J Krishi Vigyan 2023, 11 (2) : 57-60 DOI : 10.5958/2349-4433.2023.00011.9

Effect of Long-term Application of Manures and Fertilizers on Yield and Soil Nutrient Concentration in Rice Based Cropping System

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ABSTRACT

All India co-ordinated research project on long term fertilizer experiment was set up at Regional Agricultural Research Station, Pattambi, Kerala during 1997. Research finding on yield and yield attributes as well as soil nutrient concentration as affected by the continuous application of manures and fertilizers on rice-rice cropping system was given in the paper. T_{10} (100% NPK + *in-situ* green manuring) recorded the maximum number of tillers per hill (12.37). The number of panicles per hill was highest in T_{10} and T_3 (150% NPK) with 11.37 and 11.07, respectively. Treatment, T_8 (100% NPK+FYM) recorded the highest number of seeds per hill (1149.3) and yield (4650 kg/ha). The available nutrient concentration in the soil varies depending on the individual nutrients. Organic carbon (1.96%) and available nitrogen (246.54 kg/ha) was found to be higher in T_8. Available phosphorus was highest in T_3 (19.39 kg/ha) followed by T_8 (19.34 kg/ha) and T_4, 100% NPK+lime (18.92 kg/ha). Highest available potassium was recorded in T_3 (84.83 kg/ha) where super optimal dose (150%) of NPK was applied.

Key Words: Green manure, Nitrogen, Organic carbon, Phosphorus, Potassium,Yield.

INTRODUCTION

The Long Term Fertilizer Experiments (LTFE) are key tools in comprehending the alterations in soil parameters brought on by intensive cropping and persistent fertilizer/manure application. It is widely believed that long-term fertilizer studies hold troves of important knowledge on the viability of intensive agriculture. The results obtained from a 44 year old permanent manurial trial experiment showed a positive impact of integrated nutrient management on yield and yield attributes of rice-rice cropping system in the central laterites of Kerala (Thulasi *et al*, 2022). A potential option for maintaining greater productivity as well as for stabilising the crop production is the integrated use of both chemical fertilizers and soil amendments. In a 16 years LTFE with rice-rice cropping system, recommended NPK along with FYM and lime recorded highest value of organic carbon. In the FYM with lime treated plot, an elevation in organic carbon decreased the bulk density of soil and boosted aggregate stability (Garnaik *et al*, 2022). The physical, chemical, and biological characteristics of soil are changed by repeated use of chemical fertilizers and manures. The objective of the current study was to evaluate the effect of LTFE on yield and soil nutrient status of rice-rice cropping system.

MATERIALS AND METHODS

The LTFE was started during 1997 with 12 different nutrient management practices. It consisted of 12 treatments with 4 replications laid out in randomized block design. The treatments were: T_1:

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Table 1. Effect of treatments on yield and yield attributes.

Treatment	No. of tillers/hill	No. of panicles/ hill	No. of seeds/hill	Yield (Kg/ha)
T_1(50 % NPK)	10.56	10.50	830.00	2811
T_2 (100 % NPK)	10.53	10.07	950.00	3472
T_3 (150 % NPK)	11.50	11.07	1075.70	4104
T_4 (100 % NPK + lime @ 600 kg ha^{-1})	10.83	10.40	1019.30	3770
T_5 (100 % NPK)	10.53	9.77	941.30	3515
T_6 (100 % NP)	9.90	9.20	706.70	2974
T_7 (100 % N)	8.16	6.97	699.70	2175
T_8 (100 % NPK + FYM @ 5 t ha^{-1})	11.73	10.77	1149.30	4650
T_9 (50 % NPK + FYM @ 5 t ha^{-1})	10.86	10.00	856.70	3713
T_{10} (100 % NPK + in situ growing of *Sesbania aculeata*)	12.36	11.37	1054.70	4256
T_{11} (50 % NPK + in situ growing of *Sesbania aculeata*)	10.83	10.37	896.00	3453
T_{12} (Absolute control)	7.96	7.60	548.70	2141
CD (0.05)	0.941	0.73	128.80	493.6

