

**NUTRIENT BUDGETING AND ECONOMIC
ANALYSES OF SCENTED AND NON SCENTED
RICE VARIETIES IN *VERTISOL***

M.Sc. (Ag.) Thesis

by

Arun Kumar Tirkey

**DEPARTMENT OF SOIL SCIENCE AND
AGRICULTURAL CHEMISTRY**

**COLLEGE OF AGRICULTURE
INDIRA GANDHI KRISHI VISHWAVIDYALAYA
RAIPUR (C.G.)**

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Thesis

Submitted to the

Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G)

by

Arun Kumar Tirkey

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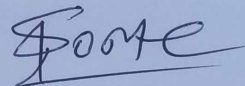
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CERTIFICATE - I

This is to certify that the thesis “Nutrient budgeting and economic analyses of scented and non scented rice varieties in *Vertisol*” submitted in partial fulfilment of the degree of **Master of Science in Agriculture** of the Indira Gandhi Krishi Vishwavidyalaya, Raipur, is a record of the bonafide research work carried out by **Arun Kumar Tirkey** under my guidance and supervision. The subject of the thesis has been approved by student’s Advisory Committee and Director of Instructions.

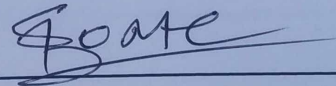
No part of the thesis has been submitted for any other degree or diploma or certificate course. All the assistance and help received during the course of the investigations have been duly acknowledged.


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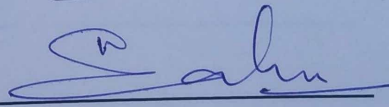
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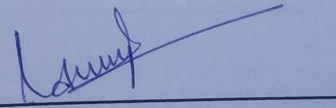
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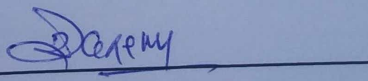
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CERTIFICATE- II

This is to certify that the thesis entitled “**Nutrient budgeting and economic analyses of scented and non scented rice varieties in Vertisol**” submitted by **Arun Kumar Tirkey** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur, in partial fulfilment 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.

K. Tedi

27.02.2021

Signature of Head of the Department

(Name.....*Keshendra Tedi*.....)

Date: *27/02/2021*

Major Advisor

Boote

Faculty Dean

Approved/Not approved

Director of Instructions

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Department of Soil Science and
Agricultural Chemistry,
College of Agriculture, IGKV
Raipur (C.G.)


Arun Kumar Tirkey

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TABLE OF CONTENTS

Chapter	Title	Page
	ACKNOWLEDGEMENT	i
	TABLE OF CONTENTS	iii
	LIST OF TABLES	vi
	LIST OF FIGURES	vii
	LIST OF ABBREVIATIONS	viii
	THESIS ABSTRACT	x
I.	INTRODUCTION	1-5
II.	REVIEW OF LITERATURE	6-26
	2.1 Nutrient budgeting of crop	6
	2.2 Economical analysis of crop production	14
	2.3 Growth characters of scented and non scented rice varieties	20
	2.4 Physico-chemical properties of soil	22
	2.5 Available macro and micronutrients	24
III.	MATERIALS AND METHODS	27-41
	3.1 Location and experimental site	27
	3.2 Climatic conditions	27
	3.3 Soils	29
	3.4 Experimental details and layout	30
	3.5 Land and Nursery bed preparation	32
	3.6 Transplanting	32
	3.7 Nutrient sources and their applications	33
	3.8 Weed management	33
	3.9 Water management	33
	3.10 Harvesting	33

3.11 Threshing and winnowing	33
3.12 Pre-harvest observations	33
3.13 Post-harvest observations	34
3.14 Soil chemical properties	34
3.15 Plant analysis	35
3.16 Nutrient uptake by crop	36
3.17 Nutrient budgeting	37
3.18 Economics	37
3.19 Statistical analysis	38
IV. RESULTS AND DISCUSSION	42-68
4.1 Physico-chemical properties of soil after harvesting of crop	42
4.1.1 Soil pH	42
4.1.2 Electrical conductivity	42
4.1.3 Organic carbon	43
4.1.4 Available Nitrogen	44
4.1.5 Available Phosphorus	44
4.1.6 Available Potassium	44
4.1.7 Available Zinc	46
4.1.8 Available Copper	46
4.1.9 Available Iron	46
4.1.10 Available Manganese	46
4.2 Growth parameters	48
4.2.1 Plant height	48
4.2.2 Number of tillers hill ⁻¹	48
4.3 Yield and yield attributes	51
4.3.1 Test weight	51
4.3.2 Grain and straw yield	51
4.4 Nutrient content and uptake by crops	53
4.4.1 Nutrient content in plants	53
4.3.2 Nutrient uptake by crop	57

4.5 Nutrient budgeting for crops	60
4.5.1 Nitrogen budgeting of different treatments	60
4.5.2 Phosphorus budgeting of different treatments	62
4.5.3 Potassium budgeting of different treatments	64
4.6 Economics	66
4.6.1 Gross Return	66
4.6.2 Net Return	66
4.6.3 Benefit Cost Ratio	67
V. SUMMARY, CONCLUSIONS AND SUGGESTIONS FOR FUTURE RESEARCH WORK	69-76
REFERENCES	77-87
APPENDICES	88-94
Appendix A	88
Appendix B	89
Appendix C	92
VITA	95

LIST OF TABLES

Table	Title	Page
3.1	Initial physical properties of the experimental soil	29
3.2	Experiment details	30
3.3	Treatment details and fertilizer dose	30
3.4	Cultural Schedule of the experiment	32
3.5	Skeleton of ANOVA table	38
4.1	Effect of different treatments on soil pH, electrical conductivity (EC) and organic carbon at post-harvest	43
4.2	Effect of different treatments on available Nitrogen, Phosphorus and Potassium of soil at post-harvest	45
4.3	Effect of different treatments on available micronutrients of soil at post-harvest	47
4.4	Average plant height of different treatments at different time interval of crop growth	49
4.5	Average number of tillers per hill of different treatments at different time interval of crop growth	49
4.6	Test weight (1000 seed), Grain and straw yield of different treatments.	52
4.7	Content of Nitrogen, Phosphorus and Potassium (%) in rice grain of different treatments	55
4.8	Content of Nitrogen, Phosphorus and Potassium (%) in rice straw of different treatments	55
4.9	Total Nitrogen, Phosphorus and Potassium uptake by grain	58
4.10	Total Nitrogen, Phosphorus and Potassium uptake by straw	58
4.11	Nitrogen budgeting of different treatments	61
4.12	Phosphorus budgeting of different treatments	63
4.13	Potassium budgeting of different treatments	65
4.14	Effect treatments on economics of scented and non scented rice varieties	67

LIST OF FIGURES

Fig. No.	Title	Page
3.1	Weekly meteorological data during the crop growth period Kharif 2019	28
3.2	Layout plan of the experimental field	31
3.3	Transplanting of the crop	40
3.4	View of the experimental field	40
3.5	view of different treatments of experiment	41
3.6	Harvesting of the crop	41
4.1	Effect of different treatments on available Nitrogen, Phosphorus and Potassium of soil at post-harvest	45
4.2	Effect of different treatments on available micronutrients of soil at post-harvest	47
4.3	Average plant height of different treatments at different time interval of crop growth	50
4.4	Average number of tillers per hill at different time interval of crop growth	50
4.5	Test weight (1000 seed) of different treatments	52
4.6	Grain and straw yield of different treatments after harvest	53
4.7	Content of Nitrogen, Phosphorus and Potassium (%) in rice grain of different treatments	56
4.8	Content of Nitrogen, Phosphorus and Potassium (%) in rice straw of different treatments	56
4.9	Total Nitrogen, Phosphorus and Potassium uptake by grain	59
4.10	Total Nitrogen, Phosphorus and Potassium uptake by straw	59
4.11	Nitrogen budgeting of different treatments	62
4.12	Phosphorus budgeting of different treatments	64
4.13	Potassium budgeting of different treatments	66
4.14	Cost of cultivation, Gross return and net returns of different treatments	68
4.15	Benefit cost ratio of different treatments	68

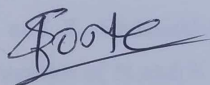
LIST OF ABBREVIATIONS

Abbreviations	Descriptions
%	Per cent
@	At the rate of
CD	Critical Difference
cm	Centimeter
Cu	Copper
DAT	Days after transplanting
df	Degree of freedom
dS/m	Deci Simens per meter
DTPA	Diethyl Triamine Penta Acetic Acid
<i>et. al.</i>	And others/ co-worker
Fe	Iron
Fig.	Figure
FYM	Farm Yard Manure
g	Gram
ha ⁻¹	Per Hectare
Hill ⁻¹	Per Hill
i.e.,	id est (that is)
kg	Kilogram
kg/ha	Kilogram per hectare
m ⁻²	Per meter square
max.	Maximum
mg/kg	Milligram per kilogram
min.	Minimum
ml	Millilitre
Mn	Manganese
No.	Number
NPK	Nitrogen, phosphorus, potassium

NS	Non significant
NUE	Nutrient use efficiency
°C	Degree Celsius
OC	Organic Carbon
p	Page
pH	Potentiality of hydrogen
Plant ⁻¹	Per plant
q	Quintal
SEm±	Standard error of mean
STV	Soil Test Value
t ha ⁻¹	Tonne per hectare
viz.	For example
Zn	Zinc

THESIS ABSTRACT

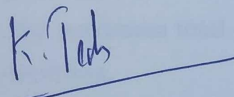
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Signature of the major
Adviser



Signature of Student



Signature of Head of the Department

Date 27/02/2021

ABSTRACT

An experiment entitled “**Nutrient budgeting and economic analyses of scented and non scented rice varieties in *Vertisol***” was conducted to study the budgeting of different nutrients and economical analysis at Instructional cum Research Farm at Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during *Kharif*, 2019. The trial consisted of 6 different varieties *viz.*, MTU 1010 (N₁₀₀P₆₀K₄₀), Zinco-rice (N₁₀₀P₆₀K₄₀), Protazin (N₁₀₀P₆₀K₄₀), Dubraj (N₆₀P₄₀K₃₀), Devbhog (N₆₀P₄₀K₃₀) and Badshahbhog (N₆₀P₄₀K₃₀) in Randomized block design with 4 replications.

The initial physico-chemical properties of the experimental site was low in available N (233.25 kg ha⁻¹), medium in available P (22.78 kg ha⁻¹) and medium in

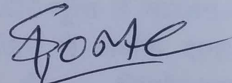
available K ($258.48 \text{ kg ha}^{-1}$) content with normal pH (7.56), EC (0.104 dSm^{-1}) and organic carbon (0.59%). The values of available micronutrients for initial soil status were Zn (1.16 mg kg^{-1}), Cu (0.248 mg kg^{-1}), Fe (1.21 mg kg^{-1}) and Mn (0.622 mg kg^{-1}) and all the fertilizers were applied as standard recommended dose. The maximum growth parameters *viz.*, plant height, number of tillers per hill was recorded with T₆-Badshahbhog and T₂-Zinco-rice whereas, the yield attributes number of tillers and test weight were found maximum in T₂-Zinco-rice and T₃-Protazin respectively. However, the maximum grain yield and straw yield were exhibited in T₅-devbhog and T₃-Protazin respectively.


The highest available N ($228.95 \text{ kg ha}^{-1}$) and K ($260.45 \text{ kg ha}^{-1}$) in soil after harvesting was recorded in T₄-Dubraj and P (22.53 kg ha^{-1}) in T₃-Protazin. The micronutrients; Zn (1.16 mg kg^{-1}) recorded maximum in T₆-Badshahbhog, Cu (0.29 mg kg^{-1}) in T₃-Protazin and T₅-Devbhog, Fe (1.22 mg kg^{-1}) in T₂-Zinco-rice, T₄-Dubraj and T₆-Badshahbhog and Mn (0.65 mg kg^{-1}) in T₂-Zinco-rice. The maximum uptake of N and K by grain and straw were recorded in T₅-Devbhog and T₃-Protazin while maximum phosphorus uptake by grain and straw were found in T₄-Dubraj and T₂-Zinco-rice respectively. However, the maximum total uptake of N and K were recorded in T₃-Protazin while, P in T₅-Devbhog.

T₂-Zinco-rice ($242.22 \text{ kg ha}^{-1}$), T₁-MTU 1010 (66.82 kg ha^{-1}) and T₁-MTU 1010 ($179.66 \text{ kg ha}^{-1}$) recorded the maximum expected balance value of N, P and K, respectively in the soil. The maximum actual balance (post harvest soil test) of N, P and K in soil were calculated in T₄-Dubraj ($228.95 \text{ kg ha}^{-1}$), T₂-Protazin (22.53 kg ha^{-1}) and T₄-Dubraj ($260.45 \text{ kg ha}^{-1}$) respectively. The maximum N–balance, P–balance and K–balance in soil were calculated in T₅-Devbhog (44.80 kg ha^{-1}), T₅-Devbhog ($-22.74 \text{ kg ha}^{-1}$) and T₅-Devbhog ($123.26 \text{ kg ha}^{-1}$) respectively on the basis of nutrient uptake by plant. However, on the basis of soil test value, the minimum loss of N–balance, P–balance and K–balance in soil were exhibited in T₄-Dubraj (-4.3 kg ha^{-1}), T₃-Protazin (-0.25 kg ha^{-1}) and T₄-Dubraj (1.97 kg ha^{-1}) respectively. The maximum gross return (Rs 110573.13), net return (Rs 86095.55) and benefit cost ratio (3.52) were received with T₅-Devbhog.

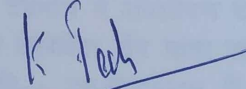
शोध सारांश

- अ. शोध ग्रंथ का शीर्षक : कन्हार मृदा में सुगंधित और बिना सुगंधित धान की किस्मों के पोषण बजट और आर्थिक विश्लेषण
- ब. छात्र का पूरा नाम : अरुण कुमार तिकी
- स. प्रमुख विषय : मृदा विज्ञान एवं कृषि रसायन विभाग
- द. प्रमुख सलाहकार का नाम और पता : डॉ. एस. एस. पोर्ते, वरिष्ठ वैज्ञानिक मृदा विज्ञान एवं कृषि रसायन विभाग कृषि महाविद्यालय, रायपुर (छ.ग.)
- इ. प्रदान की जाने वाली उपाधि : एम.एस.सी.(कृषि) मृदा विज्ञान एवं कृषि रसायन विभाग


प्रमुख सलाहकार के हस्ताक्षर


छात्र के हस्ताक्षर

दिनांक 27/02/2021


विभागाध्यक्ष के हस्ताक्षर

सारांश

प्रस्तुत अन्वेषण कन्हार मृदा में सुगंधित और बिना सुगंधित धान की किस्मों के पोषण बजट और आर्थिक विश्लेषण का अध्ययन किया गया यह परिक्षण इंदिरा गांधी कृषि विश्वविद्यालय के अनुसंधान सह अनुदेशक प्रक्षेत्र, कृषि महाविद्यालय रायपुर (छ.ग.) में खरीफ 2019 में किया गया। यह परीक्षण प्रक्षेत्र में यादृच्छिक खण्ड अभिकल्पना (आर.बी.डी.) का प्रयोग करके किया गया, जिसे चार पुनरावृत्ति तरीके से लगाया गया जिसमें 6 अलग – अलग धान की किस्मों को लिया गया जो इस प्रकार हैं:—एम.टी.यू1010 (एन₁₀₀पी₆₀के₄₀), जिन्कोराइस (एन₁₀₀पी₆₀के₄₀), प्रोटाजिन (एन₁₀₀पी₆₀के₄₀), दुबराज (एन₁₀₀पी₆₀के₄₀), देवभोग (एन₁₀₀पी₆₀के₄₀) एवं बादशाहभोग (एन₁₀₀पी₆₀के₄₀) शामिल था।

परीक्षण किये गये खेत में मृदा की प्रारम्भिक भौतिक –रासायनिक गुण जिसमें उपलब्ध नत्रजन (233.25 कि.ग्रा./हे.) उपलब्ध स्फूर (22.78 कि.ग्रा./हे.) उपलब्ध पोटाश (258.

48 कि.ग्रा./हे.) के साथ सामान्य मृदा पी.एच. मान (7.56), ई.सी. (0.104 डे.सा.प्रति मी.), मृदा कार्बनिक कार्बन (0.59) पाया गया। प्रारंभिक मृदा की स्थिति के लिए उपलब्ध सूक्ष्म पोषक तत्वों में जिंक (1.16 मि.ग्रा. प्रति कि.ग्रा.), कॉपर (0.248 मि.ग्रा.प्रति कि.ग्रा.), आयरन (1.21 मि.ग्रा.प्रति कि.ग्रा.) और मैंगनीज (0.622 मि.ग्रा.प्रति कि.ग्रा.) पाया गया। सभी उर्वरकों को मानक अनुशासित मात्रा (एन.पी.के. कि.ग्रा.प्रति हेक्टेयर) के हिसाब से प्रयोग किया गया था। अधिकतम वृद्धि के मापदंड जैसे पौधे की ऊंचाई, प्रति पौधे कंसो की संख्या, टी₂ – जिंकोराइस और टी₆ – बादशाहभोग में दर्ज की गई थी। जबकि अधिकतम उपज के मापदंड जैसे कंसो की संख्या और परीक्षण भार क्रमशः टी₂ – जिंकोराइस और टी₃ – प्रोटाजिन में अधिक पाया गया। अधिकतम दाना और भूसा की उपज तथा परीक्षण भार क्रमशः टी₅ – देवभोग और टी₃ – प्रोटाजिन में पाया गया।

फसल कटाई के बाद मृदा में सबसे अधिक उपलब्ध नत्रजन (228.95 कि.ग्रा.प्रति हेक्टेयर) और पोटाश (260.45 कि.ग्रा.प्रति हेक्टेयर) टी₄ – दूबराज में और स्फूर (22.53 कि.ग्रा.प्रति हेक्टेयर) टी₃ – प्रोटाजिन में दर्ज किया गया। मृदा में उपलब्ध सूक्ष्म पोषक तत्वों में जिंक (1.16 मि.ग्रा.प्रति कि.ग्रा.) टी₆ – बादशाहभोग में, कॉपर (0.29 मि.ग्रा.प्रति कि.ग्रा.) टी₃ – प्रोटाजिन और टी₅ – देवभोग में, आयरन (1.22 मि.ग्रा.प्रति कि.ग्रा.) टी₂ – जिंकोराइस, टी₄ – दूबराज और टी₆ – बादशाहभोग में, मैंगनीज (0.65 मि.ग्रा.प्रति कि.ग्रा.) टी₂ – जिंकोराइस में अधिकतम पाया गया। दाना और भूसा में नत्रजन और पोटाश का अधिकतम अवशोषण क्रमशः टी₅ – देवभोग और टी₃ – प्रोटाजिन में जबकि दाना और भूसा में स्फूर का अधिकतम अवशोषण क्रमशः टी₄ – दूबराज और टी₂ – जिंकोराइस में पाया गया। नत्रजन और पोटाश का अधिकतम कुल अवशोषण टी₃ – प्रोटाजिन में जबकि, स्फूर का टी₅ – देवभोग में अवशोषण दर्ज किया गया।

मृदा में नत्रजन, स्फूर और पोटाश कि सर्वाधिक आपेक्षित शेष मात्रा सर्वाधिक क्रमशः टी₂ – जिंकोराइस में (242.25 कि.ग्रा.प्रति हेक्टेयर) टी₁ – एम.टी.यू1010 में (66.82 कि.ग्रा. प्रति हेक्टेयर) और टी₁ – एम.टी.यू1010 में (179.66 कि.ग्रा.प्रति हेक्टेयर) पाया गया। मृदा में नत्रजन, स्फूर और पोटाश की अधिकतम वास्तविक शेष मात्रा क्रमशः टी₄ – दूबराज (228.95 कि.ग्रा.प्रति हेक्टेयर), टी₃ – प्रोटाजिन (22.53 कि.ग्रा.प्रति हेक्टेयर) और टी₄ – दूबराज (260.45 कि.ग्रा.प्रति हेक्टेयर), में गणना की गई। पौधों द्वारा पोषक तत्व अवशोषण के आधार पर मृदा में अधिकतम नत्रजन, स्फूर और पोटाश की शेष मात्रा टी₅ – देवभोग में क्रमशः 44.80 कि.ग्रा.प्रति हेक्टेयर, 22.74 कि.ग्रा.प्रति हेक्टेयर और 123.26 कि.ग्रा.प्रति हेक्टेयर गणना की गई। मृदा परीक्षण के आधार पर मृदा में नत्रजन और स्फूर का शेष मात्रा का न्यूनतम नुकसान क्रमशः टी₄ – दूबराज (–4.3 कि.ग्रा. प्रति हेक्टेयर) और टी₃ – प्रोटाजिन (–0.25 कि.ग्रा.प्रति हेक्टेयर), जबकि अधिकतम पोटाश का शेष मात्रा टी₄ – दूबराज (– 1.97 कि.ग्रा.प्रति हेक्टेयर) में गणना किया गया। टी₅ – देवभोग से सबसे ज्यादा सकल मूल्य (रुपये 110573.13), शुद्ध मूल्य (रुपये 86095.55) व लाभ लागत अनुपात (3.52) पायी गई है।

CHAPTER – I

INTRODUCTION

Rice (*Oryza sativa* L.) (2n=24) is the most valuable cereal crop which is also known as “Global Grain” because about 100 countries of the world use it as prime staple food. About 167 M_ha of total areas were occupied for rice production in the world, with a total production of 769.65 million tonnes. Asia alone produces over 95% of global rice with China 212.6 million tonnes and India 168.5 million tonnes. After China, India is the largest producers of rice and together producing 50% of the world’s rice. Rice crop is predominating in Chhattisgarh state. It is cultivated in 3.61 million hectare of area. Its production is 6.53 million ton and productivity is only 1.81 t ha⁻¹. (Anonymous, 2019).

The population of rice consuming increasing at an alarming rate of 100 million per year and the land to population ratio being on decreasing trend, by 2021 the rice requirements of Asia would exceed 760 million tonnes. To feed the growing population by 2035, it is predicted that an additional 116 million tons of rice will be needed (Seck *et al.*, 2012). The rice sector is also a major source of employment and income besides meeting local consumption demands in rural areas.

The highly populated countries with low income has drastically increase in population by 90% but the production of rice increased by 130% from 257 million tons in 1966 to 600 million tons in 2000. However, the population of rice eating countries continues to grow and it is estimated that 40% more rice will be required to meet the demand in 2030 (Khush, 2005). According to the projections of Population Foundation of India (PFI) Indian population will be 1.4 billion by the year 2022 and the estimated demand of rice for consumption will be about 115 million tonnes. Similarly at current rate of population growth (1.98%) the population of India is expected to be 1.63 billion by 2050 and the estimated

demand of rice will be 136 million tons for consumption purpose only (Meera *et al.*, 2018).

In India the productivity of rice is very low, which is far below than the other rice growing countries. The adoption of integrated nutrient management and modern farming practices are essential to produce crops in line with the observed global standards of quantity and quality. Hence, the introduction of high-yielding varieties (HYVs) with infusion of fertilizers, irrigation water and pesticides got a major fillip. This package of high yielding production technology has helped the country to become food surplus.

According to recent analysis on long- term soil fertility experiments, yields have declined or stagnated for rice and wheat, these two main crops of the country, raising concerns about the long term sustainability of intensively cultivated production systems and food security of the region (Ladha *et al.* 2003). Most fertilizer management practices in intensive agriculture do not consider nutrient budget in relation to yield. The major reason behind the stagnation or decline in yield is lack of notion that application of N, P, K and other nutrients are highly unbalanced.

