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SOIL HEALTH AND MICROBIAL DYNAMICS AS INFLUENCED BY ORGANIC COMPOST AND INORGANIC FERTILIZER IN RICE CULTIVATION UNDER CAUVERY DELTA REGION OF TAMIL NADU

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Abstract

Field experiments were conducted at Annamalai University, Experimental Farm, Annamalainagar, during Navarai season (January to April) 2016 and Kuruvai season (June to September) 2016 to study the Soil health and microbial dynamics as influenced by organic compost and inorganic fertilizer in rice cultivation under Cauvery delta region of Tamil Nude. The experiment comprised of ten treatments which includes control, recommend dose of nitrogen (RDN) alone and in combination with graded dose of nitrogen along with various organic manures namely sewage sludge compost, pressmud, FYM, water hyacinth compost and different sources of vermicompost. These were laid out in randomized block design and replicated thrice. The results revealed that, significant increase in microbial population of fungi, bacteria and actinomycetes were recorded in 50 % N through urea + 50% N through pressmud vermicompost over other treatments and control. Also the same treatment recorded at end of the experiment significantly registered higher soil organic carbon, soil available N, P_2O_5 and K_2O in rice crop. The least values were recorded in absolute control (no organic and chemical fertilizers). From the result of the field trials, it can be concluded that application of 50% N through urea + 50% N through pressmud vermicompost to rice crop was found to be an agronomically sound, ecologically safe and viable practice for augmenting higher productivity in rice and maintain soil health under tail end area of Cauvery deltaic zone of Tamil Nadu.

Key words: Organic Carbon, Post harvest soil available N, P_2O_5 and K_2O, Rice, Soil Microbial population,

Introduction

Rice (*Oryza sativa* L.) being the staple food for almost two thirds of the population plays a pivotal role in Indian economy. Over 2 billion people in Asia alone derive 80% of their energy needs from rice. India ranks first in the world in area of rice cultivation with 43.97 million ha and second in production with 104.32 million tonnes. The growth rate of world agricultural production and crop yields have slowed, raising fears that the world may not be able to grow enough food to meet the needs of future population. Use of faulty agricultural practices and higher depends on synthetic fertilizers may be the root cause of constant decline in factor productivity and low yield of crops. Declining trend in productivity due to continuous use of chemical fertilizers alone has been observed in several long term experiments all over India. It is however, difficult to meet the crop nutrient requirements with bulky organic manure alone and there is a need for integrated application of different sources of nutrients including vermicompost for sustaining the desired crop productivity (Ramesh. 2011). Nitrogen is universally deficient in almost all the agricultural soils and cropping systems of the world so, it is essential to use external nitrogen inputs (N fertilizers) to produce the crops for satisfying the ever increasing demands of human populations (Mohan *et al*., 2015). Soils containing a high microbial diversity are characteristic of a healthy soil-plant relationship, whereas those with low microbial diversity are characterized as an unhealthy soil that often hardly responds to environmental changes. The best remedy for soil fertility management is, therefore, a combination of both inorganic and organic fertilizers, where the inorganic fertilizer provides nutrients and the organic fertilizer mainly increases soil organic matter and improves soil structure

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and buffering capacity of the soil (Jobe 2003). Therefore fertilizers are to be integrated with organic sources to replenish the continuous removal of plant nutrients. In the present study, an effort was made to evaluate the effect of integration of Urea with Vermicompost and other organic manures, a component of integrated plant nutrition system, applied to rice during Navarai and Kuruvai season in Tamil Nadu.

