

LONG TERM EFFECT OF INORGANIC FERTILIZERS AND ORGANIC MANURES ON NUTRIENT UPTAKE, AND YIELD OF RICE ON INCEPTISOL

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Abstracts: The experiment was conducted during the kharif season at research farm, Indira Gandhi Krishi Viswavidyalaya, Raipur to investigate the long term effect of Inorganic fertilizer and organic manures on nutrient uptake and yield of rice. The soil was sandy loam and locally known as matasi, Low in nitrogen, medium in P and K. The experiment was laid in RBD and replicated three times with eleven treatments: T₁-No Fertilizer, No Organic manure (Control), T₂-50% Recommended NPK (40:30:20), T₃-75% Recommended NPK, T₄-100% Recommended NPK (80:60:40), T₅-50% Recommended NPK +50%N through Farm yard manure, T₆-75% Recommended NPK +25%N through Farm yard manure, T₇-50% Recommended NPK +50%N through rice residue, T₈-75% Recommended NPK +25%N through rice residue, T₉-50% Recommended NPK +50%N through Green manure, T₁₀-75% Recommended NPK +25%N through Green manure, T₁₁-Conventional Farmer' Practice (50:30:20). A medium duration high yielding rice variety Mahamaya was taken as test crop. The results revealed that combination application of inorganic fertilizer and organic manure i.e. integrated of fertilizer and manure improve chemical properties of soil. The macro nutrient uptake yield and attributing parameter and grain yield of rice were found superior in different organic and inorganic treatment combination at 25, 50 % and along with Green manuring and / FYM as compared to 50 % or 75 % RDF to rice crop

Keyword: Rice, Nutrient uptake, Nutrient content, Organic, Inorganic fertilizer

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. 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 17°46' to 24°6' N latitude and 80°15' to 84°51' E longitude. 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 classified as loamy, kaolinitic, isohyperthermic, Lithic Ustropepts. Inceptisol are locally called matasi soil. They have a light texture and a shallow to moderate depth.

Integrated nutrient management is one of the most important components of the production technology to sustain soil fertility and crop productivity. The combined use of organic and inorganic sources of plant nutrients not only pushed the production and profitability of field crops but also helped in maintaining the fertility status of the soil (Chandrasoorian *et al.* 1994). The advantage of combining organic and inorganic sources of nutrients in integrated nutrient management has been proved superior to the use of each component separately

(Palaniappan and Annadurai 2007). 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. Some studies showed that chemical fertilizers increase biomass C and N, 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.

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; Yougounet *et al.*, 2007). It has assumed greater significance and increasing interest in its determination (Azamet *et al.*, 2003). Long term effect of inorganic fertilizers and organic manures on nutrient uptake and yield of rice on inceptisol”

MATERIALS AND METHODS

The field experiment was conducted at the research farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh) during *kharif*. Raipur comes under agro-climatic plain Zone of Chhattisgarh State and

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lie at 21°16' N latitude and 81°26' East longitude with an altitude of 289.56 m above the mean sea level. The experiment were laid out in eleven treatment combinations. T₁ -No Fertilizer, No Organic manure (Control), T₂ -50% Recommended NPK (40:30:20), T₃-75% Recommended NPK, T₄-100% Recommended NPK (80:60:40), T₅-50% Recommended NPK +50%N through Farm yard manure, T₆ -75% Recommended NPK +25%N through Farm yard manure, T₇-50% Recommended NPK +50%N through rice residue, T₈-75% Recommended NPK +25%N through rice residue, T₉-50% Recommended NPK +50%N through Green manure, T₁₀-75% Recommended NPK +25%N through Green manure, T₁₁. Conventional Farmer' Practice (50:30:20). A medium duration high yielding rice variety Mahamaya was taken as test crop with threereplications.

Nitrogen content in plant Sample was determined by using micro-Kjeldahl method as described by Chapman and Pratt (1961). Phosphorus content was determined by Vanadomolybdo-phosphoric acid yellow color method using blue filter as described by Jackson (1958). Potassium content was determined by flame photometer method as described by Chapman and Pratt (1961). The growth and yield of rice crop depend upon all growth parameters. viz Number of total and effective tillers, Panicle length, 1000 grain weight etc.

