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Original Research Article

Long-Term Effects of Organics and Inorganic Fertilizers on Yield, Uptake and Nutrition of Sulphur, Zinc and Boron in Calcareous Soil

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A B S T R A C T

A long-term field experiment on integrated management of FYM, crop residue with inorganic fertilizers in rice-wheat system is in progress at the Rajendra Agricultural University, Pusa, Bihar, Since Rabi 1988-89. The grain and straw yield of rice and wheat increased significantly with increasing levels of NPK fertilizer. However, the grain yield at 150% per cent NPK was at par with 100% per cent NPK. The grain yield was increased with the conjoint use of organics in the order: compost + crop residue > compost > crop residue > no manure. Compost + crop residue could save 50 per cent of the recommended dose of NPK i.e. 60 kg N, 30 kg P_2O_5 and 20 kg K_2O kg ha^{-1}. Integrated effect of chemical fertilizers with organic manure and crop residue also augmented N, P, K, S, Zn and B uptake by crops. There was a build-up in available N, P, K and S and depletion of available Zn and B with conjoint use of chemical fertilizer with organics. Addition of different organic materials increased the organic carbon and also decreased the pH and EC.

Keywords

Crop residue, FYM, rice, wheat

Introduction

India has the *onerous* task of feeding almost 17 per cent of the global human population, 11 per cent of the livestock population on only 2-3 per cent of the world's land and the entire burden of producing enough depends upon the first few inches of the earth's crust-SOIL. The wide scale adoption of rice-wheat system has ushered in an increase in agricultural production, but this intensive system over a period of time has set declining yield trends as well as deterioration in soil productivity even with optimum use of fertilizers (Bhandari *et al.*, 2002). Hence, for restoration of soil productivity, there is an urgent need to look forward to other options like the uses of compost, FYM, crop residue etc. of plant nutrient supply besides the use of conventional chemical fertilizers. Continuous use of high analysis sulphur free chemical fertilizers (urea and DAP) has made sulphur a limiting nutrient in many soils of country. The estimated gap between requirement and addition of sulphur is about 1 MT presently and is likely to be doubled within few years. About 20-40 per cent soils in calcareous belt of north Bihar are deficient in available sulphur (Sakal *et al.*, 2001). The calcareous soils of Bihar occupying a sizable area are deficient in zinc to the extent of 80-90 per cent of the tested soil samples (Sakal *et al.*, 1985) and symptoms of zinc deficiency are frequently observed on many crops. Among all the micronutrient deficiency, boron occupied second rank after zinc in soils of Bihar. In view of these consideration, the present investigation was undertaken to assess the long-term effect of crop residue, compost and both with inorganic fertilizers on crop yields and soil fertility in the rice-wheat system.

Materials and Methods

A field experiment was initiated during 1988-89 on light textured highly calcareous soil at Research Farm of DRPCAU, Pusa, Bihar. The experimental soil (0-15 cm) had pH (1:2) 8.4, EC 0.37 dSm^{-1}, organic carbon 5.0 g kg-1, available N 237 kg ha^{-1} available P_2O_5 19.9 kg ha-1, available K_2O 100 kg ha^{-1}, available S 10.3 mg kg^{-1}, available Zn 0.79 mg kg^{-1} and available B 0.52 mg kg^{-1}. Four levels of fertilizers viz. no NPK (Fo), 50% recommended NPK (F_1), 100% recommended NPK (F_2) and 150% recommended NPK (F_3) were applied as treatments in main plots. The main plots was divided into 4 sub-plots in which treatments viz. no manures (M_0), compost @ 10 tha^{-1} (F_1), crop residue (F_2) and compost + crop residue (F_3) were superimposed over NPK levels. The experiment was laid out in a split plot design with three replications and plot size was 4.0m x2.5m. The recommended doses of NPK (120:60:40) were applied to each crop of rice and wheat as Urea, Single superphosphate and muriate of potash. Half of nitrogen and entire dose of P and K were applied at the time of transplanting of rice and sowing of wheat and remaining N fertilizer was applied in the equal splits at tillering and flower initiation stage. Rice and wheat crops were grown continuously under rice-wheat cropping system. Rice cv. Rajshree was 37^{th} and 39^{th} test crop and wheat cv. HD 2733 as 38^{th} and 40^{th} test crop during the reported period of 2007-08 and 2008-09.

