"LONG TERM EFFECT OF INORGANIC FERTILIZERS AND ORGANIC MANURES ON SOIL FERTILITY STATUS, MICROBIAL BIOMASS CARBON, NUTRIENT UPTAKE AND YIELD OF RICE ON INCEPTISOL"

M.Sc. (Ag.) THESIS

by

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CERTIFICATE-I

This is to certify that the thesis entitled **"LONG TERM EFFECT OF INORGANIC FERTILIZERS AND ORGANIC MANURES ON SOIL FERTILITY STATUS, MICROBIAL BIOMASS CARBON, NUTRIENT UPTAKE AND YIELD OF RICE ON INCEPTISOL"** 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 **Kiran Rathore** under my guidance and supervision. The subject of the thesis has been approved by Student's Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma (certificate awarded etc.) 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 her.

Date: 8-8-2013

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CERTIFICATE – II

This is to certify that the thesis entitled **"LONG TERM EFFECT OF INORGANIC FERTILIZERS AND ORGANIC MANURES ON SOIL FERTILITY STATUS, MICROBIAL BIOMASS CARBON, NUTRIENT UPTAKE AND YIELD OF RICE ON INCEPTISOL"** submitted by **Kiran Rathore** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur in partial fulfillment of the requirements for the degree of M.Sc.**(Ag.)** in the **Department of Soil Science and Agricultural Chemistry** has been approved by the external examiner and Student's Advisory Committee after oral examination.

Date: 04.09.2013

EXTERNAL EXAMINER

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Introduction

CHAPTER-I

INTRODUCTION

India is the second largest rice producing country in the world after China. Although rice planted area in India is 40 per cent higher than in China, Indian rice production is 30 percent below than Chinese production because of lower yields (2.3 tonnes per hectare in India vs. 4.7 tonnes in China). Indian rice yields are well below the world average (2.9 tonnes/hectare), implying there is a great potential for increasing production.

Rice is an important crop grown in nearly 44 million ha of land in the country with the productivity of 2.2 t/ha which is less than the productivity of many Asian countries. In Chhattisgarh, rice occupies average of 3.6 million ha with the productivity of the state ranging between 1.2 to 1.6 t/ha depending upon the rainfall.

Chhattisgarh state occupies 13.51 million hectares with a gross cropped area of about 5.68 million ha. The geographical area of the state is situated between 17046' to 2406' N latitude and 80015' to 84051' E longitude. Elevations are ranging from 300 to 600 meter above the mean sea level.

Rice is being grown on wide range of soil and climatic conditions, Inceptisol are shallow, well-drained, loamy soils on the gentle sloping and undulating plateau (slightly dissected) with moderate erosion and occurrence of stones. They are immature soils with weakly developed profile features. They are classified as loamy, kaolinitic, isohyperthermic, Lithic Ustropepts. Inceptisol are locally called matasi soil. They have a light texture and a shallow to moderate depth. These soils are widely used for growing short-duration rice after bunding and leveling. After rice, they are left fallow under rainfed conditions.

In the coming decades, a major issue in designing sustainable agricultural systems will be the management of soil organic matter and the rational use of organic inputs such as animal manures, industrial wastes, green manure and crop residues (Powlson 1994). Maintaining or increasing soil organic matter content is of great benefit in terms of recycling plant nutrients, minimizing the need for inorganic fertilizers, and improving soil physical condition. Farmyard manure is the most commonly used organic manure, but it is limited in supply and contains low and variable nutrient contents. Green manures offer considerable potential as a source of plant nutrients and organic matter.

Soil organic matter is thus an important component of soil quality and productivity. Nevertheless, its measurement alone does not adequately reflect changes in soil quality and nutrient status (Mathers *et al.*, 2000; Chen *et al.*, 2004). Measurements of biologically active fractions of organic matter, such as microbial biomass carbon (MBC) and nitrogen (MBN), and potential C and N mineralization better reflects changes in soil quality and productivity that alter nutrient dynamics (Hole *et al.*, 2005). Because it is living, the microbial biomass responds much more quickly to changing soil conditions, particularly decrease or increase in plant or animal residues, than does soil organic matter as a whole. Measurable changes in microbial biomass would thus reflect changes in soil fertility due, for example, to changes in the total pool of soil organic matter (Brookes, 1995; El-Ghamry *et al.*, 2001). The soil microbial biomass (MBC and MBN) is the active component of the soil organic pool playing an important role in nutrient cycling and plant nutrition and functioning of different ecosystems. It is responsible for organic matter decomposition thus affecting soil nutrient content and, consequently, primary productivity in most biogeochemical processes in terrestrial ecosystems (Gregorich *et al.*, 2000; Haney *et al.*, 2001). Applying organic amendments to soil not only increases the total organic carbon content and its different fractions but also has a series of effects on microbial proliferation and activity (Tejada *et al.*, 2006; Ros *et al.*, 2003). Soil microbial biomass is undoubtedly a valuable tool for understanding and predicting changes in soil fertility management and associated soil conditions such as nutrient dynamics and soil reaction (Sharma *et al.*, 2004; Yougun *et al.*, 2007). It has assumed greater significance and increasing interest in its determination (Azam *et al.*, 2003).

One of the most important roles of the microbial biomass is the conversion of organic matter into mineral nutrients available for plant uptake. The microbial biomass is important for transforming nitrogen, phosphorus, sulphur, potassium, calcium, magnesium, manganese and zinc into forms that can be used by plants. If it weren't for soil microbes, plant nutrients would remain 'locked away' indead plant and animal tissue. About half the microbial biomass is located in the surface 10 cm of a soil profile and most of the nutrient release also occurs here.

Soil microbial diversity is one of the most important microbial parameters in soil. It has been demonstrated that soil microbial diversity is affected by anthropogenic disturbance (Fox and MacDonald, 2003). Inorganic fertilizers, especially nitrogen (N), phosphorus (P) and potassium (K), not only serve to maintain or improve crop yields, but their application also directly or indirectly induce changes in soil chemical, physical and biological properties. These changes, in the long-term, are believed to have significant influences on the quality and productive capacity of the soil (Acton and Gregorich, 1995). However, available information is conflicting and uncertainties still remain about the long-term influence of inorganic fertilizers on soil microbial biomass and microbial diversity. Some studies showed that chemical fertilizers increase biomass C and N(Lynch and Panting, 1982; Kanazawa *et al*., 1988; Goyal *et al*., 1992), but Sarathchandra *et al.* (2001) reported that nitrogen and phosphate fertilizers had no significant effects on soil microbial populations and N application reduced the functional microbial diversity in pasture soils.

Several studies have documented the long term beneficial effect of organic fertilization on yield decline reversal. The benefits include sustaining high yield levels through the combined application of inorganic and organic amendments, and at the same time improving the overall soil health by improving SOM levels and microbial activity. Li *et al.* (2010) demonstrated that long term organic amendments (OA) usually enhanced rice yields but the effect depends on the quantity and quality of the organic amendments, and the inherent nutrient and the SOC levels in soil. Similarly, the long-term evaluation of the effects of organic amendments on the rice yields for double rice cropping systems in subtropical China was positive on the yield trends for either first or second rice crop in the treatments except for those without sufficient nutrient supply (Bi *et al.* 2009). This positive effect was attributed mainly to the increased soil organic carbon and soil nutrient capacity due to the long-term application of OA.

All the above facts draw our attention towards adopting of integrated nutrient management system and compared with use of chemical fertilizer alone. In view of the above facts, the present experiment entitled **"LONG TERM EFFECT OF INORGANIC FERTILIZERS AND ORGANIC MANURES ON SOIL FERTILITY STATUS, MICROBIAL BIOMASS CARBON, NUTRIENT UPTAKE AND YIELD OF RICE ON INCEPTISOL"** was undertaken with the following objectives:-

1. To study the influence of continuous use of inorganic fertilizers, green manuring, rice residue and F.Y.M. application on soil fertility status.
2. To quantify the macro nutrient (N, P and K) uptake by rice crop as influenced by different nutrient sources.
3. To find out the N, P and K balance sheet under internal nutrients supply system.
4. To study the effect of Integrated nutrient management practices on soil microbial biomass carbon.
5. To assess the effect of combination of inorganic and organic treatment on growth and yield of rice crop.

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

The integrated nutrient management (green manure, FYM, rice residues and fertilizers) greatly influenced the production of rice. It will guarantee for agricultural production at high level with high quality produce while restoration, improvement and maintenance of soil fertility.

A brief review of work done presented in this chapter under the following heads.

2.1 Effect of Inorganic fertilizers on

2.1.1 Soil fertility status

2.1.2 Nutrient concentration and their uptake

2.1.3 Soil microbial biomass carbon

2.1.4 Growth and development

2.1.5 Yield

2.2 Effect of Integrated nutrient management on

2.2.1 Soil fertility status

2.2.2 Nutrient concentration and their uptake

2.2.3 Soil microbial biomass carbon

2.2.4 Growth and development

2.2.5 Yield

2.1 Effect of Inorganic fertilizers on

2.1.1. Soil fertility status

Acton and Gregorich (1995) reported that inorganic fertilizers, especially nitrogen

(N), phosphorus (P) and potassium (K), serve to maintain or improve crop yields, but their application also directly or indirectly induces changes in soil chemical, physical and biological properties. These changes, in the long-term experiment are believed to have significant influences on the quality and productive capacity of the soil.

Dev G. (1997) reported that different techniques used for evaluating soil fertility and approaches for recommending balanced fertilizer use based on soil tests are described. The approach of general fertilizer recommendations related to soil test ratings is in common use though it has its shortcomings. Because of the changing trend in agriculture, yield target concept and fertilizer recommendations for maximum profits per hectare (or economic base) are more promising. Yield target concept has the added advantage that targets can be varied by taking into consideration the resources available. In case of increased cost or lesser availability of fertilizers, relatively lower yield targets can be fixed and plant nutrients applied resulting in higher returns and maintenance of soil fertility. The recommendations must necessarily be point out to loss in yield and profit under the conditions of deviation from use of fertilizers in balanced proportion.

Ogbodo E.N. (2013) the impact of long term use of inorganic fertilizers on the chemical properties of soil. The results of the analysis indicated that the soils were very strongly acidic to acidic (4.0-5.6), whereas exchangeable acidity (EA) was very high across the entire locations. Organic carbon (OC) ranged from low to high (0.51-1.84); Cation Exchange Capacity (CEC) was very low across the locations (1.65-4.5), whereas base saturation ranged from very low to low (42.06-50.10). Total nitrogen and exchangeable phosphorus ranged from moderate to medium (0.09-0.19 and 5. 70-24.8); potassium, calcium, magnesium and sodium ranged from very low to low (0.05-0.32; 0.86-5.10; 0.30-

2.0 and 0.09-0.25), respectively across the locations. The soil microbial populations were however stable and consistent with normal microbial population for natural agricultural soils.

2.1.2. Nutrient concentration and their uptake

Chaudhary and Sinha (2007) reported that N and Zn content and their uptake by rice plant at various stages of crop growth increased significantly by the application of increased dose of N and $ZnSO_4$. The maximum uptake of 90.2 kg N ha^{-1} was recorded at 120 kg N ha^{-1} application which might be due to the fact that plant absorbed N proportionately as the pool of available nitrogen increased in soil by addition of higher dose of nitrogen. Increase N adsorption by rice crop due to N. Application of $ZnSO_4$ increased the concentration and uptake of N at all the growth stages which might be attributed to easy transformation of urea available N with addition of Zn (Kumar *et al.* 1999).

Zaidi and Tripathi (2007) revealed that the application of N resulted in significant increased in total N uptake with an increase in the dose upto 150 kg N ha^{-1}, during all the three year. On average, the highest total N uptake of 123.11 kg ha^{-1} was recorded with application of 150 kg N ha^{-1} and showing additional uptake of 78.46, 2-2.95 kg N ha^{-1}over 0, 50 and 100 kg N ha^{-1}, respectively. The highest agronomic efficiency of 26.54 kg grain per kg N^{-1} applied was recorded with 100 kg ha^{-1}which showed an increase of 2.39 kg grain per kg N^{-1} applied over 50 and 150 kg N ha^{-1}, as reported by Gunri *et al.* (2004). Ramiah *et al.* (1987) have also reported that significant increases in N uptake with increase in nitrogen dose.

Sheoran *et al.* (2007) revealed that application of nitrogen through LCC based was significantly increase nitrogen content into grain (45.6-46.1 kg grain per kg^{-1} N applied). It was superior over farmer's practices (36.4 kg grain per kg^{-1} N produced) of which applied N through STCR (soil test crop response) model equation.

Bezbaruha *et al.* (2011) recorded that maximum N, P and K uptake values were recorded in 20 × 20 cm crop geometry and inorganic fertilizers treatment.

2.1.3 Soil microbial biomass carbon

Yan *et al.* (2000) showed that there was no significant correlation between soil microbial diversity (substrate utilization patterns) and soil organic C when the C contents were larger than 17.6 g kg^{-1}, but a positive relationship was observed at soil C contents below this level.

Qi and Guang (2005) revealed that the under long-term fertilizer experiment (LTFE) the balanced application of N, P and K promoted soil microbial biomass growth and improvement of community composition.

Zhong and Cai (2006) reported that the most microbial parameters were mainly correlated with soil organic carbon content rather than P and N, indicating that the application of P and N did not directly affect microbial parameters in the soil, but did so indirectly by increasing crop yields, thus promoting the accumulation of soil organic matter.

Zhong and Cai (2007) reported that microbial parameters were mainly correlated with soil organic carbon content rather than P and N, indicating that the application of P and N did not directly affect microbial parameters in the soil, but did so indirectly by increasing crop yields, thus promoting the accumulation of soil organic matter.

Liu *et al.* (2011) concluded that the application of N fertilizer improved soil microbial biomass and respiratory activity. But, microbial diversity was reduced when excessive urea was applied in the tested paddy soil and the increase both in SMBC and

SMBN under fertilization treatment was found very significantly correlated to the increase in SOC over controls across the sites. Also, the ratio of cultural fungal to bacterial population numbers (F/B ratio) was well correlated with soil organic carbon contents in all samples across the sites studied. SOC accumulation favoured a build-up of the microbial community with increasing fungal dominance in the rice paddies under fertilization treatments.

2.1.4. Growth and development

Singh *et al*. (1996) reported that increased level of N application upto 150 kg N ha^{-1} increased the growth components like plant height, leaves and dry matter accumulation in rice. Besides levels, its time of application greatly influenced the dry matter production.

Choudhary *et al.* (2007) reported that plant height and LAI significantly increase with application of N 120 kg ha^{-1} over control because of adequate N. Further they revealed that the increase of N application from 0 to 120 kg ha^{-1}, significantly and progressively increased the plant height, LAI, panicle m^{-2}, panicle length, grain $panicle^{-1}$ and 1000-grain weight. Plant growth depends on cell-division and enlargement for which adequate nutrition is essential. Hence crop receiving 120 kg ha^{-1} produced taller plants and more number of panicle m^{-2} (Gardner et al. 1988).

Sathiya *et al.* (2008) revealed that application of 175 kg N/ha in rice crop recorded significantly higher growth attributes, yield attributes and grain yield (4876 kg/ha) over 100 and 125 kg N/ha of aerobic rice.

Bezbaruha *et al*. (2011) conducted field experiments during the wet seasons of 2006 and 2007 at the Agricultural Experimental Farm of the Indian Statistical Institute, Giridih, a part of eastern plateau region of India. The study was designed to investigate the effect of planting geometry and nutrient management practices on productivity of two hybrid rice cultivars. Split-plot design with three replications was adopted to carry out the experiment by allocating combinations of treatments of planting geometry and rice cultivar in main-plots and nutrient management treatments in sub-plots. "CNRH-3" rice proved its efficiency in terms of grain yield and growth that was also reflected in yield and growth attributing characters such as number of productive tillers, number of grains per panicle, length of panicle, panicle weight, test weight and harvest index.

2.1.5. Yield

Dwivedi and Thakur (2000) reported that the treatment with 100:60:40 kg NPK/ha *i.e.* 100% NPK recorded significantly higher grain yields (43.25 and 44.38 q/ha) than the lower fertilizer rates (75 and 50% NPK) on rice crop.

Upadhyay *et al.* (2003) revealed that grain yield of rice increased significantly with 100 per cent recommended dose of N, P and K. They showed that the response to 100 per cent N, P and K dose was 311 kg ha^{-1} over the control yield of 229 kg ha^{-1} in rice, respectively.