Nutrient budgets offer insight into the balance between crop inputs and outputs (Gourley *et al.*, 2007). It is a comparison of nutrients that applied to the soil and taken up by crops. All the nutrient inputs on a farm and all those removed from the land are taken into the account of nutrient budgeting. It is a technique used to predict or quantify nutrient surpluses or deficits, either at a field scale or whole farm, in an attempt to determine fertilizer requirements. Nutrient budget can reduce nutrient losses from soil and improve nutrient use efficiency from agriculture. “Nutrient budget describes the nutrient stocks and flows as related to different land management systems is a powerful tool in determining present and future productivity of agricultural land, as well as undesirable environmental effects such as nutrient mining and pollution.” (Smaling and Fresco, 1993)

Nutrient budgets have been used all around the world, using a different scales and methodological approaches. They estimate or measure the nutrient inputs and outputs (normally nitrogen, phosphorus and potassium) to a land, farm and field or usually at the farm gate. On the basis of time period nutrient budgeting can be operate on daily, monthly, or annual time frame. (Meisinger and Randall, 1991, Watson and Atkinson, 1999). More user inputs are requires for more frequent tracking, but it is also provides the maximum opportunity for synchronizing nutrient inputs with crop needs. Inputs in fertilizers, compost, feed, manures, and bedding and outputs in saleable produce are generally includes in farm gate budgets. They also include the necessarily very detailed measurements of different losses such as denitrification, leaching and ammonia volatilization, measure transfer between fields or consider each field separately. Nutrient budgeting cannot improve nitrogen use efficiency by their nature but only can highlight the problems and raise awareness of the need for better techniques.

The use of nutrient budgeting and nutrient audits is becoming increasingly important to assess the changes in soil nutrient status and the prospects for future food production in many agricultural systems (Sheldrick *et al.*, 2002, Pathak *et al.*, 2010). To assess the change in soil fertility status nutrient budgeting is commonly used as an indicator. Raising awareness among farmers, extension personnel and researchers about rate of nutrient accumulation or depletion, nutrient flow and to develop improved nutrient management strategies are also important in developing nutrient budgets.

In low land transplanted rice the yield is better than other systems of cultivation. But it removes a major portion of the essential nutrients from the soil and causes deficiency in succeeding seasons leading to yield decline. Due to the increasing price of fertilizers, improving the nutrient use efficiency and yield and optimizing the cost of production are now the matter of concern.

Among the major nutrients, application of nitrogen is essential to obtain the higher yields from high yielding nitrogen responsive rice varieties. Among the

major nutrients nitrogen deserves a special status and is the “mineral of life” for rice. In irrigated ecosystem nitrogen is the most critical input that limits the productivity of rice. Extensive research has demonstrated that normally only 20-40% of applied N fertilizer is utilized by irrigated rice. With a view to increasing the yield and reduce the losses, a part of chemical N fertilizers, substituted by locally available organic sources of nutrients *viz.*, compost, manures, green manures, biofertilizers, crop residues etc. is inevitable.

The conventional varieties were not responsive to higher doses of fertilizer application but the new high yielding cultivars are highly responsive to the higher doses of fertilizer application. Since the higher doses of chemical fertilizer application is detrimental to the soil health, the best way of soil fertilization is combine application of organic and chemical fertilizers. Nutrient management must be sound for achieving the production target in sustainable manner. Use of chemical fertilizer is the fastest way of counteracting the pace of nutrient mining. It promotes the growth and development of rice crop and is responsible for over 50 per cent of the crop yield increment. The essential plant nutrients play a vital role in boosting the yield of aromatic rice. It responds to judicious application of fertilizer, especially nitrogen, phosphorus and potassium and gives higher yield from aromatic varieties at a particular fertilizer level (Singh and Virmani 1990).

An intensive breeding effort causes the reduction of genetic diversity of modern rice cultivars. For rice breeding programs more diverse germplasm would enhance the selection efficiency of desirable varieties. Nutrient and economical comparisons between scented and non scented rice varieties must be required for better implementation of inputs for great yield. In the present era there is a great demand for aromatic rice for the purpose of export. Cultivation of aromatic rice is very remunerative as it fetches sufficiently higher price over the coarse varieties, even in the local markets (Bali and Uppal; 1995).

In Asiatic countries (India, Pakistan, Bangladesh, Thailand, Indonesia etc.) the demand for scented rice is very high. Fine grain aromatic rice (like

Badshahbhog, Basmati and Dubraj etc.) has a flavor, heady and perfumed fragrance that can complement the complex and hot seasonings of Indian and Thai cuisine. One of the most popular scented rice (basmati) is dry, fluffy and light when cooked, like any well-behaved long grain. Aroma is the one of the most valuable traits in grain quality of the Asian cultivated rice. The main volatile chemical compound 2- acetyl-1-pyrroline (2-ACP) is responsible for the popcorn-like odour of scented rice (Bradbury et al. 2005).

Now the cultivation of scented rice has been restricted to home consumption level only, which is grown without much use of chemical fertilizers and pesticides to maintain consumption preference. Since farmers prefers traditional or high yielding cultivars for better economical security. These cultivars required low management and they are more resist to environment also but they required more inputs and soil fertility status. In comparison to traditional cultivars, scented cultivars of rice have more grain quality in respect to food purposes. There is a huge potential to export aromatic rice produced in the country. Thus the comparative behaviour of cultivation between scented and non scented cultivars of rice must be required for better implementation and higher net return for farmers.

Keeping these points in view, the present experiment entitled, “**Nutrient budgeting and economic analyses of scented and non scented rice varieties in Vertisol**” was carried out with the following objectives:

1. To study the nutrient budgeting in scented and non-scented rice.
2. To estimate economic analysis of scented and non-scented rice varieties.

CHAPTER – II

REVIEW OF LITERATURE

In this chapter, an attempt has been made to review pertinent literature in view of the problem entitled, “**Nutrient budgeting and economic analyses of scented and non scented rice varieties in Vertisol**” A brief account of the work reported by the past researchers has been discussed under the following heads of a study:

2.1 Nutrient budgeting of crop.

2.2 Economical analysis of crop production.

2.3 Growth characters of scented and non scented rice varieties.

2.4 Physico-chemical properties of soil.

2.5 Available macro and micronutrients.

2.1 Nutrient budgeting of crop:

Hai-ying *et al.*, (2010) reported that the average annual inputs as 4088, 3655 and 3437 kg ha⁻¹ for N, P₂O₅ and K₂O respectively. The total inputs provided by the chemical fertilizers was N (63%), P₂O₅ (61%) and K₂O (66%) which are the main source of soil nutrient. There are only 24, 8 and 46% utilization rates of N, P₂O₅ and K₂O. The input ratio for N, P₂O₅ and K₂O was 1:0.9:0.8, while the uptake ratio was 1:0.3:1.4. It had caused the excess of N, P₂O₅ and K₂O in the soil, and the theoretical surpluses for N, P₂O₅ and K₂O were 3214, 3401 and 2322 kg ha⁻¹, respectively. The level of the total N, nitrate N, available P, available K and organic matter was increased substantially, and their maximum level was observed in the topsoil (0–20 cm).

Ma *et al.*, (2010) reported that soil total nitrogen decreased significantly when treated with mineral fertilizer or recycled manure alone. Control treatment (557 kg ha⁻¹) reported the maximum deficit of soil total nitrogen from 1990 to

2005. Due to the high yield of the crop in response to applied nitrogen the N-treatment resulted in a significant negative balance of phosphorus. The application of nitrogen phosphorus or nitrogen to soils resulted in a greater negative potassium balance than that of the control. Under the control and N-treatment total phosphorus and available phosphorus were found in negative balance. The highest deficit of soil total potassium and exchangeable potassium were obtained under NP-treatment. To maintain soil fertility they recommended the application of $150 \text{ kg N ha}^{-1}\text{year}^{-1}$, $25 \text{ kg P ha}^{-1}\text{year}^{-1}$, and $60 \text{ kg K ha}^{-1}\text{year}^{-1}$ combined with $2\text{--}3 \text{ t ha}^{-1}$ organic manure.

Mahajan *et al.*, (2010) conducted study to optimize nitrogen levels for higher yield and nutrient use efficiency of modern aromatic rice cultivars. Across all genotypes, the mean N-fertilizer response was highest at 40 kg N ha^{-1} as compared to other N levels (0, 20, and 60 kg N ha^{-1}), indicating that further increase in nitrogen level had no effect on crop response to fertilizer. When plots were supplemented with 40 kg N ha^{-1} as compared to control (unfertilized) the mean grain yield was increased by 64.2%. The highest yield reported in Punjab Mehak-1 (4.3 t ha^{-1}), followed by Pusa-1121 (4.0 t ha^{-1}) and Punjab Basmati-2 (3.9 t ha^{-1}) among different cultivars. Interactive effect between cultivars and nitrogen levels revealed that with compared to Punjab basmati-2 and Pusa-1121, Punjab Mehak-1 responded significantly up to 60 kg N ha^{-1} due to higher nitrogen uptake and more NUE.

Srinivas *et al.*, (2010) finding similar observation as application of 150% dose of CF helped to accumulate the significantly higher N (276.8 kg ha^{-1}), P (21.2 kg ha^{-1}) and Zn (1.53 kg ha^{-1}) in soil over rest of the treatment. RDF+ 5 t FYM (T_8) showed the highest amount of K (319.5 kg ha^{-1}) available in soil at harvest. In different treatments available N ranged from 182.3 to 276.8 kg ha^{-1} , available phosphorous ranged from 13.4 to 21.2 kg ha^{-1} , available K ranged from 210.7 to 319.5 kg ha^{-1} and available Zn ranged from 0.14 to 1.53 kg ha^{-1} .

Leip *et al.*, (2011) calculated soil, land and farm N-budgets for countries in Europe and the EU27 as a whole using the agro-economic model

CAPRI. For EU27, $55 \text{ kg N ha}^{-1} \text{ yr}^{-1}$ N-surplus is calculated for a soil budget, $65 \text{ kg N}_2\text{O-N ha}^{-1} \text{ yr}^{-1}$ for land budget and $67 \text{ kg N ha}^{-1} \text{ yr}^{-1}$ for farm budget. 63% NUE obtained for the soil budget, while 60% and 31% NUE obtained for land and farm budget respectively.

Mahajan and Timsina (2011) reported that DSR (a non-basmati rice) required more nitrogen than TP rice. For improving nitrogen use efficiency and crop yields the timing and rate of nitrogen application is also an important crop management practice.

Pinitpaitoon *et al.*, (2011) reported that mineral fertilizer rate was the major factor for maize nutrient budgets as shown by its contribution to nitrogen and phosphorus balances. In the case of nitrogen, shoot uptake was the main output followed by denitrification. Phosphorus adsorption by the soil was the major phosphorus output from the available pools followed by shoot uptake. The pool of available nitrogen and phosphorus was maintained by soil organic matter mineralization if stubble of the previous crop was returned. Mineral fertilizer application, which produced surplus balances of nitrogen and phosphorus, would however, be needed to attain high yield, even with stubble return. Until 3 year, the available nitrogen and phosphorus from compost were not significant inputs in the nutrient balances. Total nitrogen and resin extractable phosphorus in soil after five crops supported the calculated nutrient balances indicating the importance of available nutrient fluxes in calculating nitrogen and phosphorus balances.

Hossain *et al.*, (2012) conducted a project which undertaken in lowland irrigated systems of Bangladesh to study the nitrogen budgets of Boro rice grown under ecological and conventional farming systems. They reported that ecological farming system produced a less negative balance in both years (-6 to -36 kg N ha^{-1} in 2007 and -76 to $-160 \text{ kg N ha}^{-1}$ in 2008) than the conventional farming system (-28 to -80 kg N ha^{-1} in 2007 and -91 to $-157 \text{ kg N ha}^{-1}$ in 2008). Beneficial impacts of ecological farming on nitrogen balances were observed due to the elimination of fertilizer nitrogen loss (30 – 133 kg N ha^{-1}).

Kabir *et al.*, (2012) revealed the significant combination of different treatments with grain and straw yields of STL-655 rice mutant. T₆ (with soil test basis high yield goal treatment) recorded the highest grain (3.95 t ha⁻¹) and straw yield (7.38 t ha⁻¹), which was significantly higher than all other treatments. They found the nutrient uptake of N, P, and K by grain of boro rice (STL-655 rice mutant) varied from 25.14 to 48.02, 5.40 to 8.14 and 11.76 to 23.02 kg ha⁻¹, respectively. The N, P and K uptake by straw of boro rice (STL-655 rice mutant) varied from 20.36 to 35.85, 5.47 to 11.05 and 59.01 to 159.6 kg ha⁻¹, respectively.

Korsaeth (2012) studied the soil system budgets of nitrogen, phosphorus and potassium in six contrasting cropping systems during 10 years of a long-term experiment in southeast Norway. He estimate all inputs and outputs of major nutrient and reported that in term of nitrogen, cash-cropping appeared to be balanced, whereas nitrogen surplus found for conventional mixed cropping. By contrast, less up to date conventional arable cash-cropping and all the organic systems showed indications of soil organic nitrogen depletion (negative nitrogen budgets). Mining of the soil phosphorus and potassium content showed by the all the organic systems, whereas phosphorus and potassium surpluses found by the conventional systems.

Singh and Sen (2012) Observed that HUR 105 during wet seasons recorded better yield than Pusa Basmati-1 by 24.6% over 3 years (on the basis of mean) and revealed 48.3% (Eastern region), 12.6% (Western region), 10.7% (Bundelkhand region) and 8.7% (Central region) higher rice grain yield than Pusa Basmati-1. The variety HUR 105 performed better than the check variety Basmati 370 in all locations, with an improvement of 83.6% over 3 years. The results found was at par with performance of HUR 105 with respect to the quality of grain, kernel length and breadth, kernel elongation ratio, scent of grain, and good taste.

Kumari *et al.*, (2013) found that the aromatic rice (Birasmati) applied with 100-21.8-20.8 kg NPK ha⁻¹ resulted considerably higher NPK content of the grain and straw of the rice crop.

Rosolem and Calonego (2013) studies the P and K budget in the soil–plant system for different soil managements and crop rotations under no-till at depths up to 60 cm for three years. They found the largest decrease in available phosphorus within 0 – 60 cm of the soil profile which led by triticale/millet rotation and the largest potassium increase within the 0 - 50 cm layer. Increases in the available potassium content and mobility in the soil profile in the 40 - 60 cm layer were independent of the management system. There is considerable potassium leaching below 60 cm, but chiseling and the use of high potassium accumulating plants as triticale results in lower K losses.

Yadav *et al.*, (2013) conducted a field experiment to find out the effect of organic nitrogen sources and biofertilizers on system productivity and energy budgeting of rice based cropping system at Varanasi, Uttar Pradesh. They reported that the highest production efficiency ($96.7 \text{ kg ha}^{-1}\text{day}^{-1}$), rice-equivalent grain yield (35.3 t ha^{-1}), land utilization efficiency (89.8%), energy-use efficiency (3.15) and economic efficiency (803 ha day^{-1}) of system by organic nutrition with biofertilizers (Azotobacter and PSB). They states rice-potato-onion cropping system as most profitable, productive, and energy efficient with application of 100% recommended dose of nitrogen through organic sources along with biofertilizers.

Yu *et al.*, (2013) conducted a field experiment to study the effects of different nitrogen levels on nutrient uptake and ammonia volatilization and results revealed that correlation analysis between rice yield and accumulative uptake of nitrogen, phosphorus and potassium by the rice plants was positive.

Azarpour *et al.*, (2014) studied the effect of nitrogen management on growth analysis of rice cultivars in which three rice cultivars and four nitrogen levels were taken. Result of this study indicated that increasing rate of nitrogen fertilizer caused increment in growth indexes viz., crop growth rate, and relative growth rate and leaf area index. Also indicate that cultivar and nitrogen levels showed significant effect on grain yield.

Das *et al.*, (2014) conducted an experiment under integrated nutrient management practices emphasizing the trends in grain yields, nutrient budgeting and sustainable yield index (SYI) and measured the long-term (28 years) sustainability of rice-wheat cropping system. Their long term data revealed that grain yield of both rice and wheat were declined under control and sub-optimal fertilizer inputs (50% or 75% recommended fertilizer NPK). He observed the negative yield trend for rice and wheat in control plots; whereas treatments which receiving organic supplements or inputs, the yield trend was positive.

Malik *et al.*, (2014) studied the effect of different nitrogen levels on different varieties of Basmati rice and results revealed that Pusa Basmati-1 was significantly different at higher level of nitrogen from all the parameters considered, which include plant height, dry weight, number of tillers per hill, length of panicle, number of filled grains per panicle, biological yield, grain yield, straw yield, harvest index and benefit cost ratio.

Ramanjaneyulu *et al.*, (2014) revealed that JGL-11727 and MTU-1001 have higher yield, yield attributes and water productivity followed by MTU-1010 than other varieties. Significantly greater amounts of nitrogen and potassium were consumed by JGL-11727 variety than other varieties of rice, barring MTU-1001 and MTU 1010. They further reported that JGL-11727 was more efficient regarding phosphorus mining by grain, straw and total plant.

Dekhane *et al.*, (2015) observed the performance of different organic and inorganic fertilizers on growth and yield of paddy crop during *kharif* season of 2014. They reported that application of 50 % nitrogen through RDF + 50% nitrogen through vermin-compost recorded highest growth attributes like number of tillers plant⁻¹ was 8.6 and 12.2 plant height was 43.9 cm and 116.5 cm, at 45 DAT and at harvest time respectively, grains per panicle (125.3), panicle length (21.3 cm), test weight of 1000 grain (19.1 g), grain yield (4.64 t ha⁻¹.) and straw yield (5.36 t ha⁻¹.) of rice over all other treatments.

Trinath *et al.*, (2015) concluded that OM showed greater available NPK contents and NPK balance in soil than those of INM and RDF. The lowest

available NPK contents and NPK balance were recorded RDF treated plots. Cultivar Pusa Basmati-1 performed significantly better than Geetanjali variety.

Gupta *et al.*, (2016) conducted field experiment in 3 treatments including NE (Nutrient Expert recommendation), GR (Government recommendation), and FP (Farmer practices). The result revealed significant difference in terms of plant height, panicle length, and numbers of effective tiller m^{-2} , total grain per panicle, filled grain per panicle, unfilled grain per panicle, sterility %, yield at 15.5% moisture, biomass, straw yield, test weight, harvesting index. NE obtained the highest yield of 5.46 ton ha^{-1} followed by GR (4.79 ton ha^{-1}) and FP (4.43 ton ha^{-1}). In comparison with GR, significantly higher yield produced by NE based practices.

Kundu *et al.*, (2016) conducted a field experiment to study the responses of integrated nitrogen management on the performance of aromatic rice varieties. They reported that all the yield attributes and yield of rice, plant height (139.33 cm) at 80 DAT, number of tillers/hill (32), number of panicles/ m^2 (90), number of grains per panicle (286) and test weight of 1000 grain (21.95 g) increased considerably due to application of 50% nitrogen through urea+50% nitrogen through vermicompost over other treatments.

Ladha *et al.*, (2016) constructed a top-down global nitrogen budget for maize, rice and wheat for a 50-year period (1961 to 2010). Total 1551 Tg (1 Teragram = 10^{12} g) of nitrogen harvested by cereals, out of which 48% was supplied through fertilizer nitrogen and 4% came from net soil depletion. An estimated 48% (737 Tg) of crop nitrogen, equal to 29, 38 and $25 \text{ kg ha}^{-1} \text{ yr}^{-1}$ for maize, rice and wheat, respectively, is contributed by sources other than fertilizer nitrogen or soil nitrogen. Major source of nitrogen was non-symbiotic nitrogen fixation, which is 370 Tg or 24% of total nitrogen in the crop. $13 \text{ kg ha}^{-1} \text{ yr}^{-1}$ for maize, $22 \text{ kg ha}^{-1} \text{ yr}^{-1}$ for rice and $13 \text{ kg ha}^{-1} \text{ yr}^{-1}$ for wheat. The other sources of nitrogen are atmospheric deposition (96 Tg or 6%) and manure (217 Tg or 14%).

Nanda *et al.*, (2016) reported that NPK levels up to 100% RDF (120-60-60 kg ha⁻¹) in basmati rice (HUBR 10-9) significantly increased NPK removal by grain (75.52, 19.12 & 17.33 kg ha⁻¹) and straw (53.31, 7.58 & 118.67 kg ha⁻¹).

Surendran *et al.*, (2016) attempts a study to apply Nutrient monitoring (NUTMON) model for carrying out nutrient budgeting to assess the stocks and flows of nitrogen (N), phosphorus (P), and potassium (K) in defined geographical unit. They reported that nutrient balances were negative for N (-3.3 and -10.1 kg ha⁻¹) and K (-58.6 and -9.8 kg ha⁻¹) while positive for P (+14.5 and 20.5 kg ha⁻¹). They revealed the positive nutrient balance when DSSIFER (Decision Support System for Integrated Fertilizer Recommendation) recommended fertilizers are applied to crops.

Bhama *et al.*, (2017) observed the experiment on nutrient budgeting under cropping sequences and found that the soil sample results on carbon pool shows that Walkley and Black method of estimating carbon (WBC) is equivalent to Total organic carbon (TOC). More TOC was measured in CSII (7895 mg/kg) i.e. Bhendi-Maize+cowpea-sunflower cropping sequence. The higher value of passive carbon was recorded in CSII: bhendi-maize+cowpes-sunflower. In the case of nutrient balance studies, between expected and actual N status is positive in CS II. In the P nutrient balance, expected and actual P status difference is negative in all the cropping pattern i.e. the applied P excess is fixed in the soil. The balance between expected and actual K status is positive in all the cropping system.

Harikesh *et al.*, (2017) carried out a field experiment at “Agronomy Farm of Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad (U.P.)” and reported that the application of 50% Recommended dose of fertilizer + 50% nitrogen through vermicompost treatment were recorded significantly higher growth attributes like plant height (cm), number of tillers per meter square, dry matter accumulation (g/m²) at 30, 60, 90 DAT and at harvest among integrated nutrient management practices during both the years and in pooled analysis.

Tiecher *et al.*, (2017) were calculated an experiment on nutrient budget considering the inputs (amount of phosphorus and potassium applied via fertilizer) and outputs of phosphorus and potassium from the system (exported by the grains), and the soil available phosphorus and potassium before and after 23-years of experiment. Long-term no tillage builds up a strong gradient of nutrient availability, with higher concentration of nutrients on the soil surface layers that abruptly decrease with soil depth, unlike continue tillage. For all treatments, the budget of phosphorus was negative due to the phosphorus-sink behaviour of strongly weathered subtropical *Oxisol*. They further reveal that no tillage system resulted in less negative budget compared to continue tillage and, therefore, higher efficiency of use of Phosphorus. Nutrient cycling reduced the phosphorus and potassium losses due to winter cover crops, especially when the soil is not ploughed. Fallow in the winter decreases the use efficiency of phosphorus and potassium.

2.2 Economical analysis of crop production:

Kumari *et al.*, (2010) reported that due to increasing cost, higher benefit cost ratio recorded in scented rice with application of RDF alone compared to sole organic alone treatment.

Promin *et al.*, (2010) concluded that significantly higher yield by 52.14% was recorded in hybrid rice along with 20% increase in ear bearing tillers per hill. They revealed that grains per panicle, ear bearing tillers per hill and test weight of 1000 grain were the most important component traits for grain yield improvement in both hybrid and inbred rice varieties. The order of magnitude of contribution of these three components toward grain yield in hybrid were ear bearing tillers > grain weight > grains panicle⁻¹ while order of their contribution in the inbred were grain weight > ear bearing tillers > grains panicle⁻¹.

Yadav and Chandrakar (2010) have worked in the Dantewada district of Chhattisgarh. They randomly selected 60 farmers from four villages namely Balood, Keeper, Ghotpal and Hiranar. They revealed that the average size of holding of the sample households was 1.78 hectare. An average the cost of

cultivation was Rs.6963.44 ha⁻¹ and gross income was Rs.15479 ha⁻¹ for upland rice. They calculated the average value of family labour income, farm business income, net income and input-output ratio as Rs.10204.22, Rs.12049.56, Rs.8515.00, and 1:2.22, respectively. They revealed that when farm size increased the cost of cultivation also increases, where as when farm size increased then the cost of production per quintal of upland rice shows decreasing trend.

