.30	0.19	0.05	0.25	1.51
CNN-3	1.07	0.30	0.18	0.05	0.25	1.49
CNN-4	1.06	0.27	0.19	0.05	0.25	1.53
CNN-5	1.08	0.30	0.20	0.06	0.25	1.51
RASI	1.08	0.25	0.19	0.05	0.25	1.49
MTU-1010	1.06	0.32	0.22	0.06	0.26	1.53
BCV-1	1.12	0.43	0.23	0.06	0.28	1.57
VARDHAN	1.11	0.37	0.23	0.06	0.27	1.53
TI93	0.98	0.21	0.18	0.04	0.24	1.40
SEm±	**0.058**	**0.062**	**0.02**	**0.01**	**0.02**	**0.06**
CD (p=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Interaction	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Fig 4.3 (a): effect of nitrogen levels on N, P and K contents (%) of the different rice cultivars

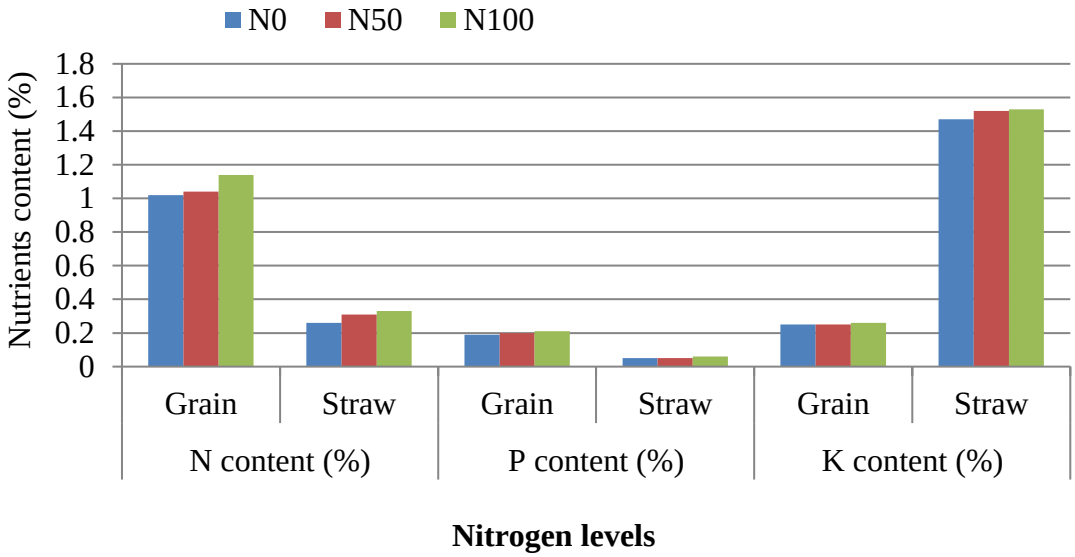
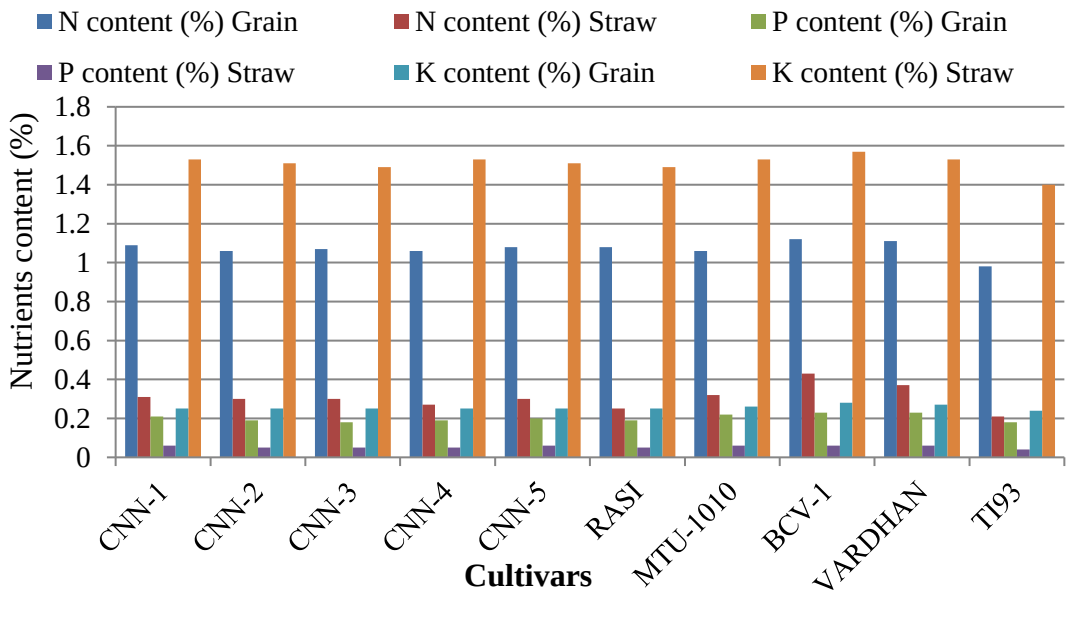


Fig 4.3 (b): effect of different cultivars of rice on N, P and K contents (%)



4.4 Effect of nitrogen levels on N, P & K uptake(kg ha^{-1})of the different rice cultivars

4.4.1 Nitrogen uptake(kg ha^{-1})

The results on grain, straw and total nitrogen uptake is presented in Table 4.4 and also illustrated graphically in Fig. 4.4 (a). The datareveals that nitrogen uptake of all rice cultivars increased significantly with levels of applied nitrogen over control.The maximum grain, straw and total N uptake(59.76,23.23 and 82.99 kg ha^{-1})was recorded under applied @100 kg N ha^{-1} which was statistically at par with @ 50 kg N ha^{-1}(5.69, 16.73 and 69.41kg ha^{-1})and the lowest obtained(31.09, 9.99 and 41.0 kg ha^{-1}) under control (N0). This may be due to significant increase in grain and straw yield with every increase in nitrogen dose.

