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Long-Term Studies on Soil Properties and Productivity of Rice—Rice System as Influenced by INM in Southern Telangana Zone

P. V. Geetha Sireesha, G. Padmaja, P. C. Rao, M. Venkata Ramana

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Abstract Studies were conducted to understand the influence of integrated nutrient management on soil properties and nutrient uptake under rice-rice cropping system since 1988. The study was aimed to find out the effect of organic sources of nitrogen integrated with chemical sources on rice and their residual effect on succeeding *rabi* rice in rice-rice cropping system. Over the 27 years of study period, highest rice yield was obtained when 75% RD of NPK + 25% N through green leaf manure. When 50% N was supplied through green leaf manure, it produced rice yield at par with the treatment where, 100% NPK had been applied through chemical fertilizers. This study showed that wherever, nitrogen was substituted through GM, FYM or crop residue (rice straw) in rice, soil fertility was significantly increased as compared to the initial status and control plot at the time of rice harvest. Similar change in the physical properties was observed due to application of 75% recommended dose of fertilizers integrated with 25% N fertilizer equivalent through any one of the three organic sources in *kharif* season and application of 75% recommended dose of fertilizers in *rabi.* Incorporation of organic sources considerably improved the soil properties such as available NPK status of the soil.

Keywords INM, GM, FYM, NPK status of soil.

P. V. G. Sireesha*, G. Padmaja, P. C. Rao, M. V. Ramana
Department of Soil Science and Agricultural Chemistry, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad 500030, India
e-mail: geethashirisha048@gmail.com
*Correspondence

Introduction

India is one of the main countries producing rice (*Oryza sativa* L.) in the world. Rice -rice is the most predominant cropping system in the Telangana, particularly in southern telangana zone. The major problem is the deterioration of soil properties due to continuous puddling and impaired soil fertility due to indiscriminate application of nutrients through the fertilizers with the threat of the declining productivity. Continuous cropping and long term fertilization are liable to change the soil properties and crop production, depending upon the type of management practices [1]. The use of locally available organic sources has higher potential to improve the soil physical properties that are in terms of soil fertility and there by soil quality as a whole sustain the level of crop productivity in the rice – rice cropping system. Incorporation of organic sources i.e. green manure. FYM and crop residues along with NPK fertilizers is effective in alleviating the nutrient deficiency in soil, improving physical properties of soil and its organic carbon status. Sustainable production of crops can-

not be maintained by using chemical fertilizers along due to deterioration in soil physical and biological environments and soil fertility status [2]. Hence, an investigation was made to assess the soil nutrient supplying capacity under different INM practices in a long-term fertilization experiment with continuous rice - rice cropping system.

Materials and Methods

The present investigation was carried out in the ongoing AICRP on Integrated Farming Systems which was initiated in *kharif,* 1988 at the College Farm, College of Agriculture, Rajendranagar, Hyderabad. The initial soil was sandy clay loam, neutral in reaction pH 8.5 [3, non saline in nature EC 0.24 dS m^{-1} [3], medium in organic carbon OC 0.54% [4], low in available N 151 kg ha^{-1} [5], medium in available P 24.0 kg ha^{-1} [6] and medium in available K 224 kg ha^{-1} [3] and plant analysis [7] were done by following standard procedures. Finally, the uptake of macro nutrients at the time of harvesting was calculated by using the following formula.

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content (\%)} \times \text{dry matter (kg ha}^{-1}\text{)}}{100}$$

This experiment was laid out in randomized block design with eight treatments and three replications. The treatment details during *kharif* season were as follows : T_1– Control (No fertilizer, no organic manure), T_2– 100% RD of NPK, T_3–50% RD of NPK + 50% N through FYM, T_4–75% RD of NPK + 25% N through FYM, T_5–50% RD of NPK + 50% N through Paddy straw, T_6– 75% RD of NPK + 25% N through Paddy straw, T_7–50% RD of NPK + 50% N through Green leaf manure, T_8–75% RD of NPK + 25% N through Green leaf manure.