Devi and Sumathi (2011) found that “the gross returns, net returns and B:C ratio were higher with application of 180 kg N ha⁻¹ over that of 150 and 120 kg N ha⁻¹ in aerobic rice at Kampasagar. Similarly, application of 150 kg N ha⁻¹ recorded maximum gross income of 42,319 ha⁻¹ with a net profit of 31,126 ha⁻¹ and maximum B: C ratio of 3.78 over 100, 125 and 175 kg N ha⁻¹.”

Veeresh *et al.*, (2011) studied the response of rice varieties to different planting methods under aerobic method of rice cultivation. They reported that variety MAS-26 recorded higher grain and straw yield of 39.78qha⁻¹ and 49.78 qha⁻¹, but it was on par with that of MAS 946-1 and both treatments were superior over other varieties. Significantly higher grain yield (39.78 q ha⁻¹) was observed among the sowing of sprouted seeds and methods of planting.

Kabir *et al.*, (2012) was conducted an experiment at “Bangladesh Institute of Nuclear Agriculture substation, Satkhira” on slightly calcareous silty clay soil to investigate the effects of different combinations of inorganic fertilizers in order to achieve sustainable high yield goal in the STL-655 rice mutant cultivar. They recorded the higher grain and straw yields with STL-655 rice mutant and responded significantly with the different treatment combinations. Treatment T₆ (Soil test basis high yield goal) recorded the highest grain (3.95 t/ha) and straw yield (7.38 t ha⁻¹). There are 60% of grain yield and 27% of straw yield increase caused by treatment T₆ (N₁₄₀ P₄₀ K₈₀ S₃₀ Zn₄) over the control.

Panwar *et al.*, (2012) evaluated the performance of 11 rice varieties and conclude that JGL-3844 has highest growth parameters like plant height (cm), number of tillers per meter square, leaf area index and dry matter accumulation (g) over rest of varieties. JGL-3844 also recorded the highest number of effective

tillers per meter square (331.6), panicle length (25.63), grains per panicle (68.23), sterility per cent (12.1) grain yield ($60.9 \text{ q}^{-1} \text{ ha}^{-1}$) and straw yield (92.58 q ha^{-1}).

Kumari *et al.*, (2013) observed that the scented rice (Birsamati) with 100 - 21.8 - 20.8 kg NPK ha^{-1} through chemical fertilizers resulted maximum net return of 39,557 ₹ ha^{-1} and a benefit cost ratio of 3.62.

Mallareddy and Padmaja (2013) opined that higher net returns were recorded under flooded condition than aerobic condition but no significant difference in B: C ratio was noticed due to high cost of cultivation in the former method. The interaction between the water management and variety showed that significantly higher net returns were realized with 'MTU 1001' in flooded condition while 'WGL 32100' gave good returns in aerobic method than the other varieties. Similar trend was observed for B:C ratio also. Higher dose of nitrogen (240 kg ha^{-1}) recorded the significant increase in net returns and B:C ratio over the rest of the nitrogen levels.

Suneetha and Kumar (2013) studied on the cost and returns in the production of paddy and revealed that the highest profit income is found the small farmers in paddy production as a whole in the study area. They reported that there is significant difference in the return among the groups of farmers.

Kumar *et al.*, (2014) reported that the rice hybrid PHB 71 recorded maximum gross return of ₹ 78007 and 79570; however the variety HUR 105 showed highest net return of ₹ 46886 and ₹ 48180 and benefit cost ratio of 2.58 and 2.63 during 2010 and 2011, respectively. The hybrid PHB 71 recorded maximum gross return (₹ 78007 and ₹ 79570) than HUR 105 and HUBR 2-1, but the return (₹ 46886 and ₹ 48180) and benefit cost ratio (2.58 and 2.63) was more with HUR 105 during both first and second year of investigation, respectively. Though hybrid seed is costly, this variety performed better in terms of higher grain and straw yields and recorded higher monetary returns than the high yielding varieties.

Lhungdim *et al.*, (2014) found the higher net return and benefit cost ratio by the application of 100% RDF through inorganic fertilizers as compared to other treatments i.e., 25% RDF + FYM 15 t /ha and 50% RDF + FYM 10 t /ha.

Mohanty *et al.*, (2014) reported the highest grain yield of 6.43 t ha⁻¹ was registered with 50% RDF + 50% RDF through organic sources (based on nitrogen requirement) of integrated nutrient management, which was 19.2% and 11.9% higher over organic management and recommended dose of fertilizer, respectively.

Rao *et al.*, (2014) concluded that “among RGL 2332, MTU 7029 and RGL 2537; RGL 2537 recorded higher number of tillers and panicles m⁻² with lengthy panicles, higher grain yield, harvest index, partial factor productivity, gross returns, net returns and rupee per rupee invested.”

Ahmad *et al.*, (2015) reported that the total per acre paddy and straw yield of rice varieties amounted a sum of Rs.165000, 115000, 110000, 104000 and 93000 for Fakhre Malakand, Basmati-385, JP5, Sara Saila and Mardanai respectively. Highest B:C ratio of 3.24 was recorded in variety Fakhre Malakand and least for variety Mardanai (1.39). The B: C ratio for varieties Basmati-385 (1.95), JP5 (1.82) and Sara Saila (1.67) was closely related. On the basis of BCR values Fakhre Malakand found to have more commercial benefits to the farming community of the area than the other cultivated varieties.

Mandal and Pramanick (2015) revealed that plant height and root length was significantly affected by the method of crop production, whereas varieties exerted significant impact on root length, leaf area index, root dry weight and dry matter accumulation. About 58.6 and 21.8% higher grain yield and straw yield recorded in SRI system than conventional system. Change in cultivation method does not affect the quality of rice. Under SRI method, variety ‘Dehurdun’ gave better response with respect to kernel length and L: B ratio than other varieties, while the highest gross returns, net return and B: C ratio was recorded in Badshahbhog. After harvest, the Physico-chemical properties of soil were appreciable improved

Trinath *et al.*, (2015) reported that the application of organic manure (FYM 15.0 t ha⁻¹) produced high grain yield (4415 kg ha⁻¹), biomass yield (10946 kg ha⁻¹) and NPK removal comparable to those of INM (50% RDF+7.5 ton FYM ha⁻¹), but significantly greater than those of inorganic fertilization (RDF). Organic manuring (OM) and INM recorded higher gross return but RDF paid higher net return.

Xinpeng *et al.*, (2015) conducted On-farm experiment to determine the relationship between nutrient uptake and grain yield in the above ground plant dry matter. They found that 14.8 kg nitrogen, 3.8 kg phosphorus, and 15.0 kg potassium were required to produce 1000 kg of single season rice grain. The corresponding internal efficiencies (IEs) were 67.6 kg grain per kg nitrogen, 263.2 kg grain per kg phosphorus, and 66.7 kg grain per kg potassium. The amount of 17.1 kg nitrogen, 3.4 kg phosphorus, and 18.4 kg potassium were required for early, middle or late rice to produce 1000 kg of grain, and corresponding IEs were 58.5 kg grain per kg nitrogen, 294.1 kg grain per kg phosphorus, and 54.3 kg grain per kg potassium.

Hossain *et al.*, (2016) found that the IPNS based manure and fertilizer application had better land use efficiency, production efficiency, yield performance, gross return, B:C ratio as compared to 100% chemical fertilizers. They concluded that the Wheat-Mungbean-Rice cropping sequence with IPNS approach is a productive and profitable technology for crop cultivation.

Kundu *et al.*, (2016) studied the responses of integrated nitrogen management on the performance of aromatic rice varieties and they recorded the highest benefit cost ratio with Badsha Bhog (1.51), when it was grown with 100% nitrogen which applied through urea followed by 50% nitrogen (by urea) +50% nitrogen through vermicompost.

Kumar (2016) after conducting the two year experiments under North Eastern Hill region reported that among the different nutrient management practices, the application of 100% RDF + 5 t rice straw ha⁻¹ recorded significantly higher yield attributes and grain yield of 4.61 and 4.73 t ha⁻¹.

Sharma (2016) conducted a study in Bilaspur district of Chhattisgarh and found that an average the cost of cultivation per hectare of Vishnubhog, Dubraj and Tulsimanjari variety of aromatic rice were calculated Rs.38776.13, Rs. 39946.69, and Rs.38503.48 respectively. The cost of cultivation per hectare in Vishnubhog variety was found maximum in case of small farm being 39237.93 and minimum in case of marginal farm being Rs.37513.33. In case of Dubraj variety, cost of cultivation was found maximum in case of large farm being 42198.67 and minimum in case of marginal farm being Rs.36766.00. In case of Tulsimanjari variety, cost of cultivation was found maximum in case of large farm being Rs.40448.11 and minimum in case of medium farm being Rs. 37392.28.

Singh and Singh (2016) reported the highest number of effected tillers was observed in variety PR-121 ($447.3/m^2$), followed PR-122 ($441.7/m^2$) and PR-114 ($435.3/m^2$). Variety PR-121 (79.3 q ha^{-1}) produced highest grain yield followed by PR-124 (78.5 q ha^{-1}), PR-122 (77.3 q ha^{-1}) and PR-123 (77 q ha^{-1}). Lowest grain yield was recorded in variety PR-111 (68.5 q ha^{-1}) and PR-114 (71.5 q ha^{-1}). The varieties PR-121 and PR-124 required less time for maturity and produced higher yield.

Krishnaprabhu *et al.*, (2017) conducted an experiment at Agricultural College and Institute, TNAU, Madurai, to study the feasibility of yield and biochemical properties in traditional red rice landraces cultivation among the Variety Chandikar produced significantly highest grain yield and straw yield (4031 and 9350 kg ha^{-1}), and higher biochemical properties viz., carbohydrates, protein, fiber, zinc content was found in variety TKM 9.

Agarwal *et al.*, (2018) revealed that SRI method has been found to be considerably more profitable than traditional method due to low input expenditure. The total cost of cultivation was higher in traditional method (Rs 14014.54 per acre) than SRI method (Rs 12154.63 per acre) in paddy cultivation. The difference of gross return gained from SRI and the traditional method of Paddy cultivation was Rs.5295.6. The net income gained from SRI was almost double as compared to traditional method, the net income was Rs. 15506.66 in SRI method and in

traditional it was Rs. 8351.15. Net Cost is almost double in the case of traditional method with a comparison to the SRI method of Paddy cultivation. The return per rupees investment was around Rs. 2.28 and 1.60 over variable cost under SRI and traditional method respectively.

Bunthan *et al.*, (2018) observed that in comparison with non-aromatic rice, the costs on materials and labour was high for aromatic rice production. Other than higher costs of production, due to favourable price and high yield, aromatic rice was found to be more profitable in net return, gross return and gross value added.

2.3 Growth characters of scented and non scented rice varieties

Dutta *et al.*, (2002) conducted an experiment and the results showed that the Group III (Badshahbhog, Kataribogh, Zabsiri, Binni, Ragusail, Birai, Zingasail, Ukunimadhu, and Balam) recorded lower yields (2.10 to 2.51 t ha⁻¹) was associated with a lower number of grains per panicle, lower harvest index, higher number of tillers, higher percentage of sterile tillers, higher percentage of grain sterility, higher LAI, higher LAR, lower flag leaf area and higher flag leaf angle. Group I (Basmati, Binasail, Masuri, Chinigura, Kaskhani, Mugy, Balagura, Chiniatab, kalajira, Bhogbala and KL5) recorded comparatively higher yields (2.97– 3.96 t ha⁻¹), was associated with a higher number of grains per panicle, lower number of tillers, lower percentage of sterile tillers, higher harvest index lower percentage of sterile grains, higher flag leaf area, lower flag leaf angle, and lower LAR.

Qamar *et al.*, (2005) suggested that productive tillers/hill, spikelets per panicle, plant height and fertility % may be considered as the selection criteria for the direct improvement of grain yield in the aromatic group, while productive tillers/hill, days to 50% flowering and days to maturity may be considered important for the improvement of grain yield in the non-aromatic group.

Ashrafuzzaman *et al.*, (2009) were evaluated the quality of grain and growth performance of 6 aromatic rice varieties (Basmati, BR38, BR34, Kalizira, Kataribhog and Chiniatop) under rainfed conditions. All rice varieties significantly

differed with respect to plant height, grain yield, straw yield, leaf chlorophyll content, and 1000 grain weight and internode length. Varieties differed in morphological and yield and yield contributing traits. Highest grain yield and 1000 grain weight were recorded in BR38. Kalazira required longer days to maturity and Basmati shorter days to maturity.

Srinivas *et al.*, (2010) observed that the rice cultivar BPT-5204 documented higher panicle weight and length, grain yield, test weight, number of panicles m^{-2} and number of filled grains panicle $^{-1}$.

Khalifa *et al.*, (2012) evaluate the different rice varieties of GZ-9362, GZ-7565, GZ-9075, Sakha 106, Sakha-105 and Sakha-106 at different levels of nitrogen and revealed that Sakha 106 gave maximum panicle initiation, root length, tillering, heading dates, grains filling rates (GFR), leaf area index, chlorophyll content, number of tillers m^{-2} , grain yield, 1000 grain weight, number of grain panicle $^{-1}$ with application of 220 kg N ha^{-1} .

Yadav (2013) concluded that the growth parameters of rice like number of tillers per hill, plant height (cm), dry matter accumulation (g per hill), LAI, crop growth rate ($\text{mg day}^{-1} \text{hill}^{-1}$) and relative growth rate ($\text{mg day}^{-1} \text{hill}^{-1}$) were significantly influenced by aromatic rice genotypes. Pusa Basmati-1 proved its significant superiority in producing taller plants, while number of tillers per hill, dry matter accumulation (g hill^{-1}), LAI, crop growth rate ($\text{mg day}^{-1} \text{hill}^{-1}$) and relative growth rate ($\text{mg day}^{-1} \text{hill}^{-1}$) were significantly recorded in aromatic rice hybrid PRH-10 in comparison to Pusa Basmati-1 and at par with HUR- 105 at all growth stages.

Hussain *et al.*, (2014) conducted an experiment on various growth and yield parameters and their data revealed that among different varieties, Koshihikari was the tallest (117 cm) and the shortest one was Nipponbare (102 cm). Japonica varieties produced higher number of stems, leaves, tillers/ m^2 , LAI, dry weight (t/ha), number of panicles/ m^2 , lower nitrogen contents in panicle and ripening ratios. Higher number of spikelets per panicle (106), values of SPAD and harvest

index (0.47) were recorded in NERICA-4. IR-28 recorded the highest grain yields (6.79 t ha⁻¹) and straw weight (11.53 t ha⁻¹).

Gimhavanekar *et. al.*, (2020) conducted an experiment to study on physiological functions, yield and yield contributing traits in aromatic and non-aromatic rice genotypes during kharif, 2017 & 2018. They reported that LDA, AGR, LAI and LAR were maximum in aromatic rice, Belgaum Basmati, Paras Sona and Phule Maval and in non-aromatic rice Karjat-9. Highest dry matter production and grain yield recorded for the variety Karjat-3 (non-aromatic), while lowest dry matter and grain yield was recorded in genotype Girga (aromatic). The aromatic and non-aromatic rice genotypes differed significantly with respect to yield components like grain yield, total number of filled spikelet's, leaf area index, leaf area duration, leaf area ratio and harvest index.

2.4 Physico-chemical properties of soil.

Nayanaka *et. al.*, (2010) conduct a study of total 43 soil samples with area consisted of 18 ha and collected within the plough depth (0- 20 cm) and variability of soil clay content, pH, organic matter, electrical conductivity, available phosphorus, available zinc and exchangeable calcium were investigated by means of standard techniques. They observed the clay content, organic matter and available phosphorus exhibited a highly spatially structured variability whereas a medium structured variability for soil pH.

Kumar *et. al.*, (2012) studied the vertical distribution of physico-chemical properties and their inter-relationship in 27 different profile representing 3 profiles from each top-sequence (up, medium and low land) of 3 agro-climatic zones of Jharkhand. They analyzed soil samples for various physico-chemical properties like silt and clay content, pH, electrical conductivity, organic carbon, cation exchange capacity and CaCO₃ by using standard laboratory procedures. Their result revealed that soil pH and CaCO₃ directly proportional to soil depth of profiles. Variation of soil pH and electrical conductivity was less in upland and

lowland profiles, respectively whereas upland profiles show maximum variations in case of CaCO_3 .

Chaudhari (2013) studied the physical and chemical properties of soil on the basis of different parameters like pH, electrical conductivity, available nitrogen, available phosphorus, available potassium and total organic carbon. Their results show the medium to high mineral content values all over the eight selected places of Bhusawal.

Mousavifard *et. al.*, (2013) conducted an investigation to find out the distribution variability of soil sand clay, pH, electrical conductivity, pH, organic carbon, CaCO_3 , and available potassium. They randomly collected 282 top soil samples (0-30 cm) and analyzed. They found normal distribution for clay and pH, whereas electrical conductivity, sand, organic carbon, available potassium and CaCO_3 were log-transformed. The lowest and highest variation was observed for soil pH and soil electric conductivity. Sand and calcium carbonate observed the spatial correlation, whereas values were moderate for electrical conductivity, clay, organic carbon and potassium.

Mahajan and Billore (2014) studied the physical and chemical parameters like pH, total alkalinity, specific conductivity, nitrate, phosphate, potassium, sulphate, calcium, sodium, chloride and magnesium for a year. Their study revealed that throughout the year the soil found alkaline in nature. They states that the productivity depends on soil quality, thus some parameters of soil observed below and above permissible limit which can affect the soil productivity and quality.

Osakwe (2014) collected the soil samples from natural flood disaster affected areas of the Isoko Region of Delta State, Nigeria and studied the physical and chemical properties. Their data revealed the overall reduction in soil pH, nitrate, phosphorus, potassium, exchangeable calcium, effective cation exchange capacity, base saturation, Base Exchange capacity and soil buffering capacity by values of 5.425 ± 0.313 , $0.34 \pm 0.07 \text{mg kg}^{-1}$, $7.47 \pm 6.34 \text{mg kg}^{-1}$, $0.09 \pm 0.01 \text{mg kg}^{-1}$, $1.97 \pm 0.31 \text{mg kg}^{-1}$, $5.076 \pm 1.532 \text{ cmolkg}^{-1}$, 77.57 ± 5.83 , 3.87 ± 0.21 , and 7.99 ± 2.72

respectively. In other hand, the values of exchangeable sodium and magnesium increased as $0.28 \pm 0.004 \text{ mg kg}^{-1}$ and $1.50 \pm 0.25 \text{ mg kg}^{-1}$ respectively. Exchangeable acidity also increased due to increased in value of hydrogen and aluminium as 0.43 ± 0.08 and $0.42 \pm 1.02 \text{ mg kg}^{-1}$ respectively. In values of total nitrogen ($0.025 \pm 0.035\%$), total organic carbon ($0.40 \pm 0.096\%$) and sulphate ($0.10 \pm 0.02 \text{ mg kg}^{-1}$), there was no appreciable change observed.

Shivanna and Nagendrappa (2014) studied on the soil fertility status of selected command areas with variables test including pH, EC, organic carbon, N, P, and K. They reported the values of pH, EC and organic carbon in range of 7.07 to 7.87, 0.26 dSm^{-1} to 0.485 dSm^{-1} and 0.50% to 0.67% respectively. For NPK the values ranged from $54.825 \text{ kg ha}^{-1}$ to 85.72 kg ha^{-1} , 5.33 kg ha^{-1} to 10.79 kg ha^{-1} and $156.18 \text{ kg ha}^{-1}$ to $434.38 \text{ kg ha}^{-1}$ respectively. The pH value was slightly alkaline in nature but comes within limits of 6.5 to 8.5 which is optimum for major crops. EC showed low salinity status of soil while organic carbon showed medium rating. The value of nitrogen and phosphorus showed deficiency status of soil, whereas potassium had medium rating except one sample which shows high rating in soil.

Mobar *et. al.*, (2015) conducted a field work on impacted and non-impacted soil of Sanganer and Durgapura of Jaipur district. They analyzed the soil quality by estimation of physicochemical parameters such as soil texture, water holding capacity, pH, cation exchange capacity, electrical conductivity (EC), total hardness, organic matter, organic carbon, potassium concentration, sodium, sodium adsorption ratio (SAR) by using standard protocols. Their result on data of both soils showed a significant difference between water holding capacity, pH, EC, ECC, SAR and total hardness, inferring the impact of industrial effluent on the quality of soil.

2.5 Available macro and micronutrients.

Barghouthi *et. al.*, (2012) compared the different values of the available macro and micronutrients obtained by conventional extraction methods and IEM extraction method. They reveal that the concentrations of available N, P,

K, Fe, and B were 37.7, 17.5, 3.6, 171.0, and 4.2 $\mu\text{g kg}^{-1}$ respectively, which are higher than the soluble forms of same element.

Singh and Mishra (2012) conducted a survey in ten representative villages and analyzed the physical, chemical properties, available NPK and sulphur status in different soil samples. They reported the sandy clay loam to clay texture of soil. They found low organic carbon, available NP, while medium K in soil samples. Available sulphur found low in 62% of soil samples. They reported that under study the correlations between organic available NPK and S status of soil and organic carbon was positive.

Ganorkar and Chinchmalatpure (2013) evaluated the physical, chemical properties and micronutrients of soils. They analyzed the soil parameters content like soil moisture, pH, EC, TDS, Carbon, Nitrogen, Phosphors, Potassium, Magnesium, Calcium carbonate, Calcium and Copper. They reported that all samples of the soils have moderate amount of available micronutrients and alkaline in nature.

Ravikumar and Somashekar (2013) selected soil samples from 28 different agricultural fields and examined the spatial distributions for twenty physical and chemical properties and they concluded that there is not much effect of various landforms on soil fertility status of soils. They found all soil samples were low to medium in organic carbon (0.06 to 1.20 %), available N (6.27 to 25.09 Kg ha^{-1}) content and available P (2.24 to 94.08 Kg/ha) and in available K (20.10 - 412.3 Kg ha^{-1}) contents. The soils of selected area were categorized in low-medium-low (LML) category based on the nutrient index calculated.

Singh *et. al.*, (2014) collected 280 soils samples from Morena district of Madhya Pradesh and evaluate macro and micronutrients. They used DTPA as extractant for micronutrients. They reported that a value for Fe, Zn and Cu varies from 0.20 to 9.70 mg kg^{-1} , 0.12 to 1.90 mg kg^{-1} and 0.02 to 0.82 mg kg^{-1} respectively. Out of total samples, 22%, 2% and 52% sample were found sufficient in Fe, Cu and Mn. 24% 13% and 24% samples were found marginal in Fe, Cu and Mn. 54%, 85% and 24% samples were found deficient in Fe, Cu and Mn. While

59% samples were deficient and remaining are sufficient in Zn. They observed the positive correlation of the availability of Fe, Zn, Cu and Mn with organic carbon, while a negative correlation with pH, EC and calcium carbonate.

Singh *et. al.*, (2014) carried out a study on fertility status of alluvial soil, medium black soil and ravinous soil of Chambal region of Madhya Pradesh to find out the fertility status and their correlation. They found the available N, P, K and S in the range of 126 to 361, 7.0 to 29.5, 128 to 391 and 6.8 to 33.5 kg ha⁻¹ in alluvial soil; 178 to 408, 7.9 to 28.8, 122 to 386 and 8.5 to 34.4 kg ha⁻¹ in medium black soil and 125 to 301, 6.2 to 25.3, 252 to 406 and 11.5 to 38.8 kg ha⁻¹ in ravinous land, respectively. Micronutrients in alluvial soils found deficient in soil, about 64.5, 11.7, 14.3 and 14.5% soil samples were deficient in Zn, Fe, Mn and B, respectively. For medium black soils the deficiency of Zn, Fe, Mn and B were 76.3, 33.3, 8.8, 8.6 and 5.1%. In ravenous soil, Zn and B were deficient with 18.4 and 15.8% respectively. They further reported that the available N and P found positive correlation with potassium and sulphur, but negative correlation with EC. For available N, P, K, S, B, Fe, Cu, Zn and Mn showed positive correlation with Mo, whereas negative correlation with pH. There are positive correlations between N, P, K, S, Fe, Cu, Zn, Mn, B and Mo and organic carbon and silt plus clay content while Zn, Fe, Cu, Mn, B and Mo have negative correlation with CaCO₃ content in soil.