The grain and straw samples were taken at the harvest of rice and wheat crops. The grain and straw samples were washed sequentially in detergent solution (0.2% liquid), 0.01 N HCl solution and deionized water and dried in oven of 70^0C finely ground samples were digested and diluted. Digested samples were analysed for N, P, K, S, Zn and B. Composite surface (0-15 cm) soil samples from each plot of the field experiment were collected at the harvest of wheat rotation. 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 and organic carbon (Jackson 1973), available S determined by method described by Williams and Stainbergs (1959) and Chesnin and Yein (1951), available Zn (Lindsay and Norvell 1978) and available Boron is extracted from soil with hot water (Berger and Truog 1939) and calorimetric estimation following reaction with carmine reagent (Hatcher and Wilcox 1950).

Results and Discussion

Grain yield

Rice crop

Significant increase in grain and straw yields of rice were recorded with the graded levels of NPK and different organic manure treatment and their combination in the year 2007 and 2008 (Table 1). Among the NPK treatment, maximum grain yield (4.85 and 4.83 t ha^{-1}) and straw yield (8.67 and 9.77 t ha^{-1}) in the year 2007 and 2008 were obtained with 150 per cent NPK which were at par with grain (4.73 and 4.67 t ha^{-1}) and straw (7.90 and 9.73 t ha^{-1}) yield obtained at optimum dose of 100 per cent NPK. This may be due to the luxury consumption of nutrients in the treatment receiving higher dose (150% NPK) of NPK fertilizer which cause lodging before harvesting time due to increased vegetative growth. An increase in grain yield over control was 104, 171, 185 per cent in 2007 and 93, 151, 164 per cent in 2008 with the application of 50, 100 and 150 per cent NPK, respectively whereas, increase in straw yields were 74, 122, 143 per cent in 2007 and 90, 143, 157 per cent in 2008 over control with respective levels of NPK. On incorporation of organic sources, grain yield of control (2.73 t ha^{-1}) in 2007 and (2.72 t ha^{-1}) in 2007 significantly increased to the tune of 28, 27 and 45 per cent during the year 2007 and 27, 23 and 43 per cent in 2008 with compost, crop residue and compost + crop residue, respectively. This indicates that either compost or crop residue produced small increase in grain yield but their combinations proved superiority over them. It may be noted that the grain yield with 50 per cent NPK + compost + crop residue (3.86 tha^{-1}) during the year 2007and (3.83 t ha^{-1}) in the year 2008 were more 'or' less similar with 100 per cent NPK alone (3.92 and 3.73 t ha^{-1}) during the year 2007 and 2008, respectively. This observation is in accordance with the results of Laxminarayana and Patiram (2006) and Kumar and Prasad (2008).

Wheat crop

Influence of continuous application of fertilizers, compost and crop residue on yield of wheat has been presented in table 1. A perusal of the data indicated that both grain and straw yields of wheat significantly increased with the application of graded dose of fertilizer and different organics alone 'or' their combination. The effect of fertilizers revealed that the grain yield of wheat (1.06 t ha^{-1}) under control increased to 86, 220 and 246 per cent with the application of 50, 100 and 150 per cent NPK, respectively during the year 2007-08. When the effect of compost and crop residue 'or' compost + crop residue was considered, the grain yield of control (1.89 t ha^{-1}) during the year 2007-08 significantly increased by 36, 35 and 65 per cent, respectively with compost, crop residue and compost + crop residue. The nutrient present in the manure were slowly mineralized as time passed and were available to plant resulting in higher yield (Kumar and Prasad, 2008 and Singh *et al.*, 2008). Application of organic sources of nutrient increased the grain and straw yield of wheat in the order: compost + crop residue (3.12 and 5.21 t ha^{-1}), compost (2.56 and 4.70 t ha^{-1}), crop residue (2.55 and 4.53 t ha^{-1}) and no manure (1.89 and 3.51 t ha^{-1}) during the year 2007-08 similar trend was also noticed in the case of grain and straw yields of wheat during the year 2008-09.

