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Integrated nutrient management boost the soil biological properties in rice rhizosphere

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ABSTRACT

A field experiment was carried out during kharif season in the year 2013 and 2014 in to assess the impact of Integrated Nutrient Management (INM) on soil biological properties in rice (Oryaza sativa). The experiment consists of nine treatments viz., T_1- Control, T_2- 100 per cent RDF, T_3- 50 per centRDF + 50 per cent N by green manure (GM), T_4 - 50 per cent RDF + 25 per centN by GM +25 per cent N by Vermicompost (VC), T_5 - 50 per cent RDF+25 per cent N by (VC)+25 per cent N by Azolla T_6- 50 per cent RDF + 25 per cent N by GM + 25 per cent N by Azolla, T_7 - 50 per cent RDF + 25 per cent N Azolla + 25 per cent N by BGA, T_8- 25 per cent RDF +25 per cent N by BGA + 25 per cent N by Azolla + 25 per cent N by GM and T_9 25 per cent N by GM + 25 per cent N by VC +25 per cent N by Azolla + 25 per cent N by BGA + PSB. The results revealed an enhancement of total bacteria, actinomycetes, fungi and phosphate solubilizing bacteria in all stages of growth and irrespective of all the treatments in comparison with initial density of respective microorganism justifying the higher rhizosphere effect and keeping with a line of organic carbon content increment. Soil dehydrogenase, acid and alkaline phosphatase activities alongwith microbial biomass carbon also increased with the gradual growth phase of the rice plan

Keywords : Acid phosphatse, alkaline phosphatase, azolla, dehydrogenase, rhizosphere, vermicompost,

The soil under the immediate influence of a plant's root system is called the rhizosphere (Dobereiner and Pedrosa,1987).It is the spatio temporal windows related to root apieces (Anthony and Hirsch,2010). Rhizosphere, the most dynamic site of nutrient exchange and soil biological activity, is composed of soil particles, microorganisms, polymeric secretions, water-soluble exudates, lysates and gases. Root effects are mainly due to the exudation of carbon substrates, creating a gradient that decreases with the distance from root (Rovira,1965). Presently, an interest is focussed to exploit the soil enzymes as indicators to study the soil fertility status, since enzyme activities are sensitive to various factors including climate, type of amendments, agricultural techniques, crop types and edaphic properties. Soil enzymes are organic proteins those catalyse all the biochemical reactions, mediated within the soil domain and their activities are actually considered to be a tool to study the overall soil microbial action. Actually, soil enzymes play a crucial role in most of the geochemical transformations of the nutrient elements. These are believed to be able to discriminate between soil management practices probably due to their intrinsic relation with microbial biomass, which in turn, may be sensitive to various treatments, applied in any experiment. Organically amended soil showed significant increase in total organic carbon, available Nitrogen, available phosphorus, available potassium, microbial biomass carbon and soil enzymatic activities compared with those treated under inorganically fertilized plots (Sanchez *et al*, 2008).

Conventional fertilizer management practices are associated with sharp decline of soil fertility level along with probable environmental hazards. This induces the inhibition of activities of soil resident microorganisms and makes the soil domain vulnerable. To achieve the sustainable agricultural production, the preservation and maintenance of soil is not only essential but it is imperative to choose the right combination of inorganic fertilizers and organic amendments to keep the soil microflora and fauna effective for benefit of soil health and crop.

Considering the above facts, the present investigation was under taken with following two fold objectives under integrated nutrient management practices (inorganic + organic) to quantify the effect on soil biological parameters under rice crop (*Oryza sativa*, var. *Sita*) for attaining higher crop yield with a better management of soil health.

