INTEGRATED NUTRIENT MANAGEMENT IN RICE IN *INCEPTISOLS* OF JANJGIR-CHAMPA DISTRICT OF CHHATTISGARH

M.Sc. (Ag) Thesis

by

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Thesis

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by

Yugal Kishor Sahu

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CERTIFICATE - I

This is to certify that the thesis entitled **"Integrated nutrient management in rice in *Inceptisols* of Janjgir-Champa district of Chhattisgarh"** submitted in partial fulfillment of the requirements for 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 **Yugal Kishor Sahu** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the ~~Director of~~ the Instructions.

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

Chairman

Date: 21-07-2015

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Member	(Dr. R. R. Saxena)	_______ 21/7/15

CERTIFICATE – II

This is certify that the thesis entitled **"Integrated nutrient management in rice in *Inceptisols* of Janjgir-Champa district of Chhattisgarh"** submitted by **Yugal Kishor Sahu** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur, in partial fulfillment of the requirements for the degree of **Master of Science in Agriculture** in the **Department of Soil Science and Agricultural Chemistry** has been approved by external examiner and Student's Advisory Committee after oral examination.

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LIST OF ABBREVIATIONS

%	Per cent
@	At the rate
˚C	Degree Celsius
CD	Critical Difference
cm	Centimetre
DHA	Dehydrogenase Activity
dS m^{-1}	Deci Simens per metre
EC	Electrical Conductivity
et al.	And co- worker/ and other
Fig.	Figure
FYM	Farmyard Manure
GM	Green Manure
GRD	General Recommended Dose of fertilizer
ha^{-1}	Per hectare
i.e.	That is
INM	Integrated Nutrient Management
kg	Kilogram
m^3	Cube metre
mg	Milligram
Mg	Mega gram
ml	Millilitre
No.	Number
NPK	Nitrogen, Phosphorus, Potassium
NS	Non- Significant
pH	Potentiality of hydrogen
q	Quintal
SEm±	Standard Error of means
SMBC	Soil Microbial Biomass Carbon
STCR	Soil Test based Crop Response
t	Tonne
TBC	Total Bacterial Count
TPF	Triphenyl Formazan
TTC	Triphenyl Tetrazolium Chloride
v*iz.*	For example
YT	Yield Target

THESIS ABSTRACT

a)	Title of the Thesis:	Integrated nutrient management in rice in *Inceptisols* of Janjgir-Champa district of Chhattisgarh
b)	Full Name of the Student:	Yugal Kishor Sahu
c)	Major Subject:	Soil Science and Agricultural Chemistry
d)	Name and Address of the: Major Advisor	Dr. A.K. Chaubey (Assist. Professor), College of Agriculture and Research Station, Janjgir-Champa, Chhattisgarh
e)	Degree to be Awarded:	Master of Science in Agriculture

Signature of the Student

Signature of Major Advisor

Date: 21-07-2015

Signature of Head of the Department

ABSTRACT

Field experiment was conducted at College of Agriculture and Research Station, Janjgir-Champa, IGKV, Raipur (C.G.) during *kharif* season of 2014 with the objective of assessing integrated nutrient management in rice in *Inceptisols* of Janjgir-Champa district of Chhattisgarh. The experiment was conducted in randomized block design with three replications comprising ten treatments *viz.* control (T_1), FYM 5 t ha^{-1}(T_2), BGA 10 kg ha^{-1}(T_3), 100% GRD (100:60:40) (T_4), 100% GRD + 5 t FYM ha^{-1} (T_5), 75% GRD + 5 t FYM ha^{-1}(T_6), 100% GRD + 10 kg BGA ha^{-1}(T_7), 75% GRD + 10 kg BGA ha^{-1}(T_8), FYM 5 t ha^{-1} + 10 kg BGA ha^{-1}(T_9) and STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}).

Different INM treatments could not produce any significant difference in pH, EC and Organic carbon after rice harvest. Maximum and significantly higher values of available N, P and K was observed in the treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) over control (T_1). Treatment 100% GRD+5 t FYM ha^{-1} (T_5) recorded maximum

and significantly higher values of dehydrogenase activity and soil microbial biomass carbon over control (T_1) at tillering and harvesting stage of rice. Whereas non-significant increase in total bacterial count was recorded over control (T_1). The N, P and K content in plant and grain and straw at harvest was found non-significant. Uptake of N, P and K by grain and straw was found significantly higher over control due to STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) and 100% GRD + 5 t FYM ha^{-1} (T_5), respectively. N and P uptake by total biomass was found significantly higher over control due to STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}), while K uptake by total biomass was found significantly higher over control due to 100% GRD + 5 t FYM ha^{-1} (T_5). A critical observation of the data reveals that the performance of treatments STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) and 100% GRD + 5 t FYM ha^{-1} (T_5), in general was better over other treatments in increasing the uptake of N, P and K in rice. Treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) was found to be significantly superior not only over control (T_1) but also rest of the treatments in increasing the plant height, dry matter, total and effective tillers of rice except 100% GRD + 5 t FYM ha^{-1} (T_5) which was statistically similar to T_{10} in case of dry matter, total and effective tillers of rice. Treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) registered significantly higher values of panicle length and total filled grains $panicle^{-1}$ over control. In case of test weight of rice, non-significant result was observed. As regards to grain and straw yield of rice, significantly higher value was noted in treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) as compared to rest of the treatments, however it was statistically similar to treatments 100% GRD (100:60:40) (T_4), 100% GRD+ 5 t FYM ha^{-1} (T_5) and 100% GRD+ 10 kg BGA ha^{-1} (T_7).

सारांश

क्षेत्र प्रयोग कृषि महाविद्यालय एवं अनुसंधान केन्द्र जांजगीर–चांपा इंदिरा गांधी कृषि विश्वविद्यालय रायपुर (छ.ग.) में खरीफ सत्र 2014 के दौरान छत्तीसगढ़ के जांजगीर–चांपा जिले के मटासी मृदा में धान में एकीकृत पोषक तत्व प्रबंधन का आंकलन करने के उद्धेश्य से आयोजित किया गया। क्षेत्र प्रयोग यादृच्छिकीकृत ब्लाक अभिकल्पना में तीन अनुकरण और दस उपचार के साथ आयोजित किया गया। उपचार (टी) जैसे नियंत्रण (टी$_1$), गोबर की खाद 5 टन प्रति हेक्टेयर (टी$_2$), नील हरित शैवाल 10 कि.ग्रा. प्रति हेक्टेयर (टी$_3$), उर्वरक की 100 प्रतिशत सामान्य अनुशंसित मात्रा (टी$_4$), उर्वरक की 100 प्रतिशत सामान्य अनुशंसित मात्रा + गोबर की खाद 5 टन प्रति हेक्टेयर (टी$_5$), उर्वरक की 75 प्रतिशत सामान्य अनुशंसित मात्रा + गोबर की खाद 5 टन प्रति हेक्टेयर (टी$_6$), उर्वरक की 100 प्रतिशत सामान्य अनुशंसित मात्रा + नील हरित शैवाल 10 कि.ग्रा. प्रति हेक्टेयर (टी$_7$), उर्वरक की 75 प्रतिशत सामान्य अनुशंसित मात्रा + नील हरित शैवाल 10 कि.ग्रा. प्रति हेक्टेयर (टी$_8$), गोबर की खाद 5 टन प्रति हेक्टेयर + नील हरित शैवाल 10 किग्रा. प्रति हेक्टेयर (टी$_9$) और 50 क्विंटल प्रति हेक्टेयर लक्षित उपज हेतु मृदा परिक्षण आधारित फसल प्रतिक्रिया (एस.टी.सी.आर.) उर्वरक की मात्रा + गोबर की खाद 5 टन प्रति हेक्टेयर (टी$_{10}$)।

विभिन्न एकीकृत पोषक तत्व प्रबंधन उपचार धान की कटाई के बाद पी.एच., विद्युत चालाकता और कार्बनिक कार्बन में सार्थकता उत्पन्न नहीं कर सके। अधिकतम और उच्च सार्थक उपलब्ध नत्रजन, सफूर और पोटाश उपचार टी$_{10}$ पर, जो नियंत्रण के ऊपर सार्थक पाया गया। उपचार टी$_5$ पर मृदा सूक्ष्मजीवी जैवभार कार्बन और डीहाइड्रोजीनेज सक्रियता धान के दोनो अवस्थायों कंसे निकलने तथा कटाई की अवस्था पर नियंत्रण के ऊपर अधिकतम सार्थक पाया गया। यहां पर कुल बैक्टिरिया नियंत्रण के ऊपर सार्थक नही पाया गया। नत्रजन, स्फूर एवं पोटाश की सांद्रता पौधों में एवं कटाई के बाद अनाज और पुआल में सार्थकता नहीं पाया गया। उपचार टी$_{10}$ एवं टी$_5$ में क्रमशः अनाज और पुआल द्वारा नत्रजन, स्फूर एवं पोटाश उद्ग्रहण करना नियंत्रण के ऊपर उच्च सार्थक पाया गया। उपचार टी$_{10}$ में कुल बायोमास द्वारा नत्रजन एवं पोटाश उद्ग्रहण करना, नत्रजन के ऊपर अधिक सार्थक पाया गया, जबकि टी$_5$ में कुल बायोमास द्वारा स्फूर उद्ग्रहण करना नियंत्रण के ऊपर अधिक सार्थक पाया गया। ऑकड़ों के गहन अवलोकन करने पर व्यक्त होता है कि उपचार टी$_{10}$ एवं टी$_5$ प्रर्दशन सामान्य रूप से अन्य उपचार के ऊपर नत्रजन, स्फूर एवं पोटाश उद्ग्रहण करना बेहतर पाया गया। पौधों की ऊंचाई, शुष्क भार और प्रभावी कंसे के संबंध में टी$_{10}$ सिर्फ नियंत्रण के ऊपर ही नही बल्कि शेष उपचार पर भी उच्च सार्थक पाया गया टी$_5$ को छोड़कर जो कि शुष्क भार और कुल एवं प्रभावी कंसे के विषय में टी$_{10}$ से सांख्यिकीय रूप से सामान पाया गया था। बाली की लंम्बाई एवं कुल भरे अनाज की मात्रा टी$_{10}$ पर नियंत्रण के ऊपर उच्च सार्थक पाया गया। धान की परीक्षित भार पर सार्थकता परिणाम नही पाया गया। धान के अनाज और पुआल के उपज के संबंघ में उपचार टी$_{10}$ बाकी बचे उपचार की तुलना में उच्च सार्थक पाया गया लेकिन यह टी$_4$, टी$_5$ और टी$_7$ से सांख्यिकीय रूप से सामान था।

CHAPTER – I
INTRODUCTION

Rice (*Oryza sativa* L.) is the most important and extensively cultivated food crop that has been referred as “Global Grain” because of its use as prime staple food in about 100 countries of the world. . Its cultivation is of immense importance to food security of Asia, where more than 90 % of the global rice is produced and consumed. Rice provides 32-59% of the dietary energy and 25-44% of the dietary protein in 39 countries. In india, it accounts for more than 40% of food grain production, providing direct employment to 70% people in rural areas (Anon., 2012).

Rice production in India has shown a steady upward trend during the period 2005–06 to 2008–09 reaching a record level of 99.18 million tons in 2008–09. Production declined to 89.09 million tons in 2009–10 due to a severe drought gripping most parts of the country but rebounded to 96 million tons in 2010–11 and further to a record 103.4 million tons in 2011–12 (Meshram, 2012). Rice, being the main source of livelihood for more than 120–130 million rural household. It is the backbone of the Indian Agriculture. The rice plays a very vital role in the national food security. Even then rice self-sufficiency in India is precarious.

In world, rice has occupied an area of 156.7 mha, with a total production of 650.2 mt. India is the second largest producer of rice after china has an area of over 45.5 million hectares and production 105.31 million tonnes with productivity 2393 kg ha^{-1} (Anon., 2013 a). Chhattisgarh popularly known as “Rice Bowl of India” occupies an area around 3.61 million hectares with the production of 5.48 million tonnes and productivity 1517 kg ha^{-1} (Anon., 2013 b).

Rice plays a vital role in our food as well as nutritional security for millions of livelihood. Thus the slogan “Rice is life” by IRRI during 2004 seems to be most appropriate (Chandrasekaran *et al*., 2007). Rice ranks second to wheat in terms of area harvested but in terms of importance as a food crop, rice provides more calories ha-1 than any cereal crop. Besides its importance as food, rice provides employment to the largest sector of the rural population in most of the Asia. With the burgeoning increase of population, demand for food is on high. It has been estimated that rice demand in 2025 will be 765 mt in the world (Thorie *et al*., 2013).

Nutrients are one of the most important inputs, required by the plants for their growth and yield. The N, P and K are major nutrients and are supplied through fertilizers and manures. At present, increasing cost of fertilizers, growing ecological concern and conservation of energy have created considerable interest for the use of organics as a source of plant nutrients with blending of chemical fertilizer to reduce losses of nutrients as integrated nutrient management system.

Integrated nutrient management system can play a vital role in balancing the soil fertility and plant nutrient supply to an optimum level through the judicious and efficient use of chemical fertilizers, green manure, FYM and biofertilizers leading to an ecofriendly approach and economically viable solution for this problem. The use of green manure, FYM or biofertilizer not only helps in supplementing requirement but also improves soil physical, chemical land biological properties (Yadav *et al*., 2009).

Application of chemical fertilisers makes the soil fertile and increases productivity of crops, while introducing adverse effects on soil and environment. Therefore, it is needed that fertility and productivity of the soil be restored, using organic fertilisers in combination (Khan *et al*., 2009). There is a need to organise the supply of nutrients to the crop through organic and renewable sources and strengthen the initiative of integrated nutrient management (INM). Use of organic manures, apart from improving physical and biological properties of soil, helps in improving the use of efficiency of chemical fertilizers (Alam *et al*., 2003, 2005). Under such circumstances, an integrated approach is suggested through complementary use of inorganic and organic fertilisers to boost/sustain soil fertility and crop productivity. This includes the use of mineral fertiliser combined to organic manures for environmentally safe, economically viable, socially feasible and ecologically sustainable production system (Baloch *et al*., 2014).

Farm yard manure and poultry manure are considered as the promising, renewable, easily available in large quantity, economical and nutrient rich source containing nearly all the essential nutrients and can be served as a substitute to cut down the cost of fertilizer input and to increase the productivity of rice in addition to maintain soil productivity, improve the eco-system and ultimately resulting in improved soil-plant-health in a sustainable agricultural eco-system.

Keeping in view the above facts, the present investigation entitled **"Integrated nutrient management in rice in *Inceptisols* of Janjgir-Champa district of Chhattisgarh"** was carried out during *kharif* season of 2014 at college of Agriculture and Research station Janjgir-Chmpa (CG) with following objectives:

1. To assess the effect of integrated nutrient management on growth and yield of rice.
2. To evaluate the effect of different treatments on nutrient content in plant and their uptake by rice at different growth stages.
3. To find out the microbial status of the soil.

CHAPTER- II
REVIEW OF LITERATURE

In this chapter, a review of literature pertaining to study on **"Integrated nutrient management in rice in *Inceptisols* of Janjgir-Champa district of Chhattisgarh"** carried out by various researchers in India and abroad has been briefly mentioned. The literature on the aspects is reviewed under following head:

2.1 Effect of INM on growth and yield attributes of rice

2.2 Effect of INM on nutrient content and their uptake by plant

2.3 Effect of INM on physico-chemical properties of soil

2.4 Effect of INM on microbial activities of soil

2.1 Effect of INM on growth and yield attributes of rice

Singh *et al.* (2005) studied the effect of integrated management of fertilizer N, vermicompost and *Azolla* on grain yield and nutrient uptake. The highest grain and straw yields were recorded with the application of 60 kg N ha^{-1} plus *Azolla*. The combined application of fertilizer N, vermicompost and *Azolla* sustained the productivity even at lower rate of fertilizer N application.

Laxminarayana and Patiram (2006) studied the effect of integrated use of inorganic fertilizers coupled with organic manures, green manure and phosphate solubilizing bacteria on yield and nutrient uptake of rice. The results revealed that application of optimum doses of NPK in combination with green manure @ 5 Mg ha^{-1} recorded highest grain and straw yields and uptake of N, P and K followed by 100% NPK + poultry manure and 100% NPK + FYM.

Khan *et al.* (2007) reported that combined application of NPK and organic manures (GM or FYM) and Zn significantly increased the paddy and straw yields of rice crop. Integrated fertilization had pronounced residual effects on grain and straw yields of wheat. The results showed that organic manures especially NPK +.FYM had direct and residual effects on both rice and wheat yields.

Patnayak *et al.* (2007) revealed that 40 kg inorganic N (50 % N dose) integrated with biofertilizers (*Azotobacter, Azospirillum* and *Azolla*) and 17.5 kg of P and 32 kg of K ha^{-1} resulted in the highest grain (3.57 t ha^{-1}) and straw yield (4.32 t ha^{-1}) of rice.

Sharma *et al.* (2008) studied the effect of organics and fertilizers on scented rice (*Oryza sativa* L.), in rice-wheat sequence. Among organics, vermicompost being at par with celrich produced significantly higher values of growth, yield, grain quality and nutrient uptake than FYM and control. FYM was found significantly superior to control in all respect.

Singh *et al.* (2008) studied the treatments consisted of FYM, vermicompost, green manure, *Azotobacter*, phosphate solubilizing bacteria (PSB), blue-green algae (BGA), rice residue incorporation and NPK fertilizers. Significantly higher yields to the tune of 4.3 t ha^{-1} for rice and 4.0 t ha^{-1} for wheat were recorded when rice-wheat were grown after green manuring of *dhaincha* in-situ or application of FYM (10 t ha^{-1} $year^{-1}$) or vermicompost (5 t ha^{-1} $year^{-1}$) in *kharif* season.

Dass *et al.* (2009) reported that combined use of 50% recommended dose of fertilizers, Gliricidia at the rate 2.5 t ha^{-1} and biofertilizers recorded the highest grain yield (2.01 t ha^{-1}) and proved to be the best integrated nutrient management option.

Kumar and Singh (2010) observed the direct and residual effect of green manures on crops with and without farmyard manure (FYM). The highest grain and straw yields of rice and wheat were obtained with the application of 100 % NPK + green gram + 5 t FYM. Combined application of 100 % NPK + green gram + 5.0 t FYM each year gave significantly higher available N, P, K in post-harvest soil.

Virdia and Mehta (2010) studied the effect of integrated nutrient management in transplanted rice with treatments comprising various quantity of press mud, FYM and RDF. They found that rice grain and straw yield was significantly higher with integrated nutrient management (pressmud @ 20 t ha^{-1} + RDF), which remained at par with pressmud @ 15 t ha^{-1}+RDF or FYM @ 10 t ha^{-1} + RDF.

Mehdi *et al.* (2011) found that different combinations of organic manures with chemical fertilizers increased paddy and straw yield significantly over application of organic manures alone. Among different combinations, Sesbania at 20 ton ha^{-1} + 75% recommended dose proved to be the best combination followed by Sesbania 20 t ha^{-1} + 50% R.D.

Singh *et al*. (2011) investigated the effect of N, P and K fertilizers with or without FYM, lime, sulphur and boron on yield. The highest grain yield of rice and pea was recorded in the treatment receiving 50% of recommended dose NPK fertilizers along with application of 5 t FYM+ 250 kg lime + 20 kg S + 1 kg B ha^{-1}.

Balasubramanian and Wahab (2012) observed that growth and yield attributes of rice crop viz. LAI at flowering, productive tillers $hill^{-1}$, DMP at harvest, filled grains $panicle^{-1}$, 1000 grain weight, grain and straw yield were favourably influenced by combined application of inorganic fertilizers and organic manures.

Kumar *et al.* (2012) reported that application of N, P and organic sources significantly increased the number of tillers, plant height and yield of rice over control. The maximum yield of rice was obtained in 100 % NP+GM (6.42 t ha^{-1}) than 100 % NP (5.31 t ha^{-1}) and 100 % NP + wheat residue (6.02 t ha^{-1}) treatment.

Singh *et al.* (2012) reported that application of 100 % RDF through inorganic fertilizers being on par with 50% RDF as inorganic fertilizers + 50 % RDN as farm yard manure but produced significantly higher mean grain and straw yield (1.46 t ha^{-1} and 2.23 t ha^{-1}, respectively) over rest of the fertility treatments.