Khihara *et. al.*, (2017) carried a field trial and by using 757 yield data rows revealed that response to Sulphur (49.4%), Zinc (23.0%), Sulphur and micronutrient combinations (11.5%), and less than 10% each for B, Cu, Fe and Mo. They found that over macronutrient treatment, application of sulphur and micronutrients increased yield by 25% and achieved an agronomic efficiencies (kg of grain increase per kg of micronutrient added) between 38 and 432 and for majority of farmers indicates positive crop response.

CHAPTER – III MATERIALS AND METHOD

The present study entitled “**Nutrient budgeting and economic analyses of scented and non scented rice varieties in *Vertisol***” was carried out at “Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh)” during *Kharif* season 2019-20. The details of experiment, prevailing weather condition, material used, and techniques adopted during the course of investigation are briefly presented in this chapter.

3.1 Location and experimental site

The field experiment was conducted at “Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh)” during *Kharif* 2019. Raipur comes under agro-climatic plain zone of Chhattisgarh state and lies between 21° 16'N latitude and 81° 60'E longitude with altitude of 289.56 meters the Mean Sea Level.

3.2 Climatic conditions

The meteorological parameter during crop growth is presented in Fig. 3.1. The place of investigation Raipur comes under dry moist, sub-humid region, out of 1200-1400 mm rainfall annually, about 88 per-cent is received during rainy season (June to September), 8 percent during winter season (October to February) and 4 percent during summer (March to May), The hottest and coolest month of the year is May and December respectively. The maximum temperature reaches up to 46°C during the summer months and mercury drops to as low as 5°C during December to January. The meteorology observations recorded during the crop period showed that the rainfall was ranges between 0.00- 237.60 mm and total rainfall was recorded 1045.80mm; the maximum temperature varied between 27-46 °C .the wind velocity ranges from 1.42 – 10.44 km hr⁻¹, the average relative humidity –I and II was 89.97 and 67.59 percent respectively. The sunshine hours varied between 1.05- 8.81 hours day⁻¹ and Evaporation was recorded between 1.53-5.49 mm.

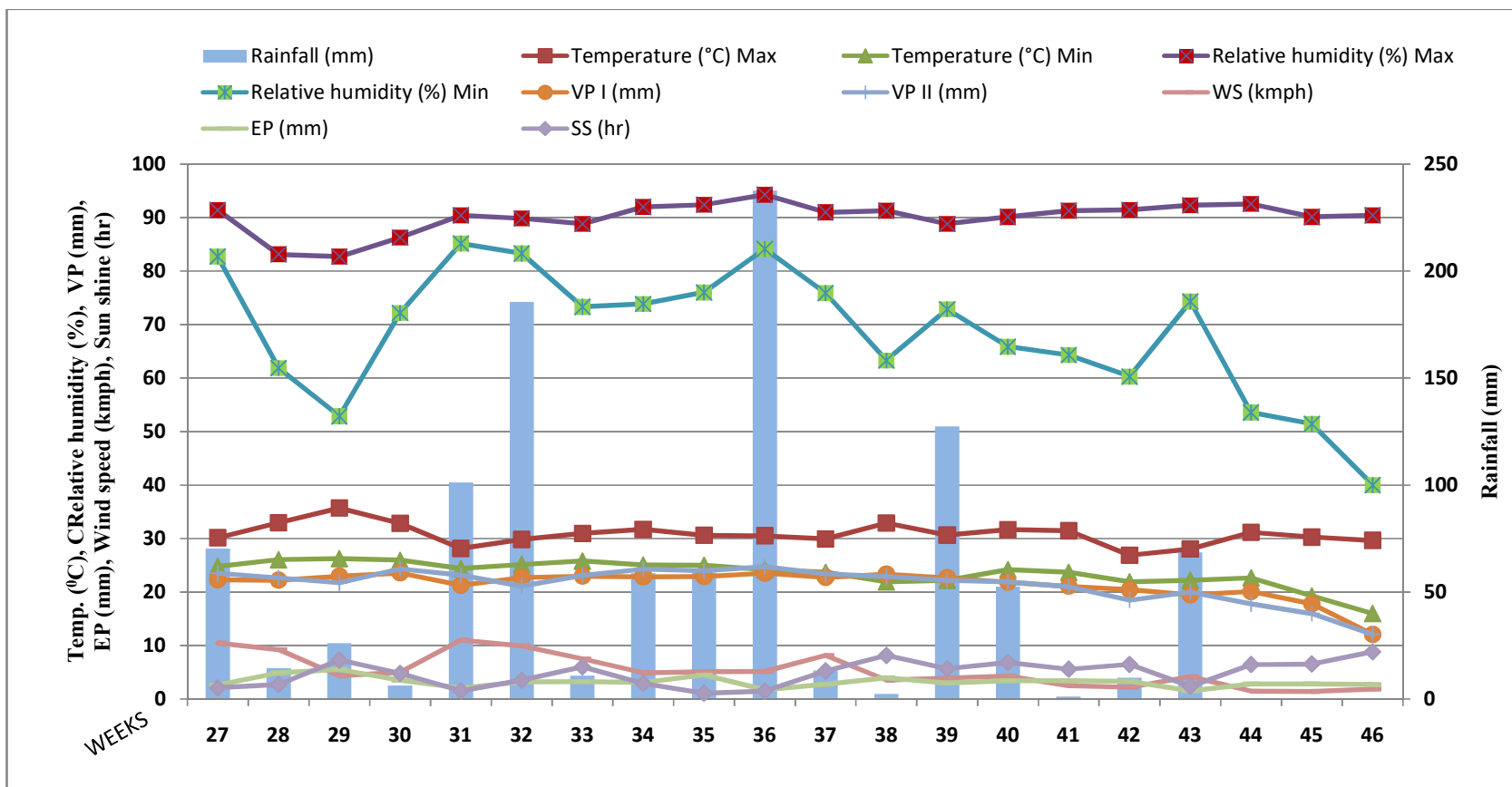


Fig 3.1: Weekly meteorological data during the crop growth period (*Kharif 2019*)

3.3 Soils

In order to determine the mechanical and chemical composition of experimental plot, soil samples were collected randomly from experimental site at 0-30 cm depth with the help of soil auger. A composite samples was drawn from mixed representative samples by dividing repeatedly till the amount of representative samples remain about 500g and then it was used for analysis .The soil of the experimental soil is locally known as *Kanhar* soil. It is deep and hence, has good water holding capacity. The soil was analysed for different parameters as per the method mentioned below in Table 3.1.

Table 3.1: Initial physical properties of the experimental soil

No.	Characteristics of the soil	Value	Rating	Method Employed
A. Physical Properties				
Mechanical Composition				
1.	Sand (%)	22.7		International Pipette method (Black ,1965)
	Silt (%)	39.1		
	Clay (%)	38.2		
	Texture class	Clay loam		
B. Chemical Properties				
1.	Soil pH (1:2.5 Soil water ratio)	7.56	Neutral	Glass electrode pH meter (Piper, 1950)
2.	Electrical conductivity (dSm ⁻¹ at 25 °C)	0.104	Normal	Conductivity meter (Piper, 1950)
3.	Organic carbon (%)	0.59	Medium	Walkley and Blacks method (Jackson, 1967)
4.	Available nitrogen (kg ha ⁻¹)	233.25	Low	Alkaline Permanganate method (Subhiah and Asiga, 1965)
5.	Available phosphorus (kg ha ⁻¹)	22.78	Medium	Sodium bicarbonate as extractant (Olsen's, 1954)
6.	Available potassium (kg ha ⁻¹)	258.48	Medium	Neutral normal ammonium acetate as extractant (Jackson, 1967)
7.	Available Zn (mg kg ⁻¹)	1.16		Soils were extracted with 0.005 M DTPA extractant and metals determined by atomic absorption spectrophotometer (Lindsay and Norvell, 1978)
	Available Cu (mg kg ⁻¹)	0.248		
	Available Fe (mg kg ⁻¹)	1.21		
	Available Mn (mg kg ⁻¹)	0.622		

3.4 Experimental details and layout

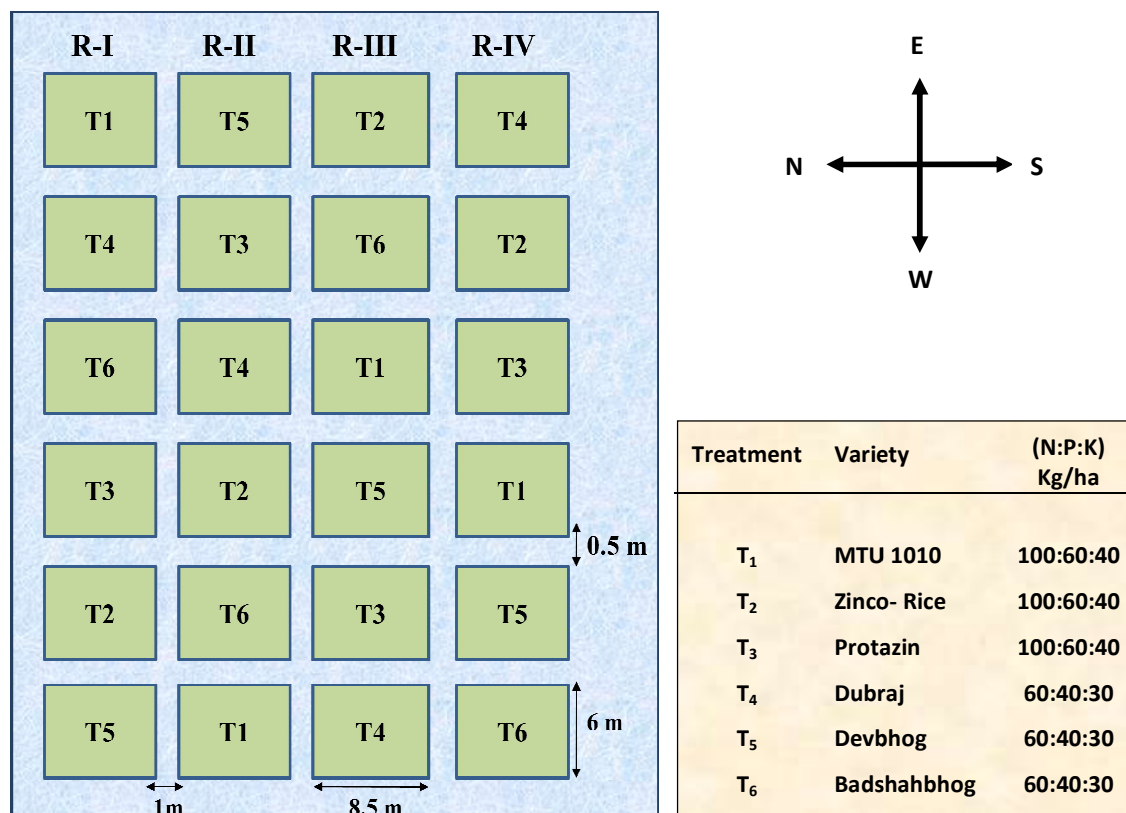
The experiment was taken in rice based cropping system which laid out in a randomized block design with six treatments and three replications during *khariif* 2019. The experimental details are given below:

Table 3.2: Experiment details

Layout plan	The layout plan of the experiment is shown in fig. 3.2
Location	“Research cum Instructional Farm Department of Agronomy, I.G.K.V, Raipur (C.G.)”
Soil type	<i>Vertisol</i>
Season	<i>Kharif</i> 2019
Crop	Rice
Seed rate	35 kg ha ⁻¹
Variety	MTU 1010, Zinco-Rice, Protazin, Dubraj, Devbhog, Badshahbhog
No. of Replication	4 (Four)
No. of Treatment	6 (Six)
Design	Randomized Block Design
Plot size	8.5x 6= 51 m ² .
Spacing	20 x 10 cm
Distance between plots	0.5 m
Distance between replication	1.0 m

Table 3.3: Treatment details and fertilizer dose

Treatment	Variety	N:P:K (kg ha ⁻¹)
T ₁	MTU 1010	100:60:40
T ₂	Zinco- Rice	100:60:40
T ₃	Protazin	100:60:40
T ₄	Dubraj	60:40:30
T ₅	Devbhog	60:40:30
T ₆	Badshahbhog	60:40:30



Soil type	: <i>Vertisol</i>
Season	: <i>Kharif 2019</i>
Crop	: Rice
Seed rate	: 35 kg ha ⁻¹
Variety	: MTU 1010, Zinco-Rice, Protazin, Dubraj, Devbhog, Badshahbhog
Design	: Randomized Block Design
Replication	: 4
No. of Treatment	: 6
Plot size	: 8.5 x 6= 51 sq.m.

Fig. 3.2: Layout plan of the experimental field

3.5 Land and Nursery bed preparation

The field was prepared with ploughing and cross ploughing with the cultivator. The field was puddle by tractor drawn puddler in presence of 4-5 cm standing water and levelled by planker.

The raised nursery bed was prepared with soil with FYM (2:1) and seed @35 kg ha⁻¹ were uniformly spread on the bed and covered with paddy straw for 2-3 days. It was watered by rose cans. At the time of transplanting, seedling were taken along with soil without disturbing root system. Seeds were sown in nursery to obtain 21 days old seedling for each transplanting dates as per treatment.

Table 3.4: Cultural Schedule of the experiment

S. No.	Cultural operations	Date of operation
1.	Nursery sowing	5th July, 2019
2.	Field preparation	30th July, 2019
3.	Layout of experimental field	2nd August, 2019
4.	Transplanting	3rd August, 2019
5.	Fertilizer application	3rd August (N,P, K as basal), 1st September (tillering), 3rd October (panicle initiation), 2019
6.	Weeding	29th August, 27th September, 2019
7.	Harvesting	11th November, 2019

3.6 Transplanting

Thirty days old seedlings of rice were transplanted on August 3, 2019 at the distance of 20 cm between rows and 10 cm between hills by 2-3 seedlings per hill.

3.7 Nutrient sources and their applications

There were different recommended doses of nutrient for each variety of rice. The nitrogen, phosphorus and potassium were applied as per the treatments of experiment. The half amount of nitrogen and full quantity of phosphorus and potassium was applied through urea, single super phosphate (SSP) and muriate of potash (MOP) as basal dose and the remaining amount of nitrogen was divided into equal quantity. One of the quantities was applied at tillering and another was applied at panicle initiation stages.

3.8 Weed management

At 45 and 75 DAT, two hand weeding were done to keep weed free experimental plot.

3.9 Water management

The water management was done as per requirement of crop with maintaining water depth of 5 cm.

3.10 Harvesting

The matured crops of rice harvested on 11-11-2019. Two rows from the either side of each plot and 50 cm from other two ends of the plot was harvested separately. The produce of each net plot was tied into bundle and allowed for sun drying in respective plot. The bundles were weighted with the help of spring balance and data were recorded for statistical analysis.

3.11 Threshing and winnowing

Threshing of produce was done separately for each net plot as per treatment then seeds were cleaned manually and weight for record and statistical analysis.

3.12 Pre-harvest observations

3.12.1 Plant height (cm)

Plant height was recorded randomly five tagged plants in each plot. The height of each plant was recorded by using scale at 30, 60, 90 DAT and at harvest. The plant height was measured in centimetre from ground surface of the crop to upper most node of the plant.

3.12.2 Number of tillers hill⁻¹

The number of tillers hill⁻¹ was counted from five randomly tagged plants in each plot at 30, 60 and 90 DAT and then average was calculated were expressed in tillers plant⁻¹.

3.13 Post-harvest observations

3.13.1 Test weight

One thousand healthy seeds were counted from the bulk produce of one plant and were dried in oven at 60°C for 20-24 hours and weights after proper drying through electronic balance and expressed in gram per thousand seed.

3.13.2 Grain and straw yield

The crop was harvested separately from individual net plot then weight of total biomass was recorded. By manual threshing grains were separated from straw. The grain weight was recorded and expressed in kg ha⁻¹ and by subtracting grain weight from biological yield, straw yield was worked out and also expressed in kg ha⁻¹.

3.14 Soil chemical properties

3.14.1 Soil analysis

The surface (0-15 cm) soil sample were collected plot wise after harvest of the crop with the help of soil auger from rice field, soil sample were air dried in shade and collected in plastic bags for further analysis. The air dried soil samples were grinded and pulverized by wooden pestle to break soil clods and were passed through sieve of 2 mm diameter. The sieved sample were mixed thoroughly and stored in polythene bags, properly labelled and store for subsequent chemical analysis. The following standard methods were used for analysis of the soil sample.

3.14.1.1 Soil pH

It was determined by glass electrode pH meter in 1:2.5 soil water solution suspensions as described by (Piper 1950).

3.14.1.2 Electrical conductivity

The clear water supernatant obtained from the suspension used for pH determination was utilized for the measurement of electrical conductivity (dSm^{-1}) using conductivity bridge as described by (Jackson, 1967).

3.14.1.3 Organic carbon

Organic carbon of soil was determined by Walkley and Black's rapid titration method (1934) as described by (Jackson 1967).

3.14.1.4 Available nitrogen

The available nitrogen was determined by alkaline potassium permanganate method as described by Subbiah and Asija (1965).

3.14.1.5 Available phosphorus

Available phosphorus was determined by using 0.5M NaHCO_3 (pH 8.5) solution for Spectrophotometric analysis as described by (Olsen, 1965).

3.14.1.6 Available potassium

Available potassium was extracted by shaking with neutral normal ammonium acetate for 5 minute and determined with the help of flame photometer method as described by Jackson (1967).

3.14.1.7 Available Zn, Cu, Fe and Mn

The micronutrients were extracted by using 0.005 M diethyl triamine penta acetic acid 0.01 m calcium chloride dehydrate and 0.1 M tri-ethanal amine buffered at pH 7.3 (Lindsay and Norvell, 1978). Then the concentrations of Zn, Cu, Fe and Mn in the filtrate were analysed by atomic absorption spectrophotometer.

3.15 Plant analysis

Rice plants were randomly selected from each treatment plot at the time of harvesting. The grain and straw sample were collected from the produce from each net plot for each treatment .the collected grain and straw samples were ground in electric grinding machine and then stored in plastic air tight containers, which were analysed for total N, P and K contents as given below.

3.15.1 Preparation of di-acid extract

Di-acid extract was prepared as per the method described by Jackson (1967). The plant samples were digested with di-acid mixture of concentrated acid HNO_3 and HClO_4 in the ratio of 9:4. This extract was used to determine the total P and K from plant samples.

3.15.2 Digestion of plant material

One gram of grain and straw samples was taken in digestion tube along with 20 ml of di-acid mixture (Concentrated HNO_3 and HClO_4 in the ratio of 9:4). The material was digested at 350°C in KEL plus digestion unit till the material become colourless. The digested material was filter into 100 ml volumetric flask by repeated washing of tube with distilled water and make up the volume up to the mark. The digested material was used for the estimation of phosphorus, potassium and micronutrients contents.

3.15.3 Total Nitrogen content

Total nitrogen content from plant sample was estimated by Kjeldahal's digestion method as described by Piper (1950).

3.15.4 Total Phosphorus content

Phosphorus was determined by Vanadomolybdo-phosphoric acid yellow colour method using by double beam Spectrophotometer (Jackson, 1985).

3.15.5 Total Potassium content

Potassium was determined by flame photometer method as described by (Chapman and Pratt, 1961).

3.16 Nutrient uptake by crop

Nitrogen, phosphorus, Potassium uptake in rice grain and straw were computed by multiplying their respective nutrient content with yields using following formula.

Nutrient uptake (kg ha^{-1}) in seed and straw = Content of nutrient (%) \times Grain and straw yield (q ha^{-1}).

3.17 Nutrient budgeting

Nutrient availability, nutrient uptake by plants and nutrient balance in soil on basis of different parameters are calculated by using following formula.

- (a) Nutrient available for crop (kg ha^{-1}) = Initial Soil test value (kg ha^{-1}) +
Nutrient added through fertilizers (kg ha^{-1})
- (b) Nutrient Removal (kg ha^{-1}) = Total nutrient uptake by crop (kg ha^{-1})
- (c) Actual nutrient balance after harvesting (kg ha^{-1}) = Available nutrient on
basis of soil test value (kg ha^{-1})
- (d) Expected nutrient balance after harvesting (kg ha^{-1}) = Nutrient available for
crop (kg ha^{-1}) - Nutrient Removal (kg ha^{-1})
- (e) Nutrient balance in soil on uptake basis (kg ha^{-1}) = Actual nutrient balance
after harvesting (kg ha^{-1}) - Expected nutrient balance after harvesting (kg ha^{-1})
- (f) Nutrient balance in soil on soil test value basis (kg ha^{-1}) = Actual nutrient
balance after harvesting (kg ha^{-1}) – Initial available nutrient in soil (kg ha^{-1})

3.18 Economics

Based on recent market prices of fertilizers, market price of produce and prevailing wages of labour, economics of the treatments have been worked out in terms of net income (Rs ha^{-1}).

3.18.1 Cost of cultivation (Rs ha^{-1})

Taking into consideration to the recent charges of agricultural operations and market price of inputs, the cost of cultivation was calculated from each treatment.

3.18.2 Gross returns (Rs ha⁻¹)

It was computed by converting the harvest (Grain and straw) into monetary terms at the recent market price during the course of studies for each treatment

$$\text{Gross returns (Rs ha}^{-1}\text{)} = \text{Yield (t ha}^{-1}\text{)} \times \text{Price of yield (Rs t}^{-1}\text{)}$$

3.18.3 Net returns (Rs ha⁻¹)

It was computed by deducting cost of cultivation from gross returns.

$$\text{Net returns (Rs ha}^{-1}\text{)} = \text{Gross returns (Rs ha}^{-1}\text{)} - \text{Cost of cultivation (Rs ha}^{-1}\text{)}$$

3.18.4 Benefit cost ratio

It was calculated by dividing the net returns from cost of cultivation of respective treatments.

$$\text{Benefit cost ratio} = \frac{\text{Net returns (Rs ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs ha}^{-1}\text{)}}$$

3.19 Statistical analysis

The data obtained from all observation were statistically analyzed by applying Randomized Block Design (RBD). Least significant differences values were obtained to test the significance of treatment difference and least significant values were evaluated at 5% level of significance (Gomez and Gomez, 1984).

Table 3.5: Skeleton of ANOVA table

Source of variation	D.F.	S. S.	M.S.S.	F cal.	F. tab %
Replication	(r-1)	RSS	RMS	RMS/EMS	
Treatment	(t-1)	Tr SS	TMS	TMS/EMS	
Error	(r-1) (t-1)	ESS	EMS		
Total	rt-1	TSS			

To test the significance of treatment differences, calculated value of 'F' was compared with tabular value of 'F' at 5 and 1 per cent levels of probability, against error degree of freedom, i.e. (r-1) (t-1).

Standard error and critical values were calculated for the comparison of the mean value of treatments, as follows:

$$(a) \text{ Standard error of mean } S.E.m \pm = \sqrt{\frac{EMS}{r}}$$

(b) Critical difference (C.D.) = SE (d) x t value at 5% at error degree of freedom

$$(c) \text{ Coefficient of variation (C.V. \%)} = \frac{SD}{\bar{X}} \times 100$$

Where,

D.F. = Degree of freedom

S.S. = Sum of square

Mss = Mean sum of square

r = Replication

Gm = General mean

Ems = Error mean square



Fig. 3.3: Transplanting of the crop



Fig. 3.4: View of the experimental field



Fig. 3.5: view of different treatments of experiment



Fig. 3.6: Harvesting of the crop

CHAPTER – IV

RESULTS AND DISCUSSION

The present investigation entitled “**Nutrient budgeting and economic analyses of scented and non scented rice varieties in *Vertisol***” was undertaken at “Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh)” during *kharif* season 2019-20. The result obtained are reported and discussed in this chapter under the following sub headings:-

- 4.1 Physico-chemical properties of soil after harvesting of crop
- 4.2 Growth parameters
- 4.3 Yield and yield attributes
- 4.4 Nutrient content and uptake by crops
- 4.5 Nutrient budgeting for crops
- 4.6 Economics

4.1 Physico-chemical properties of soil after harvesting of crop

4.1.1 Soil pH

The effect of different treatments on soil pH after harvest of rice crop was presented in table 4.1.