Zaidi *et al.* (2007) reported that the application of splits of nitrogen i.e., $^{1}/_{3}$ at 7 day after transplanting + $^{1}/_{3}$ at panicle initiation stage produced maximum grain yield of 4881 kg ha^{-1} and 1528 kg ha^{-1}or 47.9 per cent higher than in the recommended method of N application.

Sheoran *et al.* (2007) revealed that application of N as per farmer's practice (195 kg N ha^{-1}) resulted the highest grain and straw yield and it was statistically at par with nitrogen application as dictated by soil test analysis and recommendation basis (150 kg N ha^{-1}). The per cent increase in grain yield due to farmer's practice, recommended dose of N, P and K and soil test based fertilizer application was 17.6, 15.3 and 1.3 per cent, respectively over LCC (leaf colour chart) based nitrogen scheduling practice.

Liao *et al.* (2010) reported that the application of K fertilizer (NPK) increased grain yield by 56.7 kg ha^{-1} over that obtained without K application (NP).

Bezbaruha *et al.* (2011) reported that rice cultivars grown with the application of inorganic fertilizers alone produced maximum grain yield and also recorded higher values of ancillary characters.

Parvathi *et al.* (2013) showed that application of NPK (20:10:25 kg ha-1) + gypsum + zinc sulphate recorded highest pod yield of 1499 kg ha^{-1} which was on par with NPK + gypsum and FYM alone treated plot in groundnut crop.

2.2 Effect of Integrated nutrient management on

2.2.1. Soil fertility status

Rattan and Singh (1997) reported that rice-wheat cropping system practiced in 9.5 million hectares area contributed to an estimated 21.86 per cent of the total 191.09 million tonnes of food grain production from 143 million hectares net cultivated area during 1994-95. However, concerns have been expressed that adoption of this highly intensive system has fatigued the soils in terms of declining crop and factor productivity. Imbalanced fertilizer use has been one of the key factors. Even the application of recommended NPK fertilizers devoid of organics has not been able to sustain its productivity. Review has been made on the role of balanced fertilization integrated nutrient management on the sustainability of the rice-wheat system.

Jaggi *et al.* (2001) reported that the long term fertilizer experiments have shown the continuous application of suboptimal doses of chemical fertilizers to soils had a deleterious effect on soil productivity. However, integrated use of organic manures with optimal levels of NPK fertilizers not only improved the nutrient status and soil health but also stabilized the crop yields at higher level. The integrated use of organic and chemical fertilizers at optimum levels as determined by soil test in LTFE's indicate the build up of micronutrient and/or secondary nutrient reserves such as Zn and S.

Zia *et al.* (2002) reported that integrated plant nutrient management strategy involving the use of inorganic fertilizers on soil test basis at the proper time, by appropriate method of application, in balanced form and using all the possible sources of organic manure (FYM, green manures, composts, crop straw and bio fertilizer etc), has to be adopted. This will definitely enhance the productivity of rice and wheat crops by improving soil fertility and ameliorating adverse soil physical conditions.

Zhao and Zhou (2011) showed that the combined application of organic and inorganic fertilizers could increase the organic matter, alkaline nitrogen, available phosphorus and potassium and increase the nutrient contents of soil and also the highest productivity contribution to black soil fertility. It was the best fertilization structure of increasing productivity level and improving the soil fertility.

Hou *et al.* (2011) reported that the twenty-five years plantation, organic manure application combined with chemical fertilizers treatments were 65.4%-71.5% ($P<0.05$) higher than CK, and 3.9%-7.8% ($P<0.05$) higher than NPK treatment in yield. Rice yield of 30F＋70M treatment was the highest in all treatments, reached 12 346.90 kg? hm^{-2}. The difference between 30F＋70M and NPK treatments in yield was widening with each passing year, the same as the 30F＋70M and 70F＋30M treatments. No fertilization for a long time result in soil fertility degeneration, there was a significant increase of soil fertility with a long-time balanced fertilization, and organic manure application combined with chemical fertilizers showed the most obvious increase of soil fertility relatively.

Hemalatha and Chellamuthu (2013) reported that the effect of continuous fertilization on soil nutrient status was studied after 36 years of cropping cycle on an Inceptisol. The soil reaction, as reflected in the pH, soil salinity as measured by EC has not changed significantly due to the different fertilizer schedules adopted over these years. The cation exchange capacity of the soil has increased significantly in the treatment receiving 100 per cent NPK+FYM. The organic carbon content of the soil has increased significantly in all the treatments that received NPK at different levels. The highest value of 6.2 g kg^{-1} was recorded in the treatment receiving NPK+FYM @ 10 t ha^{-1} which 55 per cent higher than control and also 107 per cent higher than the initial status. Available N, P and K status increased due to 100 percent NPK+ FYM application and recorded 195, 26.7, 639 kg ha^{-1}, respectively. The available statuses of Ca and Mg of the soil have increased significantly in all treatments recording the highest status on continuous application of integrated fertilizer management. The micronutrients like iron, zinc, manganese and copper were significantly higher in the treatment receiving 100 per cent NPK + FYM. The Integrated nutrient management practice sustained the soil fertility and soil health.

Rahman *et al.* (2012) noted that addition of mungbean residues or *Sesbania* biomass to the fertilizer schedule ensures higher crop productivity and sustains soil fertility in maize-legume-rice cropping pattern.

2.2.2. Nutrient concentration and their uptake

Swarup and Yaduvashi (2000) reported that soil pH was higher in inorganic fertilizer treatment plot as compared to NPK + green manure treatment plots. Continuous use of

NPK + green manure increased the organic carbon in 0-15 cm depth. There was a significant increase in the available P status of the soil in plot receiving fertilizer P and those getting green manure application over rest of the treatment. There was significant increase in available K status of the soil in plot receiving fertilizer K and those getting green manure over rest of the treatment.

Tiwari *et al.* (2000) reported that in rice, uptake of N was higher in the treatment 60 kg N+ green manure and 120 kg N + 60 kg P_2O_5 + K_2O ha^{-1} than 60 kg N ha^{-1} and control. The uptake of K was higher in treatment 60 kg N + 60 kg P_2O_5 and 120kg N+ 60 kg P_2O_5+ 60 kg K_2O ha^{-1} than 60 kg N ha^{-1} and control.

Sharma *et al*. (2001) studied additions of green manure or FYM resulted in higher removal of nutrients by the crops as compared to chemical fertilizers and build up of soil N, P, K, Zn and organic carbon while reduced the soil pH. Katyal *et al.* (2002) reported that increase in rice yield over years with application of 50% RDF (NPK) along with 50 per cent through FYM with application.

Bajpai *et al*. (2002) reported that the substitution of 50 per cent or recommended N to rice with either FYM or green manure along with 50 per cent RDF (NPK) through chemical fertilizer improves organic carbon and available nutrient status of soil. Similar, improvement was also observed in available N and P status of soil over initial values. Zia *et al.* (2002) revealed that application of FYM to rice not only increased the rice yield but it also improved the yield of following wheat crop.

Sharma *et al.* (2004) reported that grain as well as straw yield of rice was significantly higher when it was supplied with 50 per cent of recommended dose of NPK through chemical fertilizer along with 50 per cent of N through FYM as compared to control and farmer's practices. Gill *et al.* (2004) also supported of the above result and reported that agronomic efficiency (kg grain per kg^{-1} N applied) was maximum by 50 per cent N substituted through GM followed by 50 per cent N through FYM. Agronomic efficiency and higher recovery efficiency under 100 per cent RDN (recommended dose of nitrogen) + 5 tonne FYM recorded higher than 100 per cent RDN could be ascribed to move uptake of N, which might be due to prolonged N availability, as reported by Upadhyay *et al.* (2003).

Singh and Yadav (2004) reported that the values of plant height , shoot per running meter, dry matter accumulation at harvest, number of effective shoots, length of spike, number of spikelets, number of grain, grain weight per ear head and 1000-grain weight were significantly higher in the treatment with rice residues incorporation over rice residue removed and rice residue retained. Rice straw, used as crop residues helps in increasing fertility status of soil, and thus increases grain yield and quality of rice. Similar findings were also reported by Verma (2001).

Sarwar (2005) studied that increased concentration of NPK in paddy and straw of rice with the combined use of FYM, sesbania green manure and chemical fertilizer compared with application of chemical fertilizer and organic manures alone. Laxminarayana and Patiram (2006) 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.

Islam *et al.* (2010) reported that the highest nutrients uptake by both grain and straw was obtained from T_7: N P K + PM (Poultry manure) treatment and lowest from control. Dar *et al.* (2012) studied that uptake of nitrogen by paddy and straw was higher under integrated nutrient treatments. Kumar and Prasad (2008) reported that green manuring and green gram residue incorporation enhanced the uptake of N, P and K by rice and wheat.

Choudhary and Suri (2009) reported that the grain and straw yield as well as nutrient (NPK) uptake in both rice and wheat were significantly higher in plots receiving farm yard manure (FYM) @ 10 t ha^{-1}, followed by berseem (*Trifolium alexandrinum* L.) and green manure '*in-situ*'+ FYM incorporation.

Kumari and Reddy (2011) reported that the incorporation of field bean crop residues was found to be superior to any other crop residue incorporation with regard to growth and yield of rice as well as nutrient uptake.

Das *et al.* (2013) showed that FYM application @ 15 t ha^{-1} along with 100% NPK fertilizers produced maximum yields, nutrients uptake and along with improvement in soil properties.

2.2.3. Soil microbial biomass carbon

Goyal *et al.* (2009) showed that the application of rice straw compost @ 5 t/ha along with half of the recommended dose of inorganic fertilizer increased the microbial biomass C from 136 to 258 mg/kg.

Sun *et al*. (2010) showed that after 19-years fertilization, the soil MBC and MBN under the application of organic manure plus inorganic fertilizers were 231 and 81 mg x kg^{-1} soil, and 148 and 73 mg x kg^{-1} soil, respectively, being significantly higher than those under non-fertilization, inorganic fertilization, and inorganic fertilization plus straw incorporation. The ratio of soil MBN to total N under the application of organic manure and organic manure plus inorganic fertilizers was averagely 6.0%, significantly higher than that under non-fertilization and inorganic fertilization. Biolog-ECO analysis showed that the average well color development (AWCD) value was in the order of applying organic manure plus inorganic fertilizers = applying organic manure > non-fertilization > inorganic fertilization = inorganic fertilization plus straw incorporation. Under the application of organic manure or organic manure plus inorganic fertilizers, the microbial utilization rate of carbon sources, including carbohydrates, carboxylic acids, amino acids, polymers, phenols, and amines increased; while under inorganic fertilization plus straw incorporation, the utilization rate of polymers was the highest, and that of carbohydrates was the lowest. Our results suggested that long-term application of organic manure could increase the red soil MBC, MBN, and microbial utilization rate of carbon sources, improve soil fertility, and maintain a better crop productivity.

Shah *et al.* (2010) showed that the green manure legumes and N fertilizer application significantly increased the microbial biomass and activities in rice-wheat cropping system.

Nakhro and Dkhar (2010) studied the application of organic fertilizers increased the organic carbon content of the soil and thereby increasing the microbial counts and microbial biomass carbon.

Ultra and Javier (2011) revealed that soils subjected to long term organic fertilization have unique microbial functional community and higher enzyme activities compared to plots continuously fertilized with synthetic inorganic fertilizers.

Nath *et al.* (2011) studied that soil enzymes, microbial biomass carbon (MBC) and bacterial population were assessed to gain understanding the effects of integrated nutrient management (INM) under rice-wheat sequence grown during 2008 and 2009 in acid soils of Assam. MBC (183.66 micro g/g) and maximum organic carbon (10.38 g/kg) accretion were obtained in the treatment received enriched compost (2 tonnes/ha) continuously for four crops. Compost (2 tonnes/ha) coupled with biofertilizers resulted maximum Azospirillum (5.79 log cfu/g), whereas enriched compost (2 tonnes/ha) favored elevated phosphate-solubilizing bacterial (PSB) (5.10 log cfu/g) population in the study. Significant correlations were existed among the enzymes as well as with buildup MBC, OC, Azospirillum and PSB population under the sequence. Application of compost (2 tonnes/ha) and biofertilizers with 25% recommended N and P fertilizer resulted significant increase in available N (234.11 kg/ha). Similarly, rock phosphate (RP) carrying enriched compost showed highest P (28.04 kg/ha) status of the soils. The overall multifaceted effects of different INM treatments that facilitated beneficial soil conditions in the present study reflected the significant increasing the grain yields of both rice (3.68 tonnes/ha) and wheat (0.98 tonnes/ha) even over the 100% NPK.

Ghosh *et al.* (2012) studied that inclusion of pulses in the rice-based system improved the SOC content, being greater in surface soil (0-20 cm) and declining with soil depth. The rice-wheat-mung bean system resulted in 6% increase in SOC and 85% increase in soil microbial biomass carbon as compared with the conventional rice-wheat system. Application of crop residues, farm yard manure (5 t ha^{-1}) and biofertilisers had greater amount of carbon fractions and carbon management index (CMI) over control and the recommended inorganic (N, P, K, S, Zn and B) treatment in the soil surface, particularly in the system where pulses are included. Interestingly, in the puddled rice system, passive carbon pool is more in surface soil than deeper layers. The relative proportion of active carbon pool in surface layer (0-20 cm) to subsurface layer (20-40 cm) was highest in rice-wheat-rice-chickpea (1.14:1) followed by rice-wheat-mung bean (1.07:1) and lowest in the rice-wheat system (0.69:1). Replacing wheat with chickpea either completely or during alternate year in the conventional rice-wheat system also had positive impact on SOC restoration and CMI. Therefore, inclusion of pulses in the rice-based cropping system and organic nutrient management practices had significant impact on maintaining SOC in an Inceptisol of the Indo-Gangetic plains of India.

Moharana *et al.* (2012) studied the significant build-up in soil fertility in terms of alkaline $KMnO_4$-N, Olsen-P, NH_4OAc-K and $CaCl_2$-S as well as SOC pools namely, total organic carbon (TOC), Walkley and Black organic carbon (WBC), labile organic carbon (LBC) and microbial biomass carbon (MBC) were maintained under FYM and integrated nutrient management involving FYM and NPK than unfertilized control plot in 0–15 and 15–30 cm soil depths. The highest values of TOC (11.48 g kg^{-1}) and WBC (7.86 g kg^{-1}) were maintained in FYM treated plot, while the highest values of LBC (1.36 g kg^{-1}) and MBC (273 mg kg^{-1}) were found in FYM + NPK. The magnitude of change in pools of SOC in sub-surface (15–30 cm) soil was low as compared to the surface soil (0–15 cm). Significant increase in all the pools of SOC in FYM treated plots indicates the importance of application of organic manure like FYM in maintaining organic carbon in soil. Highly strong relationships were exhibited between LBC and MBC with yield, indicating that these pools are more important for nutrient turn-over and their availability to plants than total SOC. Carbon management index revealed that integrated nutrient management could be followed for enhancing crop productivity, nutrient availability and soil carbon pools for long-term. These results conclude that for sustainable crop production and maintaining soil quality, input of organic manure like FYM is of major importance and should be advocated in the nutrient management of intensive cropping system for improving soil fertility and biological properties of soils.

Nayak *et al.* (2012) reported that application of NPK either through inorganic fertilizers or through combination of inorganic fertilizer and organics such as farm yard manure or crop residue or green manure improved the SOC, particulate organic carbon, microbial biomass carbon concentration and their sequestration rate.

Bhattacharyya *et al.* (2012) studied the combined application of rice straw and green manure was more effective in increasing WSC (water soluble carbon), MBC (microbial biomass carbon), $KMnO_4$-C concentrations and CMI (carbon management index) than the inorganic fertilizer treatments, although it increased gaseous carbon emission. The combined application of rice straw and an inorganic fertilizer was effective in sequestrating soil organic carbon (1.39 Mg ha^{-1}), resulting in a higher grain yield. Therefore, it could be the best option for improving productivity and carbon storage in the rice-rice cropping system.

