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Integrated nutrient management for better soil fertility and rice productivity

Vipin Kumar*, R. K. Prasad, S.N. Suman and S. Tiwari
Rajendra Agricultural University, Pusa, Samastipur - 848 125, Bihar

ABSTRACT

A field experiment was conducted to study the influence of farmyard manure in combination with chemical fertilizers on rice productivity and soil quality. The highest grain yield (4.37 t ha^{-1}) was recorded with 150% with 10 kg Zn + 10 t FYM ha^{-1}. The availability of nutrients like organic carbon, N, P_2O_5 and K_2O increased with increasing fertility levels. Similarly, the effect of FYM and Zn were also conspicuous. The availability of micronutrients like Zn and Cu decreased while Fe and Cu increased with increasing fertility levels. The addition of FYM either maintained the Zn and Cu level in soil or checked its volume to go down the threshold limit.

Key words : *farmyard manure, rice productivity, zinc fertilizer, soil health*

Introduction of high yielding and fertilizer responsive varieties after green revolution witnessed an increase in use of synthetic fertilizers from 89.8 thousand tones in 1950-51 to 21.7 Mt in 2006-07 (Paswan 2008). Declining trend in productivity due to continuous use of chemical fertilizers alone has been observed in several long-term experiments all over India (Nambiar, 1994). Therefore, empasis should be given to optimize the use of chemical fertilizers and to improve their use-efficiency. Organic sources constitute an important component of the integrated nutrient management. The productivity of soils depends upon the adequate and balanced amount of all essential nutrients including the micronutrients. About 45% of the Indian soils are deficient in Zn (Singh, 2001). Crops require only small amount of Zn for their normal growth but its application rate is high due to very low fertilizer-use-efficiency. Therefore, it should be used with organic sources which increase nutrient-use-efficiency as well as availability. The present investigation was planned to study the effect of integrated nutrient management on rice productivity and soil fertility.

MATERIALS AND METHODS

A long term field experiment was initiated at the university farm of Rajendra Agricultural University, Bihar, Pusa during 2004 wet season on clay loam Calciorthents which has the following characteristics : $CaCO_3$ 37.5%, Organic Carbon 4.5 g kg^{-1} (Walkley and Black 1934), pH 8.8, EC 0.54 dSm^{-1}, $KMnO_4$ -N 187 kg ha^{-1} (Subbiah and Asija 1956), Olsen-P 7.37 kg ha^{-1} (Olsen *et al.* 1954), 1*N* NH_4OAc-K 215 kg ha^{-1} (Jackson 1973) and DTPA extractable Zn, Cu, Fe and Mn in the initial soil were 0.56, 1.86, 12.76, 6.0 mg kg^{-1}, respectively. Treatment consisting four levels of NPK fertilizers based on soil test viz. No NPK, 50% NPK, 100% NPK and 150% NPK were allotted in the main plots. Each main plot was divided into 5 sub-plots in which five sub treatments : no manure, 10 t FYM ha^{-1}, 10 kg Zn ha^{-1}, 5 t FYM + 10 kg Zn ha^{-1} and 10 t FYM + 10 kg Zn ha^{-1} were imposed. The experiment was laid out in a split plot design with three replications. The 100% NPK constituted the application of 120 kg N, 26.7 kg P and 33.2 kg K ha^{-1} and they were applied as urea, single super phosphate and muriate of potash, respectively. Half of nitrogen and entire dose of P and K were applied at the time of transplanting of rice and remaining N fertilizer was applied in equal splits of tillering at 35 DAS and flower initiation stage at 75 DAS. Composite surface (0-15 cm), soil samples from each plots of field experiments were collected at harvest of 5th rice crop. Soil samples were air dried and pulverized to pass through 2 mm sieve. Available N (alkaline $KMnO^-_4$), Olsen's P, 1*N* NH_4OAc-K, pH, EC, organic carbon and DTPA extractable micronutrients were determined by standard methods.

