Available Online at http://www.recentscientific.com

ISSN: 0976-3031

International Journal of Recent Scientific Research
Vol. 7, Issue, 7, pp. 12349-12354, July, 2016

International Journal of Recent Scientific Research

Research Article

EFFECT OF ORGANIC MANURES INCORPORATION ON ELECTRO KINETIC PROPERTIES AND MICROBIAL DYNAMICS IN RICE SOIL

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ARTICLE INFO

Article History:

Received 05th March, 2016
Received in revised form 21st May, 2016
Accepted 06th June, 2016
Published online 28th July, 2016

Key Words:

C mineralization, CO_2 evolution, microbial population, enzyme activity, Organic manures

ABSTRACT

Incubation experiments were conducted to elucidate the impact of incorporation of organic manures on the electrokinetic properties and microbial dynamics under field capacity and flooded moisture regimes of rice soil. The treatment consisted of T_1 - Absolute control, T_2 - Recommended dose of fertilizers (RDF - 120/60/60 kg N, P_2O_5, K_2O ha^{-1}), T_3 - Farm yard manure @12.5t ha^{-1}, T_4- Vermicompost @ 5 t ha^{-1}, T_5- Green manures @ 6.25t ha^{-1} and T_6 - Pressmud @10 t ha^{-1}. The results revealed that incorporation of organic manures at all incubation periods, electro kinetic properties viz., pH, EC and carbon mineralization were higher under flooded condition. While carbon dioxide evolution, microbial population viz., bacteria, actinomycetes and fungus and dehydrogenase activity were higher under field capacity. Similarly, irrespective of treatments and moisture regimes, carbon mineralization, EC, pH, microbial population and dehydrogenase activity increased up to 60 DAI and then declined. But EC increased with incubation periods. With regard to organic manures, incorporation of FYM@12.5t ha^{-1} registered the highest CO_2 evolution (73.2, 81.6 mg 100 g soil), carbon mineralization (7.1,6.6 g kg^{-1}), bacterial population(21.1, 40.1 (X x 10^6efu g^{-1}), fungal population (17.8,27.6(X x10^3efu g^{-1}) , incorporation of green manures@ 6.25 t ha^{-1} registered the highest dehydrogenase activity (115.7, 125.9 (TPF g soil / 24 Hr) and actinomycetes population (14.8, 18.2 (X x 10^6efu g^{-1}) and incorporation of pressmud @ 10 t ha^{-1} recorded the highest pH(7.96, 7.79) and EC(1.86, 2.40 dSm^{-1}) in flooded and field capacity moisture regimes respectively

INTRODUCTION

It is important to recognize that the best soil and crop management practices is to achieve a more sustainable agriculture through enhanced growth, numbers and activities of beneficial soil microorganism that, in turn, increase, yield and quality of crops [14].Fertilization is an important agricultural measure that affects soil quality and sustainable utilization of soil. A considerable number of studies have focused on the effects of organic manures on soil physicochemical properties, such as SOC [15]. Soil carbon mineralization and CO_2 evolution have been paid great attention for its important effects on the global carbon cycle and terrestrial ecosystem functioning [16]. Paddy soils globally covered a total area of about 1.5 x 10^6 km^2, which accounts for about 22% of the global cropping area [17]. Microbial biomass is not only used as an indicator of soil quality, it is the main agent that also controls the cycling of important nutrient elements such as C, N, P, S and other nutrients in terrestrial ecosystems. The soil microbial biomass serves as a sink (immobilization) and a source (mineralization) of important nutrient elements, controlling the supply of nutrients to crops through mineralization and immobilization processes [11] depending on moisture, temperature and other environmental influences [22]. Dehydrogenase activity of soil as influenced by its physico-chemical characteristics and agricultural management practices provides correlative information on biological activity and microbial population in soil [34]. Dynamic characteristics such as microbial biomass, soil enzymes and soil respiration responds more quickly to changes in crop management practices and type of cultivation than physico-chemical properties of soils [24]. Dehydrogenase enzymes play a significant role in the biological oxidation of soil organic matter by transferring protons and electrons from substrate to accepters. The expected results by measuring soil biochemical and microbiological properties would provide strong evidence for improving the quality of rice soil