The data presented in Table 4.4 and also illustrated graphically in Fig. 4.4 (b), indicated that the all varieties proved significantly superior with respect to grain, straw and total N uptake and was ranged from (34.73 to 61.86, 10.72 to 30.43 and 45.44 to 92.29 kg ha^{-1}),respectively. Among rice cultivars BCV-1 produced the maximum grain, straw and total nitrogen uptake (61.86, 30.43 and 92.29 kg ha^{-1}) and at par with VARDHAN (56.0, 23.99 and 79.96 kg ha^{-1})respectively, and lowest obtained in cultivar TI93 (34.73, 10.72 and 45.44 kg ha^{-1}). The highest nitrogen uptake of BCV-1 this may be due to maximum straw and grain yield of rice in respective varieties.These results are in conformity with the findings of Ramiah *et al*. (1987), Zaidi *et al*. (2007) and Iqbal *et al.* (2014). The interaction effect of nitrogen and rice cultivars for nitrogen uptake was obtained to be non-significantly.

4.4.2 Phosphorus uptake(kg ha^{-1})

The results on grain, straw and total phosphorus uptake is showed in Table 4.4 and also illustrated graphically in Fig. 4.4 (a). The datareveals that phosphorus uptake of all rice cultivars increased significantly with levels of applied nitrogen over control. The highest grain, straw and total phosphorus uptake(11.71,3.40 and 15.11 kg ha^{-1})was reported under applied @100 kg N ha^{-1}, which was statistically at par with @ 50 kg N ha^{-1}(9.49, 3.02 and 12.51kg ha^{-1})and the lowest obtained(5.78, 2.05 and 7.83 kg ha^{-1}) under control (N0). This might be due to significant increase in grain and straw yield with every increase in nitrogen dose.

The data presented in Table 4.4 and also illustrated graphically in Fig. 4.4 (b), indicated that the all varieties proved significantly superior with respect to

grain, straw and total P uptake and was ranged from (6.47 to 12.52, 1.67 to 4.20 and 8.14 to 16.72 kg ha^{-1}), respectively. Among rice cultivars BCV-1 produced the highest grain, straw and total phosphorus uptake (12.52, 4.20 and 16.72 kg ha^{-1}) and at par with VARDHAN (11.55, 3.33 and 14.89 kg ha^{-1}), respectively and lowest obtained in cultivar TI93 (6.47, 1.67 and 8.14 kg ha^{-1}. The highest phosphorus uptake of BCV-1 this may be due to maximum grain and straw yield of rice in respective varieties.These results are in conformity with the findings of Zaidi *et al*. (2007) and Iqbal *et al.* (2014). The interaction effect of nitrogen and rice cultivars for phosphorus uptake was obtained to be non-significantly.

4.4.3 Potassium uptake(kg ha^{-1})

The results on grain, straw and total potassium uptake is showed in Table 4.4 and also illustrated graphically in Fig. 4.4 (a). The data reveals that potassium uptake of all rice cultivars increased significantly with levels of applied nitrogen over control. The highest grain, straw and total potassium uptake(14.21, 93.96 and 108.17 kg ha^{-1})was registered under applied @100 kg N ha^{-1} which was statistically at par with @ 50 kg N ha^{-1}(1.32, 87.67 and 99.99 kg ha^{-1})and the lowest obtained (7.58, 59.58 and 67.16 kg ha^{-1}) under control (N0). This might be due to significant increase in grain and straw yield with every increase in nitrogen dose.

The data presented in Table 4.4 and also illustrated graphically in Fig. 4.4 (b), indicated that the all varieties proved significantly superior with respect to grain, straw and total K uptake and was ranged from (8.51 to 15.18, 62.90 to 104.67 and 71.40 to 119.85 kg ha^{-1}), respectively. Among rice cultivars BCV-1 produced the highest grain, straw and total phosphorus uptake (15.18, 104.67 and 119.85 kg ha^{-1}) and at par with VARDHAN (13.72, 90.18 and 103.90 kg ha^{-1}),respectively and lowest obtained in cultivar TI93 (8.51, 62.90 and 71.40 kg ha^{-1}. The highest potassium uptake of BCV-1 this may be due to maximum straw and grain yield of rice in respective varieties. These results are in conformity with the findings of Zaidi *et al*. (2007) and Iqbal *et al.* (2014). The interaction effect of nitrogen and rice cultivars for K uptake was registered to be non-significantly.

Table 4.4: Effect of nitrogen levels on N, P and K uptake (kg ha^{-1}) of the different rice cultivars

Treatment	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})			K uptake (kg ha^{-1})		
N levels	**Grain**	**Straw**	**Total**	**Grain**	**Straw**	**Total**	**Grain**	**Straw**	**Total**
N0	31.01	9.99	41.00	5.78	2.05	7.83	7.58	59.58	67.16
N50	52.69	16.73	69.41	9.49	3.02	12.51	12.32	87.67	99.99
N100	59.76	23.23	82.99	11.71	3.40	15.11	14.21	93.96	108.17
SEm±	**2.15**	**2.07**	**1.09**	**0.73**	**0.23**	**0.59**	**0.40**	**1.77**	**1.52**
CD (p=0.05)	**8.44**	**8.14**	**4,28**	**2.88**	**0.89**	**2.33**	**1.57**	**6.95**	**5.97**
Cultivars									
CNN-1	49.77	15.20	64.97	9.60	2.98	12.58	11.23	81.66	92.88
CNN-2	45.60	13.61	59.21	8.19	2.65	10.84	10.72	79.53	90.25
CNN-3	42.09	12.27	54.36	6.93	2.39	9.31	10.16	72.35	82.51
CNN-4	45.44	11.93	57.37	8.33	2.44	10.77	11.08	76.33	87.41
CNN-5	50.17	13.10	63.27	8.93	2.97	11.90	11.68	80.35	92.03
RASI	41.04	11.26	52.30	7.38	2.59	9.97	9.37	71.88	81.25
MTU-1010	51.50	23.96	75.49	10.01	3.03	13.04	12.07	84.20	96.27
BCV-1	61.86	30.43	92.29	12.52	4.20	16.72	15.18	104.67	119.85
VARDHAN	56.00	23.99	79.96	11.55	3.33	14.89	13.72	90.18	103.90
TI93	34.73	10.72	45.44	6.47	1.67	8.14	8.51	62.90	71.40
SEm±	**4.53**	**3.69**	**5.63**	**0.83**	**0.38**	**0.71**	**0.81**	**4.34**	**4.36**
CD (p=0.05)	**12.84**	**10.46**	**15.97**	**2.35**	**1.07**	**2.02**	**2.29**	**12.32**	**12.36**
Interaction	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Fig 4.4 (a): effect of Nitrogen levels on N, P and K uptake (kg ha^{-1}) of the different rice cultivars

