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Soil Microbial Population and Soil Enzyme Activity under Organic and Conventional Management Systems in Low Land Rice Ecosystem System of Godavari Delta, Andhra Pradesh

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ABSTRACT: A field experiment was conducted in wet land condition during *rabi* season of 2016-17 at Regional Agricultural Research Station, Maruteru to evaluate the production potential of rice (*Oryza sativa* L.) under organic farming and conventional farming system. The main aim of this study is to compare soil microbial activity and soil enzymatic activity (dehydrogenase, acid phosphatase, alkaline phosphatase, urease) in organic and conventional farming systems. As the soil enzymes are natural mediators and catalysts of many important soil processes, such as: decomposition of organic matter released into soil during plant growth, processes of soil humus formation and decomposition, the release of mineral nutrients and their supply to plants. The package followed for organic farming was *insitu* incorporation of green manure crop (Diancha), application of Farm Yard Manure @10t/ha as basal and application of Neem cake @500 kg/ha in two splits at tillering and PI stage. Under inorganic farming chemical fertilizers were applied as per recommendation (180-90-60 kg NPK per ha). Variety tested was MTU-1121 (Sreedruthi). Data was collected at the time of harvesting. Soil and Plant samples were collected at the time of harvesting for analysis in the laboratory. The results revealed that the grain and straw yield of rice was high in conventional farming system (7490 kg/ha and 8910 kg/ha) as compared with organic farming(3845kg/ha and 5060 kg/ha). This may be due to mismatch of soil nutrient supply with crop demand. Soil microbial population determined by serial dilution soil plate count (count/g soil) of bacteria, fungi and actinomycetes were also found to be high under organic farming system as compared to conventional farming system. Soil enzyme activity (dehydrogenase, urease and phosphotase) also followed the same trend. This may be attributed to application of huge quantities of organic manures under organic farming system of cultivation of rice in low land rice ecosystem of Godavari delta.

Keyword: organic farming, conventional farming, soil microbial population and soil enzyme activity.

INTRODUCTION

Rice is the major food crop and is the primary food source for more than one third of the population and it receives maximum quantity of fertilizers (40%) and pesticides (17-18%) and it is the foremost cultivated crop all over the Globe and India. Due to green revolution in mid-1960's, short statured rice varieties, pesticides and fertilizers were introduced. Exorbitant use of pesticides and fertilizers, the soil environment got polluted. Declining trend in productivity observed in several long term experiments all over India.

Increased/indiscriminate use of chemical fertilizers and pesticides during green revolution period resulted in several harmful effects on soil, water and air causing their pollution. Organic farming is a unique option to recover the hostile effects of soil environment that being polluted.. Organic farming is a system of production that relies on animal manures, organic wastes, crop rotations, legumes and aspects of biological pest control. It avoids (or legumes excludes) the use of synthetically produced fertilizers, pesticides, growth regulators and livestock additives. It emphasizes the ecological production management system that promotes and enhances biodiversity, biological cycles and biological activity of the soil .The essence of organic farming is to feed the soil rather than the crops to maintain optimum soil health with its vibrancy and resilience. Thus, making the soil capable of supplying all the essential nutrients to the crop for its proper growth and development (Shannon *et al*., 2002 and Wang *et al*., 2011). Organic farming aims at sustaining and increasing the productivity by improving the soil health and overall improvement of agro ecosystem. The excess/indiscriminate use of chemical fertilizers and pesticides reduces the productivity of the soil by deteriorating soil health in terms of soil fertility and biological activity. Microorganisms play a crucial part in soil nutrient cycling, maintenance of soil structure, degradation of agrochemicals and pollutants, and plant pest control (Stockdale and Brookes, 2006), hence it has often been indicated as an important component of soil fertility (Nogueira *et al*., 2006). Enzymatic activities in the soil highly affect nutrient cycling and organic matter decomposition (Pavel *et al*., 2004). Phosphatases, meanwhile, are involved in the transformation of organic phosphorus compounds in soil (Amador *et al*., 1997). Moreover, ureases are in charge of releasing inorganic N in the N-cycle (Bandick and Dick, 1999). A case study indicated that excessive cultivation decreased both microbial biomass and its activities (Gupta and Germida, 1988). The objective of the present study was to determine the effect of application of organic manures on grain and straw yield of rice along with its influence on soil microbial population and enzyme activities. The results are in accordance with the findings of Kwiatkowski *et al*. (2020); Marinari *et al.* (2006); Roldan *et al.* (2005).