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MATERIALS AND METHODS

An incubation experiment was conducted to study the effect of incorporation of organic manures on electro kinetic and microbial dynamics in rice soil under flooded and field capacity moisture regimes. A bulk soil sample from a depth of 0 to 15 cm was collected from the experimental farm of Faculty of Agriculture, Annamalai University. After collection of the soil sample unwanted roots and debris were removed and dried in air for at least 3 days until a constant weight is achieved. After air drying the soil sample was screened by passing through 2 mm sieve**.** One kilogram of 2 mm sieved soil sample was filled in plastic containers of size 15 cm height and 22.5 cm diameter. The treatment consisted of T_1 **-** Absolute control, T_2 **-** Recommended dose of fertilizers (RDF - 120/60/60 kg N, P_2O_5, K_2O ha^{-1}), T_3 **-** Farm yard manure @12.5t ha^{-1}, T_4**-** Vermicompost @ 5 t ha^{-1}, T_5 **-** Green manures @ 6.25t ha^{-1} and T_6 **-** Pressmud @10 t ha^{-1}. A set of 18 containers (Total 36) were maintained separately to maintain the soil moisture at field capacity and flooded conditions. After allowing two days for equilibrium, the calculated quantities of fertilizers and organic manures were added as per treatments schedule, mixed well and one set was maintained at field capacity and another set in flooded condition for four months (120 days). The moisture level was maintained by adding water daily to compensate the loss due to evaporation. Soil samples were drawn at 15 days intervals. The soil samples in the containers were thoroughly mixed at the specific period and soil samples of 10 gm was drawn approximately from the incubation containers at 15 days interval (0, 15, 30, 45, 60, 75, 90, 105 and 120 DAI) and dried under shade. The dried samples were ground, mixed well and taken for analysis of soil organic carbon content as described by [36]. To study the CO_2 evolution, microbial population and dehydrogenase activity in soil hundred grams of 2 mm sieved soil samples were filled in 250 ml flat bottom conical flask. A set of 18 conical flasks (Total 18 x 8 + 18 x 8 =248) were maintained separately to maintain the soil moisture at field capacity and flooded conditions for each stage of analysis. The materials for each treatment combination as described in the previous incubation experiment were mixed on polythene sheet and transferred to a series of flat-bottomed flasks. The content of the flasks were brought to desired moisture conditions. Twenty ml of standard NaOH was taken in a 50 ml injection vial and hung in threads to trap the liberated carbon dioxide. The flasks were closed with cotton plugs air tightly and sealed. The flasks were incubated at room temperature. The CO_2 trapped in NaOH was determined at 15 days intervals (0, 15, 30, 45, 60, 75, 90, 105 and 120 DAI). On the days of observations, in the separate set of flask maintained, the alkali traps were removed and the flasks were kept open for 5 min to prevent complete anaerobic situations. The loss of carbon dioxide during this exposure time is ignored in all the treatments. After 5 min, another trap with 20 ml alkali was hung in another set of flask and sealed. To estimate the observed carbon dioxide, the alkali in the glass traps were treated with 0.5 g barium chloride and titrated against standard H_2SO_4 as per the procedure of [28] and expressed the result in mg l00g^{-1}. After the alkali traps were removed the soil samples were dried under shade. The dried samples were ground, mixed well and subjected for analysis of soil pH, EC, organic carbon, microbial population (Bacterial, fungal and actinomycetes) and enzyme dehydrogenase activity following the standard procedures.

RESULTS

The perusal of data furnished in the Table 1 and Fig 1 to 4 clearly demonstrated the significant effect of different organic manures addition on carbon mineralization, soil pH, soil EC and carbon dioxide evolution over control during incubation periods of 120 days.

