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Influence of Integrated Nutrient Management on Microbial Biomass and Enzymes under Long term Rice-rice Cropping System in Alfisols

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ABSTRACT

Soil microbial biomass dynamics and the activity of soil enzymes were studied in different integrated nutrient management treatments in rice-rice cropping system in Alfisols of southern Telangana zone of Andhra Pradesh during 2005-06 and 06-07. The substitution of 25 or 50% N fertilizer with *Glyricidia* significantly enhanced the CO_2 evolution indicating, higher respiration rate than the fertilized soil in the upper 0 to 15 cm depth. The effect of different integrated nutrient management treatments did not increase the microbial biomass significantly over the complete reliance on fertilizing the crop with optimum nutrient requirement. The biochemical assay indicated higher enzymatic activity in the upper 0 to 15 than 15 to 30 cm depth of the soil. The influence of FYM, paddy straws, as well as *Glyricidia* was superior on enzymatic activity when combined with fertilizers.

Key words : Alfisols, Integrated Nutrient Management, Soil microbial biomass, Soil enzymes.

Rice–rice is the most predominant cropping system in southern Telangana zone of Andhra Pradesh state. Impaired soil fertility due to indiscriminate application of nutrients through the fertilizers has become major threat for the productivity. The soil micro organisms are the primary driving forces for many chemical and bio-chemical processes that influence the nutrient cycling, soil fertility and global carbon change. Measurement of microbial biomass, carbon, organic matter, soil respiration and N mineralization or available N gives a reliable profile of soil biological quality. Saha *et al.,* (1995) and Sharma and Gupta (1998) reported the enrichment in microbial population due to organic additions and integrated supply of nutrients. Hence, an investigation was made to understand soil microbial biomass dynamics and the activity of soil enzymes *viz.,* urease, acid phosphatase, alkaline phosphatase, and dehydrogenase in different integrated nutrient management (INM) treatments.

MATERIAL AND METHODS

The investigation was conducted during 2005-06 and 2006-07 in Alfisols of southern Telangana zone of Andhra Pradesh. The experiment was conducted on a sandy clay loam soil on which rice is grown continuously in both *kharif* and *rabi* seasons since 1988 at Agricultural College Farm, Rajendranagar, Hyderabad. The experiments were laid out in a randomized block design with 12 treatments (Table 1) in three replications. Rice variety namely RNR 23064 was planted adopting a spacing of 20 cm x 10 cm in 59.8 m^2 sized plot. The soil samples were collected with soil auger at random from each treatment plot at 0-15 and 15-30 cm depth before transplanting, panicle initiation and harvesting stages of the crop in each season. Soil microbial biomass was estimated by fumigation extraction technique (Sparling and West, 1988) while, soil respiration (CO_2 evolution) was estimated by titration method (Jaggi, 1976). Activities of different enzymes *viz;* urease (μ g NH_4^+ released g^{-1} soil hr^{-1}) (Tabatabai and Bremner, 1972), acid phosphatase and alkaline phosphatase (μg of p-nitrophenol - released g^{1} soil h^{-1}) (Tabatabai and Bremner (1969) and dehydrogenase (mg of TPF produced g^{-1} soil d^{-1}) (Casida *et al.*, 1964) were estimated following the standard protocols.

RESULTS AND DISCUSSION

Microbial biomass

The microbial biomass was significantly influenced by different nutrient management strategies in rice-rice cropping system in the upper

Table 1. Details of the treatments.