RESULTS AND DISCUSSION

Grain and straw yield increased significantly with increasing level of NPK fertilizers (Table 1). Grain yield of rice varied from 1.76 to 3.86 t ha^{-1} with different fertilizer levels. An increase in grain yield over control was 52.8, 98.8 and 119.3 percent with the application of 50, 100 and 150 per cent NPK, respectively. Among the NPK treatment maximum grain yield (3.86 t ha^{-1}) and straw yield (5.77 t ha^{-1}) were obtained with 150 per cent NPK. On the other hand, incorporation of FYM and Zinc, the grain yield of control (2.57 t ha^{-1}) significantly increased to the tune of 0.29, 0.35, 0.44 and 0.83 t ha^{-1} with the application of 10 kg Zn, 5t FYM + 10 kg Zn, 10t FYM and 10t FYM + 10 kg Zn, respectively registered small increase in grain but their combination proved superiority over them. Similar results were also reported by Sharma and Bali (2001).

Organic carbon content of the surface soil increased significantly with integrated use of FYM and Zn with fertilizers over control (Table 1). The highest build up of organic carbon in the soil was observed with the application of 150 percent NPK + 10kg Zn+FYM. The increase in organic carbon under FYM treatment is attributed to direct addition of organic matter in the soil and its subsequent decomposition. The available-N in the post harvest soils increased significantly with increasing fertility levels and it increased from 179.1 kg ha^{-1} in control to 192.7, 229.5 and 249.5 kg ha^{-1} at 50%, 100% and 150% NPK levels (Table 1). The addition of Zn and FYM either alone or their combination influenced the availability of N in soil. The highest value of 294.2 kg ha^{-1} of available-N in soil was recorded when 10 kg Zn + 10t FYM was incorporated with 150% NPK fertilizers. This showed an increase of 64 per cent over control. The available N in control soil increased significantly with use of recommended dose of fertilizers and manures (Datt *et al.*, 2003).

The available P_2O_5 content in soil increased significantly with increasing fertility levels (Table 1) and it increased from 9.2 kg ha^{-1} in control to 13.7, 19.8 and 24.9 kg ha^{-1} with the application of 50, 100 and 150 % NPK, respectively. The addition of 10 kg Zn, 10 kg Zn + 5 t FYM, 10 t FYM and 10 kg Zn + 10 t FYM ha^{-1} increased P_2O_5 content in soil from 13.8 kg ha^{-1} in control to 15.4, 17.1, 18.9 and 19.2 kg ha^{-1}, respectively. These findings indicated that the complexing agents like organic acid, humic and fulvic acids solublised insoluble P in soil and enhance the available phosphorus content of soil. These results were in conformity with the findings of Subramanian and Kumaraswami (1989) and Chettri *et al.* (2004) who attributed the appreciable increase in available P_2O_5 content of soil due to the influence of organic manure which could have enhanced the labile phosphorus in soil by complexing the cations like Ca and Mg responsible for the fixation of phosphorus in calcareous soil. The data indicated that available K_2O in soil increased significantly with

Table 1. Long term effect of fertilizers and FYM on grain, straw yield, organic carbon and available nutrients under rice based cropping system

Treatments	Grain Yield (t ha^{-1})	Straw Yield (t ha^{-1})	Organic Carbon (g ha^{-1})	Avail. N (kg ha^{-1})	Avail. P_2O_5 (kg ha^{-1})	Avail. K_2O (kg ha^{-1})
0% NPK	1.76	2.59	5.0	190.7	9.2	221
50% NPK	2.69	3.72	5.6	210.7	13.7	234
100% NPK	3.50	5.05	6.0	253.8	19.8	252
150% NPK	3.86	5.77	6.3	271.4	24.9	273
Mean	2.95	4.28	5.72	231.6	16.9	245
CD (0.05)	0.037	0.112	0.300	5.21	0.76	5.54
Control	2.57	3.67	5.3	212.7	13.8	233
10 kg Zn	2.86	4.14	5.5	213.1	15.4	234
5t FYM + 10 kg Zn	2.92	4.29	5.6	236.2	17.1	243
10t FYM	3.01	4.42	6.0	246.0	18.9	256
10t FYM + 10 kg Zn	3.40	4.88	6.1	250.1	19.2	258
Mean	2.95	4.28	5.7	231.6	16.9	245
CD (0.05)	0.070	0.091	0.162	4.91	1.29	1.71