MATERIALS AND METHODS

A field experiment was laid out during rabi, 2016-17 in two large size plots as 40 cents each for organic management system and conventional management system of rice with a variety MTU-1121 (Sreedruthi) with a spacing of 20cm × 15cm.

Table 1: Initial Soil Properties.

Variety	MTU-1121
Texture	Clay loam
pH	6.20
Organic carbon (%)	1.05
CEC (cmol (p^+)/kg)	48.6
EC (dS/m)	0.63
Avail. N (kg/ha)	254
Avail. P (kg/ha)	44.9
Avail. K (kg/ha)	278

The package followed for organic farming. Insitu incorporation of *calotropis* as green leaf manure, Basal application of FYM @ 10 t/ha, at the time of first puddling. Bio-fertilizers such as azospirillum and PSB @ 1250 ml/ha can be mixed with 25 kg FYM and applied to the soil just before planting. Split application of neem cake 500 kg/ha at tillering and PI stage. For control of pests spraying of Neem formulations (Azadirectin at nursery and 10 and 25 DAT) 1500 ppm at 5ml per lit and erecting pheromone traps, for BPH control formation of alleyways, Alternate wetting and drying + NSKE (neem seed kernel extract) sprays and water management. For control of diseases spraying of *Pseudomonas fluorescence* @ 10 g/lit in thrice during croppin period.

Table 2: Nutrients supplied through organic sources in organic farming.

Nutrient source	N	P	K
Dhaincha	30	18	22
FYM	50	20	30
Neemcake	18	05	08
Total	**98**	**43**	**60**

The package followed for conventional farming. Recommended dose of fertilizers i.e., **180-90-60** kg N-P-K per ha was applied. Nitrogen was applied through urea in three equal splits ($1/3^{rd}$ basal+1/ 3^{rd} at tillering+$1/3^{rd}$ at panicle initiation stage). Phosphorus was applied through SSP as basal and potassium as muriate of potash. Need based chemical management of pests and diseases was done.

Initial soil was analysed for physic chemical, chemical properties and presented in table.1. Data on yield attributes was collected during crop growth period and yield data was collected at the time of harvesting.

Microbial Analysis. The soil samples were collected after harvest of rice crop and the soil was thoroughly mixed to obtain a composite sample. The soil samples were collected in separate sterilized samples bottles. Each sample bottle was labelled properly and was taken to the laboratory for microbial analysis. The number of soil microorganisms was determined using the dilution spread plate technique. Nutrients agar (NA) and Potato Dextrose agar (PDA) were the culture media of choice used for bacteria and fungi. One milliliter aliquot of sample was pipetted into sterile test tube and serially diluted in another six set of test tubes each containing 9ml of sterile distilled water to dilution ratio10-6., 0.1 ml portion of the diluents from the fourth (10-4) and fifth (10-5) dilution factors were pipette separately aseptically into different sterile petridishes and 20 ml of the cool (45ºC) sterile molten agar media was added under aseptic condition, swirled gently for even distribution of the inoculums allowed to set and incubated at 30–37 ºC for 24 hours (for bacterial), and at 25–27 ºC for 72 hours for fungi and actinimycetes. At the end of incubation (24 hours) microbial colony were counted and recorded appropriately for bacteria while after 72 hours microbial colony were counted and recorded appropriately for fungi and actinomycetes.

Soil Enzyme Activities:

Dehydrogenase activity. One gram of soil sample was taken in 50 ml glass tube. Then 50 mg of $CaCO_3$ was added followed by 2.5 ml of distilled water and 1ml of 3% Triphenyltetrazolium chloride (TTC). Swirled for few minutes and incubated at 37^{0C} for 24 hours. The red precipitate of the Triphenylformazan (TPF) was dissolved in 10 ml of methanol and the contents were shaken for 30 minutes, the contents were filtered into 25 ml volumetric flask and the volume made upto 25 ml with methanol. Intensity of red colour was measured with spectrophotometer at 485 nm (Casida *et al*., 1964).