RESULTS AND DISCUSSION

Effect of various combinations of inorganic fertilizer and organic manure application on nutrient content and their uptake Content in rice grain and straw

Nitrogen, Phosphorus and potassium content in grain as well as straw are given in table 1 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 1. 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.

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 (9.7gmkg⁻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.

Table 1. 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)

Treatments	Nutrient Content (gm kg ⁻¹)					
	Grain	Straw	Grain	Straw	Grain	Straw
	N		P		K	
T1-Control	7.9d	3.8e	1.6e	0.4d	2.1d	1.32d
T2-50% RDF (40:30:20)	8.4d	4.3de	2.4d	0.5cd	2.3cd	1.72bc
T3-75% RDF	8.5cd	5.1bc	2.4cd	0.5c	2.5abcd	1.79bc
T4-100% RDF (80:60:40)	9.4abcd	5.0cd	2.6bcd	0.6bc	2.6abc	1.81abc
T5-50% RDF+50% FYM-N	10.7ab	6.4a	2.9ab	0.8ab	2.9a	1.97a
T6-75%RDF+25% FYM-N	10.2abc	5.5bc	2.7bcd	0.7abc	2.7ab	1.74bc
T7-50%RDF+50% RR-N	8.8cd	5.9ab	2.8abc	0.7abc	2.6abc	1.81abc
T8-75% RDF+25% RR-N	9.2bcd	5.4bc	2.6bcd	0.7abc	2.3bcd	1.76bc

T9-50% RDF+50% GM-N	10.9a	6.5a	3.2a	0.8a	2.9a	1.88ab
T10-75% RDF+25% GM-N	10.2abc	5.9ab	2.8ab	0.7ab	2.8a	1.72bc
T11-Farmer practices (50:30:20)	8.6cd	4.9cd	2.6cd	0.6c	2.5abcd	1.69c
SEm+	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

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 2. 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.

Table 2. Nitrogen uptake by rice as affected by nutrient management practices (after 21 crop cycle)

Treatments	Nitrogen uptake (kg ha ⁻¹)		
	Grain	Straw	Total
T1-Control	10.34	8.78	19.12 h
T2-50% RDF (40:30:20)	36.45	29.00	65.45 g
T3-75% RDF	52.72	47.10	99.82 dc
T4-100% RDF (80:60:40)	65.69	47.42	113.11 cd
T5-50% RDF+50% FYM-N	74.33	59.26	133.59 ab
T6-75%RDF+25% FYM-N	68.71	51.21	119.92 bc
T7-50%RDF+50% RR-N	53.70	47.75	101.45 dc
T8-75% RDF+25% RR-N	52.90	41.50	94.40 ef
T9-50% RDF+50% GM-N	76.29	61.87	138.20 a
T10-75% RDF+25% GM-N	69.47	56.54	126.01 abc
T11-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

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 2) 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

Phosphorus uptake

Phosphorus uptake by rice grain, straw and total under different treatment is given in table 3. 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 3. Phosphorus uptake by rice as affected by nutrient management practices (after 21 crop cycle)

Treatments	Phosphorus uptake (kg ha ⁻¹)		
	Grain	Straw	Total
T1-Control	2.13	0.91	3.05 i
T2-50% RDF (40:30:20)	10.32	3.57	13.9 h
T3-75% RDF	14.74	4.97	19.7 f
T4-100% RDF (80:60:40)	18.30	5.95	24.3 cd
T5-50% RDF+50% FYM-N	19.83	7.1	26.9 b
T6-75%RDF+25% FYM-N	18.01	6.18	24.2 cd
T7-50%RDF+50% RR-N	17.01	5.46	22.5 de
T8-75% RDF+25% RR-N	15.19	5.03	20.2 ef
T9-50% RDF+50% GM-N	22.09	7.52	29.6 a
T10-75% RDF+25% GM-N	19.11	6.86	26 bc
T11-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 3). Similar finding were observed by Makarim *et al.* (2005).

