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Effect of long term fertilization and manuring on microbial population and yield under rice-rice cropping system

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Abstract
The present investigation was carried out at RARS, Pattambi, Kerala during 2020-2021 on continuous application of manures and fertilizers under rice-rice cropping system since 1997. The experiment consists of twelve treatments with four replications viz., : T_1: 50 percent NPK, T_2 : 100 percent NPK, T_3 : 150 percent NPK, T_4 : 100 percent NPK + 600 kg ha^{-1} $CaCO_3$, T_5 : 100 percent NPK, T_6 : 100 percent NP, T_7 : 100 percent N, T_8: 100 percent NPK + FYM @ 5 t ha^{-1}, T_9: 50 percent NPK + FYM @ 5 t ha^{-1}, T_{10} : 100 percent NPK + *in situ* growing of *Sesbania aculeate*, T_{11} : 50 percent NPK + *in situ* growing of *Sesbania aculeata*) and T_{12} : Absolute control (No fertilizers or manures). The effect of treatments on microbial population and yield of crop confirmed integrated nutrient management as the best treatment in enhancing the soil biological properties. Results showed that the population of bacteria, fungi and actinomycetes was highest in T_8 (100% NPK + FYM). Seed yield and straw yield was also found to be highest in the T_8 which was on par with T_{10}.

Keywords: INM, grain yield, straw yield, microbial population, LTFE

1. Introduction

It is important to look into how fertilizers affect soil and the environment amid intensive cropping systems, as well as crop yields and quality, as fertilizer has become a crucial factor in improving agricultural production and its consumption in agriculture is rising quickly. Studying such gradual changes in soil over time was made possible by long-term or ongoing field experiments. The first long-term fertilizer experiment in India was initiated at Kanpur in 1885, and many other locations followed during the start of the 20th century (Nambiar and Abrol, 1989) [7]. The LTFEs produced insightful data on how organic manure and chemical fertilizers affect crop yields, nutrient removal, and soil characteristics. Long-term field studies are seen to offer the closest practical representation of a test of the sustainability of agricultural techniques. The long-term fertilizer trials in India have shown that they might be used to assess and evaluate the impact of continuous cropping and fertilizer use on soil quality and sustainability (Bhatt *et al*. 2019) [2].

The primary threat to Indian agriculture is the degradation of soil health, which is made worse by the region's heavy use of fertilizers on its less responsive, low-organic matter-content soils (Gora *et al*. 2022) [5]. In high input production systems, neither sole application of chemical fertilizers nor independent usage of natural amendments can maintain soil nutrients and crop productivity (Thaneshwar *et al*. 2017) [14]. Degradation of soil health due to heavy use of fertilizers on low organic carbon soils is a threat to Indian agriculture. Integrated nutrient management (INM), which guarantees high crop output while preserving soil health and fertilizer use effectiveness, is a preferable choice. Appropriate and coordinated utilization of plant nutrients from both organic and inorganic sources can offer remedies for declining soil productivity and health. For enhancing the physical, chemical, and biological health of the soil, combined use of organic and inorganic nutrient sources are essential (Urmi *et al*. 2022) [16]. Judicious application of organic and inorganic nutrients enhanced the microbial population and yield of crops (Ranjan *et al*. 2020) [9].

Soil microorganisms play a significant role in the production and health of agricultural systems. It is well acknowledged that soil microbial dynamics have a significant role in deciding how ecosystems function. Production techniques like management systems have a major impact on microbial ecosystems (Germida and Siciliano, 2001) [4].

It is crucial to examine how microbes react to various cultural practices since soil microbiota are anticipated to be effective bioindicators of soil conditions because they easily adapt to changing environments (Avidano *et al*. 2005) [1]. Hence the study focuses on the effect of continuous application of manures and fertilizers on microbial population and the growth of paddy.

2. Materials and Methods

An all India Co-ordinated Research Project on Long Term Fertilizer Experiment (LTFE) was laid out in 1997 at Regional Agricultural Research Station (RARS), Pattambi, Kerala. The present study was conducted on the LTFE fields of Pattambi, from 2020 to 2021. The experiment was set up in a Randomized Block Design (RBD) with four replications, each plot measuring 120 m^2 using rice variety Aiswarya. The treatments include: T_1: 50 percent NPK, T_2 : 100 percent NPK, T_3 : 150 percent NPK, T_4 : 100 percent NPK + 600 kg ha^{-1} $CaCO_3$, T_5 : 100 percent NPK, T_6 : 100 percent NP, T_7 : 100 percent N, T_8: 100 percent NPK + FYM @ 5 t ha^{-1}, T_9: 50 percent NPK + FYM @ 5 t ha^{-1}, 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). In treatments T_8 and T_9, FYM was applied at 5 t ha^{-1}. In treatments T_{10} and T_{11}, *Sesbania aculeata* was sown at the rate of 12.5 kg ha^{-1} as a green manure crop and it was incorporated in the fields 40 days after sowing. FYM was applied 15 days before planting paddy seedlings. The full amount of phosphatic fertilizers applied as basal dose. N and K were applied in two halves, one as basal application and the other as top dressing at the maximum tillering stage. The crops were harvested from each plot to determine the grain and straw yield. For the determination of microbial population, the soils were collected from each treatment plot and stored in the refrigerator at 4° C. For the enumeration of bacterial, fungi and actinomycetes populations serial dilution technique was adopted.