MATERIALS AND METHODS

The field experiment was carried out during *kharif* season in the year 2013 and 2014 at the farm of Bihar Agricultural University, Sabour, Bhagalpur, Bihar. The farm is situated on the bank of the river Ganga at 25°15'40" N latitude and 78°02'42" E longitude with an altitude of 45.57 meters above the sea level. Experimental soil was sandy-loam in nature with water holding capacity of 45%, Bulk Density 1.42, slightly alkaline in reaction pH 7.60, with available N (Subbiah and Asija, 1956), P (Olsen *et al*., 1954) and K (Brown and Wranckle, 1988) was 284.00, 27.72 and 197.52

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kg ha^{-1} respectively. The initial microbial count of experimental soil was recorded as bacteria (cfu $x10^6$ g^{-1} of oven dry soil), actinomycetes (cfu $x10^5$ g^{-1} of oven dry soil) , fungi (cfu $x10^4 g^{-1}$ of oven dry soil), PSB (cfu x 10^5 g^{-1} of oven dry soil), and Cyanobacteria (BGA) (cfu x 10^4 g^{-1} of oven dry soil) recorded 285.00, 19.67, 19.66, 19.45, 14.39, respectively. Microbial biomass carbon of the initial soil sample was found to be 115.00 ìgm gm^{-1} $soil^{-1}$. Initial enzymatic status with respect to dehydrogenase (ìgm TPF hr^{-1} g^{-1} soil), acid phosphatase (ìg PNP g^{-1} soil hr^{-1}), and alkaline phosphatase (ìg PNP g^{-1} soil hr^{-1}) were quantified as 33.36, 55.35 and 65.20 respectively .The experiment was laid out in a Randomised complete block design with three replications and 9 treatment combinations. The treatments details can be visualized from table 1. Viable and healthy seedlings of rice (*Oryza sativa*, cv-Sita) were obtained from University farm and transplanted. The treatments under inorganic fertilizers, green manure, vermicompost and PSB were administered before transplanting. Subsequent application of Azolla and BGA were done 10 DAT (day after transplanting). The soil samples were collected in tillering, panicle initiation and harvesting stage of the grown rice crop. The chemical composition of vermicompost, Green manure and *Azolla* has been depicted in table 2.

Table 1: Treatment combinations

T_1	Control
T_2	100% RDF
T_3	50% RDF + 50 % N by green manure
T_4	50 % RDF + 25%N by green manure + 25 %N by VC
T_5	50% RDF+25 % N by Vermicompost (VC)+25 % N by Azolla
T_6	50 % RDF + 25 % N by green manure + 25 % N by Azolla
T_7	50 % RDF + 25% N Azolla + 25 % N by BGA
T_8	25 %RDF +25 % N by BGA + 25 %N by Azolla + 25 % N by green manure
T_9	25 % N by GM + 25 % N by VC +25 % N by Azolla + 25 % N by BGA + PSB

Table 2: Chemical composition of vermicompost, green manure and *Azolla*

Charact-eristics	Vermi-compost	Green Manure	*Azolla*
N (%)	1.20	0.53	2.5
P(%)	1.80	0.10	0.15
K(%)	0.50	0.18	0.25

RESULTS AND DISCUSSION

Organic carbon

Results presented in the table 3 show that amount of organic carbon content is highest at maturity stage of the rice plant (0.57%), which produced significantly higher effect at 5% level of significance over initial organic –C (%), *i.e.*, 0.54% as well as above the two stages of growth of the rice plants, i.e., tillering and panicle initiation. The plots under the treatment T_9 (25 % N by GM + 25 % N by VC +25 % N by Azolla + 25 % N by BGA + PSB) produced the highest significant value(0.58%) in both 5 and 1% level over control as well as over other treatments. The plots received the treatment T_9 (25 % N by GM + 25 % N by VC +25 % N by Azolla + 25 % N by BGA + PSB) under maturity stage produced the highest individual effect (0.60%) over initial (0.54%), control(0.53%) and the plots under other treatments at 5% level. Overall, the treatment T_6 (50 % RDF + 25 % N by green manure + 25 % N by Azolla) under maturity stage and treatment T_4 (50 % RDF + 25%N by green manure +25 %N by VC) and T_5(25 %RDF + 25% N by VC + 25 % N by BGA) under the same growth stage produced the organic carbon status at par. An over all depletion in organic carbon content was resulted in the plots under the treatment T_2, (RDF) and control (T_1).