Liu *et al.* (2013) showed that SOC concentration in the 0-20 cm soil layer increased with time except in the CK (control) and N treatments. Long-term fertilization significantly influenced SOC concentrations and storage to 60 cm depth. Below 60 cm, SOC concentrations and storages were statistically not significant between all treatments. The concentration of SOC at different depths in 0-60 cm soil profile was higher under NP+FYM followed by under NP+S, compared to under CK. The SOC storage in 0-60 cm in NP+FYM, NP+S, FYM and NP treatments were increased by 41.3%, 32.9%, 28.1% and 17.9%, respectively as compared to the CK treatment. Organic manure plus inorganic fertilizer application also increased labile soil organic carbon pools in 0-60 cm depth. The average concentration of particulate organic carbon (POC), dissolved organic carbon (DOC) and microbial biomass carbon (MBC) in organic manure plus inorganic fertilizer treatments (NP+S and NP+FYM) in 0-60 cm depth were increased by 64.9-91.9%, 42.5-56.9%, and

74.7-99.4%, respectively, over the CK treatment. The POC, MBC and DOC concentrations increased linearly with increasing SOC content. These results indicate that long-term additions of organic manure have the most beneficial effects in building carbon pools among the investigated types of fertilization.

2.2.4. Growth and development

Gupta (2000) reported the available N, P, and K status in soil improved with the individual application of fertilizer nutrients but still higher build-up of available N, P, and K was noted in FYM/Compost treated plots.

Reddy *et al.* (2000) revealed that application of poultry manure (9 tonne ha^{-1}) to paddy produced grain yield at par with recommended dose of fertilizers + 10 tonne farmyard manure (FYM), but both were higher (67 and 69 per cent, respectively) than FYM or urban compost alone. Poulty manure and sewage sludge produced better growth components, viz., plant height, and number of tillers $hill^{-1}$, total dry matter $plant^{-1}$ and yield components like number of panicles $hill^{-1}$ and panicle weight. Usman (2000) reported that effects of organic sources alone on the growth of rice plant and its growth parameters were not significant due to their slow supply of nutrients. These growth parameters were improved when supplemented with mineral fertilizers at the rate of 100-75-60 kg N, P_2O_5 and K_2O ha^{-1} along with organic materials.

Suresh and Reddy (2002) applied, chemical N and K from different fertilizer sources was found dry matter production and plant height was non- significant. But application 50:50 proportion of FYM and complex fertilizer recorded significantly highest amount of dry matter production at harvest compared with rest of the treatments.

Kundu *et al.* (2004) revealed that the growth factors like plant height, dry matter accumulation and yield response positively correlated when the crop was provided with inorganic nitrogen fertilizers along with crop residues.

Chaudhary *et al.* (2007) observed that maximum panicle length (27.80 cm) obtained under 120 kg N ha^{-1} as compared to (20.22 cm) in control. While the effect of N at 80 or 120 kg ha^{-1} with FYM on 1000-grain weight was equally effective as reflected in their statistical methods. Bhuaneshwari *et al.* (2007) revealed that application of 40 kg S ha^{-1} in the presence of FYM registered the highest (CGR, RGR and NAR) over other treatments. Similarly the chlorophyll content increased with crop growth and was highest in presence of S @ 40 kg $ha^{-1}$and FYM compared to rest of the treatment. Incorporation of green manure @ 8 to 10 tonne ha^{-1} combined with 60 kg N ha^{-1} produced nursery plant biomass equal to that with 120 kg ha^{-1} of inorganic nitrogen.

Kumari and Reddy (2011) reported that the incorporation of fieldbean crop residues was found to be superior to any other crop residue incorporation with regard to growth and yield of rice as well as nutrient uptake.

2.2.5 Yield

Bhat *et al.* (2001) reported that application of FYM and BGA inoculation either alone or in combination increased the yield of rice. The increase in grain yield with the application of FYM was 9.77 per cent over control.

Banik *et al*. (2002) reported that the highest mean grain yield was 3.53 tonne $ha^{-1}$and maximum agronomic efficiency was 60.3 per cent with the application of inorganic fertilizer followed by cow dung, where as 3.47 tonne ha^{-1} grain yields was recorded with an agronomic efficiency of 57.5 per cent. Grain yield of rice recorded under organic sources of nutrient was not significantly different from that of inorganic fertilization though there was improvement in soil quality parameters under organic sources.

Sudha and Chandini (2002) reported that NPK up to 105:52.5:52.5 kg ha^{-1} and S up to 25 kg ha^{-1} , along with organic manures either as 10 tonnes farmyard manure or 5 tonne vermicompost ha $^{-1}$, were effective in the improvement of the grain yield of rice. They opined that application of N, P and K fertilizer along with FYM increased the growth attributes, yield components and grain yield of rice compared to N, P and K fertilizer alone.

Upadhyay *et al.* (2003) observed that the three organic sources tried, green manuring with Sesbania aculeate, compensating 50% of the recommended N gave the highest rice yield of (59.7 q ha^{-1}).When same amount of N was supplemented through FYM and paddy straw, production was higher with FYM. The superior effect of green manure over FYM of paddy straw can be attributed to its fast decomposition which might led to enhanced availability or release of nutrient as compared to other source of organic manure (Bhandari *et al.* 1992).

Mandal *et al.* (2004) studied that rice straw incorporation coupled with organic manure increases grain yield of wheat and improves soil physical condition. Residue incorporation results more microbial activity than residue removal or burning. Thus, if residues are managed properly, then it can warrant the improvements in soil properties and the sustainability in crop productivity.

Pandey *et al.* (2007) reported that the application of FYM at N_{150} $P_{75}K_{60}$ or N_{100} P_{60} K_{40} or organic fertilizer level of N_{100} P_{60} $K_{40\ +FYM+\ Zn}$, being at par, produced significantly higher panicle m^{-2} and test weight, which was at per from control and by N_{150} P_{75} K_{60} +FYM and N_{100} P_{60} $K_{40\ +}$FYM, respectively. It could be due to slow release of nutrients for longer period after decomposition of FYM +Zn which favored better plant growth and improved the yield component of hybrid rice.

Raul *et al*. (2007) reported that grain yield of rice under 100 per cent RDN blended with FYM was at par with 100 per cent RDN + 5 tonne FYM significantly superior to all other treatment. The yield attributes like number of spikeletes panicle^{-1},1000-grain weight and reduced sterility percentage were highest under 100 per cent RDN blended with FYM, variation in yield of rice on account of yield attributes under integrated nitrogen nutrition is in conformity with the earlier finding of Upadhyaya *et al*. (2000). Maiti *et al*. (2006) observed that maximum plant height (101.25 cm), dry matter accumulation (891.3 gm^{-2}), LAI (5.13), number of panicles m^{-2} (245), were recorded when crop received 125 per cent increase in dose along with 5 tonne FYM.

Chaudhary and Sinha (2007) observed that yield attributes of rice, viz; effective tiller hill^{-1}, dry matter (g m^{-2}), spikelets panicle^{-1}, fertility percentage and day taken to heading increased due to hogher level of N and $ZnSO_4$ application over the control and also revealed that application of 120 kg N ha^{-1} significantly increased tiller hill^{-1} and dry matter production whereas, spikelets panicle^{-1}, fertility percentage and days to heading increased only upto 60 kg N ha^{-1}.

Choudhary and Suri (2009) reported that the Grain and straw yield as well as nutrient (NPK) uptake in both wheat and rice were significantly higher in plots receiving farm yard manure (FYM) @ 10 t ha^{-1}, followed by berseem (*Trifolium alexandrinum* L.) or green manure '*in-situ*'+ FYM.

Ogbodo *et al.* (2009) studied that there is significantly greater grain yield achieved in the organic manure treated plots was partially attributed to improvement in the physical properties of the soil.

Kundu *et al*. (2010) reported that the growth parameters, yield components and seed yield of rice were maximum when organic manure was applied along with inorganic fertilizer at 75% of the recommended dose (RDF).

Mehdi *et al.* **(**2011) studied the comparison of sesbania and FYM applied at 20 (ton ha^{-1}) showed that sesbania remained superior over the farm yard manure for improving the paddy and straw yield of rice. The increased efficiency of NPK fertilizer with green manuring may be due to chemical, enzymatic and metabolic transformation of organic material, as the green manuring is continuously subject to degradation, thus more susceptible to change in metal uptake than inorganic soil fractions.

Hossaen *et al.* (2011) studied the maximum number of total grain per plant (97.45), the highest weight of 1000 seeds (21.80 g), the maximum grain yield (7.30 t ha^{-1}) and straw yield (7.64 t ha^{-1}) was recorded from T5: (70% NPKS+2.4 t poultry manure ha^{-1}) treatment over control.

Shah *et al.* (2011) studied the relationship of green manure (GM) legumes grown in the gap between wheat (*Triticum aestivum*) harvest and rice (*Oryza sativa*) planting for sustainable rice-wheat system. These results suggested that grain and straw yields of both rice and wheat crops have shown strong relationship with the total biomass of GM legumes. The improvement gained in crop yields from GM legumes could be attributed to improvement in the soil conditions and nutrient status of the soil. It is therefore recommended that green manure legumes should be encouraged for sustainable soil and crop productivity in rice-wheat system.

Rahman *et al.* (2012) reported that the highest grain yield 4.31 t/ha was found in

IPNS dhaincha along with fertilizers for HYG (high yield goal basis) treatment. Tadesse *et al.* (2013) showed that application of 15 t·FYM·ha^{-1} significantly increased soil organic matter and available water holding capacity but decreased the soil bulk density, creating a good soil condition for enhanced growth of the rice crop. Application of 15 tFYM·ha^{-1} increased the level of soil total nitrogen from 0.203% to 0.349%. Combined application of 15 t·ha^{-1}·FYM and 100 kg·P_2O_5·ha^{-1} increased the available phosphorous from 11.9 ppm to 38.1 ppm. Positive balances of soil N and P resulted from combined application of FYM and inorganic N and P sources. Application of 15·t ha^{-1}·FYM and 120 kg·N·ha^{-1}resulted in 214.8 kg·ha^{-1}·N positive balance while application of 15 t·ha^{-1}·FYM and 100 kg·P_2O_5·ha^{-1} resulted in a positive balance of 69.3 kg·P_2O_5·ha^{-1} available P. From the results of this experiment, it could be concluded that combined application of FYM and inorganic N sand P fertilizers improved the chemical and physical properties, which may lead to enhanced and sustainable production of rice in the study area.

Subehia *et al.* (2013) studied that the long-term integrated effects of organics and chemical fertilizers on grain yield of rice–wheat system and soil quality. Based on five years' moving average values, continuous cropping without fertilization or manuring (control) gave the lowest grain yields of both rice and wheat. Application of 50% N through FYM plus 50% NPK through chemical fertilizers to rice followed by 100% NPK through chemical fertilizers to wheat (T_3) maintained the highest productivity of rice and wheat at about 3.4 Mg ha^{-1} and 3.3 Mg ha^{-1}, respectively, as found from the pooled grain yield over the years. The highest values of organic carbon, cation exchange capacity and available N, P, and K were also recorded under this treatment (T_3).

Materials and Methods

CHAPTER – III

MATERIALS AND METHODS

A field experiment entitled **"LONG TERM EFFECT OF INORGANIC FERTILIZERS AND ORGANIC MANURES ON SOIL FERTILITY STATUS, MICROBIAL BIOMASS CARBON, NUTRIENT UPTAKE AND YIELD OF RICE ON INCEPTISOL"** was conducted in permanent plots since 1991-92 under All India Coordinated Research Project on Integrated Farming System (IFS) with rice-wheat cropping system. Details of materials used and the experimental techniques adopted during the course of studies are briefly described in this chapter.

3.1 Location and Experimental site

The field experiment is being undergoing from 1991 at the Instructional Farm of All India Coordinated Research Project on Integrated farming system (IFS), Indira Gandhi Krishi Vishavidyalaya, Raipur, Chhattisgarh. The present experiment was undertaken during kharif season of 2012 only i.e. after 21 crop cycle.

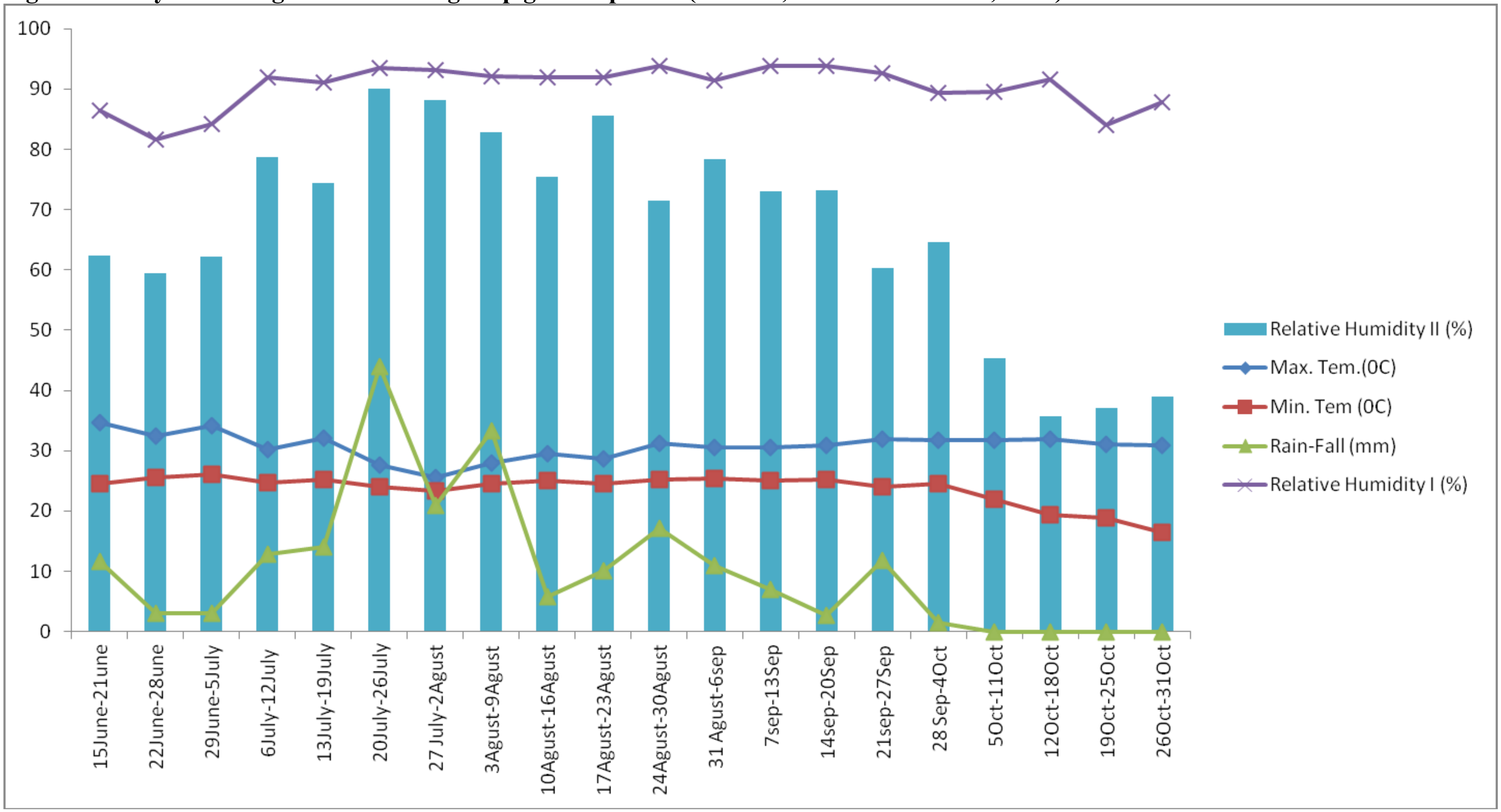
3.2 Geographical situation

Raipur is situated in mid eastern part of Chhattisgarh and lies at $21^0$16' N latitude, $81^0$36' E longitude with an altitude of 298 m above the mean sea level.

3.3 Climatic condition

The general climate of this region is dry moist, sub humid and the region receives 1200-1400 mm rainfall annually out of which about 88 percent is received during rainy season (June to September) and o nly 12% during winter season (October to February). May is the hottest and December is the coolest month of the year. The rainfall pattern has great variation during rainy season from year to year. Atmospheric

Fig 3.1 Weekly meterological data during crop growth period (June 15, 2012 to Octber 26, 2013)



humidity varies between 70 to 90 percent from mid June to March and wind velocity is high from May to August with peak in June to July months. Soil
surface temperature of this region crosses 60^0C, air temperature to 48^0 C and humidity drops up to 3 to 4% during summer season.

