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Effect of continuous cropping and fertilization on availability of nutrients in an acidic soil

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Abstract : In a long-term field experiment started in 1991 following rice-wheat sequence, the effect of substitution of nitrogen through different organics was studied on different soil properties after 17^{th} cropping cycle. In this experiment, 25 to 50 % of N was substituted through different organics *viz.*, farmyard manure, wheat cut straw and green manure. Continuous cropping and fertilizer use over the years significantly increased organic carbon content over its initial value and the highest increase of 48 % in organic carbon and 25 % in cation exchange capacity over control was observed when 50 % N was substituted through FYM. Integrated use of fertilizers and organics also increased pH and macronutrients in soils. Application of chemical fertilizers without organics reduced available micronutrients over control, whereas their integrated use with organics, either increased or maintained its status. Amongst different organic sources tried, FYM proved to be the best.

Additional key words : *Organics, green manure, integrated nutrient use*

Introduction

Rice, among cereals is one of the important crops of India and occupies an area of about 45 million hectare with the production level of 132 million tonnes. In H.P., rice is cultivated on 81.4 thousand ha with the production of 120.62 thousand tonnes (Anonymous 2006). Rice followed by wheat is grown in sizable area. Both the crops are heavy feeders of nutrients. Under this situation, sustainability is always at stake. This has resulted in nutrient mining in soils causing stagnant or decline in crop yields. High productivity of rice-wheat cropping system cannot be sustained until and unless the nutrient supply at a desired level is not maintained. Though, use of chemical fertilizers is the fastest way of replenishing the nutrient depletion, yet ever increasing energy cost, limited input availability and rising fertilizer prices deter the farmers from using these inputs to required level. Further, chemical fertilizers alone are unable to maintain the long-term soil health and crop productivity (Subba Rao and Srivastava 1998) as they lack in secondary and micro-nutrients. Incorporation of organic amendments has a profound influence on rice growth and for supplementing essential nutrients in soil. The present investigation was, therefore, undertaken to study the integrated effect of mineral fertilizers and organics on different soil properties.

Materials and Methods

The study was undertaken during *kharif* 2008 in an ongoing long-term field experiment initiated in 1991 at Bhadiarkhar Farm of Chaudhary Sarwan Kumar HP Krishi Vishvavidyalaya, Palampur, H. P.

under rice-wheat cropping system. The soil of the study area was classified as Typic Hapludalf and was silty clay loam in texture, acidic(pH 5.5) in reaction and had CEC 11.5 c mol (p^+) kg^{-1}, and organic carbon 6.0 g kg^{-1}. The available N, P and K were 675.3, 21.9 and 221.0 kg ha^{-1}, respectively. The experiment was laid out in randomized block design with twelve treatments replicated four times.

The treatments were T_1 - No fertilizer or manure to rice and wheat (Control); T_2 - 50% NPK to both rice and wheat; T_3 - 50% NPK to rice, followed by 100% NPK to wheat; T_4 - 75% NPK to both rice and wheat; T_5 - 100% NPK to both rice and wheat; T_6 - 50% NPK+50% N through FYM to rice followed by 100% NPK to wheat; T_7 - 75% NPK+25% N through FYM to rice followed by 75% NPK to wheat; T_8 - 50% NPK+50% N through wheat cut straw to rice followed by 100% NPK to wheat, T_9 - 75% NPK+25% N through wheat cut straw to rice followed by 75% NPK to wheat, T_{10} - 50% NPK+50% N through green manure *(Sesbania aculeata)* to rice followed by 100% NPK to wheat; T_{11} - 75% NPK + 25% N through green manure to rice followed by 75% NPK to wheat; T_{12} - Farmers' practice *i.e.* 40% NPK+5t FYM ha^{-1} to rice followed by 40% NPK to wheat. Surface soil samples (0.15 m depth) were collected in June 2008, after completion of seventeenth crop cycle and were analysed for different soil properties using standard methods of analysis.

Results and Discussion

Soil pH

Soil pH was relatively less in the treatments T_5 and T_4 where 100% and 75% NPK was applied compared to control (T_1). This might be due to the acid producing nature of the fertilizers. Continuous cropping and fertilizer use over the years tended to decrease the soil pH marginally over initial value, except T_7 and T_{10} (Table 1). Addition of organics (T_6 to T_{11}) played a buffering role on soil pH which is evidenced by only 0.1 or 0.2 units increase/ decrease in comparison to 100% NPK where soil pH decreased by 0.3 units after 17^{th} copping cycles.