Table 3: Effect of inorganic and organic treatments on organic carbon (%) status of rice rhizosphere at different stages of growth of rice plants

Treatment	Stages of growth			Mean
	S_1 (Tillering)	S_2 (Panicle initiation)	S_3 (Maturity)	
T_1	0.51	0.54	0.55	0.53
T_2	0.52	0.51	0.55	0.53
T_3	0.55	0.56	0.57	0.56
T_4	0.54	0.57	0.58	0.56
T_5	0.54	0.55	0.58	0.56
T_6	0.57	0.56	0.59	0.57
T_7	0.57	0.57	0.57	0.57
T_8	0.54	0.54	0.57	0.57
T_9	0.56	0.57	0.60	0.58
Mean	0.55	0.55	0.57	0.56
Initial value				0.54

Particulars	LSD(0.05)	LSD(0.01)
Stage (S)	**0.01**	**NS**
Treatment (T)	**0.01**	**0.02**
Interaction (SXT)	**0.03**	**NS**

Table 4: Effect of different treatments on total bacterial population (x 10^6 gm^{-1} oven dry soil) of rice rhizosphere.

Treatment	Stages of growth			Mean
	S_1(Tillering)	S_2(Panicle initiation)	S_3 (Maturity)	
T_1	33.55	45.33	41.67	40.18
T_2	33.67	46.33	23.67	34.56
T_3	44.77	44.67	36.33	41.92
T_4	51.67	60.33	47.00	53.00
T_5	47.33	57.67	43.33	49.44
T_6	45.33	63.67	45.33	51.44
T_7	42.33	55.67	42.00	46.67
T_8	53.33	65.00	55.33	57.89
T_9	63.00	67.33	63.67	64.67
Mean	46.11	56.22	44.26	48.86
Initial value				28.50
Particulars			**LSD(0.05)**	**LSD(0.01)**
Stage (S)			**2.32**	**3.09**
Treatment (T)			**4.02**	**5.36**
Interaction (SXT)			**6.96**	**9.28**

Table 5: Effect of different treatments on Actinomycetes population (x10^5 gm^{-1} oven dry soil) of rice rhizosphere

Treatment	Stages of growth			Mean
	S_1(Tillering)	S_2(Panicle initiation)	S_3 (Maturity)	
T_1	22.67	34.00	30.00	28.89
T_2	25.33	37.33	31.33	31.33
T_3	44.33	46.33	41.67	44.11
T_4	46.33	42.33	41.33	43.33
T_5	41.67	46.67	39.00	42.44
T_6	36.67	49.33	37.67	41.22
T_7	27.33	35.00	33.00	31.78
T_8	30.33	35.67	30.67	32.22
T_9	46.67	45.67	47.00	46.44
Mean	35.70	41.37	36.85	37.98
Initial value				19.67
Particulars			**LSD(0.05)**	**LSD(0.01)**
Stage (S)			**1.74**	**2.31**
Treatment (T)			**3.01**	**4.01**
Interaction (SXT)			**5.21**	**6.94**

Table 6: Effect of inorganic and organic treatments on fungal population (x 10^4 gm^{-1} oven dry soil) in rice rhizosphere

Treatment	Stages of growth			Mean
	S_1(Tillering)	S_2(Panicle initiation)	S_3 (Maturity)	
T_1	17.00	24.67	21.33	21.00
T_2	23.67	34.00	33.33	30.33
T_3	31.33	42.00	41.33	38.22
T_4	34.67	40.67	33.33	36.22
T_5	31.00	48.00	33.67	37.56
T_6	35.00	46.00	42.00	41.00
T_7	32.33	36.67	33.33	34.11
T_8	41.67	51.33	43.33	45.44
T_9	47.67	60.00	56.67	54.78
Mean	32.70	42.59	37.59	37.63
Initial value				19.66
Particulars			**LSD(0.05)**	**LSD(0.01)**
Stage (S)			**3.40**	**4.53**
Treatment (T)			**5.89**	**7.85**
Interaction (SXT)			**10.20**	**13.59**

Table 7: Effect of different treatments on phosphate solubilizing bacterial population (x10^5 gm^{-1} oven dry soil) in rice rhizosphere