3.4 Soil of experiment field

The soil is locally known as Matasi belonging to the order Inceptisol and classified as mixed hyperthermic udic Ustrochrept (Chandra Khuri series). The texture of the soil is sandy loam.

3.5 Experimental details and layout plan

Location	**:**	**Instructional Farm, AICRP on IFS, College of Agriculture, I.G.K.V. Raipur (C.G.)**
Season	**:**	***Kharif*-2012**
Crop variety	**:**	**Rice (Mahamaya)**
Gross Plot	**:**	**100.8 m^2**
Plot Size	**:**	**62.4 m^2**
Spacing	**:**	**Row x Row (20 x 20cm)**
Replications	**:**	**Three**
Design	**:**	**Randomized Block Design**
Treatments	**:**	**Eleven**

T_1 :No Fertilizer, No Organic manure (Control)

T_2 :50% Recommended NPK dose through fertilizer (40:30:20::N:P_2O_5:K_2O)

T_3:75% Recommended NPK dose through fertilizer

T_4 :100% Recommended NPK dose through fertilizer (80:60:40 ::N:P_2O_5:K_2O)

T_5 :50% Recommended NPK dose through fertilizer+50%N through Farm yard manure

T_6 :75% Recommended NPK dose through fertilizer+25%N through Farm yard manure

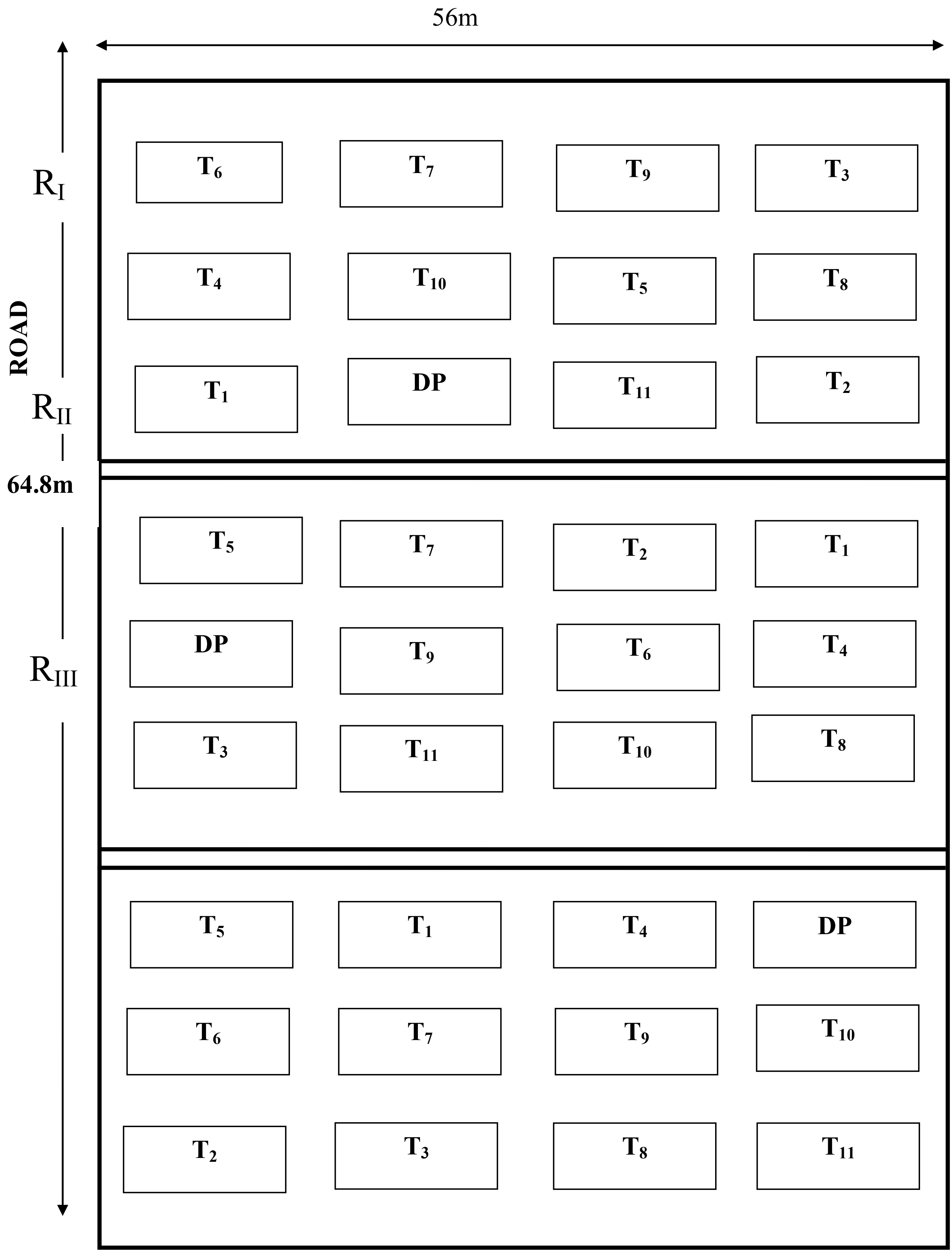
T_7 : 50% Recommended NPK dose through fertilizer+50%N through rice residue

T_8 : 75% Recommended NPK dose through fertilizer+25%N through rice residue

T_9: 50% Recommended NPK dose through fertilizer+50%N through Green manure

T_{10}: 75% Recommended NPK dose through fertilizer+25%N through Green manure

T_{11}: Conventional Farmer’ Practice (50:30:20)



Spacing between: Replication - 2m and Plot - 2m

DP= Dummy plot

Figure 3.1: LAY OUT PLAN OF THE EXPERIMENT

3.6 Crop Husbandry

3.6.1 Preparatory cultivation

The experimental field was prepared by two cross ploughing followed by one harrowing with the help of tractor. Thereafter, the field was flooded with water and puddling was done by tractor drawn puddler.

3.6.2 Test Crop

Rice cultivar **Mahamaya** was taken as test crop. This variety was evolved at IGKV, Raipur and is a multiple cross of Asha and Kranti. This is a high yielding semi dwarf variety having good tillering capacity with bold grains. It is photo insensitive and medium duration (128-130 days) variety. The yield potential is about (6-6.5 tonne ha^{-1}).

3.6.3 Nursery management

Raised nursery beds of 10 m x 1 m x 0.15 m (length x width x height) were prepared on well ploughed and levelled field with 30 cm distance between two beds. Seeds were sown on 16 June 2012 in lines 10 cm apart @40 kg seed ha^{-1}. Basal dose of fertilizers @ 25 g urea m^{-2} and 50 g super phosphate m^{-2} were applied at the time of nursery bed preparation. One hand weeding was performed at 15 day after sowing to keep the nursery weed free. The seedbeds received frequent light irrigation until the seedling was transplanted.

3.6.4 Manures and fertilizer application

The treatment include different organic manure such as farmyard manure, rice straw and green manure i.e. sunnhemp (*Crotolaria juncea*). These sources were combined with the inorganic fertilizer to assess the response of combined application of both the organic and inorganic sources on the various soil and plant parameters of paddy crop. The nutrient content of different organic sources is given in table 3.2.

Table 3.2: Average N, P and K content in FYM, rice straw and green manure

Manure	Nutrient content (%)			Dry biomass (t ha^{-1}) for treatment
	N	P	K	
FYM	0.5	0.2	0.5	T_{5}- 13.50 and T_6-6.75
Rice straw	0.2	0.2	0.3	T_7-11.31 and T_8-5.65
Green manure	1.9	0.5	1.8	T_9-10.00 and T_{10}-5.00

The *insitu* incorporation of 30 days old green manure crop was done at the time of puddling. FYM and rice straw were also applied at the same time.

The N, P and K fertilizer were applied as per treatment through straight fertilizer i.e. urea, single super phosphate and muriate of potash, respectively. One third dose of N and entire P and K were applied as basal dose just before transplanting. The rest of N was applied in two equal splits at tillering and panicle initiation stage.

3.6.5 Transplanting and crop raising

Twenty five days old seedlings of rice were transplanted on 11^{th} July 2012 with the distance of 20cm between rows and 10cm between hills by using 2-3 seedlings per hill. Hand weeding operation was carried out at 20 and 50 days after transplanting.

3.6.6 Harvesting and Threshing

The matured crop of rice was harvested on 26^{th} October 2012. Grain and straw yield was recorded plot wise and calculated on hectare basis.

3.7 Pre-harvest observation

3.7.1. Number of tiller (m^2)

Number of tiller m^{-2} were counted manually and then divided by plant population m^{-2} for obtaining number of tiller $hill^{-1}$.

3.7.2 Post harvest observation

3.7.2.1 Panicle length

The length of panicle was taken from 10 panicle selected randomly after harvest of rice. It was measured from the neck node to the tip of the apical grain. After this, average length of panicle was determined.

3.7.2.2 Test weight

Grain samples were taken from the produce of each net plot. Out of the samples, 1000 grains were counted and the same were dried in an oven at 60^0C to constant weight. Thereafter, weight was recorded on an electronic balance.

3.7.2.3 Grain yield

The weighed bundles were threshed, winnowed and cleaned separately from each net plot. The grain yield was observed at about 14% moisture content and converted to q ha^{-1}.

3.7.2.4 Straw yield

It was calculate by deducting the grain yield from bundle weight and converted to q ha^{-1}.

3.8. Methods of analysis

3.8.1. Chemical analysis

pH

It was measured by glass electrode pH meter in 1:2.5 soil water suspensions after stirring for 30 minutes as described by Piper (1967).

Electrical conductivity

The soil samples used for pH determination were allowed to settle down the soil particles for 24 hours. The conductivity of supernatant liquid was determined by Solubridge as described by Black (1965).

Organic carbon

It was estimated by Walkley and Black's (1934) rapid titration method as described by Jackson (1967). In this method, organic matter is oxidized with chromic acid (potassium dichromate + sulphuric acid).The unconsumed potassium dichromate is back titrated against ferrous sulphate or ferrous ammonium sulphate.

Available nitrogen

Available nitrogen content in soil was determined by alkaline potassium permanganate method as described by Subbiah and Asija (1956). The procedure involves distilling the soil with alkaline potassium permanganate solution and absorbs the ammonia liberated in boric acid which is then titrated with standard sulphamic acid.

Available phosphorus

Available phosphorus was estimated by the ascorbic acid method as described by Olsen, (1954). In this method, 2.5 gm soil sample was taken and extracted with 0.5 M sodium bicarbonate at pH 8.5. After extraction from the soil, phosphate in the extract is measured by the reaction of phosphate with ammonium molybdate in an acid medium to form molybdophosphoric acid which is then reduced to a blue coloured complex through reaction with ascorbic acid. Absorbance readings were taken at an 882 nm wavelength using a double beam spectrophotometer.

A standard curve constructed from absorbance readings of standards is used to deduce phosphate concentration of sample.

Available potassium

Available potassium was extracted from the 5 gm soil with the help of suitable extractant neutral normal ammonium acetate by shaking, followed by filtration or centrifugation and K is determined in the extract using flame photometer. It was described by Jackson in 1967. The analysis photometer is based on the measurement of the intensity of characteristic line emission given by the element to be determined.

Microbial biomass carbon

Microbial biomass carbon is determined by the modified fumigation –incubation method (Vance *et al* 1987) in which the main aim was to see if the amounts of C which could be directly extracted from soils following fumigation were related to microbial biomass C. In this method, 40-45gm soil was weighed in to a 500ml reagent bottle and kept for fumigation. Ethanol- free chloroform was prepared immediately before fumigation. The chloroform was poured in a separating funnel and 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 washing was given to make the chloroform free of ethanol. The required volume of ethanol free chloroform (10-20 ml) was kept in 500 ml reagent bottle containing soil and placed in dark for 24 hrs. After 24 hours, the lid of the bottle is opened for ½ hours so that gasses pass out.

In both fumigated and non-fumigated bottles, 160 ml of 0.5 M K_2SO_4 is added and shaking was done for 45 minutes. After shaking the suspension was filtered and 10 ml of the filtrate was transferred in 500 ml conical flask. Then 10 ml 0.035 N $K_2Cr_2O_7$ and 20 ml of concentrated H_2SO_4 were added to each flask. The blank was also run with 40 ml distilled water each along with same procedure mentioned above. The flasks were kept on hot plate at 100-150^o C for half an hour under refluxing condition. Then the flasks were taken out and about 20 ml of distilled water added immediately. The contents were allowed to cool down then add 5 ml orthophasphoric acid and 4-5 drops of diphenylamine indicator were added. The content was titrated against 0.05 N ferrous ammonium sulphates to get a sea green/sea blue end point.

Microbial biomass carbon in soil ($\mu g\ Cg^{-1}$)

$$MBC = \frac{E_{CF} - E_{CUF}}{K_{EC}}$$

Where, E_{CF} = extractable carbon in the fumigated soil sample

E_{CUF} = extractable carbon in the unfumigated soil sample

K_{EC} = 0.25 + 0.05 it represent the efficiency of extraction of SMBC

Plant chemical analysis

Plant and grain samples were dried at 55^{o}C in an oven for 24 hours and were grinded and used for analysis.

Nitrogen content

Nitrogen content analysis of grain and straw sample was done by taking 0.25 gm uniform prepared sample in digestion tube. 1 gm salt mixture (K_2SO_4 and $CuSO_4.5H_2O$ in the ratio of 10:1) was added in the tube. The 5 ml of concentrated H_2SO_4 acid was added and material was digested at 350 ^{0}C in digestion block till the material becomes colourless. Then the nitrogen in digested material was distilled by automatic KEL plus distillation apparatuses.

Phosphorus and Potassium

One gram of grain and straw samples was taken in digestion tube and add 10 ml of di- or tri acid mixture (Concentrated HNO_3, $HClO_4$ and H_2SO_4 in the ratio of 9:4:1). The material was digested at 150 ^{0}C in KEL plus digestion block till the material become colourless. The digested material was transferred in to 100 ml volumetric flask by repeated washing with distilled water and made up the volume up to the mark. This digested material was used for the estimation of P and K content analysis as given below.

Phosphorus content

Phosphorus content was determined by vanadomolybdo-phosphoric acid yellow colour complex method as described by Jackson (1973). An aliquot of 10 ml was taken, 10 ml of vanado-molebdate yellow reagent was added and volume was made up to 50 ml. After half an hour colour intensity was measured by Spectrophotometer.

Potassium content

Potassium content was determined by flame photometer as described by Chapman and Pratt (1961). An aliquot of 10 ml was taken and made up to volume of 50 ml in volumetric flask and potassium content was determined by flame photometer.

Nutrient uptake

The N, P and K uptake was also worked out by multiplying concentration with respective dry weight of rice grain and straw on over dry basis *i.e.*

Nutrient uptake (kg ha^{-1}) = Concentration (%) × Dry matter yield (q ha^{-1})

Grain and straw yield (kg h^{-1})

At harvest, the grain and straw yield were recorded from the net plot area from each treatment and converted into kg ha^{-1}.

3.9 Statistical analysis

The experiment was laid out in Randomized Block Design (RBD) with 11 treatments and 3 replications. The data obtained from various characters under study were analyzed by the method of analysis of variance as described by Gomez and Gomez (1984).

Results and Discussion

CHAPTER –IV

RESULT AND DISCUSSION

A field experiment was conducted in *kharif* season of 2012 at the Instructional Farm, Indira Gandhi Krishi Vishwavidyakya, Raipur on **"Long Term Effect of Inorganic Fertilizers and Organic Manures on Soil Fertility Status, Microbial Biomass Carbon, Nutrient Uptake and Yield of Rice on Inceptisol".** The result obtained from the present investigation are presented and discussed in this chapter on the basis of yield attributes an assessment of the soil fertility, soil microbial biomass carbon, nutrient uptake and yield data of rice crop in three following sub headings:-

4.1 Effect of long term inorganic fertilizer and organic manure application on soil chemical properties.

4.2 Effect of continuous application of inorganic fertilizer and organic manure on soil microbial biomass carbon.

4.3 Effect of various combination of inorganic fertilizer and organic manure application on nutrient content and uptake.

4.4 Relationship of soil microbial biomass carbon with soil fertility and crop yield.

4.5 Effect of combined application of inorganic fertilizer and organic manure application on nutrient balance sheet.

4.6 Effect of different nutrient management practices on yield attributing characters and yield of rice.

4.1 Effect of long term inorganic fertilizer and organic manure application on soil chemical properties

4.1.1 Soil pH

Soil pH was determined in different treatments after the harvest of rice crop and the data was presented in Table 4.1. The soil pH after the harvest of rice crop showed non-significant difference with respect to different organic manures and inorganic fertilizers applied. In all the treatments, there was no remarkable change in soil pH as compared to the control. However, higher value (7.5) of pH was recorded in 75% RDF treatment and lower value (7.1) of pH recorded in 75% RDF + 25% GM-N. Similar finding had been recorded by Sime (2001). Buffering action of soils does not permit to alter the soil pH. The rise in pH is ascribed to decrease in organic carbon concentration of the soil due to continuous cropping as reported by Agarwal *et al* (2010) and Swarup and Yaduvashi (2000) also reported that soil pH was higher in inorganic fertilizer treatment plot as compared to NPK + green manure treatment plots.