Chesti *et al*. (2013) studied the effect of integrated nutrient management on yield and nutrient uptake by wheat and soil properties. Significantly higher grain yield (4.92 t ha^{-1}) were observed and total NPK uptake by wheat (116, 20.4 and 125 kg ha^{-1}, respectively) with the application of 100 % NPK + 10 t FYM ha^{-1} as compared to the grain yield of 4.41 t ha^{-1} and total NPK uptake (95.7, 18.1 and 111 kg ha^{-1}, respectively) with the 100 % NPK alone.

Ranjitha *et al.* (2013) reported that application of 50 percent recommended dose of nitrogen (through urea) and remaining 50 percent RDN through vermicompost resulted in significantly higher grain (5520.8 kg ha^{-1}) and straw yield (6264.9 kg ha^{-1}) in addition to nutrient uptake (157.9,30.7 and 166 N, P and K kg ha^{-1}, respectively) followed by 100 % RDN (through urea) application.

Singh *et al.* (2013) reported that addition of organic amendment like FYM, BGA and Azolla in integrated manner with chemical fertilizers produced higher quantity of grains and the seed quality was also more superior to those obtained in sole chemical fertilizer application and control treatments.

Dutta and Sangtam (2014) evaluated the effect of INM on performance of upland rice involving N, P and K (NPK) fertilizers, farmyard manure (FYM), poultry litter, forest litter, *Azospirillum* and Zn either alone or in combinations applied continuously for ten years. The findings revealed that plant height, numbers of tillers and productive tillers increased significantly in all the treatments whereas, grain yield increased significantly in all the treatments.

Sharma and Subehia (2014) revealed that continuous substitution of 50 % N through green manure in rice produced maximum rice grain (7.37 t ha^{-1}) and straw (6.21 t ha^{-1}) yield which was 16.8 and 14.8 % higher over 100 % NPK added through chemical fertilizers.

2.2 Effect of INM on nutrient content and their uptake by plant.

Bandyopadhyay and Sarkar (2005) reported that integrated use of urea and FYM could save 50% of urea N in terms of rice grain yield and resulted in the highest physiological nitrogen use efficiency and highest fertilizer N recovery by rice plant and maximum retention of fertilizer N in soil.

Kumar *et al*. (2006) reported that maximum mean nitrogen uptake (94.9 kg ha^{-1}) was recorded under combined use of farm yard manure and poultry manures. Incorporation of organic manures caused improvement in organic carbon and available nitrogen content of soil after crop harvest as compared to control.

Singh *et al.* (2006) reported that total N, P and K uptake and yield of rice were higher in the treatments having FYM, green manure, biofertilizer and crop residue combined with inorganic fertilizers.

Singh *et al.* (2006) reported that application of soil test based N, P, K and S (80, 26, 25 and 20 kg ha^{-1}), FYM (5 t ha^{-1}) and green manuring to upland rice produced significantly higher mean grain yield of 3.36 t ha^{-1}. The highest N, P and

K uptake was also associated with the conjunctive use of soil test based application of N, P, K and S, FYM and green manuring treatment.

Reddy *et al.* (2009) observed that application of 250 kg N ha^{-1} recorded higher N uptake (150 and 151 kg ha^{-1} during *kharif* and summer 2001, respectively) than recommended 150 kg N ha^{-1} (122.8 and 112.8 kg N uptake ha^{-1}, respectively during *kharif* and summer). Application of 200:44:62 and 250:44:62 kg N, P and K ha^{-1} in *kharif* and summer resulted in higher grain yields than recommended practice mainly by improving N uptake.

Urkurkar *et al.* (2010) reported that application of green manure along with 50 % of recommended dose of fertilizer is the most favourable treatment to have highest available N (255 kg ha^{-1}) in surface soil. The results show that available P content of soil increased significantly with farmyard manure, composted rice straw and green manure in conjunction with 50 % recommended dose of fertilizer over initial value and control.

Sathish *et al*. (2011) studied the effect of combination of organic and inorganic fertilizers on yield, fertility status and uptake pattern of nutrients in rice maize cropping system. Higher rice grain yields were observed in *kharif* season in T_9 receiving 25 % N through paddy straw and %NPK through inorganic fertilizers with least in control.

Singh *et al.* (2011) studied the effect of N, P and K fertilizers with or without FYM, lime, sulphur and boron on nutrient uptake. Integrated use of FYM, lime, sulphur and boron with 50 % RDF increased considerably total N, P, K and S uptake by rice-pea cropping system over the existing farmer’s practice.

Weijabhandara *et al.* (2011) reported that application of 75 % RDF + biofertilizers resulted in significantly higher grain yield, uptake of N, P, K and Zn by grains and residual available N, P, Zn compared to other treatments.

Acharya *et al*. (2012) revealed that nutrient uptake of rice was highest due to integrated nutrient application than that of inorganic nutrients alone, whereas lowest value was observed with control plot where no nutrient was applied.

Shilpashree *et al.* (2012) studied with two levels of nitrogen applied through organics (FYM and vermicompost) and in-organics involving nine treatments combinations tried in a RCBD with three replications. Significantly lower available nitrogen status was recorded in the treatments which received nitrogen only through fertilizers and without any organic matter application (196.00-200.50 kg ha^{-1}) including absolute control compared to all other treatments (238.00-243.60 kg ha^{-1}).

Mohanty *et al.* (2013) studied the application of 50 % RDN as chemical fertilizer + 50 % RDN either as *dhaincha* or *Azolla.* N and P uptake by rice was highest with the use of 1/3rd N each as chemical fertilizer, FYM and *Azolla*, but higher K uptake was reported with application of 50 % N as chemical fertilizer and 50% N as *dhaincha*.

Ranjitha *et al.* (2013) studied the different nutrient management options and noted that application of 50 % recommended dose of nitrogen (through urea) and remaining 50 % RDN through vermicompost resulted in significantly higher grain (5520.8 kg ha^{-1}) and straw yield (6264.9 kg ha^{-1}) in addition to nutrient uptake (157.9, 30.7 and 166 N, P and K kg ha^{-1}, respectively) followed by 100 % RDN (through urea) application.

Ranjitha and Reddy (2013) reported that higher nitrogen uptake by grain and straw (56.0 and 26.7 kg ha^{-1} respectively) was observed with the application of FYM @ 10 t ha^{-1} + 100 percent RDF but was comparable with the treatment of 100 percent RDF alone. Similarly, highest P and K uptake (16.6 kg ha^{-1} and 10.3 kg ha^{-1} P; 18.9and 127.1 kg ha^{-1} K) by grain and straw was obtained by FYM @ 10 t ha^{-1} +100 percent RDF, followed by 100 percent RDF and lowest was with FYM @ 10 t ha^{-1}.

Shormy *et al.* (2013) studied the organic materials used, farm yard manure was better than other organic sources due to its higher nutrient content except green manure which contained higher amount of N. Nutrient contents (N, P, K, S, Ca and Mg) and their uptake by grain and straw were significantly influenced by the application of different treatments except the S content of grain. The highest values of most of the parameters were obtained from RD-NPKS + PSB treatment which was statistically identical with GM + FYM + PSB, GM 10 t ha^{-1} and GM 5 t ha^{-1} + FYM 5 t ha^{-1} treatment combinations in many cases.

Singh *et al*. (2013) reported that significantly higher uptake of N in grains and straws was found due to the integrated nutrient management and recommended doses of fertilizers. The protein content and N uptake in grains were positively influenced due to integrated nutrient management practices.

Zayed *et al.* (2013) reported that combination of farmyard manure, rice straw compost and Azospirillum brasilense culture significantly increased rice grain yield and yield components over the control. Application of 7 t ha^{-1} farmyard manure + 110 kg N ha^{-1} was comparable to application of 5 t ha^{-1} rice straw compost + 110 kg N ha^{-1} with regard to the potential to increase soil organic matter content and soil nutrient availability, and both were better in this respect than the sole application of chemical nitrogen fertilizer.

2.3 Effect of INM on physico-chemical properties of soil.

Fan *et al.* (2005) observed that combination of organic and inorganic fertilization enhanced the accumulation of soil organic carbon and maintained the highest productivity.

Bajpai *et al*. (2006) found that incorporation of organic sources considerably decreased the bulk density of the soil. The lowest bulk density was observed in the 50 % NPK through fertilizer + 50 % N through green manure treatment (1.43 Mg m^{-3}), while the highest was noted in control plot (1.56 Mg m^{-3}).

Chaudhary and Thakur (2007) revealed that FYM along with fertilizers had a positive response on penetration resistance and bulk density of soil.

Pothare *et al*. (2007) reported that all the soil properties such as electrical conductivity (EC) were favorably influenced with the conjuctive use of organics and inorganics. Highest values were observed in the treatment of 100% NPK + 10 t FYM ha^{-1}.

Sharma *et al.* (2007) reported non-significant results in soil pH after 31 years of experimentation. The addition of organics in the form of FYM @ 10 t ha^{-1} in the treatment 100% NPK + 10 t FYM ha^{-1} (T_8) and FYM only 10 t ha^{-1} (T_{10}) reduced the pH.

Rather and Sharma (2009) revealed that significant improvement in soil properties and fertility status was found under treatment (T_{20}) comprising of 100% Rec NPK + Vermicompost + Zinc + PSB. Organic carbon content of soil improved from 3.0 to 4.6 g kg^{-1} soil, Bulk density reduced from 1.50 to 1.32 Mg m^{-3}, water holding capacity increased from 20.32 to 23.72 %, available N from 197.0 to 219.0

kg ha^{-1}, available P from 13.0 to 19.1 kg ha^{-1}, available K from 113.0 to 130.4 kg ha^{-1} and available Zn from 1.50 to 1.87 mg kg^{-1} soil by the integration of organics with inorganics.

Singh *et al.* (2011) studied the effect of N, P and K fertilizers with or without FYM, lime, Sulphur and Boron on fertility status of soil. Application of lime @ 250 kg ha^{-1} in furrows along with 5 t FYM ha^{-1} and 50% RDF significantly improved the pH of soil after harvest of pea crop.

Babar and Dongale (2013) reported the different soil fertility parameters *viz*., bulk density, porosity, organic carbon and available nutrients (NPK) content in soil showed significant improvement with the application of organic, inorganic and organic + inorganic sources of nutrients compared to the control treatment. The available nutrients content in soil was also slightly higher under T_7 [50% NPK (IF) + 50% N (M)] treatment compared to only chemical fertilizers (T_3).

Gabhane *et al.* (2013) observed significantly highest yield with build up of soil fertility and maximum economic returns were obtained with the application of 25 kg N and 25 kg P_2O_5 ha^{-1} through Urea and single super phosphate and 25kg N ha^{-1} through FYM over the years. Hence, it is concluded that, Integrated Plant Nutrient Supply (IPNS) system sustains fertility and productivity of soils in dryland agriculture.

Kannan *et al.* (2013) studied that bulk density and pore space was recorded maximum in INM practice including vermicompost and recommended dose of NPK. Particle density was recorded maximum in FYM treatments. Organic carbon was recorded maximum in INM treatment including vermicompost and recommended dose of NPK.

Kharche *et al.* (2013) studied with combination of NPK fertilizers with organics *viz.*, farmyard manure (FYM), wheat straw and green manure, 100% organics . Soil physical properties were improved due to continuous application of chemical fertilizers in conjunction with organics over only chemical fertilizers. The integrated use of organics with chemical fertilizers recorded 31.8% increase in hydraulic conductivity, 5.5% increase in aggregate stability, 23.4% increase in available moisture, 15.1% increase in labile carbon and 6.9% reduction in bulk density over only chemical fertilizers.

Rao *et al*. (2013) reported that pH of soil was not influenced statistically by various treatments. The continuous use of manures and fertilizer slightly lowered the pH. Increased dose of fertilizer decreased the pH.

Yaduvanshi *et al.* (2013) evaluated the effect of inorganic fertilizers alone and in combination with organic manures for soil organic carbon (SOC), bulk density, available soil N, P, K and yields of rice and wheat grown on a reclaimed sodic soil. The SOC increased in plots receiving N120P26K42 plus green manure (GM) and N120,P26,K42 plus farmyard manure (FYM) by 28 and 23% over the initial value but decreased by 31 and 24% in unfertilized and N120,P26,K42 treated plots, respectively.

Yabagi *et al.* (2014) reported that poultry manure used for the experiment was analyzed for its chemical composition. The results of the experiment revealed an increased in soil pH for all treatments except T_6 (4 t ha^{-1} of poultry dropping + 45 kg ha^{-1} of urea) However, organic carbon, total N, available P and cation exchange capacity values also increased.

2.4 Effect of INM on microbial activities of soil

Bhattacharya *et al*. (2001) reported that compost addition increased the microbial biomass carbon and soil respiration.

Bedi *et al*. (2009) reported that the total microbial population was minimum in the absolute control and maximum in the treatment where 50% nitrogen was substituted by wheat straw at both the depth. Total population as well as individual population of different microorganism increased with increased in inorganic fertilizer doses. Highest microbial population was recorded in T_5 (100%NPK) and lower in T_2 treatment (50%) both at surface as well as sub-surface.

Deubel *et al*. (2002) observed that microbial population both in diversity as well as numbers in soil is influenced by the amount and type of various compounds entering soil through plant litter, root exudates and management factors like mineral and organic fertilizers under various climatic conditions. High number of total microorganisms, nitrogen fixers and phosphate solubilizers were observed in the rhizosphere of *Medicago sativa* and Secale cereal compared to bulk soils.

Microbial counts were especially higher in treatments of NPK+FYM (farmyard manure) and NPK in Secale.

Selvi *et al*. (2004) reported that population of bacteria, fungi and actinomycetes was affected significantly with different treatments. The application of 100% N alone and control recorded lower values of microbial population. Higher grain and straw yields recorded by the application of 10 t FYM ha^{-1} along with 100% NPK continuously followed by 150% NPK. There was a gradual increase in biomass C content of the soil for the graded levels of NPK from 50 to 150%. Application of 100% NPK + FYM recorded significantly the highest biomass C followed by 150% NPK application.

Krishnakumar *et al.* (2005) reported that microbial population viz., bacteria, and fungi conspicuously increased with application of different organic N source compared to the control. Among the organic N sources, application of FYM + neem cake registered maximum population of bacteria, and fungi. They also observed higher dehydrogenase activities with the application of FYM + neem cake.

Zhang and Wang (2005) investigated the relationship between the Microbial biomass and chemical properties of the soil, such as available N, P and K contents. Their investigation aimed at analyzing the effects of fertility on soil microbial biomass and soil nutrient supplying capacity and obtained the results that long term balanced fertilizer application of N, P and K promoted microbial biomass in the soil but unbalanced Fertilization reduced microbial N and increased C/N ratio of the microbial biomass.

Diosma *et al*. (2006) observed the effect of soil disturbances, such as N fertilization and tillage management, on soil microbial communities in a Typic Argiudoll. The soil microbial community used to differentiate responses to N fertilization and tillage at each of three growth stages of wheat (*Triticum aestivum* L.). Tillage had an adverse effect on microbial diversity, in which reduced and conventional tillage treated soils had different populations. However, N fertilization also altered microbial diversity depending on the crop developmental stage.

Ghose *et al.* (2006) studied the effect of integrated nutrient management on soil quality parameters. In case of biological parameters, it enhances the microbial biomass carbon from 56.75 to 77.85 mg kg^{-1} and dehydrogenase activity for 27.06 to 195.32 mg TPF g^{-1} soil. These plots also maintained stable soil fertility level with 1.23% organic carbon, 26.7kg P_2O_5 and 85.20 kg K_2O kg ha^{-1}.

Mishra *et al.* (2008) studied the change in chemical and microbial activity of acid soil in maize in *kharif* and wheat in *Rabi* in an *Alfisol*. Continuous organic manure application or in combination with inorganic fertilizer significantly influenced the grains yield, uptake of nutrient available NPK in soil. The 100 % NPK treatment does not show significant changes in microbial population over 100% NP treatment. The microbial population and microbial biomass carbon were found highly significantly correlated with grain yield and nutrient uptake.

Vineela *et al*. (2008) studied the effects of long-term cropping, fertilization, manuring and their integration on microbial community in soil. Fungal population was higher in acidic soils and in treatments under continuous inorganic fertilization treatments, whereas a high number of bacteria were found in integrated use of organic and inorganic fertilizers. At most of the locations, soil organic C and microbial biomass C showed significant positive correlation with microbial populations. Thus, results suggest that even under arid and semi-arid tropical conditions, regular addition of nutrients in an integrated manner could improve soil organic carbon and microbial population counts.

Gogai *et al.* (2010) revealed that the application of different INM treatments showed a significant impact on microbial biomass carbon of soil after the harvest of both the crops. The SMBC in soil varied from 47.3 to 136.2 and 27.0 to 112.5 mg kg^{-1} and it comprised 1.1-2.3% and 0.6-1.8% of total organic carbon content of soil, after the harvest of both *kharif* rice and *Rabi* Niger crops, respectively. The highest microbial biomass carbon content in soil was recorded from the biofertilizer-based INM package, followed by 50% recommended dose of fertilizers plus 50% N supplied through FYM and 50% N (inorganic) + 50% N (FYM) + PK (inorganic and adjusted), after the harvest of both the crops. The treatment with biofertilizer- based INM package showed 65.3 and 76.0% increase of SMBC over control.

Nakhro and Dkhar (2010) reported that organically treated plot recorded the maximum microbial population counts and microbial biomass carbon, followed by the inorganically treated plot and control. Organic plot exhibited a significant variation in bacterial population (both the soil depth) with the inorganically treated plot and control (Turkey's test at $p \leq 0.05$). Organic carbon showed significant positive correlation with the fungal and bacterial populations. They also found the application of organic fertilizers increased the organic carbon content of the soil and thereby increasing the microbial count and microbial biomass carbon.

Bahadur *et al*. (2012) observed the significant increase in bacterial population under the conjoint use of inorganic fertilizer with organic manure and dual inoculation of biofertilizer (PSB + BGA/*Azotobacter*). As such maximum population of 80 × 105 cfu g^{-1} soil was recorded under 100% STR + 5 t NADEP compost ha^{-1} followed by integrated use of chemical fertilizer + FYM + PSB + BGA/*Azotobacter* value (79 × 105 cfu g^{-1}soil).

Dubey *et al.* (2013) studied the effect of nutrient management and cropping system on productivity and soil microbial growth under different rice based cropping systems in Madhya Pradesh. The highest grain yield of 34.78 q ha^{-1} was recorded from rice-wheat-green manuring cropping systems and the best nutrient management for growth of micro organisms is organic nutrient management and rice-wheat green manuring cropping system.

Lakshmi *et al.* (2014) observed that vermicomposts, vegetable market waste and weed composts exhibited highest urease and dehydrogenase activity and the cellulase activity was more in cane trash and rice straw composts. Urease and dehydrogenase activity at flowering stage was increased by 136 and 63.2 %, respectively in the plots treated with 75% chemical fertilizers with vegetable market waste vermicompost @ 2.5 t ha-1 over 100% recommended dose of fertilizer nitrogen (RDFN).

Shingha *et al.* (2014) observed the highest dehydrogenase activity as 2.09, 1.58 and 1.30 μg TPF g^{-1} hr^{-1} and the lowest as 0.92, 0.50 and 0.21 μg TPF g^{-1} hr^{-1} in 0-10, 10-20 and 20-30 cm depth, respectively. The results recognized that NPK application had a major role in dehydrogenase activity. Frequency distribution revealed that even after a short-term use of organic and inorganic amendments, improvement of SOC content was not above 0.50%.

CHAPTER- III
MATERIALS AND METHODS

This chapter deals with the concise description of the materials used and the techniques adopted during the course of investigation. The present investigation entitled **“Integrated nutrient management in rice in *Inceptisols* of Janjgir-Champa district of Chhattisgarh”** was conducted at the College of Agriculture &Research station , Janjgir-Champa, Chhattisgarh during the *kharif* season (August to November), 2014.

3.1 Geographical situation

Geographically, Janjgir-Champa is situated in north Mahanadi and the centre of Chhattisgarh and lies between 21°06' to 22°04' North latitude and 82°03' to 83°02' East longitude with an altitude of 294.4 meters above the mean sea level.

3.2 Experimental site

The experiment was conducted at the College of Agriculture and Research station, Janjgir-Champa, (C.G.). The site selected for experiment was ideal, since it has assured irrigation and drainage facilities. The upper 30 cm soil was removed to develop the field bunds.

