International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2017; 5(5): 2368-2372

Received: 03-07-2017
Accepted: 04-08-2017

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Long term influence of organic and inorganic fertilizer on some chemical properties of calciorthents under rice-wheat cropping system

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Abstract
To study the effect of long term fertilizer on pH, electrical conductivity, cation exchange capacity, free calcium carbonate, total-N, P, K and S in calcareous soil. A long term field experiment was conducted during *rabi* 1988-89 at RAU, Pusa farm in split plot design with NPK levels in main plot and organic sources in sub-plot treatment under rice-wheat cropping system. After increasing doses of fertilizers and with the incorporation of compost and crop residue. Electrical conductivity increased with increase in NPK levels and decreased with the incorporation of organic sources. Cation exchange capacity of soil increased significantly with application of NPK fertilizer as well as incorporation of organic sources whereas compost and crop residue either alone or in combination with different levels of NPK fertilizer decreased the amount of free $CaCO_3$ of the soil. There was a buildup of total N, P K and S with conjoint use of chemical; fertilizers with compost and crop residue in soil.

Keyword: Chemical properties, Rice-wheat Cropping system, Organic manure, inorganic fertilizer, Calciorthents

Introduction

The agricultural scene in India has recently changed considerably with the introduction of high yielding varieties of crops, intensive cropping system and use of high analysis fertilizer. Continuous addition of chemical fertilizer pose problems like toxicity due to high amount of salt as a residue of fertilizer, deterioration of the physical properties of soil impairing the aeration and soil water plant relationship resulting decreased productivity. The recycling of organic matter and plant nutrient elements that can be effectively used as a source of organic manure (Badanur *et al.,* 1990) [1]. However, due to its low nutrient content and slow acting nature, compost alone may not be able to meet the high nutrient requirement of crop. Likewise, the use of only NPK fertilizer under modern intensive farming will not be sufficient. Therefore, integrated use of organic and inorganic fertilizer and their management for efficient and economic use of fertilizer and maintenance of soil fertility and productivity is very important. The present study was aimed to find out the integrated effect of chemical fertilizer along with compost and crop residue on some chemical properties of calcareous soil under rice-wheat cropping sequence.

Materials and Methods

A long term field experiment was conducted at RAU, Pusa farm in the year 1988 (*rabi*) with rice-wheat cropping sequence. The experimental site is located at 25°59’ North latitude and 85°48’ East longitude with an altitude of 52·92 meters above mean sea level. The climate of the experimental area is sub-tropical with a mean annual precipitation of 1270 mm and mean annual temperature of 25.3°C. The crops reported in this report are 26^{th} crop rice (*cv*. Rajshree) in *kharif* season (2001) and 27^{th} crop wheat (*cv*. Rajeshwari) in *rabi* season (2001-02). The experiment was conducted in a split plot design with four levels of NPK namely; No NPK (control), 50 per cent NPK, 100 per cent NPK and 150 per cent NPK in the main treatment and organic sources namely; No manure, compost, crop residue and compost + crop residue in sub-plot treatment. The treatments were replicated thrice. The recommended N, P_2O_5 and K_2O doses were 100, 60 and 40 kg ha^{-1}. The soil sample were collected after harvest of wheat and analyzed for their pH, electrical conductivity, cation exchange capacity and free $CaCO_3$, total

N, P, K and S content. The chemical properties of surface soil (0-15 cm) analysed at the start of the experiment are presented in table 1. The pH of the soil sample was determined in a 1:2.5 soil water suspension using pH meter (Jackson, 1973) [4]. The salt concentration in soil sample was determined in aqueous extract of soil in the soil and water ratio 1:2.5 using solubridge (Jackson, 1973) [4]. Cation exchange capacity and free calcium carbonate in soil sample were determined as per method suggested by Piper, 1966 [10] and Piper, 1950 [9], respectively. To analyze the total N, soil sample was digested in a salicylic sulphuric acid mixture containing a catalyst mixture of K_2SO_4, $CuSO_4$. $5H_2O$ and selenium powder in the ration of 10:1:0.1 as described by Jackson, 1973 [4]. Digested solution was taken for total N determination by semi micro Kjeldahl method as described by Bremner, 1965 [2]. For determination of total P soil sample was placed in a platinum crucible and digestion was carried out using HF and $HClO_4$ as described by (Jackson, 1973) [4]. From this extract total P was determined by vanodomolybdate yellow phosphoric acid method. From this extract total K was also determined with the help of flame photometer as described by (Jackson, 1973) [4]. Total S was determined by acid digestion method of Tabatabai, 1982 [15].