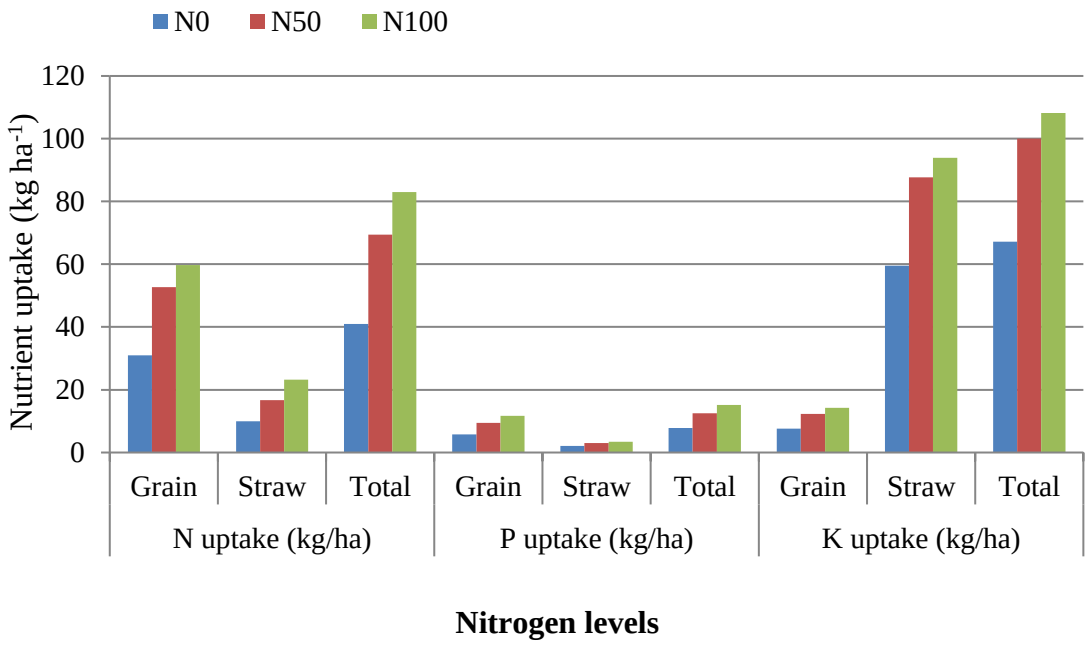
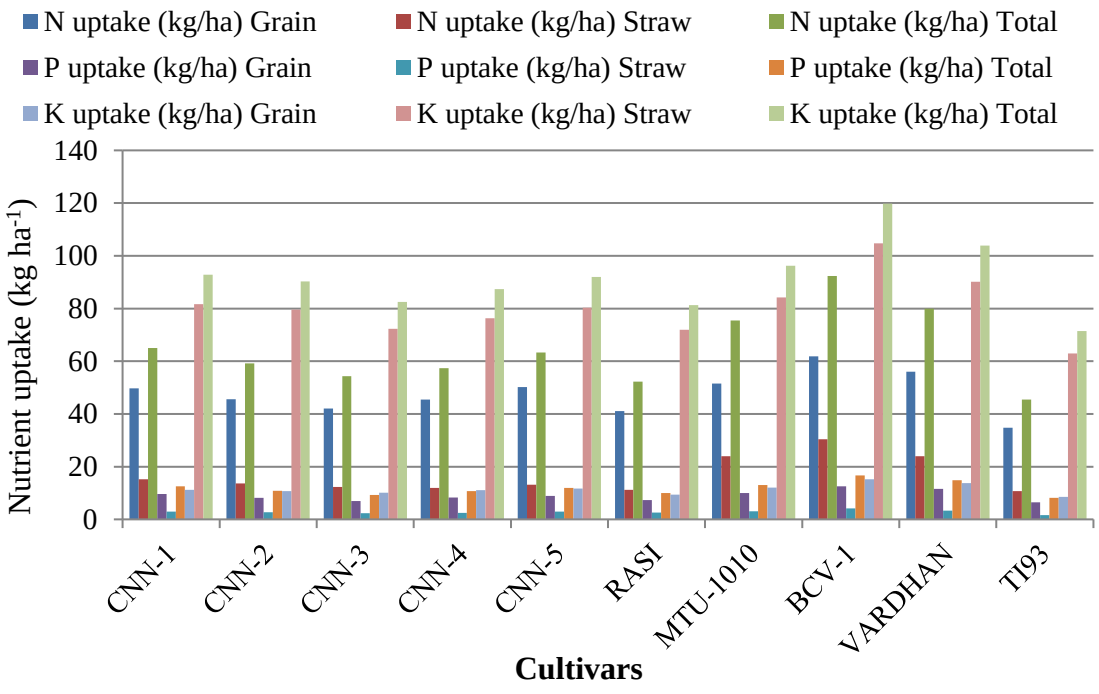


Fig 4.4 (b): effect of different cultivars of rice on N, P and K uptake (kg ha^{-1})



