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Effect of FYM and Inorganic Fertilizer on Soil Microbial Biomass and Enzyme Activities of Indo Gangetic Plains, Varanasi, India

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A B S T R A C T

A field experiment was conducted during *kharif* season 2015 in alluvial soil at farmer field, in village Loharapur, Varanasi, to study the soil microbial biomass, dynamics and selected enzyme activities as influenced by farm yard manure and inorganic fertilizer. The soil microbial biomass carbon; nitrogen and phosphorous was improved significantly with the different treatments. Highest soil biomass carbons, nitrogen, phosphorous were recorded with the combined application of inorganic nutrients and farm yard manure (T_7) over the remaining other treatments. The highest soil biomass were recorded in treatment T_7 and lowest in T_1. Maximum soil enzymatic activity such as urease 227.38µg UH g^{-1} soil h^{-1}, dehydrogenase 175.12µg TPF g^{-1} soil/day and phosphatase 112.25ìg p-NP g^{-1} soil/h were observed with T_7 (NPK+2 t ha^{-1}). Enzymatic activities were positively and significantly correlated with content of organic carbon. As a consequence application of NPK and FYM combination was more effective on increasing rice productivity targeted to 40 q/ha and 50 q/ha and soil nutrient status than single application of FYM or chemical fertilizer.

Introduction

India has to produce 300 Mt of food grains by 2020 to feed growing population. The net cultivated land (142.5 M ha) is limited and pressure for production of food grains is increasing, therefore, maintenance of soil fertility is a prime issue for farmers (Jatav *et al.,* 2016). The role that microbial activity plays in ecosystem processes is significant because approximately 80% to 90% of soil processes are mediated by microorganisms (Nannipieri and Badalucco, 2003). Soil microbial population are the driving force behind regulating soil processes such as organic matter decomposition and nutrient cycling, it is imperative to have a better understanding of the factors that regulate its size, activity, and structure (Masto *et al.,* 2006). 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 (Tejada *et al.,* 2011). Soil enzymatic activities can be used as an index of soil fertility and microbial functional diversity (Nannipieri *et al.,* 2002; Maurya *et al.,* 2011) in catalyzing several biochemical reactions which are necessary for the life processes of soil micro-organisms, organic wastes decomposition, organic matter

formation and nutrients cycling (Tabatabai, 1994). The microbial population dynamics is governed by interactions between plant type, climate, and management practices. In addition, the soil microbial biomass in soil system responds more quickly to management practices than OM and is often used as an indicator of soil quality and health (Ge *et al.,* 2010). The addition of organic manure greatly influences the microbial populations which expected to cause changes in microbial dynamics of soil (DeForest *et al.,* 2012). The microbiological and biochemical conditions of a soil can serve as a marker of the soil status and is closely linked to its natural soil fertility. Addition of the organic fraction stimulates the natural soil micro organisms and reactivates the biogeochemical cycles (Watts *et al.,* 2010). Urease and phosphatase are two important enzymes involved in the N and P cycles, respectively (Badiane *et al.,* 2001). The increase in soil organic matter with the application of inorganic fertilizers is because of greater input of root biomass due to better crop growth (Goyal *et al.,* 1992). It has been seen that FYM along with recommended dose of fertilizer increases soil enzymatic activity which is indication of effect of FYM in combination with inorganic fertilizer on soil biological activity (Saha *et al.,* 2008). Organic source as FYM enrich soil organic matter and inorganic fertilizer have priming effect on native soil organic matter (Marinari *et al.,* 2000), thus both have role in increasing soil biological activity. Plassart *et al.,* (2008) microbial activities depend upon the substrate availability in soil. Soil microbial biomass is an important ecological indicator and acts as a source and sink of available nutrient for plant growth. It is supposed to be an integral part of decomposer subsystem. Soil microorganisms play a crucial role in ecosystem functions such as organic matter decomposition, nutrient cycling, transformation, mineralization etc. It also provides information regarding the organic matter decomposition, nutrient cycling, soil fertility restoration and development of ecosystem function in tropical abandoned agro ecosystems. Little change in soil microbial biomass affects directly on ecosystem stability and fertility of soil. Therefore microbiological status is considered as a suitable indicator of soil health during restoration process of degraded agro ecosystems. It has been possible to sense the pace and progress of soil restoration following degradation through the assessment of microbial biomass pool (Harris, 2003). The objective of this study was to evaluate the microbial dynamics as influenced by concentrate organic manure and inorganic fertilizer in alluvium soil.