Potassium uptake

Potassium uptake by grain, straw and total under inorganic fertilizer and INM treatments is given in table 4. The K uptake by grain ranged from 2.80 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.

Table 4. Potassium uptake by rice as affected by different treatment (after 21 crop cycle)

Treatments	Potassium uptake (kg ha ⁻¹)		
	Grain	Straw	Total
T1-Control	2.8	30.85	33.65 f
T2-50% RDF (40:30:20)	9.84	117.16	127.00 e
T3-75% RDF	15.4	165.03	180.43 b
T4-100% RDF (80:60:40)	18.18	171.72	189.90 ab
T5-50% RDF+50% FYM-N	19.88	183.34	203.22 a
T6-75%RDF+25% FYM-N	18.11	162.79	180.91 b
T7-50%RDF+50% RR-N	15.75	147.34	163.09 c
T8-75% RDF+25% RR-N	13.45	136.16	149.61 d
T9-50% RDF+50% GM-N	20.18	179.79	199.97 a
T10-75% RDF+25% GM-N	18.96	165.92	184.88 b
T11-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

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.

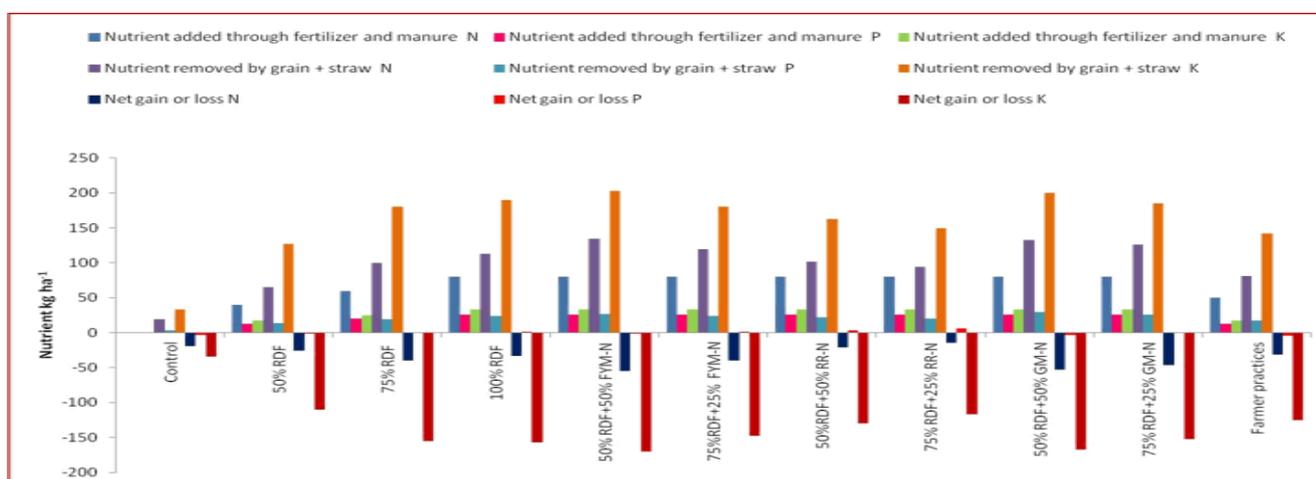
Effect of combined application of inorganic fertilizer and organic manure on nutrient balance sheet

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 5. 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 buildup 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 5. Effect of application of inorganic fertilizer and organic manure on nutrients (N, P and K) balance sheet (after 21 crop cycle)