The pH of the soil was not influenced significantly among various treatments. However, the numerically higher value of pH (7.59) was observed in the treatment T₁-MTU 1010 and T₅-Devbhog. The minimum soil pH (7.55) was recorded in the treatment T₂-Zinco-rice and T₄-Dubraj. However the initial soil pH value was 7.56.

4.1.2 Electrical conductivity (dSm⁻¹)

The EC of the soil was not significantly different in entire treatments. Data related to EC after harvest of rice crop was presented in table 4.1.

The EC was not shown significant effect by all the treatments. The maximum EC (0.104 dSm^{-1}) however, recorded in treatment T₂-Zinco-rice. The lowest amount of EC (0.101 dSm^{-1}) was observed in T₆-Badshahbhog. The initial value of soil EC was 0.104 dSm^{-1} .

4.1.3 Organic carbon

The effect of different treatments on organic carbon after harvest of crop presented in table 4.1

All treatments not significantly affected the soil organic carbon. Soil organic carbon (0.61 %) was recorded highest in treatment T₂-Zinco-rice and T₆-badshahbhog. The lowest soil organic carbon (0.58 %) recorded in treatments T₄-Dubraj and T₅-Devbhog.

Table: 4.1. Effect of different treatments on soil pH, electrical conductivity (EC) and organic carbon after harvest of rice

Treatment	pH	EC(dS m⁻¹)	OC (%)
T ₁ - MTU 1010 (N ₁₀₀ P ₆₀ K ₄₀)	7.59	0.102	0.59
T ₂ - Zinco- Rice (N ₁₀₀ P ₆₀ K ₄₀)	7.55	0.104	0.61
T ₃ - Protazin (N ₁₀₀ P ₆₀ K ₄₀)	7.58	0.102	0.60
T ₄ - Dubraj (N ₆₀ P ₄₀ K ₃₀)	7.55	0.103	0.58
T ₅ - Devbhog (N ₆₀ P ₄₀ K ₃₀)	7.59	0.103	0.58
T ₆ - Badshahbhog (N ₆₀ P ₄₀ K ₃₀)	7.56	0.101	0.61
SE (m)±	0.024	0.002	0.008
CD (P = 0.05)	NS	NS	NS

4.1.4 Available Nitrogen

The effect of different treatments on soil available Nitrogen in soil after harvest of crop presented in table 4.2 and figure 4.1.

The data pertaining to soil available nitrogen was ranged between 225.31-228.95 kg ha⁻¹. The data was found no significant difference among various treatments. The highest available Nitrogen (228.95 kg ha⁻¹) was recorded in T₄-Dubraj. However, it was statistically at par with T₁-MTU 1010 (228.41 kg ha⁻¹). Whereas, the minimum soil available N (225.31 kg ha⁻¹) was observed in T₂-Zinco-rice. The initial mean value of available Nitrogen was 233.25 kg ha⁻¹.

4.1.5 Available Phosphorus

The effect of different treatments on soil available Phosphorus in soil after harvest of crop presented in table 4.2 and figure 4.1.

The available Phosphorus in soil was ranged between 21.40-22.53 kg ha⁻¹. The data was found no significant different among the various treatments. The highest available phosphorus (22.53 kg ha⁻¹) was observed in T₃-Protazin followed by T₂-Protazin (22.52 kg ha⁻¹). The lowest value of available phosphorus (21.40 kg ha⁻¹) was observed in T₁-MTU 1010. The initial mean value of available Phosphorus was 22.78 kg ha⁻¹.

4.1.6 Available Potassium

The effect of different treatments on soil available Potassium in soil after harvest of crop presented in table 4.2 and figure 4.1.

The available Potassium in soil was ranged between 257.64-260.45 kg ha⁻¹. The data was found no significant different among the various treatments. The highest available Potassium (260.45 kg ha⁻¹) was observed in T₄-Dubraj. The lowest value of available Potassium (257.64 kg ha⁻¹) was observed in T₁-MTU 1010. The initial mean value of available potassium was 258.48 kg ha⁻¹.

Table: 4.2. Effect of different treatments on available Nitrogen, Phosphorus and Potassium of soil after harvest of rice

Treatment	N (kg ha ⁻¹)	P (kg ha ⁻¹)	K (kg ha ⁻¹)
T ₁ - MTU 1010 (N ₁₀₀ P ₆₀ K ₄₀)	228.41	21.40	257.64
T ₂ - Zinco- Rice (N ₁₀₀ P ₆₀ K ₄₀)	225.31	22.52	258.61
T ₃ - Protazin (N ₁₀₀ P ₆₀ K ₄₀)	227.25	22.53	259.79
T ₄ - Dubraj (N ₆₀ P ₄₀ K ₃₀)	228.95	22.24	260.45
T ₅ - Devbhog (N ₆₀ P ₄₀ K ₃₀)	226.16	21.61	258.45
T ₆ - Badshahbhog (N ₆₀ P ₄₀ K ₃₀)	225.67	22.23	258.85
SE (m)±	2.30	0.65	3.04
CD (P = 0.05)	NS	NS	NS

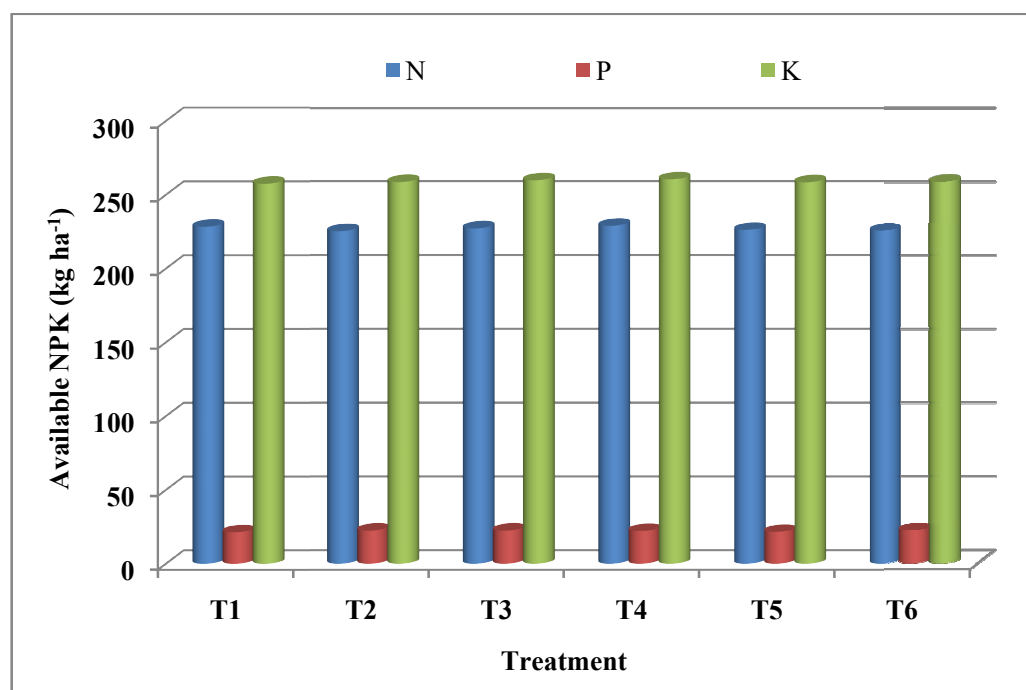


Fig. 4.1: Effect of different treatments on available Nitrogen, Phosphorus and Potassium of soil at post-harvest

4.1.7 Available Zinc

Data related to the effect of different treatments on soil available Zinc in soil after harvest of crop presented in table 4.3 and figure 4.2.

The available zinc in soil was ranged between 1.05-1.16 mg kg⁻¹. The data was found no significant different among the various treatments. The highest available zinc (1.16 mg kg⁻¹) was observed in treatment T₆-Badshahbhog. The lowest value of available zinc (1.05 mg kg⁻¹) was observed in treatment T₂-Zinco-rice. The initial mean value of available zinc was 1.16 mg kg⁻¹.

4.1.8 Available Copper

Data related to the effect of different treatments on soil available copper in soil after harvest of crop showed in table 4.3 and figure 4.2.

The available copper in soil was ranged between 0.25-0.29 mg kg⁻¹. The data was found no significant different among the various treatments. The highest available coppers (0.29 mg kg⁻¹) were observed in T₃-Protazin and T₅-Devbhog. The lowest value of available copper (0.25 mg kg⁻¹) was observed in T₂-Zinco-rice and T₆-Badshahbhog. Initial mean value of available copper was 0.248 mg kg⁻¹.

4.1.9 Available Iron

Data related to the effect of different treatments on soil available iron in soil after harvest of crop presented in table 4.3 and figure 4.2.

The available iron in soil was ranged between 1.18-1.22 mg kg⁻¹. The data was found no significant different among the various treatments. The highest available iron (1.22 mg kg⁻¹) was observed in T₂-Zinco-rice, T₄-Dubraj and T₆-Badshahbhog. The lowest value of available iron (1.18 mg kg⁻¹) was calculated in T₅-Devbhog. The initial mean value of available iron was 1.21 mg kg⁻¹.

4.1.10 Available Manganese

Data related to the effect of different treatments on soil available manganese in soil after harvest of crop presented in table 4.3 and figure 4.2.

The available manganese in soil was ranged between 0.56-0.65 mg kg⁻¹. The data was found no significant different among the various treatments. The

highest available manganese (0.65 mg kg^{-1}) was observed in T₂-Zinco-rice. The lowest value of available manganese (0.56 mg kg^{-1}) was calculated in T₁-MTU 1010 and T₅-Devbhog. The initial mean value of available manganese was 0.622 mg kg^{-1} .

Table: 4.3. Effect of different treatments on available micronutrients of soil at post-harvest

Treatment	Available micronutrients (mg kg^{-1})			
	Zn	Cu	Fe	Mn
T ₁ - MTU 1010 (N ₁₀₀ P ₆₀ K ₄₀)	1.14	0.26	1.21	0.56
T ₂ - Zinco- Rice (N ₁₀₀ P ₆₀ K ₄₀)	1.05	0.25	1.22	0.65
T ₃ - Protazin (N ₁₀₀ P ₆₀ K ₄₀)	1.14	0.29	1.20	0.58
T ₄ - Dubraj (N ₆₀ P ₄₀ K ₃₀)	1.09	0.27	1.22	0.61
T ₅ - Devbhog (N ₆₀ P ₄₀ K ₃₀)	1.12	0.29	1.18	0.56
T ₆ - Badshahbhog (N ₆₀ P ₄₀ K ₃₀)	1.16	0.25	1.22	0.64
SE (m)±	0.03	0.017	0.024	0.022
CD (P = 0.05)	NS	NS	NS	NS

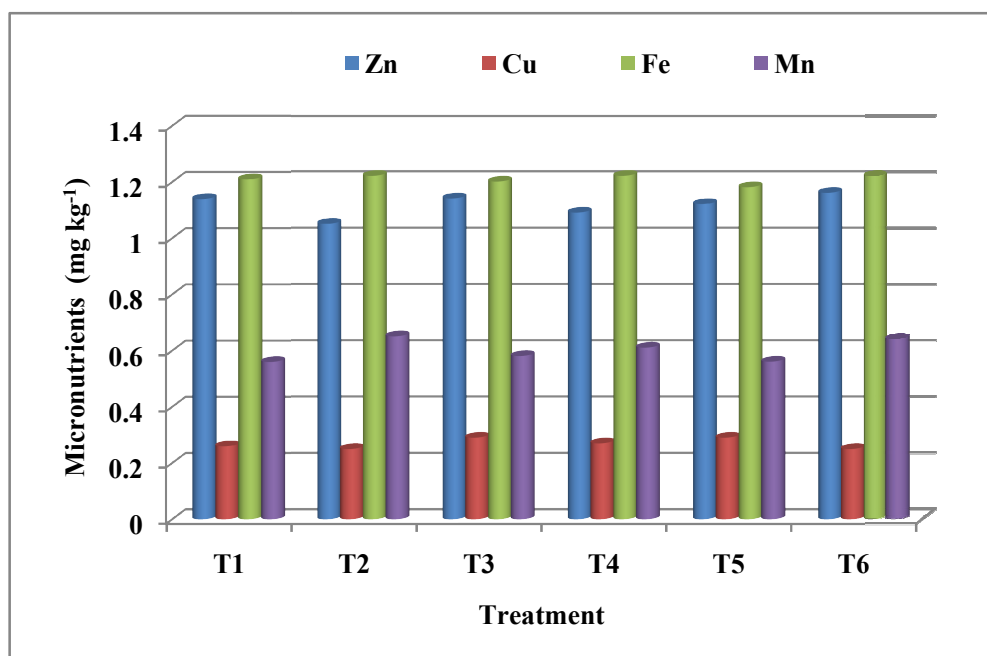


Fig.4.2: Effect of different treatments on available micronutrients of soil at post-harvest

4.2 Growth parameters

4.2.1 Plant height

Plant height was recorded at 30, 60 and 90 DAT (days after transplanting) are showed in table 4.4 and graphically depicted in figure 4.3. Plant height differs significantly due to different scented and non scented rice varieties at all growth periods.

The maximum plant height was observed with T₆-Badshahbhog (73.25, 123.30 and 165.20 cm) at all the intervals of observation respectively. The minimum plant height was observed with T₁-MTU-1010 (51.50 cm) at 30 DAT. At 60 DAT and at harvest intervals T₄-Dubraj (82.37 cm and 95.23 cm) found shortest. These results might be due to genotypic characteristics and different growth habits of scented and non scented rice varieties.

4.2.2 Number of tillers hill⁻¹

Number of tillers hill⁻¹ is presented in table 4.5 and depicted in figure 4.4 and it was significantly influenced by different scented and non scented rice varieties at 30 days after transplanting and at harvesting stage. In general, number of tillers hill⁻¹ increase with increase in crop age.

Maximum number of tillers hill⁻¹ was observed with T₄-Dubraj (13.3), T₅-Devbhog (15.0) and T₂-Zincorice (13.0) at 30 DAT, 60 DAT and at harvest respectively. The minimum number of tillers hill⁻¹ was observed with T₁-MTU 1010 (8.7 and 9.7) at 30 DAT and at harvest stage of observation, whereas T₃-Protazin (11.0) recorded lowest at 60 DAT. These results might be due to genotypic characteristics and different growth habits of scented and non scented rice varieties.

Table: 4.4. Average plant height of different treatments at different time interval of crop growth

Treatment	Plant height (cm)		
	30 DAT	60DAT	At harvest
T ₁ - MTU 1010 (N ₁₀₀ P ₆₀ K ₄₀)	51.50	83.22	97.98
T ₂ - Zinco- Rice (N ₁₀₀ P ₆₀ K ₄₀)	60.07	89.25	98.30
T ₃ - Protazin (N ₁₀₀ P ₆₀ K ₄₀)	62.17	92.30	116.20
T ₄ - Dubraj (N ₆₀ P ₄₀ K ₃₀)	62.31	82.37	95.23
T ₅ - Devbhog (N ₆₀ P ₄₀ K ₃₀)	60.21	84.99	105.93
T ₆ - Badshahbhog (N ₆₀ P ₄₀ K ₃₀)	73.25	123.30	165.20
SE (m)±	1.50	1.03	0.95
CD (P = 0.05)	4.75	3.25	3.00

Table: 4.5. Average number of tillers per hill of different treatments at different time interval of crop growth

Treatment	No. of tillers per hills		
	30 DAT	60DAT	At harvest
T ₁ - MTU 1010 (N ₁₀₀ P ₆₀ K ₄₀)	8.7	12.0	9.7
T ₂ - Zinco- Rice (N ₁₀₀ P ₆₀ K ₄₀)	10.3	13.0	13.0
T ₃ - Protazin (N ₁₀₀ P ₆₀ K ₄₀)	10.0	11.0	11.0
T ₄ - Dubraj (N ₆₀ P ₄₀ K ₃₀)	13.3	14.0	10.0
T ₅ - Devbhog (N ₆₀ P ₄₀ K ₃₀)	10.7	15.0	11.7
T ₆ - Badshahbhog (N ₆₀ P ₄₀ K ₃₀)	11.0	14.3	12.0
SE (m)±	0.38	0.50	0.54
CD (P = 0.05)	1.19	1.58	1.71

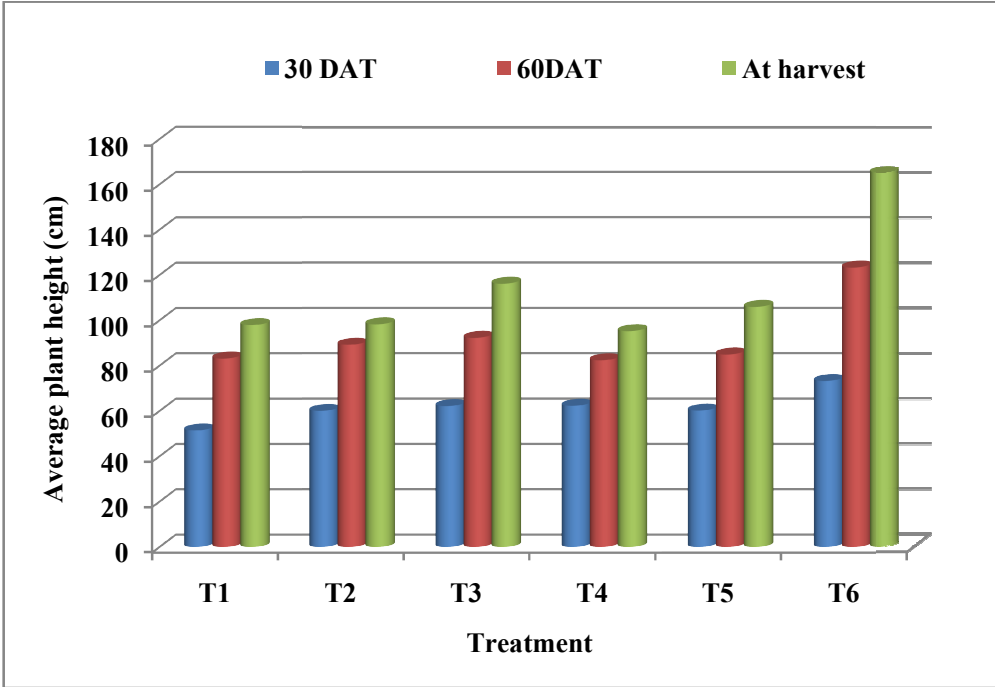


Fig. 4.3: Average plant height of different treatments at different time interval of crop growth

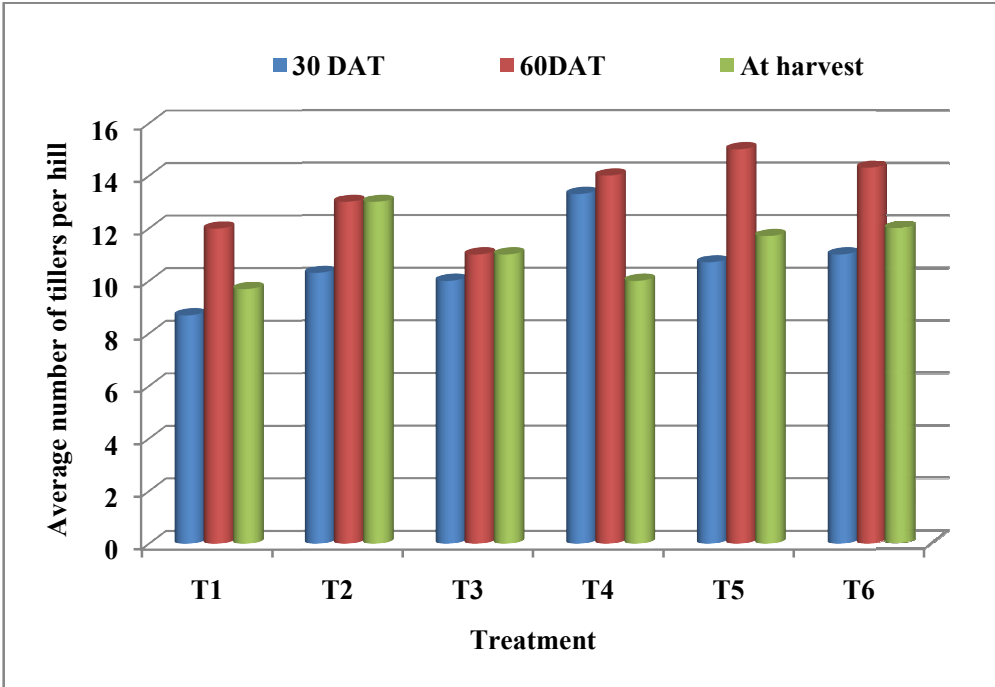


Fig. 4.4: Average number of tillers per hill at different time interval of crop growth

4.3 Yield and yield attributes

4.3.1 Test weight

Test weights of different treatments are presented in table 4.6 and figure 4.5 and they are significantly differ due to different varieties. The variation in test weight is directly related with genetic characters of different rice varieties such as seed size, seed breadth and seed length.

Variety T₃-Protazin showed significantly higher test weight (29.15 g) over other varieties. The minimum test weight was recorded with T₆-Badshahbhog (14.44 g).

4.3.2 Grain and straw yield

Grain and straw yields of scented and non scented varieties were significantly affected by different varieties (table 4.6). Graphical representation was shown in figure 4.6.

The maximum grain yield (50.57 q ha⁻¹) was recorded with T₅-Devbhog. However, it was statistically at par with T₁-MTU 1010 (47.50 q ha⁻¹). The minimum grain yield was obtained from T₆-Badshahbhog (16.17 q ha⁻¹).

The maximum straw yield (98.98 q ha⁻¹) was recorded with T₃-Protazin. The minimum straw yield was recorded with variety MTU 1010 (83.85 q ha⁻¹).