Sl. No	Kharif	Rabi
T_1	No fertilizers, No organic manures	No fertilizers, No organic manures
T_2	50 % Rec. NPK dose through fertilizers	50 % Rec. NPK dose through fertilizers
T_3	50 % Rec. NPK dose through fertilizers	100 % Rec. NPK dose through OM
T_4	75 % Rec. NPK dose through fertilizers	75 % Rec. NPK dose through fertilizers
T_5	100 % Rec. NPK dose through fertilizers 120:60:60 kg ha^{-1}	100 % Rec. NPK dose through fertilizers120:60:60 kg ha^{-1}
T_6	50 % Rec. NPK dose through fertilizers + 50 % N through FYM	100 % Rec. NPK dose through fertilizers
T_7	75 % Rec. NPK dose through fertilizers + 25 % N through FYM	75 % Rec. NPK dose through fertilizers
T_8	50 % Rec. NPK dose through fertilizers + 50 % N through paddy straw	100 % Rec. NPK dose through fertilizers
T_9	75 % Rec. NPK dose through fertilizers + 25 % N through paddy straw	75 % Rec. NPK dose through fertilizers
T_{10}	50 % Rec. NPK dose through fertilizers + 50 % N through *glyricidia*	100 % Rec. NPK dose through fertilizers
T_{11}	75 % Rec. NPK dose through fertilizers + 25 % N through *glyricidia*	75 % Rec. NPK dose through fertilizers
T_{12}	Conventional farmers practice 80:50:20 kg ha^{-1} NPK	Conventional (farmers) practice 80:50:20 kg ha^{-1} NPK

Table 2. Influence of integrated nutrient management treatments on microbial biomass (μg^{-1} g^{-1} soil) in rice-rice cropping system at 0-15 cm.

Treatments	2005-06						2006-07					
	Transplanting		Panicle initiation		Harvesting		Transplanting		Panicle initiation		Harvesting	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
T_1	170.6	158.3	185.2	164.6	98.3	82.6	171.2	159.2	188.3	164.2	99.6	83.5
T_2	200.2	180.6	212.6	188.3	110.2	93.6	204.4	181.1	216.3	189.6	112.0	94.2
T_3	198.6	181.8	210.5	187.6	105.4	92.4	200.3	182.3	215.8	187.8	110.1	94.2
T_4	200.8	178.3	215.4	186.5	108.2	93.2	205.8	181.5	220.6	188.5	111.5	94.5
T_5	205.5	185.6	219.2	191.2	110.5	96.8	209.6	186.4	224.6	192.3	109.6	94.2
T_6	200.4	186.3	215.2	192.6	107.5	94.7	206.8	182.2	220.5	192.3	116.2	97.3
T_7	210.3	181.5	225.4	189.8	115.2	92.6	216.3	183.4	231.6	190.1	120.2	94.2
T_8	215.4	190.4	230.6	197.2	118.2	98.2	219.6	191.2	236.2	197.6	123.3	94.2
T_9	220.2	186.2	235.5	191.4	120.2	99.2	226.3	187.6	241.9	192.3	121.6	99.0
T_{10}	222.3	171.2	240.3	198.8	120.6	103.1	227.6	192.3	246.5	198.8	122.3	104.2
T_{11}	222.6	189.4	252.4	193.4	120.5	95.2	226.8	190.7	257.8	194.0	126.0	100.2
T_{12}	190.8	172.8	211.5	175.2	102.2	89.8	193.6	173.2	215.2	176.0	103.6	90.0
SE $\pm$	8.9	7.4	9.9	10.8	8.05	7.7	12.8	9.0	10.5	8.9	6.1	7.8
CD at 5 %	18.6	15.4	20.6	22.5	16.7	14.8	26.5	18.6	21.8	18.4	10.7	7.8

Table 3. Influence of integrated nutrient management treatments on microbial biomass (µg^{-1} g^{-1} soil) in rice-rice cropping system at 15-30 cm.