50 per cent NPK, T_2 : 100 percent NPK, T_3 : 150 percent NPK, T_4 : 100 percent NPK + 600 kg/ha $CaCO_3$, T_5 : 100 percent NPK, T_6 : 100 percent NP, T_7 : 100 percent N, T_8: 100 percent NPK + FYM @ 5 t/ha , T_9: 50 per cent NPK + FYM @ 5 t/ha,T_{10} : 100 percent NPK + *in situ* growing of *Sesbania aculeate,* T_{11} : 50 percent NPK + *in situ* growing of *Sesbania aculeate*) and T_{12} : Absolute control (No fertilizers or manures).

The surface soil samples were analyzed for estimating the nutrient status of the soil. Soil samples were dried, sieved and organic carbon, nitrogen, phosphorus, potassium were analyzed using the standard procedures. Organic carbon was estimated by chromic acid wet digestion method (Walkley and Black, 1934). Available N in soil was estimated by alkaline permanganate method (Subbiah and Asija, 1956), available P by Colorimetry method (Olsen *et al*, 1954) and available K by Neutral Normal Ammonium Acetate method (Stanford and English, 1949).

RESULTS AND DISCUSSION

Yield and yield attributes

The mean value of tillers per hill ranges from 7.96 to 12.37. The maximum number of tillers were observed in treatment, T_{10} receiving 100% NPK along with green manuring (12.37), which was significantly different from all other treatments. It was followed by 100% NPK+FYM (T_8) and 150% NPK (T_3) with values 11.73 and 11.50 respectively. The control, T_{12} recorded the least value (7.96). The number of panicles per hill ranged from 6.97 to 11.37 with T_{10} and T_3 recorded the highest value as 11.37 and 11.07 respectively. The results were significantly different from all other treatments. It was followed by T_8 (10.77). Treatment T_7 (100% N) recorded the lowest value (6.97). The application of green manure alone and in integration with green manure with NPK fertilizers showed a significant enhancement in the yield attributes of rice cropping system (Saravanapandian and Haroon, 2012).

The average number of seeds per hill ranged between 548.70 to 1149.30. The maximum number of seeds per hill was recorded in T_8 (1149.30), significantly higher from all other treatments. It was followed by T_3 (1075.70) and T_{10} (1054.70) which were statistically at par with T_8. The unfertilized control recorded the least with a value of 548.70. The grain yield ranges between the mean values of 2141 to 4650 kg/ha. The integrated nutrient management

Table 2. Effect of treatments on soil nutrient concentration

Treatment	Organic carbon (%)	Available N (Kg/ha)	Available P (Kg/ha)	Available K (Kg/ha)
T_1(50 % NPK)	1.56	216.44	16.78	68.68
T_2 (100 % NPK)	1.59	206.55	18.63	70.57
T_3 (150 % NPK)	1.68	217.35	19.39	84.83
T_4 (100 % NPK + lime @ 600 kg ha^{-1})	1.49	236.34	18.92	73.83
T_5 (100 % NPK)	1.57	205.23	18.61	69.73
T_6 (100 % NP)	1.51	200.69	16.94	49.89
T_7 (100 % N)	1.41	183.42	9.89	46.97
T_8 (100 % NPK + FYM @ 5 t ha^{-1})	1.96	246.54	19.34	78.69
T_9 (50 % NPK + FYM @ 5 t ha^{-1})	1.71	213.21	17.45	67.51
T_{10} (100 % NPK + in situ growing of *Sesbania aculeata*)	1.82	227.45	18.65	69.93
T_{11} (50 % NPK + in situ growing of *Sesbania aculeata*)	1.73	227.55	18.15	66.55
T_{12} (Absolute control)	1.19	179.78	12.70	48.30
CD (0.05)	0.065	8.435	0.689	2.838

