

## Soil Fertility and Crop Yields Changes under Long-Term Application of FYM in Rice-Rice System

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Received 5 September 2016; Accepted 7 October 2016; Published online 28 October 2016

**Abstract** The effect of continuous application of chemical fertilizers with and without farmyard manure (FYM) on soil fertility changes and crop yields was studied in a long-term field experiment initiated during *khariif*, 2001. The imbalanced use of inorganic fertilizers continuously for 13 cropping years led to the deterioration of soil health that rendered. Application of 100% NPK+FYM @ 10 t ha<sup>-1</sup> recorded highest grain yield and nutrient uptake of rice. Residual effect of FYM plus 100% recommended dose of NPK significantly increased the yield of rice over 100% recommended dose of NPK. Long-term application of farm yard manure and inorganic fertilizers increased the soil organic C content of soil. The combined use of organic amendments and chemical fertilizers significantly increased the availability of N, P, K, S and micronutrients in soil over chemical fertilizers alone.

**Keywords** FYM, Rice, Soil fertility, Rice yields and Total uptake.

### Introduction

Rice is one of the major contributor to the success by contributing approximately 43% of total food grain production of India, now witnessed the yield stagnation and declining productivity due to continuous use of high level of chemical fertilizers had led to soil degradation problems. The low productivity of rice is a serious concern and is mainly attributed to decline in soil fertility, particularly soil organic matter [1]. In recent times, emphasis has been on the increased use of crop residues, green manures as well other organic manures as a source of soil organic matter and plant nutrients [2]. Addition of FYM and inorganic fertilizers to soil has been reported to increase the efficiency of applied fertilizers. Incorporation of organic sources i.e. FYM along with NPK fertilizers is effective in alleviating the nutrient deficiency in soil, improving physical properties of soil and its organic carbon status. The objective of the present study was to investigate the combined effect of these organic sources with inorganic fertilizers on organic carbon, available NPK status of soil, yield and uptake under rice-rice cropping system.

### Materials and Methods

The experiment was conducted at Regional Agricultural Research Station, Jagtial farm. The farm is located at 78°45' E 79°0' E Longitude and 18°45' N to 19°0' N Latitude and at an altitude of 264 m above mean sea level. The mean annual rainfall is 900-1150

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**Table 1.** Long-term effects of INM on physico-chemical and chemical properties of soil after harvest of rice-rice system at Jagtial.

Treatments	pH		EC (dS m <sup>-1</sup> )		OC (%)		Avail. N		Avail. P <sub>2</sub> O <sub>5</sub> (kg ha <sup>-1</sup> )		Avail. K <sub>2</sub> O	
	<i>kharif</i>	<i>rabi</i>	<i>kharif</i>	<i>rabi</i>	<i>kharif</i>	<i>rabi</i>	<i>kharif</i>	<i>rabi</i>	<i>kharif</i>	<i>rabi</i>	<i>kharif</i>	<i>rabi</i>
T <sub>1</sub> – Control	8.1	8.1	0.29	0.30	0.78	0.80	94.3	93.7	12.0	12.3	290.7	285.0
T <sub>2</sub> – 100% RD of NPK	8.0	8.1	0.27	0.29	0.80	0.88	203.7	221.9	30.0	38.2	382.8	398.1
T <sub>3</sub> – FYM @ 10 t ha <sup>-1</sup>	8.0	8.0	0.25	0.27	0.90	1.01	192.8	201.3	25.1	28.1	362.1	372.9
T <sub>4</sub> – 100% RD of NPK + FYM @ 10 t ha <sup>-1</sup>	8.0	8.0	0.23	0.22	1.01	1.04	219.2	239.8	40.2	43.2	400.7	418.0
CD ( <i>p</i> =0.05)	NS	NS	0.03	NS	0.06	0.06	12.80	50.88	3.19	1.87	17.29	17.34
SEm±	0.05	0.05	0.01	0.02	0.02	0.02	3.95	15.68	0.98	0.58	5.33	5.34

Treatments	Zn		Fe		Cu		Mn	
	<i>kharif</i>	<i>rabi</i>	<i>kharif</i>	<i>rabi</i>	<i>kharif</i>	<i>rabi</i>	<i>kharif</i>	<i>rabi</i>
T <sub>1</sub> – Control	8.1	8.1	0.29	0.30	0.78	0.80	94.3	93.7
T <sub>2</sub> – 100% RD of NPK	8.0	8.1	0.27	0.29	0.80	0.88	203.7	221.9
T <sub>3</sub> – FYM @ 10 t ha <sup>-1</sup>	8.0	8.0	0.25	0.27	0.90	1.01	192.8	201.3
T <sub>4</sub> – 100% RD of NPK + FYM @ 10 t ha <sup>-1</sup>	8.0	8.0	0.23	0.22	1.01	1.04	219.2	239.8
CD ( <i>p</i> =0.05)	NS	NS	0.03	NS	0.06	0.06	12.80	50.88
SEm±	0.05	0.05	0.01	0.02	0.02	0.02	3.95	15.68