Treatments	2005-06						2006-07					
	Transplanting		Panicle initiation		Harvesting		Transplanting		Panicle initiation		Harvesting	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
T_1	112.6	101.6	122.2	107.2	65.0	56.3	113.5	101.8	122.6	107.6	65.0	57.2
T_2	134.8	112.4	144.8	117.8	75.8	62.8	135.2	113.2	145.2	118.1	76.1	63.0
T_3	135.2	120.8	145.6	125.2	76.2	64.6	135.2	119.3	145.6	126.2	76.1	64.9
T_4	136.8	121.2	148.8	126.4	78.3	64.6	137.0	122.4	149.0	126.2	78.2	6.0
T_5	144.6	125.5	153.6	128.8	80.8	68.4	150.0	126.0	153.8	129.3	81.0	69.0
T_6	142.3	132.2	150.2	136.4	82.2	71.8	142.6	132.8	150.6	137.6	82.6	72.0
T_7	145.4	130.3	155.5	134.2	86.4	70.2	145.8	131.4	156.0	137.6	87.0	70.0
T_8	150.2	131.5	160.4	135.8	89.2	74.7	150.0	131.4	160.8	137.6	89.8	22.1
T_9	155.8	129.3	165.2	134.6	90.8	70.2	156.2	130.0	165.8	135.7	91.2	72.3
T_{10}	158.2	132.7	170.6	137.2	95.2	72.3	158.8	133.7	171.2	138.2	96.6	76.3
T_{11}	160.2	131.6	176.3	135.5	90.6	71.0	160.6	130.0	186.9	136.2	103.0	71.6
T_{12}	135.4	119.4	146.0	122.7	79.2	68.6	175.6	120.2	146.2	122.9	80.0	69.0
SE ±	10.0	11.3	8.8	11.5	6.2	7.1	11.9	11.5	13.8	9.0	7.6	4.7
CD at 5 %	20.8	23.4	18.2	23.9	12.8	14.7	24.6	23.8	28.6	18.6	15.7	9.8

Table 4. Influence of integrated nutrient management treatments on respiration(µg CO_2 g^{-1} soil 24 h^{-1}) in rice-rice cropping system at 0-15 cm.

Treatments	2005-06						2006-07					
	Transplanting		Panicle initiation		Harvesting		Transplanting		Panicle initiation		Harvesting	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
T_1	0.082	0.070	0.090	0.090	0.050	0.040	0.088	0.080	0.095	0.085	0.050	0.042
T_2	0.105	0.090	0.115	0.105	0.055	0.045	0.119	0.100	0.128	0.110	0.055	0.050
T_3	0.117	0.095	0.125	0.105	0.058	0.050	0.123	0.105	0.130	0.115	0.060	0.055
T_4	0.110	0.090	0.125	0.105	0.055	0.045	0.117	0.103	0.125	0.115	0.060	0.050
T_5	0.115	0.095	0.125	0.105	0.058	0.050	0.125	0.105	0.128	0.115	0.060	0.058
T_6	0.120	0.100	0.130	0.110	0.060	0.050	0.125	0.110	0.135	0.120	0.065	0.060
T_7	0.125	0.105	0.130	0.115	0.065	0.055	0.120	0.115	0.130	0.115	0.065	0.055
T_8	0.127	0.105	0.140	0.120	0.065	0.055	0.132	0.115	0.142	0.128	0.068	0.060
T_9	0.120	0.105	0.130	0.130	0.060	0.056	0.130	0.110	0.140	0.132	0.068	0.060
T_{10}	0.182	0.130	0.195	0.145	0.075	0.070	0.185	0.140	0.200	0.158	0.080	0.075
T_{11}	0.164	0.110	0.190	0.103	0.070	0.060	0.168	0.130	0.180	0.140	0.075	0.065
T_{12}	0.115	0.090	0.120	0.105	0.056	0.045	0.120	0.100	0.125	0.110	0.058	0.050
SE ±	0.010	0.009	0.011	0.007	0.005	0.004	0.008	0.009	0.010	0.004	0.005	0.005
CD at 5 %	0.022	0.018	0.024	0.015	0.010	0.008	0.016	0.019	0.021	0.009	0.012	0.010

Table 5. Influence of integrated nutrient management treatments on respiration (µg CO_2 g^{-1} soil 24 h^{-1}) in rice-rice cropping system at 15-30 cm.

