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Influence of long term application of farm yard manure and *in situ* green manures on crop productivity and soil organic carbon under rice-rice system in a typic haplustalf

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ABSTRACT : The effect of long- term application of inorganic fertilizers and organic materials (farmyard manure, *in situ* green manuring with daincha) on rice productivity, soil organic carbon and nutrient availability was analysed at Regional Agricultural Research Station, Pattambi, Kerala Agricultural University. 15 year rice-rice cropping system experiment consisted of twelve treatments including control, inorganic fertilizers alone and fertilizers along with organic materials such as farmyard manure (FYM) and *in situ* green manuring with daincha. Long term fertilizer experiments (LTFE) provide an opportunity to evaluate the sustainability of agricultural practices. Integrated nutrient management and *in situ* green manuring with daincha recorded higher grain and straw yields and *in situ* green manuring was identified as a cost effective and farmer friendly technology. The organic carbon content (%) in soil in 100 per cent NPK+ FYM plot and that in 100 per cent NPK+ *in situ* green manured (daincha) plot was higher than the plot receiving inorganic nutrients alone. In addition to high productivity, these also had retained soil fertility.

KEY **W**ORDS : Long term fertilizer experiment, Rice, Productivity, Soil fertility, *In situ* green manuring, FYM

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The importance of long term fertilizer experiments in studying the effects of continuous cropping and fertilizer or manure application on sustenance of crop production is widely recognized (Manna *et al.,* 2007). Many intensive cereal based cropping systems according to agro-climatic regimes are practiced in the country. Rice-rice cropping system is the predominant crop sequence in the lateritic belts of Kerala. Yield, nutrient uptake and nutrient dynamics in soil under continuous use of fertilizers or manures assume great significance for the sustainability of this cropping system. Intensive cropping, cultivation of high yielding varieties, crop residue burning and indiscriminate use of chemical fertilizers have resulted in depletion of nutrients and soil organic carbon with deterioration of soil physical conditions. Long term studies indicated that supplying plant nutrients only through chemical fertilizers depleted soil organic matter and declined the soil productivity (Srivastava, 1998 and Singh *et al.,* 1999). There is a need to manage the long- term soil productivity through integrated use of both inorganic

and organic sources of nutrients. The organic sources of nutrients including farmyard manure, green manure, crop residues etc. have potential to increase the soil organic matter.

The soil organic matter plays an important role in improvement of soil physical, chemical and biological properties and ultimately increasing soil productivity and crop yields (Antil *et al.*, 2011 and Bhagat *et al.*, 2003). Long-term experiments have shown that incorporation of crop residues, farmyard manures and green manures increased soil organic carbon and nutrient availability as compared to the chemical fertilizers (Babhulkar *et al*., 2000). The present study was carried out to investigate the long-term effect of different nutrient management options on soil physico-chemical properties under rice-rice cropping system in a sandy clay loam soil.

RESEARCH PROCEDURE

Long-term fertilizer experiment wherein application of different organic materials (FYM and green manure) and inorganic fertilizers in rice-rice cropping system is being conducted for the last 15 years at research farm of Regional Agricultural Research Station, Pattambi, Kerala agricultural University was selected for the study. The climate of the region is sub humid. The soil of the location was typical lateritic coming in acid range of pH. The All India Co-ordinated Research Project on Long Term Fertilizer Experiments started with an objective of assessing the impact of different nutrient management practices on crop yield, soil health and sustainability. It follows a rice- rice cropping system with rice variety Aiswarya with 12 treatments such as T_1-50 per cent NPK of 90:45:45 (KAU recommendation), T_2-100 per cent NPK, T_3-150 per cent NPK, T_4-100 per cent NPK+600 kg lime, T_5-100 per cent NPK, T_6-100 per cent NP, T_7-100 per cent N, T_8-100 per cent NPK+FYM@5 t/ha in *Kharif* season, T_9-50 per cent NPK + FYM@5 t/ha in *Kharif* season, T_{10}-100 per cent NPK+ *in situ* green manuring in *Kharif*, T_{11}-50 per cent NPK + *in situ* green manuring in *Kharif* and T_{12}- control. The individual plot area was 120 m^2 and the experiment was laid out in a Randomized Block Design (RBD) with four replications. Farm yard manure was applied @ 5 ton/ha on dry weight basis in T_8 and T_9. In T_{10} and $_{11}$, dhaincha (Sesbania aculeata) was sown (seed rate 12.5 kg/ha) in the same field in pre-*Kharif* season as green manure crop and after about 40 days, incorporated into the soil. The amount of organic materials applied is expressed on dry weight basis. All the organic materials were applied 15 days before the planting of paddy seedlings. The N, P and K were supplied through urea, rajphos and muriate of potash. Full amount of phosphatic fertilizers applied as basal while N and K applied in two equal splits half basal and half top dressing at the stage of maxiumum tillering. Area of each plot was harvested manually to record the grain and straw yield. Composite soil samples of 0-15 cm depth were collected from each plot for soil analyses after harvest. Soil pH and electrical conductivity were determined by pH meter and electrical conductivity meter, respectively. Soil organic carbon content was estimated using Walkley and Black's titration method (Walkley and Black, 1934), available P by Bray-P method and available K content by ammonium acetate method (Piper, 1966).