Nutrient uptake by rice

Graded dose of fertilizer, compost and crop residue incorporation resulted in significant increase in N uptake in both the year (2007 and 2008). Nitrogen uptake increased by 59.2, 83.4 and 93.9 per cent over control (26.8 kg ha^{-1}) during the year 2007 and 114, 187 and 223 per cent over control (29.2 kg ha^{-1}) during the year 2008 at 50, 100 and 150 per cent NPK level, respectively. Incorporation of compost, crop residue and compost + crop residue significantly increased N-uptake to a tune of 38, 31, 64 per cent over control (49.3 kg ha^{-1}) during the year 2007 and 37, 30, 71 per cent over control (50.1 kg ha^{-1}) in the year 2008, respectively. Phosphorus uptake by rice varied from 2.0 to 24.0 and 2.4 to 23.1 kg ha^{-1} in the year 2007 and 2008, respectively (Table 2). Phosphorus uptake by rice during both the year increased significantly with increase in graded dose of NPK fertilizers and different organic sources. P uptake increased by 145, 245, 276 per cent over control (5.5 kg ha^{-1}) and 131, 220, 226 per cent over control (5.5 kg ha^{-1}) during the year 2007 and 2008 at 50, 100 and 150 per cent NPK, respectively. Such an increase in P uptake with increasing levels of NPK fertilizer has also been reported by Jha *et al.*, (2004) and Singh *et al.*, (2005). K uptake by rice varied from 24.1 to 160.6 kg ha^{-1} in 2007 and from 21.0 to 164.9 kg ha^{-1} during the year 2007, respectively under different treatment combination. Per cent increase in K-uptake by rice was noted to be 35, 35, 58 over control (72.8 kg ha^{-1}) and 25, 24, 49 over control (89.2 kgha^{-1}) with the incorporation of compost, crop residue and compost + crop residue during the year 2007 and 2008, respectively. Overall effect of continuous application of graded doses of fertilizer, compost and crop residue separately or in combination were observed on significant enhancement of S uptake by rice over their respective control. S-uptake by rice varied from 1.0 to 8.1 kg ha^{-1} during the year 2007 and from 1.0 to 8.9 kg ha^{-1} in the year 2008 under different treatment combination, respectively. Increasing the dose of fertilizer significantly increased the total S uptake. The increase in S uptake by increasing fertilizer levels might be due to addition of S through single super-phosphate (Bansal 1992 and Azami *et al.*, 2004). Incorporation of compost and crop residue also increased the S uptake by rice significantly. The order of effectiveness was recorded as: compost + crop residue (6.9 and 8.9 kg ha^{-1}) > compost (5.0 and 5.5 kg ha^{-1}) > crop residue (4.6 and 5.1 kg ha^{-1}) > no manure (2.9 and 3.4 kg ha^{-1}) during 2007 and 2008. It might be due to solubilisation of native S and enhancement of the efficiency of applied S through the process of decomposition and addition of S through organic manure. Zn uptake by rice varied from 40.0 to 429.9 g ha^{-1} and 38.5 to 445.6 g ha^{-1} during the year 2007 and 2008, respectively under different treatment combinations. The uptake of Zn by rice during the year 2007 increased by 116, 114, 214 and 200, 251, 225 per cent over control (92.8 and 101.0 g ha^{-1}) during the year 2007 and 2008 at 50, 100 and 150 per cent NPK levels, respectively. Zn uptake by rice increased form 155.2 to 237.8, 204.5, 313.5 g ha^{-1} and from 175.5 to 249.2, 214.2 to 332.4 g ha^{-1} during the year 2007 and 2008 with the incorporation of compost, crop residue and compost + crop residue, respectively. Organics incorporation on decomposition might have increased the Zn-use- efficiency of applied as well as partially dissolved the comparatively insoluble form of Zn by the decomposition product of organic matter (Singh *et al.*, 1998). B uptake varied from 23.2 to 372.6 g ha^{-1} and 22.0 to 377.5 g ha^{-1} during the year 2007 and 2008, respectively under the different treatment combination. Maximum uptake of B by rice was registered with the treatment when 150 per cent NPK was integrated with compost and crop residue (372.6 and 377.5 g ha^{-1}) in both years. Beneficial effects of integrated use of nutrients in association with FYM on the uptake have also been reported by Singh and Pathak (2003).

Nutrient uptake by wheat

The N-uptake by wheat ranged from 16.5 to 125.3 kg ha^{-1} and 16.6 to 147.1 kg ha^{-1} during the year 2007-08 and 2008-09, respectively. Increasing dose of fertilizers up to 150 per cent significantly increased the N-uptake by wheat in both the year. Similarly, incorporation of organic sources of nutrients also increased the N uptake by wheat significantly. N-uptake increased to a tune of 82, 214, 270 per cent over control (27.3 kg ha^{-1}) and 96, 185, 239 per cent over control (36.8 kg ha^{-1}) during the year 2007-08 and 2008-09, respectively. P-uptake by wheat varied from 3.6 to 30.0 kg ha^{-1} and 3.4 to 30.2 kg ha^{-1} under different treatment combination during the year 2007-08 and 2008-09, respectively.