Urease activity: Urease activity in soil was assayed by quantifying the ratio of release of $NH^{4\ +}$ from the hydrolysis of urea (Tabatabai and Bremner, 1969). 5g of soil was taken in a 50 ml volumetric flask, after adding 0.2 ml of toluene and 9 ml THAM buffer, the flask was swirled for a few seconds to mix the contents and 1ml of 0.2M urea solution was added and swirled the flask again for a few seconds. Then the flask was stoppered and placed in an incubator at 37oC. After 2 hours, the stopper was removed, and approximately 35 ml of KCl-Ag_2SO_4 solution was added, swirled the flask for a few seconds, and allowed the flask to stand until the contents have cooled to room temperature (about 5 min). The contents were made to 50 ml by addition of KCl-Ag2SO4 solution, the flask was stoppered and inverted several times to mix the contents. $NH^{+\ 4}$ - N was determined in the resulting soil suspension, by pipetting out 20 ml aliquot of the suspension distilling with 0.2 g of MgO for 4 min. Controls were performed by following the procedure described for assay of urease activity, but for the addition of 1ml of 0.2M urea solution after the addition of KCl-Ag_2SO_4 solution.

Phosphotase activity : The procedure followed was of Tabatabai and Bremner (1969) for assay of acid phosphatases and Eivazi and Tabatabai (1977) for alkaline phosphatases. One gram of soil sample was taken in glass tube. Then 0.2 ml of toluene was added followed by 4 ml of MUB buffer pH 6.5 (for acid phosphatase), 4 ml MUB buffer pH 11.0 (for alkaline phosphatase) and 1 ml of p- nitro phenyl phosphate (only for samples) was added. Glass tubes swirled for few seconds, stoppered and incubated for 1 hour at 37^{0C}. After incubation, 1 ml of 0.5M $CaCl_2$ $2H_2O$ and 4 ml of 0.5M NaOH was added, swirled and filtered. The intensity of yellow color was measured with spectrophotometer at 420 nm. Controls were run simultaneously following the same procedure except adding 1ml of p-nitro phenyl phosphate (PNP) solution.

RESULTS AND DISCUSSION

Grain and Straw Yield. Yield attributing characters like tillers per sq.meter and panicles per sq. meter and filled grains per panicle were found to be high with conventional farming as compared with organic management system. The grain yield was higher with conventional farming (7490 kg/ha) than organic farming of rice (3845 kg/ha), Yields of rice was found to be low with organic farming during rabi season. This could be due to mismatch of nutrient release from organic sources and crop demand. Similar results were observed by Surekha *et al.,* (2012) indicating during rabi, inorganics were superior to organics for the first four years. This could be due to mismatch of nutrient release from organic sources and crop demand as influenced by seasonal conditions in the initial years and once the soil fertility was built up sufficiently, organic system also produced equal yields as conventional system. Thus, slow and gradual release of nutrients from organics during the initial years of conversion to organic farming could not result in increased yields. But, repeated application of organics over the years built up sufficient soil fertility by improving soil biological activity. A 20-30% less yields of crops in organic farming was reported by Rajendraprasad (2006). Significant reduction in rice yield when 50% chemical fertilizers were substituted with organics was also reported by Yadav *et al*., (2000). The recession in the crop yields during initial phase of transition from conventional to organic agriculture and recovery in yields after 2-3 years was reported by Sharma and Mohan Singh (2004). Yield loss of organically grown rice is reported to the tune of 24% (Mader *et al*., 2002), though organic farming system showed efficient resource utilization

Table 3: Effect of organic and conventional farming systems on rice grain and straw yield of rice.

	Rabi, 2016-17	
	Organic	**Conventional**
Tillers/m^2	276	491
Panicles/m^2	295	364
Filled grains/Panicle	128	182
1000 Grain wt (g)	19.98	21.04
Grain Yield (kg/ha)	3845	7490
Straw yield (Kg/ha)	5060	8910

Microbial Population. The data on the soil microbial population (bacteria, fungi and actinomycetes) has followed a trend of natural population i.e. predominance of bacteria followed by actinomycetes and fungi. Microbial population under organic farming system recorded highest population of bacteria (4.67 cfu × 10^6 g^{-1}), fungi (1.5 cfu × 10^4 g^{-1}) and actinomycetes (8.3 cfu × 10^5 g^{-1}) after rice, however conventional farming system recorded population of bacteria (6.5 cfu × 10^6 g^{-1}), fungi (1.47 cfu × 10^4 g^{-1}) and actinomycetes (8.5 cfu × 10^5 g^{-1}). The data indicated higher soil microbial population in treatments receiving organic manures compared to recommended dose of fertilizers. The increased microbial population under organic manure application mainly attributed to the higher organic carbon especially biologically active phase of carbon which acted as source of energy for microbes proliferating in soil as reported by Rajannan & Oblisami (1979).