The treatments in *rabi* season were as follows : T_1–Control (No fertilizer, no organic manure), T_2 – 100% RD of NPK (120-60-60 kg N, P_2O_5 and K_2O ha^{-1}), T_3–100% RD of NPK, T_4–75% RD of NPK, T_5– 100% RD of NPK, T_6– 75% RD of NPK, T_7–100% RD of NPK, T_8–75% RD of NPK.

The organic sources such as FYM, Paddy straw and *Glyricidia* (green leaf manure) were applied two weeks before transplanting of paddy as per the treatments. The rice variety MTU 1010 were sown uniformly and raised in the field with a spacing of 20 cm × 10 cm. The recommended fertilizer dose (120-60-40 kg N, P_2O_5 and K_2O ha^{-1}) was applied in the form of urea, diammonium phosfate and muriate of potash, respectively. All the PK and 1/3rd of N fertilizer were applied at the time of transplanting while remaining nitrogen was applied in two equal splits. All cultural practices were performed. Crops were harvested at maturity. Paddy and straw yield data was collected. The data on the observations made were analyzed statistically by applying the technique of analysis of variance for randomized block design [8].

Results and Discussion

Soil properties

The continuous application of chemical fertilizers and manures led to a significant change in the soil reaction (Table 1). The pH decreased in all the treatments indicating neutral in reaction and ranged from 7.3 to 7.7. Use of 100% N (urea) alone caused a maximum reduction in soil pH. Similarly, EC decreased slightly from initial (0.24 dS m^{-1}) and ranged from 0.70 to 0.99 dS m^{-1} indicating non saline in nature. The highest organic carbon content (1.70 and 1.88%, respectively) was noticed in the treatment receiving 50% RD of NPK + 50% N thropugh FYM in *kharif* and 75% RD of NPK in *rabi.* Application of green manures over the seasons has lead to an increase in soil organic carbon content.It has been shown that green maures contain polyphenols which combine with proteins to render the residue recalcitrant to microbial attack and thus provided an increased soil organic carbon. Similar results were reported earlier [9].

The results pertaining to the available nitrogen under *kharif* rice indicated that T_4 (75% RD of NPK+ 25% N through FYM) showed highest available N (230.0 kg ha^{-1}) while lowest available N (125.5 kg ha^{-1}) registered under control. Whereas during *rabi* rice T_3 showed highest available N (233.1 kg ha^{-1}). This indicated that application of organic manures during *kharif* maintained available nitrogen status in *rabi* with a saving of 25% RD of inorganic fertilizer this might be due to mineralization of organic manures

Table 1. Long-term effects of INM on soil properties after harvest of rice-rice system at Rajendranagar.

Treatments		pH		EC (dS m^{-1})		OC (%)	
		Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
T_1–Control	T_1–Control	7.3	7.5	0.99	1.09	0.57	0.59
T_2–100% RD of NPK	T_2– 100% RD of NPK	7.4	7.7	0.91	1.02	0.68	0.57
T_3–50% RD of NPK + 50% N through FYM	T_3– 100% RD of NPK	7.6	7.6	0.70	0.72	0.72	0.65
T_4– 5% RD of NPK + 25% N through FYM	T_4–75% RD of NPK	7.7	7.7	0.73	0.78	0.67	0.61
T_5–50% RD of NPK + 50% N through Paddy straw	T_5–100% RD of NPK	7.5	7.6	0.71	0.76	0.70	0.68
T_6–75% RD of NPK + 25% N through Paddy straw	T_6–75% RD of NPK	7.3	7.6	0.76	0.72	0.71	0.70
T_7–50% RD of NPK + 50% N through Green leaf manure	T_7–100% RD of NPK	7.5	7.6	0.92	0.94	0.68	0.60
T_8–75% RD of NPK + 25% N through Green leaf manure	T_8–75% RD of NPK	7.4	7.7	0.87	0.85	0.66	0.71
CD (p = 0.05)		NS	NS	0.14	0.15	NS	0.09
SEm ±		0.21	0.05	0.05	0.05	0.04	0.03

Table 1. Continued.