increasing levels of fertility (Table 1). It varied from 221 kg ha^{-1} in control to 273 kg ha^{-1} at 150% NPK. There is a decline in available K_2O compared to initial status of potash in soil might be due to removal of potassium by crops and the native K was not able to meet the crop requirement. On the other hand, FYM alone as well as with Zn markedly increased the available K_2O in soil.

The available Zn in post harvest soil significantly decreased with increasing fertility levels (Table 2). The available Zn in treatment receiving only NPK, ranging from 0.86 to 0.69 mg kg^{-1} showed a reduction of 20 percent. The soil available Zn progressively decreased with increasing fertility levels in control (only NPK) Zn, Zn + 5 t FYM, 10t FYM, Zn + 10 t FYM treatments from 0.86 to 0.69, 3.31 to 2.30, 3.50 to 2.46, 2.03 to 1.61, 3.75 to 2.86 mg kg^{-1}, respectively. The 10 t FYM alone increased the available Zn in soil to the lesser extent than when combined with 10 kg Zn ha^{-1} (Bellakhi and Badanur, 1997). However, the mean available Zn under FYM and Zn treatment was much higher than those of NPK control. The magnitude of available Fe in 10 t FYM or 10 t FYM + Zn treatment was high as compared to other treatments (Table 2). The buildup of Fe in soil might be due to transformation of fixed form of Fe into available form by decomposed roots, stubbles and leaves left over the soil. Increasing fertility level was expected to produce more root and leaf biomass (Singh *et al.*, 1999; Gupta *et al.*, 2000).

Table 2. Long term effect of fertilizers and FYM on available micronutrients (mg kg^{-1}) in post harvest soil under rice based cropping system

Treatments	Available micronutrients (mg kg^{-1})			
	Zn	Fe	Cu	Mn
0% NPK	2.69	15.83	2.13	5.46
50% NPK	2.45	17.18	2.11	5.25
100% NPK	2.10	18.55	2.07	5.15
150% NPK	1.98	19.50	2.03	4.86
Mean	2.30	17.76	2.08	5.18
CD (0.05)	0.051	1.19	NS	NS
Control	0.76	16.34	1.79	4.64
10 kg Zn	2.76	16.94	1.78	5.17
5t FYM + 10 kg Zn	2.95	17.88	2.06	5.31
10t FYM	1.79	18.71	2.33	5.35
10t FYM + 10 kg Zn	3.26	18.95	2.46	5.34
Mean	2.30	17.76	2.08	5.16
CD (0.05)	0.043	0.283	0.127	0.327

The available Cu in post harvest soil exhibited decreasing trend with increasing fertility levels irrespective of treatments which might be due to greater dry matter production causing continuous removal of element from soils by crops. The available Cu decreased in NPK control, Zn, Zn + 5 t FYM, 10 t FYM and Zn + 10 t FYM ha^{-1} treatments from 1.81 to 1.78, 1.80 to 1.76, 2.12 to 2.00, 2.52 to 2.36 and 2.40 to 2.26 mg kg^{-1}, respectively with increasing levels of fertility. Similar results have been obtained by Gupta *et al.* (2000) and Hegde (2000). Similar trend was also observed in case of available Mn.

From the present investigation it may be inferred that integrated use of 150% NPK with 10 t FYM ha^{-1} produced higher rice yield (3.86 t ha^{-1}) compared to NPK application alone (1.76 t ha^{-1}). It was further observed that conjoint use of graded levels of fertilizers with FYM augmented soil available N, P, K, Zn and Cu. Integrated use of chemical fertilizers with organic manure not only hold a great promise in sustaining soil fertility and rice productivity but protect soil against multiple nutrient deficiency and deterioration of soil health.

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