4.5 Effect of nitrogen levels on nitrogen uptake, agronomic N use and physiological efficiency of the different rice cultivars

4.5.1 Nitrogen uptake efficiency (%)

The results on nitrogen use efficiency by different rice cultivars with applied nitrogen levels is showed in Table 4.5 and also illustrated graphically in Fig. 4.5 (a) shown overall significant increase with increase in the dose of N up to 50 kg ha^{-1} and further increase in the dose registered significant reduction in NUE. The highest NUE (56.83 %) was recorded with applied 50 kg N ha^{-1} and the lowest (41.96 %) obtained with the applied 100 kg N ha^{-1}, respectively. Decreases in NUE at higher levels of applied N have also been reported by Eagle *et al*. (2001), Timsina *et al*. (2001), Mae *et al.* (2006), Zaidi *et al*. (2007) and Metwally *et al*. (2011).Among rice cultivars efficiency of nitrogen use was differed non-significantly and ranged from (22.96 to 42.14%). The maximum N uptake efficiency was observed in rice cultivar MTU-1010 and followed by varieties CNN-3, CNN-1, BCV-1, RASI, CNN-4,VARDHAN, CNN-5, TI93 and the lowest obtained in cultivar CNN-2. Several scientists have also reported variations in NUE among different genotypes may be attributed due to genetic factors, biochemical and physiological process such as translocation, assimilation and remobilization of nitrogen (Fageria and Baligar, 2003). The interaction effect of nitrogen and rice cultivars for N use efficiency was found to be non-significantly.

4.5.2 Agronomic Nitrogen use efficiency (kg grain kg^{-1} N)

The results on agronomic N use efficiency by different rice cultivars with applied levels of nitrogen is showed in Table 4.5 and also illustrated graphically in Fig. 4.5 (a) shown overall significant increase with increase in the dose of N up to 50 kg ha^{-1} and further increase in the dose registered significant reduction in ANUE. The highest ANUE (36.29 kg grain kg^{-1} N), recorded with applied 50 kg N ha^{-1} and the lowest (24.10 kg grain kgN^{-1}) was observed with the applied 100 kg N ha^{-1}. Higher agronomic N use efficiency at lower doses of nitrogen application have also been reported Gunri *et al.* (2004), Saleque *et al.* (2004), Zaidi *et al*. (2007) and Gewaily *et al*.(2018). Among rice cultivars, efficiency of agronomic N

use (kg grain kg^{-1} N) was differed significantly and ranged from (15.26 to 25.61kg grain kg^{-1} N) .The maximum ANUE was obtained in rice cultivar CNN-3 and followed by CNN-2, VARDHAN CNN-5, CNN-4, RASI, CNN-1, MTU-1010, BCV-1, and the lowest obtained in cultivar TI93. The interaction effect of nitrogen and rice cultivars for agronomic N use efficiency was found to be non-significantly.

4.5.3 Physiological efficiency (kg biomass kg^{-1} N uptake)

The results on physiological efficiency by different rice cultivars with applied levels of nitrogen is showed in Table 4.5 and also illustrated graphically in Fig. 4.5 (a) shown overall significant increase with increase in the dose of N up to 50 kg ha^{-1} and further increase in the dose registered significant reduction in PE. The highest PE (135.05 kg biomass kg^{-1} N uptake) recorded with applied 50 kg N ha^{-1} and the lowest (129.58 kg biomass kg^{-1} N uptake) was observed with the applied 100 kg N ha^{-1}. Higher physiological efficiency at lower doses of N application have also been registered (Fageria and Baligar, 2003). Among rice cultivars efficiency of physiological (kg biomass kg^{-1} N uptake) was differed significantly and ranged from (65.72 to 121.09kg biomass kg^{-1} N uptake). The maximum PE was recorded in rice cultivar CNN-2 and followed by varieties CNN-4, CNN-5, TI93, VARDHAN, BCV-1, CNN-1, RASI, CNN-3, and the lowest obtained in cultivar MTU-1010. The results are in conformity with the findings of Zaidi *et al*. (2007) and Gewaily *et al*. (2018). The interaction effect of N and rice cultivars for physiological efficiency was found to be non-significantly.

Table 4.5: Effect of N levels on nitrogen uptake, agronomic N use and physiological efficiency of rice cultivars

Treatment	N uptake efficiency (%)	ANUE (kg grain kg^{-1} N)	PE (kg biomass kg^{-1} N Uptake)
N levels			
N0	----	----	----
N50	56.83	36.29	135.05
N100	41.96	24.10	129.58
SEm±	**1.57**	**0.81**	**11.25**
CD (p=0.05)	**6.17**	**3.17**	**44.20**
Cultivars			
CNN-1	35.47	19.09	85.81
CNN-2	22.96	23.18	121.09
CNN-3	40.61	25.61	74.58
CNN-4	33.26	20.78	93.03
CNN-5	28.76	21.13	92.42
RASI	34.02	19.64	81.22
MTU-1010	42.14	17.63	65.72
BCV-1	35.21	17.37	87.36
VARDHAN	32.14	21.64	89.89
TI93	24.70	15.26	91.01
SEm±	**5.39**	**1.55**	**13.84**
CD (p=0.05)	**NS**	**4.39**	**39.25**
Interaction	**NS**	**NS**	**NS**

Fig 4.5 (a): effect of N levels on nitrogen uptake, agronomic N use and physiological efficiency of the different rice cultivars