Table 1 Effect of organic manures incorporation on carbon mineralization, electro kinetic properties and CO_2 evolution

Treatments	Carbon mineralization (g kg^{-1})		Soil pH		Soil EC (dSm^{-1})		CO_2 evolution (mg100^{-g} g)	
	M1	M2	M1	M2	M1	M2	M1	M2
T_1	6.2	5.7	7.83	7.60	1.70	2.52	65.6	69.5
T_2	6.2	5.8	7.87	7.64	1.86	2.60	67.2	72.3
T_3	7.1	6.6	7.89	7.69	1.72	2.25	73.2	81.6
T_4	6.5	6.1	7.91	7.71	1.76	2.31	69.3	75.6
T_5	6.5	6.0	7.93	7.75	1.80	2.36	74.7	84.9
T_6	6.8	6.3	7.96	7.79	1.86	2.40	70.9	78.3
SE_d	0.32	0.28	0.009	0.010	0.023	0.038	0.76	0.84
CD(p=.05)	0.74	0.56	0.019	0.021	0.046	0.076	1.52	1.70

M1- Flooded, M2- Field capacity
T_1- Absolute control;T_2- RDF;T_3- FYM @12.5 t ha^{-1};T_4- Vermicompost @ 5 t ha^{-1}; T_5- Green manuring @ 6.25 t ha^{-1};T_6- Pressmud @10 t ha^{-1}

Treatments	Bacteria (X x 10^6 cfu g^{-1})		Fungus (X x 10^3 cfu g^{-1})		Actinomycetes (X x 10^5 cfu g^{-1})		Dehydrogenase activity (µg TPF/g soil/24hr)	
	M1	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**
T_1	15.0	34.0	14.0	24.0	12.0	14.3	74.8	79.8
T_2	16.3	35.1	15.1	24.8	12.7	15.0	89.6	95.6
T3	21.1	40.1	17.8	27.6	14.0	17.0	107.2	114.3
T_4	17.8	36.1	16.1	26.0	13.0	15.6	97.9	104.4
T_5	26.2	45.0	18.3	28.2	14.8	18.2	115.7	125.9
T_6	19.2	38.2	17.1	26.9	13.7	16.1	101.7	109.2
SE_d	0.95	1.11	0.42	0.36	0.95	0.62	3.84	2.65
CD(p=.05)	1.91	2.22	0.84	0.72	1.91	1.26	8.92	5.33

M1- Flooded, M2- Field capacity
T1- Absolute control;T2- RDF;T3- FYM @12.5 t ha-1;T4- Vermicompost @ 5 t ha-1; T5- Green manuring @ 6.25 t ha-1;T6- Pressmud @10 t ha-1

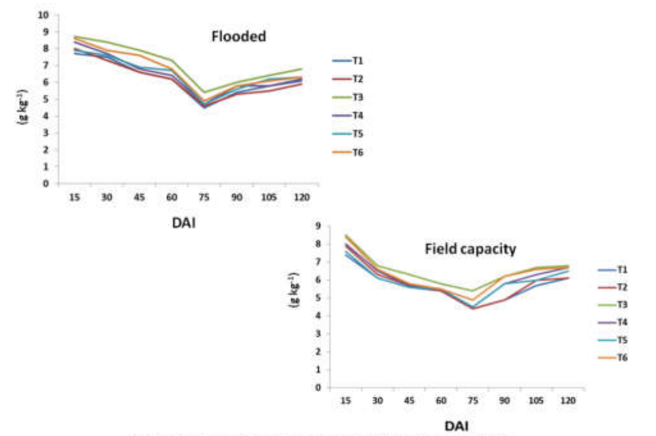

Fig 1. Fluctuation in carbon mineralization due to treatments

Irrespective of treatments and moisture regimes, carbon mineralization progressively decreased up to 60 DAI and then slightly increased up to 120 DAI. Further, at all incubation periods and irrespective of treatments, carbon mineralization was higher under flooded condition compared to field capacity.

Among treatments, incorporation of FYM @12.5 t ha^{-1} registered the highest carbon mineralization 7.1 and 6.6 g kg^{-1} at flooded and field capacity respectively.