RESEARCH ANALYSIS AND REASONING

The findings of the present study as well as relevant discussion have been presented under following heads :

Grain yield and straw yield :

The effect of different treatments on grain yield was significant during *Kharif* and *Rabi* seasons. Pooled values of the grain yield of 2008-09 to 2011-12 indicate that highest yield recorded by 100 per cent NPK as per package of practices of Kerala Agricultural University along with FYM @ 5 t /ha to the *Kharif* rice only followed

Table 1: Pooled average grain yield of paddy (2008-12) in kg/ha as affected by the long-term application of fertilizers and organic materials

Treatments	Pooled grain yield 2008-12 kg/ha	
	Kharif	*Rabi*
T_1	2215	2780
T_2	2522	3084
T_3	2672	3299
T_4	2818	3183
T_5	2645	3197
T_6	2238	2790
T_7	2161	2503
T_8	3355	3773
T_9	2737	3131
T_{10}	3362	3582
T_{11}	2644	2983
T_{12}	1477	2007

by 100 per cent NPK+*in situ* green manuring with daincha. *In situ* green maturing with 50 per cent NPK can also be substituted for 100 per cent NPK so that 50 per cent chemical fertilizer can be saved. T_{12} (Control) had given lowest yield. Straw yield also revealed almost the same trend. The grain and straw yields in the two seasons of 2011-12 are shown in Table 2.

The grain and straw yield of rice indicated an increasing trend with the continous application of organic manures along with inorganic fertilizers (Table 2). Application of FYM (T_8) and *in situ* green manuring gave highest grain and straw yield in both the seasons. This indicated the potential use of farmyard manure and *in situ* green manuring for sustaining the soil productivity. Similar effect of long-term application of FYM on yield of wheat in pearl millet-wheat cropping system was reported by Antil *et al*. (2011).

In situ green manuring identified as a substitute for farm yard manure application :

In situ green manuring (Daincha) identified and popularized as a cost effective and farmer friendly technology as is clear from the graph in Fig. 1.

Generally, incorporation of green manures grown in situ is cost effective (Beena *et al*., 2002). *In situ* green manuring with dhaincha gives on an average 35mt green

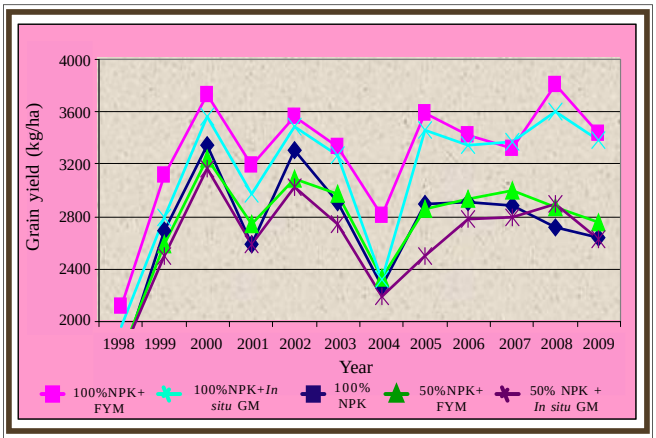

Fig. 1 : Effect of nutrient management on grain yield of rice over years

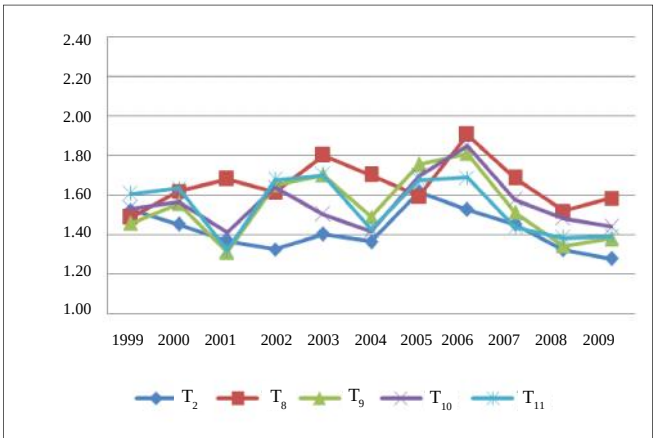

Fig. 2 : Effect of nutrient management on soil organic carbon in rice rhizosphere over years

Table 2 : Grain and straw yield of paddy in the *Kharif* and *Rabi* seasons of 2011 as affected by the long-term application of fertilizers and organic materials