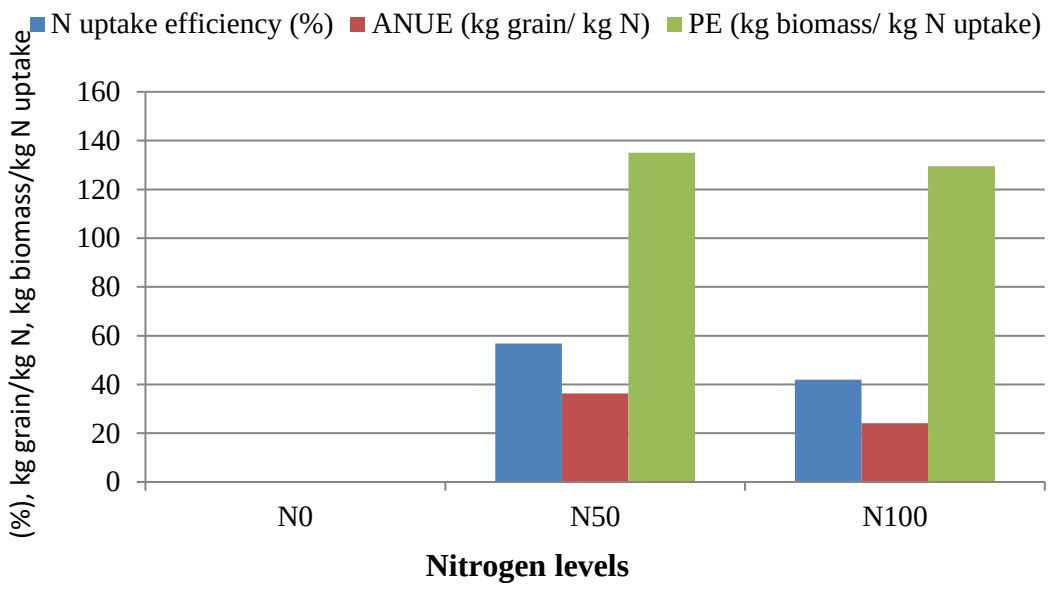
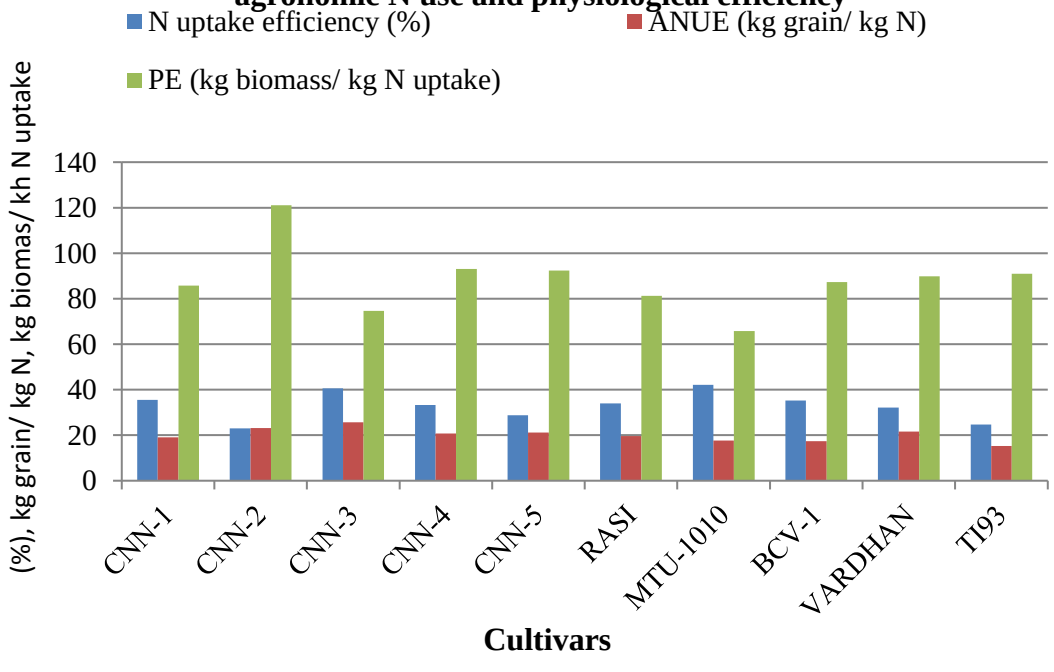


Fig 4.5 (b): effect of different cultivars of rice on nitrogen uptake, agronomic N use and physiological efficiency



4.6 Effect of nitrogen levels on physico-chemical properties of soil after harvest of the different rice cultivars

4.6.1 Soil pH

The results on soil pH is recorded after harvest and showed in Table 4.6 and also illustrated graphically in Fig. 4.6. Soil pH differed non-significantly. The highest pH was found in control plot (7.43) followed by N50 treatment (7.38) and the lowest pH was associated with N100 treatment (7.25).The soil pH on rice cultivars was found to benon-significantly. The interaction effect of nitrogen and rice cultivars for pH was obtained to be non-significantly. Similar results were also reported by Sikdar *et al.* (2008), Srivastava *et al*. (2014) and Kumar *et al*. (2017).

4.6.2 Electrical conductivity (ds m^{-1})

The results on soil EC is recorded after harvest and showed in Table 4.5 and also illustrated graphically in Fig. 4.5. Soil EC differed non-significantly. The highest EC was found in @ 100 kg N ha^{-1} (0.41 ds m^{-1}) and the lowest EC was associated with control (0.37 ds m^{-1}), The soil EC on rice cultivars was obtained to benon-significantly. The interaction effect of nitrogen and rice cultivars for EC was found to be non-significantly. Similar results were also reported by Sikdar *et al.* (2008), Srivastava *et al*. (2014) and Kumar *et al*. (2017).

4.6.3 Organic carbon (%)

The results on soil organic carbon is recorded after harvest and showed in Table 4.6 and also illustrated graphically in Fig. 4.6. Soil organic carbon differed non-significantly. The highest organic carbon was found in @ 100 kg N ha^{-1} (0.60 %), followed by @ 50 kg N ha^{-1} (0.57 %). and the minimum was associated with control (0.51 %), The soil organic carbon on rice cultivars was obtained to be non-significantly. The interaction effect of nitrogen and rice cultivars for organic carbon was found to be non-significantly. Similar results were also reported by Sikdar *et al.* (2008), Srivastava *et al*. (2014) and Kumar *et al*. (2017).