Treatments		Avail. N		Avail. P_2O_5 (kg ha^{-1})		Avail. K_2O	
		Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
T_1–Control	T_1–Control	125.5	124.7	18.6	16.2	204.5	200.1
T_2–100% RD of NPK	T_2–100% RD of NPK	196.5	208.3	32.9	34.8	362.6	380.5
T_3–50% RD of NPK + 50% N through FYM	T_3–100% RD of NPK	217.4	233.1	44.0	45.5	392.9	394.0
T_4–75% RD of NPK + 25% N through FYM	T_4–75% RD of NPK	230.0	216.0	40.4	40.6	363.3	355.7
T_5–50% RD of NPK + 50% N through Paddy straw	T_5–100% RD of NPK	179.8	200.7	33.9	32.6	320.6	347.2
T_6–75% RD of NPK + 25% N through Paddy straw	T_6–75% RD of NPK	183.1`	198.2	32.3	30.3	306.4	332.6
T_7–50% RD of NPK + 50% N through Green leaf manure	T_7–100% RD of NPK	204.0	218.3	38.6	36.2	356.5	387.7
T_8–75% RD of NPK + 25% N through Green leaf manure	T_8–75% RD of NPK	209.1	207.3	37.0	29.8	344.5	370.0
CD (p = 0.05)		28.7	30.00	8.01	2.91	50.08	60.69
SEm ±		9.70	10.23	2.67	1.03	16.65	20.47

which might have maintained the N status in soils. The addition of organic manures in combination with recommended dose of fertilizer buildup the status of different inorganic forms of nitrogen in soil [10]. Among different treatments, T_3 recorded highest available P_2O_5 (44.0 kg ha^{-1}) followed by T_4 (40.4kg ha^{-1}) and lowest value was recorded in control (18.6 kg ha^{-1}) at harvest of *kharif* rice. Similar trends as that of *kharif* were observed at harvest of *rabi* rice.

Integrated use of fertilizers and manures in long-term experimental plots helps in increased available phosphorus content than initial value (24.0 kg ha^{-1}) due to mineralization of P from organic sources in addition to phosphorus availability from inorganic fertilizers. Addition of organic manures enhanced the labile P in soil through complexation of cations like Ca^{+2} and Mg^{+2} when it is applied in combination with inorganic fertilizers. Generally, addition of organic

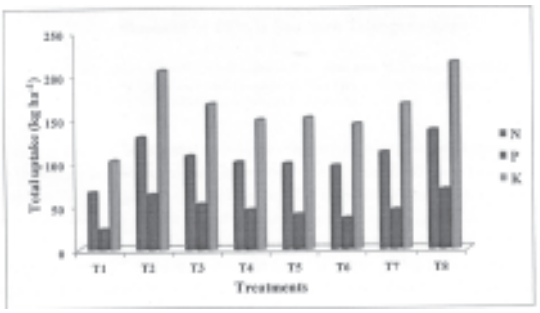

Fig. 1. Long-term effects of INM on total N, P and K uptake (grain + straw) after harvest of *kharif* rice under rice-rice cropping system at Rajendranagar.

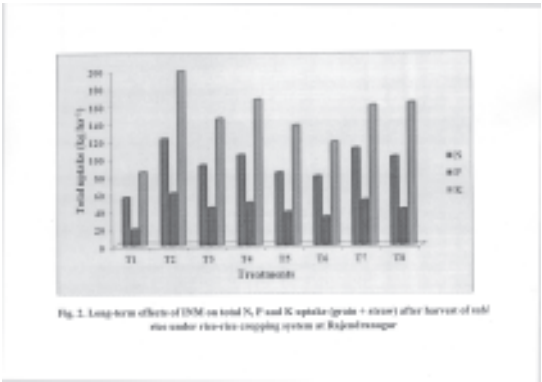

Fig. 2. Long-term effects of INM on total N, P and K uptake (grain + straw) after harvest of *rabi* rice under rice-rice cropping system at Rajendranagar.