Treatments	Balance sheet of Nutrients (kg ha ⁻¹)								
	Nutrient added through fertilizer and manure			Nutrient removed by grain +straw			Net gain or loss		
	N	P	K	N	P	K	N	P	K
T1-Control	0	0	0	19.12	3.05	33.65	-19.12	-3.05	-33.65
T2-50% RDF (40:30:20)	40	13	17	65.45	13.9	127	-25.45	-0.9	-110
T3-75% RDF	60	20	25	99.82	19.7	180.43	-39.82	+0.3	-155.43
T4-100% RDF (80:60:40)	80	26	33	113.11	24.3	189.9	-33.11	+1.7	-156.9
T5-50% RDF+50% FYM-N	80	26	33	134.83	26.9	203.22	-54.83	-0.9	-170.22
T6-75%RDF+25% FYM-N	80	26	33	119.92	24.2	180.91	-39.92	+1.8	-147.91
T7-50%RDF+50% RR-N	80	26	33	101.45	22.5	163.09	-21.45	+3.5	-130.09
T8-75% RDF+25% RR-N	80	26	33	94.40	20.2	149.61	-14.4	+5.8	-116.61
T9-50% RDF+50% GM-N	80	26	33	132.98	29.6	199.97	-52.98	-3.6	-166.97
T10-75% RDF+25% GM-N	80	26	33	126.01	26	184.88	-46.01	0	-151.88
T11-Farmer practices (50:30:20)	50	13	17	81.53	17.2	142.06	-31.53	-4.2	-125.06



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

Yield attributing character of rice

Number of tiller per m²

Data pertaining on number of effective tillers per m² (Table 6) 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 m²), FYM (456 m²), and RS (424 m²), and 25% N through GM (453 m²), FYM (440 m²) and RS (434 m²) 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 m²) number of effective tillers and minimum (298 m²) in farmer's practice plot.

Table 6. Effect of continuous cropping and fertilization on yield attributing characters of Rice (after 21 crop cycle)

Treatments	Effective tiller	Panicle length	Test weight
	(m ²)	(cm)	(gm)
T1-Control	113 f	16.04 c	30.86 c
T2-50% RDF (40:30:20)	353 d	21.3 b	31.89 bc
T3-75% RDF	348 d	21.83 ab	33.01 ab
T4-100% RDF (80:60:40)	460 a	22.52 ab	33.56 a
T5-50% RDF+50% FYM-N	456 b	24 ab	34.21 a
T6-75% RDF+25% FYM-N	440 b	22.38 ab	33.94 a
T7-50% RDF+50% RR-N	424 c	21.23 b	33.92 a
T8-75% RDF+25% RR-N	434 b	22.32 ab	33.46 a
T9-50% RDF+50% GM-N	483 a	24.55 a	33.31 ab
T10-75% RDF+25% GM-N	453 b	22.56 ab	32.86 ab
T11-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

Panicle length

The data on panicle length is given in Table 6 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.

Test weight

The data on test weight (1000- seeds) is presented in Table 6. 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 Hossain *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

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 T₉ 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 (T₄), 50% (T₅) and 75% (T₆) RDF +25/50% N as received from FYM and 25% N received from GM in T₁₀ respectively (Table 7). 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 7. Effect of long term inorganic fertilizer and organic manure application on rice yield

Treatments		Yield q/ha	
		Grain	Straw
T1	Control	13.13 e	23.29 e
T2	50% RDF (40:30:20)	43.54 cd	68.13 cd
T3	75% RDF	61.77 b	92.08 a
T4	100% RDF (80:60:40)	70.1 a	94.79 a
T5	50% RDF+50% FYM-N	69.27 a	93.13 a
T6	75%RDF+25% FYM-N	67.5 a	93.75 a
T7	50%RDF+50% RR-N	60.73 b	81.46 b
T8	75% RDF+25% RR-N	57.6 b	77.5 b
T9	50% RDF+50% GM-N	70.23 a	95.83 a
T10	75% RDF+25% GM-N	68.29 a	96.25 a
T11	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

CONCLUSION

The above result the following conclusions can be drawn:-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. 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. 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. 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. The yield of rice increased with increasing the levels of mineral nutrients from 50 to 100% RDF. Treatment T₉ consisting of 50% RDF + 50% GM-N as received from green manuring registered highest grain yield (70.23 q/ha).

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