Table 1: Chemical properties of initial soil of experimental plot

Sl. No.	Particulars	Value obtained
1.	pH (1:2.5 Soil: water)	8.4
2.	Electrical conductivity (dSm^{-1}) at 25ºC	0.36
3.	CEC (Cmol {P^+} kg^{-1})	9.79
4.	Free $CaCO_3$ (%)	34.24
5.	Total nitrogen (%)	0.050
6.	Total phosphorus (%)	0.048
7.	Total potassium (%)	0.637
8.	Total sulphur (mg kg^{-1})	347.2

Result and Discussion

pH

Continuous application of inorganic fertilizers with compost and crop residue for 13th year in rice-wheat cropping system, the results so far obtained on soil pH were depicted in table 2. An examination of the data revealed that the soil pH was reduced from control 8.4 to 8.2 but did not reach the level of significance either by fertilizers or organic sources. The per cent decreased in pH was noticed by 0.24, 0.24 and 0.60 over control (8.31) at 50, 100 and 150 per cent NPK levels, respectively. The lowering of pH could be due to acid forming nature of urea (Minhas and Mehta, 1994). Incorporation of compost, crop residue and compost + crop residue also decreased the soil pH over control (8.36). The relative effectiveness of organic manure and crop residue in decreasing the soil pH was in the order: compost + crop residue > crop residue > compost > no manure. Organic acid released after decomposition of organic material decreased the soil pH (Chaudhry *et al.*, 1981) [3]. The maximum pH (8.40) was recorded in control plot, whereas, the minimum (8.20) was noted in the treatment receiving compost + crop residue.

Electrical Conductivity

Like soil pH, electrical conductivity also registered decrease in control (0.28) in different treatments (Table 2). The decrease of electrical conductivity was non-significant. Maximum electrical conductivity (0.36 dSm^{-1}) was recorded at 150 per cent NPK level whereas minimum (0.21 dSm^{-1}) was noted in the treatment receiving crop residue. The effect of organic sources & fertilizer and their interaction effects were found to be significant. The comparative effectiveness of organic sources in decreasing the electrical conductivity varied in the order: Crop residue = compost > compost + crop residue > no manure. The decrease in electrical conductivity might be due to release of several organic acids during decomposition process, which solubilized the salt and may be leached down through irrigation water (Nambiar and Ghosh, F1984) [8].

Table 2: Long term influence of organic and inorganic fertilizer on pH and EC after harvest of wheat (27th crop) under rice-wheat cropping system in calcareous soil

Treatment	pH					EC (dSm^{-1})				
	Organic sources					Organic sources				
	No Manure	Compost	Crop residue	Compost + Crop residue	Mean	No Manure	Compost	Crop residue	Compost + Crop residue	Mean
No NPK	8.40	8.34	8.33	8.20	8.31	0.28	0.22	0.21	0.24	0.24
50% NPK	8.37	8.30	8.28	8.23	8.29	0.30	0.24	0.25	0.25	0.26
100% NPK	8.35	8.28	8.28	8.27	8.29	0.33	0.28	0.27	0.28	0.29
150% NPK	8.33	8.23	8.22	8.27	8.26	0.36	0.31	0.30	0.30	0.31
Mean	8.36	8.29	8.27	8.24		0.31	0.26	0.26	0.27	

Source	S. Em. (±)	CD (P = 0.05)	S. Em (±)	CD (P = 0.05)
Fertilizer (F)	0.084	0.29	0.025	0.08
Manure (M)	0.049	0.14	0.016	0.06
F x M	0.097	NS	0.012	NS

Cation Exchange Capacity

The cation exchange capacity was not altered to any great extent (table 3). The scrutiny of the data revealed that CEC of the soil increases significantly with the increase of fertilizer levels. The per cent increase in CEC was noticed 1.85, 3.13 and 4.69 over control (10.22 Cmol $\{P^+\}$ kg^{-1}) with the incorporation of compost, crop residue and compost + crop residue, respectively. The increase in CEC was associated with rise in organic matter content of soil.

Free calcium carbonate

Free calcium carbonate of the soil varied from 30.75 to 34.40 per cent in different treatment. Per cent decrease in free $CaCO_3$ of the soil was found to be 1.15, 3.81 and 2.88 per cent over control (34.25%) at 50, 100 and 150 per cent NPK, respectively (table 3). Incorporation of organic sources also decreased the free $CaCO_3$ content of the soil to some extent but was non-significant as compared to compost and crop residue. Free $CaCO_3$ decreased by 1.72, 1.89 and 7.29 percent over control (34.14%) with the addition of compost, crop residue and compost + crop residue, respectively. The maximum decrease in free $CaCO_3$ content of soil was observed in the treatment receiving 150 per cent NPK in conjunction with compost and crop residue where it went down to 30.75 from 34.40 per cent. The reduction may be due to organic acid released during the decomposition of organic material which might have reacted with $CaCO_3$ and solubilized thereby reducing $CaCO_3$ content in the soil (Prasad, 1994) [11].