Table.2 Long-term influence of organic manure, crop residues and inorganic fertilizers on nutrient uptake by rice and wheat under rice-wheat cropping system in calcareous soil

Treatment	Nutrient uptake by Rice											
	2007						2008					
	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	S (kg ha^{-1})	Zn (g ha^{-1})	B (g ha^{-1})	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	S (kg ha^{-1})	Zn (g ha^{-1})	B (g ha^{-1})
No NPK	26.8	5.5	41.2	2.5	92.8	68.4	29.2	5.5	45.4	2.9	101.0	71.6
50% NPK	59.2	13.4	86.2	4.9	200.8	170.4	62.5	12.8	98.7	5.4	216.4	180.8
100% NPK	83.4	18.9	120.1	5.9	291.3	270.0	84.0	17.7	132.4	6.4	303.5	282.5
150% NPK	93.49	20.6	137.1	5.9	326.0	313.1	94.3	20.2	148.1	6.7	348.5	329.9
CD (P = 0.05)	3.64	0.87	5.38	0.15	10.43	12.75	6.36	1.37	12.6	0.68	21.1	19.42
No organics	49.3	11.2	72.8	2.9	155.2	133.1	50.1	11.0	85.2	3.4	173.5	154.5
Compost	68.2	15.0	98.6	4.0	237.8	210.5	68.8	14.4	106.8	5.5	249.2	218.6
Crop residues	64.9	14.4	98.1	4.6	204.5	214.5	65.3	13.5	105.4	5.1	214.2	218.2
Compost + crop residues	80.9	17.8	115.0	6.9	313.5	263.8	85.8	17.1	127.1	7.4	332.4	273.4
CD (P = 0.05)	4.54	0.78	6.29	0.25	9.85	9.51	4.90	0.95	6.63	0.42	14.93	15.10

Table.3 Long-term influence of organic manure, crop residues and inorganic fertilizers on nutrient uptake by wheat under rice-wheat cropping system in calcareous soil

Treatment	Nutrient uptake by Wheat											
	2007-08						2008-09					
	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	S (kg ha^{-1})	Zn (g ha^{-1})	B (g ha^{-1})	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	S (kg ha^{-1})	Zn (g ha^{-1})	B (g ha^{-1})
No NPK	27.3	6.3	34.3	4.6	83.3	47.7	36.8	7.5	36.7	5.1	89.1	52.6
50% NPK	51.9	11.9	67.9	8.0	157.7	105.5	72.1	15.0	80.9	9.1	183.4	123.4
100% NPK	85.9	20.3	100.7	10.8	238.3	174.7	105.1	23.1	125.2	13.6	296.5	215.5
150% NPK	101.1	24.6	124.7	11.9	273.2	212.0	124.0	26.4	144.4	14.9	343.5	265.3
CD (P = 0.05)	12.2	0.68	3.19	0.37	7.2	4.9	13.7	1.46	11.5	0.87	14.6	9.9
No organics	46.7	10.9	59.2	6.8	127.9	79.9	63.4	13.8	76.6	7.6	169.2	107.3
Compost	68.4	16.3	82.0	8.6	191.6	132.5	85.6	18.3	94.9	10.4	227.5	158.9
Crop residues	66.1	15.7	84.2	8.6	180.6	137.6	79.5	17.5	91.8	9.8	209.4	161.8
Compost + crop residues	85.1	20.1	102.1	11.4	252.4	190.0	110.5	22.4	123.9	13.2	306.3	228.7
CD (P = 0.05)	12.1	0.87	5.1	0.42	8.0	5.8	9.0	1.25	9.5	0.6	13.1	7.6

Table.4 Long-term influence of organic manure, crop residues and inorganic fertilizers on soil properties after harvest of wheat (40th crop) under rice-wheat cropping system in calcareous soil

Treatments	Soil properties								
	Organic carbon (g/ha)	PH	EC (dSm^{-1})	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	S (mg kg^{-1})	Zn (mg kg^{-1})	B (mg kg^{-1})
No NPK	5.2	8.33	0.32	266	26.2	102.3	10.4	0.91	0.66
50% NPK	6.1	8.30	0.29	309	36.2	109.7	20.1	0.88	0.60
100% NPK	6.4	8.29	0.26	328	44.6	115.4	23.5	0.84	0.56
150% NPK	6.7	8.24	0.24	346	48.4	125.9	27.5	0.82	0.53
CD (P = 0.05)	0.6	NS	NS	14.2	1.49	3.3	2.8	0.03	0.05
No organic	5.1	8.47	0.31	259	32.8	103.9	15.8	0.73	0.47
Compost	6.1	8.27	0.26	322	38.2	111.2	19.9	0.90	0.62
Crop residues	5.9	8.28	0.27	315	38.7	114.5	18.6	0.89	0.60
Comported + crop residues	7.1	8.24	0.27	352	45.8	121.7	27.1	0.92	0.65
CD (P = 0.05)	0.5	NS	NS	9.73	1.42	3.4	2.7	0.02	0.05