Table: 4.6: Test weight (1000 seed), Grain and straw yield of different treatments

Treatment	Yield (q ha ⁻¹)		
	1000 seed weight (g)	Grain Yield	Straw Yield
T ₁ - MTU 1010 (N ₁₀₀ P ₆₀ K ₄₀)	26.31	47.62	73.85
T ₂ - Zinco- Rice (N ₁₀₀ P ₆₀ K ₄₀)	20.25	24.75	94.67
T ₃ - Protazin (N ₁₀₀ P ₆₀ K ₄₀)	29.15	42.76	98.98
T ₄ - Dubraj (N ₆₀ P ₄₀ K ₃₀)	14.91	42.95	72.56
T ₅ - Devbhog (N ₆₀ P ₄₀ K ₃₀)	15.73	50.57	93.25
T ₆ - Badshahbhog (N ₆₀ P ₄₀ K ₃₀)	14.44	16.17	93.79
SE (m)±	0.31	0.44	3.15
CD (P = 0.05)	0.97	1.39	9.94

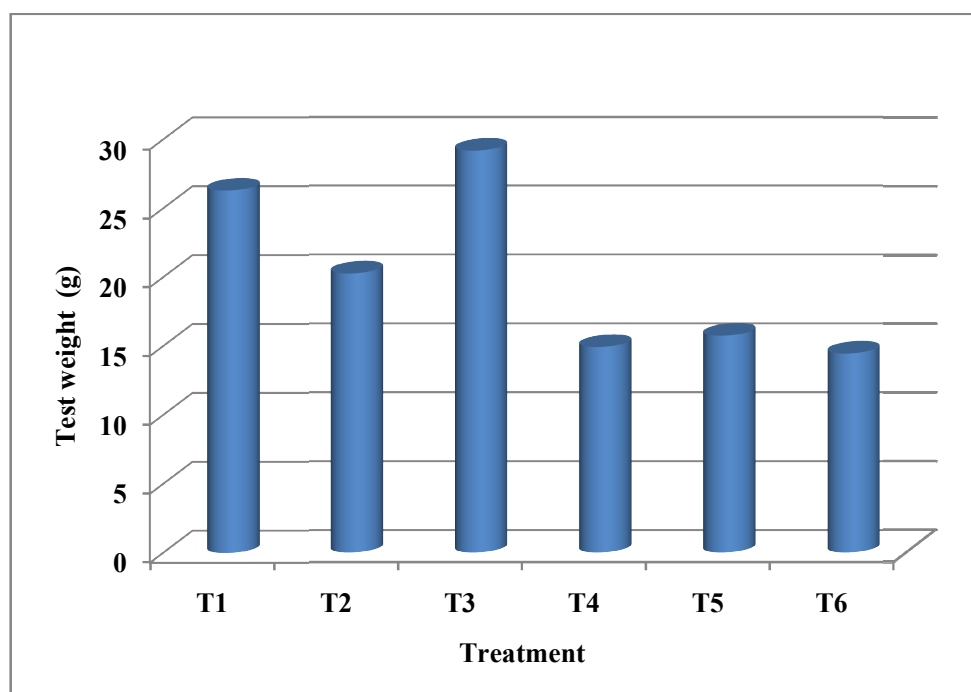


Fig. 4.5: Test weight (1000 seed) of different treatments

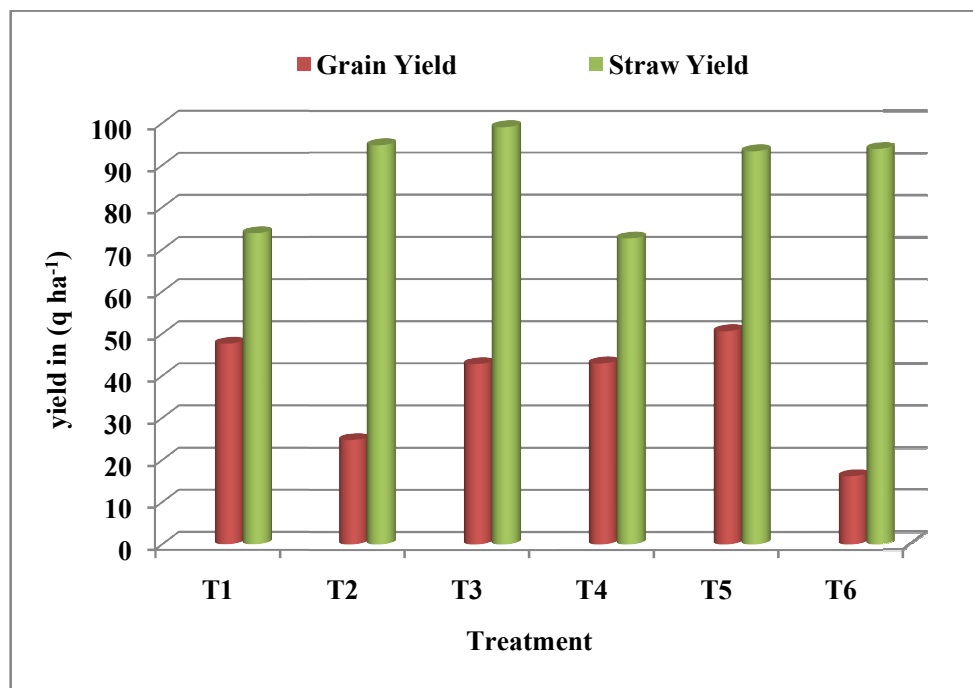


Fig. 4.6: Grain and straw yield of different treatments after harvest

4.4 Nutrient content and uptake by crops

4.4.1 Nutrient content in plants

4.4.1.1 Nitrogen content in grain and straw

Nitrogen content in grain of scented and non scented rice varieties were found significantly different and showed in table 4.7 and figure 4.7. Significantly higher nitrogen content in grain was obtained with T₃-Protazin (1.34%). Minimum nitrogen content was observed with T₁-MTU 1010 (1.17%).

Nitrogen content in straw of scented and non scented rice varieties were found significantly different and showed in table 4.8 and figure 4.8. Maximum nitrogen content in straw was recorded in variety T₁-MTU 1010 and T₃-Protazin (0.65 %) which was statistically at par with T₂-Zinco-rice (0.64 %). Minimum nitrogen content was observed in T₅-Devbhog (0.56 %).

4.4.1.2 Phosphorus content in grain and straw

Phosphorus content in grain of scented and non scented rice varieties was found significantly different and showed in table 4.7 and figure 4.7. Maximum phosphorus content in grain was observed in T₂-Zinco-rice (0.24 %). The minimum phosphorus content in grain was recorded in T₁-MTU 1010 and T₅-Devbhog (0.18 %).

Phosphorus content in straw of scented and non scented rice varieties was found significantly different and showed in table 4.8 and figure 4.8. Maximum phosphorus content in straw was recorded in T₂-Zinco-rice (0.12 %) which was statistically at par with variety T₃-Protazin, T₄-Dubraj and T₆-Badshahbhog (0.11 %). The minimum phosphorus content in straw was recorded in T₁-MTU 1010 and T₅-Devbhog (0.10 %).

4.4.1.3 Potassium content in grain and straw

Potassium content in grain of scented and non scented rice varieties were found significantly different and showed in table 4.7 and figure 4.7. Maximum potassium content in grain was observed in T₂-Zinco-rice (0.25%), which is statistically at par with T₄-Dubraj (0.24 %). Minimum potassium content in grain was observed with T₅-Devbhog (0.21 %).

Potassium content in straw of scented and non scented rice varieties was found significantly different and showed in table 4.8 and figure 4.8. Maximum potassium content in straw was observed with T₂-Zinco-rice (1.56 %), which is statistically at par with T₄-Dubraj and T₅-Devbhog (1.53 %). Minimum potassium content in straw was recorded with T₁-MTU 1010 and T₆-Badshahbhog (1.48 %).

Table: 4.7: Content of Nitrogen, Phosphorus and Potassium (%) in rice grain of different treatments

Treatment	(% In rice grain)		
	N	P	K
T ₁ - MTU 1010 (N ₁₀₀ P ₆₀ K ₄₀)	1.17	0.18	0.20
T ₂ - Zinco- Rice (N ₁₀₀ P ₆₀ K ₄₀)	1.23	0.24	0.25
T ₃ - Protazin (N ₁₀₀ P ₆₀ K ₄₀)	1.34	0.19	0.23
T ₄ - Dubraj (N ₆₀ P ₄₀ K ₃₀)	1.20	0.21	0.24
T ₅ - Devbhog (N ₆₀ P ₄₀ K ₃₀)	1.18	0.18	0.21
T ₆ - Badshahbhog (N ₆₀ P ₄₀ K ₃₀)	1.19	0.20	0.22
SE (m)±	0.007	0.009	0.005
CD (P = 0.05)	0.023	0.028	0.018

Table: 4.8: Content of Nitrogen, Phosphorus and Potassium (%) in rice straw of different treatments

Treatment	(% In rice straw)		
	N	P	K
T ₁ - MTU 1010 (N ₁₀₀ P ₆₀ K ₄₀)	0.65	0.10	1.48
T ₂ - Zinco- Rice (N ₁₀₀ P ₆₀ K ₄₀)	0.64	0.12	1.56
T ₃ - Protazin (N ₁₀₀ P ₆₀ K ₄₀)	0.65	0.11	1.51
T ₄ - Dubraj (N ₆₀ P ₄₀ K ₃₀)	0.59	0.11	1.53
T ₅ - Devbhog (N ₆₀ P ₄₀ K ₃₀)	0.56	0.10	1.53
T ₆ - Badshahbhog (N ₆₀ P ₄₀ K ₃₀)	0.57	0.11	1.48
SE (m)±	0.006	0.009	0.010
CD (P = 0.05)	0.021	0.030	0.032

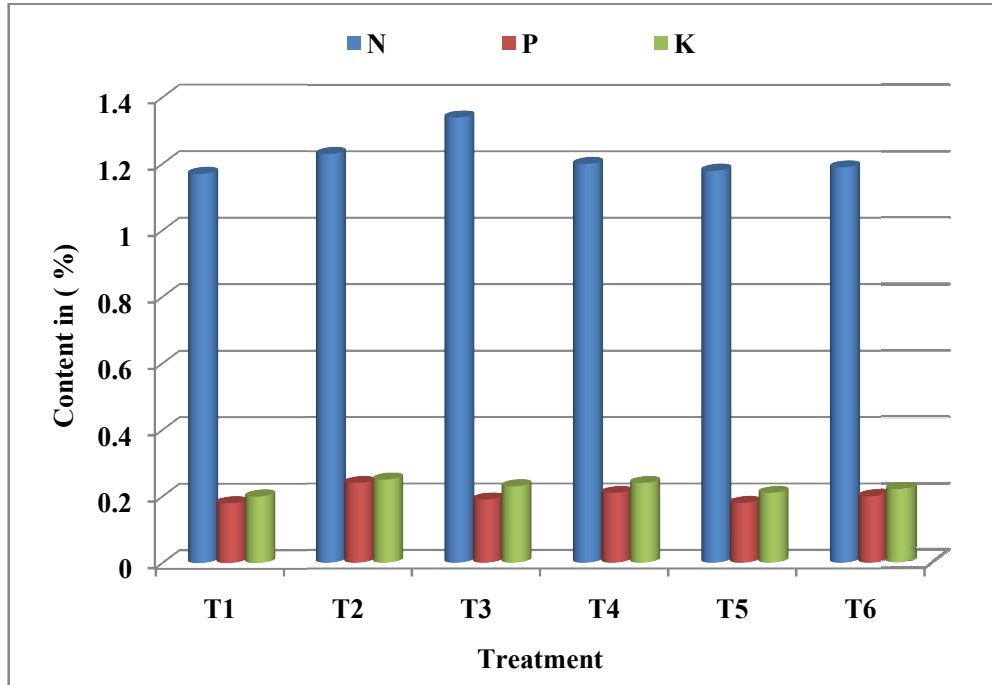


Fig.4.7: Content of Nitrogen, Phosphorus and Potassium (%) in rice grain of different treatments

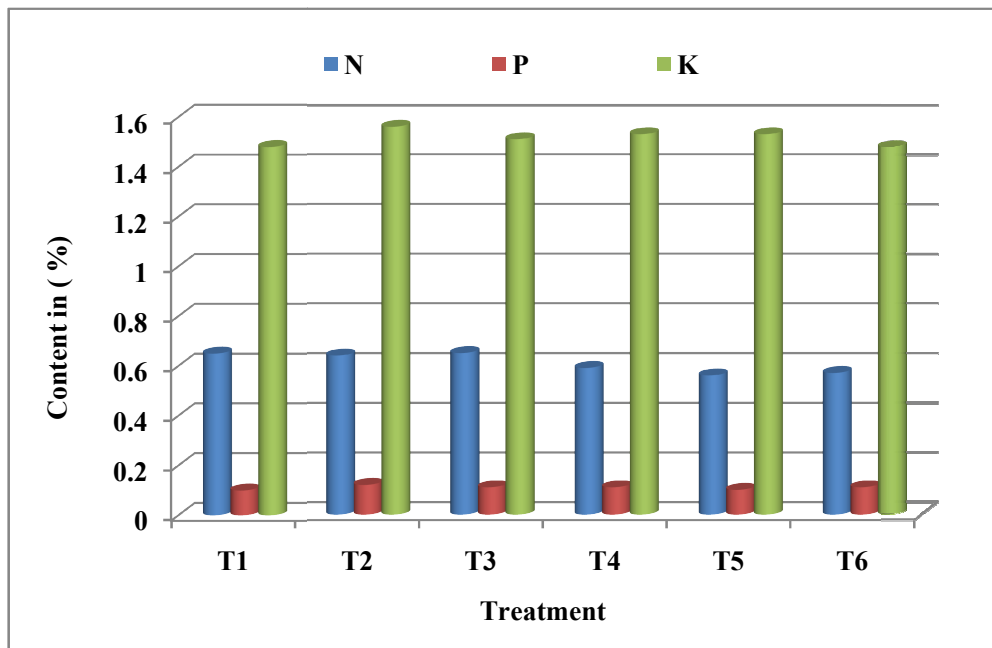


Fig.4.8: Content of Nitrogen, Phosphorus and Potassium (%) in rice straw of different treatments

4.3.2 Nutrient uptake by crop

4.3.2.1 Nitrogen uptake by grain and straw

Data related to nitrogen uptake by grain of scented and non scented rice varieties were found significantly different and showed in table 4.9 and figure 4.9. Maximum uptake of nitrogen by grain was obtained in T₅-Devbhog (59.67 kg ha⁻¹) which was statistically at par with T₃-Protazin (57.30 kg ha⁻¹). Minimum uptake of nitrogen by grain was observed in T₆-Badshahbhog (19.24 kg ha⁻¹).

Data related to nitrogen uptake by straw is showed in table 4.10 and figure 4.10. In straw nitrogen uptake was significantly influenced by different rice varieties. Maximum nitrogen uptake by straw was observed in T₃-Protazin (64.34 kg ha⁻¹). Minimum nitrogen uptake by straw was observed in T₄-Dubraj (42.81 kg ha⁻¹).

4.3.2.2 Phosphorus uptake by grain and straw

Data related to phosphorus uptake by grain is showed in table 4.9 and figure 4.9. Scented and non scented rice varieties were found significantly different due to different varieties. Maximum phosphorus uptake by grain was recorded in variety T₅-Devbhog (9.10 kg ha⁻¹) which was statistically at par with T₄-Dubraj (9.02 kg ha⁻¹). The minimum phosphorus uptake by grain was observed in T₆-Badshahbhog (3.23 kg ha⁻¹).

Data related to phosphorus uptake by straw is showed in table 4.10 and figure 4.10. In straw phosphorus uptake was significantly influenced by different rice varieties. Maximum phosphorus uptake by straw was recorded in T₂-Zincorice (11.36 kg ha⁻¹). The minimum phosphorus content in straw was observed in T₁-MTU 1010 (7.39 kg ha⁻¹), which was statistically at par with variety T₄-Dubraj (7.98 kg ha⁻¹).

4.3.2.3 Potassium uptake by grain and straw

Data related to potassium uptake by grain is presented in table 4.9 and figure 4.9. Potassium uptake by grain of different treatment was significantly affected due to different varieties. Maximum uptake of potassium by grain was obtained with T₅-Devbhog (10.62 kg ha⁻¹) which was statistically at par with

variety T₄-Dubraj (10.31 kg ha⁻¹). Minimum uptake of potassium by grain was recorded in T₆-Badshahbhog (3.56 kg ha⁻¹).

Data related to potassium uptake by straw is showed in table 4.10 and figure 4.10. Potassium uptake by straw was significantly influenced due to different varieties. Maximum uptake of potassium by straw was observed with T₃-Protazin (149.46 kg ha⁻¹). Minimum uptake of potassium by straw was observed in T₁-MTU 1010 (109.30 kg ha⁻¹).

Table: 4.9: Total Nitrogen, Phosphorus and Potassium uptake by grain

Treatment	N (kg ha ⁻¹)	P (kg ha ⁻¹)	K(kg ha ⁻¹)
T1- MTU 1010 (N ₁₀₀ P ₆₀ K ₄₀)	55.72	8.57	9.52
T2- Zinco- Rice (N ₁₀₀ P ₆₀ K ₄₀)	30.44	5.94	6.19
T3- Protazin (N ₁₀₀ P ₆₀ K ₄₀)	57.30	8.12	9.83
T4- Dubraj (N ₆₀ P ₄₀ K ₃₀)	51.54	9.02	10.31
T5- Devbhog (N ₆₀ P ₄₀ K ₃₀)	59.67	9.10	10.62
T6- Badshahbhog (N ₆₀ P ₄₀ K ₃₀)	19.24	3.23	3.56
SE (m)±	1.21	0.26	0.37
CD (P = 0.05)	3.82	0.84	1.18

Table: 4.10: Total Nitrogen, Phosphorus and Potassium uptake by straw

Treatment	N (kg ha ⁻¹)	P (kg ha ⁻¹)	K(kg ha ⁻¹)
T ₁ - MTU 1010 (N ₁₀₀ P ₆₀ K ₄₀)	48.00	7.39	109.30
T ₂ - Zinco- Rice (N ₁₀₀ P ₆₀ K ₄₀)	60.59	11.36	147.69
T ₃ - Protazin (N ₁₀₀ P ₆₀ K ₄₀)	64.34	10.89	149.46
T ₄ - Dubraj (N ₆₀ P ₄₀ K ₃₀)	42.81	7.98	111.02
T ₅ - Devbhog (N ₆₀ P ₄₀ K ₃₀)	52.22	9.33	142.67
T ₆ - Badshahbhog (N ₆₀ P ₄₀ K ₃₀)	53.46	10.32	138.81
SE (m)±	2.25	0.71	5.11
CD (P = 0.05)	7.10	2.25	16.11

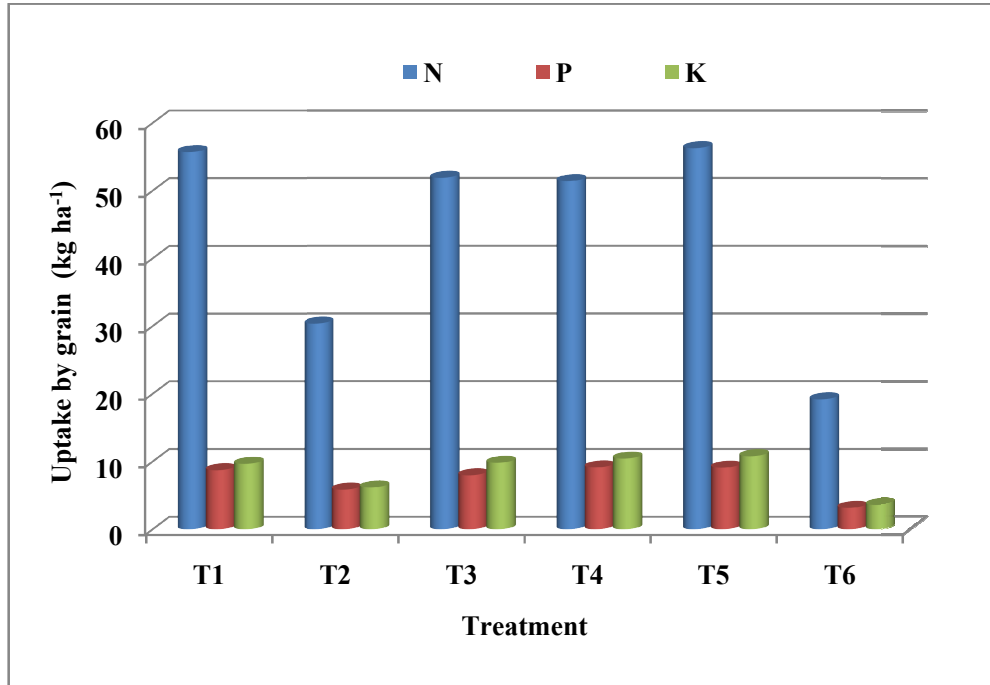


Fig.4.9: Total Nitrogen, Phosphorus and Potassium uptake by grain

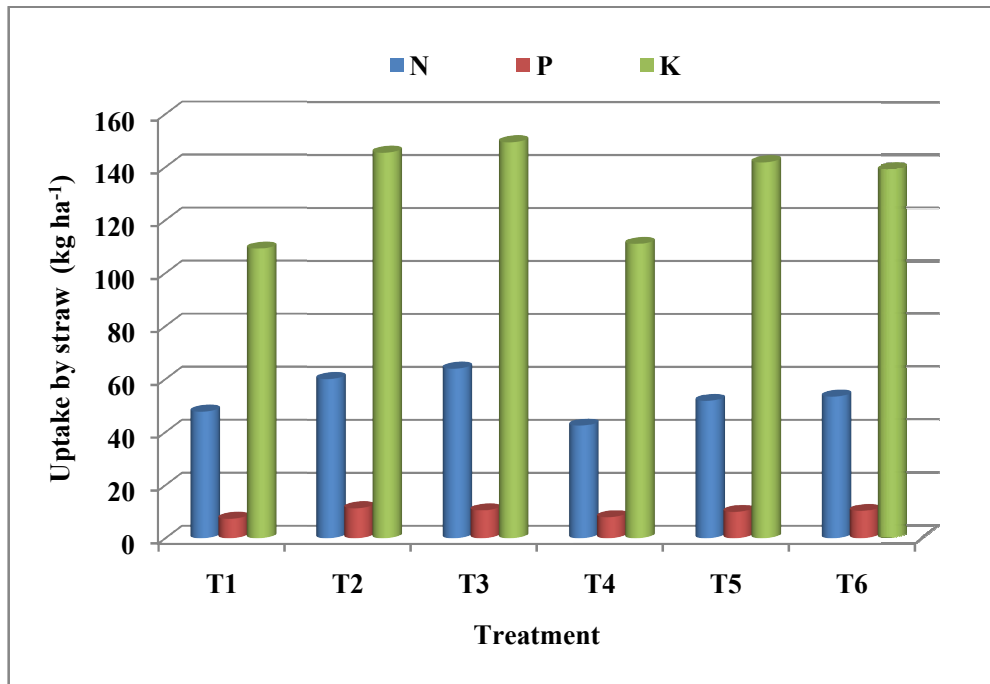


Fig.4.10: Total Nitrogen, Phosphorus and Potassium uptake by straw

4.5 Nutrient budgeting for crops

4.5.1 Nitrogen budgeting of different treatments

The data related to nitrogen budgeting for different treatment is showed in table 4.11 and figure 4.11. Nitrogen uptake by crop was recorded maximum in T₃-Protazin (121.64 kg ha⁻¹). The minimum nitrogen uptake by crop was observed in T₆-Badshahbhog (72.70 kg ha⁻¹).

The maximum expected balance of nitrogen in soil was calculated in T₂-Zinco-rice (242.22 kg ha⁻¹). The minimum expected balance of nitrogen in soil was obtained in T₅-Devbhog (181.36 kg ha⁻¹).

The maximum actual balance (post harvest soil test) of nitrogen in soil was calculated in T₄-Dubraj (228.95 kg ha⁻¹). The minimum actual balance of nitrogen in soil was obtained in T₂-Zinco-rice (225.31 kg ha⁻¹).

On the basis of nutrient uptake by plant, the maximum N-balance of nitrogen in soil was calculated in T₅-Devbhog (44.80 kg ha⁻¹), minimum nitrogen balance in soil was obtained in T₂-Zinco-rice (-16.91 kg ha⁻¹).

On the basis of soil test value, the minimum loss of N-balance of nitrogen in soil was calculated in T₄-Dubraj (-4.3 kg ha⁻¹); while the maximum loss of nitrogen balance in soil was obtained in T₂-Zinco-rice (-7.94 kg ha⁻¹).