Materials and methods

Field experiments were conducted at Experimental Farm, Annamalai University, Annamalainagar, during Navarai (January-April) 2016 and Kuruvai (June-September) 2016 to study the Soil health and microbial dynamics as influenced by organic compost and inorganic fertilizer in rice cultivation under Cauvery delta region of Tamil Nude. The experimental soil was deep clay, low in available soil nitrogen (193 kg ha^{-1}), medium in available soil phosphorus (21.3 kg ha^{-1}) and high in available soil potassium (274 kg ha^{-1}). The experiment was laid out in randomized block design and replicated thrice. The experiment comprised of ten treatments *viz.,* T_1-control (no fertilizer and no organic manure), T_2 - recommended dose of nitrogen (RDN), T_3-50 % N through urea + 50% N through sewage sludge compost, T_4-50 % N through urea + 50% N through pressmud, T_5-50 % N through urea + 50% N through FYM, T_6-50 % N through urea + 50% N through water hyacinth compost, T_7-50 % N through urea + 50% N through sewage sludge vermicompost, T_8-50 % N through urea + 50% N through pressmud vermicompost, T_9-50 % N through urea + 50% N through FYM vermicompost, T_{10}-50 % N through urea + 50% N through water hyacinth vermicompost. A fertilizer schedule of 120 kg N, 38 kg P_2O_5 and 38 kg K_2O ha^{-1} was applied. The earthworms used for composting was *Eisenia fetida* and vermicompost was prepared under heap method. After three months, matured vermicompost was applied to the experimental plots as per the treatment schedule. Twenty four days old paddy seedlings were planted with a spacing of 15 × 10 cm. Need based plant protection measures were taken up based on the economic threshold level of pest and diseases. All necessary management practices were carried out as per standard recommendation for rice crop. Five plants were selected from each plot at random. These five plants were harvested separately for post harvest observations. The grain yield was assessed at 14 % moisture level.

Soil analysis

Before commencement of the experiment, composite soil samples were collected from the Experimental field for analysis of physical and chemical characteristics. After the harvest of crop, soil samples were collected from each plot separately. The soil samples were air dried and sieved through 2 mm sieve and analysed for the following constituents.

Particulars	Author(s)	Method
Organic carbon	Walkley and Black (1934)	Chromic acid wet digestion method
Available N	Subbiah and Asija (1956)	Alkaline permanganate method
Available P	Olsen *et al.* (1954)	Colorimeter method
Available K	Stanford and English (1949)	Flame photometric method

Soil microbial Analysis

Soil samples were taken from individual plots at the end of experiments, dried and powdered. Soil water extract of respective treatments was cultured to assess the soil microbial population. For bacterial counts, the soil extract at a concentration of 10^{-5} and 10^{-6} was inoculated in Nutrient Glucose Agar medium and observed on 3rd day. For assessing the fungal population, the extract was inoculated at a concentration of 10^{-3} and 10^{-4} in Rose Bengal Agar medium and the counts were taken on 4th day. For actinomycetes, the soil water extract was inoculated in Kenknight's Agar medium at a concentration of 10^{-4} and 10^{-5} and count was taken on 11th day. The population of microorganisms was expressed in ten thousands. Fungi and actinomycetes were identified based on morphology. Bacteria were identified through Hewlett Packard microbial identification system. The data were analysed using standard procedures of ANOVA at 5 % level of significance.

Results and Discussion

Grain yield

Integration of 50% N through urea + 50% N through pressmud vermicompost (T_8) recorded significantly higher grain yield of 5.81and 5.98 t ha^{-1} (Table 1) than control (T_1) and 100% RDN (T_2) during first and second crop, respectively. This might be due to the fact that vermicompost offer a balanced nutritional release pattern to plants, providing nutrients such as available N, soluble K, exchangeable Ca, Mg and P that can be taken readily by plants (Edwards and Fletcher, 1988) and greater microbial diversity and activity resulting in higher grain capacity of soil. These results of the present study corroborate with earlier report of Urkurkar *et al*. (2010).

Available potassium

Higher amount post harvest soil available potassium

Table 1: Effect of different INM practices on organic carbon and post harvest available soil nutrients status in rice