Table.1 Long-term influence of organic manure, crop residues and inorganic fertilizers on yield of rice and wheat under rice-wheat cropping system in calcareous soil

Treatment	Grain yield (t ha^{-1})				Straw yield (t ha^{-1})			
	Rice		Wheat		Rice		Wheat	
	2007	2008	2007-08	2008-09	2007	2008	200-07	2007-08
No NPK	1.59	1.67	1.06	1.35	2.64	3.44	2.44	2.40
50% NPK	3.24	3.22	1.98	2.61	5.20	6.53	4.20	4.54
100% NPK	4.32	4.17	3.41	3.65	7.11	8.38	5.40	7.16
150% NPK	4.53	4.40	3.68	4.02	7.67	8.82	5.92	7.96
CD (P = 0.05)	0.18	0.31	0.13	0.36	0.24	0.50	0.28	0.43
No organics	2.73	2.72	1.89	2.39	4.45	5.56	3.51	4.60
Compost	3.50	3.46	2.56	2.92	5.84	6.99	4.70	5.65
Crop residues	3.48	3.35	2.55	2.87	5.75	6.69	4.53	5.27
Compost + crop residue	3.97	3.89	3.12	3.45	6.58	7.94	5.21	6.53
CD (P = 0.05)	0.13	0.14	0.11	0.23	0.20	0.35	0.18	0.27

P-uptake increased by 89, 221, 289 per cent and 99, 207, 250 per cent over control (6.3 and 7.5 kg ha^{-1}) at 50, 100 and 150 per cent NPK levels during the year 2007-08 and 2008-09, respectively. With the incorporation of organic manures, P uptake by wheat followed the order compost + crop residue (20.1 and 22.4 kg ha^{-1}) compost (16.3 and 18.3 kg ha^{-1}) > crop residue (15.7 and 17.5 kg ha^{-1}) > no manure (11.0 and 13.8 kg ha^{-1}) during the year 2007-08 and 2008-09, respectively. Incorporation of compost and crop residue enhanced the uptake of applied as well as native phosphorus by the crop through its influence on solubility and availability in the soil (Kumar and Prasad 2008). K-uptake by wheat varied from 15.6 to 150.3 kg ha^{-1} and 13.8 to 169.9 kg ha^{-1} under different treatment combination during the year 2007-08 and 2008-09, respectively. K.-uptake by wheat significantly increased (34.3 to 124.7 kg ha^{-1} and 36.7 to 144.4 kg ha^{-1}) with the application of NPK fertilizer up to 150 per cent during the year 2007-08 and 2008-09, respectively. The relative effectiveness of organic manure and crop residue on the enhancement of K-uptake by wheat varied in the order : compost + crop residues (102.1 kg ha^{-1}) > crop residue (84.2 kg ha^{-1}) > compost (82.0 kg ha^{-1}) > no manure (59.2 kg ha^{-1}) during the year 2007-08 and compost + crop residue (123.9 kg ha^{-1}) > compost (94.9 kg ha^{-1}) > crop residue (91.8 kg ha^{-1}) > no manure (76.6 kg ha^{-1}) in 2008-09. Incorporation of compost and crop residue and compost + crop residue increased the S-uptake by wheat by 8.6, 8.6 and 11.4 kg ha^{-1} over control (6.8 kg ha^{-1}) during the year 2007-08 while the per cent increase in S-uptake was recorded to a tune of 37, 28 and 73 per cent over control (7.63 kg ha^{-1}) in the year 2008-09, respectively. This may be due to remarkable increase in yield of crop beside addition of S through SSP (Dwivedi *et al.,* 2002). Zn-uptake by wheat under control (83.3 g ha^{-1}) increased to 157.7, 238.3 and 273.2 gha^{-1} during the year 2007-08, whereas, it increased by 105, 233 and 285 per cent over control (89.1 g ha^{-1}) during the year 2008-09 under 50, 100 and 150 per cent NPK level, respectively. The higher uptake of Zn was observed in both compost and crop residues treatments. The natural complexing agent in the form of organic manure are important in enhancing diffusion and mass flow of Zn which are considered to be primarily responsible for transportation of Zn by crops (Prasad *et al.*,1984) this missing in reference section. Effect of crop residue, compost and compost + crop residue either alone 'or' in combination with different levels of NPK increased the uptake of B by wheat significantly.