Treatment	Stages of growth			Mean
	S_1(Tillering)	S_2(Panicle initiation)	S_3 (Maturity)	
T_1	23.67	28.67	30.67	27.67
T_2	23.00	32.67	40.67	32.11
T_3	28.67	36.00	29.33	31.33
T_4	34.00	41.00	30.67	35.22
T_5	28.33	40.33	33.67	34.11
T_6	39.67	45.67	43.00	42.78
T_7	38.67	38.33	38.67	38.56
T_8	37.33	37.67	32.33	35.78
T_9	39.00	35.00	32.33	35.44
Mean	32.48	37.26	34.59	34.78
Initial value				19.45
Particulars			**LSD(0.05)**	**LSD(0.01)**
Stage (S)			**1.74**	**2.32**
Treatment (T)			**3.01**	**4.01**
Interaction (SXT)			**5.22**	**6.95**

Table 8: Effect of different treatments on cyanobacterial population (x$10^4$$gm^{-1}$ oven dry soil) in rice rhizosphere

Treatment	Stages of growth			Mean
	S_1(Tillering)	S_2(Panicle initiation)	S_3 (Maturity)	
T_1	15.00	24.67	22.33	20.67
T_2	18.67	24.33	20.33	21.11
T_3	19.00	28.67	23.67	23.78
T_4	21.00	30.67	15.67	22.44
T_5	30.67	34.00	27.00	30.56
T_6	22.33	31.67	24.67	26.22
T_7	35.33	37.00	33.00	35.11
T_8	43.00	36.00	38.33	39.11
T_9	48.00	60.67	51.00	53.22
Mean	28.11	34.19	28.44	30.25
Initial value				14.39
Particulars			**LSD(0.05)**	**LSD(0.01)**
Stage (S)			**1.85**	**2.46**
Treatment (T)			**3.20**	**4.27**
Interaction (SXT)			**5.55**	**7.39**

Table 9: Effect of different treatments on microbial biomass carbon (ìgm gm^{-1} soil) in rice rhizosphere

Treatment	Stages of growth			Mean
	S_1(Tillering)	S_2(Panicle initiation)	S_3 (Maturity)	
T_1	122.00	136.00	148.00	135.33
T_2	129.00	139.00	139.00	135.67
T_3	135.00	148.00	150.67	144.56
T_4	139.67	194.67	162.67	165.67
T_5	141.33	144.27	165.67	150.42
T_6	137.67	141.00	137.00	138.56
T_7	146.00	156.23	153.00	151.74
T_8	159.27	161.99	150.33	157.20
T_9	159.93	163.30	160.33	161.19
Mean	141.10	153.83	151.85	148.93
Initial value				115.00
Particulars			**LSD(0.05)**	**LSD(0.01)**
Stage (S)			**2.72**	**3.63**
Treatment (T)			**4.71**	**6.28**
Interaction (SXT)			**8.17**	**10.88**

Table 10: Effect of different treatments on dehydrogenase activity (ìg PNP g^{-1} soil hr^{-1}) in rice rhizosphere

Treatment	Stages of growth			Mean
	S_1(Tillering)	S_2(Panicle initiation)	S_3 (Maturity)	
T_1	59.71	28.63	20.22	36.19
T_2	25.87	29.95	33.37	29.73
T_3	35.17	47.14	76.63	52.98
T_4	44.22	45.83	39.48	43.18
T_5	36.00	39.61	30.15	35.25
T_6	32.45	27.19	33.70	31.11
T_7	36.26	33.87	42.54	37.56
T_8	21.60	20.68	26.93	23.07
T_9	31.89	30.38	28.37	30.21
Mean	35.91	33.70	36.82	35.48
Initial value				33.36
Particulars			**LSD(0.05)**	**LSD(0.01)**
Stage (S)			**2.59**	**3.45**
Treatment (T)			**4.49**	**5.98**
Interaction (SXT)			**7.77**	**10.35**

Table 11: Effect of different treatments on acid phosphatase activity (ìg PNP g^{-1} soil hr^{-1}) in rice rhizosphere