4.1.2 Soil EC

The data on electrical conductivity (EC) was presented in Table 4.1 revealed that the effect of applied organic and inorganic fertilizer on EC was statistically non significant. However, higher value (0.25dSm^{-1}) of EC was recorded in 75% RDF + 25% FYM-N treatment and lower value (0.20dSm^{-1}) of EC recorded in Farmer's practice treatment. Soil pH showed non-significant change over initial value with the applied organic manure and inorganic fertilizer treatment. The different treatment did not influence the pH and EC of soil. The values were almost constant and similar finding was also reported by Urkurkar *et al.* (2010), with almost same set of treatment in rice crop.

4.1.3 Organic carbon

The data on soil organic carbon (SOC) after harvest of rice crop was presented in Table 4.1. The SOC ranges vary from 0.56 to 0.75gm kg^{-1} amongst different treatments. The level of application of inorganic fertilizer along with organic manure significantly increased the organic carbon. After harvest of rice, SOC was recorded highest (7.5gm kg^{-1}) in 50% RDF + 50% FYM-N, followed by 50% RDF + 50% GM-N while, lowest (5.6gm kg^{-1}) under control plots. The same finding during experimentation revealed that integrated use of inorganic fertilizer with organic manures increased the organic carbon and N, P and K status of the soil as reported by Sharma *et al.* (2009).

Table 4.1: Effect of long term fertilizer and manure application on soil pH, EC and organic carbon after harvest of rice (after 21 crop cycle)

Treatments		After harvest of rice		
		pH	**EC(dSm^{-1})**	**Organic carbon(gm kg^{-1})**
T_1	Control	7.3	0.22	5.6 e
T_2	50% RDF (40:30:20)	7.3	0.22	6.2 d
T_3	75% RDF	7.5	0.23	6.4 d
T_4	100% RDF (80:60:40)	7.4	0.21	7.2 b
T_5	50% RDF+50% FYM-N	7.2	0.22	7.5 a
T_6	75%RDF+25% FYM-N	7.3	0.25	6.8 c
T_7	50%RDF+50% RR-N	7.2	0.21	6.8 c
T_8	75% RDF+25% RR-N	7.2	0.23	6.7 c
T_9	50% RDF+50% GM-N	7.2	0.22	7.2 b
T_{10}	75% RDF+25% GM-N	7.1	0.22	6.8 c
T_{11}	Farmer practices (50:30:20)	7.3	0.2	6.6 c
SEm±		**0.08**	**0.01**	**0.09**
CD (P= 0.05)		**NS**	**NS**	**0.27**

FYM- farm yard manure, RR- rice residues, GM- green manure

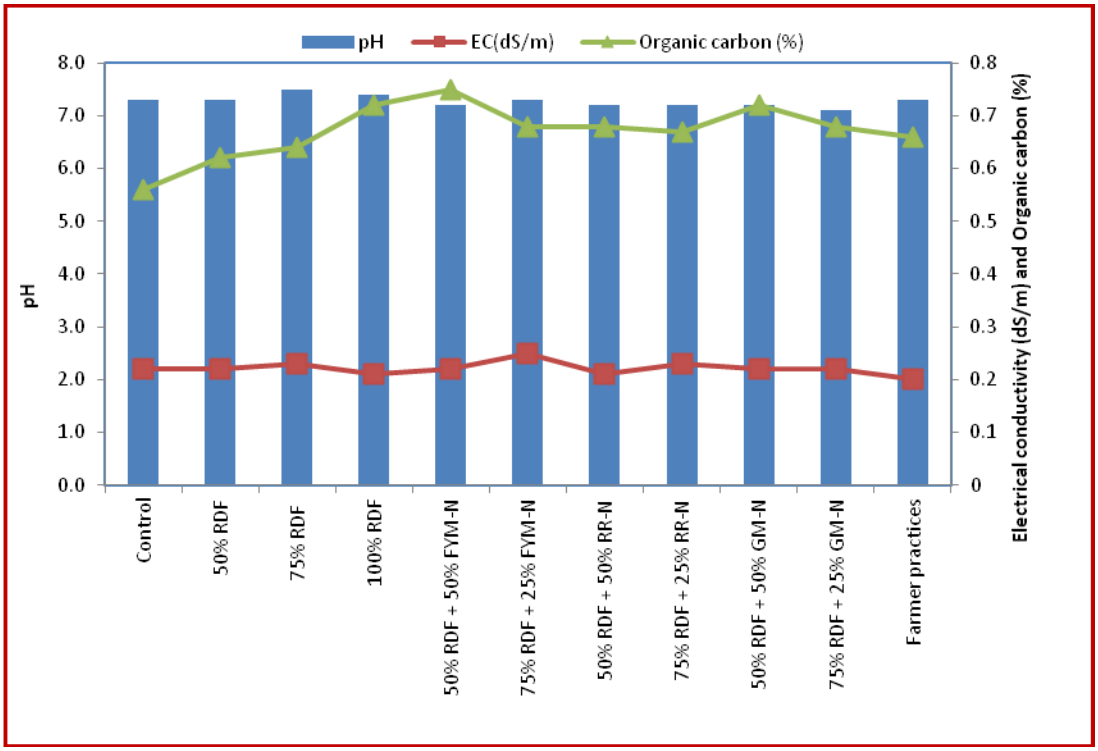


Fig 4.1: Effect of continuous cropping and fertilization on soil pH, electrical conductivity and organic carbon

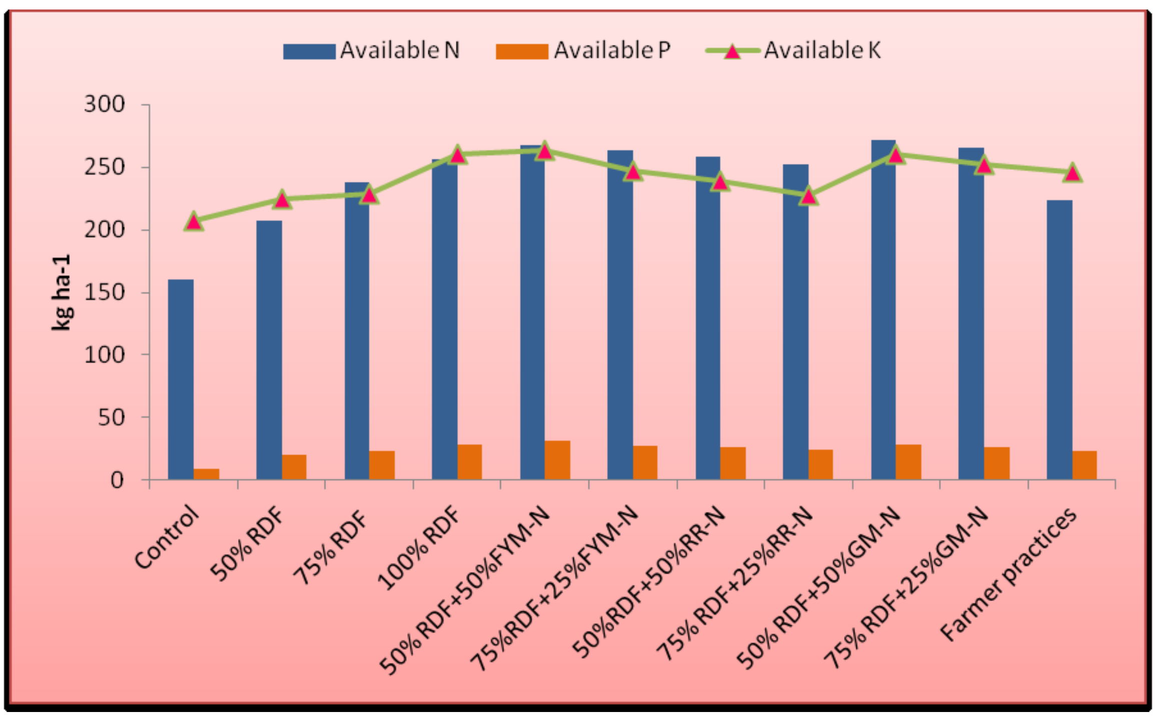


Fig 4.2: Effect of inorganic fertilizer and organic manure application on available nitrogen, phosphors and potassium content in soil

4.1.4 Available N

The data on available N content in soil after harvest of rice crop was tabulated in Table 4.2. The available N varies between 160 to 272 kg/ha amongst different treatments. Application of fertilizer along with FYM and GM significantly increase the available N in soil over 100 % RDF alone treatment. Higher amount of available N (272 kg ha^{-1}) in soil was noted in 50% RDF + 50% GM-N followed by 50% RDF + 50% FYM-N and rice residues and lowest (160 kg ha^{-1}) was recorded in control. Adding green manure favoured the soil conditions and might have helped in the mineralisation of soil N leading to build up of increased available N.

4.1.5 Available P

The data on available P content in soil after harvest of rice crop was arranged in Table 4.2. The range of available P was vary from 8.68 to 31.37 kg/ha in various treatments. Available P content of soil was increased as compared to its initial status. Highest available P (31.37 kg ha^{-1}) was obtained with 50% RDF + 50% FYM-N followed by (28.88 kg ha^{-1}) 50% RDF+ 50% GM-N treatment and lowest (20.55kgha^{-1}) in 50% RDF treated plot except control. When RR was incorporated in the soil, the P availability increases, but the response was not significant when compared with 50% as well as 75% RDF i.e. absolute inorganic fertilizer application.

Continuous use of balanced fertilizer since 1991-92 is conducive for maintaining the soil available P. The results of the present study also revealed that higher available P content were recorded in integrated nutrient management treatments as compared to absolute control. It was also observed that successive significant increase had occurred due to increasing levels of fertilizer application along with organic manure addition in soil. Similar results have also been reported by Thakur *et al*., (2010). They found that exclusion and/or omission of P in the fertilizer schedule had resulted in lowering the available P content in the soil. The results also support that increasing levels of fertilizer application had resulted in substantially enhancing the available P content and so was the case with use of FYM along with balanced dose of fertilizer. Swarup and Yaduvanshi (2000), Thakur *et al*., (2010) have also reported the beneficial effects of organic matter on available P in soils.

Table 4.2: Effect of continuous application of fertilizer and manure on available N, P and K content in soil after harvest of rice (after 21 crop cycle)

Treatment		**Available nutrients (kg ha^{-1})**		
		N	**P**	**K**
T_1	Control	160 h	8.68 c	207 f
T_2	50% RDF (40:30:20)	207 g	20.55 bc	225 e
T_3	75% RDF	238 e	22.81 b	229 e
T_4	100% RDF (80:60:40)	256 d	27.87 a	260 a
T_5	50% RDF+50%FYM-N	268 ab	31.37 a	264 a
T_6	75%RDF+25%FYM-N	263 bc	27.58 a	247 bc
T_7	50%RDF+50%RR-N	258 cd	26.22 ab	239 d
T_8	75% RDF+25%RR-N	252 d	24.38 b	228 e
T_9	50% RDF+50%GM-N	272 a	28.88 a	260 a
T_{10}	75% RDF+25%GM-N	266 b	26.21 b	252 b
T_{11}	Farmer practices (50:30:20)	224 f	23.42 b	246 c
SEm±		**1.97**	**1.62**	**1.73**
CD (P= 0.05)		**6.0**	**4.77**	**5.1**

FYM-farm yard manure, RR- rice residues, GM- green manure

4.1.6 Available K

The data on available K after harvest of rice crop was presented in Table 4.2.Available K ranged between from 207 to 264 kg/ha amongst various combination of inorganic and organic nutrient management treatment. The higher available K (264 kg ha^{-1}) was obtained with 50% RDF + 50% FYM-N and lower (207 kg ha^{-1}) in control. Application of FYM along with 50% RDF inorganic fertilizer results significantly higher amount of available N, P and K in soil as compared to 100% RDF fertilizer alone. Continuous use of N,P and K fertilizer over the years reduced the organic carbon status leading to a decline in the availability of macronutrients in soil whereas, FYM incorporation along with N,P and K fertilizers increased the organic C status of soil which consequently caused higher availability of N,P and K in soil. These findings are in agreement with those of Krishna (2003).

4.2 Effect of long term inorganic fertilizer and organic manure application on soil microbial biomass carbon

It was revealed that increase in application of inorganic fertilizers increased the microbial biomass carbon (Table no 4.3) in soil. Application of 50% and 100% RDF in rice significantly influenced the biomass C over control. The 50% RDF and 50% FYM-N significantly increased the MBC than 100% RDF. The combination of inorganic fertilizer with organic manure at 50% and 75% recommended dose of fertilizer in rice showed significant increase in MBC over chemical fertilizer alone. The incorporation of green manure legumes and N fertilizer application significantly increased the microbial biomass and activities in rice-wheat system reported by Shah *et al.* (2010). For sustainable crop production and maintaining soil quality, input of organic manure like FYM is of major importance and should be advocated in the nutrient management of intensive cropping system for improving soil fertility and biological properties of soils concluded by Moharana *et al.* (2012). The effect was more pronounced at higher level of FYM and GM application and/or incorporation in soil. However, rice residues did not show any remarkable effect in the rice crop. The increase in MBC is the result of combination of inorganic and organic can be attributed to the readily available compound after decomposition of these organics supplying the required substrate to microbes for their multiplication. Such increase in MBC has also been reported by Dhull *et al.* (2004).

Table 4.3: Effect of different combination of the inorganic fertilizer and organic manure on soil microbial biomass carbon after harvest of rice (after 21 crop cycle)

Treatment		Microbial biomass carbon (μgCg^{-1}) of dry soil
T_1	Control	135.28 f
T_2	50% RDF (40:30:20)	165.12 e
T_3	75% RDF	207.71 d
T_4	100% RDF (80:60:40)	237.40 c
T_5	50% RDF+50%FYM-N	334.55 a
T_6	75%RDF+25%FYM-N	283.20 b
T_7	50%RDF+50%RR-N	184.99 e
T_8	75% RDF+25%RR-N	179.56 e
T_9	50% RDF+50%GM-N	327.66 a
T_{10}	75% RDF+25%GM-N	279.44 b
T_{11}	Farmer practices (50:30:20)	217.35 cd
SEm±		**7.42**
CD (P= 0.05)		**21.90**

FYM-farm yard manure, RR- rice residues, GM- green manure

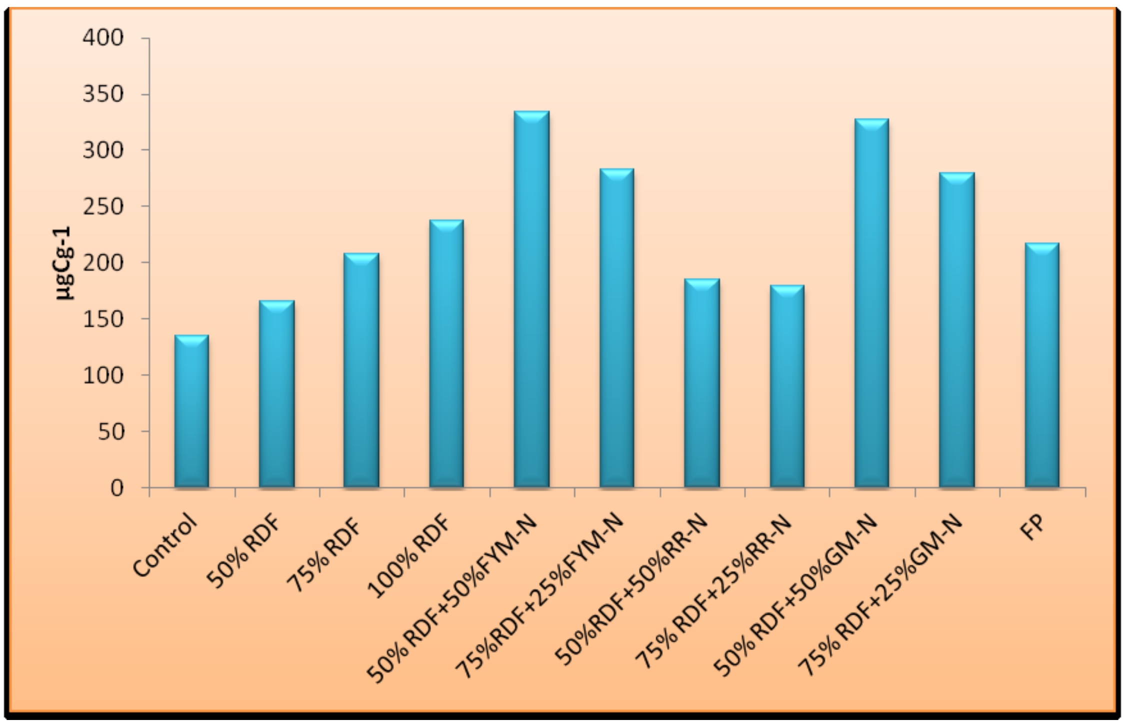


Fig 4.3: Soil microbial biomass carbon under different treatments

4.3 Effect of various combination of inorganic fertilizer and organic manure application on nutrient content and their uptake

4.3.1 Content in rice grain and straw

Nitrogen, Phosphorus and potassium content in grain as well as straw are given in table 4.4. The different treatment combination significantly affected the N, P and K concentration in grain and straw at harvest stage.