3. Results and Discussion

3.1 Effect of treatments on grain and straw yield

The effect of treatments on grain and straw yield is shown in Fig. 1. Statistical analysis of the data revealed that treatments differed significantly with respect to grain yield and it varied from 2141 to 4650 kg ha^{-1}. The treatment T_8 (100 percent NPK+FYM) was significantly superior to all other treatments, which is on par with that in the treatment T_{10} (100 percent NPK + *in situ* growing of *Sesbania aculeate*) with mean value 4256 kg ha^{-1}. The grain yield recorded by the treatment 100% NPK was found to be on par with that recorded by T_9 and $T_{11,}$ wherein integrated nutrient management was followed with 50 percent NPK. The lowest value of grain yield, 2141 kg ha^{-1} was noticed in treatment T_{12} (absolute control), which was on par with that in $T_{7,}$ where nitrogenous fertilizers alone were applied since the inception of the AICRP on LTFE in 1997. The increase in yield on integrated use of manures and fertilizers may be due to the reason that there may be greater availability of macro and micronutrients, which are needed in starch formation, photosynthesis and translocation of photosynthates. A similar positive effect of INM was also reported in the LTFE maintained at Pattambi (Thulasi *et al*. 2020) [15] during previous years.

The treatments had a significant effect on the straw yield of rice, which ranged from 2384 to 5562 kg ha^{-1}. The highest average yield of 5562 kg ha^{-1} was recorded by the crop under treatment T_8 which received 100 percent NPK along with 5 tonnes of FYM. It was on par with that recorded in treatment T_{10} wherein Daincha was sown and incorporated *in situ* along with 100% NPK (5228 kg ha^{-1}). The treatment T_{12} (absolute control) recorded the lowest mean value of 2384 kg ha^{-1} for straw yield. The crop under treatment T_7 had a straw yield of 3135 kg ha^{-1} which was significantly higher than that under control and is on par with that recorded in T_1 (50% NPK). There was a significant increase in straw yield with an increase in fertilizer load from 50 percent NPK (T_1) to 150 percent NPK (T_3). The higher nutrient level received through the application of chemical fertilizers and the sustained release of plant nutrients by the mineralization of the applied organics account for the highest straw yield recorded under INM. Moreover, the integrated use of organic manures and inorganic fertilizers has been found promising in improving crop productivity through the correction of some secondary and micronutrient deficiencies in the soil. Similar results were recorded by Ranjini (2002) [10] and Saravanapandian and Haroon (2012) [11].