3.3 Tested variety

Rice cultivar MTU-1010 was taken as test crop. It is a semi dwarf variety which is a cross of Krishnaveni and IR-64. It is recommended for direct seeding and transplanting in upland and lowland ecosystem of different states (including Chhattisgarh) respectively. The crop matures in about 115-125 days. The variety is medium grain type and having yield potential of 5-6 t ha^{-1} and susceptible to brown spot.

3.4 Physico-chemical and biological properties of experimental soil

Random soil samples were collected up to 15 cm soil depth from five places to determine the physico-chemical and biological properties of the soil. The procedure adopted for analysis and values obtained are given in Table 3.1.

Table 3.1: Physico-chemical and biological properties of the experimental soil (*Inceptisols*)

No.	Particulars		Value
1	Texture (Sandy loam)	Sand (%)	52
		Silt (%)	29.2
		Clay (%)	18.9
2	pH (1:2.5)		6.96
3	EC (dS m^{-1})		0.26
4	Organic carbon (%)		0.27
5	Available nitrogen (kg ha^{-1})		202
6	Available phosphorus (kg ha^{-1})		5.3
7	Available potassium (kg ha^{-1})		267
8	Dehydrogenase activity (µg TPF g^{-1} soil day^{-1})		13.75
9	Total bacterial count (CFU 10^{7} g^{-1} soil)		3.85
10	Soil microbial biomass carbon (µg C g^{-1} dry soil)		68.95

3.5 Treatment and layout plan

In all ten treatments, BGA, FYM and different doses of GRD (100:60:40) with and without FYM & BGA were laid out in randomized block design with three replications.

Table 3.2: Treatment details

Notation	Treatment details
T_1	Control
T_2	FYM 5 t ha^{-1}
T_3	BGA 10 kg ha^{-1}
T_4	100 % GRD (100:60:40)
T_5	100% GRD + 5 t FYM ha^{-1}
T_6	75% GRD + 5 t FYM ha^{-1}
T_7	100% GRD + 10 kg BGA ha^{-1}
T_8	75% GRD + 10 kg BGA ha^{-1}
T_9	FYM 5 tha^{-1}+ 10 kg BGA ha^{-1}
T_{10}	STCR dose with 5 t FYM for YT 50 q ha^{-1} (125:50:46)

FYM- Farm yard manure, BGA- Blue green algae, GRD- General recommended dose of fertilizer, STCR- Soil test crop response, YT- Yield target

STCR based fertilizer prescription equations used for rice

FN = 4.28 Y – 0.44 SN – 0.18 FYM

FP = 1.32 Y – 2.92 SP – 0.14 FYM

FK = 1.84 Y – 0.17 SK – 0.16 FYM

Where:-

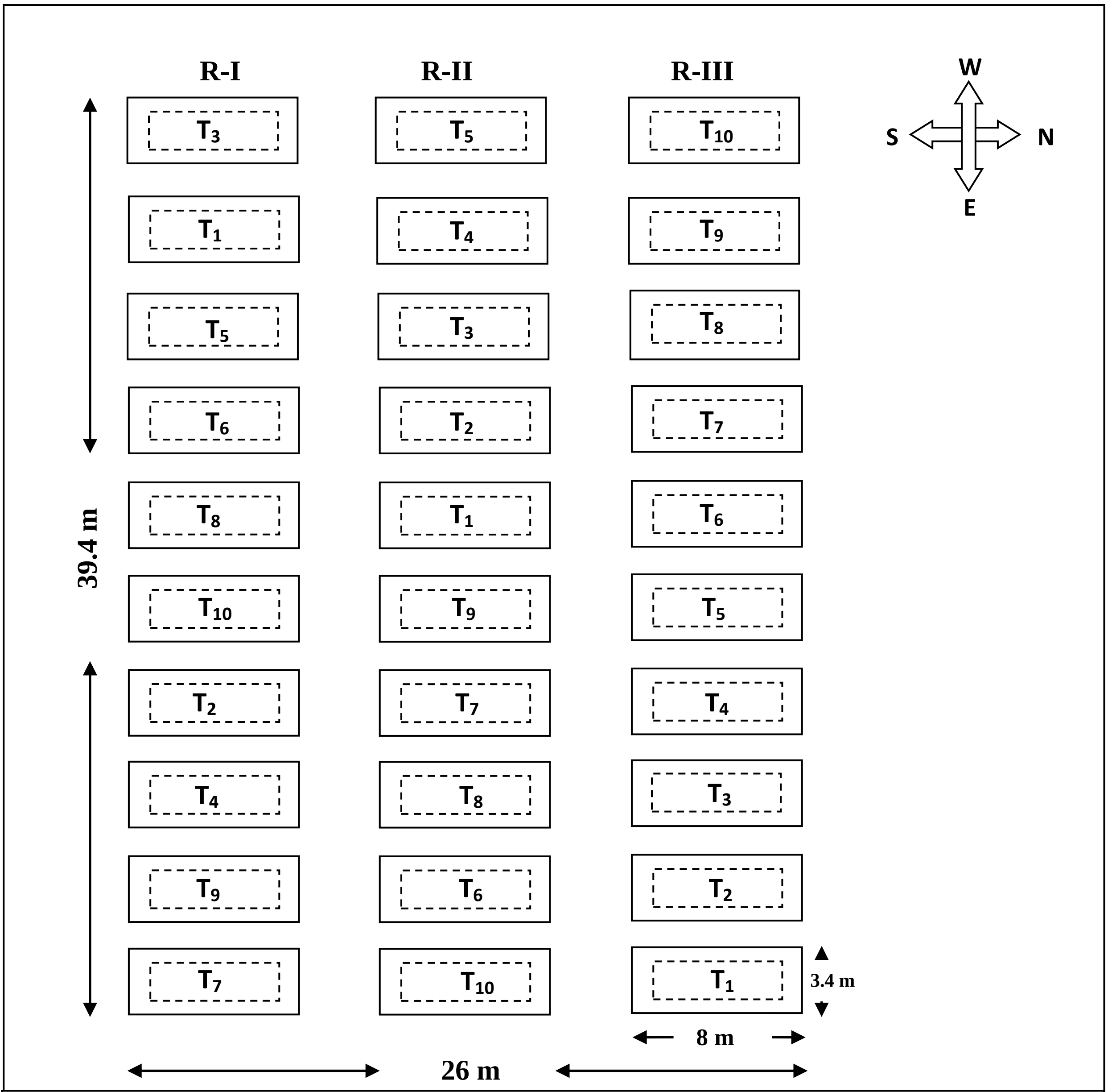
FN, FP and FK are fertilizer N, P_2O_5 and K_2O in kg ha^{-1} and SN, SP and SK are soil test values for available N, P and K.

Fertilizer doses were calculated based on the initial soil test values for rice in *Inceptisols:-*

Fertilizer N dose for yield target of 5 t ha^{-1} = 125

Fertilizer P_2O_5 dose for yield target of 5 t ha^{-1} = 50

Fertilizer K_2O dose for yield target of 5 t ha^{-1} = 46



Treatment Details

T_1	:	Control
T_2	:	FYM 5 t/ha
T_3	:	BGA 10 kg/ha dry culture
T_4	:	GRD (100:60:40)
T_5	:	100% GRD + 5 t FYM/ha
T_6	:	75% GRD + 5 t FYM/ha
T_7	:	100% GRD + 10 kg BGA/ha dry culture
T_8	:	75% GRD + 10 kg BGA/ha dry culture
T_9	:	FYM 5 t/ha + 10 kg BGA/ha dry culture
T_{10}	:	STCR dose for yield target 5 t/ha + 5 t FYM/ha

Variety	:	MTU- 1010
Design	:	Randomized Block Design
Treatments	:	10
Replications	:	3
Plot size Gross	:	8 x 3.4 m = 27.2 m^2
Net	:	7.6 x 3.2 = 24.32 m^2
Spacing	:	20 x 10cm (R-R x P-P)
Transplanting Date	:	02/08/2014
Harvesting Date	:	08/11/2014
Spacing between Replication	:	1 m
Spacing between treatment	:	0.6 m

Fig.3.1: Layout plan of experimental field

3.6 Field preparation

The field was prepared by ploughing and cross ploughing with the cultivator. The field was puddled by tractor drawn puddler in presence of standing water and was leveled by planker.

3.7 Transplanting

The 21 days old seedlings was planted. Seedlings were carefully uprooted from the nursery and transplanted. The planting was done at a spacing of 20 x 10 cm.

3.8 Nutrients management practices

Nutrients management practices (Chemical fertilizers and Organic manures) were applied as per the treatments. Nutrients were applied through urea, SSP and muriate of potash and FYM & BGA respectively. The whole amount of P and K was applied as basal dressing, while nitrogen was applied in three splits as basal and remaining two in equal splits at tillering and panicle initiation stage as per the treatment dose. The required quantity of basal doses of FYM, and chemical fertilizers were broadcasted in the field before transplanting. Blue green algae dry flakes was applied after seven days of transplanting in standing water @ 10 kg ha^{-1}. The nutrients content in FYM was presented in Table 3.3.

Table 3.3: Chemical properties of FYM used in the experiment

No.	Particulars	FYM
1	Total nitrogen (%)	0.49
2	Total phosphorus (%)	0.23
3	Total potassium (%)	0.45

3.9 Harvesting

Harvesting was done when crop attained maturity. The stalk was manually harvested with the help of sickle at 3-4 cm from ground surface. Crop was threshed and winnowed manually after sun drying and yield per plot was recorded.

3.10 Observations recorded

3.10.1 Growth and yield attributes of rice

3.10.1.1 Plant height (cm)

Plant height of rice from randomly selected ten plant was recorded in each plot at harvest stage. The height was recorded from ground level to the tip of the longest leaf of the hill. At maturity, it is measured up to tip of the panicle of mother shoot of the plants.

3.10.1.2 Dry matter accumulation (g hill^{-1})

In order to get dry matter production plant^{-1} randomly selected five plants in each plot were carefully uprooted and the dry weights were taken after oven drying at 60 °C for 48 hours at 30, 60 DAT and at harvest. The average dry weight hill^{-1} was worked out and expressed in gram.

3.10.1.3 Total and effective tillers hill^{-1}

The total numbers of tillers of ten randomly selected plants were counted from each plots and its average value was recorded. Similarly, effective tillers from the above selected plant were also counted and average was recorded.

3.10.1.4 Panicle length (cm)

The length of panicle was taken from ten panicles selected randomly from harvested produce. It was measured from the neck node to the tip of the apical grain. After this, average length of panicle was determined.

3.10.1.5 Filled grains panicle^{-1}

The five panicles from each plot were randomly selected and filled grains were counted then mean was calculated.

3.10.1.6 Test weight (g)

Seed samples were taken randomly from the each plot separately and dried in oven until the weight become constant. Thousand seeds were counted from the oven dried samples of each plot and then weight was recorded on electronic balance.

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

Grain yield (kg $plot^{-1}$) of the net plot was recorded after threshing, winnowing and drying, which was then converted in q ha^{-1} by multiplying with appropriate multiplication factor (4.118).

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

The straw yield of each net harvested plot was recorded in kilogram and converted into q ha^{-1} by multiplying with appropriate multiplication factor (4.118).

3.10.2 Plant chemical analysis

3.10.2.1 Sample preparation

Plant samples (straw and grain) were dried in oven at 45°C until constant dry weight obtained. The plant samples were grinded and used for NPK content in each treatment estimated at 30, 60 DAT and at harvest and their uptake by rice crop.

3.10.2.2 Nitrogen content (%)

Nitrogen content was determined by Micro kjeldahl methods as described by Chapman and Pratt, (1961).

3.10.2.3 Phosphorus content (%)

Phosphorus content in plant was determined by vanadomolybdate acid yellow color method, using blue filter as described by Jackson (1967).

3.10.2.4 Potassium content (%)

Potassium content plant was determined by flame-photometric method, using diacid digestion system respectively by Jackson (1967).

3.10.2.5 Uptake of nutrients (kg ha^{-1})

Nitrogen, phosphorus and potassium uptake (kg ha^{-1}) in each treatment estimated at 30, 60 DAT and at harvest. The NPK uptake in plant at 30 and 60 DAT was calculated by multiplying NPK content (%) with dry matter (q ha^{-1}). However, at harvest, the NPK uptake in grain and straw was calculated by multiplying the NPK content (%) with the yields of grain and straw.

3.10.3 Microbial analysis of soil

3.10.3.1 Dehydrogenase activity (µg TPF g^{-1} soil day^{-1})

The dehydrogenase activity in soil was determined by method given by Klein *et al.* (1971). One g air-dried soil ample was taken in an air tight screw capped test tube (15ml capacity) 0.2 ml of 3% TTC (Triphenyl Tetrazolium Chloride) solution was added to saturate the soil. Afterwards 0.5 ml of 1% glucose solution was added in tube followed by gentle tapping of the tube to drive out all trapped oxygen. The tubes were incubated at 28± 0.5 for 24 hrs. After incubation, 10 ml of methanol was added shaked vigorously and allow to stand for six hours. Clear pink colored supernatant was withdrawn and reading was taken with the help of spectrophotometer at a wave length of 485 nm (blue filter).The amount of TPF (Triphenyl Formazan) formed was calculated from the standard curve drawn in the range of 10 mg to 90 mg TPF/ml. The result was expressed as µg triphenyl formazan formed per g of soil (µg TPF g^{-1}).

3.10.3.2 Total bacterial count (CFU 10^7 g^{-1} soil)

The method followed was given by Wollum (1982) and is given below;

Serial dilution was prepared for plating of the soil within the laminar flow assembly. In 500 ml conical flask 10 g of soil sample with 95 ml distilled water was added. One ml soil suspension obtained was transferred into 9 ml of distilled water in the test tubes. The series was continued in similar manner to get up to 10-7 dilution level. One ml of required dilution was transferred into sterile petri plates. The required selective media was poured uniformly into plates. Clockwise and anti-clockwise rotations were made to mix soil suspension with medium. Then plates were incubated at 28°C and examined for the colonies developed after the required incubation period. Number of colonies formed were counted and examined under microscope.

3.10.3.3 Soil microbial biomass carbon (µg C g^{-1} dry soil)

Biomass carbon was determined by the fumigation extraction method as per the procedure of Jenkison and Powlson (1976). 10 g soil was weighed into a100 ml beaker and kept for fumigation. Ethanol-free chloroform was prepared immediately before fumigation. The chloroform was poured in a separating funnel washed with concentrated H_2SO_4 (each with half the volume of chloroform) and another three times with the same volume of distilled water similarly and the bottom whitish phase was collected. All the washings were given to make the chloroform free of ethanol. The required volume of ethanol free chloroform (20 ml) was kept in 100 ml beakers containing soil and placed in a vacuum dessicator. High density silica vacuum grease was used at the lid-joint to ensure sealing. Vacuum pump was run until the chloroform boiled for about five minutes. Afterwards the outlet was closed and the dessicator was placed in dark for 24 hrs. Then the vacuum was released and beakers were taken out.

Both the fumigated and non-fumigated soil were transferred in 250 ml conical flask 25ml of 0.5 M K_2SO_4 was added and shaking was done for half an hour. After shaking the suspension was filtered and 10 ml of the filtrate was transferred in 500 ml conical flask. Then 2 ml of $K_2Cr_2O_7$, 10 ml of concentrated H_2SO_4 and 5 ml of orthophosphoric acid were added to each flask. The blank was also run with 10 ml of distilled water each along with same procedure mentioned above. The flasks were kept on hot plate at 100°C for half an hour under refluxing condition. Then the flasks were taken out and about 250 ml of distilled water added immediately. The contents were allowed to cool down then two to three drops of diphenylamine indicator were added. The contents were titrated against 0.005 M ferrous ammonium sulphate to get a brick red/light green end point.

Microbial biomass carbon in soil (SMBC)

$$\text{SMBC (ppm)} = \frac{(E_{CF} - EC_{NF})}{K_{EC}}$$

Where,

E_{CF} = Extractable carbon in the fumigated soil sample.

EC_{NF} = Extractable soil sample in the non- fumigated soil sample.

KEC = 0.25 ± 0.05 it represents the efficiency of extraction of microbial biomass Carbon.

3.10.4 Chemical analysis of soil

The soil samples were taken up to 15 cm depth from each plot at initial and after the harvest of rice crop. The samples were air dried, grinded, sieved (2mm sieve) and used for the analysis of following soil chemical properties.

3.10.4.1 Soil reaction

Soil pH was determined by glass electrode pH meter taking 1:2.5 soil water suspensions after stirring it for 30 minutes as described by (Jackson, 1973).

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

Electrical conductivity was determined by taking supernatant liquid of soil water suspension prepared for pH determination by using electrical conductivity meter (Black, 1965).

3.10.4.3 Organic carbon (%)

Organic carbon was determined by Walkley and Black's rapid titration method (1934) as determined by Black (1965).

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

Available nitrogen was determined by alkaline permanganate method as described by Subbiah and Asija (1956).

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

Available phosphorus was extracted using $NaHCO_3$ (pH 8.5) by the method described by Olsen *et al.* (1954) and the amount of available phosphorus was determined by ascorbic acid method described by Watnabe and Olsen (1965) using spectrophotometer at wavelength using filter.

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

Available potassium was extracted by neutral normal ammonium acetate (pH-7) and determined with the help of Flame photometer as described by Jackson (1967).

3.11 Statistical analysis

The experiment was laid out in Randomized Block Design (RBD). The data obtained from various characters under study were analyzed by the method of analysis of variance as described by Gomez and Gomez (1984). The level of significance used in "F" test was given at 5 per cent. Critical difference (CD) values are given in the table at 5 percent level of significance, wherever the "F" test was significant at 5 percent level. The skeleton of analysis of variance and formula used for various estimations are given below:

Table 3.4: The skeleton of the analysis of variance

Source of variation	DF	SS	MSS	F_{cal}	F_{tab}	SEm±	CD 5%
Replication(r) Treatment(t) Error	(r-1) = 2 (t-1) = 9 (r-1)(t-1)=18	RSS TrSS ESS	RMS TrMS EMS	RMS/ EMS TrMS/EMS			
Total	rt-1= 29						

The following formula was used for standard error, critical difference andcoefficient of variance estimation.

(a) SEm± = $\frac{\sqrt{EMS}}{R}$

(b) CD = SEm± x $\sqrt{2}$ x t_7 DF at 5%

(c) CV (%) = $\frac{\sqrt{EMS} \text{ x } 100}{GM}$

Where,

R = Number of replication, DF = Degree of freedom

T = Number of treatment, SS = Sum of square

CD = Critical difference, CV = Coefficient of variance

MSS = Mean sum of square, EMS = Error mean square

SEm ± = Standard error of mean, GM = Grand mean

CHAPTER -IV
RESULTS AND DISCUSSION

The present investigation **"Integrated nutrient management in rice in *Inceptisols* of Janjgir-Champa district of Chhattisgarh"** was carried in *kharif* 2014 at College of Agriculture and Research Station, Janjgir-Champa ,an out campus of IGKV, Raipur. The details of the results obtained during the experimental period (July to November 2014) are explained in this chapter under the following heads:

4.1 Effect of INM on growth, yield attributes and yield of rice

4.2 Effect of INM on NPK contents and their uptake by rice at different stages

4.3 Effect of INM on microbial status of soil

4.4 Effect of INM on pH, EC and Organic carbon in soil

4.5 Effect of INM on available NPK in soil

4.1 Effect of INM on growth, yield attributes and yield of rice

4.1.1 Plant height (cm)

Data pertaining to plant height (cm) at harvesting of rice ranged from 67.2 to 100.5 cm (Table 4.1). Treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) was found to be significantly superior not only over control (T_1) but also rest of the treatments in increasing the plant height.

Application of treatment FYM 5 t ha^{-1} (T_2), BGA 10 kg ha^{-1} (T_3) and FYM 5 t ha^{-1} + 10 kg BGA ha^{-1} (T_9) significantly increased plant height of rice over control at 5 % level of significance. Application of chemical fertilizer and FYM gave taller plants height at harvest as compared to other treatment combinations (Mohanty *et al*., 2013).