Treatments	Grain and straw yield (2011-12)kg/ha			
	Kharif		*Rabi*	
	Grain yield	Straw yield	Grain yield	Straw yield
T_1	2062	2254	2801	2836
T_2	2549	2635	3114	2945
T_3	2750	2859	3227	3062
T_4	2784	2789	3151	3096
T_5	2685	2568	3026	3020
T_6	2167	2273	2700	2938
T_7	1750	1698	1955	2144
T_8	3333	3524	4069	3531
T_9	2967	3025	3669	3347
T_{10}	3167	3268	3817	3476
T_{11}	2833	2987	3474	3094
T_{12}	1661	1723	1937	2000
C.D.	94.43	114.5	104.6	81.03

matter per hectare

The long-term application of organic materials along with fertilizers significantly increased the soil organic carbon (SOC) (Fig. 2). The organic carbon contents in soil varied from 1.09 to 1.80 per cent between the treatments over ten years.

The organic carbon content in soil in integrated management plots, 100 per cent NPK+ FYM and 100 per cent NPK+ *in situ* green manuring (daincha) was higher than the plot receiving inorganic nutrients alone. It is in accordance with the finding of Brar *et al.* (2000) and Beena *et al.* (2002). It is clear that organic manures improve soil quality through the enrichment of soil organic carbon. However, the positive effect of organic manuring was more in FYM treatment than *in situ* green manured one. The organic carbon content in soil of the 50 per cent NPK+FYM plot was lower than that in 100 per cent NPK+FYM. The application of inorganic fertilizers also contributes to the soil carbon pools through increased biomass production.

SOC content in 0–15 cm soil layer was highest in FYM treatment (T_8) and lowest in control treatment however, fertilizers alone had also increased the SOC as compared to the control. The increase in SOC with application of inorganic fertilizers could be attributed to higher biomass than in control plots. Further, higher level of SOC with the long- term application of manures along with the fertilizers may be due to additional C inputs resulting from return of crop residues into soils.

The pH and electrical conductivity did not show any significant changes (Table 3). The lime requirement estimated by SMP buffer method indicated the role of lime, FYM and *in situ* green manuring in reducing the acidity of soil (Fig. 3).

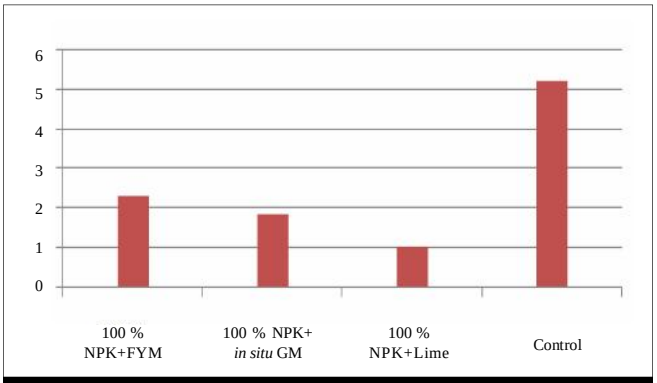

Fig. 3 : Effect of nutrient management options on lime requirement (tons/acre(SMP buffer method) of soil after 15 continuous crop cycles

Conclusion :

Long term fertilizer experiments provide opportunity to evaluate the sustainability of agricultural practices. The indicators of sustainability in continuous rice production systems include stable or increasing productivity over time and maintenance or enhancement of key soil fertility factors like soil organic carbon, nutrient availability etc. As rice-rice cropping

Table 3 : Soil organic carbon and pH of 0-15 cm soil layer as affected by the long-term application of fertilizers and organic materials

Treatments	pH		Organic carbon %	
	Kharif 11-12	*Rabi* 11-12	*Kharif* 11-12	*Rabi* 11-12
T_1	5.10	5.44	1.57	1.31
T_2	5.17	5.34	1.67	1.45
T_3	4.90	5.51	1.73	1.55
T_4	5.10	5.51	1.61	1.32
T_5	5.14	5.69	1.63	1.49
T_6	5.04	5.75	1.67	1.41
T_7	5.18	5.65	1.68	1.37
T_8	5.17	5.38	1.93	1.78
T_9	5.04	5.44	1.74	1.55
T_{10}	5.02	5.43	1.87	1.53
T_{11}	5.09	5.46	1.78	1.4
T_{12}	5.04	5.48	1.19	1.19
C.D.	0.18	0.17	0.28	0.29

system is the predominant crop sequence in the lateritic belts of Kerala state, the changes in physical, chemical and biological properties of soil and nutrient uptake occurring due to continuous use of fertilizers or manures assume significance for the sustainability of this cropping system. The results from long term fertilizer experiments show that integrated nutrient management and *in situ* green manuring with dhaincha gave higher grain and straw yields. Long- term integrated nutrient management by applying organic manures and inorganic fertilizers had potential to improve soil organic carbon and buffer soil pH for increasing the crop yield for sustainable agriculture.

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