Treatment	Stages of growth			Mean
	S_1(Tillering)	S_2(Panicle initiation)	S_3 (Maturity)	
T_1	59.45	78.13	68.48	68.69
T_2	57.22	57.63	53.57	56.14
T_3	59.73	71.23	61.57	64.18
T_4	61.75	76.43	69.93	69.37
T_5	79.24	106.19	99.49	94.97
T_6	78.88	100.34	97.75	92.33
T_7	63.13	77.56	51.99	64.23
T_8	97.52	105.56	98.63	100.57
T_9	97.75	117.82	105.19	106.92
Mean	72.74	87.88	78.51	79.71
Initial value (ìgm PNP gm^{-1} soil)				55.35
Particulars			**LSD(0.05)**	**LSD(0.01)**
Stage (S)			**3.51**	**4.68**
Treatment (T)			**6.08**	**8.10**
Interaction (SXT)			**10.53**	**14.03**

Table 12: Effect of different treatments on alkaline phosphatase activity (ìg PNPg^{-1} soil hr^{-1}) in rice rhizosphere

Treatment	Stages of growth			Mean
	S_1(Tillering)	S_2(Panicle initiation)	S_3 (Maturity)	
T_1	73.42	77.60	66.11	72.38
T_2	56.60	68.97	56.51	60.69
T_3	70.26	73.22	65.61	69.70
T_4	79.63	80.00	70.79	76.81
T_5	71.37	85.90	80.97	79.41
T_6	79.00	80.90	77.95	79.28
T_7	70.97	81.57	68.74	73.76
T_8	73.97	86.37	73.05	77.80
T_9	80.57	87.34	74.30	80.74
Mean	72.87	80.21	70.45	74.51
Initial value (ìgm gm^{-1} soil)				72.38
Particulars			**LSD(0.05)**	**LSD(0.01)**
Stage (S)			**2.90**	**3.86**
Treatment (T)			**5.02**	**6.69**
Interaction (SXT)			**8.70**	**11.59**

The indication observed after perusal of the result presented in table 3 that the loss of organic carbon in soil is appeared to be due to its rapid mineralization, resulting from intensive cropping on one hand and attaining a stable equilibrium with the changing soil crop environment on the other. Maximum loss in soil organic carbon occurred under control, which was minimized with the balanced use of NPK fertilizers. However the original status was more or less maintained by combined use of BGA, Azolla, green manure, vermicompost. It might be due to incorporation of organic amendments and biofertilizers and their combined effect, which in turn, caused to substantiate the SOM content of the experimental soil, are keeping in the line of findings of Nand Ram (1995) and Mathur (1997). The NPK application increased crop growth and root biomass in soil which reflected in terms of higher organic carbon in soils under fertilized treatments as reported by Singh (2000), Nand Ram (2000) and Krishna (2003).

Total bacterial population

Data presented in table 4 shows that the total bacterial count recorded significantly highest in panicle initiation stage ($46.1x10^6$ g^{-1} of oven dry soil) over tillering (56.22 $x10^6$ g^{-1} of oven dry soil) and maturity (44.26 $x10^6$ g^{-1} of oven dry soil) respectively. So far the treatments are concerned, the plots under the treatment, T_9 (25 % N by GM + 25 % N by VC +25 % N by Azolla + 25 % N by BGA + PSB) induced the significantly highest total bacterial density (64.67 $x10^6$/gm of oven dry soil) followed by T_8 (25 %RDF +25 % N by BGA + 25 %N by Azolla + 25 % N by green manure), T_4 (50% RDF + 25%N by green manure +25 %N by VC), T_6 (50 % RDF + 25 % N by green manure + 25 % N by Azolla), respectively.

Total bacterial count increased as compared with initial density, in all experimental plots under rice crop irrespective of all the treatments justified that higher rhizosphere effect induced the higher microbial density (Subbarao, 2009). It is evident from the data presented in the said table that bacterial count resulted highest in the panicle initiation stage of growth might be due accumulation of various root exudates and which in turn, established a strong and well defined root-microbe interaction (Rovira,1965). The logarithmic growth pattern observed in the bacterial count is justified by keeping with line of previous finding (Alexander,1965).Changes in soil microbial counts induced by different types of mineral, organic and microbiological fertilizers suggest that they can be justifiably used for soil fertility and crop yield. The bacterial count conspicuously increased with application of different organic N sources compared to control (Krishnakumar *et al*, 2005) justified the finding of present experimentation.