4.1.2 Dry Matter accumulation (g $hill^{-1}$)

Data related to dry matter accumulation (g hill-^{1}) at 30 DAT, 60 DAT and at harvest stages of rice ranged from 0.56 to 2.23, 1.02 to 7.26 and 5.12 to 20.70 g hill-^{1}, respectively (Table 4.1). In general, dry matter accumulation showed increasing trend upto harvesting. Treatment STCR dose with 5 t FYM for YT 50 q ha-^{1} (T_{10}) was found significantly higher not only over control but also over rest of the treatments, but it was statically at par with 100% GRD + 5 t FYM ha-^{1} (T_5) at 30 DAT, 60 DAT and at harvest stages of rice.

4.1.3 Total and effective tillers hill^{-1} (No.)

Data pertaining to number of total and effective tillers hill^{-1} at harvesting of rice ranged from 3.4 to 9.4 tillers hill^{-1} and 2.6 to 7.7 tillers hill^{-1}, respectively (Table 4.1). Treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) was observed significantly higher not only over control but also over rest of the treatments in increasing the number of total and effective tillers in rice, but it was statically at par to 100% GRD + 5 t FYM ha^{-1} (T_5). Nayak *et al.* (2007) also noted significant increase in number of effective tillers hill^{-1} due to application of chemical fertilizer with organic manure.

4.1.4 Panicle length (cm) and number of total filled grains panicle^{-1}

Data pertaining to panicle length (cm) and number of total filled grains panicle^{-1} at harvesting of rice ranged from 17.9 to 23.2 cm and 54.9 to 114.3 grains panicle^{-1}, respectively (Table 4.1). Treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) registered significantly higher panicle length over control, but it was statistically similar with treatment 100% GRD (100:60:40) (T_4), 100% GRD + 5 t FYM ha^{-1} (T_5), 75% GRD + 5 t FYM ha^{-1} (T_6), 100% GRD + 10 kg BGA ha^{-1} (T_7) and 75% GRD + 10 kg BGA ha^{-1} (T_8). In case of number of total filled grains panicle^{-1} treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) recorded significantly higher value as compared to rest of the treatment, however it was statistically similar to treatments 100% GRD + 5 t FYM ha^{-1} (T_5) and 100% GRD + 10 kg BGA ha^{-1} (T_7).

Application of neither FYM 5 t ha^{-1} (T_2) nor BGA 10 kg ha^{-1} (T_3) and FYM 5 t ha^{-1} + 10 kg BGA ha^{-1} (T_9) did not give significant impact on panicle length (cm) and number of total filled grains panicle^{-1} (No.) in rice over control (T_1) at 5 % level of significance. Mohanty *et al*. (2013) also found that application of chemical fertilizer, FYM and Biofertilizer produced significantly higher number of tillers and significantly highest number of grains panicle^{-1} as compared to 100% recommended dose of fertilizer and control.

4.1.5 Test weight (g)

The size and boldness of rice seed measured as 1000-grain weight as influenced by different INM treatments have been presented in Table 4.1. The test weight (1000-grain weight) of rice varied from 25.75 to 26.48 g. All the treatments failed to give significant impact on test weight of rice. The maximum value of test weight was recorded with STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) which was statistically similar to control. Yang *et al.* (2004) recorded that 1000-grain weight was increased by the application of chemical fertilizer along with organic manure.

Table 4.1: Effect of INM on growth and yield attributes of rice

Integrated nutrient management	Plant height at harvest (cm)	Dry matter accumulation hill^{-1} (g)			Total tillers hill^{-1} (No.)	Effective tillers hill^{-1} (No.)	Panicle length (cm)	Total filled grain panicle^{-1} (No.)	Test weight (g)
		30 DAT	60 DAT	At harvest					
T_1- Control	67.2	0.56	1.02	5.12	3.4	2.6	17.9	54.6	25.75
T_2- FYM 5 t ha^{-1}	74.2	0.81	1.93	7.58	5.0	3.9	19.4	65.5	25.86
T_3- BGA 10 kg ha^{-1}	73.2	0.79	1.58	5.86	4.2	3.2	17.9	60.4	25.77
T_4- 100% GRD (100:60:40)	90.0	2.00	6.61	19.06	7.8	6.5	21.9	92.3	26.30
T_5- 100% GRD + 5 t FYM ha^{-1}	91.5	2.14	6.94	20.30	9.0	7.3	22.3	104.7	26.39
T_6- 75% GRD + 5 t FYM ha^{-1}	87.4	1.83	6.22	18.43	7.2	5.8	21.3	90.3	26.28
T_7- 100% GRD + 10 kg BGA ha^{-1}	90.2	2.02	6.73	19.71	8.4	6.2	22.2	103.0	26.34
T_8- 75% GRD + 10 kg BGA ha^{-1}	84.7	1.80	6.10	18.03	6.7	5.2	20.6	79.0	26.24
T_9- FYM 5 t ha^{-1} + 10 kg BGA ha^{-1}	76.9	1.24	2.51	8.26	5.4	3.6	19.8	68.9	25.87
T_{10}- STCR dose with 5 t FYM for YT 50 q ha^{-1}	100.5	2.23	7.26	20.70	9.4	7.7	23.2	114.3	26.48
SEm±	1.69	0.05	0.12	0.21	0.18	0.25	0.94	5.35	0.28
CD (P = 0.05)	5.01	0.15	0.37	0.62	0.55	0.76	2.79	15.88	NS

4.1.6 Grain and Straw yield of rice (q ha^{-1})

The average grain and straw yield of rice was significantaly affected by different INM treatments. The yields of grain and straw of rice varied from 7.79 to 45.93 and 9.97 to 54.95 kg ha^{-1}, respectively (Table 4.2 and Fig. 4.1). As regards to grain and straw yield of rice, significantly higher value was noted in treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) as compare to rest of the treatments, however it was statistically similar to treatments100% GRD (100:60:40) (T_4), 100% GRD+ 5 t FYM ha $^{-1}$ (T_5) and 100% GRD+ 10 kg BGA ha^{-1} (T_7). Application of BGA alone (T_3) could not cause significant increase in yield of grain and straw over control (T_1), while FYM individually (T_2) and in combination with BGA treatment FYM 5 t ha^{-1} + 10 kg BGA ha^{-1} (T_9) significantly increased grain and straw yield of rice over control (T_1) at 5 % level of significance. The integrated use of fertilizers with organic manures *viz.*, FYM and BGA might have added huge quantity of organic matter in soil that increased grain and straw yield. This might be due to the improvement in physicochemical properties of soil that resulted in increased productivity by increasing availability of plant nutrients (Chaudhary and Thakur, 2007). Further, the addition of organic matter also maintains regular supply of macro and micronutrients in soil resulting in higher yields. These results are in conformity with the finding of Gupta *et al.* (2006).

Table 4.2: Effect of INM on grain and straw yield of rice (q ha^{-1})

Integrated nutrient management	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
T_1- Control	7.79	9.97
T_2- FYM 5 t ha^{-1}	13.43	16.85
T_3- BGA 10 kg ha^{-1}	10.13	13.05
T_4- 100% GRD (100:60:40)	42.60	50.68
T_5- 100% GRD + 5 t FYM ha^{-1}	44.76	53.38
T_6- 75% GRD + 5 t FYM ha^{-1}	40.46	48.32
T_7- 100% GRD + 10 kg BGA ha^{-1}	43.06	51.25
T_8- 75% GRD + 10 kg BGA ha^{-1}	38.77	46.62
T_9- FYM 5 t ha^{-1} + 10 kg BGA ha^{-1}	15.84	19.08
T_{10}- STCR dose with 5 t FYM for YT 50 q ha^{-1}	45.93	54.95
SEm±	1.33	1.74
CD (P = 0.05)	3.96	5.16

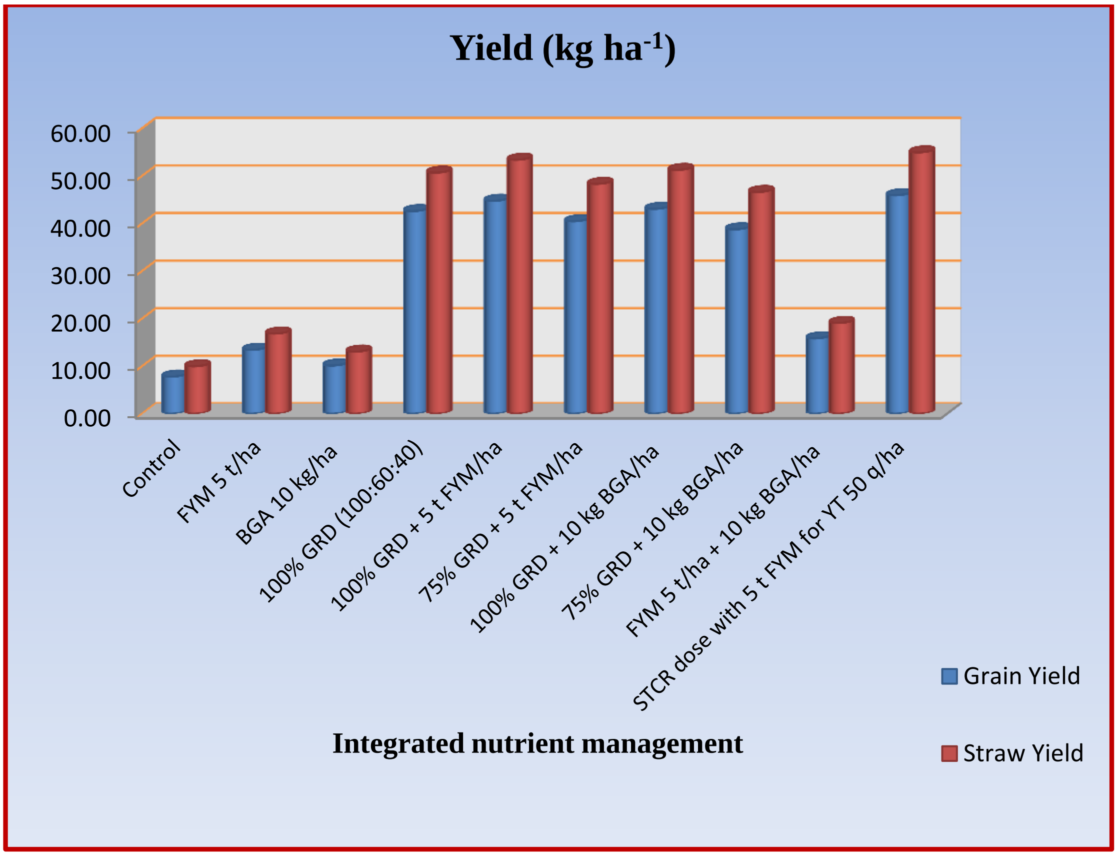


Fig.4.1: Effect of INM on grain and straw yield of rice

4.2 Effect of INM on NPK contents and their uptake by rice at different stages

4.2.1 Nitrogen content (%) and uptake (kg ha^{-1})

Data recorded on N contents in plants at 30 and 60 DAT ranged from 2.26 to 2.32 % and 1.58 to 1.63 % and in grain and straw at harvest ranged from 1.01 to 1.13 % and 0.31 to 0.35 %, respectively (Table 4.3 and Fig. 4.2). Different integrated nutrient management failed to show significant influence on nitrogen contents at any stage of observation.

Nitrogen uptake by shoot at 30 DAT & 60 DAT varied from 6.32 to 25.82 and 8.03 to 59.25 kg ha^{-1}(Table 4.4). At both the stages treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) recorded maximum Nitrogen uptake by shoot. At 30 DAT, STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) was found statistically superior not over control but also over other treatments except 100% GRD + 5 t FYM ha^{-1} (T_5). At 60 DAT, STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) was found statistically superior not over control but also over other treatments however, it was found statistically similar with 100% GRD + 5 t FYM ha^{-1} (T_5), 100% GRD (100:60:40) (T_4) and 100% GRD + 10 kg BGA ha^{-1} (T_7).

The uptake of N, as influenced by different treatments, by grain, straw and total biomass ranged from 7.71 to 51.70, 3.06 to 18.37 and 10.77 to 69.86 kg ha^{-1}, respectively and the data are presented in Table 4.4 and Fig. 4.3. There was significant increase in N uptake by grain, straw and total biomass over control (T_1) by all treatments except treatment BGA 10 kg ha^{-1} (T_3). Application of BGA @ 10 kg ha^{-1} (T_3) could not cause significant increase over control in uptake of N by grain, straw and total biomass, while application of FYM 5 t ha^{-1} (T_2) and FYM 5 t ha^{-1} + BGA 10 kg ha^{-1} (T_9) significantly increased uptake of N over control (T_1) by grain, straw and total biomass.

The uptake of N by grain and total biomass was found to be maximum due to STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) which was statistically at par with 100% GRD + 5 t FYM ha^{-1} (T_5) and 100% GRD + 10 kg BGA ha^{-1} (T_7). The uptake of N by straw was found maximum (18.37 kg ha^{-1}) due to treatment 100% GRD + 5 t FYM ha^{-1} (T_5) which was statistically at par with treatments STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}), 100% GRD + 10 kg BGA ha^{-1} (T_7), 100% GRD (100:60:40) (T_4) and 75% GRD + 5 t FYM ha^{-1} (T_6) in decreasing order. A critical observation of the data reveals that the performance of treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) and 100% GRD + 5 t FYM ha^{-1} (T_5), in general, was better over other interactions in increasing the uptake of N in rice. The highest N, P and K uptake was associated with treatment of soil test based N, P and K application, FYM and green manuring. This might be due to added fertilizers, FYM and green manure, as a result better availability of N, P, and K in soil to the rice crop (Singh *et al*., 2006). The lowest N uptake in control plot by the crops is due to the lower yield obtained in these plots. The application of organics and chemical fertilizers increased crop yields that resulted in increased uptake. The increase in nutrient uptake was directly related to the crop yields. It can be explained on the basis that application of fertilizers along with manures improved initial process of plant growth such as cell division, number of root hairs etc. Enabling the plant to have healthy root system that helped in better absorption of nutrients and moisture from soil (Subehia and Sepehya, 2012). Similar positive influence of nutrients on crop yields and uptake has also been reported by Gupta *et al*. (2006) and Prasad *et al*. (2010).

Table 4.3: Effect of INM on nitrogen content (%) in rice

Integrated nutrient management	Nitrogen content (%)			
	30 DAT	60 DAT	At harvest	
			Grain	Straw
T_1- Control	2.26	1.58	1.01	0.31
T_2- FYM 5 t ha^{-1}	2.26	1.58	1.04	0.31
T_3- BGA 10 kg ha^{-1}	2.27	1.59	1.07	0.31
T_4- 100% GRD (100:60:40)	2.30	1.62	1.09	0.34
T_5- 100% GRD + 5 t FYM ha^{-1}	2.32	1.63	1.11	0.35
T_6- 75% GRD + 5 t FYM ha^{-1}	2.31	1.63	1.09	0.34
T_7- 100% GRD + 10 kg BGA ha^{-1}	2.32	1.63	1.11	0.35
T_8- 75% GRD + 10 kg BGA ha^{-1}	2.31	1.62	1.10	0.35
T_9- FYM 5 t ha^{-1} + 10 kg BGA ha^{-1}	2.28	1.60	1.08	0.33
T_{10}- STCR dose with 5 t FYM for YT 50 q ha^{-1}	2.32	1.63	1.13	0.33
SEm±	0.07	0.07	0.05	0.01
CD (P = 0.05)	NS	NS	NS	NS

Table 4.4: Effect of INM on nitrogen uptake (kg ha^{-1}) by rice

Integrated nutrient management	Nitrogen uptake (kg ha^{-1})				
	30 DAT	60 DAT	At harvest		
			Grain	Straw	Total
T_1- Control	6.32	8.03	7.71	3.06	10.77
T_2- FYM 5 t ha^{-1}	9.20	15.25	13.85	5.16	19.00
T_3- BGA 10 kg ha^{-1}	9.02	12.54	10.83	4.07	14.90
T_4- 100% GRD (100:60:40)	22.91	53.56	46.52	17.24	63.75
T_5- 100% GRD + 5 t FYM ha^{-1}	24.76	56.61	49.45	18.37	67.82
T_6- 75% GRD + 5 t FYM ha^{-1}	21.15	50.75	44.14	16.64	60.79
T_7- 100% GRD + 10 kg BGA ha^{-1}	23.29	54.87	48.04	17.99	66.03
T_8- 75% GRD + 10 kg BGA ha^{-1}	20.80	49.52	42.56	16.27	58.84
T_9- FYM 5 t ha^{-1} + 10 kg BGA ha^{-1}	14.09	20.04	16.96	6.19	23.15
T_{10}- STCR dose with 5 t FYM for YT 50 q ha^{-1}	25.82	59.25	51.70	18.16	69.86
SEm±	0.66	2.54	1.58	0.60	2.03
CD (P = 0.05)	1.96	7.55	4.69	1.79	6.02

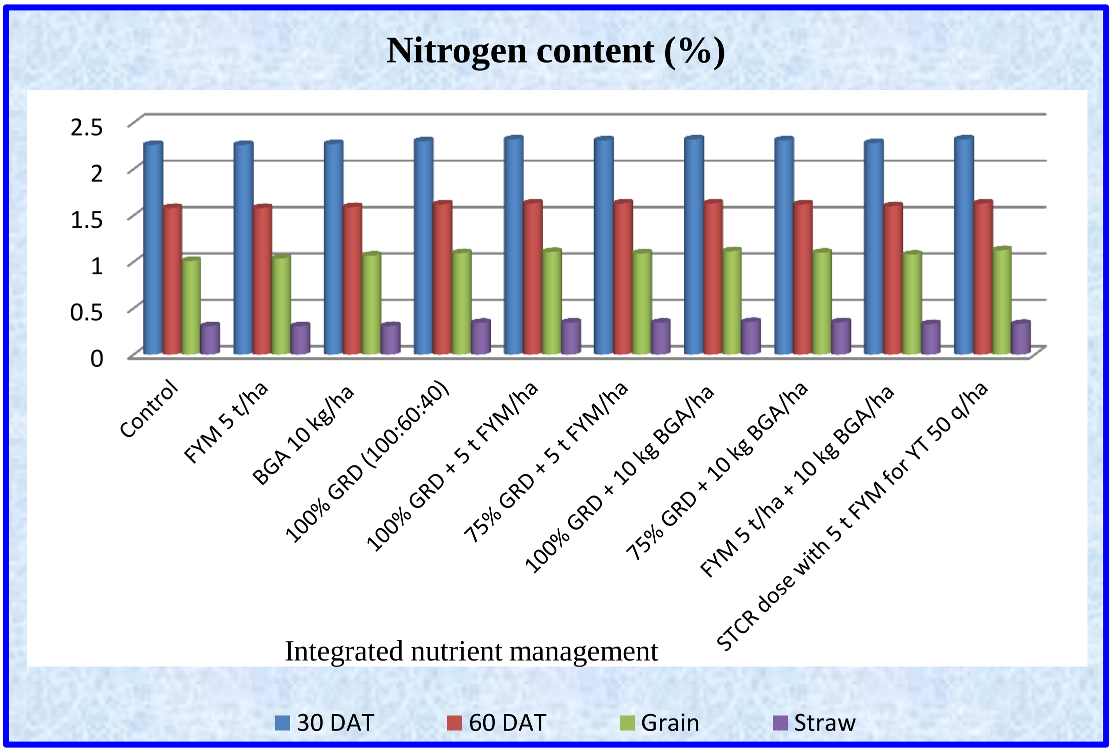


Fig.4.2: Effect of INM on nitrogen content (%) in rice at different stages

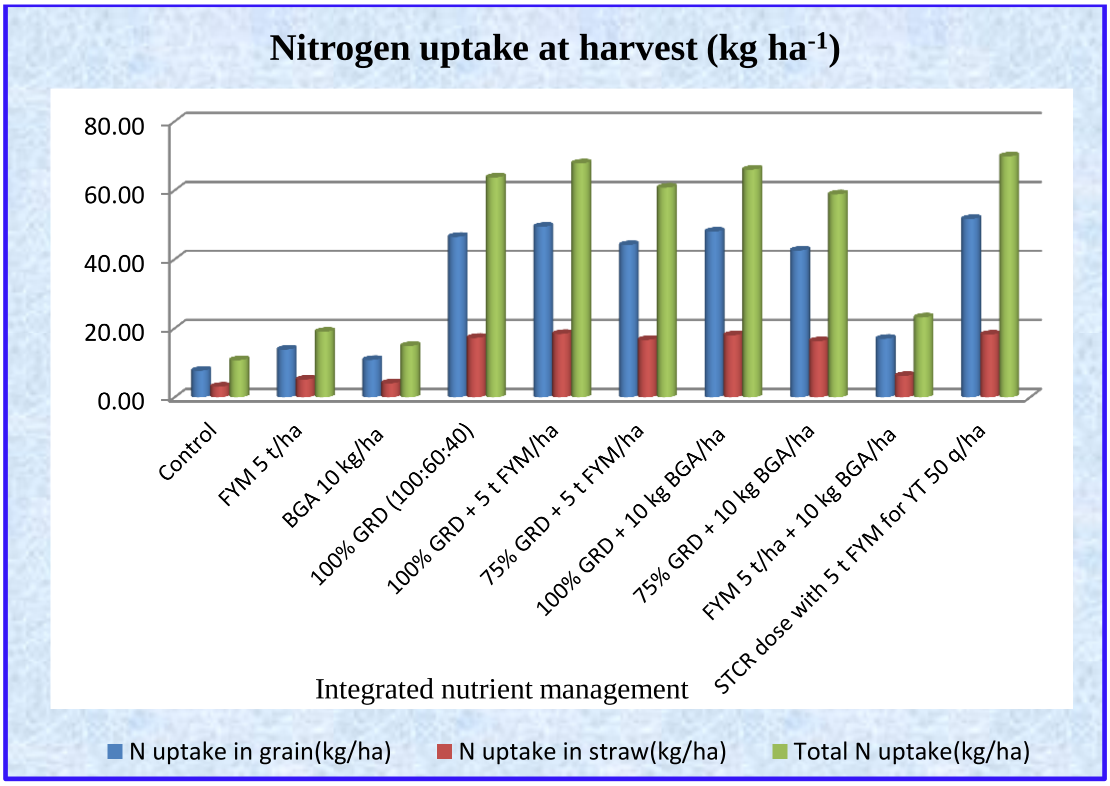


Fig.4.3: Effect of INM on nitrogen uptake (kg ha^{-1}) by rice

4.2.2 Phosphorus content (%) and uptake (kg ha^{-1})

Data recorded on P contents in plants at 30 and 60 DAT ranged from 0.55 to 0.59 % and 0.32 to 0.33 % and in grain and straw at harvest ranged from 0.22 to 0.26 % and 0.06 to 0.08 %, respectively (Table 4.5 and Fig. 4.4). Different integrated nutrient management failed to show significant influence on phosphorus contents at any stage of observation.