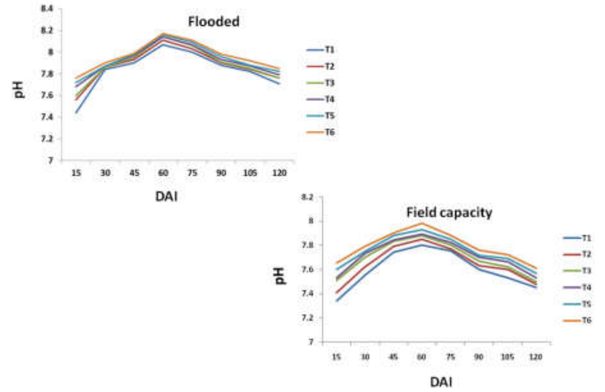

Fig 2. Fluctuation in soil pH due to treatments

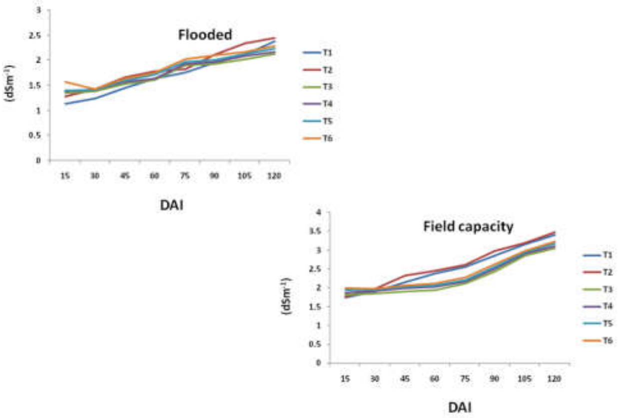

Fig 3. Fluctuation in soil EC due to treatments

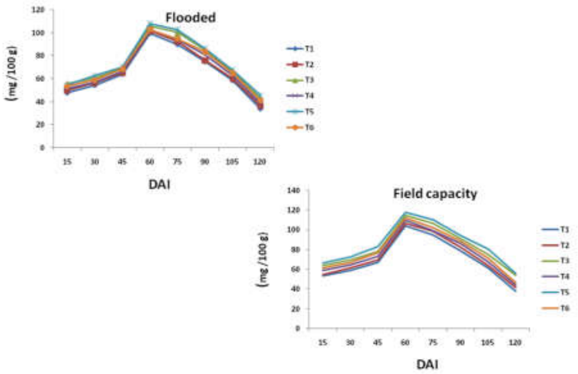

Fig 4. Fluctuation in soil CO_2 evolution due to treatments

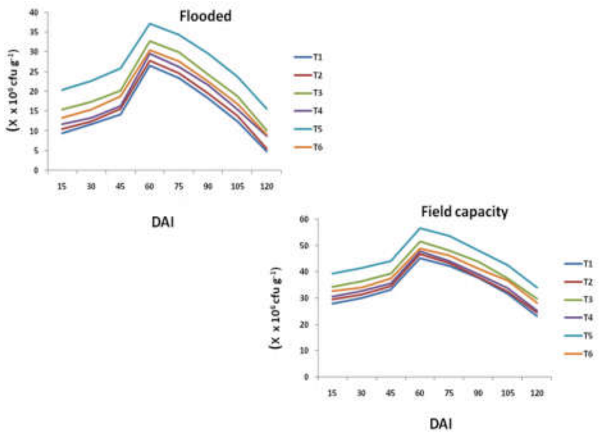

Fig 5. Fluctuation in bacterial population due to treatments

Soil pH progressively increased up to 60 DAI and then declined up to 120 DAI irrespective of moisture regimes and treatments. Similarly, at all treatments and incubation periods, soil pH was higher under flooded condition compared to field capacity. The highest soil pH was noticed with incorporation of pressmud @ 10 t ha^{-1} 7.96 and 7.79 at flooded and field capacity respectively.

Irrespective of treatments and moisture regimes, soil EC content increased up to 120 DAI 2.27 dS m^{-1}; 3.24 dS m^{-1} field capacity and flooded respectively. With respect to moisture regime the soil EC was higher under field capacity compared to flooded condition. Irrespective of moisture regimes and incubation periods, addition of RDF alone recorded highest soil EC 1.86 dSm^{-1} in flooded condition and 2.60 dS m^{-1} in field capacity and was comparable with organics and superior to control.