Total actinomycetes population

Perusal of the data presented in the table 5 reveals that highest actinomycetes population was induced under panicle initiation stage of growth (41.37 $x10^5$ g^{-1} of oven dry soil) followed by maturity and tillering stages, respectively. Treatment T_9 (25 % N by GM + 25 % N by VC +25 % N by Azolla + 25 % N by BGA + PSB) resulted highest effect(46.44 $x10^5 g^{-1}$ of oven dry soil) in comparison over control and other treatments as a whole. RDF (T_2) and T_7 (50 % RDF + 25 % N by Azolla + 25 % N by BGA) treated plots produced almost equal density of actinomycetes. The physiology and biochemical characteristic similarity of bacteria and actinomycetes has been well corroborated by this finding (Alexander,1965).

Total fungal population

Data recorded in the table 6 reveals that the highest fungal density was observed in the plots under panicle initiation stage (42.59 $x10^4$ g^{-1} of oven dry soil) followed by maturity (37.59 $x10^4$ g^{-1} of oven dry soil) and tillering stages (32.70 $x10^4$ g^{-1} of oven dry soil), respectively. The highest overall treatment effect (54.78 $x10^4$ g^{-1} of oven dry soil) was observed under the treatment, T_9 (25 % N by GM + 25 % N by VC +25 % N by Azolla + 25 % N by BGA + PSB) followed by T_8 (25 %RDF +25% N by BGA + 25 %N by Azolla + 25 % N by green manure) and T_6 (50 % RDF + 25% N by green manure + 25 % N by Azolla), respectively. On single individual effect, the highest fungal density was recorded under panicle initiation stage followed by the same treatment under maturity stage of growth of the plants. Overall, all the treatments individually or under interaction with different stages induced higher effect on rhizosphere fungal density in comparison with control.

Fungal count, increased under irrespective of all the treatment under all stages of growth excepting in the control plot under tillering stage of growth might be due initial immobilization of nutrient elements, required for growth of fruiting bodies of fungal component (Gilman,1957). The highest fungal density was recorded under panicle initiation stage supported the sigmoid growth character of this particular class of organism (Alexander,1965). The plots under the treatment T_9 resulted the highest fungal count might be due to synergistic effect of biofertilizers with added two green manurial components having low C/N ratio, which in turn, induced high degree of mineralization. It is evident from the data presented in the said table that fungal count resulted highest in the panicle initiation stage of growth might be due accumulation of various root exudates and which in turn, established a strong and well defined root-microbe interaction (Mitchell and Alexander,1962, Rovira,1965) also as compared to bacteria and fungi.

Phosphate solubilising bacteria

Results presented in the table 7 states that the highest density of phosphate solubilizing bacteria was observed under panicle initiation stage (37.26 $x10^5$ g^{-1} of oven dry soil) and which produced significant higher effect over maturity and tillering stages of growth, respectively. So far the overall treatment effect is concerned, T_6 (50 % RDF + 25 % N by green manure + 25 % N by Azolla) produced the highest effect (42.78 $x10^4$ g^{-1} of oven dry soil) followed by T_7 (50 % RDF + 25% N Azolla + 25% N by BGA) and T_8 (25 %RDF +25 % N by BGA + 25% N by Azolla + 25 % N by green manure), respectively, induced almost equal higher effect over control as well as other treatment. Cyanobacteria benefit the rice plants by producing growth-promoting substances, and by increasing the availability of Phosphorus by excretion of organic acids by phosphate solubilizing bacteria. It is obvious that inclusion of organic matter in the form of different amendments induced the higher proliferation of heterotrophic phosphate solubilizers (Somani *et al*, 2011).