Phosphorus uptake by shoot at 30 DAT & 60 DAT varied from 1.52 to 6.59 and 1.63 to 12.16 kg ha^{-1} (Table 4.6). At both the stages treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) recorded maximum phosphorus uptake by shoot. At 30 DAT, STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) was found statistically superior not over control but also over other treatments except 100% GRD (100:60:40) (T_4) and 100% GRD + 5 t FYM ha^{-1} (T_5). At 60 DAT, STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) was found statistically superior not over control but also over other treatments however, it was found statistically similar with 100% GRD + 5 t FYM ha^{-1} (T_5), 100% GRD (100:60:40) (T_4) and 100% GRD + 10 kg BGA ha^{-1} (T_7).

The uptake of P, as influenced by different treatments, by grain, straw and total biomass ranged from 1.68 to 12.05 and 0.64 to 4.0, 2.33 to 15.66 kg ha^{-1}, respectively and the data are presented in Table 4.6 and Fig. 4.5. As for as phosphate uptake in grain and total biomass significantly higher value was noted in treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) as compare to rest of the treatment, however it was statistically similar to treatment 100% GRD + 5 t FYM ha^{-1} (T_5) and 100% GRD + 10 kg BGA ha^{-1} (T_7). Whereas, in case of straw, significantly higher P uptake over cotrol was noted in treatment 100% GRD + 5 t FYM ha^{-1} (T_5) then other, but it was found at par to treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}). Application of either BGA or FYM alone could not cause significant increase in uptake of P by grain and straw, total biomass over control (T_1), while treatment FYM 5 t ha^{-1} + BGA @ 10 kg ha^{-1} (T_9) significantly increased uptake of P by grain, straw and total biomass over control (T_1). A critical observation of the data reveals that the performance of treatments STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) and 100% GRD + 5 t FYM ha^{-1} (T_5), in general, was better over other treatments in increasing the uptake of P in rice.

Singh (2006) reported that application of 100% NPK + FYM @10 t ha^{-1} was equally beneficial for nutrient uptake in comparison to other treatments. Satyanarayana *et al.* (2002) also reported that application of 100% NPK + 10 t FYM significantly increased the NPK uptake in comparison to application of NPK alone. The increase in NPK uptake under application of organic manures could be attributed to improvement in the nutrient availability through improving soil physicochemical and biological properties of the soil (Bahadur *et al*., 2012). The highest N, P and K uptake was associated with treatment of soil test based N, P and K application, FYM and green manuring. This might be due to added fertilizers, FYM and green manure, as a result better availability of N, P, and K in soil to the rice crop (Singh *et al*., 2006).

Table 4.5: Effect of INM on phosphorus content (%) in rice

Integrated nutrient management	Phosphorus content (%)			
	30 DAT	60 DAT	At harvest Grain	At harvest Straw
T_1- Control	0.55	0.32	0.22	0.07
T_2- FYM 5 t ha^{-1}	0.56	0.32	0.23	0.06
T_3- BGA 10 kg ha^{-1}	0.55	0.31	0.23	0.06
T_4- 100% GRD (100:60:40)	0.57	0.31	0.24	0.07
T_5- 100% GRD + 5 t FYM ha^{-1}	0.58	0.33	0.26	0.08
T_6- 75% GRD + 5 t FYM ha^{-1}	0.58	0.32	0.23	0.07
T_7- 100% GRD + 10 kg BGA ha^{-1}	0.57	0.32	0.25	0.07
T_8- 75% GRD + 10 kg BGA ha^{-1}	0.56	0.31	0.25	0.07
T_9- FYM 5 t ha^{-1} + 10 kg BGA ha^{-1}	0.57	0.31	0.25	0.06
T_{10}- STCR dose with 5 t FYM for YT 50 q ha^{-1}	0.59	0.33	0.26	0.07
SEm±	0.03	0.03	0.02	0.01
CD (P = 0.05)	NS	NS	NS	NS

Table 4.6: Effect of INM on phosphorus uptake (kg ha^{-1}) by rice

Integrated nutrient management	Phosphorus uptake (kg ha^{-1})				
	30 DAT	60 DAT	At harvest		
			Grain	Straw	Total
T_1- Control	1.52	1.63	1.68	0.64	2.33
T_2- FYM 5 t ha^{-1}	2.28	3.11	3.14	1.05	4.19
T_3- BGA 10 kg ha^{-1}	2.19	2.47	2.33	0.81	3.13
T_4- 100% GRD (100:60:40)	5.76	10.42	10.03	3.44	13.47
T_5- 100% GRD + 5 t FYM ha^{-1}	6.19	11.38	11.62	4.00	15.62
T_6- 75% GRD + 5 t FYM ha^{-1}	5.33	9.95	9.18	3.36	12.54
T_7- 100% GRD + 10 kg BGA ha^{-1}	5.73	10.77	10.76	3.43	14.18
T_8- 75% GRD + 10 kg BGA ha^{-1}	5.07	9.61	9.81	3.05	12.86
T_9- FYM 5 t ha^{-1} + 10 kg BGA ha^{-1}	3.51	3.93	3.95	1.19	5.13
T_{10}- STCR dose with 5 t FYM for YT 50 q ha^{-1}	6.59	12.16	12.05	3.61	15.66
SEm±	0.28	0.69	0.61	0.16	0.72
CD (P = 0.05)	0.83	2.05	1.80	0.48	2.14

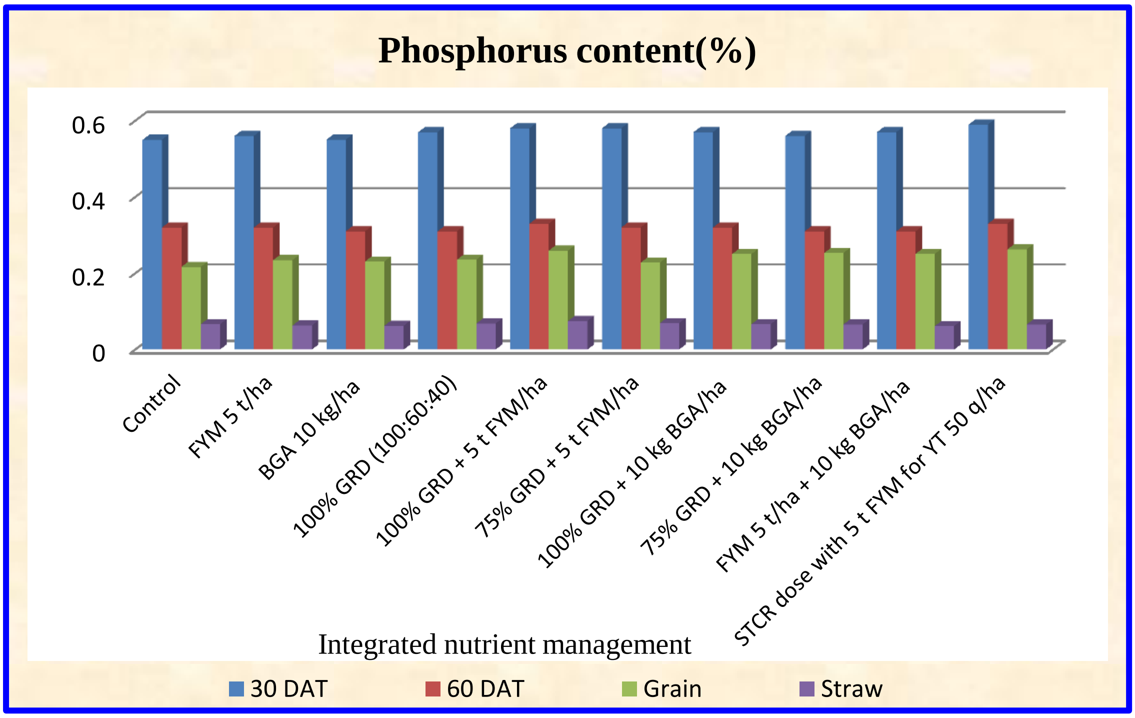


Fig.4.4: Effect of INM on phosphorus content (%) in rice at different stages

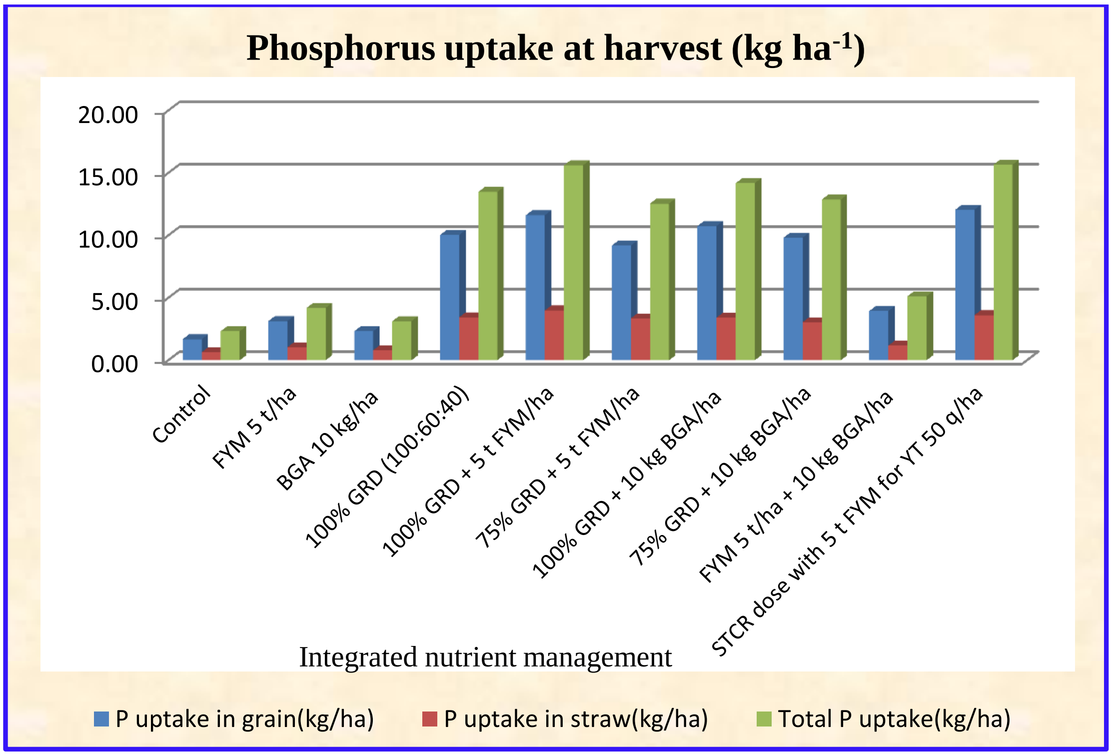


Fig.4.5: Effect of INM on phosphorus uptake (kg ha^{-1}) by rice

4.2.3 Potassium content (%) and uptake (kg ha^{-1})

Data recorded on K contents in plants at 30 and 60 DAT ranged from 2.32 to 2.36 % and 1.82 to 1.86 % and in grain and straw at harvest ranged from 0.48 to 0.52 % and 1.08 to 1.19 %, respectively (Table 4.7 and Fig. 4.6). Different integrated nutrient management failed to show significant influence on potassium contents at any stage of observation.

Potassium uptake by shoot at 30 DAT & 60 DAT varied from 6.47 to 26.32 and 9.22 to 67.65 kg ha^{-1} (Table 4.8). At both the stages treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) recorded maximum potassium uptake by shoot. At 30 DAT, STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) was found statistically superior not over control but also over other treatments except 100% GRD + 5 t FYM ha^{-1} (T_5). At 60 DAT, STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) was found statistically superior not over control but also over other treatments however, it was found statistically similar with 100% GRD + 5 t FYM ha^{-1} (T_5), 100% GRD (100:60:40) (T_4) and 100% GRD + 10 kg BGA ha^{-1} (T_7).

The uptake of K, as influenced by different treatments, by grain, straw and total biomass ranged from 3.85 to 23.12, 11.01 to 62.93 and 14.85 to 85.94 kg ha^{-1}, respectively and data are presented in Table 4.8 and Fig. 4.7. Potassium uptake in grain was significantly higher in treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) but it was at par to treatment 100% GRD(100:60:40) (T_4), 100% GRD + 5 t FYM ha^{-1} (T_5), 75% GRD + 5 t FYM ha^{-1} (T_6), 100% GRD + 10 kg BGA ha^{-1} (T_7), 75% GRD + 10 kg BGA ha^{-1} (T_8). In case of straw, significantly higher K uptake was observed in treatment 100% GRD + 5 t FYM ha^{-1} (T_5), however it was statistically similar to treatment 100% GRD(100:60:40) (T_4), 75% GRD + 5 t FYM ha^{-1} (T_6), 100% GRD + 10 kg BGA ha^{-1} (T_7) and STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}). As regards to K uptake by total biomass, treatment 100% GRD + 5 t FYM ha^{-1} (T_5) registered significantly higher value as compared to rest of the treatment, it was comparable to GRD (100:60:40) (T_4), 75% GRD + 5 t FYM ha^{-1} (T_6), 100% GRD + 10 kg BGA ha^{-1} (T_7), 75% GRD + 10 kg BGA ha^{-1} (T_8) and STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}). Application of either BGA or FYM alone could not cause significant increase in uptake of P by grain and straw, total biomass over control (T_1), while treatment FYM 5 t ha^{-1} + BGA @ 10 kg ha^{-1}

(T_9) significantly increased uptake of K by grain and total biomass over control (T_1) except FYM 5 t ha^{-1} + BGA @ 10 kg ha^{-1} (T_9) in case of straw of rice which was statistically similar with control.

Surenda *et al*. (2006) reported that application of farm yard manure and green manure increased the K content in both rice grain and straw. Application of different organic nutrients showed a significant variation in K uptake by rice grain and straw. The minimum K uptake in rice grain and straw were obtained from control where no fertilizers were applied. Use of chemical fertilizers all the nutrients were present in balanced proportion; it might be responsible for increasing the K uptake by rice grain and straw (Shormy *et al*., 2013).

Table 4.7: Effect of INM on potassium content (%) in rice

Integrated nutrient management	Potassium content (%)			
	30 DAT	60 DAT	At harvest	
			Grain	Straw
T_1- Control	2.32	1.82	0.48	1.08
T_2- FYM 5 t ha^{-1}	2.30	1.83	0.51	1.14
T_3- BGA 10 kg ha^{-1}	2.31	1.82	0.51	1.18
T_4- 100% GRD (100:60:40)	2.34	1.84	0.52	1.19
T_5- 100% GRD + 5 t FYM ha^{-1}	2.36	1.86	0.52	1.19
T_6- 75% GRD + 5 t FYM ha^{-1}	2.36	1.85	0.50	1.13
T_7- 100% GRD + 10 kg BGA ha^{-1}	2.36	1.84	0.51	1.19
T_8- 75% GRD + 10 kg BGA ha^{-1}	2.35	1.84	0.52	1.13
T_9- FYM 5 t ha^{-1} + 10 kg BGA ha^{-1}	2.33	1.84	0.48	1.14
T_{10}- STCR dose with 5 t FYM for YT 50 q ha^{-1}	2.36	1.86	0.51	1.17
SEm±	0.07	0.09	0.04	0.08
CD (P = 0.05)	NS	NS	NS	NS

Table 4.8: Effect of INM on potassium uptake (kg ha^{-1}) by rice

Integrated nutrient management	Potassium uptake (kg ha^{-1})				
	30 DAT	60 DAT	At harvest		
			Grain	Straw	Total
T_1- Control	6.47	9.22	3.85	11.01	14.85
T_2- FYM 5 t ha^{-1}	9.31	17.68	7.13	20.13	27.26
T_3- BGA 10 kg ha^{-1}	9.17	14.38	5.10	14.65	19.75
T_4- 100% GRD (100:60:40)	23.28	60.81	21.47	56.24	77.72
T_5- 100% GRD + 5 t FYM ha^{-1}	25.25	64.58	23.01	62.93	85.94
T_6- 75% GRD + 5 t FYM ha^{-1}	21.59	57.34	21.32	53.64	74.95
T_7- 100% GRD + 10 kg BGA ha^{-1}	23.81	61.73	20.40	57.21	77.61
T_8- 75% GRD + 10 kg BGA ha^{-1}	21.22	55.90	20.67	50.97	71.64
T_9- FYM 5 t ha^{-1} + 10 kg BGA ha^{-1}	14.44	23.06	8.04	22.11	30.15
T_{10}- STCR dose with 5 t FYM for YT 50 q ha^{-1}	26.32	67.65	23.12	61.05	84.17
SEm±	0.83	2.51	1.26	3.74	4.95
CD (P = 0.05)	2.47	7.45	3.76	11.12	14.71