Treatments	Grain yield (t ha^{-1})		Organic carbon		Available Nitrogen (kg ha^{-1})		Available Phosphorus (kg ha^{-1})		Available Potassium (kg ha^{-1})	
	First crop	Second crop	First crop	Second crop	First crop	Second crop	First crop	Second crop	First crop	Second crop
T_1	2.07	2.25	0.39	0.41	168.01	171.73	14.74	15.12	252.63	255.08
T_2	3.49	3.64	0.48	0.47	180.14	180.00	17.18	17.63	264.15	266.44
T_3	4.36	4.56	0.57	0.59	187.72	189.00	19.91	20.43	272.97	275.69
T_4	4.74	4.92	0.61	0.63	193.97	195.65	24.44	25.07	279.43	282.73
T_5	4.42	4.61	0.59	0.61	190.99	192.27	20.22	20.74	276.25	279.01
T_6	4.08	4.24	0.56	0.58	186.20	187.29	18.79	19.28	271.06	273.98
T_7	5.39	5.59	0.64	0.66	199.97	202.11	22.86	23.57	285.81	289.31
T_8	5.81	5.98	0.68	0.71	204.90	208.69	24.96	25.60	291.41	295.54
T_9	5.52	5.67	0.67	0.69	201.85	204.98	23.44	24.05	288.20	292.09
T_{10}	5.06	5.25	0.64	0.65	197.31	199.11	21.34	21.90	283.20	286.32
SEd	0.13	0.14	0.01	0.01	1.47	1.75	0.74	0.73	1.55	1.62
CD (p=0.05)	0.26	0.28	0.02	0.02	2.96	3.52	1.50	1.49	3.14	3.29

Treatment details : T_1- control (no fertilizer and no organic manure), T_2- recommended dose of nitrogen (RDN), T_3- 50 % N through urea + 50% N through sewage sludge compost, T_4 – 50 % N through urea + 50% N through pressmud, T_5 - 50 % N through urea + 50% N through FYM, T_6 – 50 % N through urea + 50% N through water hyacinth compost , T_7 – 50 % N through urea + 50% N through sewage sludge vermicompost, T_8 – 50 % N through urea + 50% N through pressmud vermicompost, T_9 – 50 % N through urea + 50% N through FYM vermicompost, T_{10} – 50 % N through urea + 50% N through water hyacinth vermicompost.

Table 2: Effect of INM practices on microbial population in post harvest rice soil

Treatments	*Fungal (CFU × 10^{-4} g^{-1}) population		*Bacterial (CFU ×10^{-6} g^{-1}) population		*Actinomycetes (CFU× 10^{-3} g^{-1}) population	
	First crop	Second crop	First crop	Second crop	First crop	Second crop
T_1	4.31	5.48	15.68	17.26	1.78	1.97
T_2	11.17	11.65	33.50	34.94	4.19	4.37
T_3	13.95	14.59	41.86	43.78	5.23	5.47
T_4	15.17	15.74	45.50	47.23	5.69	5.90
T_5	14.14	14.75	42.43	44.26	5.30	5.53
T_6	13.06	13.57	39.17	40.70	4.90	5.09
T_7	17.25	17.89	51.74	53.66	6.47	6.71
T_8	18.59	19.14	55.78	57.41	6.97	7.18
T_9	17.66	18.14	52.99	54.43	6.62	6.80
T_{10}	16.19	16.80	48.58	50.40	6.07	6.30

Treatment details : T_1- control (no fertilizer and no organic manure), T_2- recommended dose of nitrogen (RDN), T_3- 50 % N through urea + 50% N through sewage sludge compost, T_4 – 50 % N through urea + 50% N through pressmud, T_5 - 50 % N through urea + 50% N through FYM, T_6 – 50 % N through urea + 50% N through water hyacinth compost , T_7 – 50 % N through urea + 50% N through sewage sludge vermicompost, T_8 – 50 % N through urea + 50% N through pressmud vermicompost, T_9 – 50 % N through urea + 50% N through FYM vermicompost, T_{10} – 50 % N through urea + 50% N through water hyacinth vermicompost.

***Data was not statically not analysed**

production (Edwards, 2004). The next best order of ranking was 50% N through urea + 50% N through FYM vermicompost (T_9). The least yield was registered under T_1 (No fertilizer and no organic manure).