Treatments	2005-06						2006-07					
	Transplanting		Panicle initiation		Harvesting		Transplanting		Panicle initiation		Harvesting	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
T_1	0.075	0.072	0.076	0.074	0.050	0.059	0.076	0.082	0.082	0.082	0.060	0.060
T_2	0.102	0.107	0.110	0.107	0.056	0.054	0.112	0.110	0.120	0.095	0.065	0.055
T_3	0.110	0.107	0.115	0.110	0.056	0.054	0.125	0.117	0.120	0.125	0.062	0.057
T_4	0.110	0.107	0.115	0.113	0.058	0.054	0.125	0.119	0.120	0.125	0.062	0.057
T_5	0.115	0.114	0.120	0.118	0.058	0.054	0.125	0.124	0.120	0.125	0.065	0.057
T_6	0.115	0.112	0.110	0.108	0.060	0.58	0.125	0.124	0.120	0.127	0.065	0.059
T_7	0.120	0.122	0.115	0.118	0.063	0.060	0.130	0.135	0.120	0.125	0.065	0.058
T_8	0.125	0.118	0.120	0.120	0.066	0.066	0.135	0.130	0.125	0.140	0.065	0.058
T_9	0.125	0.124	0.125	0.128	0.063	0.062	0.135	0.135	0.125	0.145	0.060	0.062
T_{10}	0.180	0.125	0.130	0.130	0.065	0.066	0.160	0.140	0.130	0.148	0.065	0.064
T_{11}	0.170	0.120	0.125	0.128	0.063	0.062	0.150	0.135	0.130	0.140	0.065	0.062
T_{12}	0.105	0.106	0.110	0.112	0.052	0.055	0.110	0.116	0.115	0.125	0.065	0.056
SE $\pm$	0.012	0.013	0.015	0.013	0.008	0.004	0.010	0.009	0.013	0.006	0.005	0.007
CD at 5 %	0.026	0.028	0.031	0.027	NS	NS	0.021	0.018	0.028	0.012	NS	NS

Table 6. Influence of integrated nutrient management treatments on urease activity (µg $NH_4 g^{-1}$ soil h^{-1}) in rice-rice cropping system at 0-15 cm.

Treatments	2005-06						2006-07					
	Transplanting		Panicle initiation		Harvesting		Transplanting		Panicle initiation		Harvesting	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
T_1	3.15	3.00	3.51	2.43	1.55	1.57	3.20	3.13	2.75	2.52	1.65	1.62
T_2	3.75	3.56	4.80	4.62	1.64	1.68	3.66	3.56	4.61	4.69	1.71	1.62
T_3	3.87	3.75	4.80	4.62	1.64	2.68	3.94	3.76	4.95	4.73	1.66	2.68
T_4	4.06	4.00	5.22	5.00	1.80	2.72	4.10	4.28	5.27	5.22	1.82	1.76
T_5	4.25	4.17	5.80	5.55	2.98	2.87	4.34	4.28	5.91	5.64	2.84	2.82
T_6	4.44	4.17	5.76	5.60	2.77	2.80	5.57	4.15	5.86	5.64	2.75	2.87
T_7	4.24	4.00	6.60	5.15	2.77	2.80	6.06	4.15	6.33	5.64	2.82	2.62
T_8	4.24	4.25	5.75	5.60	2.77	2.90	4.85	4.52	5.78	5.73	2.84	2.87
T_9	4.35	4.00	5.20	5.45	2.85	2.90	4.91	4.15	5.22	5.88	2.84	2.94
T_{10}	4.35	4.30	5.86	5.77	2.93	2.95	5.39	4.45	5.96	5.64	2.93	2.98
T_{11}	4.28	4.20	6.48	5.60	2.95	2.95	6.28	4.25	6.20	5.75	2.95	2.98
T_{12}	3.90	3.86	5.13	4.79	1.62	1.63	4.57	3.97	5.07	4.81	1.63	1.65
SE $\pm$	0.21	0.18	0.56	0.78	0.15	0.12	0.20	0.18	0.87	0.81	0.03	0.02
CD at 5 %	0.43	0.38	1.20	1.63	0.31	0.24	0.41	0.37	1.80	1.68	0.06	0.04