manures like FYM, green manures with inorganic fertilizers had the beneficial effect in increasing the phosfate availability. The organic material forms a protective cover on sesquioxide and thus reduces the phosphate fixing capacity [11]. Application of NPK fertilizers in conjunction with organics might be due to release of organic acids during decomposition which inturn helped in releasing phosphorus through solubilizing action of native phosphorus [12]. The available potassium in these soils was influenced by INM treatments. T_3 (50% RD of NPK + 50% N through FYM) recorded highest available K_2O of 392.9 kg ha^{-1} followed by T_4 (363.3 kg ha^{-1}). In *rabi* T_5 recorded highest available K_2O of 394.0 kg ha^{-1} followed by T_7 (387.7 kg ha^{-1}). In *rabi,* application of 75% RD of fertilizers also showed higher K content in soil due to residual effect of organic manures applied during *kharif*. Increase in available potassium under integrated treatments might be due to the addition of organic matter that reduced potassium fixation and released potassium due to interaction of organic matter with clay, besides the direct addition of potassium to the pool of soil [12].

Grain and straw yields

The data regarding the effect of different rates of or-

Table 2. Long-term effects of INM on grain and straw yield after harvest of rice-rice system at Rajendranagar.

Treatments		Grain yield (kg ha^{-1})		Straw yield (kg ha^{-1})	
		Kharif	*Rabi*	*Kharif*	*Rabi*
T_1–Control	T_1–Control	3776	3730	5906	4038
T_2–100% RD of NPK	T_2–100% RD of NPK	6551	5531	8853	7435
T_3–50% RD of NPK + 50% N through FYM	T_3—100% RD of NPK	5338	4307	7828	6884
T_4–75% RD of NPK + 25% N through FYM	T_4–755 RD of NPK	5509	5077	7022	7192
T_5–50% RD of NPK + 50% N through Paddy straw	T_5–100% RD of NPK	5151	4237	7394	6810
T_6–75% RD of NPK + 25% N through Paddy straw	T_6–75% RD of NPK	5321	4073	7002	6571
T_7–50% RD of NPK + 50% N through Green leaf manure	T_7–100% RD of NPK	5483	5343	7704	7425
T_8–75% RD of NPK + 25% N through Green leaf manure	T_8–75% RD of NPK	6662	4087	8890	6683
CD (p= 0.05)	CD (p=0.05)	814.1	633.5	791.4	694.3
SE m ±	SEm ±	265.8	206.9	258.6	226.7

ganic manures in combination with various doses of NPK are given in Table 2 which showed that combined application of organic manures and mineral nutrients remained superior compared to individual application of mineral and organic fertilizers. Maximum paddy (6662 kg ha^{-1}) and straw yield (8890 kg ha^{-1}) was observed in the treatment where 75% RD of NPK + 25% N through green leaf manure were applied. It was followed by the treatment in which 100% RD of NPK (6551 and 8853 kg ha^{-1}, respectively) was applied while minimum grain (3776 kg ha^{-1}) and straw (5906 kg ha^{-1}) yield was recorded in the treatment receiving without the external input of manures and fertilizers. Among the different combinations of organic and mineral fertilizers, maximum residual effect on grain (5531 kg ha^{-1}) and straw (7435 kg ha^{-1}) yield of *rabi* rice was observed where 100% RD of NPK (residual) was applied and it remained statistically at par with the combination of 75% RD of NPK + 25% N through Green leaf manure (5343 and 7425 kg ha^{-1}, respectively) and 75% RD of NPK + 25% N through FYM (5077 and 7192 kg ha^{-1}, respectively). The minimum residual effect was noted in control (3730 and 4038 kg ha^{-1}, respectively). The comparison of among *Glyricidia,*FYM and paddy straw showed that green leaf manure remained superior over the others 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. The results get support from the findings of Sarwar [13] who reported that yield and different yield parameters of rice increased significantly with the use of chemical fertilizers alone or in combination with various organic materials applied in the form of green manure, FYM and compost in field and pot experiments.