Soil microbial communities play an important role in maintaining soil fertility and productivity because they not only regulate transformation processes of elements in soils but also control the build up and break down of organic matter and decomposition of organic residues (Mandal *et al.,* 2007). Microbial characteristics of soils, such as biomass, enzyme activity and diversity, are generally evaluated because of the clear relationships between these factors with soil quality and ecosystem sustainability (Doran and Parkin, 1994). Increased availability of substrates (C and N) required for microbial population build up could be the probable reason for this increase (Bunemann *et al.,* 2006). Higher microbial diversity in organically managed soils was reported by Rao (2005). These results on microbial population in present study are in close agreement with the earlier observations reported by Graham & Haynes (2005); Sanzano *et al.,* (2009). Liu *et al.,* (2017) reported significantly higher microbial population in organically managed plots as compared to the conventional practice.

Table 4: Effect of organic and conventional farming systems on soil microbial and enzyme activity.

Microbial Population	**Organic**	**Conventional**
Bacteria	4.67 × 10^6 CFU	6.5 × 10^6 CFU
Fungi	1.5 × 10^4 CFU	1.47 × 10^4 CFU
Actinomycetes	8.3 × 10^5 CFU	8.5 x 10^5 CFU
Enzyme activity:		
Dehydrogenase (ug TPF/ g soil/ hr)	1.54	3.54
Urease (ug NH_4^+/ g soil/ hr)	6.71	7.36
Acid Phosphatase (ug PNP/ g soil/ hr)	18.61	20.14
Alkaline Phosphatase (ug PNP/ g soil/ hr)	24.36	24.14

Soil Enzymes :

Dehydrogenase activity: Dehydrogenase enzyme activity was found to be higher under organic farming system as compared to conventional farming system. Dehydrogenase activity can serve as a good indicator of soil quality. Dehydrogenases, as respiratory chain enzymes, play a major role in the energy production by microorganisms in the soil (Boltan *et al.,* 2004). Incorporation of organic matter to the soil increased soil dehydrogenase activity (Singh *et al.,* 2007). The organic materials amended to soil serve as an electron donor in dehydrogenase process. The soil under continuous treatment of NPK+ organic manures inherited higher dehydrogenase activity than the soil under NPK treatment.

Urease Activity: Urease enzyme activity was found to be higher under organic farming system as compared to conventional farming system.

Phosphatase activity : Acid and Alkaline phosphatase enzyme activity was found to be higher under organic farming system as compared to conventional farming system. But the variation in both acid and alkaline phosphatase activity was low between organic and conventional systems . Phosphatase play key roles in phosphorus cycling, including degradation of phospholipids. Incorporation of organic matter to the soil increased phosphatase activity in the soil (Singh *et al.,* 2007).

Increase in enzyme activities (dehydrogenase, phosphatase and urease) has been reported to be higher in soils under organic management than under conventional management because the addition of organic amendments activates microorganisms to produce enzymes (Melero et al., 2008). Soil respiration rate, another important indicator of soil biological activity was also significantly higher with organics over inorganics. Addition of organic sources provide a stable supply of C and energy for micro-organisms and cause an increase in the microbial biomass pool, thereby increasing soil respiration rate. Several authors have also observed higher respiration rates in organically managed soils than in conventionally managed soils (Carpenter-Boggs *et al*., 2000) due to additional carbon inputs in organically managed soils. Favourable improvement in soil physical, fertility and biological properties was reported in many organic farming experiments (Carpenter Boggs *et al*., 2000).

CONCLUSION

The results revealed that, grain and straw yield of rice during rabi season was found to be low under organic farming system as compared to conventional farming system. Because, the crop requirement of nutrients during rabi season was high, it can not be supplemented through organic sources in a short time. Hence, continues application of organic manures may helps to improve yields in long time. The soil microbial population (bacteria, fungi and actinomycetes), soil enzyme activities *viz*., dehydrogenase, alkaline phosphatase and urease were found higher under organic farming followed by conventional farming system. Hence using easily available local natural resources, organic farming can be practiced with a view to protect/preserve/safe guard our own natural resources and environment for a fertile soil, healthy crop and quality food and let our future generations enjoy the benefits of non-chemical agriculture.

Field View

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