layer of 0-15 cm soil depth (Table 2). The unfertilized soil had a low biota than the fertilized and integrated supply of nutrients through the inorganic and organic sources. The application of 50 % recommended dose of nutrients through the fertilizers significantly increased the microbial biomass consistently during transplanting and panicle initiation during the two year rice-rice rotation. The microbial biomass was high due to the substitution of 25 or 50 % N fertilizer with FYM, paddy straw or *glyricidia* in the *kharif* season as compared to the unfertilized soil. The lower depth of the soil at 15-30 cm hosted far less microbial biomass per gram in different treatments as compared to the upper layer (Table 3). The microbial biomass of the soil increased rapidly by the application of different levels of fertilizers. This improvement was similar due to the application of optimum dose of fertilizers and the substitution of N fertilizer with FYM, paddy straw or *Glyricidia* and application of recommended dose of fertilizers. Since the microbial biomass mg C g^{-1} soil accumulation in the soil is a dynamic property, it could be possible that the readily available nutrients from the chemical fertilizer were utilized by the micro organisms which in turn also depended on the incorporated organic matter for its decomposition thereby improving the organic content of the soil. Selvi *et al.,* (2004) also observed an increase in the microbial biomass with increase in the level of fertilizers.

Soil respiration

The respiration of soil was measured in terms of carbon dioxide (CO_2) released per gram after 24 hours under the influence of different integrated nutrient management treatments at 0-15 cm depth (Table 4). The soil had a poor respiration without the external input of manures and fertilizers. The application of 50 % recommended dose of fertilizers both in *kharif* and *rabi* significantly increased the CO_2 evolution at transplanting and panicle initiation stages of the crop during both the years. The incorporation of green leaf manures through *glyricidia* by substituting 25 or 50 % N fertilizer in the *kharif* season was more effective than the application of fertilizer alone during *kharif* and rabi season. Though the soil respiration was relatively less in the lower layer of 15-30 than the upper 0-15 cm depth similar trend was followed (Table 5). Increase in the microbial biomass with increase in the level of fertilizers significantly increased the soil respiration as indicated by the large quantity of CO_2 released as compared to the unfertilized soil. This trend was existed at different stages of crop growth during the two years. The combined application of FYM or paddy straw by partly substituting the N fertilizer to the extent of 25 or 50 % had a similar effect as with the application of recommended dose of fertilizers. The increase in bacterial number in response to chemical fertilizers may be attributed to better nutrient status of the soil. This effect was greater in the green manure treatment. Kang *et al*., (2005) also reported increase in microbial content and CO_2 evolution in response to fertilization. The effect of green manure in improving the microbial biomass, potentially mineralizable N and phosphatase activity was more pronounced than FYM and wheat straw treatments, probably because green manure degrades faster than these materials. The relative variation in CO_2 evolution due to the three organic sources partly substituted for N fertilizer in the present investigation could probably be due to their variation in C / N ratio which altered the rate of decomposition (Sharma and Bordoloi, 1994). Since *Glyricidia* twigs are tender and succulent with narrow C / N ratio of 12:1, they decompose rapidly while the paddy straw with a wider C / N ratio of 79 perhaps decomposed very slow. Although farm yard manure also has a relatively narrow C / N ratio than paddy straw, it had already undergone substantial decomposition before its incorporation into the soil. Higher CO_2 evolution is an indication of higher C content of green manured soil.

Activity of enzymes

Urease (EC 3.5.1.5)

An over view of the pattern indicated that the urease enzyme activity increased from transplanting to panicle initiation stage of rice in the *kharif* as well in *rabi* season during both the years at 0-15 cm depth (Table 6). This was followed by a steep fall at harvest stage of the crop. The application of 50 % recommended dose of fertilizers increased the activity of ammoniaat transplanting, panicle initiation and harvesting in *kharif* 2005-06. The amount of ammonia per gram soil per hour showed that the activity of urease was relatively

Table 7. Influence of integrated nutrient management treatments on urease activity (µg g^{-1} soil h^{-1}) in rice-rice cropping system at 15-30 cm.