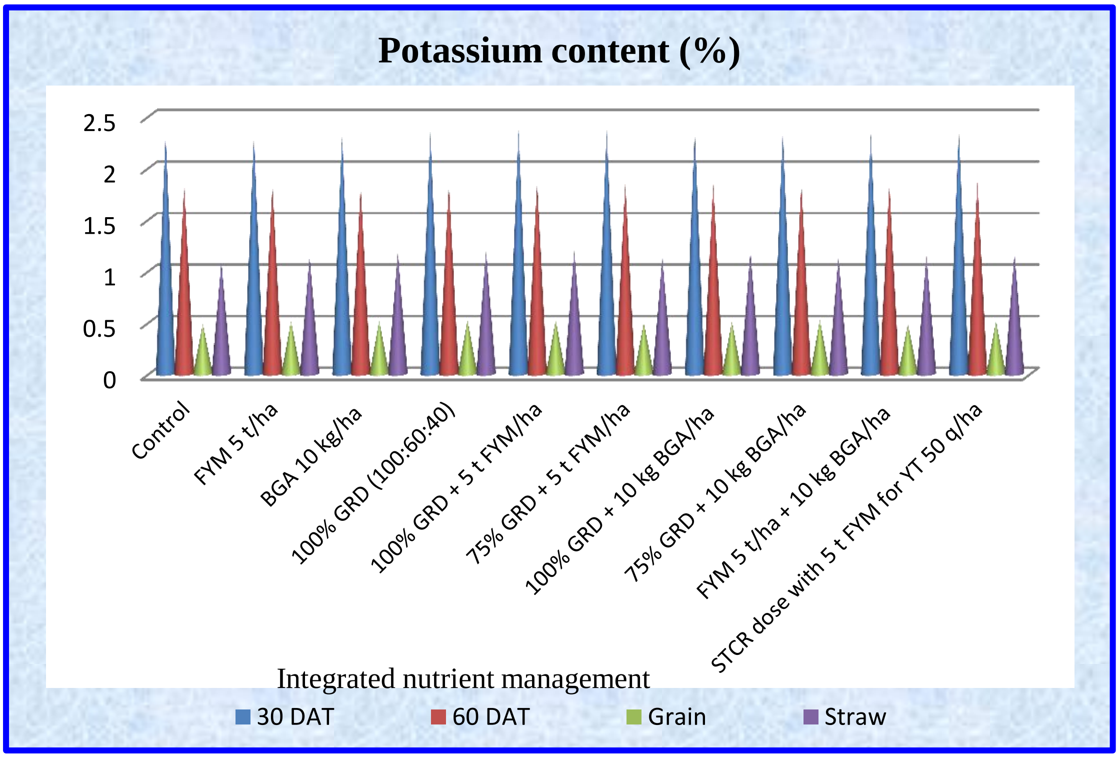


Fig.4.6: Effect of INM on potassium content (%) in rice at different stages

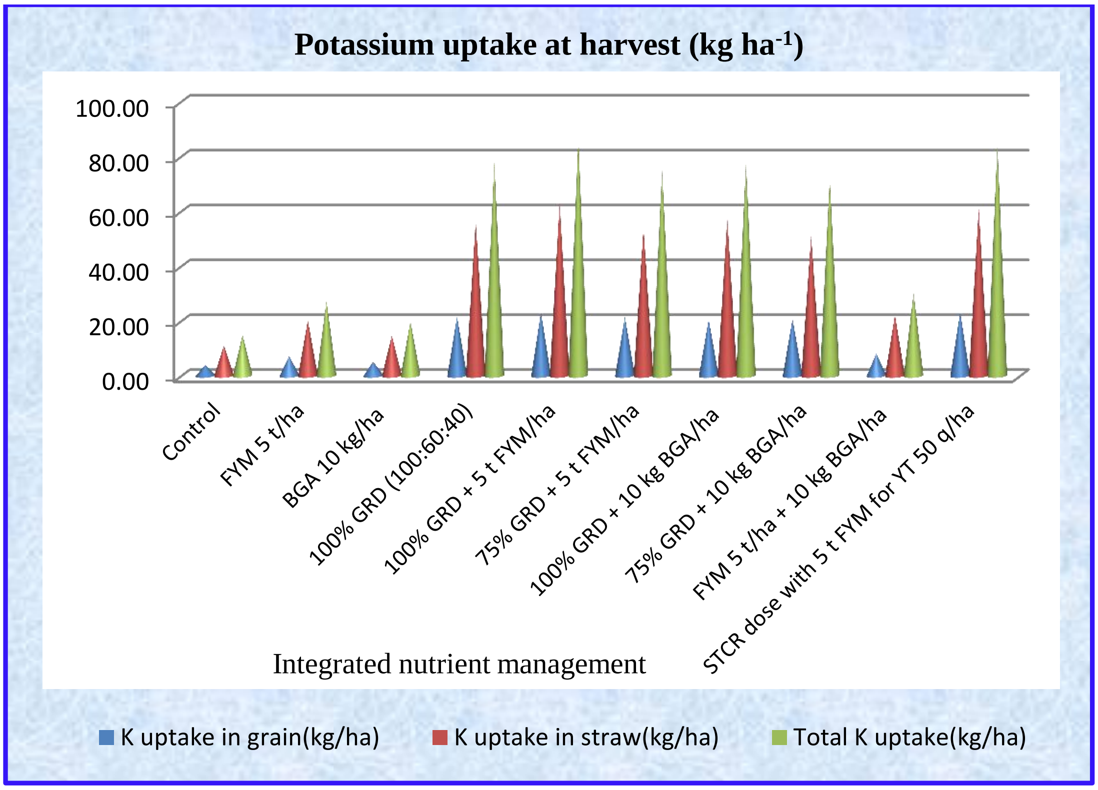


Fig.4.7: Effect of INM on potassium uptake (kg ha^{-1}) by rice

4.3 Effect of INM on microbial status of soil

4.3.1 Dehydrogenase activity (µg TPF g^{-1} soil day^{-1})

The dehydrogenase activities in soil as influenced by different INM treatments have been presented in Table 4.9 and Fig. 4.8. The dehydrogenase activities at tillering and maturity varied from 20.07 to 25.19 and 16.45 to 20.73 µg TPF g^{-1} soil day^{-1}, respectively. All the treatments significantly increased dehydrogenase activity over control at both the stages. Dehydrogenase is considered as an indicator of overall microbial activity because it occurs intracellularly in all living microbial cells and it is linked with microbial respiratory processes. The dehydrogenase activity is commonly used as an indicator of biological activity in soils (Burns 1978).

Dehydrogenase activity at tillering was found significantly higher not only over control but also over rest of the treatments because of the treatment 100% GRD + 5 t FYM ha^{-1} (T_5) containing both inorganic (100% GRD) and organic (5 t FYM ha^{-1}) in their treatment combination. However, after harvesting of rice maximum value of dehydrogenase activity was recorded with 100% GRD + 5 t FYM ha^{-1} (T_5) which was statistically superior over control (T_1) but statistically smilar with STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}), 100% GRD + 10 kg BGA ha^{-1} (T_7) and 75% GRD + 5 t FYM ha^{-1} (T_6). The activities of dehydrogenase enzyme in the soil system is very important as it may give indications of the potential of the soil to support biochemical processes which are essential for maintaining soil fertility (Joychim *et al.*, 2008). Significantly highest dehydrogenase activity in INM treatments might be due to addition of organic matter which in turn increased microbial activity and microbial biomass and consequently increased activity of dehydrogenase (Tejada and Gonalez, 2009). The applied organic sources were able to get mineralized rapidly in early days of incubation hence, there was more mineralization than immobilization which consequently provided sufficient nutrition for the proliferation of microbes and their activities in terms of soil dehydrogenase. Similar observations were noted by Joychim *et al.* (2008) and Lakshmi *et al.* (2014).

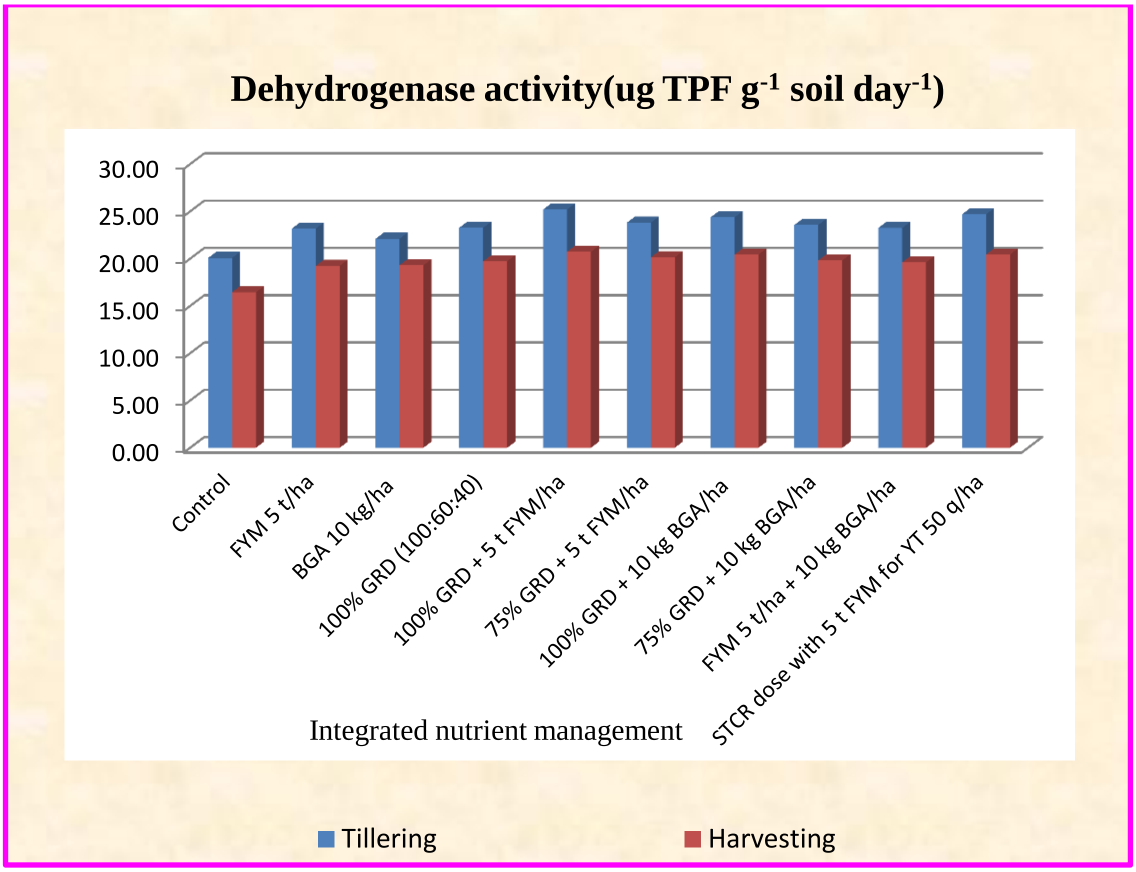


Fig.4.8: Effect of INM on the dehydrogenase activity (µg TPF g^{-1} soil day^{-1}) at tillering and harvesting stage of rice

Table 4.9: Effect of INM on Dehydrogenase activity (µg TPF g^{-1} soil day^{-1}) at tillering and harvesting stage of rice

Integrated nutrient management	Dehydrogenase activity (µg TPF g^{-1} soil day^{-1})	
	Tillering	Harvesting
T_1- Control	20.07	16.45
T_2- FYM 5 t ha^{-1}	23.18	19.24
T_3- BGA 10 kg ha^{-1}	22.10	19.30
T_4- 100% GRD (100:60:40)	23.28	19.73
T_5- 100% GRD + 5 t FYM ha^{-1}	25.19	20.73
T_6- 75% GRD + 5 t FYM ha^{-1}	23.80	20.14
T_7- 100% GRD + 10 kg BGA ha^{-1}	24.38	20.44
T_8- 75% GRD + 10 kg BGA ha^{-1}	23.57	19.82
T_9- FYM 5 t ha^{-1} + 10 kg BGA ha^{-1}	23.25	19.61
T_{10}- STCR dose with 5 t FYM for YT 50 q ha^{-1}	24.69	20.44
SEm±	0.16	0.23
CD (P = 0.05)	0.46	0.68

4.3.2 Total Bacterial count (CFU 10^7 g^{-1} soil)

The population of bacteria in soil, as influenced by INM treatments varied from 4.53 to 5.0 and 4.27 to 4.73 × 10^7 CFU's g^{-1} at tillering and after harvesting, respectively (Table 4.10 and Fig. 4.9).There was non-significant increase in total bacterial count over control (T_1) at both the stages tillering and after harvesting. A critical observation of the data reveals that the performance of treatment 100% GRD + 5 t FYM ha^{-1} (T_5) and STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}), in general was better over other treatments in increasing the total bacterial count in soil at both the stages tillering and after harvesting of rice.

The microbial population of the experimental soil accelerated upon receiving nutrients either through chemical fertilizer or organic manure or biofertilizers as compared to control. Organic manure addition with inorganic fertilizer showed a profound increase in the microbial population in comparison to chemical fertilizer used alone. Added organic matter acts as a source of the nutrients and also as a substrate for decomposition and mineralization of nutrients, thereby creating a favourable condition for the proliferation of microbes in the soil. Selvi *et al.* (2004) recorded highest bacterial counts at the end of the crop with the addition of FYM along with 100% NPK. Jain *et al*. (2003) reported that FYM + 100% NPK increased the population of *Azotobacter* in comparison to treatments not having FYM.

Table 4.10: Effect of INM on total bacterial count (CFU 10^7 g^{-1} soil) at tillering and harvesting stage of rice

Integrated nutrient management	Total bacterial count (CFU 10^7 g^{-1} soil)	
	Tillering	Harvesting
T_1- Control	4.53	4.27
T_2- FYM 5 t ha^{-1}	4.67	4.30
T_3- BGA 10 kg ha^{-1}	4.67	4.30
T_4- 100% GRD (100:60:40)	4.80	4.33
T_5- 100% GRD + 5 t FYM ha^{-1}	5.00	4.73
T_6- 75% GRD + 5 t FYM ha^{-1}	4.87	4.37
T_7- 100% GRD + 10 kg BGA ha^{-1}	4.90	4.40
T_8- 75% GRD + 10 kg BGA ha^{-1}	4.80	4.37
T_9- FYM 5 t ha^{-1} + 10 kg BGA ha^{-1}	4.77	4.33
T_{10}- STCR dose with 5 t FYM for YT 50 q ha^{-1}	4.93	4.60
SEm±	0.27	0.30
CD (P = 0.05)	NS	NS

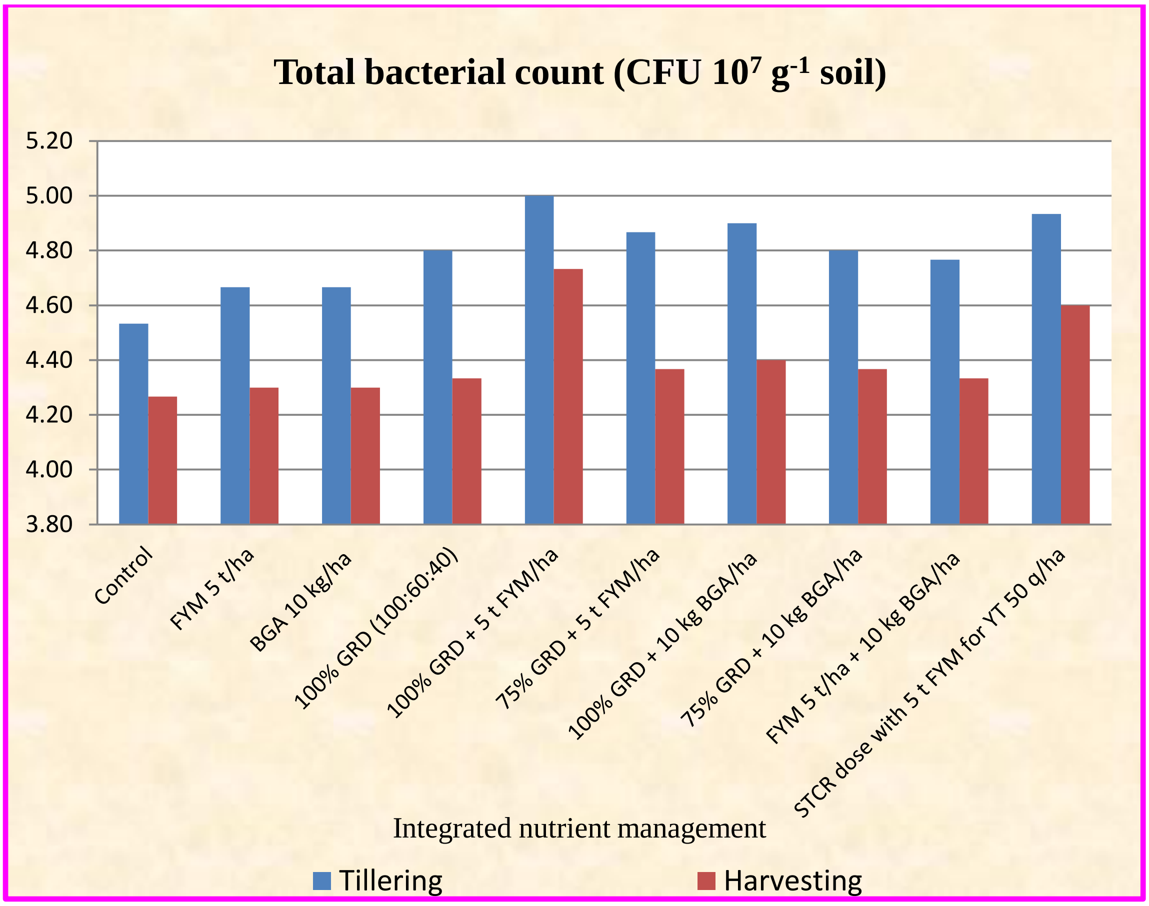


Fig.4.9: Effect of INM on the total bacterial (CFU 10^7 g^{-1} soil) at tillering and harvesting stage of rice

4.3.3 Soil Microbial Biomass Carbon (µg C g $^{-1}$ dry soil)

The Soil Microbial Biomass Carbon (SMBC) in soil, as influenced by INM treatments varied from 103.56 to 133.39 and 74.86 to 110.01 at tillering and after harvesting of rice, respectively (Table 4.11 and Fig. 4.10). All the treatments significantly increased Soil Microbial Biomass Carbon (SMBC) in soil over control at both the stages. Application of FYM and BGA individually and in combination with inorganics recorded significant increase in SMBC in soil over control at tillering and after harvest of rice. At both the stages, tillering and after harvesting of rice. Treatment 100% GRD+5 t FYM ha^{-1} (T_5) recorded maximum and significantly higher value of Soil Microbial Biomass Carbon (SMBC) over control (T_1) and rest of the treatments except STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}). Application of NPK+ farmyard manure at 10 t ha^{-1} recorded significant increase in biological parameters, viz soil microbial biomass carbon (SMBC), soil microbial biomass nitrogen (SMBN) and dehydrogenase activity (DHA) compared to NPK through chemical fertilizers without organics. Application of farmyard manure at 10 t ha^{-1} significantly increased SMBC, SMBN and DHA over control which might be due to a steady source of organic carbon to support the microbial community (Bhattacharya *et al.*, 2008).

Table 4.11: Effect of INM on soil microbial biomass carbon (µg C g $^{-1}$ dry soil) at tillering and harvesting stage of rice

Integrated nutrient management	Soil Microbial Biomass Carbon (µg C g $^{-1}$ dry soil)	
	Tillering	Harvesting
T_1- Control	103.56	74.86
T_2- FYM 5 t ha^{-1}	119.69	95.62
T_3- BGA 10 kg ha^{-1}	110.60	98.75
T_4- 100% GRD (100:60:40)	122.30	97.38
T_5- 100% GRD + 5 t FYM ha^{-1}	133.39	110.01
T_6- 75% GRD + 5 t FYM ha^{-1}	129.82	102.38
T_7- 100% GRD + 10 kg BGA ha^{-1}	130.72	102.78
T_8- 75% GRD + 10 kg BGA ha^{-1}	122.67	86.34
T_9- FYM 5 t ha^{-1} + 10 kg BGA ha^{-1}	120.44	96.72
T_{10}- STCR dose with 5 t FYM for YT 50 q ha^{-1}	131.96	109.42
SEm±	0.57	0.34
CD (P = 0.05)	1.71	1.01

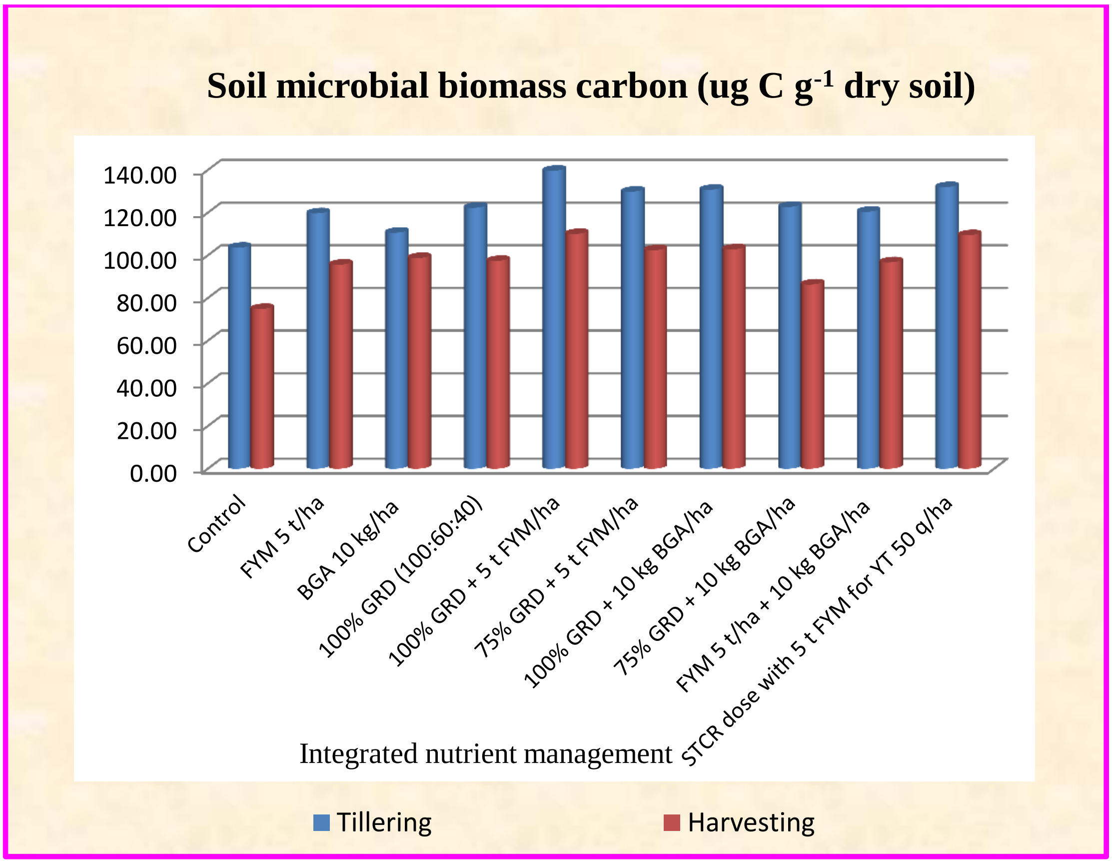


Fig.4.10: Effect of INM on the soil microbial biomass carbon (µg C g $^{-1}$ dry soil) at tillering and harvesting stage of rice

4.4 Effect of INM on pH, EC and Organic carbon in soil

4.4.1 pH

The data pertaining to pH after rice harvest as influenced by different INM treatments have been presented in Table 4.12. The pH ranged from 6.90 to 6.97 after rice harvesting. Different INM treatments could not produce any significant difference in pH after rice harvest.