mm falls under Northern Telangana Agro-Climatic zone of Telangana. The monthly mean maximum temperatures during the crop growth period ranged from 29.9 °C to 42.1°C with an average of 32.7°C, while the monthly mean minimum temperature ranged from 12.5 °C to 26.7°C with an average of 20.8°C. The total rainfall received during the crop growth period was 1198.1 mm distributed throughout the year had a total of 62 rainy days. The initial soil was clay loam, neutral in reaction pH 8.2 [3], non saline in nature EC 0.47 dS m<sup>-1</sup> [3], high in organic carbon OC 0.79% [4], low in available N 107 kg ha<sup>-1</sup> [5], medium in available P 19.6 kg ha<sup>-1</sup> [6] and high in available K 364 kg ha<sup>-1</sup> [3]. DTPA extractable micronutrients [7] and plant analysis [8] were done by following standard procedures. The data on the observations made were analyzed statistically by applying the technique of analysis of variance for randomized block design as suggested by Panse and Sukhatme [9]. This experiment was laid out in randomized block design with four treatments and four replications. The treatment details were as follows: T<sub>1</sub> – Control (No manure and no fertilizer), T<sub>2</sub> – 100% NPK (120-60-40 N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>3</sub> – FYM @ 10 t ha<sup>-1</sup>, T<sub>4</sub> – 100% NPK + FYM @ 10 t ha<sup>-1</sup>.

## Results and Discussion

### Physico-chemical properties of soil

The pH values of 1 : 2.5 soil water suspensions ranged from 8.0 to 8.2 after harvest of both *kharif* and *rabi* rice, indicating alkaline in reaction. Electrical conductivity was decreased slightly from the initial level with continuous cropping of rice-rice but the differences among different treatments were not significant. The values of CEC varied from 27.58 to 40.23 and 24.20 to 40.56 cmol (p<sup>+</sup>) kg<sup>-1</sup> for *kharif* and *rabi* soils, respectively. The organic carbon content of the soil increased significantly with the incorporation of organic materials with chemical fertilizers as well as with 100% fertilizer treatment over control (Table 1). The highest (1.01 and 1.04%) organic carbon content was observed in 100% RD of NPK + FYM @ 10t ha<sup>-1</sup> in *kharif* and *rabi*, respectively. There was an improved organic carbon in treatments receiving both inorganic and organic sources over the years, this may be attributed to higher contribution of biomass to the soil in the form of FYM, which upon decomposition might have resulted in enhanced organic carbon content of the soil [10]. The treatments which received only inorganic

fertilizers showed lower organic carbon values which could be due to no addition of organic manures as well as intensive oxidation process aided by degradation and decomposition of organic matter [11]. The available nitrogen status of surface soil after the harvest of rice differed significantly with incorporation of FYM combined with chemical fertilizer over control. The highest available N, P and K in soil was found to be significantly higher in  $T_4$  recording 219.2, 40.2 and 400.7  $\text{kg ha}^{-1}$ , respectively, during *kharif*. Similar trends were observed at harvest of *rabi* rice with 239.8, 43.2 and 418.0  $\text{kg ha}^{-1}$ , respectively. Application of inorganic fertilizers in combination with FYM increased the available nutrients status. This might be due to enhanced microbial activity and mineralization of nutrients. The physical condition of the soil was also improved through INM practices, which helped in better crop growth and yield [12]. Available contents of Fe, Mn, Zn and Cu in soil increased with the application of FYM as compared with 100% NPK, irrespective of different treatments. The DTPA-extractable Zn, Fe, Cu and Mn at harvest of *kharif* rice, varied from 0.61 to 1.51, 4.05 to 7.08, 2.07 to 2.30 and 2.02 to 4.51  $\text{mg kg}^{-1}$ , respectively. Higher available micronutrients were recorded in  $T_4$  (100% RD of NPK + FYM @  $\text{t ha}^{-1}$ ) followed by  $T_3$  (FYM @  $10\text{t ha}^{-1}$ ). Similar trends were observed during *rabi* with DTPA-extractable Zn, Fe, Cu and Mn values ranged from 0.93 to 1.31, 4.47 to 7.70, 2.25 to 2.43 and 2.13 to 4.82  $\text{mg kg}^{-1}$ , respectively. Application of FYM alone or in combination with inorganic fertilizers was effective in enhancing available micronutrients in the soil. This might be due to higher rooting activity and enhanced organic carbon which contributed to accumulation of bio-available micronutrients in the surface soils [11].