Treatments	2005-06						2006-07					
	Transplanting		Panicle initiation		Harvesting		Transplanting		Panicle initiation		Harvesting	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
T_1	3.02	2.78	3.85	2.82	0.54	0.52	3.15	2.80	3.06	2.86	0.55	0.55
T_2	3.28	3.17	4.65	4.60	1.65	1.66	3.30	3.55	4.73	4.62	1.65	1.65
T_3	3.58	3.73	4.65	4.60	1.65	2.64	3.65	3.75	4.73	4.62	1.65	2.65
T_4	3.89	4.60	5.04	5.12	0.80	0.70	3.93	3.98	5.12	5.15	1.82	1.70
T_5	3.89	4.15	5.25	5.45	1.95	2.82	3.93	4.16	5.33	5.48	2.95	2.80
T_6	4.15	4.15	6.25	5.46	2.80	2.84	4.20	4.19	6.17	5.48	2.82	2.86
T_7	4.30	4.08	5.92	5.05	2.75	2.80	4.35	4.10	6.17	5.10	2.76	2.82
T_8	4.30	4.15	5.65	5.55	2.75	2.80	4.35	4.19	5.78	5.48	2.76	2.81
T_9	4.55	4.06	5.04	5.46	2.65	2.82	4.20	4.65	5.33	5.48	2.70	2.82
T_{10}	4.30	4.29	5.25	5.46	2.80	2.88	4.35	4.25	5.33	5.0	2.82	2.87
T_{11}	4.30	4.06	5.65	5.12	2.75	2.84	4.35	4.10	5.78	5.20	2.76	2.85
T_{12}	3.50	3.73	4.93	4.58	1.58	1.60	3.65	3.75	4.98	4.60	1.60	0.162
SE $\pm$	0.10	0.23	0.47	0.78	0.33	0.23	0.13	0.41	0.42	0.64	0.32	0.34
CD at 5 %	0.22	0.48	0.98	1.62	0.69	0.48	0.26	0.85	0.88	1.32	0.66	0.71

Table 8. Influence of integrated nutrient management treatments on acid phosphates activity (p – nitrophenol g^{-1} soil h^{-1}) at 0–15cm depth.

Treatments	2005-06						2006-07					
	Transplanting		Panicle initiation		Harvesting		Transplanting		Panicle initiation		Harvesting	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
T_1	55.20	54.41	30.00	29.51	44.58	41.36	56.17	55.98	30.51	28.72	44.55	54.44
T_2	93.42	92.24	46.85	44.58	81.20	80.21	94.80	93.38	47.46	44.58	80.32	81.20
T_3	91.23	93.20	46.85	44.58	80.32	79.56	92.58	92.58	47.75	44.58	81.20	84.55
T_4	95.54	96.38	47.21	45.27	84.55	79.56	94.80	93.20	48.84	45.27	84.55	85.34
T_5	96.36	96.38	48.88	44.58	86.63	84.54	95.72	94.51	48.33	44.58	85.34	84.55
T_6	125.40	122.82	68.28	66.30	110.26	109.40	126.35	125.40	69.25	65.55	110.26	109.40
T_7	126.50	123.51	66.85	66.30	114.00	113.52	127.38	126.50	67.40	65.55	113.52	112.16
T_8	113.52	112.28	48.88	47.21	91.26	90.61	114.00	114.00	49.36	46.85	92.58	91.64
T_9	114.00	113.52	50.05	48.88	93.42	90.61	115.46	114.00	51.28	47.21	93.42	92.58
T_{10}	114.46	113.52	54.26	53.25	96.63	95.35	115.46	114.00	54.90	52.75	96.63	95.72
T_{11}	115.75	114.00	55.61	52.40	95.40	94.72	116.28	115.41	55.44	51.28	95.54	94.80
T_{12}	95.48	95.48	47.12	46.85	84.55	82.22	95.55	94.25	48.12	45.27	85.34	84.55
SE $\pm$	10.1	8.7	5.8	4.7	5.2	9.8	12.1	10.7	6.4	7.2	6.3	5.1
CD at 5 %	20.9	18.0	12.0	9.7	10.7	20.3	25.0	22.2	13.2	14.9	13.0	10.6