4.4.2 Electrical Conductivity (dS m^{-1})

The electrical conductivity of soil after rice harvest as influenced by different INM treatments have been presented in Table 4.12. The EC ranged from 0.24 to 0.27 dS m^{-1} after rice harvesting. All the treatments were statistically similar as different INM treatments could not produce any significant difference in EC after rice harvest. Similar findings were observed by Chesti *et al.* 2013. They observed non-significant change in soil pH and EC of the soil even after three consecutive years.

4.4.3 Organic Carbon (%)

The organic carbon content of soil after rice harvest as influenced by different INM treatments have been presented in Table 4.12. The OC ranged from 0.28 to 0.32 % after rice harvesting. All the treatments were statistically similar as different INM treatments could not produce any significant difference in OC after rice harvest. However, the treatment 100% GRD + 5 t FYM ha^{-1} T_5 and FYM 5 t ha^{-1} + 10 kg BGA ha^{-1} (T_9) recorded the maximum value of organic carbon content. Addition of FYM might have created environment conducive for formation of humic acid, which ultimately resulted in an increase in the organic carbon content of the soil (Bajpai *et al*. 2006). Barar and Dongale (2013) found non-significant increase over control in organic carbon content in soil after rice harvest.

Table 4.12: Effect of INM on pH, EC and Organic carbon in soil at harvest stage of rice

Integrated nutrient management	pH	Electrical Conductivity (dS m^{-1})	Organic Carbon (%)
T_1- Control	6.93	0.26	0.28
T_2- FYM 5 t ha^{-1}	6.90	0.25	0.31
T_3- BGA 10 kg ha^{-1}	6.91	0.25	0.30
T_4- 100% GRD (100:60:40)	6.97	0.27	0.31
T_5- 100% GRD + 5 t FYM ha^{-1}	6.91	0.25	0.32
T_6- 75% GRD + 5 t FYM ha^{-1}	6.90	0.25	0.31
T_7- 100% GRD + 10 kg BGA ha^{-1}	6.91	0.26	0.31
T_8- 75% GRD + 10 kg BGA ha^{-1}	6.91	0.26	0.31
T_9- FYM 5 t ha^{-1} + 10 kg BGA ha^{-1}	6.90	0.24	0.32
T_{10}- STCR dose with 5 t FYM for YT 50 q ha^{-1}	6.90	0.25	0.31
SEm±	0.04	0.01	0.02
CD (P = 0.05)	NS	NS	NS

4.5 Effect of INM on available NPK in soil

4.5.1 Available nitrogen (kg ha^{-1}) in soil

The fertility status of soil in terms of available nitrogen as affected by INM treatments after harvesting of rice crop have been shown in Table 4.13 and Fig. 4.11. Available N in soil after harvest of rice crop ranged from 205 to 238 kg ha^{-1}. Based on the overall means, treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) recorded maximum value of available N, it was statistically superior not only over control (T_1), but also over treatments FYM 5 t ha^{-1} (T_2) and BGA 10 kg ha^{-1} (T_3). However, it was statistically similar with rest of the treatments. The increase in available N might be attributed to the enhanced multiplication of microbes by the incorporation of manures for the conversion of organically bound N to inorganic form. The favourable soil conditions under organic manure application might have facilitated the mineralization of soil N leading to build-up of higher available N (Kumar and Singh, 2010). These results are in line with findings of

Singh *et al.* (2009) who also observed that available N content in soil increased with the use of recommended dose of fertilizer in combination with manure.

4.5.2 Available phosphorus (kg ha^{-1}) in soil

The fertility status of soil in terms of available phosphorus as affected by INM treatments after harvesting of rice crop have been shown in Table 4.13 and Fig. 4.12. Available P in soil after harvest of rice crop ranged from 5.8 to 9.0 kg ha^{-1}. There was significant increase in available P over Control (T_1), FYM 5 t ha^{-1} (T_2), BGA 10 kg ha^{-1} (T_3), and FYM 5 t ha^{-1} + 10 kg BGA ha^{-1} (T_9) due to treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}), while it was statistically similar to treatments 100% GRD (100:60:40) (T_4), 100% GRD + 5 t FYM ha^{-1} (T_5), 75% GRD + 5 t FYM ha^{-1} (T_6), 100% GRD + 10 kg BGA ha^{-1} (T_7) and 75% GRD + 10 kg BGA ha^{-1} (T_8). Application of only FYM and BGA could not cause significant increase in available P in soil over control while treatment FYM 5 t ha^{-1} + 10 kg BGA ha^{-1} (T_9) significantly increased available P in soil. Increase in available phosphorus with the application of NPK fertilizers alone or in conjunction with organics might be due to the release of organic acids during decomposition which in turn helped in releasing phosphorus through solubilizing action of native phosphorus in the soil (Babhulkar *et al.,* 2000; Gupta *et al.,* 2006; Singh *et al.,* 2007 and Urkurkar *et al.,* 2010). The organic matter also forms a cover on sesquioxides and makes them inactive and thus reduces the phosphate fixing capacity of the soil, which ultimately, helps in release of ample quantity of phosphorus as reported by Tandon (1987).

4.5.3 Available potassium (kg ha^{-1}) in soil

The fertility status of soil in terms of available potassium as affected by INM treatments after harvesting of rice crop have been shown in Table 4.13 and Fig. 4.13. Available K in soil after harvest of rice crop ranged from 268 to 284 kg ha^{-1}. Maximum and significantly higher value of available K was observed in treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}). There was non-significant increase in available K in soil after rice harvest with the addition of different treatments. Increase in available potassium due to addition of organic manures may be ascribed to the reduction of potassium fixation and release of potassium due to interaction of organic matter with clay, besides the direct potassium addition to the pool of soil (Urkurkar *et al.*, 2010). Such increase in the content of available potassium with the use of organics with chemical fertilizers has also been reported by Gupta *et al.* (2006) and Singh *et al.* (2007).

Table 4.13: Effect of INM on available NPK in soil at harvest stage of rice

Integrated nutrient management	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
T_1- Control	205	5.8	268
T_2- FYM 5 t ha^{-1}	213	7.0	275
T_3- BGA 10 kg ha^{-1}	209	6.7	273
T_4- 100% GRD (100:60:40)	226	8.3	277
T_5- 100% GRD + 5 t FYM ha^{-1}	234	8.9	282
T_6- 75% GRD + 5 t FYM ha^{-1}	230	8.8	281
T_7- 100% GRD + 10 kg BGA ha^{-1}	234	8.8	279
T_8- 75% GRD + 10 kg BGA ha^{-1}	230	8.4	277
T_9- FYM 5 t ha^{-1} + 10 kg BGA ha^{-1}	217	8.2	277
T_{10}- STCR dose with 5 t FYM for YT 50 q ha^{-1}	238	9.0	284
SEm±	7.9	0.2	4.8
CD (P = 0.05)	23.5	0.7	NS

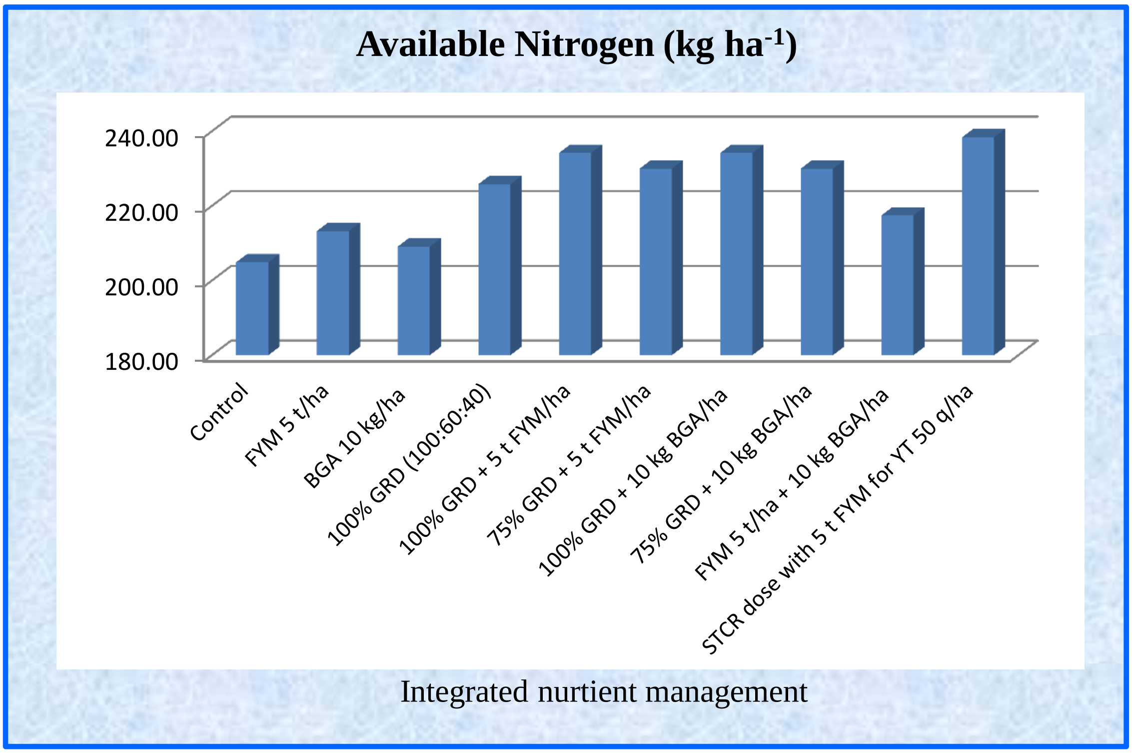


Fig.4.11: Effect of INM on the available nitrogen (kg ha^{-1}) in soil at harvest stage of rice

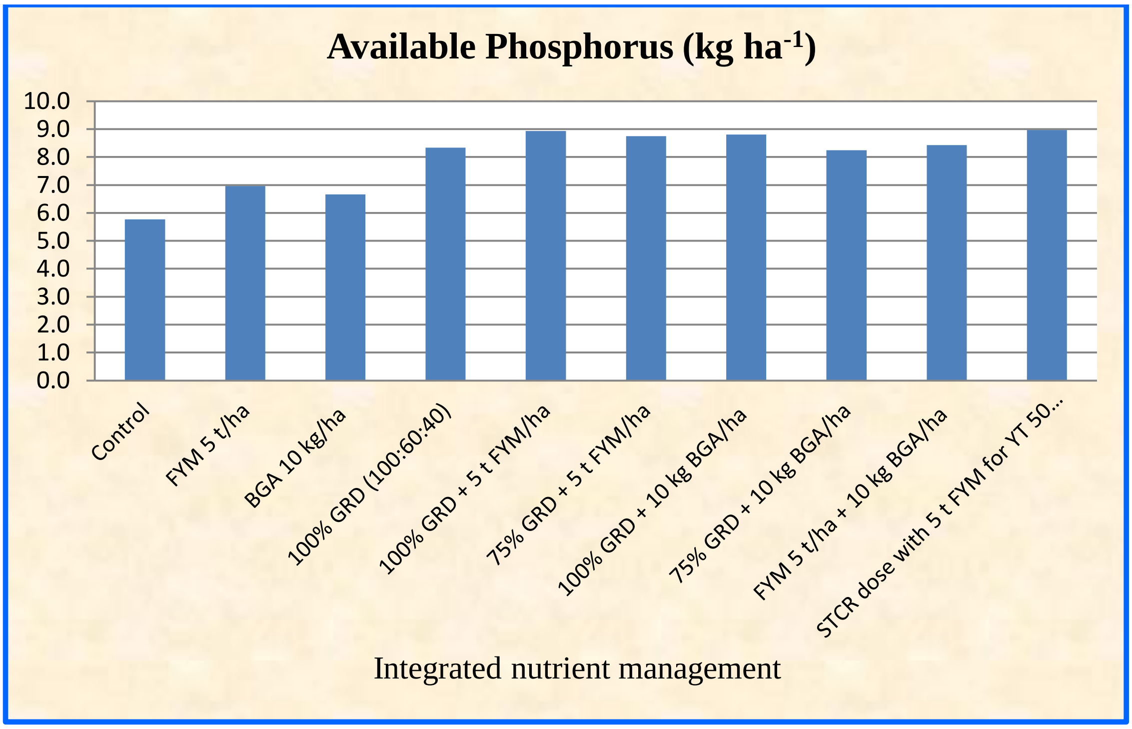


Fig.4.12: Effect of INM on the available phosphorus (kg ha^{-1}) in soil at harvest stage of rice