Nitrogen content

The nitrogen content in grain and straw was increased significantly with integrated nutrient management practices over control. The nitrogen content in grain and straw was ranged from 7.9 to 10.9 and 3.8 to 6.5 gm kg^{-1}, respectively. The higher nitrogen content in grain was noted under treatment 50%RDF+ 50%GM followed by 50% RDF+ 50%FYM and lowest under the control. Similar kind of result in nitrogen content was obtained in straw also.

Phosphorus content

Phosphorus content in grain and straw of rice under different treatment combination is given in table 4.4. The P content in grain was ranged from 1.6 to 3.2 gm kg^{-1} amongst different treatment. The highest (3.2 gm kg^{-1}) P content in grain was recorded in 50%RDF+ 50%GM-N and lowest in control plot. Almost similar kind of pattern was observed in phosphorus content in straw amongst various treatment combinations.

Table 4.4: Effect of integrated nutrient management fertilizer and organic manure application on N, P and K content in grain and straw of rice (after 21 crop cycle)

Treatment		Nutrient Content (gm kg^{-1})					
		Grain	Straw	Grain	Straw	Grain	Straw
		N		P		K	
T_1	Control	7.9d	3.8e	1.6e	0.4d	2.1d	1.32d
T_2	50% RDF (40:30:20)	8.4d	4.3de	2.4d	0.5cd	2.3cd	1.72bc
T_3	75% RDF	8.5cd	5.1bc	2.4cd	0.5c	2.5abcd	1.79bc
T_4	100% RDF (80:60:40)	9.4abcd	5.0cd	2.6bcd	0.6bc	2.6abc	1.81abc
T_5	50% RDF+50% FYM-N	10.7ab	6.4a	2.9ab	0.8ab	2.9a	1.97a
T_6	75%RDF+25% FYM-N	10.2abc	5.5bc	2.7bcd	0.7abc	2.7ab	1.74bc
T_7	50%RDF+50% RR-N	8.8cd	5.9ab	2.8abc	0.7abc	2.6abc	1.81abc
T_8	75% RDF+25% RR-N	9.2bcd	5.4bc	2.6bcd	0.7abc	2.3bcd	1.76bc
T_9	50% RDF+50% GM-N	10.9a	6.5a	3.2a	0.8a	2.9a	1.88ab
T_{10}	75% RDF+25% GM-N	10.2abc	5.9ab	2.8ab	0.7ab	2.8a	1.72bc
T_{11}	Farmer practices (50:30:20)	8.6cd	4.9cd	2.6cd	0.6c	2.5abcd	1.69c
SEm$\pm$		**0.56**	**0.27**	**0.15**	**0.05**	**0.14**	**0.55**
CD (P = 0.05)		**1.65**	**0.79**	**0.43**	**0.14**	**0.40**	**1.63**

FYM-farm yard manure, RR- rice residues, GM- green manure

Potassium content

Potassium content in grain was ranged from 2.1 to 2.9gm kg^{-1} in different treatments. The higher (2.9 gm kg^{-1}) potassium content in grain was recorded in 50% RDF+50%FYM-N and 50% RDF+ 50%GM-N and lowest (2.1gm kg-1) in control plots. Potassium content in straw was ranged from 13.2 to 19.7gm kg^{-1} and increased significantly with applied all treatment combination over control. The highest (9.7gm

kg^{-1}) potassium content in straw was measured in 50% RDF+ 50%FYM-N treated plot, while lowest (16.9 gm kg^{-1}) in farmer's practices. The results are in agreement with the finding of Sarwar (2005) who studied that increased concentration of N, P and K in paddy grain and straw of rice with the combined use of FYM, Sesbania green manure and chemical fertilizer compared with application of chemical fertilizer and organic manures alone.

4.3.2. Uptake of N, P and K by grain and straw as influenced by different fertilizer and integrated nutrient management practices

Nitrogen uptake

Nitrogen uptake by grain, straw and total by rice is given in table 4.5. and fig 4.4. The nitrogen uptake by grain was ranged from 10.34 to 76.29 kg ha^{-1}. The 50% RDF+ 50% GM-N had highest nitrogen uptake 76.29 kg ha^{-1} by grain followed by 74.33 kg ha^{-1} in 50% RDF + 50% FYM-N and the lowest (10.34 kg ha^{-1}) under control plots. Almost similar trend was observed in nitrogen uptake by straw among various treatment combinations. Due to incorporation of 50% or 25% RR-N with 50% or 75% RDF the N uptake by straw was similar to that obtained in 100% RDF.

Among INM combinations 50% RDF + 50% GM –N gave highest N uptake by grain as compared to other INM treatment at 50% RDF (T5, T7 and T9). The INM treatments at 75% RDF level were almost similar (T6, T8 and T10) in N uptake by grain. The results are in agreement with the findings of Dar *et al.* (2012) who studied that uptake of nitrogen by paddy and straw was higher under integrated nutrient treatments.

Total uptake

The total nitrogen uptake by rice crop was ranged from 19.12 to 138.2 kg ha^{-1} and increased significantly with applied fertilizer treatment over control. Significantly higher (138.2 kg ha^{-1}) N uptake was recorded in treatment 50%RDF +50% GM-N, followed by 133.59 kg ha^{-1} in 50%RDF + 50% FYM-N and lowest (65.45 kg ha^{-1}) under 50% RDF among fertilizer treatment plot (Table 4.5. and Fig 4.4.) The results are in agreement with Laxminarayana and Patiram (2006), 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.

Table 4.5: Nitrogen uptake by rice as affected by nutrient management practices (after 21 crop cycle)

Treatment		Nitrogen uptake (kg ha^{-1})		
		Grain	**Straw**	**Total**
T_1	Control	10.34	8.78	19.12 h
T_2	50% RDF (40:30:20)	36.45	29.00	65.45 g
T_3	75% RDF	52.72	47.10	99.82 dc
T_4	100% RDF (80:60:40)	65.69	47.42	113.11 cd
T_5	50% RDF+50%FYM-N	74.33	59.26	133.59 ab
T_6	75%RDF+25%FYM-N	68.71	51.21	119.92 bc
T_7	50%RDF+50%RR-N	53.70	47.75	101.45 dc
T_8	75% RDF+25%RR-N	52.90	41.50	94.40 ef
T_9	50% RDF+50%GM-N	76.29	61.87	138.20 a
T_{10}	75% RDF+25%GM-N	69.47	56.54	126.01 abc
T_{11}	Farmer practices (50:30:20)	44.13	37.39	81.53 f
SEm±		**3.68**	**2.34**	**4.76**
CD (P= 0.05)		**10.87**	**6.92**	**14.03**

FYM-farm yard manure, RR- rice residues, GM- green manure

Phosphorus uptake

Phosphorus uptake by rice grain, straw and total under different treatment is given in table 4.6. and fig 4.5. The increase in application of inorganic fertilizer significantly increased the P uptake by grain and simultaneously the uptake by straw and total also. The phosphorus uptake by grain ranged from 2.13 to 22.09 kg ha^{-1}. The highest (22.09 kg ha^{-1}) phosphorus uptake by grain was noted under 50%RDF +50% GM-N, followed by 19.83 kg ha^{-1} in 50%RDF+50%FYM-N and lowest (10.32 kg ha^{-1}) under 50% RDF with respect to applied treatment. The highest (18.3 kg ha^{-1}) uptake was recorded in 100% RDF compared to all inorganic fertilizer. Similar trend was observed in phosphorus uptake by straw among various treatment combinations.

Table 4.6: Phosphorus uptake by rice as affected by nutrient management practice (after 21 crop cycle)

Treatment		Phosphorus uptake (kg ha^{-1})		
		Grain	**Straw**	**Total**
T_1	Control	2.13	0.91	3.05 i
T_2	50% RDF (40:30:20)	10.32	3.57	13.9 h
T_3	75% RDF	14.74	4.97	19.7 f
T_4	100% RDF (80:60:40)	18.30	5.95	24.3 cd
T_5	50% RDF+50%FYM-N	19.83	7.1	26.9 b
T_6	75%RDF+25%FYM-N	18.01	6.18	24.2 cd
T_7	50%RDF+50%RR-N	17.01	5.46	22.5 de
T_8	75% RDF+25%RR-N	15.19	5.03	20.2 ef
T_9	50% RDF+50%GM-N	22.09	7.52	29.6 a
T_{10}	75% RDF+25%GM-N	19.11	6.86	26 bc
T_{11}	Farmer practices (50:30:20)	13.04	4.21	17.2 g
SEm±		**0.93**	**0.45**	**0.79**
CD (P= 0.05)		**2.73**	**1.32**	**2.35**

FYM-farm yard manure, RR- rice residues, GM- green manure

Total uptake

Total phosphorus uptake by rice ranged from 3.05 to 29.6 kg ha^{-1} and increasing significantly with increasing dose of applied fertilizer and manure over control. The significantly highest (29.6 kg ha^{-1}) P uptake was recorded in 50% RDF + 50% GM-N closely followed (26.9 kg ha^{-1}) by 50%RDF + 50%FYM-N and lowest (13.9 kg ha^{-1}) in 50% RDF with respect to applied inorganic fertilizer. The nitrogen and phosphorus uptake by grain and straw were also increased due to increased grain yield and concentration of the nutrients in respective treatments (Table 4.5). Similar finding were observed by Makarim *et al.* (2005) and Natarajan *et al.* (1994).

Potassium uptake

Potassium uptake by grain, straw and total under inorganic fertilizer and INM treatments is given in table 4.7 and fig 4.6. The K uptake by grain ranged from2.80 to 20.18 kg ha^{-1}. The highest (20.18 kg ha^{-1}) K uptake was recorded in 50%RDF + 50% GM-N followed by 19.88 kg ha^{-1} in 50%RDF + 50%FYM-N and lowest (2.80 kg ha^{-1}) in control plots. The K uptake by straw ranged from 30.85 to 183.34 kg ha^{-1}. The highest (183.34 kg ha^{-1}) K uptake by straw was noted in 50%RDF + 50%FYM-N followed by (179.79 kg ha^{-1}) in 50%RDF + 50% GM-N and the lowest 30.85 kg ha^{-1} in control plots.

Total uptake

The total potassium uptake by rice ranged from 33.65 to 203.22 kg ha^{-1} and increased significantly by increasing dose of applied fertilizer and manure over control. Significantly highest 203.22 kg ha^{-1} K uptake was recorded in 50%RDF + 50% FYM-N closely followed by 199.97 kg ha^{-1} in 50%RDF + 50% GM-N and lowest 127 kg ha^{-1}

in 50%RDF with respect to applied treatment. The results are in agreement with the findings of Das *et al.* (2013), showed that FYM application @ 15 t ha $^{-1}$ along with 100% NPK fertilizers produced maximum yields, nutrients uptake and improve in soil properties.

Table 4.7: Potassium uptake by rice as affected by different treatment (after 21 crop cycle)

Treatment		Potassium uptake (kg ha^{-1})		
		Grain	**Straw**	**Total**
T_1	Control	2.8	30.85	33.65 f
T_2	50% RDF (40:30:20)	9.84	117.16	127.00 e
T_3	75% RDF	15.4	165.03	180.43 b
T_4	100% RDF (80:60:40)	18.18	171.72	189.90 ab
T_5	50% RDF+50%FYM-N	19.88	183.34	203.22 a
T_6	75%RDF+25%FYM-N	18.11	162.79	180.91 b
T_7	50%RDF+50%RR-N	15.75	147.34	163.09 c
T_8	75% RDF+25%RR-N	13.45	136.16	149.61 d
T_9	50% RDF+50%GM-N	20.18	179.79	199.97 a
T_{10}	75% RDF+25%GM-N	18.96	165.92	184.88 b
T_{11}	Farmer practices (50:30:20)	12.74	129.32	142.06 d
SEm±		**0.78**	**4.53**	**4.55**
CD(P= 0.05)		**2.29**	**13.36**	**13.41**