Table: 4.11: Nitrogen budgeting of different treatments

Treatment	Nitrogen budgeting (kg ha ⁻¹) in soil							
	Initial N in soil	Added N	Total N	N Uptake by crop	Post harvest (Actual)	Expected balance in soil	N balance uptake basis	N balance (STV) Basis
T₁- MTU 1010 (N₁₀₀P₆₀K₄₀)	233.25	100	333.25	103.72	228.41	229.53	-1.12	-4.84
T₂- Zinco- Rice (N₁₀₀P₆₀K₄₀)	233.25	100	333.25	91.03	225.31	242.22	-16.91	-7.94
T₃- Protazin (N₁₀₀P₆₀K₄₀)	233.25	100	333.25	121.64	227.25	211.61	15.64	-6
T₄- Dubraj (N₆₀P₄₀K₃₀)	233.25	60	293.25	94.35	228.95	198.90	30.05	-4.3
T₅- Devbhog (N₆₀P₄₀K₃₀)	233.25	60	293.25	111.89	226.16	181.36	44.80	-7.09
T₆- Badshahbhog (N₆₀P₄₀K₃₀)	233.25	60	293.25	72.70	225.67	220.55	5.12	-7.58

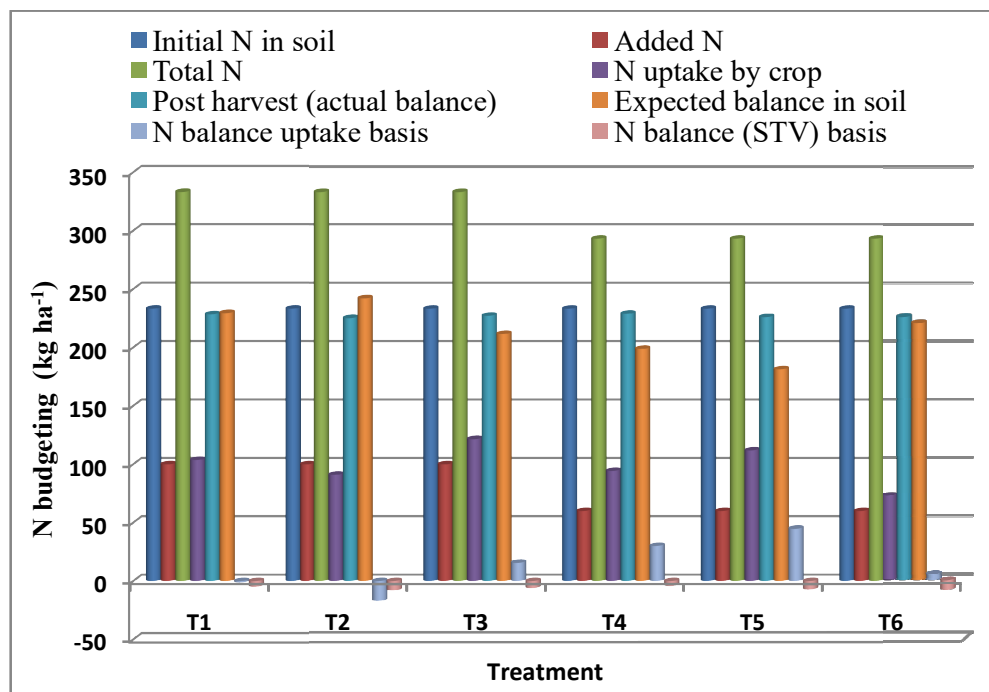


Fig.4.11: Nitrogen budgeting of different treatments

4.5.2 Phosphorus budgeting of different treatments

The data related to phosphorus budgeting for different treatment is presented in table 4.12 and figure 4.12. Maximum phosphorus uptake by crop was recorded in T₃-Protazin (19.01 kg ha⁻¹). The minimum phosphorus uptake by crop was observed in T₆-Badshahbhog (13.55 kg ha⁻¹).

The maximum expected balance of phosphorus in soil was calculated in T₁-MTU 1010 (66.82 kg ha⁻¹). The minimum expected balance of phosphorus in soil was obtained in T₅-Devbhog (44.35 kg ha⁻¹).

The maximum actual balance (post harvest soil test) of phosphorus in soil was calculated in T₃-Protazin (22.53 kg ha⁻¹). The minimum actual balance of phosphorus in soil was obtained in T₁-MTU 1010 (21.40 kg ha⁻¹).

On the basis of nutrient uptake by plant, the maximum loss of P-balance in soil was calculated in T₁-MTU 1010 (-45.42 kg ha⁻¹); while the minimum phosphorus balance loss in soil was calculated in T₅-Devbhog (-22.74 kg ha⁻¹).

On the basis of soil test value, the maximum loss of P-balance in soil was calculated in T₁-MTU 1010 (-1.38 kg ha⁻¹); while the minimum P-balance loss in soil was calculated in T₃-Protazin (-0.25 kg ha⁻¹).

Table: 4.12: Phosphorus budgeting of different treatments

Treatment	Phosphorus budgeting (kg ha ⁻¹) in soil							
	Initial P in soil	Added P	Total P	P Uptake by crop	Post harvest (Actual)	Expected balance in soil	P balance uptake basis	P balance (STV) Basis
T ₁ - MTU 1010 (N ₁₀₀ P ₆₀ K ₄₀)	22.78	60	82.78	15.96	21.40	66.82	-45.42	-1.38
T ₂ - Zinco- Rice (N ₁₀₀ P ₆₀ K ₄₀)	22.78	60	82.78	17.30	22.52	65.48	-42.96	-0.26
T ₃ - Protazin (N ₁₀₀ P ₆₀ K ₄₀)	22.78	60	82.78	19.01	22.53	63.77	-41.24	-0.25
T ₄ - Dubraj (N ₆₀ P ₄₀ K ₃₀)	22.78	40	62.78	17.00	22.24	45.78	-23.54	-0.54
T ₅ - Devbhog (N ₆₀ P ₄₀ K ₃₀)	22.78	40	62.78	18.43	21.61	44.35	-22.74	-1.17
T ₆ - Badshahbhog (N ₆₀ P ₄₀ K ₃₀)	22.78	40	62.78	13.55	22.23	49.23	-27.00	-0.55

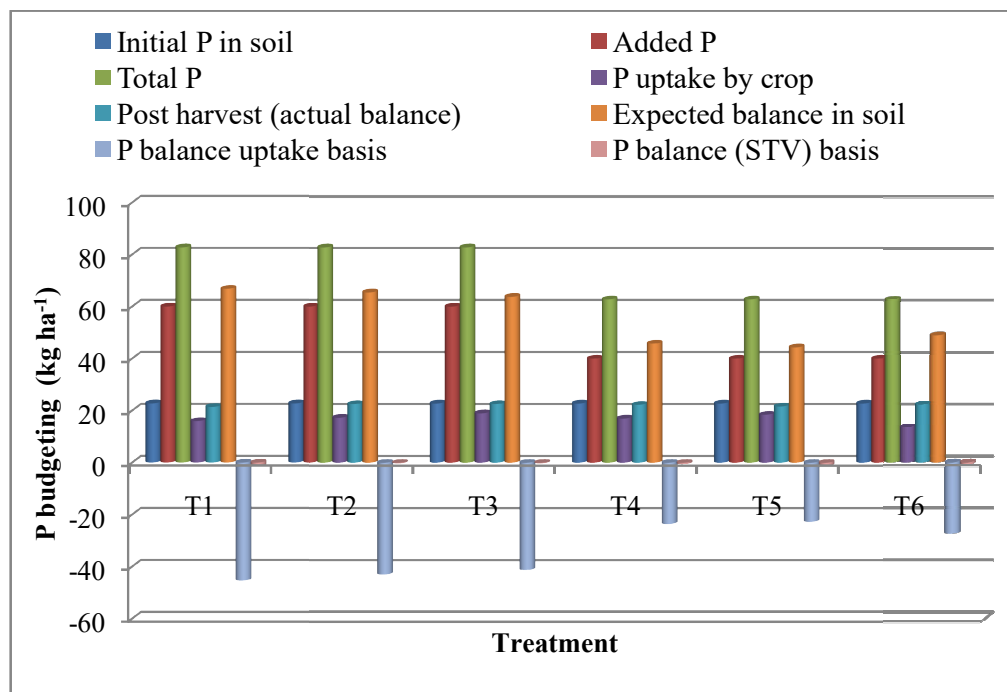


Fig.4.12: Phosphorus budgeting of different treatments

4.5.3 Potassium budgeting of different treatments

The data related to potassium budgeting for different treatment is showed in table 4.13 and figure 4.13. Potassium uptake by crop was recorded maximum in T₃-Protazin (159.29 kg ha⁻¹). Potassium uptake by crop was observed minimum in T₁-MTU 1010 (118.82 kg ha⁻¹).

The maximum expected balance of potassium in soil was calculated in T₁-MTU 1010 (179.66 kg ha⁻¹). The minimum expected balance of potassium in soil was obtained in T₅-Devbhog (135.19 kg ha⁻¹).

The maximum actual balance (post harvest soil test) of potassium in soil was calculated in T₄-Dubraj (260.45 kg ha⁻¹). The minimum actual balance of potassium in soil was obtained in T₁-MTU 1010 (257.64 kg ha⁻¹).

On the basis of nutrient uptake by plant, the maximum K-balance in soil was calculated in T₅-Devbhog (123.26 kg ha⁻¹); while the minimum phosphorus balance in soil was calculated in T₁-MTU 1010 (77.98 kg ha⁻¹).

On the basis of soil test value, the maximum K-balance in soil was calculated in T₄-Dubraj (1.97 kg ha⁻¹); while the maximum K-balance loss in soil was calculated in T₁-MTU 1010 (-0.84 kg ha⁻¹).

Table: 4.13: Potassium budgeting of different treatments

Treatment	Potassium budgeting (kg ha ⁻¹) in soil							
	Initial K in soil	Added K	Total K	K Uptake by crop	Post harvest (Actual)	Expected balance in soil	K balance uptake basis	K balance (STV) Basis
T₁- MTU 1010 (N₁₀₀P₆₀K₄₀)	258.48	40	298.48	118.82	257.64	179.66	77.98	-0.84
T₂- Zinco- Rice (N₁₀₀P₆₀K₄₀)	258.48	40	298.48	153.87	258.61	144.61	114.00	0.13
T₃- Protazin (N₁₀₀P₆₀K₄₀)	258.48	40	298.48	159.29	259.79	139.19	120.60	1.31
T₄- Dubraj (N₆₀P₄₀K₃₀)	258.48	30	288.48	121.32	260.45	167.16	93.29	1.97
T₅- Devbhog (N₆₀P₄₀K₃₀)	258.48	30	288.48	153.29	258.45	135.19	123.26	-0.03
T₆-Badshahbhog (N₆₀P₄₀K₃₀)	258.48	30	288.48	142.37	258.85	146.11	112.74	0.37

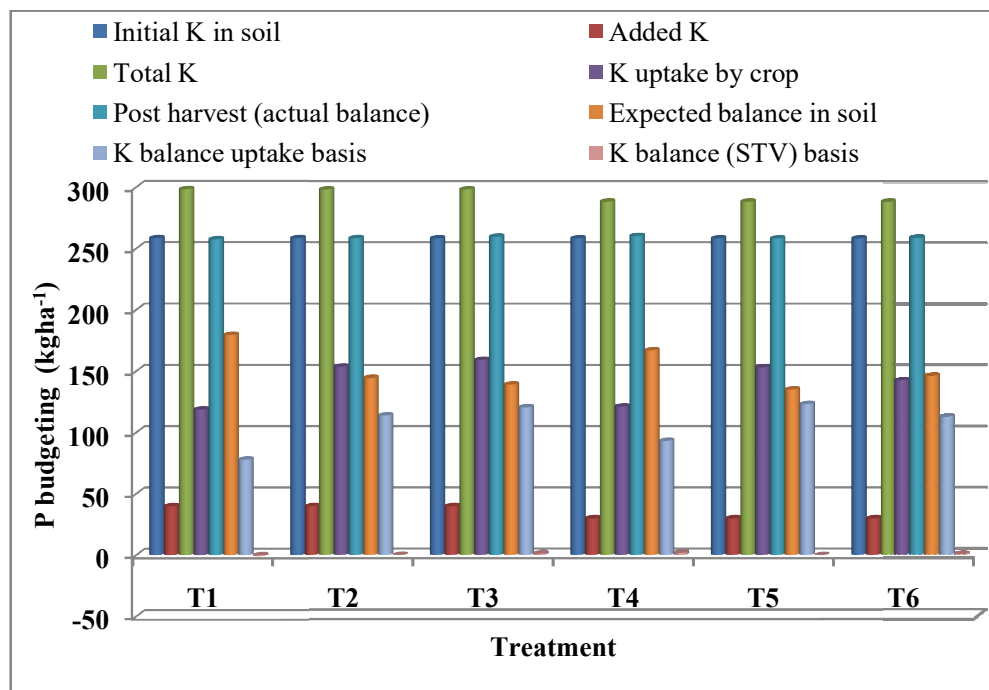


Fig.4.13: Potassium budgeting of different treatments

4.6 Economics

To find out the economic feasibility and viability of different treatment under study, economics of rice production in terms of gross return, net return and benefit cost ratio was calculated for scented and non scented rice varieties.

4.6.1 Gross Return

The Gross return of crop was found significantly different at all treatments and shown in table 4.14 and figure 4.14. The data concluded that the maximum gross return (Rs 110573.13 ha⁻¹) was received with T₅-Devbhog. The lowest gross return (Rs 417551.01 ha⁻¹) was obtained with T₆-Badshahbhog.

4.6.2 Net Return

The net return of crop was found significantly different at all treatments and shown in table 4.14 and figure 4.14. The data concluded that the maximum net return (Rs 86095.55 ha⁻¹) was obtained with variety T₅-Devbhog. The lowest net return (Rs 17273.41 ha⁻¹) was obtained with T₆-Badshahbhog.

4.6.3 Benefit Cost Ratio

The benefit cost ratio of crop was found significantly different at all treatments and shown in table 4.14 and figure 4.15. The data concluded that the maximum benefit cost ratio (3.52) was received with variety T₅-Devbhog. The lowest benefit cost ratio (0.71) was obtained with T₆-Badshahbhog.

Table 4.14: Effect treatments on economics of scented and non scented rice varieties

Treatment	Cost of cultivation (Rs ha⁻¹)	Gross returns (Rs ha⁻¹)	Net returns (Rs ha⁻¹)	B:C Ratio
T ₁ - MTU 1010 (N ₁₀₀ P ₆₀ K ₄₀)	26570.50	94774.15	68203.65	2.57
T ₂ - Zinco- Rice (N ₁₀₀ P ₆₀ K ₄₀)	26840.00	59016.50	32176.50	1.20
T ₃ - Protazin (N ₁₀₀ P ₆₀ K ₄₀)	26840.00	95496.85	68656.85	2.56
T ₄ - Dubraj (N ₆₀ P ₄₀ K ₃₀)	24477.60	93241.90	68764.30	2.81
T ₅ - Devbhog (N ₆₀ P ₄₀ K ₃₀)	24477.60	110573.13	86095.55	3.52
T ₆ - Badshahbhog (N ₆₀ P ₄₀ K ₃₀)	24477.60	41751.01	17273.41	0.71
SE (m)±	-	911.01	911.01	0.037
CD (P = 0.05)	-	2870.66	2870.67	0.117

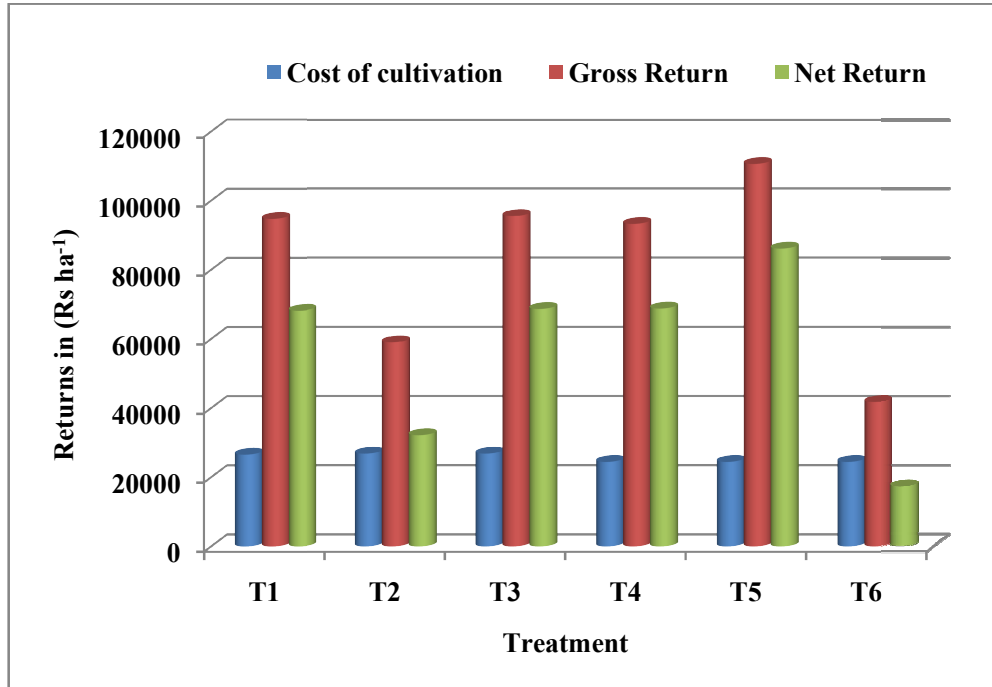


Fig.4.14: Gross and net returns of different treatments

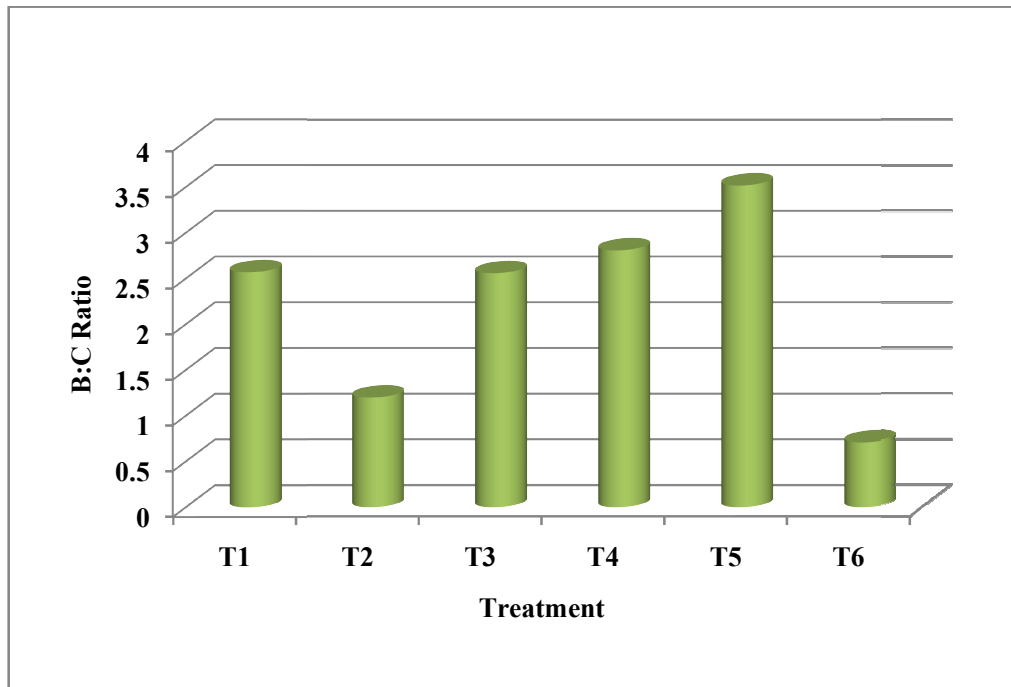


Fig.4.15: Benefit cost ratio of different treatments

CHAPTER – V

SUMMARY AND CONCLUSIONS

The present experiment entitled “**Nutrient budgeting and economic analyses of scented and non scented rice varieties in *Vertisol***” was undertaken at Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh) during *kharif* season 2019-20. The nutrient budgeting is important for balancing the nutrient in soil and soil fertility status is major component for crop production. Therefore, the current research was carried out to study the nutrient budgeting for different varieties of rice crop in *Vertisol*. The experiment was consisted with 6 treatments *viz.*, T₁ - MTU 1010 (N₁₀₀P₆₀K₄₀), T₂ - Zinco- Rice (N₁₀₀P₆₀K₄₀), T₃ - Protazin (N₁₀₀P₆₀K₄₀), T₄ - Dubraj (N₆₀P₄₀K₃₀), T₅ - Devbhog (N₆₀P₄₀K₃₀) and T₆ - Badshahbhog (N₆₀P₄₀K₃₀) in RBD with 4 replications. The Soil texture, pH, EC, OC, NPK and micronutrient, nutrient uptake by crop, yields and economics were analyzed during the experimentation period.

SUMMARY

The outcomes of the experiment are given below:

1. The numerically higher soil pH (7.59) was observed in the treatment T₁ - MTU 1010 and T₅ - Devbhog. The minimum soil pH (7.55) was recorded in the treatment T₂ - Zinco-rice and T₄-Dubraj.
2. The numerically higher EC (0.104 dSm⁻¹) recorded in treatment T₂ - Zinco-rice and lowest amount of EC (0.101 dSm⁻¹) was observed in T₆ - Badshahbhog.
3. The highest soil organic carbon (0.61 %) recorded in treatment T₂ - Zinco-rice and T₆ - Badshahbhog. The lowest soil organic carbon (0.58 %) recorded in treatments T₄ - Dubraj and T₅-Devbhog.
4. The available nitrogen in soil was ranged between 225.31 - 228.95 kg per ha. The highest available Nitrogen (228.95 kg per ha) was recorded in T₄ - Dubraj. Whereas, the minimum soil available N (225.31 kg per ha) was recorded in T₂ - Zinco-rice.

5. The available phosphorus in soil was ranged between 21.40-22.53 kg per ha. The highest available phosphorus (22.53 kg per ha) was recorded in T₃ - Protazin. The lowest value of available phosphorus (21.40 kg per ha) was observed in treatment T₁ - MTU 1010.
6. The available potassium in soil was ranged between 257.64-260.45 kg per ha. The data was found no significant different among the various treatments. The highest available Potassium (260.45 kg per ha) was recorded in T₄ - Dubraj. The lowest value of available Potassium (257.64 kg per ha) was observed in treatment T₁ - MTU 1010
7. The available zinc in soil was ranged between 1.05-1.16 mg kg⁻¹. The data was found no significant different among the various treatments. The highest available zinc (1.16 mg kg⁻¹) was recorded in treatment T₆ - Badshahbhog. The lowest value of available zinc (1.05 mg kg⁻¹) was observed in treatment T₂ - Zinco-rice.
8. The available copper in soil was ranged between 0.25-0.29 mg kg⁻¹. The highest available coppers (0.29 mg kg⁻¹) were obtained in treatment T₃ - Protazin and T₅ - Devbhog. The lowest value of available copper (0.25 mg kg⁻¹) was observed in treatment T₂ - Zinco-rice and T₆ . Badshahbhog.
9. The available iron in soil was ranged between 1.18-1.22 mg kg⁻¹. The data was found no significant different among the various treatments. The highest available iron (1.22 mg kg⁻¹) was obtained in treatment T₂ - Zinco-rice, T₄ - Dubraj and T₆ - Badshahbhog. The lowest value of available iron (1.18 mg kg⁻¹) was observed in treatment T₅ - Devbhog.
10. The available manganese in soil was ranged between 0.56-0.65 mg kg⁻¹. The data was found no significant different among the various treatments. The highest available manganese (0.65 mg kg⁻¹) was obtained in treatment T₂ - Zinco-rice. The lowest value of available manganese (0.56 mg kg⁻¹) was observed in treatment T₁ - MTU 1010 and T₅ - Devbhog.
11. The maximum plant height was recorded with variety T₆ - Badshahbhog (73.25, 123.30 and 165.20 cm) at all the intervals of observation respectively. The minimum plant height was recorded with T₁ - MTU-1010

- (51.50 cm) at 30 DAT. At 60 DAT and at harvest intervals T₄ - Dubraj (82.37 cm and 95.23 cm) found shortest.
12. The maximum number of tillers hill⁻¹ was recorded with variety T₄ - Dubraj (13.3), T₅ - Devbhog (15.0) and T₂ - Zinco-rice (13.0) at 30 DAT, 60 DAT and at harvest respectively. The minimum number of tillers hill⁻¹ was recorded with T₁ - MTU 1010 (8.7 and 9.7) at 30 DAT and at harvest stage of observation, whereas T₃ - Protazin (11.0) recorded lowest at 60 DAT.
 13. Variety T₃ - Protazin recorded higher test weight (29.15) over rest of the varieties. The minimum test weight was observed in T₆ - Badshahbhog (14.44)
 14. The maximum grain (50.57 Q/ha) and straw yield (98.98 Q/ha) was recorded with variety T₅ - Devbhog and T₃ - Protazin respectively. The minimum grain (16.17 Q/ha) and straw yield (83.85 Q/ha) was obtained from variety T₆ - Badshahbhog and T₁ - MTU 1010 respectively.
 15. Higher nitrogen content in grain was obtained in variety T₃ - Protazin (1.34%). Minimum nitrogen content was observed with variety T₁ - MTU 1010 (1.17%). Maximum nitrogen content in straw was recorded in variety T₁ - MTU 1010 and T₃ - Protazin (0.65 %), while minimum in variety T₅ - Devbhog (0.56 %).
 16. Maximum phosphorus content in grain was recorded in variety T₂ - Zinco-rice (0.24 %) and minimum in variety T₁ - MTU 1010 and T₅ - Devbhog (0.18 %). Maximum phosphorus content in straw was recorded in variety T₂ - Zinco-rice (0.12 %) and minimum in variety T₁ - MTU 1010 and T₅ - Devbhog (0.10 %).
 17. The maximum potassium content in grain was recorded in variety T₂ - Zinco-rice (0.25%) and minimum with T₅ - Devbhog (0.21 %). The maximum potassium content in straw was recorded with variety T₂ - Zinco-rice (1.56 %) and minimum in variety T₁ - MTU 1010 and T₆ - Badshahbhog (1.48 %).
 18. The maximum uptake of nitrogen by grain was obtained in variety T₅ - Devbhog (59.67 kg per ha) and minimum in variety T₆ - Badshahbhog

(19.24 kg per ha). The maximum nitrogen uptake by straw was recorded in variety T₃ - Protazin (64.34 kg per ha) and minimum in variety T₄ - Dubraj (42.81 kg per ha).