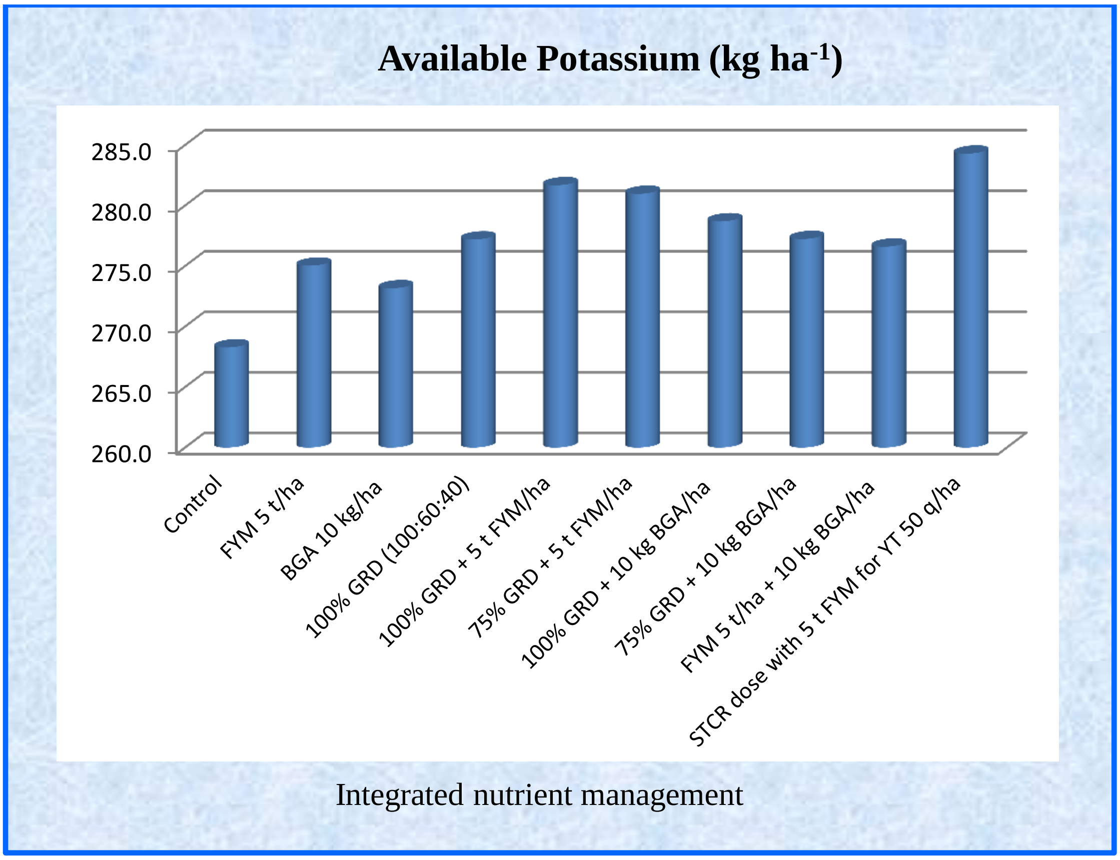


Fig.4.13: Effect INM on the available potassium (kg ha^{-1}) in soil at harvest stage of rice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जाँजगीर-चाम्पा
शोध विषय :-
''धान में एकीकृत पोषक तत्व प्रबंधन''
परीक्षण वर्ष :-
खरीफ 2014
शोध विद्यार्थी :-
युगलकिशोर साहू
एम.एस.सी. कृषि रसायन विभाग
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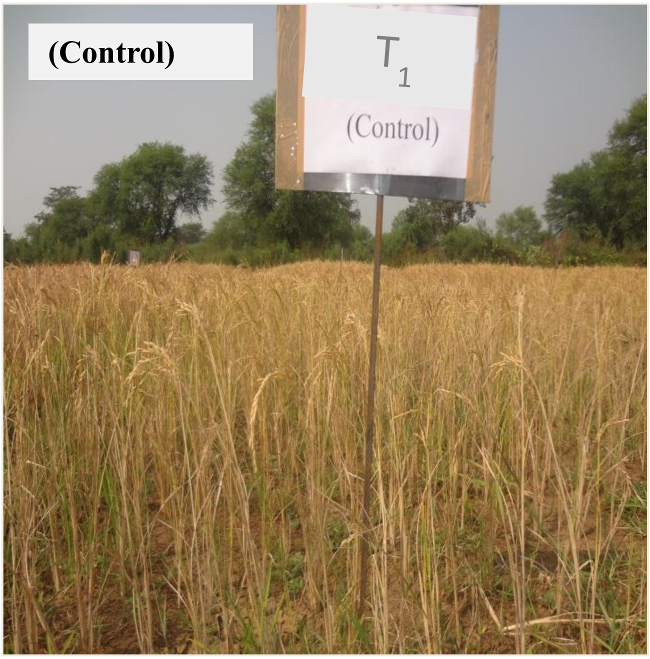
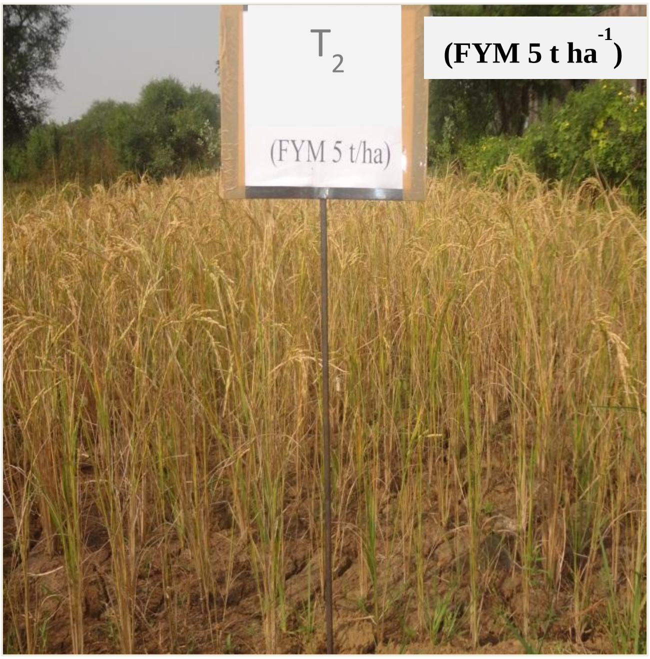
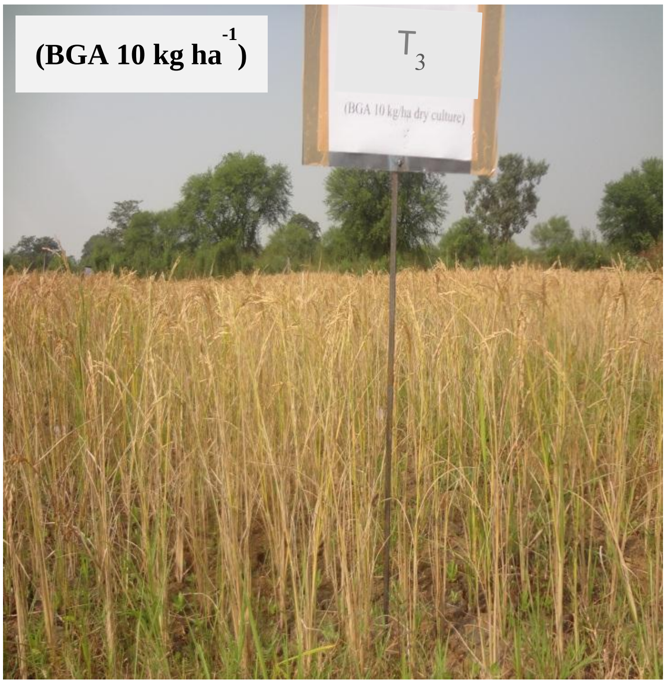
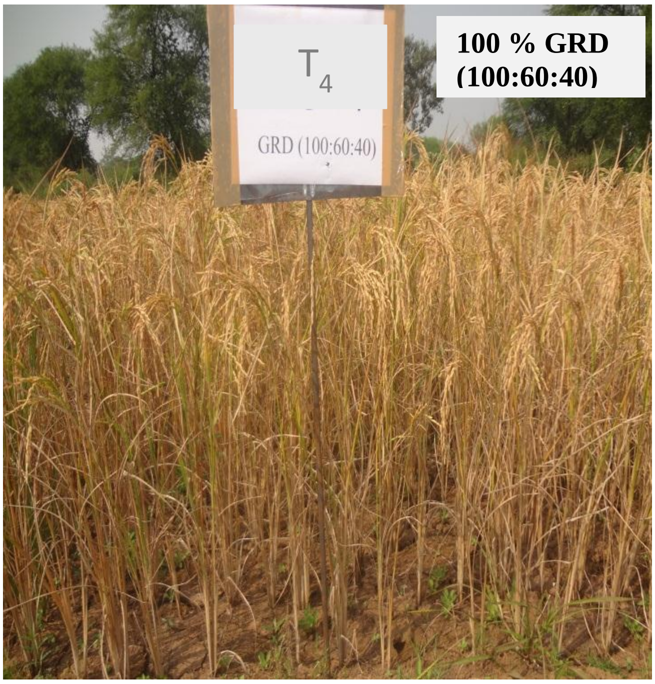
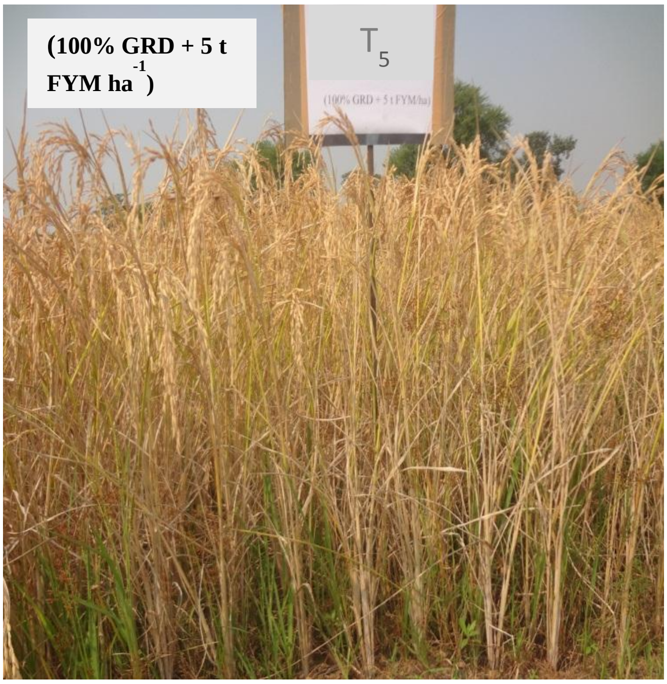
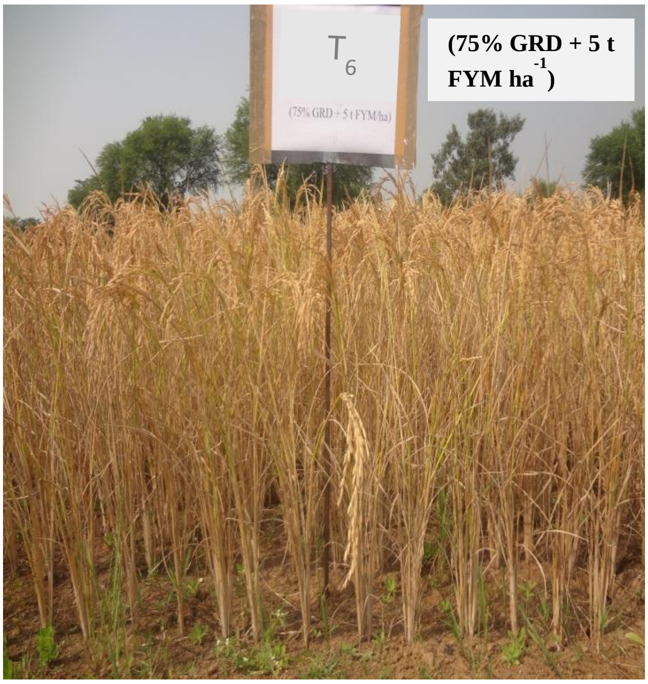

(Control)
T1
(Control)

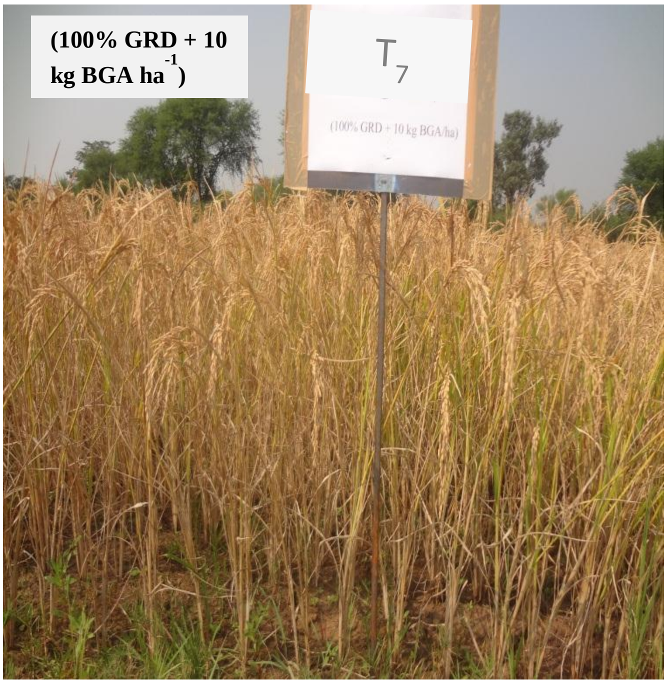

T2
(FYM 5 t/ha)
(FYM 5 t ha-1)

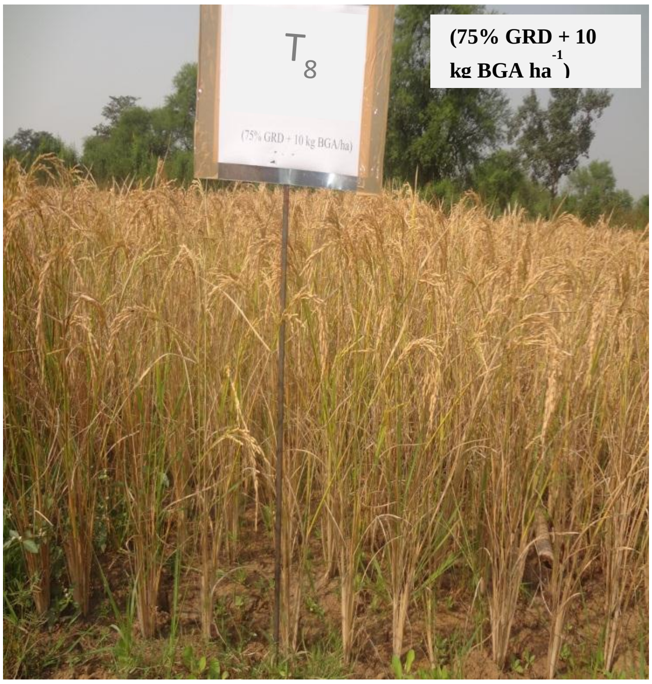

(BGA 10 kg ha^{-1})
T_3
(BGA 10 kg/ha dry culture)


100 % GRD (100:60:40)
T_4
GRD (100:60:40)


(100% GRD + 5 t FYM ha^{-1})
T_5


(75% GRD + 5 t FYM ha^{-1})
T_6


(100% GRD + 10 kg BGA ha-1)
T7
(100% GRD + 10 kg BGA/ha)


(75% GRD + 10 kg BGA ha-1)
T8
(75% GRD + 10 kg BGA/ha)


(FYM 5 t ha-1 + 10kg BGA ha-1)
T9
(FYM 5 t/ha + 10 kg BGA/ha)


(STCR dose with 5 t FYM for YT 50 q ha-1
T10

CHAPTER-V
SUMMARY AND CONCLUSION

Under limited nutrient supply the possibility of taking successful production of rice crop is feasible only through careful implementation of scientific agro-techniques. In Chhattisgarh plains, cultivation of rice is possible with judicious utilization of nutrient sources with respect to different inputs management. Among several constraints of production, nutrient management plays a key role in realizing sustainable yield from any given cultivation practices. Use of organics not only helps to sustain crop yields but also plays a key role by exhibiting both direct as well as indirect influence on nutrient availability in soil by improving the various biological, physical and chemical properties of the soils that lead to increased fertilizer use efficiency. It also plays vital role on sustaining crop growth, productivity and soil fertility on long-term basis. Keeping this background in view, present investigation entitled **"Integrated nutrient management in rice in *Inceptisols* of Janjgir-Champa district of Chhattisgarh"** was carried out with the following objectives:

4. To assess the effect of integrated nutrient management on growth and yield of rice
5. To evaluate the effect of different treatments on nutrient content in plant and their uptake by rice at different growth stages
6. To find out the microbial status of the soil

Field experiment was conducted at College of Agriculture and Research Station, Janjgir-Champa, an out campus of IGKV, Raipur (C.G.) during *Kharif* season 2014. The total gross plot area experimental was 816 m^2 with gross plot size of 8.0 m x 3.4 m and net plot size of 7.6 m x 3.2 m. The experiment consisted of ten treatments i.e. Control (T_1), FYM 5 t ha^{-1} (T_2), BGA 10 kg ha^{-1} (T_3), 100% GRD (100:60:40) (T_4), 100% GRD + 5 t FYM ha^{-1} (T_5), 75% GRD + 5 t FYM ha^{-1} (T_6), 100% GRD + 10 kg BGA ha^{-1} (T_7), 75% GRD + 10 kg BGA ha^{-1} (T_8), FYM 5 t ha^{-1} + 10 kg BGA ha^{-1} (T_9) and STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10})

laid out in randomized block design with three replications. The rice variety "MTU-1010" was transplanted on 02 August 2014 and harvested on 08 November 2014.

The experimental findings are summarized as follows:

Treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) was found to be significantly superior not only over control (T_1) but also rest of the treatments in increasing the plant height and in case of dry matter accumulation of rice STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) was found significantly higher not only over control but also over rest of the treatments, but it was statically at par with 100% GRD + 5 t FYM ha-^{1} (T_5) at 30 DAT, 60 DAT and at harvest stages of rice.

Treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) was observed significantly higher not only over control but also over rest of the treatments in increasing the number of total and effective tillers in rice, but it was statistically at par to 100% GRD + 5 t FYM ha^{-1} (T_5).

Treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) registered significantly higher panicle length over control, but it was statistically similar with treatment 100% GRD (100:60:40) (T_4), 100% GRD + 5 t FYM ha^{-1} (T_5), 75% GRD + 5 t FYM ha^{-1} (T_6), 100% GRD + 10 kg BGA ha^{-1} (T_7) and 75% GRD + 10 kg BGA ha^{-1} (T_8). In case of number of total filled grains $panicle^{-1}$ treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) recorded significantly higher value as compared to rest of the treatment, however it was statistically similar to treatments 100% GRD + 5 t FYM ha^{-1} (T_5) and 100% GRD + 10 kg BGA ha^{-1} (T_7).

The highest values of test weight and grain and straw yield of rice was recorded with STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}). In case of test weight of rice, non-significant result was observed. As regards to grain and straw yield of rice, significantly higher value was noted in treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) as compare to rest of the treatments, however it was statistically similar to treatments100% GRD (100:60:40) (T_4), 100% GRD+ 5 t FYM ha $^{-1}$ (T_5) and 100% GRD+ 10 kg BGA ha^{-1} (T_7).

The N, P and K content at different stages of rice was found non-significant.

The uptake of N by grain and total biomass was found to be maximum due to STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) which was statistically at par with 100% GRD + 5 t FYM ha^{-1} (T_5) and 100% GRD + 10 kg BGA ha^{-1} (T_7). The uptake of N by straw was found maximum due to treatment 100% GRD + 5 t FYM ha^{-1} (T_5) which was statistically at par with treatments STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}), 100% GRD + 10 kg BGA ha^{-1} (T_7), 100% GRD(100:60:40) (T_4) and 75% GRD + 5 t FYM ha^{-1} (T_6) in decreasing order.

As for as phosphate uptake in grain and total biomass significantly higher value was noted in treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) as compare to rest of the treatment, however it was statistically similar to treatment 100% GRD + 5 t FYM ha^{-1} (T_5) and 100% GRD + 10 kg BGA ha^{-1} (T_7). Whereas, in case of straw, significantly higher P uptake over cotrol was noted in treatment 100% GRD + 5 t FYM ha^{-1} (T_5) then other, but it was found at par to treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}).

Potassium uptake in grain was significantly higher in treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) but it was at par to treatment 100% GRD(100:60:40) (T_4), 100% GRD + 5 t FYM ha^{-1} (T_5), 75% GRD + 5 t FYM ha^{-1} (T_6), 100% GRD + 10 kg BGA ha^{-1} (T_7), 75% GRD + 10 kg BGA ha^{-1} (T_8). In case of straw, significantly higher K uptake was observed in treatment 100% GRD + 5 t FYM ha^{-1} (T_5), however it was statistically similar to treatment 100% GRD(100:60:40) (T_4), 75% GRD + 5 t FYM ha^{-1} (T_6), 100% GRD + 10 kg BGA ha^{-1} (T_7) and STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}). As regards to K uptake by total biomass, treatment 100% GRD + 5 t FYM ha^{-1} (T_5) registered significantly higher value as compared to rest of the treatment, it was comparable to GRD(100:60:40) (T_4), 75% GRD + 5 t FYM ha^{-1} (T_6), 100% GRD + 10 kg BGA ha^{-1} (T_7), 75% GRD + 10 kg BGA ha^{-1} (T_8) and STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}).

A critical observation of the data reveals that the performance of treatments STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) and 100% GRD + 5 t FYM ha^{-1} (T_5), in general was better over other treatments in increasing the uptake of N, P and K in rice.

Dehydrogenase activity at tillering was found significantly higher not only over control but also over rest of the treatments because of the treatment 100% GRD + 5 t FYM ha^{-1} (T_5) containing both inorganic (100% GRD) and organic (5 t FYM ha^{-1}) in their treatment combination. However, after harvesting of rice maximum value of dehydrogenase activity was recorded with 100% GRD + 5 t FYM ha^{-1} (T_5) which was statistically superior over control (T_1) but statistically smilar with STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}), 100% GRD + 10 kg BGA ha^{-1} (T_7) and 75% GRD + 5 t FYM ha^{-1} (T_6). There was non-significant increase in total bacterial count over control (T_1) at both the stages tillering and after harvesting. Treatment 100% GRD+5 t FYM ha^{-1} (T_5) recorded maximum and significantly higher value of Soil Microbial Biomass Carbon (SMBC) over control (T_1) and rest of the treatments except STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}).

Different INM treatments could not produce any significant difference in pH, EC, Organic carbon after rice harvest. However, the treatments 100% GRD + 5 t FYM ha^{-1} (T_5) and FYM 5 t ha^{-1} + 10 kg BGA ha^{-1} (T_9) recorded the maximum value of organic carbon (%).

Based on the overall means, treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) recorded maximum value of available N, it was statistically superior not only over control (T_1), but also over treatments FYM 5 t ha^{-1} (T_2) and BGA 10 kg ha^{-1} (T_3). However, it was statistically similar with rest of the treatments. There was significant increase in available P over Control (T_1), FYM 5 t ha^{-1} (T_2), BGA 10 kg ha^{-1} (T_3), and FYM 5 t ha^{-1} + 10 kg BGA ha^{-1} (T_9) due to treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}), while it was statistically similar to treatments 100% GRD (100:60:40) (T_4), 100% GRD + 5 t FYM ha^{-1} (T_5), 75% GRD + 5 t FYM ha^{-1} (T_6), 100% GRD + 10 kg BGA ha^{-1} (T_7) and 75% GRD + 10 kg BGA ha^{-1} (T_8). Maximum and significantly higher value of available K was observed in treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) which was statistically similar with rest of the treatments.

CONCLUSION

- Combined application of organic sources with inorganic fertilizer was found more effective as compared to single application. Integrated use of organics and inorganics has sustained the crop yield, improved the soil physical, chemical, biological properties and nutrient status of the soil.
- As regards to grain and straw yield of rice, significantly higher value was noted in treatment STCR dose with 5 t FYM for YT 50 q ha-1 (T10) as compared to rest of the treatments, however it was statistically similar to treatments 100% GRD (100:60:40) (T4), 100% GRD+ 5 t FYM ha -1 (T5) and 100% GRD+ 10 kg BGA ha-1 (T7).
- A critical observation of the data reveals that the performance of STCR dose with 5 t FYM for yield target of 50 q ha^{-1} (T_{10}) and 100% GRD+ 5 t FYM ha^{-1} (T_5), in general, was better over other treatments in increasing the uptake of N, P & K in rice, available N, P, K and microbial status in soil, yield and yield attributes of rice crop.

SUGGESTIONS FOR FUTURE RESEARCH WORKS

Since, it was the first year of experimentation, the present investigation needs confirmation and field experiment may be further repeated for two more growing season. The information generated as soil test based fertilizer application with organic source need to be tested on farmer’s field in the similar soil situation for its suitability. If possible alternative organic sources should be tested for sustaining the yield and improving soil properties under Chhattisgarh agro climatic conditions to find out the best one.

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APPENDICES

Appendix – A

Media for Total Bacteria

Nutrient Agar Media

Beef extract-3.0g

Peptone- 5.0g

Agar - 15.0g

Distilled water - 1000ml

Appendix – B

Preparation of TTC (Triphynyl Tetrazolium Chloride) 3% solution

1. Take 100 ml volumetric flask.
2. Weight 3 g. TTC powder in 100 ml volumetric flask.
3. Add 80 ml distil water in volumetric flask and mixed properly.
4. Made the volume 100 ml with distil water.

Appendix - C

Preparation of TPF (Triphynyl Farmzone) solution

1. Take 100 ml volumetric flask.
2. Weight 0.1 g. TPF powder in 100 ml volumetric flask.
3. Add 80 ml methanol in volumetric flask and mixed properly.
4. Made the volume 100 ml with methanol.

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