FYM-farm yard manure, RR- rice residues, GM- green manure

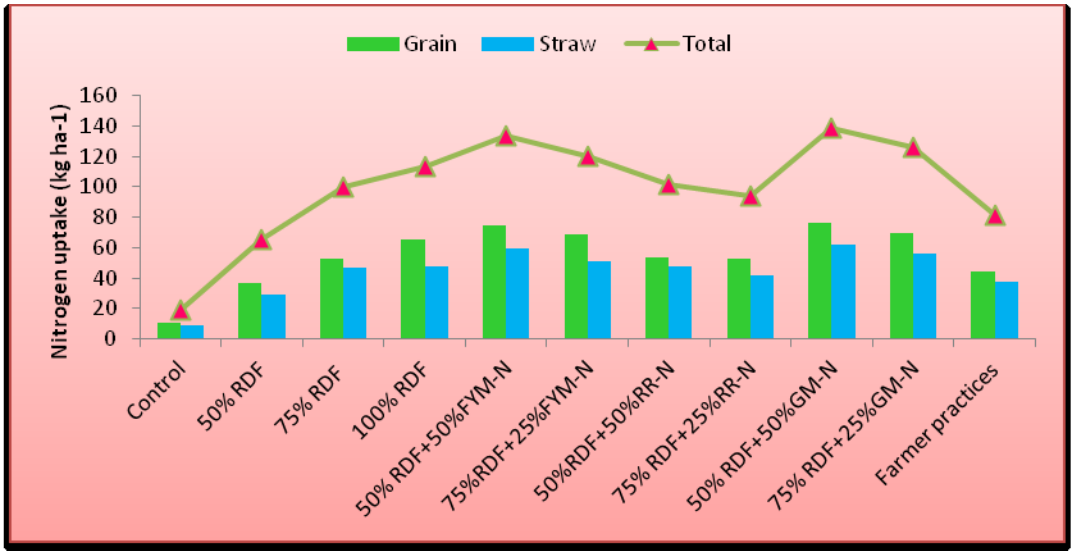


Fig4.4: Effect of INM management practices on nitrogen uptake

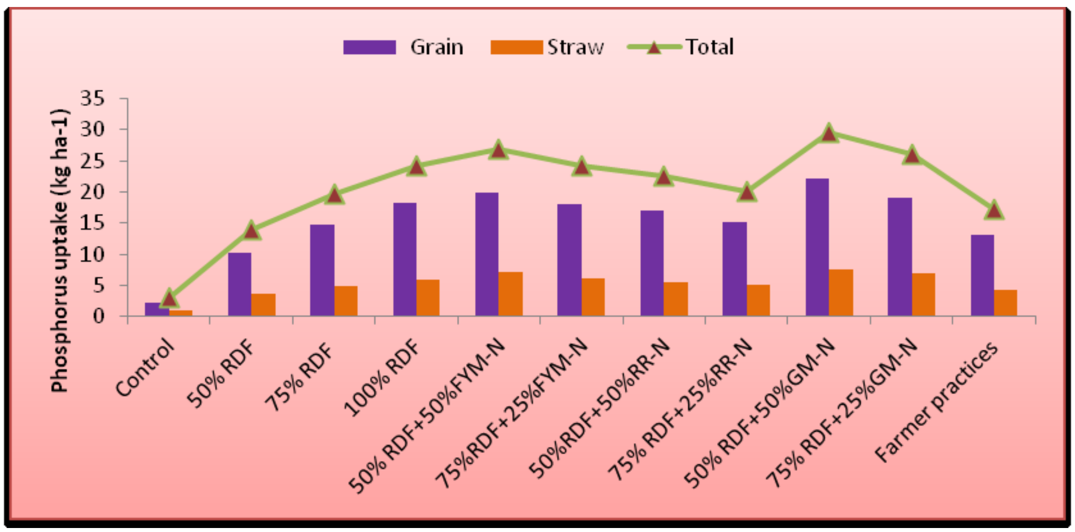


Fig 4.5: Effect of continuous cropping and fertilization on P uptake by rice

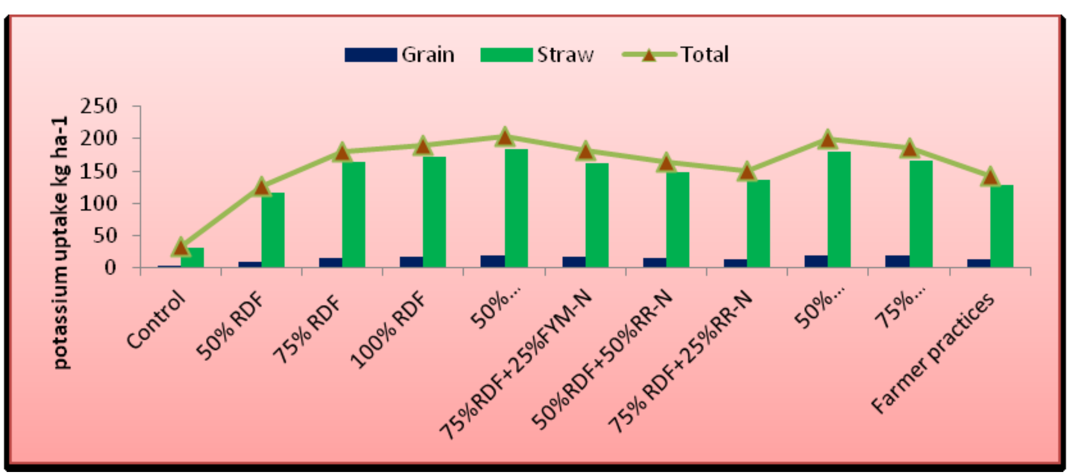


Fig 4.6: Potassium uptake by rice as affected by different treatment

4.4 Relationship of soil microbial biomass carbon with soil fertility and crop yield

Correlation coefficient between the selected various component of soil fertility with soil microbial biomass carbon (MBC) was worked out and the values of correlation coefficient are presented in table 8. Correlation analysis was performed to quantify the relationship of soil MBC with soil fertility and crop yield. This analysis was carried out to find out the contribution of various component of soil fertility to soil MBC. The correlation study revealed that soil MBC was significantly and positively correlated with organic carbon, available nitrogen, phosphorous, potassium and crop yields. It can be concluded from the above results that the highly positive significant correlation coefficient was found between organic carbon, available nitrogen, phosphorous, potassium, and crop yield and it was explained by r =, 0.82, 0.76, 0.79, 0.89, 0.76 and 0.74, respectively during rice season. Zhong and Cai (2006) reported that the most microbial parameters were mainly correlated with soil organic carbon content rather than P and N indicating that the application of P and N did not directly affect microbial parameters in the soil, but did so indirectly by increasing crop yields, thus promoting the accumulation of soil organic matter.

Table 4.8: Relationship between of soil fertility and crop yield with soil microbial biomass carbon (after 21 crop cycle)

S. No.	Parameters	r-value
1.	Microbial biomass carbon vs. organic carbon	0.82**
2.	Microbial biomass carbon vs. available nitrogen	0.76**
3.	Microbial biomass carbon vs. available phosphorous	0.79**
4.	Microbial biomass carbon vs. available potassium	0.89**
5.	Microbial biomass carbon vs. grain yield	0.76**
6.	Microbial biomass carbon vs. straw yield	0.74**

** significant at 1%

4.5 Effect of combined application of inorganic fertilizer and organic manure on nutrient balance sheet

It is always desirable to calculate the apparent nutrient balance to attain the desirable level of production without depleting the native reserves and ensuring the maintenance and improvement in soil fertility. Nutrient's drain has been calculated on the basis of the removal by grain and straw of the crops which were harvested. The balance sheets of available N, P and K in rice as influenced by inorganic fertilizer and organic manure are presented in Table 4.9. The data showed that on inputs (nutrient applied) and outputs (nutrient uptake) of nutrients indicated the N, P and K removal was the highest in 50%RDF+50%FYM-N followed by 50% RDF+50%GM-N over rest of the treatments. The maximum negative N balance was recorded in treatment 50%RDF+50%FYM-N (-54.83). Phosphorus is relatively immobile in soil as compared to N and K. The maximum positive balance of P was recorded in treatment 75% RDF+25% RR-N (+5.8 kg ha^{-1}) followed by 50%RDF+50% RR-N (+3.5 kg ha^{-1}) while, maximum negative balance of P was recorded in treatment Farmer practices (-4.2 kg ha^{-1}). The negative P balance is obviously due to absence and/or lower dose of P in fertilization schedule whereas positive P balance is because of addition of P in excess of its uptake by crops (Dwivedi *et al.* 2007). The maximum negative balance of K in soil was recorded under 50%RDF+50%FYM-N (-170 kg ha^{-1}) treatment. Thakur *et al.* (2011) reported that balanced use of fertilizers alone significantly responsible for build up of organic carbon and available P. A declining trend of available N and K from its initial status was noticed as a result of continuous cropping, which indicated considerable soil mining of available N and K.

Table 4.9: Effect of application of inorganic fertilizer and organic manure on nutrients (N, P and K) balance sheet (after 21 crop cycle)

Balance sheet of Nutrients (kg ha^{-1})										
Treatment		**Nutrient added through fertilizer and manure**			**Nutrient removed by grain + straw**			**Net gain or loss**		
		N	**P**	**K**	**N**	**P**	**K**	**N**	**P**	**K**
T_1	Control	0	0	0	19.12	3.05	33.65	-19.12	-3.05	-33.65
T_2	50% RDF	40	13	17	65.45	13.9	127	-25.45	-0.9	-110
T_3	75% RDF	60	20	25	99.82	19.7	180.43	-39.82	+0.3	-155.43
T_4	100% RDF	80	26	33	113.11	24.3	189.9	-33.11	+1.7	-156.9
T_5	50%RDF+50%FYM-N	80	26	33	134.83	26.9	203.22	-54.83	-0.9	-170.22
T_6	75%RDF+25%FYM-N	80	26	33	119.92	24.2	180.91	-39.92	+1.8	-147.91
T_7	50%RDF+50% RR-N	80	26	33	101.45	22.5	163.09	-21.45	+3.5	-130.09
T_8	75% RDF+25% RR-N	80	26	33	94.40	20.2	149.61	-14.4	+5.8	-116.61
T_9	50% RDF+50%GM-N	80	26	33	132.98	29.6	199.97	-52.98	-3.6	-166.97
T_{10}	75% RDF+25%GM-N	80	26	33	126.01	26	184.88	-46.01	0	-151.88
T_{11}	Farmer practices	50	13	17	81.53	17.2	142.06	-31.53	-4.2	-125.06

FYM= farm yard manure, RR= rice residues, GM= green manure.

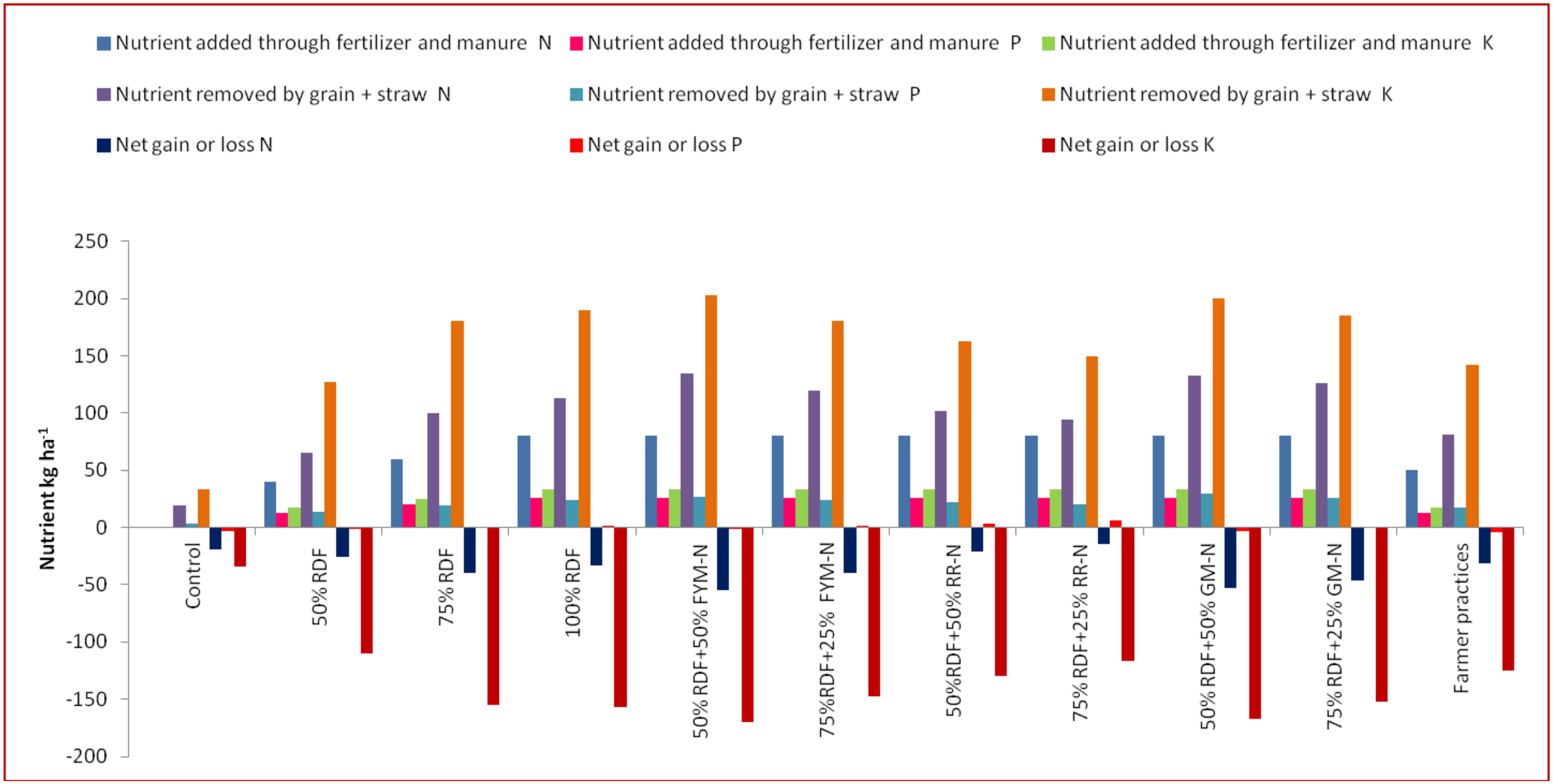


Fig.4.7: Effect of continuous cropping and fertilization of nutrients balance sheet

4.6 Effect of different nutrient management practices on yield attributing characters and yield of rice

4.6.1 Yield attributing character of rice

1. Number of tiller per m^2

Data pertaining on number of effective tillers per m^2 (Table 4.10.) showed that this parameter was significantly influenced with combination of applied inorganic fertilizer and organic manure over control. The 50% RDF+ 50% GM-N showed higher response on number of tillers as compare to other treatment combination. The integration of recommended fertilizer dose along with organic residues like 50% N through GM (483 m^2), FYM (456 m^2), and RS (424 m^2), and 25% N through GM (453 m^2), FYM (440 m^2) and RS (434 m^2) along with 50 and 75% RDF showed comparable and/or on par number of effective tillers amongst them.

At harvest, all the treatments combination proved significantly superior over control in producing effective tillers per square meter. The 50% RDF+ 50% GM-N gave maximum (453 m^2) number of effective tillers and minimum (298 m^2) in farmer's practise plot.

2. Panicle length

The data on panicle length is given in Table 4.10 showed that all the treatments had significant differences over the control. The highest (24.55 cm) panicle length was recorded in 50% RDF+ 50% GM-N followed by 24 cm in 50% RDF+ 50% FYM-N and lowest (16.04 cm) under control plots. The 50, 75 and 100% RDF alone and in combination with 25 and 50% RR-N and farmer practice were at par on panicle length and significantly inferior over rest of the INM treatments. The results are in agreement with the finding of Chaudhary *et al.* (2007) who observed that maximum panicle length was obtained under 120 kg N ha^{-1} (27.80 cm) as compared to in control (20.22 m).

While the effect of N at 80 or 120 kg ha^{-1} with FYM on 1000-grain weight was equally effective as reflected in their statistical methods also.

Table 4.10: Effect of continuous cropping and fertilization on yield attributing characters of Rice (after 21 crop cycle)

Treatment		Effective tiller (m^{-2})	Panicle length (cm)	Test weight (gm)
T_1	Control	113 f	16.04 c	30.86 c
T_2	50% RDF (40:30:20)	353 d	21.3 b	31.89 bc
T_3	75% RDF	348 d	21.83 ab	33.01 ab
T_4	100% RDF (80:60:40)	460 a	22.52 ab	33.56 a
T_5	50% RDF+50% FYM-N	456 b	24 ab	34.21 a
T_6	75%RDF+25% FYM-N	440 b	22.38 ab	33.94 a
T_7	50%RDF+50% RR-N	424 c	21.23 b	33.92 a
T_8	75% RDF+25% RR-N	434 b	22.32 ab	33.46 a
T_9	50% RDF+50% GM-N	483 a	24.55 a	33.31 ab
T_{10}	75% RDF+25% GM-N	453 b	22.56 ab	32.86 ab
T_{11}	Farmer practices (50:30:20)	298 e	21.5 ab	33.85 a
SEm±		**9**	**1.06**	**0.48**
CD (P= 0.05)		**26**	**3.11**	**1.43**

FYM-farm yard manure, RR- rice residues, GM- green manure

3. Test weight

The data on test weight (1000- seeds) is presented in Table 4.10. The highest test weight, 34.21 g was recorded in 50%RDF+ 50% FYM-N followed by 33.31 g in 50%RDF+ 50% GM-N and lowest (30.86 g) in control plot. The results are conformity with the findings of Hossaen *et al.* (2011) who revealed that the maximum number of total grain per plant (97.45), the highest weight of 1000 seeds (21.80 g), the maximum grain yield (7.30 t ha^{-1}) and straw yield (7.64 t ha^{-1}) were recorded in treatment T5 (70% NPKS+2.4 t poultry manure ha^{-1}) whereas the lowest number of effective tillers per hill was 6.1.

4.6.2. Effect of different nutrient management practices on rice yield

The yield of rice increased with increasing the levels of mineral nutrients from 50 to 100% RDF. Treatment T_9 consisting of 50% RDF + 50% GM-N as received from green manuring registered highest grain yield (70.23 q/ha) of rice which was significantly superior to the control, farmer's practice and different levels of mineral nutrients i.e. from 50 to 100 % RDF. It was because of the immobilization of nitrogen and comparable to that of 100% inorganic fertilizer treatment (T_4), 50% (T_5) and 75% (T_6) RDF +25/50% N as received from FYM and 25% N received from GM in T_{10} respectively (Table 4.11).