Materials and Methods

A field experiments were conducted in participatory mode in Loharapur village of Varanasi district in *kharif* season in year 2015. The experimental crop rice was chosen as test crop *variety* HUR-105 and was transplanted during 2nd fortnight of July 2015, in alluvial soils, nearly neutral to alkaline in reaction with low soluble salts (0.21 dS m^{-1}), low in organic carbon (0.49%) and available nitrogen (180 kg ha^{-1}), medium in available phosphorus (13 kg ha^{-1}) and available potassium was (160 kg ha^{-1}). The soil was puddled at desirable field condition and followed by planking. Nitrogen (N), Phosphorus (P) and Potassium (K) were applied in the form of urea, diammonium phosphatase (DAP) and muriate of potash (MOP) respectively. The total calculated quantity of fertilizers phosphorus, potassium and one third quantity of the N were side dressed at the time of transplanting, while the remaining N was top dressed in two equal splits at tillers initiation and pre-flowering stages respectively. Soil samples were collected from the experimental field and analyze for physico-chemical and biological

properties. The physico- chemical properties of initial soil is presented in table 1.

Experimental design and treatments

The field experiment was laid out in a randomized block design (RBD) with three replications having a plot size of 4 x 5 m^2 experiment consisted seven treatments of different levels of recommended dose of fertilizers .After harvest of rice, soil samples were taken from the surface layer (0-15) of seven treatments and three replications. The details of treatments were

- T_1: control - NPK at 0:0:0 kg ha^{-1}
- T_2: Farmer's practice - NPK at 100:40:40 kg ha^{-1}
- T_3: General recommended dose (GRD) at 120:60:60 NPK kg ha^{-1}
- T_4: NPK application based on soil test crop response (NPK at 100:46:60 kg ha^{-1})
- T_5: NPK application based on soil test crop response (NPK at 146:61:89 kg ha^{-1})
- T_6: NPK application based on soil test crop response (NPK-96-45-58 kg ha^{-1} and 2 t FYM)
- T_7: NPK application based on soil test crop response (NPK-141-60-86 kg ha^{-1} and 2 t FYM)

The equation used for calculating NPK recommended dose for target yield developed by Singh *et al.*, 2011 for *alluvial* soils of Varanasi region, on the basis of soil test value.

Based on this value, the fertilizer doses for different treatments were calculated for fertilizer recommendation. Soil test based recommendation for yield target by utilizing the following fertilizer adjustment equation.

- Nitrogen dose (kg ha^{-1}) = $4.76T_1$-0.49SN-0.34FYM-N.....(1)
- Phosphorus dose (kg ha^{-1}) = $1.53T_2$-1.41SP-0.09FYM-P.....(2)
- Potassium dose (kg ha^{-1}) = $2.92T_3$-0.35K-0.11FYM-K.....(3)

Where;

T_1 = Yield target (q ha^{-1}) SN+ Alkaline $KMnO_4$-N

SN= Initial test value of nitrogen

FYM = Farm Yard Manure

T_2 = Yield target (q ha^{-1}) SP + Olsen's P (kg ha^{-1})

Olsen's P = Initial soil test value of Phosphorus

T_3 = Yield target (q ha^{-1}) SK + Amm. Ac.- K (kg ha^{-1})

NH_4OAc.-K = Initial soil test value of Potassium

Soil sampling

Initial soil samples were collected in month of June prior to the start of the experiment. After final harvest of rice, soil samples were taken from the surface layer (0-15 cm) of seven treatments with three replications, soil sampling was done after the harvest of rice crop in November, 2015. The microbial analysis soil samples were kept at 4 ^oC in

plastic bags for a few days to stabilize the microbiological activity disturbed during soil sampling and handling and then analysed. The soil biomass activity by fumigation method (Edwards and Bremner, 1967) and dehydrogenase and urease activities by colorimeter method (Tabatabai, 1982) and alkaline phosphatase activity measured by Tabatabai and Bremner (1986) method.