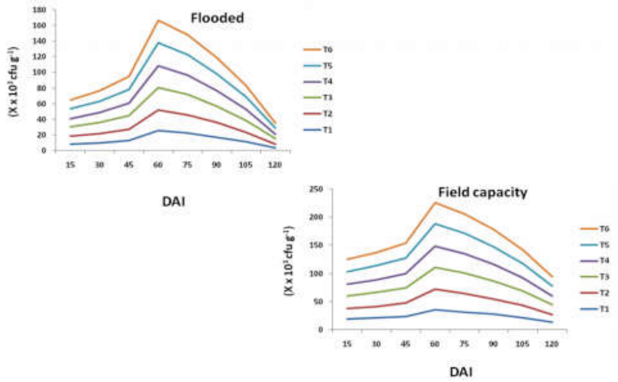

Fig 6. Fluctuation in fungal population due to treatments

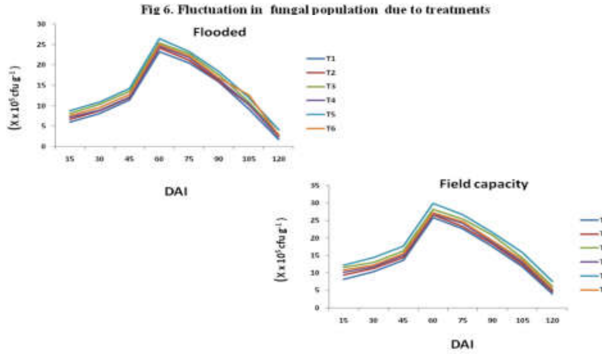

Fig 7. Fluctuation in actinomycetes population due to treatments

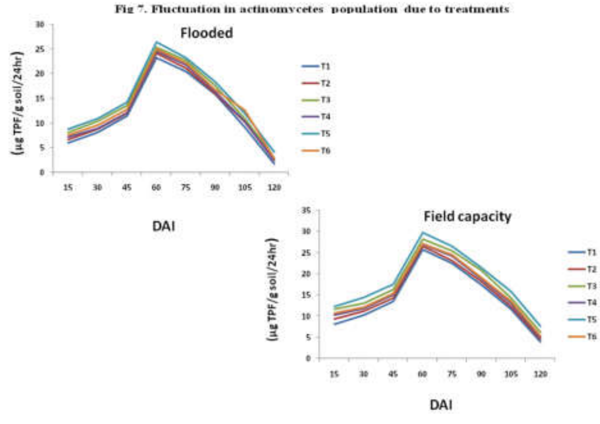

Fig 8. Fluctuation in dehydrogenase activity due to treatments

Irrespective of treatments and moisture regimes, soil CO_2evolution increased up to 60 DAI and declined thereafter up to 120 days. With respect to moisture regime the soil CO_2 evolution was less under flooded and field condition (70.16 mg

100^{-1}) compared to field capacity (77.03 mg 100^{-1}). Irrespective of moisture regime and incubation periods, incorporation of green manure @ 6.25 t ha^{-1} recorded highest soil CO_2 evolution of 74.7 mg 100^{-1} in flooded condition and 84.9 mg/100 in field capacity and was comparable with organics and superior to control.

Addition of different organic manures under different moisture regimes brought out significant changes in microbial activity in terms of microbial population and dehydrogenase activity over control (Table 2 and Fig 5 to 8)

Irrespective of treatments and moisture regimes, soil bacterial population increased upto 60 DAI (30.5 x 10^6 cfu g^{-1}, 49.5 x 10^6cfu g^{-1}) and declined thereafter upto 120 days. With respect to moisture regime, the soil bacterial population was higher under field capacity (30.08 x 10^6cfu g^{-1}) compared to flooded condition (19.27 x 10^6cfu g^{-1}). Irrespective moisture regime and incubation periods, incorporation of green manure@6.25 t ha^{-1} recorded the highest soil bacterial population of 26.2 x 10^6 cfu g^{-1} in flooded condition and 45.0 x 10^6cfu g^{-1} in field capacity and was comparable with other organics and superior to RDF and absolute control.