4.6.4 Available nitrogen (kg ha^{-1})

The results on soil available N is recorded after harvest and showed in Table 4.6 and also illustrated graphically in Fig. 4.6 (a). The fertility status of the

soil is influenced by various nitrogen levels. The available soil nitrogen after harvest the rice crop ranged from (156.80 to 201.11 kg ha^{-1}). Treatment with @ 100 kg N ha^{-1} reported the highest value of available nitrogen, based on all means. Control (N1) reported the minimum nitrogen available. The addition of fertilizer alone or with various nitrogen levels. Soil status is primarily due to nutrient mineralization and the shift of insufficient forms of nutrients into available forms in addition to the nutrients applied. The mineralization of soil nitrogen leading to the build-up of available nitrogen can be due to this small increase in available nitrogen content.

Available nitrogen on different rice cultivars showed in Table 4.6 and also illustrated graphically in Fig. 4.6 (b), differed non-significantly. The highest available nitrogen was found in BCV-1 (184.34 kg ha^{-1}) followed by VARDHAN, CNN-3, CNN-5, MTU-1010, CNN-1, CNN-4, RASI, CNN-2 and the lowest was associated with TI-93 (178.37 $kgha^{-1}$). The interaction effect of nitrogen and rice cultivars for available nitrogen was found to be non-significantly. Similar findings were also reported by Sudhakar *et al*. (2003), Meena *et al*. (2011), Patel *et al.* (2014) and Saha *et al.* (2017).

4.5.5 Available phosphorus (kg ha^{-1})

The results on soil available phosphorus is recorded after harvest and showed in Table 4.6 and also illustrated graphically in Fig. 4.6 (a). The fertility status of the soil in terms of available phosphorus is influenced by various nitrogen levels. The available soil phosphorus after harvest the rice crop ranged from (13.37 to 15.13 kg ha^{-1}). Treatment with @ 100 kg N ha^{-1} reported the highest value of available phosphorus, based on all means. Control (N1) reported the minimum phosphorus available. With the application of N,P and K fertilizers alone or in combination with different nitrogen levels, the rise in available phosphorus helped to release phosphorus by solubilizing the action of natural phosphorus in the soil.

Available phosphorus on different rice cultivars showed in Table 4.6 and also illustrated graphically in Fig. 4.6 (b), differed non-significantly. The highest available phosphorus was found in BCV-1 (15.17 kg ha^{-1}) followed by RASI, VARDHAN, CNN-3, MTU-1010, CNN-2, CNN-1, CNN-5, CNN-4, and the lowest was associated with TI-93 (12.51 kg ha^{-1}). The interaction effect of

nitrogen and rice cultivars for available phosphorus was found to be non-significantly. Similar findings were also reported by Sudhakar *et al*. (2003), Meena *et al*. (2011) and Patel *et al.* (2014).

4.5.6 Available potassium (kg ha^{-1})

The results on soil available K is recorded after harvest and shown in Table 4.6 and also illustrated graphically in Fig. 4.6 (a). The fertility status of the soil in terms of available potassium is influenced by various nitrogen levels. The available soil potassium after harvest the rice crop ranged from (407.35 to 487.68 kg ha^{-1}). Treatment with @ 100 kg N ha^{-1} registered the highest value of available K, based on all means. Control (N1) reported the minimum potassium available. Increase in available potassium due to addition of different nitrogen levels,the decrease in K fixation and release of K can be related to the interaction of various amounts of nitrogen.

Available potassium on different rice cultivars showed in Table 4.6 and also illustrated graphically in Fig. 4.6(b), differed non-significantly. The maximum available potassium was found in BCV-1 (460.44kg ha^{-1}) fallowed by CNN-5, CNN-2, CNN-1, CNN-3, CNN-4, MTU-1010, VARDHAN, RASI, (457 kg ha^{-1}) and the lowest was associated with TI-93 (435.51 kg ha^{-1}). The interaction effect of nitrogen and rice cultivars for available potassium was found to be non-significantly. Similar findings were also reported by Sudhakar *et al*. (2003), Sikdar *et al.* (2008) and Kumar *et al*. (2017).

Table 4.6: Effect of nitrogen levels on physico-chemical properties in soil after harvest of the different rice cultivars

Treatment	Soil pH	Soil EC (ds m^{-1})	Soil OC (%)	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
N levels						
N0	7.43	0.37	0.51	156.80	13.37	407.35
N50	7.38	0.37	0.57	188.86	13.86	455.91
N100	7.25	0.41	0.60	201.11	15.13	487.68
SEm±	**0.09**	**0.007**	**0.02**	**3.83**	**0.33**	**11.62**
CD(p=0.05)	**NS**	**NS**	**NS**	**15.05**	**1.30**	**45.64**
Cultivars						
CNN-1	7.37	0.39	0.57	182.90	13.97	456.60
CNN-2	7.38	0.38	0.59	180.13	14.08	456.83
CNN-3	7.34	0.38	0.53	183.64	14.47	453.09
CNN-4	7.38	0.37	0.55	182.05	13.46	450.22
CNN-5	7.34	0.38	0.59	183.37	13.94	457.00
RASI	7.39	0.39	0.55	180.98	14.72	442.60
MTU-1010	7.33	0.39	0.60	182.98	14.39	447.88
BCV-1	7.44	0.41	0.60	184.34	15.17	460.44
VARDHAN	7.30	0.39	0.52	183.79	14.50	442.94
TI93	7.29	0.36	0.51	178.37	12.51	435.51
SEm±	**0.12**	**0.015**	**0.03**	**6.17**	**0.98**	**20.16**
CD(p=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Interaction	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Fig 4.6 (a): effect of nitrogen levels on available N, P and K (kg ha^{-1}) in soil after harvest of the different rice cultivars