Cyanobacteria (Blue green Algae)

The cyanobacterial density was found highest under panicle initiation stage as obtained in the other previous cases (Table 8). The presented results also depicts the significant higher effect of the treatment induced by T_9 (25 % N by GM + 25 % N by VC +25 % N by Azolla + 25 % N by BGA + PSB), *i.e.*, 53.22 x $x10^4$ g^{-1} of oven dry soil above all other treatments as well over control (14.39x $x10^4$ g^{-1} of oven dry soil).The plots received the combined treatment of BGA and PSB induced the highest individual effect under panicle initiation stage, followed by the same treatment in the subsequent stage of growth, i.e., under maturity stage of the plants. An overall enhancing effect on cyanobacterial count has been observed in all the experimental plots including control over initial density might be explained in the light of higher moisture retention the soil of the experimental plots caused by inclusion of BGA culture (Saha and Mandal, 1980) in addition to Azolla and PSB and which in turn, resulted high degree of rhizospheric effect (Rovira,1965).

Microbial biomass carbon (MBC)

Highest microbial biomass carbon was obtained under the panicle initiation stage followed by maturity and tillering stages, respectively (Table 9). Significant higher treatment effect was resulted under T_9 (25 % N by GM + 25 % N by VC +25 % N by Azolla + 25 % N by BGA + PSB) followed by T_8 (25 %RDF +25 % N by BGA + 25 %N by Azolla + 25 % N by green manure) and T_7 (50 % RDF + 25% Azolla + 25 % N by BGA). All the amended treatments resulted higher content of microbial bio mass carbon over control.

Data indicated that soil microbial biomass carbon (SMBC) was more in treatments where balanced fertilization with organic amended treatment was practiced. Results of this study showed that the addition of organic amendments increased the SMBC compared to the fertilizer and control. The increase in SMBC with organic amendment addition could be attributed to an increase in microbial biomass compared to other treatments due to availability of substrates. Similar observations were reported in organic recycling experiments by Chakrabarti *et al.* (2000). The findings of Islam and Weil (2002) also suggested that the soil receiving manure had larger SMBC pools than in the same soil receiving only fertilizers. Application of N alone showed significant reduction in SMBC content in comparison to rest fertilized treatments. This could be due to acidifying effect of N fertilizers applied in the form of urea alone, which probably resulted in the appearance of unfavorable conditions to diverse microorganisms. Negative effect of fertilizer N alone due to acidification on soil microbial biomass has also been observed by Kowalenko (1978) and Vance *et al.* (1987).

Dehydrogenase activity

Intermediate decline of Dehydrogenase activity (33.70 ìgm TPFhr^{-1} g^{-1} soil) was observed in panicle initiation stage (Table10). The maturity stage of the plants induced the highest microbial respiration, 36.82 ìgm TPF $hr^{-1}g^{-1}$ soil. The highest treatment effect was resulted (52.98 ìgm TPF $hr^{-1}g^{-1}$ soil) in the plots under the treatment T_3 (50% RDF+50% N by green manure) followed by T_4 (50% RDF+25% N by green manure+25%N VC) and T_7 (50 % RDF + 25% Azolla + 25 % N by BGA), respectively. The highest significant individual treatment effect was resulted with T_3 under maturity stage (76.63 ìgm TPF $hr^{-1}g^{-1}$ soil**)**.

Microbial respiration is supposed to be highest in maturity stage over initial as well as tillering stage of growth. This finding might be explained in the light of the report made by (Zeng Lu-sheng *et al.* 2005). In present course of study, soil dehydrogenase activities increase with the gradual growth phase of the rice plants. From the tillering to grain filling stage, the rice was just at the most flourished stage and the soil enzymatic activities were at strongest hold, the rice roots excreted more organic acid and carbohydrate, which stimulated the correlative soil enzymatic activities. The soil dehydrogenase only occurred within living cells, come from the life activities of soil microorganism and rice growth, thus, with the different change trends from other enzymes. In the present course of study, the highest result obtained under the effect of green manure, having low C/N ratio supported the findings of Albiach, *et al.* (2000) and Tejada *et al.* (2008),as C/N ratio of the organic waste

will largely determine the balance between mineralization and immobilization.