Irrespective of treatments and moisture regimes soil fungal population increased upto 60 DAI (27.8 x 10^3cfu g^{-1}, 37.7 x 10^3cfu g^{-1}) and declined thereafter upto 120 days. With respect to moisture regime, the soil fungal population was higher in field capacity (26.25 x 10^3cfu g^{-1}) compared to flooded condition (16.4 x 10^3cfu g^{-1}). Irrespective moisture regimes and incubation periods, soil amended with green manure @ 6.25 t ha^{-1} recorded the highest soil fungal population of 18.3 x 10^3cfu g^{-1} in flooded condition and 28.2 x 10^3cfu g^{-1} in field capacity and was comparable with other organics and superior to RDF and absolute control.

Irrespective of treatment and moisture regimes soil actinomycetes population increased upto 60 DAI (24.8 x 10^4cfu g^{-1}, 27.4 x 10^3cfu g^{-1}) and declined thereafter upto 120 days. With respect to moisture regime, the soil actinomycetes population was higher in field capacity (16.03 x 10^4cfu g^{-1}) compared to flooded condition (13.7 x 10^4cfu g^{-1}). Irrespective moisture regime and incubation periods, soil amended with green manure @ 6.25 t ha^{-1} recorded the highest soil actinomycetes population of 14.8 x 10^4cfu g^{-1} in flooded condition and 18.2 x 10^4cfu g^{-1} in field capacity and was comparable with other organics and superior to RDF and absolute control.

Irrespective of treatments and moisture regimes, soil dehydrogenase activity increased upto 60 DAI (150.0 µg TPF/g soil/24 hr, 157.0 µg TPF/g soil 24/hr) and declined thereafter upto 120 days. With respect to moisture regime, the soil dehydrogenase activity was higher in field capacity (104.87 µg TPF/g soil 24/hr) compared to flooded condition (97.81 µg TPF/g soil 24/hr). Irrespective moisture regime and incubation period, soil amended with green manure @ 6.25 t ha^{-1} recorded the highest soil dehydrogenase Activity of115.7 µg TPF/g soil/24 hr, in flooded condition and 125.9 µg TPF/g soil/24 hr, in field capacity and was comparable with over organics and superior to RDF and absolute control

DISCUSSION

Mineralization of soil organic carbon play a vital role in supplying nutrient elements essentials to plant growth, in providing long-term carbon sequestration and the nutrients required for ecosystem productivity [38] and is a key indicator of soil functional capacity [25]. Carbon mineralization is generally determined by monitoring CO_2 fluxes from field moist samples that are wetted to roughly 50% of field capacity and subsequently incubated in the laboratory for various periods of time [13].The losses of soil organic matter can only be replenished in short time by application of organic matter such as manure [12]. [23] also found that inorganic fertilizer and organic materials can increase the SOC content of soil. In our present study on flooded conditions, among organic manure amended treatments, FYM @ 12.5 t ha^{-1} recorded the maximum SOC content followed by other organic amendments. The same treatment was also recorded maximum SOC in field condition. The most of soil organic matter (SOM) models assume a linear increase in SOC levels with increasing C input [38].[21] observed and suggested that SOC stock of the profile was also significantly ($p<0.05$) higher in the organic manure treatments (FYM, NP+FYM and NP+S) compared to inorganic fertilizer (N, NP) and control treatments. [31] also investigated by studying the carbon mineralization in soil under laboratory incubation. The kinetic parameters also differed significantly and the highest mineralization rate constant was observed in decomposed neem cake and the lowest in vermicompost.

The initial increase in soil pH by pressmud @ 10 t ha^{-1} in the present study can primarily be attributed to high pH of pressmud @ 10 t ha^{-1} (7.76 in flooded condition and 7.65 in field capacity). It may also partly be explained by proton (H^+) exchange between soil and the added manure [35].The increase in soil pH due to application of organic amendments in this study is consistent with results reported by several workers [26]. The principal mechanisms involved in increasing soil pH by various types of organic amendments differ considerably. [27] investigated the application of FYM and the tithonia either alone or in combination with three organic P sources and it increased the pH level of soil. [3] reported that soil pH of cattle and goat manures are significantly greater than that of poultry manure treatments.