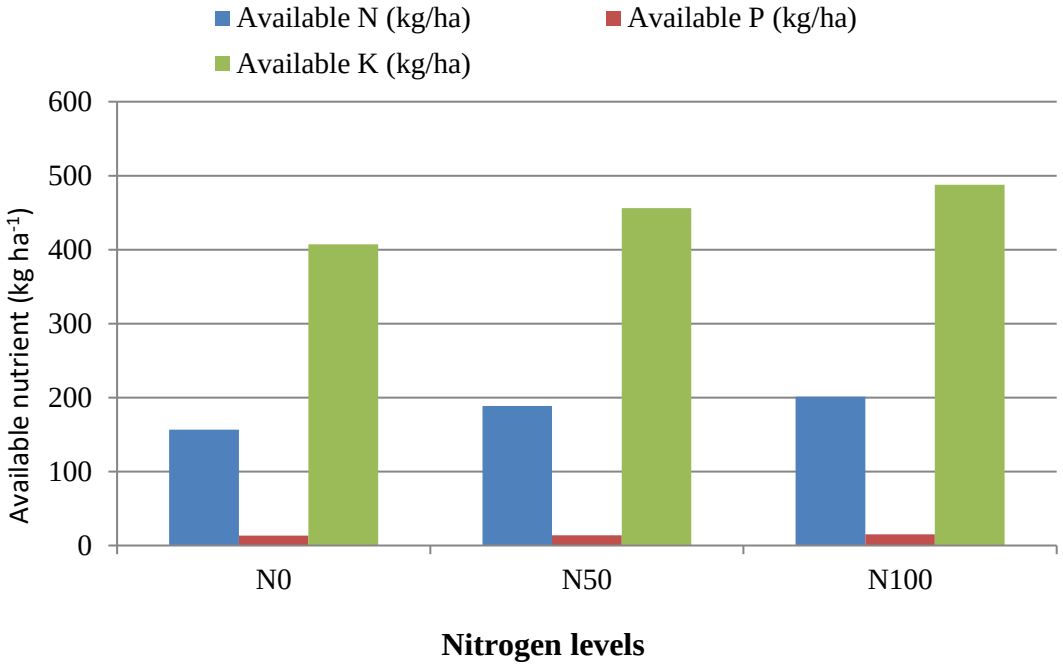
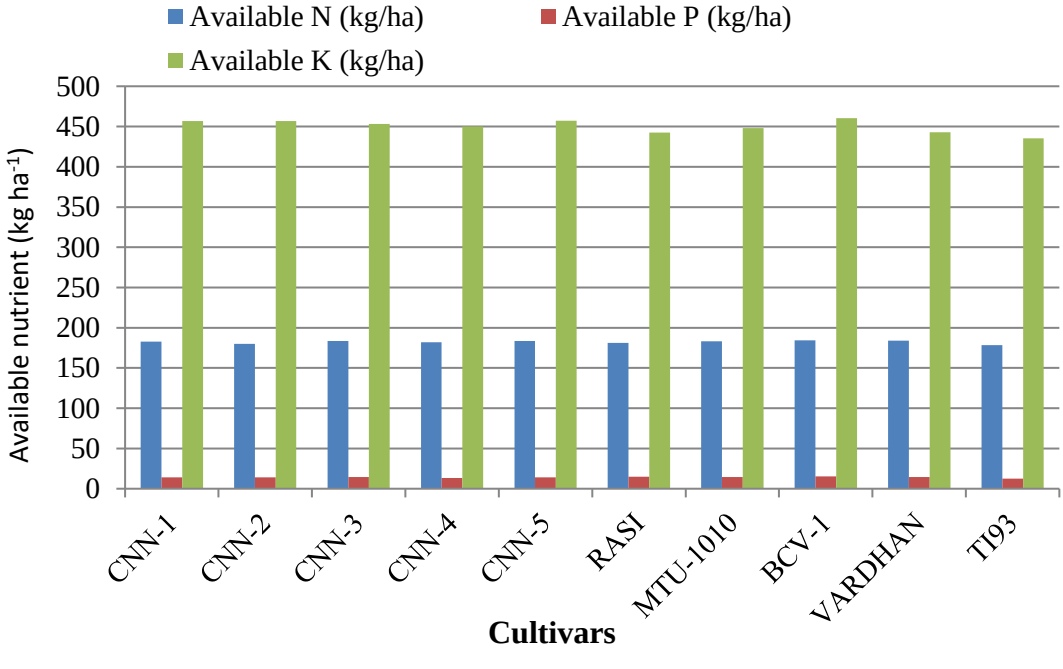


Fig 4.6 (b): effect of different cultivars of rice on available N, P and K (kg ha^{-1}) in soil after harvest



CHAPTER - V

SUMMARY AND CONCLUSIONS

The present investigation entitled **"Studies on response of nitrogen levels on growth, yield and N use efficiency of different rice cultivars in *Vertisol"*** was carried out during the *kharif* season of 2019 at Research Cum Instructional Farm of IGKV, Raipur, Chhattisgarh. The field experiment was laid out in split-plot designand treatments allocated randomly in main plots i.e. 3 nitrogen levels (N1, N2 and N3 :0,50 & 100 kg N ha^{-1}) and in sub plots 10 rice cultivars (V1- CNN-1, V2- CNN-2, V3- CNN-3, V4- CNN-4, V5- CNN-5, V6- RASI, V7- MTU-1010, V8 -BCV-1, V9- VARDHAN & V10- TI93) with total thirty treatments combinations and replicated thrice. Various field observations and soil and plant analysis carried out during this experiment to study the effect of different nitrogen levels on yield, nutrient uptake and various nitrogen use efficiencies of rice cultivars. The results from the present investigation have been discussed and the major findings of the experiment in brief are summarized as below:

- The experimental soil was clayey in texture, pH (7.3) neutral to alkaline in reaction, EC (0.42 ds m^{-1}) and low in OC (0.49 %). Available nitrogen, phosphorus and potassium status in soil was (144, 13.26 and 372 kgha-^{1}),respectively.
- Levels of applied nitrogen significantly influenced yield contributing characters viz. number of tillers m^{-2}, number of panicles^{-2}, number of grains panicle^{-1} and test weight of different rice cultivars and recorded maximum at the highest level of applied nitrogen @ 100 kg N ha^{-1}over control. Among rice cultivars highest yield contributing characters was recorded inBCV-1 followed VARDHAN, and the lowest recorded under cultivar TI93. The interaction effect of nitrogen and rice cultivars on yield contributing characters was found to be differed non-significantly.