Data analysis

Data was analysed statistically according to Fisher's analysis of variance technique (Steel *et al.*, 1997) and critical difference (CD) at 5% probability level was applied to compare the treatments means.

Results and Discussion

SMBC

The data given in table 2 dealt with the available biomass carbon, determined by chloroform extraction fumigation method of the experimental field ranged between 140.60 and 230.70 µg g^{-1} in the experimental field. The minimum (140.60 µg g^{-1}) biomass carbon was recorded in control plot T_1 whereas maximum in treatment T_7, it was recorded (230.70 µg g^{-1}).

SMBN and SMBP

The available biomass phosphorous, determined by chloroform extraction fumigation method of the experimental field ranged between 12.10 and 21.40 µg g^{-1} in the experimental field of the farmer. The minimum (12.10 µg g^{-1}) biomass phosphorous was recorded in control plot T_1 whereas in treatment T_7, it was maximum (21.40 µg g^{-1}). The available biomass nitrogen, determined by chloroform extraction fumigation method of the experimental field ranged between 24.27 and 56.68 µg g^{-1} in the experimental field. The minimum (24.27 µg g^{-1}) biomass nitrogen was recorded in control whereas in treatment T_7, it was 56.68 µg g^{-1}. Soil enzyme activity is an indirect indication on the activities of microbial biomass which is directly correlated with soil microbial dynamics.

Urease activity

Enzyme activity in the soil environment is considered to be a major contributor of overall soil microbial activity (Table 3). Urease enzyme activity is determined by colorimeter method. The experimental field ranged between 184.07 and 227.38 µg g^{-1} soil h^{-1} in the experiment of farmer field. The minimum (184.07 µg g^{-1} soil h^{-1}) Urease enzyme activity was recorded in control plot whereas in treatment T_7, it was recorded maximum (227.38 µg g^{-1} soil h^{-1}).

Dehydrogenase activity

Dehydrogenase enzyme activity is determined by colorimeter method. The experimental field ranged between 124.0 and 175.12 µg $TPFg^{-1}$ soil h^{-1} in the experiment of farmer field. The minimum (124.0 µg TPFg $^{-1}$ soil h^{-}) Dehydrogenase enzyme activity was recorded in control plot T_1 whereas in treatment T_7, it was recorded maximum (175.12 µg $TPFg^{-1}$ soil h^{-1}).

Alkaline phosphatase

Alkaline phosphatase enzyme activity is determined by Colorimetric method. The experimental field ranged between 45.63 and 112.25 µg p-nitrophenol g $^{-1}$ soil h^{-1} in the experiment of farmer field. The minimum (45.63 µg p-nitrophenol g $^{-1}$ soil h^{-1}) alkaline phosphatase activity was recorded in control whereas in treatment T_7, it was 112.25 µg p-nitrophenol g $^{-1}$ soil h^{-1}.

Soil is living body and hence their nourishment is essential to full fill their nutrients requirement as macro as well as micro (Jatav *et al.*, 2016). The biological properties is integral part of soil health hence soil health can't be overlooked. Soil microbial dynamics significantly contribute to soil health; the enzymatic activities were significantly influenced by the crop growth stages (Mandal *et al.*, 2007; Marinari *et al.*, 2000). The treatment T_7: (NPK application based on soil test crop response NPK-141-60-86 kg ha^{-1} and 2 t FYM) reported as ideal in SMBC; SMBP; and SMBN followed by T_5 (NPK application based on soil test crop response NPK at 146:61:89 kg ha^{-1}). The biological properties performance was poor in case of control plot that is T_1. The enzyme activities were found superior in case of treatment T_7: (NPK application based on soil test crop response NPK-141-60-86 kg ha^{-1} and 2 t FYM) followed by T_5 (NPK application based on soil test crop response NPK at 146:61:89 kg ha^{-1}).