19. Maximum phosphorus uptake by grain was recorded in variety T₅ - Devbhog (9.10 kg per ha) and the minimum in variety T₆ - Badshahbhog (3.23 kg per ha). Maximum phosphorus uptake by straw was recorded in variety T₂ - Zinco-rice (11.36 kg per ha) and minimum in variety T₁ - MTU 1010 (7.39 kg per ha).
20. Maximum uptake of potassium by grain was obtained with variety T₅ - Devbhog (10.62 kg per ha) and minimum in T₆ - Badshahbhog (3.56 kg per ha). Maximum uptake of potassium by straw was observed with variety T₃ - Protazin (149.46 kg per ha) and minimum in T₁ - MTU 1010 (109.30 kg per ha).
21. For Nitrogen, the maximum uptake by crop was recorded in treatment T₃ - Protazin (121.64 kg per ha) and minimum in T₆ - Badshahbhog (72.70 kg per ha). The maximum expected balance in soil was calculated in treatment T₂ - Zinco-rice (242.22 kg per ha) and minimum in T₅ - Devbhog (181.36 kg per ha). The maximum actual balance (post harvest soil test) was calculated in treatment T₄ - Dubraj (228.95 kg per ha) and minimum in T₂ - Zinco-rice (225.31 kg per ha). On the basis of nutrient uptake by plant, the maximum N-balance of nitrogen in soil was calculated in treatment T₅ - Devbhog (44.80 kg per ha); while the minimum in Treatment T₂ - Zinco-rice (-16.91 kg per ha). On the basis of soil test value, the minimum loss of N-balance was calculated in treatment T₄ - Dubraj (-4.3 kg per ha); while maximum in T₂ - Zinco-rice (-7.94 kg per ha).
22. For phosphorus, maximum uptake by crop was recorded in treatment T₃ - Protazin (19.01 kg per ha) and minimum in T₆ - Badshahbhog (13.55 kg per ha). The maximum expected balance was calculated in treatment T₁ - MTU 1010 (66.82 kg per ha) and minimum in T₅ - Devbhog (44.35 kg per ha). The maximum actual balance (post harvest soil test) was calculated in treatment T₃ - Protazin (22.53 kg per ha) and minimum in T₁ - MTU 1010

(21.40 kg per ha). On the basis of nutrient uptake by plant, the maximum loss of P–balance in soil was calculated in treatment T₁ - MTU 1010 (-45.42 kg per ha); while the minimum in T₅ - Devbhog (-22.74 kg per ha). On the basis of soil test value, the maximum loss of P–balance in soil was calculated in treatment T₁ - MTU 1010 (-1.38 kg per ha); while the minimum in T₃ - Protazin (-0.25 kg per ha).

23. Maximum potassium uptake by crop was recorded in T₃ - Protazin (159.29 kg per ha) and minimum in T₁ - MTU 1010 (118.82 kg per ha). The maximum expected balance was calculated in T₁ - MTU 1010 (179.66 kg per ha) and minimum in T₅ - Devbhog (135.19 kg per ha). The maximum actual balance (post harvest soil test) calculated in T₄ - Dubraj (260.45 kg per ha) and minimum in T₃ - Protazin (257.64 kg per ha). On the basis of nutrient uptake by plant, the maximum K–balance in soil was calculated in T₅ - Devbhog (123.26 kg per ha) and minimum in T₁ - MTU 1010 (77.98 kg per ha). On the basis of soil test value, the maximum K–balance in soil was calculated in T₄ - Dubraj (1.97 kg per ha) and minimum in T₁ - MTU 1010 (-0.84 kg per ha).
24. The maximum gross return (Rs 110573.13 ha⁻¹), net return (Rs 86095.55 ha⁻¹) and benefit cost ratio (3.52) was received with variety T₅-Devbhog. The lowest gross return (Rs 417551.01 ha⁻¹), net return (Rs 17273.41 ha⁻¹) and benefit cost ratio (0.71) was obtained with T₆-Badshahbhog.

CONCLUSION

The following conclusions are drawn from the present investigation:

- The soil pH, EC and organic carbon were non-significant in all the treatments. The pH value was found higher in T₁ - MTU 1010 and T₅ - Devbhog. The maximum EC observed in T₂ - Zinco-rice and maximum organic carbon (0.61 %) in T₂ - Zinco-rice and T₆- Badshahbhog.
- The available soil NPK is significantly not affected by all treatments. The highest available Nitrogen (228.95 kg per ha) was recorded in T₄ - Dubraj. The highest available phosphorus was recorded in T₂ - Protazin (22.52 kg per ha). The highest available Potassium (260.45 kg per ha) was recorded in T₄ - Dubraj.

- The available soil micronutrients were not influenced significantly by all treatments. The highest available Zn (1.16 mg kg^{-1}) was recorded in T₆-Badshahbhog. The highest available Cu (0.29 mg kg^{-1}) was recorded in treatment T₃ - Protazin and T₅ - Devbhog. The highest available Fe (1.22 mg kg^{-1}) and Mn (0.65 mg kg^{-1}) was recorded in treatment T₂-Zinco-rice.
- The maximum plant height was recorded with variety T₆ - Badshahbhog (73.25, 123.30 and 165.20 cm) at all the intervals of observation respectively. Maximum number of tillers hill⁻¹ was recorded with variety T₄ - Dubraj (13.3), T₅ - Devbhog (15.0) and T₂ - Zinco-rice (13.0) at 30 DAT, 60 DAT and at harvest respectively.
- Highest test weight (29.15) recorded in T₃ - Protazin.
- Grain and straw yields were significantly affected by different treatments. The maximum grain yield (50.57 Q/ha) was recorded with T₅ - Devbhog. The maximum straw yield (98.98 Q/ha) was obtained from T₃ - Protazin.
- The nitrogen content in grain and straw were found significantly different among all treatments. Higher nitrogen content in grain was obtained in T₃ - Protazin (1.34%). Maximum nitrogen content in straw was recorded in T₁ - MTU 1010 and T₃ - Protazin (0.65 %).
- The phosphorus content in grain and straw were found significantly different among all treatments. Maximum phosphorus content in grain (0.24 %) and straw (0.12 %) was recorded in T₂ - Zinco-rice.
- The potassium content in grain and straw were found significantly different among all treatments. The maximum potassium content in grain (0.25%) and straw (1.56 %) was recorded in T₂ - Zinco-rice.
- Nitrogen uptake by grain and straw was significantly influenced by different treatment. Maximum uptake of nitrogen by grain was obtained in T₅ - Devbhog (59.67 kg per ha). Maximum nitrogen uptake by straw was recorded in T₃ - Protazin (64.34 kg per ha).
- Phosphorus uptake by grain and straw was significantly influenced by different treatment. Maximum phosphorus uptake by grain was recorded in T₅ - Devbhog (9.10 kg per ha). Maximum phosphorus uptake by straw was recorded in T₂ - Zinco-rice (11.36 kg per ha).

- Potassium uptake by grain and straw was significantly influenced by different treatment. Maximum uptake of potassium by grain was obtained with T₅ - Devbhog (10.62 kg per ha). Maximum uptake of potassium by straw was observed with T₃ - Protazin (149.46 kg per ha).
- Highest total uptake of N (121.64 kg per ha), P (19.01 kg per ha) and K (159.29 kg per ha) by crop was recorded with T₃ - Protazin.
- The maximum expected balance of nitrogen in soil was calculated in treatment T₂ - Zinco-rice (242.22 kg per ha). The maximum actual balance (post harvest soil test) of nitrogen in soil was calculated in treatment T₄ - Dubraj (228.95 kg per ha). On the basis of nutrient uptake by plant, the maximum N-balance of nitrogen in soil was calculated in treatment T₅ - Devbhog (44.80 kg per ha). On the basis of soil test value, the minimum loss of N-balance of nitrogen in soil was calculated in treatment T₄ - Dubraj (-4.3 kg per ha).
- The maximum expected balance of phosphorus in soil was calculated in treatment T₁ - MTU 1010 (66.82 kg per ha). The maximum actual balance (post harvest soil test) of phosphorus in soil was calculated in treatment T₃ - Protazin (22.53 kg per ha). On the basis of nutrient uptake by plant, the minimum phosphorus balance loss in soil was calculated in Treatment T₅ - Devbhog (-22.74 kg per ha). On the basis of soil test value, the minimum P-balance loss in soil was calculated in Treatment T₃ - Protazin (-0.25 kg per ha).
- The maximum expected balance of potassium in soil was calculated in treatment T₁ - MTU 1010 (179.66 kg per ha). The maximum actual balance (post harvest soil test) of potassium in soil was obtained in treatment T₄ - Dubraj (260.45 kg per ha). On the basis of nutrient uptake by plant, the maximum K-balance in soil was calculated in treatment T₅ - Devbhog (123.26 kg per ha). On the basis of soil test value, the maximum K-balance in soil was calculated in Treatment T₄ - Dubraj (1.97 kg per ha).
- The Gross return, net return and benefit cost ratio of crop was found significantly different at all treatments. The maximum gross return (Rs

110573.13 ha⁻¹), net return (Rs 86095.55 ha⁻¹) and benefit cost ratio (3.52) was received with T₅ - Devbhog.

Suggestions for future research work

- It is suggested that this experiment should be repeated at least for another two - three years for confirmation and better result.
- Different fertilizer level should be use in experiment for better result.
- Separate experiment should be done for each scented and non scented rice varieties.
- Selection of varieties should be based on similar performance.

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APPENDIX A

Table 1: Weekly Meteorological data during crop growth period (from June to December, 2019)

Week No.	Temperature (°C)		Relative humidity (%)		VP I (mm)	VP II (mm)	WS (kmph)	EP (mm)	SS (hr)	Rainfall (mm)
	Max	Min	Max	Min						
27	30.14	24.77	91.42	82.71	22.28	23.49	10.44	2.59	2.05	70.4
28	32.92	26.01	83.14	61.86	22.2	22.63	9.21	4.88	2.69	14.4
29	35.67	26.23	82.72	52.86	22.97	21.68	4.34	5.49	7.26	26.1
30	32.83	25.91	86.29	72.14	23.57	24.3	4.97	3.5	4.77	6.2
31	28.14	24.39	90.43	85.14	21.27	23.14	11	2.06	1.5	101.2
32	29.8	25.11	89.86	83.29	22.71	21.11	9.94	3.21	3.48	185.6
33	30.94	25.76	88.85	73.29	22.97	23.07	7.47	3.24	6	11
34	31.71	25.03	92	73.85	22.84	24.26	4.89	3.1	2.88	58.8
35	30.57	24.98	92.42	76	22.89	23.94	5.1	4.45	1.05	59
36	30.5	24.16	94.29	84.14	23.5	24.7	5.14	1.73	1.45	237.6
37	29.9	23.67	91	75.86	22.74	23.37	8.17	2.73	5.25	13.4
38	32.86	21.9	91.29	63.29	23.33	22.86	3.51	3.96	8.13	2.4
39	30.61	22.19	88.85	72.86	22.64	22.14	3.94	2.94	5.65	127.4
40	31.64	24.16	90.14	65.86	21.86	21.91	4.27	3.4	6.83	52.5
41	31.46	23.67	91.29	64.29	21.09	21	2.5	3.41	5.56	1.2
42	26.86	21.9	91.43	60.28	20.44	18.46	2.17	3.29	6.44	10
43	28.01	22.19	92.29	74.29	19.47	19.97	4.16	1.53	2.35	68.6
44	31.13	22.64	92.57	53.57	20.08	17.79	1.46	2.81	6.43	0
45	30.25	19.26	90.14	51.43	17.79	15.96	1.42	2.81	6.53	0
46	29.63	15.98	90.43	40	12.1	12.1	1.84	2.71	8.81	0

Source: Department of Agricultural Meteorology, Indira Gandhi Agricultural University, Raipur - 492 012 (Chhattisgarh) India.

APPENDIX B

Table 1: Total uptake of Nitrogen, Phosphorus and Potassium in rice grain and straw

Treatment	Nitrogen (kg ha ⁻¹)			Phosphorus (kg ha ⁻¹)			Potassium (kg ha ⁻¹)		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
T ₁ - MUT1010 (N ₁₀₀ P ₆₀ K ₄₀)	55.72	47.76	103.48	8.74	7.38	16.12	9.68	109.31	118.99
T ₂ -Zinco-Rice (N ₁₀₀ P ₆₀ K ₄₀)	30.36	60.20	90.56	5.86	11.35	17.21	6.19	145.71	151.90
T ₃ -Protazin (N ₁₀₀ P ₆₀ K ₄₀)	51.88	64.12	116.00	7.98	10.58	18.56	9.83	149.64	159.47
T ₄ -Dubraj (N ₆₀ P ₄₀ K ₃₀)	51.40	42.58	93.98	9.15	7.97	17.12	10.45	111.23	121.68
T ₅ - Devbhog (N ₆₀ P ₄₀ K ₃₀)	56.26	51.92	108.18	9.11	9.96	19.07	10.80	142.05	152.85
T ₆ - Badshabhog (N ₆₀ P ₄₀ K ₃₀)	19.19	53.52	72.71	3.18	10.35	13.53	3.61	139.16	142.77
SE (m)±	1.21	2.25	3.46	0.26	0.71	0.97	0.37	5.11	5.48
CD (p=0.05)	3.82	7.10	10.92	0.84	2.25	3.09	1.18	16.11	17.29

Table 2: Nitrogen budgeting for different treatment (in kg ha⁻¹)

Treatment	Initial Soil test value	Add	Nutrient available for crop	Nutrient Removal	Post harvest (Actual)	Post harvest (expected)	N balance Uptake basis	N balance (STV) Basis
	1	2	3=(1+2)	4	5	6=(3-4)	7=(5-6)	8=(5-1)
T ₁ - MUT1010 (N ₁₀₀ P ₆₀ K ₄₀)	213.25	100	313.25	103.48	228.41	209.77	18.64	15.16
T ₂ -Zinco-Rice (N ₁₀₀ P ₆₀ K ₄₀)	213.25	100	313.25	90.56	225.31	222.69	2.62	12.06
T ₃ -Protazin (N ₁₀₀ P ₆₀ K ₄₀)	213.25	100	313.25	116.00	227.25	197.25	30.0	14.00
T ₄ -Dubraj (N ₆₀ P ₄₀ K ₃₀)	213.25	60	273.25	93.98	228.95	179.27	49.68	15.70
T ₅ - Devbhog (N ₆₀ P ₄₀ K ₃₀)	213.25	60	273.25	108.18	226.16	165.07	61.09	12.91
T ₆ - Badshabhog (N ₆₀ P ₄₀ K ₃₀)	213.25	60	273.25	72.71	225.67	200.54	25.13	12.42

Table 4.3: Phosphorus budgeting for different treatment (in kg ha⁻¹)

Treatment	Initial Soil test value	Add	Nutrient available for crop	Nutrient Removal	Post harvest (Actual)	Post harvest (expected)	P balance Uptake basis	P balance (STV) Basis
	1	2	3=(1+2)	4	5	6=(3-4)	7=(5-6)	8=(5-1)
T ₁ - MUT1010 (N ₁₀₀ P ₆₀ K ₄₀)	27.78	60	87.78	16.12	21.15	71.66	-50.51	-6.63
T ₂ -Zinco-Rice (N ₁₀₀ P ₆₀ K ₄₀)	27.78	60	87.78	17.21	22.18	70.57	-48.39	-5.60
T ₃ -Protazin (N ₁₀₀ P ₆₀ K ₄₀)	27.78	60	87.78	18.56	22.53	69.22	-46.69	-5.25
T ₄ -Dubraj (N ₆₀ P ₄₀ K ₃₀)	27.78	40	67.78	17.12	21.88	50.66	-28.78	-5.90
T ₅ - Devbhog (N ₆₀ P ₄₀ K ₃₀)	27.78	40	67.78	19.07	21.86	48.71	-26.85	-5.92
T ₆ - Badshabhog (N ₆₀ P ₄₀ K ₃₀)	27.78	40	67.78	13.53	22.57	54.25	-31.68	-5.21

Table 4: Potassium budgeting for different treatment (in kg ha⁻¹)

Treatment	Initial Soil test value	Add	Nutrient available for crop	Nutrient Removal	Post harvest (Actual)	Post harvest (expected)	K balance Uptake basis	K balance (STV) Basis
	1	2	3	4	5	6=(3-4)	7=(5-6)	8=(5-1)
T ₁ - MUT1010 (N ₁₀₀ P ₆₀ K ₄₀)	256.48	40	296.48	118.99	254.30	177.49	76.81	-2.18
T ₂ -Zinco-Rice (N ₁₀₀ P ₆₀ K ₄₀)	256.48	40	296.48	151.90	255.48	144.58	110.9	-1.00
T ₃ -Protazin (N ₁₀₀ P ₆₀ K ₄₀)	256.48	40	296.48	159.47	249.79	137.01	112.78	-6.69
T ₄ -Dubraj (N ₆₀ P ₄₀ K ₃₀)	256.48	30	286.48	121.68	256.18	164.80	91.38	-0.3
T ₅ - Devbhog (N ₆₀ P ₄₀ K ₃₀)	256.48	30	286.48	152.85	250.44	133.63	116.81	-6.04
T ₆ - Badshabhog (N ₆₀ P ₄₀ K ₃₀)	256.48	30	286.48	142.77	252.18	143.71	108.47	-4.3

APPENDIX C

Cost of cultivation (Rs ha⁻¹) of scented and non scented rice varieties

Table 1: Cost of Cultivation of MTU 1010 during Kharif season 2019-20

S. No.	Particulars	Input	Rate(Rs.)	Total cost (Rs.)
A.	Fixed cost			
1	Nursery preparation			
a.	Ploughing harrowing and leveling	1 Tractor (1.5hr)	400	600
2	Land preparation			
a.	Ploughing	1 Tractor (3hr)	400	1200
		1 Tractor (1.5hr)	400	600
b.	Harrowing and leveling			
c.	Puddling	1 Tractor (2 hr)	400	800
3	Seed sowing			
a.	Seed kg/ha	35 kg/ha	18 kg ⁻¹	630
b.	seed bed preparation	2 labour	180	360
c.	Nursury uprooting	10 labour	180	1800
d.	Transplanting	12 labour	180	2160
4	Irrigation	10 labour	180	1800
5	Labours			
a.	Hand weeding	16	180	2880
b.	fertilizer application	4	180	720
6	Harvesting (Threshing, Winnowing and Cleaning)	20	180	3600
B.	Variable cost			
1	Fertilizers 100:60:40 kg NPK/ha			
a.	Urea	217.4 kg ha ⁻¹	6 kg ⁻¹	1304.4
b.	SSP	375 kg ha ⁻¹	12 kg ⁻¹	4500
c.	MOP	66.7 kg ha ⁻¹	18 kg ⁻¹	1200.6
	Total			24154.9
	Misllanious at 10%			2415.5
	Total cost			26570.5

Table 2: Cost of Cultivation of Zinco-rice and Protazin during Kharif season 2019-20

S. No.	Particulars	Input	Rate (Rs.)	Total cost (Rs.)
A.	Fixed cost			
1	Nursery preparation			
a.	Ploughing harrowing and leveling	1 Tractor (1.5hr)	400	600
2	Land preparation			
a.	Ploughing	1 Tractor (3hr)	400	1200
b.	Harrowing and leveling	1 Tractor (1.5hr)	400	600
c.	Puddling	1 Tractor (2 hr)	400	800
3	Seed sowing			
a.	Seed kg/ha	35 kg/ha	25 kg ⁻¹	875
b.	seed bed preparation	2 labour	180	360
c.	Nursery uprooting	10 labour	180	1800
d.	Transplanting	12 labour	180	2160
4	Irrigation	10 labour	180	1800
5	Labours			
a.	Hand weeding	16	180	2880
b.	fertilizer application	4	180	720
6	Harvesting (Threshing, Winnowing and Cleaning)	20	180	3600
B.	Variable cost			
1	Fertilizers 100:60:40 kg NPK/ha			
a.	Urea	217.4 kg ha ⁻¹	6 kg ⁻¹	1304.4
b.	SSP	375 kg ha ⁻¹	12 kg ⁻¹	4500
c.	MOP	66.7 kg ha ⁻¹	18 kg ⁻¹	1200.6
	Total cost			24400
	Misllanious at 10%			2440
	Total cost			26840

Table 3: Cost of Cultivation of scented rice varieties (Dubraj, Devbhog and Badshahbhog) during Kharif season 2019-20

S. No.	Particulars	Input	Rate (Rs.)	Total cost (Rs.)
A.	Fixed cost			
1	Nursery preparation			
a.	Ploughing harrowing and leveling	1 Tractor (1.5hr)	400	600
2	Land preparation			
a.	Ploughing	1 Tractor (3hr)	400	1200
b.	Harrowing and leveling	1 Tractor (1.5hr)	400	600
c.	Puddling	1 Tractor (2 hr)	400	800
3	Seed sowing			
a.	Seed kg/ha	35 kg/ha	30 kg ⁻¹	1050
b.	seed bed preparation	2 labour	180	360
c.	Nursery uprooting	10 labour	180	1800
d.	Transplanting	12 labour	180	2160
4	Irrigation	10 labour	180	1800
5	Labours			
a.	Hand weeding	16	180	2880
b.	fertilizer application	4	180	720
6	Harvesting (Threshing, Winnowing and Cleaning)	20	180	3600
B.	Variable cost			
1	Fertilizers 60:40:30 kg NPK/ha			
a.	Urea	130.4 kg ha ⁻¹	6 kg ⁻¹	782.4
b.	SSP	250 kg ha ⁻¹	12 kg ⁻¹	3000
c.	MOP	50 kg ha ⁻¹	18 kg ⁻¹	900
	Total			22252.4
	Misllanious at 10%			2225.2
	Total cost			24477.64

VITA

Name : Arun Kumar Tirkey

Date of birth : 09 January 1996

Present Address : Room no. 112, Sundram boys hostel
College of Agriculture Raipur,(C.G.)
IGKV Raipur,
Pin code-492012

Phone no. : 9131960413

E-mail : aruntirkey24@gmail.com

Permanent Address : Village: Saraitola (Chatidhab)
Post: Sekharpur, District: Jashpur (C.G.) Pin
code: 496220

Academic Qualification:

Degree	Year	University/institution
High School	2011	CBSE
Higher Secondary	2013	CBSE
B. Sc. (Ag.)	2018	IGKV, Raipur(C.G.)
M. Sc. (Ag.)	2020	IGKV, Raipur(C.G.)

Professional Experience (if any): RAWE (Rural Agricultural Work Experience)

Membership of Professional Societies (If any): Nil

Awards / Recognitions (If any): Nil

Publications (If any) : Nil


Signature

Date: 05/03/2021