Organic carbon

The data (Table 1) indicated build-up of organic carbon in all the treatments over its initial value of 6.0 g kg^{-1} (*kharif*, 1991). Soil organic carbon varied from

Table 1. Effect of continuous fertilization and amendments on soil properties after seventeenth rice-wheat cycle (*kharif, 2008*)

Treatment	Soil properties					
	pH	OC (g kg^{-1})	CEC {c mol (p^+) kg^{-1}}	Available nutrient (kg ha^{-1})		
				N	P	K
T_1	5.5	6.2	11.20	198.61	19.85	173.23
T_2	5.3	7.0	12.43	201.40	45.55	142.61
T_3	5.4	7.3	12.90	220.00	81.34	142.61
T_4	5.2	7.4	13.15	232.00	60.48	137.97
T_5	5.2	7.5	13.47	240.43	63.59	139.63
T_6	5.4	9.2	14.08	257.80	66.08	150.08
T_7	5.6	8.1	13.88	249.52	40.38	138.13
T_8	5.3	8.6	13.45	221.50	69.44	147.84
T_9	5.4	8.0	13.53	209.07	42.56	153.07
T_{10}	5.6	7.4	13.33	238.00	67.95	143.82
T_{11}	5.3	6.8	13.23	241.01	76.33	146.35
T_{12}	5.4	7.8	12.73	211.57	65.88	144.11
Initial (1991)	5.5	6.0	11.50	675.30	21.90	221.00
CD (0.05)	0.17	0.04	1.29	26.44	8.46	12.61

6.2 g kg^{-1} under control (T_1) to 9.2 g kg^{-1} under the treatment receiving 50% NPK+50% N through FYM during *kharif* and 100% NPK during *rabi* (T_6). Application of 50, 75 and 100% NPK through chemical fertilizers to both the crops (T_2, T_4 and T_5) also increased the organic carbon content of soil with their respective values of 7.3, 7.4 and 7.5 over control. It is because of increased vegetative growth which subsequently added more root biomass to the soil continuously over the years.

Application of organic manures and chemical fertilizers further increased the organic carbon content of the soil significantly over control and initial value. The highest increase of about 48% and 53% in organic carbon content over control and initial status respectively was observed under T_6. The results are in conformity with the earlier works of Korwar *et al.* (2006) and Singh *et al.* (2007). The temperate climate also caused accumulation of organic carbon due to its low decomposition rate.

Cation exchange capacity

Cation exchange capacity (CEC) increased significantly in all the treatments except T_2 (Table 1). Maximum increase in CEC (25%) over control (T_1) was observed in the T_6 treatment receiving 50% NPK+50% N through FYM to rice followed by 100% NPK to wheat (T_6). Similarly, wheat cut straw and green manure also improved CEC of soil when applied in conjunction with chemical fertilizers. All the organic sources (T_6 to T_{11}) were equally effective in influencing CEC of soil. This increase is ascribed to formation of humus on incorporation of organics which provides a store house for exchangeable cations *viz.*, K^+, Ca^{2+}, Mg^{2+} *etc.* (Phogat *et al.* 2004).

Available nitrogen

Continuous manuring and cropping for 17 years decreased available N content of soil in all the treatments in comparison to its initial status (Table 1). This decline in available soil N under continuous application of NPK may be attributed to the lack of association between organic carbon and available N as the soil submergence during rice cultivation results in structural changes in organic carbon pool which become enriched with phenolic compounds that may immobilize N containing compounds and result in decline in available soil N (Katyal *et al.* 2000). The reduction in available N over the years in soils is associated mainly to the high rainfall (annual 2500 mm) in the area causing leaching losses.

Available Phosphorus

A perusal of the data (Table 1) indicated a build-up of available P with the application of chemical fertilizers alone or in conjunction with organics. Increase in available P of the soil with the use of recommended dose of NPK may be attributed to lower utilization of P from the applied sources. Since these soils are rich in sesquioxides so phosphorus gets accumulated over the years and as such contributes to the pool of available P in the soil (Katyal *et al.* 2000). Amongst integrated nutrient management treatments (T_6 to T_{12}), 50% substitution of N through any of the organic source (T_6, T_8, T_9) was equally effective and significantly superior over 25% substitution through respective source except in green manure, where both the levels were at par. This may be due to higher content of P_2O_5 in green manure in comparison to other two sources.