- Grain yield of all cultivars of rice increased significantly with levels of applied N over control. The highest grain yield was obtained at highest

level of applied N100 kg ha^{-1}over control. All rice cultivars shown significantly superior with respect to grain yield production and was ranged from(35.39 to 54.86q $h^{-1)}$. Among rice cultivars BCV-1 produced the highest grain yield which was at par with VARDHAN and followed by cultivars MTU-1010, CNN-1, CNN-5 and the lowest yield obtained under cultivar TI93. The interaction effect of nitrogen and rice cultivars for grain yield was not found significant.

- Straw yield of all cultivars of rice increased significantly with levels of applied nitrogen over control. The highest straw yield was obtained at highest level @ 100 kg of applied N ha^{-1} over control. All rice cultivars shown significantly superior with respect to straw yield production and was ranged from (44.89 to 66.76q h^{-1}). Among rice cultivars,BCV-1 produced the highest straw yield which was at par with VARDHAN and followed by cultivars MTU-1010, CNN-1, CNN-5 and the lowest yield obtained under cultivar TI93. The interaction effect of nitrogen and rice cultivars for straw yield was not found significant.
- Application of nitrogen levels showed significant effect on N, P and K uptake (kg ha^{-1}) by different rice cultivars. The highest N, P and K uptake were observed at highest level of applied N 100 kg ha^{-1} over control. Among the rice varieties maximum N, P and K uptake were observed by BCV-1 and the lowest found under cultivar TI93, respectively.
- Overall nitrogen uptake efficiency (%), agronomic N use efficiency (kg grain kg^{-1} N) and physiological efficiency (kg biomass kg^{-1} N uptake) decreased with increasing applied nitrogen levels from 50 to 100 kg ha^{-1} over control.
- Nitrogen uptake efficiency (%) for studied rice cultivars ranged from (22.14 to 42.14%) and among the rice cultivars highest NUE (%) was obtained by MTU-1010 and the lowest in CNN-2 cultivar, respectively.
- Agronomic N use efficiency for studied rice cultivars ranged from (15.26 to 25.61kg grain kg^{-1} N), and the highest and lowest was recorded by rice cultivars CNN-3 and TI93 (25.61and15.26)kg grain yield produced per kg of applied nitrogen respectively.

- Physiological efficiency for studied rice cultivars ranged from (65.72 to 121.09 and the highest 121.09and lowest 65.72physiological efficiency kg biomass per kg of uptake nitrogen was obtained by rice cultivars CNN-2 and MTU-1010, respectively.
- In post-harvest analyzed soil samples after rice crop, Soil pH, EC and organic carbon were not significantly influenced with levels of applied nitrogen, whereas the available N, P and K in soil increased significantly over control. Different rice cultivars were not shown any significant effect with respect to changes in pH, EC and OC, available N, P and K in soil.

Conclusion

Based on the above studies and findings of applied nitrogen levels on different rice cultivars, it may be concluded that 100 kg N ha^{-1}registered better yield and growth parameters of rice cultivars as compared to 50 kg of applied N ha^{-1}over control . Among the different rice cultivars, BCV-1 produced maximum yield, growth parameters and N, P and K uptake followed by VARDHAN, MTU-1010, CNN-1 and CNN5, CNN-2, CNN-4, CNN-3, RASI and lowest in TI93. Higher NUE, AE and PE was found 50 kg N/ha. After harvest of rice soil physico-chemical properties like pH, EC OC was not affected with applied nitrogen levels whereas improved N, P and K status.

Suggestions for future research works

Keeping in view the above observations and knowledge gained during the course of the investigation, it is considered that future studies should take due account of the following points:

- The detailed research work should be conducted with higher levels of nitrogen with different sources for maximization of productivity under different agro-ecological situations.
- Nutrient interaction studies may be designed for the effect of N, P and K to explore higher nutrients use efficiencies for rice cultivars.

Fig 4.7: View of the experimental field pictures


T5
N100%

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APPENDIX

Weekly meteorological data during the crop growth period (2019)

weeks	Max temperature (°C)	Min temperature (°C)	Rainfall (mm)	Relative humidity-I (%)	Relative humidity-II (%)	Wind speed (kmph)	Evaporation (mm)	Sunshine (hr)
32	30.94	25.75	1.57	88.85	73.29	7.47	3.24	4.29
33	31.71	25.02	8.4	92.00	73.86	4.89	3.10	2.89
34	30.57	24.98	8.42	92.43	76.00	5.10	2.54	1.09
35	30.5	25.05	33.94	94.00	84.14	5.14	1.97	1.24
36	29.9	24.92	1.91	91.29	75.86	8.17	2.73	3.00
37	32.85	25.47	0.34	88.86	66.71	3.80	3.96	6.99
38	30.61	24.64	18.2	91.14	72.86	3.94	2.94	4.84
39	31.64	24.15	7.5	90.14	65.86	4.27	3.40	6.69
40	31.45	23.67	0.17	91.29	64.29	2.50	3.41	5.56
41	28.3	22.3	3.94	91.86	69.86	3.77	1.94	2.73
42	31.12	22.64	00	92.57	53.57	1.46	2.81	6.43
43	30.94	19.76	00	91.40	47.20	1.14	2.82	6.84
44	31.38	22.24	00	92.28	51.28	1.24	2.74	6.02
45	30.05	19.14	00	89.57	51.42	1.62	2.81	7.25
46	29.62	15.52	00	90.42	38.42	1.81	2.48	8.62
47	30.30	15.21	00	89.00	38.42	1.35	2.88	8.25

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