Table 3: Long term influence of organic and inorganic fertilizer on CEC and Free Calcium carbonate after harvest of wheat (27th crop) under rice-wheat cropping system in calcareous soil

Treatment	CEC Coml. (P^+) kg^{-1}					Free Calcium carbonate (%)				
	Organic sources					Organic sources				
	No Manure	Compost	Crop residue	Compost + Crop residue	Mean	No Manure	Compost	Crop residue	Compost + Crop residue	Mean
No NPK	9.81	10.32	10.30	10.45	10.22	34.40	33.80	33.78	32.55	34.25
50% NPK	10.12	10.41	10.39	10.72	10.41	34.12	33.63	33.60	32.10	33.86
100% NPK	10.24	10.55	10.49	10.90	10.54	34.05	33.41	33.40	31.90	32.99
150% NPK	10.42	10.74	10.56	11.10	10.70	34.00	33.39	33.36	30.75	33.29
Mean	10.14	10.50	10.44	10.79		34.14	33.56	33.53	31.82	
Source	S. Em. (±)		CD (P = 0.05)		S. Em. (±)			CD (P = 0.05)		
Fertilizer (F)	0.022		0.08		0.41			1.4		
Manure (M)	0.033		0.10		0.73			2.4		
F x M	0.067		0.20		0.97			NS		

Total nitrogen

The amount of total-N in soil under different treatment varied from 0.045-0.068% (table 4). Amount of total-N in soil increased with increasing levels of fertilizer but not significant to each other. Similarly application of compost, crop residue and compost + crop residue significantly augmented total-N over control. Combination of compost, crop residue or compost + crop residue with chemical fertilizer produced relatively higher total-N content in soil then chemical fertilizer alone. This may be due to mineralization of organic matter added regularly to the soil (Lal and Mathur, 1987) [5] and (Mandal *et al.*, 1991) [6].

Total phosphorus

Total-P content of soil was significantly influenced by long term application of organic manure and chemical fertilizer over control as depicted in table 4. Maximum total-P content in soil 0.069% was recorded 150% NPK + compost + crop residue treatment. This may be due to addition of phosphorus in soil through compost and crop residue (Subramanian and Kumarsawamy, 1989) [14].

Table 4: Long term influence of organic and inorganic fertilizer on total nitrogen and total phosphorus content in soil after harvest of wheat (27th crop) under rice-wheat cropping system in calcareous soil

Treatment	Total nitrogen (%)					Total phosphorus (%)				
	Organic sources					Organic sources				
	No Manure	Compost	Crop residue	Compost + Crop residue	Mean	No Manure	Compost	Crop residue	Compost + Crop residue	Mean
No NPK	0.045	0.056	0.051	0.058	0.052	0.041	0.049	0.050	0.052	0.048
50% NPK	0.050	0.058	0.055	0.063	0.056	0.053	0.055	0.056	0.059	0.055
100% NPK	0.054	0.066	0.062	0.067	0.062	0.055	0.061	0.060	0.066	0.060
150% NPK	0.056	0.064	0.063	0.068	0.062	0.058	0.065	0.064	0.069	0.064
Mean	0.051	0.061	0.057	0.064		0.051	0.057	0.057	0.061	
Source	S. Em. (±)		CD (P = 0.05)		S. Em. (±)			CD (P = 0.05)		
Fertilizer (F)	0.004		0.010		0.0019			0.007		
Manure (M)	0.005		0.009		0.0022			0.006		
F x M	0.010		0.020		0.0043			0.013		

Total potassium

Long term influences of organic and inorganic fertilizer on total-K content of soil are presented in table 5. The total-K was increased significantly with increasing level of fertilizer. Significant effect of total-K content in soil was noticed with the application of compost, crop residue and compost + crop residue. Integrated use of organic manure and chemical fertilizer resulted always high total-K content of soil than chemical fertilizer alone. This may be due to extra addition of K through organic matter decomposition. Sharma *et al.,* 2000 [13] also confirms these results.

Total sulphur

There was a significant increase in total-S status of soil with increasing level of fertilizer (table 5). This may be due to addition of sulphur through SSP. A significant increase in total-S was recorded with incorporation of compost, crop residue and compost + crop residue as compared to inorganic fertilizer treatment. This indicates that organic manure increase the sulphur retaining power of soil (Ram *et.al.,* 1993) [12].

Table 5: Long term influence of organic and inorganic fertilizer on total potassium and total sulphur content in soil after harvest of wheat (27th crop) under rice-wheat cropping system in calcareous soil

Treatment	Total potassium (%)					Total sulphur (mg kg^{-1})				
	Organic sources					Organic sources				
	No Manure	Compost	Crop residue	Compost + Crop residue	Mean	No Manure	Compost	Crop residue	Compost + Crop residue	Mean
No NPK	0.60	0.72	0.70	0.81	0.70	180	230	228	267	226
50% NPK	0.67	0.76	0.72	0.85	0.75	211	259	250	303	256
100% NPK	0.68	0.79	0.75	0.88	0.77	240	275	281	308	276
150% NPK	0.70	0.81	0.78	0.90	0.79	359	369	350	442	380
Mean	0.66	0.77	0.73	0.86		247	283	277	330	
Source	S. Em. (±)		CD (P = 0.05)		S. Em. (±)			CD (P = 0.05)		
Fertilizer (F)	0.0056		0.02		2.83			9.8		
Manure (M)	0.0071		0.05		3.08			8.9		
F x M	0.0134		0.04		6.16			17.9		

Acknowledgement

The authors are thankful to the Director Research of the Experiment Station, R.A.U. Pusa, Samastipur, Bihar for provide the financial assistance through the Soil Test Crop Response Correlation Scheme to carry out the present investigation.

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