Available potassium

There is a clear evidence of mining of potassium in all the treatments over initial status of 221.0 kg ha^{-1} after 17 years of continuous cultivation. The decrease in available K content of the soil in all the fertilizer and manurial treatments is attributed to its higher removal by crops. Sharma *et al.* (2005) also reported decline in available K where recommended application of K was made. The decline in available potassium was maximum (39%) in plots receiving 50% N substitution through green manure (T_{10}) and lowest (22%) in control over initial value.

Micronutrient cations

All the treatments significantly affected the DTPA extractable micronutrient cations (Table 2).

Table 2. Effect of continuous fertilization and cropping on micronutrient cations in soil after seventeenth rice-wheat cycle (*kharif, 2008*)

Treatment			Micronutrient cations (mg kg^{-1})			
	Rice	Wheat	Cu	Fe	Mn	Zn
T_1	Control	Control	2.30	49.20	3.1	0.54
T_2	50% NPK	50% NPK	2.23	47.11	2.5	0.58
T_3	50% NPK	100% NPK	2.20	48.77	2.3	0.56
T_4	75% NPK	75% NPK	2.19	48.71	2.2	0.55
T_5	100% NPK	100% NPK	2.10	46.32	2.1	0.54
T_6	50% NPK+50% N through FYM*	100% NPK	2.64	59.01	6.5	0.80
T_7	75% NPK+25% N through FYM	75% NPK	2.61	57.82	6.2	0.68
T_8	50% NPK+50% N through WCS	100% NPK	2.34	56.18	5.2	0.64
T_9	75% NPK+25% N through WCS	75% NPK	2.18	54.08	5.0	0.62
T_{10}	50% NPK+50% N through GM	100% NPK	2.57	55.53	6.2	0.66
T_{11}	75% NPK+25% N through GM	75% NPK	2.29	54.53	5.8	0.60
T_{12}	Farmers' practice**	Farmers' practice	2.41	53.77	5.2	0.60
	CD (0.05)		0.11	4.30	1.00	0.04

**FYM- Farmyard manure, WCS- Wheat cut straw, GM- Green manure Dhaincha*

***40% NPK+5t FYM ha^{-1} to rice followed by 40% NPK to wheat*

Chemical fertilizer treated plots (T_2 to T_5) registered a decrease in available Cu content in comparison to control while integrated use of chemical fertilizers and manures (T_6 to T_{12}) either increased or maintained its status. Among different sources of organics, FYM was found to be superior over others. Significantly higher Cu content in FYM treated plots over non-FYM treated plots may be explained on the basis that Cu forms Cu-humus complex of relatively high stability with humus that decreases its susceptibility to fixation or precipitation in the soil. This is in consonance with the findings of Kumar *et al.* (2008).

Available Fe content in chemical fertilizer treated plots (T_2 to T_5) was observed to be statistically at par with control (T_1). Application of organic manures in conjunction with chemical fertilizers (T_6 to T_{11}) resulted in significant increase in DTPA-Fe over control and chemical fertilizer treated plots. Kumar *et al.* (2008) also reported an increase in the availability of Fe in soil with the application of FYM as compared to 100% NPK. Similar to Fe content, DTPA-Mn in fertilizer treated plots (T_2 to T_5) was statistically at par with control (T_1). Significant increase in available manganese was found in organically amended (T_6 to T_{12}) treatments over control (T_1) and inorganic treatments (T_2 to T_5). This is in consonance with the findings of Kumar *et al.* (2008).

The available Zn was highest (0.80 mg kg^{-1}) in T_6. Among graded doses of inorganic fertilizers, available zinc did not differ significantly among treatments and over the control. Application of organic manures along with fertilizers (T_6 to T_{12}) resulted a significant increase over control (T_1) and treatments receiving chemical fertilizers alone (T_2 to T_5). This may be due to mineralization of organically bound forms of Zn in the plots treated with organics and that might have resulted in the formation of organic chelates of higher stability, because Zn is known to form relatively stable chelates with organic legends which decrease their susceptibility to adsorption, fixation or precipitation.

Conclusion

Present study indicates that the integrated use of chemical fertilizers and organic sources improved different soil properties over the years. Amongst the various sources of organics tried, farmyard manure proved to be the best. There was significant increase in soil organic carbon and available P status. Decline in available N contents under high rainfall area warrants judicious use of N through split applications. A significant reduction in available K over initial status warrants a need to reschedule of K fertilizer doses.

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