(INM) treatments recorded the highest value with T_8 (4650 kg/ha) recording the maximum yield which was on par with T_{10} (4256 kg/ha) where fertilizer along with green manure was applied. The treatments T_7 (100% N) and T_{12} registered the lowest yield with values 2175 and 2141 kg/ha, respectively. The higher availability of macro and micronutrients, which are necessary for starch production, photosynthesis, and the transportation of photosynthates, may be the cause of the increased yield. The findings of the current study showed that INM practices among the LTFE enhanced the soils physical, chemical and biological qualities and increased yield. The FYM supplied to the soil the issue of the build-up of autotoxins released by rice roots and thus contributes to a favourable impact on yield characteristics (Ranjini, 2002). Similar results were reported by Sumayya (2017) and Esther Longkumer (2021).

Soil nutrient status

The mean value of organic carbon (OC) content in soil ranges from 1.19 to 1.96 per cent. The highest organic carbon content, 1.96% was recorded in treatment where 100% NPK along with FYM was applied and it was found to be on par with treatment where 100% NPK along with green manure (1.82%) was applied. The lowest value was registered in T_{12} (1.19%). The content of organic carbon in various soils and crop management was significantly raised by the continual administration of FYM and green manure. It also improved the organic matter content of soil. It was also observed that when the fertilizer dosage was increased from 50 to 150 % NPK, the amount of OC increased.

The average value of available nitrogen content varied from 179.78 to 246.54 kg/ha . Available nitrogen content was recorded highest in T_8 (246.54 kg/ha) with integrated nutrient management administered. It was followed by T_4 (236.34 kg/ha) where 100% NPK+lime was applied. Available nitrogen was found to be the lowest in treatments T_7 (183.42 kg/ha) followed by T_{12} (179.78 kg/ha). The administration of inorganic nitrogen fertilizers in combination with organic sources were found to increase the available nitrogen content in soil than solely application of inorganic fertlilizers (Alok kumar and Yadav, 1993).

The mean value of available phosphorus content in the soil varied between 9.88 to 19.39 kg/ha . The phosphorus content in soil was found to be highest in T_3 (19.39 kg/ha) which was on par with T_8 (19.34 kg/ha) and T_4 (18.92 kg/ha). The least value was recorded in treatment T_7 (9.88 kg/ha). Little or no incorporation of phosphorus fertilizers in a continuous cropping field might be the reason the least value of available phosphorus in T_7. According to Goyal *et al* (1999) when 100% NPK was applied continuously, either by itself or in combination with organics, available P content rose in comparison to the preliminary available P status.

The average potassium content in LTFE soils ranges from 46.96 to 84.83 kg/ha. Highest available potassium was recorded in T_3 (84.83 kg/ha), where super optimal dose (150%) of NPK was applied. The application of a larger quantity of NPK compared to the recommended dosage might be the reason for increased potassium in T_3 which was significantly different from the rest of the treatments. It was then followed by T_8 (78.69 kg/ha) where a balanced dosage of chemical and organic amendments enhanced the nutrient status of soils. This could be explained by the higher ability of organic colloids to store K^+ ions on the exchange complexes.

CONCLUSION

The present study emphasizes the adoption of integrated nutrient management practices as a powerful technique to improve yield of crop and the soil characteristics in a long run. Although the application of inorganic fertilizers increases the yield, it might deplete the indigenous soil properties due to its injudicious application over time. The finding from the study showed that treatment T_8 (100% NPK + FYM) was found to be the best management technique in a rice based cropping system in the central laterites of Kerala followed by T_{10} (100% NPK + *in-situ* growing of *Sesbania aculeate*). Thus, practicing an integrated approach on nutrient management strategies strengthens the physical, chemical and biological properties of soil and thereby increases crop production and productivity.

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Received on 24/1/2023 *Accepted on 16/4/2023*