Table.1 Initial soil bio-chemical properties of experimental site (Depth 0-15 cm)

Properties	**Content**
pH (soil: water, 1:2.5)	8.2
EC (dS m^{-1})	0.21
Organic C (g kg^{-1} soil)	0.49
Available N (kg ha^{-1} in soil)	180
Available P (kg ha^{-1} in soil)	13
Available K (kg ha^{-1} in soil)	160
Soil Biomass Carbon (µg g^{-1})	138
Soil Biomass Phosphorus (µg g^{-1})	10
Soil Biomass Nitrogen (µg g^{-1})	21
DHA (ìg TPF g^{-1} soil day^{-1})	120
UH (ìg UH g^{-1} Soil h^{-1})	182
APA (µg PNP g^{-1} soil h^{-1})	42

Table.2 Soil microbial biomass activities in post harvest soil

Treatments	Soil Biomass- C (µg g^{-1})		Soil Biomass- P (µg g^{-1})		Soil Biomass- N (µg g^{-1})	
	BT	AT	BT	AH	BT	AH
T_1	138	140.60	10	12.10	21	24.27
T_2	138	168.90	10	14.83	21	32.45
T_3	138	182.07	10	15.97	21	39.33
T_4	138	199.97	10	16.33	21	43.00
T_5	138	225.92	10	18.10	21	51.87
T_6	138	209.77	10	16.43	21	46.63
T_7	138	230.70	10	21.40	21	56.68
CD at 5%	NS	2.23	NS	1.82	NS	0.52

BT- Before Transplanting, AH – After Crop Harvest, And NS- Non Significant

Table.3 Soil enzyme activities in post harvest soil

Treatments	Urease Activity (µg g-^{1} soil hr-^{1})		Dehydrogenase activity (µg TPF g^{-1} soil h^{-1})		Alkaline Phosphatase activity (µg p- nitrophenol g^{-1} soil h^{-1})	
	BT	AH	BT	AH	BT	AH
T_1	183	184.07	122	124.00	44.0	45.63
T_2	183	193.67	122	138.10	44.0	64.95
T_3	183	201.12	122	143.40	44.0	75.98
T_4	183	206.31	122	153.33	44.0	83.35
T_5	183	219.67	122	159.65	44.0	99.98
T_6	183	214.33	122	164.69	44.0	88.64
T_7	183	227.38	122	175.12	44.0	112.25
CD at 5%	NS	7.34	NS	10.13	NS	0.85

BT-Before transplanting, AH – After crop harvest, and NS- non significance

Hence it is recommended for farmer that judicious application of NPK and FYM is required for better nourishment which result the batter soil health in terms of biomass and enzymes activities. Manure along with reduced dose of nutrient level not only improved crop growth but also significantly restore nutrient in soil, which lead to manage the balance enzymatic activity with a minimum pollution as compare to higer dose of chemical fertilizer (Kaur *et al.,* 2008; Bhattacharyya *et al.,* 2008; Maurya *et al.,* 2011).

In conclusion, the results of this study confirmed that application of organic and inorganic fertilizers alter rice productivity and soil biological properties. The combined application of chemical fertilizer and FYM was the most effective for increasing rice productivity and soil nutrient balance than sole chemical fertilizer or compost amendment. Fertilization had a significantly beneficial impact on soil microbial properties. Farm yard manure and along with chemical fertilizers application significantly improved soil microbial and enzymatic activity in soil. Based on data, it could be concluded that the combined application of chemical and organic (FYM) fertilizers at 2t/ha could be rational strategy to sustain soil productivity as well as improving soil health status than the sole chemical fertilizer or organic (FYM) fertilizer application.

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