Nutrient uptake

The results of grain uptake under *kharif* indicated that, treatment T_8 (75% RD of NPK + 25% N through green leaf manure) recorded higher uptake of nitrogen, phosphorus and potassium (78.6, 32.6and 84.6 kg ha^{-1}) followed by T_2 (74.7, 29.5 and 79.9 kg ha^{-1}). During *rabi* higher grain uptake of nitrogen, phosphorus and potassium (69.7, 28.8 and 73.0 kg ha^{-1}) were registered under T_2 followed by T_7 (65.7, 26.2 and 67.9 kg ha^{-1}). The total uptake (grain + straw) of N, P and K values (grain + straw) during *kharif* recorded in T_8 (136.4, 68.2and 214.4 kg ha^{-1}, respectively) followed by T_2. Whereas in *rabi* the higher N, P and K uptake (121.7, 59.9 and 198.6 kg ha^{-1}, respectively) were recorded in T_2 (Fig. 1 and 2). The highest concentration of nutrients as well as uptake by rice grain and straw in the above said treatments was due to organic manures which were found to provide favorable physical and chemical conditions in soil that enhance the availability of nutrients. Application of organic manures not only increased the uptake of N through mineralization but also reduces the loss of N from the soil. Similar results were reported earlier [12].

Conclusion

It can be concluded that managing organic sources of plant nutrients with mineral fertilizer and their incorporation into the soil in a cropping system has certain favorable and augmenting effects on soil properties and on crop productivity. Sustainability and high productivity of rice-rice cropping system is possible by providing 50% of the recommended N through FYM to the rice crop and rest of the 50% of N through chemical fertilizers followed by 100% RD of NPK to *rabi* rice through chemical fertilizers 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 50% RD of NPK + 50% N through FYM effective in increasing grain and straw yield of rice, improving the nutrients uptake, build up N, P, K and organic carbon in the soil.

References

1. Khan MS, Shil NC, Noor S (2008) Integrated nutrient management for sustainable yield of major vegetable crops in Bangladesh. J Agric Environ 4 : 81—94.
2. Islam MM, Karim AJMS, Jahiruddin M, Majid NM, Miah MG, Ahmed MM, Hakim MA (2011) Effects of organic manure and chemical fertilizers on crops in the radish-stem amaranth-Indian spinach cropping pattern in home-stead area. Aust J Crop Sci 5 : 1370—1378.

3. Jackson ML (1973) Soil chemical analysis. Oxford IBH Publ House, Bombay, pp 38.
4. Walkley A, Black CA (1934) Estimation of organic carbon by chromic acid titration method. Soil Sci 37 : 29—38.
5. Subbiah BV, Asija CL 91956) A rapid procedure for the estimation of available nitrogen in soils. Curr Sci 25—32.
6. Olsen SR, Cole CV, Watanabe FS, Dean LA (1954) Estimation of available phosphorus in soils by extraction with sodium bicarbonate. Circular of United States Dep Agric, pp 939.
7. Piper CS (1966) Soil and plant analysis. Hans Publ, Bombay, pp 137—153.
8. Panse VG, Sukhatme PV (1978) Statistical methods for agricultural workers ICAR, New Delhi.
9. Kundu S, Ranjan B, Ved Prakash, Gupta HS (2008) Carbon sequestration potential of Inceptisols under long-term soybean-wheat rotation in sub-temperate rainfed agro-ecosystem of Sorth-West Himalayas. J Ind Soc Soil Sci 56 : 423—429.
10. Singh D, Singh JP, Megla A, Bhardwaj K (2005) Effect of integrated use of inorganic fertilizers and organic materials on the distribution of different forms of nitrogen and phosphorus in soil. J Ind Soc Soil Sci 53 : 80—85.
11. Tandon HLS (1987) Phosphorus research and agricultural production in India. FDCO, New Delhi.
12. Subehia SK, Swapna S (2012) Influence of long-term nitrogen substitution through organics on yield, uptake and available nutrients in a rice-wheat system in an acidic soil. J Ind Soc Soil Sci 60 : 213—217.
13. Sarwar G (2005) Use of compost for crop production in Pakistan. PhD thesis. Univ Kassel, Germany.