Soil properties

The effect of chemical fertilizer and organic manure on organic carbon content of the soil was significant. The organic carbon increased by 16.2, 23.4 and 28.7 per cent over control (5.2 g kg^{-1}) at 50, 100 and 150 per cent NPK levels, respectively. The increase in soil organic carbon content of soil with increasing levels of NPK over the control may be attributed to better root growth of rice and wheat and subsequent decomposition of these roots. Significant increase in organic carbon content of soil was noticed with the incorporation of compost and crop residue. Different levels of chemical fertilizers and organics either alone 'or' in combination decreased soil pH and electrical conductivity. The available N due to various treatment combination of organic and inorganic fertilizer ranged from 190 to 382 kg ha^{-1}. The highest available N content of soil (382 kg ha^{-1}) was recorded in the treatment receiving 150 per cent NPK with compost + crop residue and lowest (190 kg ha^{-1}) in no manure and no NPK. Available phosphorus increased by 38.2, 70.4 and 85.0 per cent over control (26.2 kg ha^{-1}) of 50, 100 and 150 per cent NPK levels. Large build-up of available P with compost and crop residue may be attributed to the influence of organic manure in increasing the labile P in soil through complexation of cations like Ca^{2+} and Mg^{2+} which are mainly responsible for the fixation of phosphorus in calcareous soil (Yashpal *et al.,* 1993). The benefit derived from the application of 50, 100 and 150 per cent NPK over control (102.3 kg ha^{-1}) was to the tune of 7, 13 and 21 per cent increase in available potassium, respectively while available under no manure (103.9 kg ha^{-1}) also enhanced to 7, 10 and 17 per cent due to compost, crop residue and compost + crop residue, respectively. Available S varied from 7.98 to 35.59 mg kg^{-1} under different treatment combinations. Maximum available (35.59 mg kg^{-1}) was noticed, when 150 per cent NPK of the recommended dose was applied nutrients in conjunction with compost and crop- residue, whereas minimum soil available S (7.0 mg kg^{-1}) was recorded in control. The build-up of available S due to increased fertilizer level might be due to addition of S through single-super-phosphate as a source of phosphate and organic manure might be attributed to be the mineralization of organic S as well as holding the water soluble S to minimize leaching loss (Sinha and Sakal, 1993). The available Zn in soil decreased significantly with increasing levels of chemical fertilizer. It decreased from 0.91 mg kg^{-1} in control to 0.57, 0.84 and 0.81 mg kg^{-1} at 50, 100 and 150 per cent NPK. Decrease in available Zn content with increasing levels of NPK may be due to more dry matter yield which accrued to more removal of Zn from soil. Incorporation of organic materials significantly increased the available Zn of the soil. Available Zn increased to a tune of 23, 20 and 26 per cent over control (0.61 $mgkg^{-1}$) with incorporation of compost, crop residue and compost + crop residue, respectively. The soil available B ranged from 0.43 to 0.75 mg kg^{-1} under different treatment combination. The available B decrease significantly with increasing levels of chemical fertilizer. The available B decreased to a tune of 10, 20 and 27 per cent over control (0.44 mg kg^{-1}) of 50, 100 and 150 per cent NPK level. Incorporation of compost and crop residue alone 'or' in combination significantly increased the soil available B and the effectiveness followed the order: compost + crop residues (0.64 mg kg^{-1}) > compost (0.61 mg kg^{-1}) > crop residue (0.60 mg kg^{-1}) > control (0.46 mg kg^{-1}). Higher availability of B with the incorporation of FYM was reported by Chander *et al.,* (2007).

Based on the results, it can be concluded that with the use of NPK fertilizers along with compost @ 10 t/ha + crop residue of previous crop could save 50 per cent of the recommended dose of NPK i.e. 60 kg N, 30 kg P_2O_5 and 20 kg K_2O/ha. Incorporation of crop residue of previous crop could substitute compost @ 10 t/ha. Conjoint use of inorganic fertilizer with organics improved the soil productivity and fertility and also prevents emergence of multi-nutrients deficiencies and deterioration of soil health and so it mill maintain soil health for longer period of time.

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