Organic amendments generally increase soil Electrical conductivity (EC). In the present study, among organic amendments, FYM @ 12.5 t ha^{-1} treatment in both flooded and field conditions gradually increased with incubation time significantly and the magnitude of increase was higher than the other organic amendmened soil. The similar work reported by [30]. Electrical conductivity (EC) can serve as a measure of soluble nutrients for both cations and anions. Soil EC indicates mineralization of organic matter in soil and serves as a measure of soluble nutrients [7]. [8] observed increased electrical conductivity with increasing rates of chicken manures. [2] found that electrical conductivity of soil significantly increased with the application of poultry, cattle and goat manures and the potential manure induced soil salinization was very high in poultry manure and goat manures compared with cattle manure.

Climate change due to global warming has become an important national concern. A dramatic evidence of global warming is the emission of green house gases from various agricultural practices of which carbon dioxide (CO_2) is the chief component where it is sequestered by green plants in the process of photosynthesis and the same is by all living organisms. The present study revealed that CO_2 evolution was significantly influenced by organic amendments as well as moisture regimes. Among organic amendments, maximum evolution of CO_2 was noticed from the soil treated with green manure @ 12.5 t ha^{-1} followed by pressmud and vermicompost in both flooded condition and field capacity. The similar finding was reported by [31]. The magnitude of decomposition of different organic manure influence the rate of decomposition as reported by several workers [9]. CO_2 evolution resulting from degradation of organic materials is a good indicator to measure the organic compound decomposition rate and also is a good index to determine the nutrient release pattern and the optimum time for organic matter application [1]. Also predicting carbon mineralization of residues return to soil is important for forecasting carbon dioxide (CO_2) emissions into the atmosphere [20].

Soil microorganisms play a vital role in soil environment. They are critical factors that determine soil organic matter decomposition, nutrients cycling, soil degradation and bioremediations of soil pollution [19]. Shifts in the structure and composition of microbial community are strong indicators of soil biological activity, soil quality and crop productivity of terrestrial agro-systems [10].Soil microorganisms maintain soil health which inturn influences crop management practices and input use required for proper plant growth and development. Soil organisms are also very important in organic farming as an index of soil health. Long-term chemical fertilizer application without organic matter amendment could result into the deterioration of soil health and quality [6].

The initial increase is due to moistening of soil which activates the microorganisms and supply of amendment nutrients from organics stimulate the growth and activity of microorganisms [37]. The present study, revealed that the bacterial, fungal and actinomycetes populations were significantly influenced by organic amendments as well as moisture regimes at all sampling periods. In both flooded condition and field capacity, among organic manure amended treatments, soil amended with green manure @ 6.25 t ha^{-1} (T_5) recorded maximum bacterial population of 37.2 x 10^5cfu g^{-1} and 56.6 x 10^5cfu g^{-1}, fungal population of 29.8 x 10^4cfu g^{-1} and 39.4 x 10^5cfu g^{-1} and the actinomycetes population of 26.4 x 10^5cfu g^{-1} and 29.8 x 10^5cfu g^{-1} at 60 days of incubation period. Similar findings were reported by [33].

Soil enzymes play a vital role in the cycling of nutrients in nature and soil enzyme activity can be used as an index of soil microbial activity and fertility [4]. [32] reported favorable effect of organics on the activity of dehydrogenase in soil and it was more pronounced due to combined application of organics along with NPK fertilizers which was attributed to increased mineralization of nutrients from microbial decomposition of organic matter. The result is in conformity with the findings of [29].The increase in soil enzyme activities with the fall in microbial biomass count suggested that the release of enzymes was associated with analysis of microbial cells at the end of their life cycle [5].

In both flooded condition and field capacity, among organic manure amended treatments, soil amended with green manure @ 6.25 t ha^{-1} (T_5) recorded the maximum dehydrogenase activity of 180.9 µg TPF/g soil/24 hr and 188.9 µg TPF/g soil/24 hr at 60 days of incubation period. [18] reported that the farm yard manure amended soil showed the greatest enzyme activity followed by vermicompost.

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How to cite this article:

Selva Anbarasu S *et al*.2016, Effect of Organic Manures Incorporation on Electro Kinetic Properties And Microbial Dynamics in Rice Soil. *Int J Recent Sci Res.* 7(7), pp. 12349-12354.