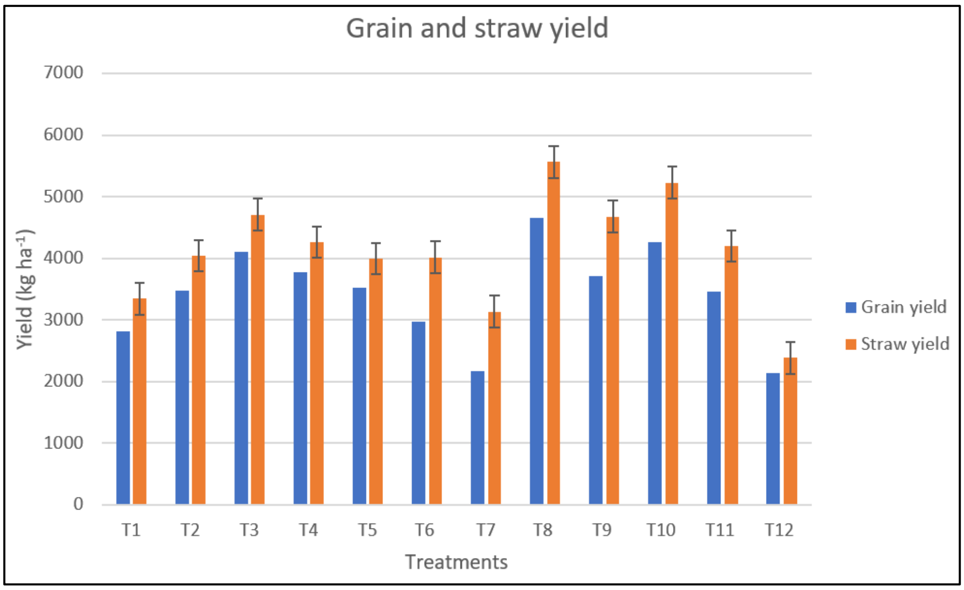

Fig 1: Effect of treatment on grain and straw yield

3.2 Effect of treatments on microbial population

The effect of treatments on the microbial population is recorded and given in Table 1. The results from the current field study showed an increase in bacterial population in the integrated nutrient management plots compared to fertilizer treated plots. In the treatment, T_8 where 100% NPK and five tonnes of FYM was applied per hectare had the greatest number of bacterial population (42.63 x 10^7 cfu/g soil) which was significantly different from all other treatments. It was followed by T_{10}, where the bacterial population was 36.57 x 10^7 cfu/g soil. The least number of bacterial population was recorded in the absolute control. In INM, the application of organic amendments acts as a substrate for the growth and development of bacterial population. The carbon rich material provided the nourishments needed for the enhanced growth of microbes. In 16 years, LTFE with rice-rice cropping system, recommended NPK along with FYM and lime recorded highest population of bacteria and actinomycetes where the bacterial population was almost 1.8 times greater than plots with 100% NPK treated (Garnaik *et al*. 2022) [3].

The population of fungi also followed the same trend. The treatment receiving fertilizers along with organic amendments recorded the highest fungi population. In the treatment, T_8 where 100% NPK and five tonnes of FYM applied per hectare showed the greatest number of fungi population (7.25 x 10^4 cfu/g soil) which was significantly different from all other treatments. It was followed by T_{10}, where the fungi population was 4.52 x 10^4 cfu/g soil followed by T_7 (100% N) which was on par with T_6 (100% NP) where nitrogenous fertilizers were applied. The least number of fungi population was recorded in the absolute control. The microbial populations in the soil are nourished by the supplementation of organic manures and on adopting INM practices (Tamilselvi *et al*. 2015) [13]. Acidifying nature of the nitrogenous fertilizers might contribute to a favorable environment for fungi (Mahajan *et al*. 2007) [6].

The population of actinomycetes was highest in INM with FYM (8 x 10^5 cfu/g soil). It was significantly different from all other treatments and followed by INM with green manure (1.9 x 10^5 cfu/g soil). The least population of actinomycetes were recorded in control, T_6 and T_7 where imbalanced application of fertilizers decoded the fate. The results are in agreement with those of Swarup (2000) [12] and Nikhil (2014) [8] who found that continuous application of FYM with NPK resulted in greater counts of actinomycetes. The organic compound present in FYM together with inorganic nutrients act as energy supplements needed for the growth and multiplication of beneficial microorganisms.

Table 1: Effect of treatments on microbial population

Treatments	Bacteria (10^7cfu/g soil)	Fungus (10^4 cfu/g soil)	Actinomycetes (10^5 cfu/g soil)
T1 (50% NPK)	29.87	3.51	1.67
T2 (100% NPK)	33.48	4.12	1.90
T3 (150% NPK)	35.00	5.59	2.25
T4 (100% NPK+Lime)	31.54	3.72	1.50
T5 (100% NPK)	33.48	4.11	1.90
T6 (100% NP)	29.49	5.92	1.00
T7 (100% N)	28.56	6.12	1.00
T8 (100% NPK+FYM)	42.63	7.25	8.00
T9 (50% NPK+FYM)	36.57	6.41	3.25
T10 (100% NPK+Daincha)	35.00	4.52	4.22
T11 (50% NPK+ Daincha)	32.84	4.2	2.25
T12 (absolute control)	7.42	2.65	1.00
CD	1.37	0.23	0.15

*N- Nitrogen; *P- Phosphorus; *K- Potassium; *FYM- Farm Yard Manure

4. Conclusion

On the basis of results obtained from the current study, it was concluded that integrated nutrient management was found to be a promising management practice that enhanced the biological properties of soil and thereby effect to a productive ecosystem for the micro and macro flora. The yield of rice was also significantly higher in INM treatments. A sustainable approach that needs to be used in agriculture may be the prudent application of fertilisers coupled with organic amendments. Treatments T_8 (100 percent NPK+FYM) and T_{10} (100 percent NPK + *in situ* growing of *Sesbania aculeate)* were proved to be the best management practices in light of the yield and biological health of the soil. Hence, to summarise the integrated and balance application of organic and inorganic nutrients is crucial for sustainability of the rice-rice ecosystem.

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