Post Harvest Soil Nutrient Status

Available Nitrogen

Application of organic compost enhanced the available soil N, P and K contents at the end of the experiments when compared to their initial status and over recommended dose of nitrogen alone and control. Among the different treatments, plots received with 50 % N through urea + 50% N through pressmud vermicompost (T_8), significantly recorded the highest post harvest soil available nitrogen of 204.90 and 208.69 kg ha^{-1} during first crop and second crop, respectively. Increase in available nitrogen might be due to interaction of nutrients with vermicompost which exerted beneficial effects in the release of ammoniacal and nitrate nitrogen. Addition of nitrogenous fertilizer along with vermicompost helps in narrowing down of C:N ratio and thus, increased mineralization resulted in rapid conversion of organically bound N to inorganic forms (Singh *et al.*, 2006).

Available phosphorus

Application of 50 % N through urea + 50% N through pressmud vermicompost (T_8), significantly recorded the highest post harvest soil available phosphorus of 24.96 and 25.60 kg ha^{-1} during first crop and second crop, respectively . This might be due to slow release nature of nutrients from organics. It has the capacity to form phospho–humic complex with anions replacement of the phosphate by humate ion and the coating of sesquioxide by humus to form a protective cover and thus reducing the phosphate fixing of 291.41 and 295.54 kg ha^{-1} during first crop and second crop, respectively was registered under plots received with 50 % N through urea + 50% N through pressmud vermicompost (T_8). Increase in available potassium due to addition of organic manures may be ascribed to the reduction of K-fixation and release of K due to interaction of organic matter with clays, besides the direct K addition to the soil. This is consistent with the views of Sharma and Sepehya (2014).

The lowest post harvest soil available nitrogen of 168.01 and 171.73, available phosphorus of 14.74 and 15.12 and potassium of 252.63 and 255.08 kg ha^{-1} during first crop and second crop, respectively was recorded in control (T_1).

Organic Carbon

INM treatments exerted significant influence on organic carbon content in soil over control. Plots received with 50 % N through urea + 50% N through pressmud vermicompost (T_8) significantly registered the highest organic carbon content of 0.68 and 0.71 per cent during first crop and second crop, respectively. Beneficial effect of integrated use of inorganic fertilizer and organic manures was related to the incorporation of organic material in the soil and increase in number and activity of microorganism and better regulation of organic carbon dynamics in soils. An increase in the soil organic matter leads to an improvement in the nutrient status of the soil. Similar observations have been made by Yaduwanshi *et al*. (2013). The lowest organic carbon content of 0.39 and 0.41 per cent during first crop and second crop, respectively registered under control.

Microbial Status

Before transplanting, initially the population of fungi, bacteria and actinomycetes were 6.0 CFU × 10^4 g^{-1}, 23.0 CFU × 10^6 g^{-1} and 3.4 CFU × 10^3 g^{-1} respectively.

The microbial population in the post harvest soil was affected by application of different sources of vermicompost. Among the INM treatments, 50 % N through urea + 50% N through pressmud vermicompost applied plots (T_8) registered higher microbial population of 55.78 and 57.41 of bacteria and 18.59 and 19.14 of fungi and 6.97 and 7.18 of actinomycetes during first crop and second crop, respectively. This might be due to gradual mineralization of organic matter, resulting in release of nutrients in optimum level of better proliferation of soil micro flora (Mahajan *et al.,* 2007). Integration of organics and chemical fertilizers resulted in maximum bacterial population than their alone application. The positive and significant relationship of organic carbon with micro-organism indicates that the increase in fungal population of soil may be due to high organic matter build-up with the regular addition of crop residue (Mahajan *et al.,* 2007). Cellulolytic micro-organism which degraded plant residues in soil, are known to encourage the proliferation of fungal population in soil. Similar observation has also been reported by Selvi *et al. (2005)*. The increased actinomycetes population due to application of inorganic fertilizer and organic manure might be due to manifesting the gradual exhaustion of assimilable organic nutrient from compost and crop residue by various soil micro-organism. The results of present findings are in agreement with the finding of Mahajan *et al.* (2007). The least count of bacteria (15.68 and 17.26), fungi (4.31 and 5.48) and actinomycetes (1.78 and 1.97) registered under control (T_1).

Conclusion

Based on two season study, it may be concluded that application of 50% N through urea + 50% N through pressmud vermicompost could be recommended to enhance the productivity, maintain and sustain the soil health in rice cultivation under Cauvery delta region of Tamil Nadu.

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