Significant residual effect of FYM and GM incorporation in soil was recorded on grain yield of rice. Thus, the use of FYM and GM with fertilizer N has helped in sustaining the yield of rice as reported by Singh *et al* (2001). Rice was found to be more responsive than rabi crops to green manuring, which might be due to direct effect of green manure in supplying nutrient to rice crop and beneficial effect on soil health as reported by Kumar and Singh (2010). Mehdi *et al.* (2011) studied the comparison of Sesbania and FYM applied at 20 ton ha^{-1} showed that Sesbania remained superior over the farm yard manure for improving the paddy and straw yield. The increased efficiency of NPK fertilizer with green manuring may be due to chemical, enzymatic and metabolic transformation of organic material, as the green manuring is continuously subject to degradation, thus more susceptible to change in metal uptake than inorganic soil fractions.

Table 4.11: Effect of long term inorganic fertilizer and organic manure application on rice yield (after 21 crop cycle)

Treatment		Yield (q ha^{-1})	
		Grain	**Straw**
T_1	Control	13.13 e	23.29 e
T_2	50% RDF (40:30:20)	43.54 cd	68.13 cd
T_3	75% RDF	61.77 b	92.08 a
T_4	100% RDF (80:60:40)	70.1 a	94.79 a
T_5	50% RDF+50%FYM-N	69.27 a	93.13 a
T_6	75%RDF+25%FYM-N	67.5 a	93.75 a
T_7	50%RDF+50%RR-N	60.73 b	81.46 b
T_8	75% RDF+25%RR-N	57.6 b	77.5 b
T_9	50% RDF+50%GM-N	70.23 a	95.83 a
T_{10}	75% RDF+25%GM-N	68.29 a	96.25 a
T_{11}	Farmer practices (50:30:20)	51.04 c	76.46 b
SEm±		**2.78**	**3.72**
CD (P= 0.05)		**8.15**	**10.90**

FYM-Farm yard manure, RR- Rice residues, GM- Green manure

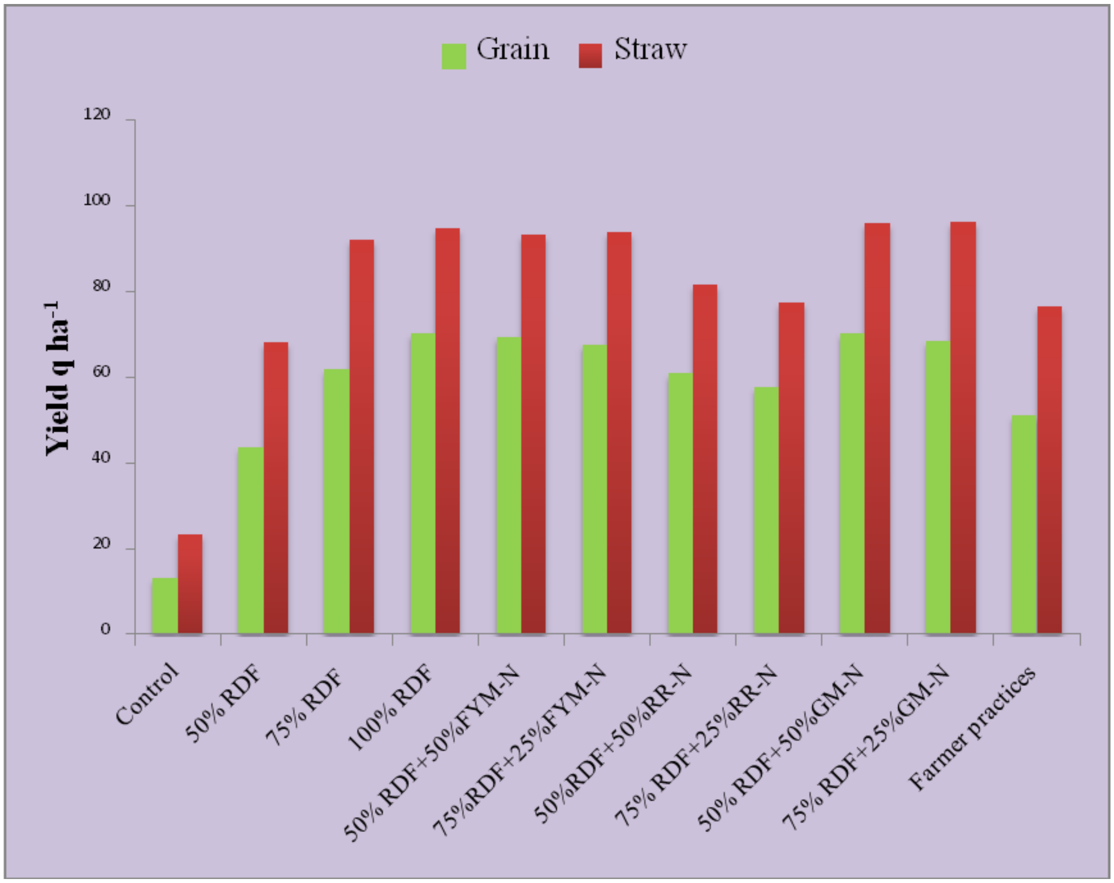


Fig 4.8: Grain and straw yield of rice as affected by different inorganic fertilizer and integrated nutrient management practices

Summary, Conclusion and Suggestions for Future Research Work

CHAPTER-V

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FUTURE RESEARCH WORK

The present study entitled **"LONG TERM EFFECT OF INORGANIC FERTILIZERS AND ORGANIC MANURES ON SOIL FERTILITY STATUS, MICROBIAL BIOMASS CARBON, NUTRIENT UPTAKE AND YIELD OF RICE ON INCEPTISOL"** was carried out during kharif season of 2012 under All India Coordinated Research Project (AICRP) on Integrated Farming System (IFS) at the Instructional Farm of College of Agriculture, Indira Gandhi Krishi Vishavidyalaya, Raipur, Chhattisgarh. The present experiment was laid in randomized block design (RBD) and replicated three times with eleven treatments viz. control (no fertilizer and manure application) (T_1), 50% RDF (T_2), 75% RDF (T_3), 100%RDF (T_4), 50% RDF + 50% FYM-N (T_5), 75%RDF +25% FYM-N (T_6), 50% RDF + 50% RR-N (T_7), 75% RDF + 25% RR-N (T_8), 50% RDF + 50% GM-N (T_9), 75% RDF+ 25% GM-N (T_{10}), Farmer's practices 50:30:20 (T_{11}). A medium duration high yielding rice variety "Mahamaya" was taken as a test crop.

The findings indicated that application of inorganic fertilizer alone did not influence soil pH and EC, but showed higher pH recorded in inorganic fertilizer compared to integrated nutrient management practices and/or control. The electrical conductivity did not vary in different treatments. Incorporation of inorganic fertilizer and organic manure had significantly increased the organic carbon status of the soil. The FYM helped in sustaining / maintaining the highest level of organic carbon (7.5gm kg^{-1}) in 50% RDF + 50% FYM-N followed by application of inorganic fertilizer along with green manure (7.2 gm kg^{-1}).

The different organic and inorganic treatment combinations had significantly influenced the soil fertility status. The highest available nitrogen (272 kg ha^{-1}) content was recorded in 50% RDF + 50% GM-N while, available phosphorus (31.37 kg ha^{-1}) and potassium (264 kg ha^{-1}) status in soil were recorded maximum under 50% RDF + 50% FYM-N followed by 100% RDF (260 kg ha^{-1}).

The different combination of inorganic fertilizer and organic manure increased the N, P and K content in grain and straw of rice crop. The nitrogen and phosphorus content in grain was significantly higher under 50% RDF and 50%GM-N, whereas in case of straw the pattern was found almost similar as observed in grain. Potassium content in grain and straw was found higher in 50% RDF and 50% FYM-N.

The total N, P and K uptake by rice was significantly increased with different treatment of inorganic fertilizer and organic manure. The total uptake of nitrogen (138 kgha^{-1}) and phosphorus (29.6 kg ha^{-1}) by rice was found higher in 50% RDF and 50% GM-N whereas, total potassium (203 kg ha^{-1}) uptake was found maximum in 50% RDF along with 50% FYM-N and lowest (33.65 kg ha^{-1}) in control.

Soil microbial biomass carbon was significantly influenced by different treatment combinations. The FYM helped in maintaining highest (334.55 μgCg^{-1} of dry soil) microbial biomass carbon followed by green manure. A gradual increase was observed due to graded levels of N, P and K i.e. 50 to 100 % over absolute control.

The balance sheets of N, P and K in rice as influenced by inorganic fertilizer and organic manures showed that on inputs (nutrient applied) and outputs (nutrient uptake) of nutrients indicated that the N, P and K removal was higher in 50%RDF+50%FYM-N followed by 50% RDF+50%GM-N over rest of the treatments. The maximum negative N balance (-54.83) was recorded in treatment 50% RDF+50%FYM-N. The maximum positive balance (+5.8 kg ha^{-1}) of P was recorded in treatment 75% RDF+25% RR-N followed (+3.5 kg ha^{-1}) by 50%RDF+50% RR-N while, maximum negative balance (-4.2 kg ha^{-1}) of P was recorded in Farmer practices treatment. The maximum negative balance (-170 kg ha^{-1}) of K in soil was recorded under 50%RDF+50%FYM-N treatment.

The growth and yield parameter were significantly affected by different treatments. The highest (34.21 g) weight of 1000 grain was observed in 50% RDF and 50% FYM-N and lowest in control. The maximum number (483 m^{-2}) of effective tiller was recorded in 50% RDF + 50% GM-N over control. The highest panicle length (24.55cm) was recorded in 50% RDF+ 50% GM-N followed by 50% RDF+ 50% FYM-N (24 cm) and lowest (16.04cm) under control plot.

The yield of rice increased with increasing the levels of mineral nutrients from 50 to 100% RDF. Treatment T_9 consisting of 50% RDF + 50% GM-N as received from green manuring registered highest grain yield (70.23 q/ha) of rice which was significantly superior over control. It was because of the immobilization of nitrogen and comparable to that of 100% inorganic fertilizer treatment (T_4), 50% (T_5) and 75% (T_6) RDF +25/50% N as received from FYM and 25% N received from GM in $T_{10,}$ respectively.

Conclusions

From the above result the following conclusions can be drawn:-

1. Continuous application of chemical fertilizers alone or integration with any of the organics did not influence pH and electrical conductivity of soil. However, the organic carbon content was higher in 50% inorganic NPK fertilizers alongwith 50 % GM-N. The inorganic fertilizer and organic manure maintained and/or sustained highest levels of available N, P and K due to its long-term application. The green manure was next in maintaining above nutrient / element followed by FYM.
2. Higher response was observed in integrated use of organic along with inorganic fertilizer for the nutrient supply of rice crop and further it improves the organic carbon and available nitrogen and potassium content of soil.
3. Long term integrated nutrient management in continuous cropping system resulted in a significant accumulation of microbial biomass in soil.
4. The accumulation of microbial biomass augmented the yield of rice crop. Among the component of soil fertility studied, microbial biomass contributed only towards organic carbon while other component remained unaffected.
5. The balance sheets of N, P and K in rice as markedly influenced by inorganic fertilizer and organic manures, The maximum negative N balance (-54.83)was recorded in treatment 50%RDF+50%FYM-N. The maximum positive balance (+5.8 kg ha^{-1}) of P was recorded in treatment 75% RDF+25% RR-N followed by 50%RDF+ 50% RR-N (+3.5 kg ha^{-1}) while, maximum negative balance (-4.2 kg ha^{-1}) of P was recorded in Farmer practices treatment. The maximum negative balance (-170 kg ha^{-1}) of K in soil was recorded under 50%RDF+50%FYM-N treatment.

6. Green manure is second best option for long-term sustainability and high yield in this system followed by chemical fertilizer alone and integration with FYM.
7. All the yield attributing character and yield of rice significantly increased due to residual effect of GM/FYM/RR residues along with 75% and 100% RDF in rice over control.
8. The yield of rice increased with increasing the levels of mineral nutrients from 50 to 100% RDF. Treatment T_9 consisting of 50% RDF + 50% GM-N as received from green manuring registered highest grain yield (70.23 q/ha).

Suggestions for Future Work

1. Long- term effect of integrated use of organics along with chemical fertilizer on nutrient dynamics and fractionation of soil organic matter and biological properties of soil need to be studied.
2. The extent of microbial biomass accumulation is closely related to microbial and enzyme activities in soil which should also be determined simultaneously to establish and define their role in the dynamics of soil microbial biomass.
3. The changes in physical properties of soil in relation to micronutrient due to chemical fertilizer and INM over the year need to be studied.
4. Role of long-term fertilizer experiment on developing suitable model for precision farming with higher input use efficiency may be determined.

Abstract

"LONG TERM EFFECT OF INORGANIC FERTILIZERS AND ORGANIC MANURES ON SOIL FERTILITY STATUS, MICROBIAL BIOMASS CARBON, NUTRIENT UPTAKE AND YIELD OF RICE ON INCEPTISOL"

BY

Kiran Rathore

ABSTRACT

The experiment was conducted during the *kharif* season of 2012 at Instructional Farm of IGKV, Raipur (C.G.) to investigate the long term effect of inorganic fertilizers and organic manures on soil fertility, nutrients uptake, nutrients balance sheet, microbial biomass carbon (MBC) and yield of rice. The soil was sandy loam and locally known as matasi, neutral in pH, low in available N, medium in available P and K. The experiment was laid in randomized block design and replicated three times with eleven treatments *i.e.* control (no fertilizer and manure application) (T_1), 50% RDF (T_2), 75% RDF (T_3), 100%RDF (T_4), 50% RDF + 50% FYM-N (T_5), 75%RDF +25% FYM-N (T_6), 50% RDF + 50% RR-N (T_7), 75% RDF + 25% RR-N (T_8), 50% RDF + 50% GM-N (T_9), 75% RDF+ 25% GM-N (T_{10}), Farmer's practices 50:30:20 (T_{11}). A medium duration high yielding rice variety "Mahamaya" was taken as a test crop.

The results revealed that combined application of inorganic fertilizer and organic manure *i.e.* integration of fertilizers and manures during *kharif* improves chemical properties of soil like organic carbon content, available N, P and K status in soil, microbial biomass carbon in soil and nutrient balance sheet as compared to absolute and/or alone inorganic fertilizer application. At harvest of rice no significant change was observed with respect to pH and EC of soil. However, application of organics (farm yard manure, rice residues, green manure) with inorganic fertilizer treatment in rice along with 50 and 75% RDF gave higher soil organic carbon, available P and MBC content of soil as compared to control. Whereas, depletion of negative balance of available N and K were found in all the treatments, show the mining of these nutrients from available pool of soil.

Further, the result revealed that MBC positively significant correlated with organic carbon, available N, P and K and yield of rice. The macro nutrients uptake, yield attributing parameter and grain yield were found superior in different organic and inorganic treatment combination at 25, 50% and along with GM and/or FYM as compared to 50% or 75% RDF to the rice crop.

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Appendix

Appendix- I

Weekly Meteorological data during crop period (2012-13)

Std. Met. Weeks no.	Date	Maxi. Temp. (°C)	Mini. Temp. (°C)	Rain-Fall (mm)	Relative Humidity (%)	
					I	II
22	**Jun 2-8**	43.9	30.6	0.3	36.6	22.3
23	9-15	40.0	28.7	7.1	65.7	35.1
24	16-22	33.8	23.7	13.7	89.6	69.4
25	23-29	34.1	26.2	0.9	78.4	52.0
26	**Jul** 30-06	33.5	25.5	3.6	87.7	70.9
27	07-13	30.3	25.1	12.4	91.1	75.6
28	14-20	31.4	24.7	19.7	92.0	76.7
29	21-27	26.5	24.2	41.1	93.7	89.6
30	28-03	26.5	23.3	31.3	93.4	89.7
31	**Aug** 04-10	28.2	24.6	21.6	92.0	82.1
32	11-17	29.4	25.1	4.2	90.6	73.0
33	18-24	29.0	24.7	10.1	92.6	83.3
34	25-31	31.4	25.2	20.1	93.9	74.1
35	**Sep** 1-7	30.3	25.4	8.1	91.9	77.3
36	08-14	30.5	25.0	6.7	93.6	73.1
37	15-21	31.2	24.8	4.2	93.6	72.4
38	22-28	31.8	24.2	10.3	92.4	57.6
39	**Oct** 29-05	31.7	24.5	1.5	90.1	63.9
40	06-12	31.5	21.3	0.0	88.6	44.0
41	13-19	32.0	19.3	0.0	90.6	35.3
42	20-26	31.3	18.6	0.0	85.4	37.6