#### Grain and straw yields

Grain and straw yield was significantly influenced by the different treatment combinations over the control (Table 2). Highest grain yield (5191  $\text{kg ha}^{-1}$ ) and straw yield (7043  $\text{kg ha}^{-1}$ ) of *kharif* rice crop were recorded in  $T_4$  (100% RD of NPK + FYM @  $10\text{t ha}^{-1}$ ) followed by  $T_2$  (4883 and 6348  $\text{kg ha}^{-1}$ , respectively). However,  $T_4$  showed significantly higher yields than the other treatments. Similarly, highest

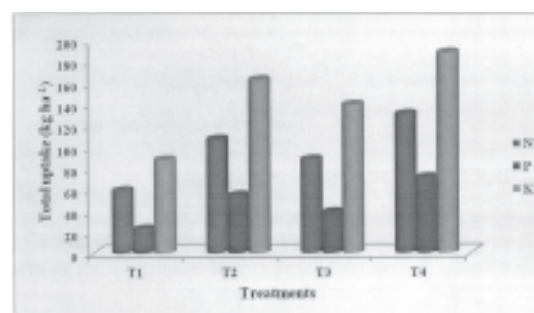
**Table 2.** Long-term effects of INM on grain and straw yields after harvest of rice -rice system at Jagtial.

Treatments	Grain yield		Straw yield	
	<i>kharif</i>	<i>rabi</i>	<i>kharif</i>	<i>rabi</i>
$T_1$ - Control	3223	2710	4960	4586
$T_2$ - 100% RD of NPK	4883	5638	6348	7145
$T_3$ - FYM @ $10\text{t ha}^{-1}$	4125	3856	6345	5129
$T_4$ - 100% RD of NPK + FYM @ $10\text{t ha}^{-1}$	5191	6432	7043	8552
CD ( $p=0.05$ )	231.9	257.1	278.0	273.8
SEm $\pm$	71.47	79.26	85.70	84.39

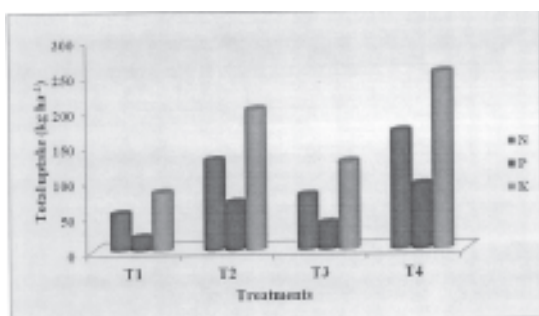
grain yield (6432  $\text{kg ha}^{-1}$ ) and straw yield (8552  $\text{kg ha}^{-1}$ ) of *rabi* rice was recorded in  $T_4$  followed by  $T_2$ . Application of FYM although offer the twin benefits of soil quality and fertility enhancement but while meeting a part of nutrients need of crops, not only sustain the high yields required these days but also cut the cost on expensive fertilizers. Higher yields were also associated with added fertilizer levels which might be due to the cumulative effect of increased translocation of photosynthates to sink resulting in enhanced levels of yield components [3].

#### Nutrient uptake

The data on NPK uptake by rice at the end of *kharif* and *rabi* are reported in Figures 1 and 2, respectively. The treatments were statistically significant in case of grain and straw for all the three nutrients. Among different treatments,  $T_4$  (100% RD of NPK + FYM



**Fig. 1.** Long-term effects of INM on total N, P and K uptake (grain + straw) after harvest of *kharif* rice under rice-rice cropping system at Jagtial.



**Fig. 2.** Long-term effects of INM on total N, P and K uptake (grain + straw) after harvest of *kharif* rice under rice-rice cropping system at Jagtial.

@ 10 t ha<sup>-1</sup>) recorded higher uptake of nitrogen (68.5 and 87.5 kg ha<sup>-1</sup>), phosphorus (46.2 and 59.2 kg ha<sup>-1</sup>) and potassium (83.1 and 119.6 kg ha<sup>-1</sup>) followed by T<sub>2</sub> in both *kharif* and *rabi*. The total uptake of N, P and K values (grain + straw) during *kharif* (130.5, 71.6 and 188.0 kg ha<sup>-1</sup>, respectively) and *rabi* (167.9, 92.5 and 252.2 kg ha<sup>-1</sup>, respectively) were recorded in T<sub>4</sub> followed by 100% RD of NPK.

The nutrient uptake by whole plant was increased significantly in the above said treatments. This higher content was mainly due to higher drymatter accumulation, since farm yard manure supply major and minor nutrients along with organic acids provides good soil physical condition for plant growth. This increased uptake of nutrients increased photosynthesis and finally yield. These results confirm the earlier findings of [14, 15].

## Conclusion

It can be concluded that organics in conjunction with inorganic fertilizers improved sustainability of crop production. Recycling of crop residues on long-term basis along with application of FYM and green manure increased organic carbon, fertility status of soil and nutrient uptake of rice. However, application of organic manure alone could not sustain high crop yield. Application of was 100% RD of NPK + FYM @ 10 t ha<sup>-1</sup> effective in increasing grain and straw

yield of rice, improving the nutrients uptake, build up N, P, K and organic carbon in the soil. Integrated nutrient management found to be good option to stabilize the production and profits besides maintaining soil health.

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