Acid phosphatase

Perusal of the results presented in table 11 depicts that acid phosphatase activity was found highest in the panicle initiation stage (87.88 ìg PNP g^{-1} soil hr^{-1}) followed by maturity and tillering stages, respectively. The combined inoculation of all chemical fertilizer, organic amendments along with two biofertilizers under the treatment T_9 (25 % N by GM + 25 % N by VC +25 % N by Azolla + 25 % N by BGA + PSB) induced the highest significant effect on this enzymatic activity (106.92 ìg PNP/g soil hr^{-1}) over all other treatments and control (68.69 ìg PNP g^{-1} soil hr^{-1}). The treatment,T_2 (RDF) produced the lowest effect on this enzymatic activity(56.14 ìg PNP g^{-1} soil/hr). The plots under the effect of the treatments, T_3 (50% RDF+ 50% N by green manure) and T_4 (50% RDF+25% N by green manure+ 25% N by VC) produced a declining trend as produced in the plots under control.

Acid phosphatase activity in the experimental plots under different stages of growth has been stated in table 11.The highest individual effect is for acid phosphatase is observed in the treatment T_9 (25% RDF + 25% N by BGA + 25% N by Azolla + 25% by green manure + PSB) under the panicle initiation stage of growth of the rice plant. This finding has been well supported by the experimentation, undertaken by Zeng Lu-Sheng *et al.* (2005) and emphasized on the fact that there was a relation between rice physiological indices and soil biochemical indices, which indicated that soil biochemical characteristics were affected significantly by rice growth in the interaction system of the rice, soil and microorganisms. It also unfolded the fact that soil respiration ascended slightly on way to maturity of the rice plants. However, soil metabolic quotient declined at all the stages.

Alkaline phosphatase activity

Data presented in the table 12 reveals the same trend of result as shown in the case of acid phosphatase activity. Panicle initiation stage produced significantly highest result in comparison with other two stages of growth. Overall highest treatment effect was obtained in the plots received the treatment T_9 ((25 % N by GM + 25 % N by VC + 25 % N by Azolla + 25 % N by BGA + PSB). followed by T_5 (50% RDF+25%N by VC+25% N by Azolla) and T_6 (50% RDF+25%N by green manure+25% N by Azolla), which produced the same effect in between. It is very clear from the experimental data that plots received the recommended doses of fertilizers (T_2:RDF) resulted the lowest enzymatic activity, even below the control plots. The highest individual enzymatic activity was mediated in the plots under the treatment, T_9, followed by T_8 (25 %RDF +25 % N by BGA + 25 %N by Azolla + 25 % N by green manure), T_5(50% RDF+25%N by VC+25% N by Azolla), respectively, under panicle initiation stage. It is very much evident from the experimental findings that alkaline phosphatase activity resulted highest in panicle initiation stage of growth, irrespective of any treatment.

The application of organic amendments which would have favoured more microbial populations and this ultimately reflected on more enzymatic activity. In addition to that other soil microflora, plant residues undergoing varying degree of decay also contributed to this pool (Krishnakumar *et al.* 2005). Rice crop produced higher amount of root exudation in initial stages of growth which enhanced microbial activity in crop and modify nutrient concentration in soil (Dotaniya *et al.*, 2014).

Combined effect of inorganic fertilizers and organic amendments, *i.e.*, sub optimal level of inorganic fertilizer, BGA, green manure, vermicompost and PSB induced higher acid and alkaline phosphatase activity supported the relation between rice physiological indices and soil biochemical indices, justified soil biochemical characteristics were affected significantly by rice growth in the interaction system of the rice, soil and microorganisms. It is also stated that soil respiration ascended slightly on way to maturity of the rice plants. However, soil metabolic quotient declined at all the stages. The enzyme activity was proved to be more active in juvenile stage of growth. From the above findings, it is apparent that there are depressing effect with the combined application of inorganic fertilizers and organic amendments including biofertilizers on the yield attributes and some of the soil chemical parameters, there is no such significant declining trend has been resulted out of the application of organics that might be a out come of slow release of plant nutrient elements. But, an overall positive effect has been observed that integrated nutrient management induces the higher soil biological activities which in turn, help to promote a sustainable crop growth and development with a sound soil health.

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