Table 9. Influence of integrated nutrient management treatments on acid phosphatase activity (p–nitrophenol g $^{-1}$ soil h^{-1}) at 15–30 cm depth.

Treatments	2005-06						2006-07					
	Transplanting		Panicle initiation		Harvesting		Transplanting		Panicle initiation		Harvesting	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
T_1	50.57	51.32	28.32	29.51	51.32	51.32	50.51	51.32	26.26	27.16	36.70	38.12
T_2	84.55	85.34	40.45	45.70	74.26	75.57	80.32	83.57	37.61	38.51	60.15	61.72
T_3	85.34	86.63	39.60	40.45	74.26	75.57	80.32	81.57	37.61	38.51	60.15	60.45
T_4	86.63	87.72	41.70	42.50	74.26	75.57	80.32	81.57	39.78	39.82	60.15	60.45
T_5	86.63	87.72	42.50	42.50	75.57	76.82	84.55	84.55	39.78	40.26	65.11	66.25
T_6	110.26	111.46	60.26	61.62	91.26	94.58	93.42	94.80	51.32	52.71	71.25	72.61
T_7	112.16	113.52	61.62	62.30	94.80	95.54	90.129	92.58	50.57	52.71	72.61	73.19
T_8	98.80	100.62	58.35	59.15	90.12	92.58	86.29	88.45	49.66	51.72	74.38	74.38
T_9	97.26	100.62	55.75	56.63	86.29	87.56	84.55	86.54	48.44	50.57	73.19	74.38
T_{10}	98.80	100.62	56.63	56.63	88.58	89.37	82.60	84.55	47.62	49.66	72.61	73.19
T_{11}	96.63	98.80	55.25	56.63	87.56	88.58	83.45	85.32	47.62	48.44	71.25	72.61
T_{12}	85.34	84.55	40.45	41.20	74.26	75.57	80.32	81.20	39.75	40.25	68.25	69.12
SE $\pm$	10.2	10.4	4.5	3.9	4.8	5.9	3.6	4.5	3.1	2.9	3.4	3.2
CD at 5 %	21.1	21.6	9.3	8.09	9.9	12.2	7.5	9.3	6.4	6.0	7.0	6.6

Table 10. Influence of integrated nutrient management treatments on alkaline phosphatase activity (p nitrophenol g^{-1} soil h^{-1}) in rice-rice cropping system at 0-15 cm.

Treatments	2005-06						2006-07					
	Transplanting		Panicle initiation		Harvesting		Transplanting		Panicle initiation		Harvesting	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
T_1	91.12	90.80	59.05	58.75	97.05	93.40	95.42	92.45	60.70	59.00	98.25	94.00
T_2	135.14	134.25	64.58	64.72	125.00	124.50	136.26	134.25	65.00	64.00	125.60	124.50
T_3	130.25	134.25	64.58	64.72	125.00	124.50	131.45	130.00	65.00	64.00	125.60	124.00
T_4	138.68	138.00	65.22	64.72	126.35	124.50	139.67	135.00	65.00	64.00	140.35	138.46
T_5	140.57	138.00	66.98	66.30	130.00	128.50	141.51	138.00	67.50	66.25	131.44	130.25
T_6	190.05	189.38	102.45	101.50	182.62	180.64	191.45	192.6	105.75	162.75	183.19	180.25
T_7	200.10	198.25	114.90	113.45	190.00	189.29	200.98	198.15	115.75	114.54	191.36	190.15
T_8	161.28	160.25	68.28	67.50	10.75	106.28	161.37	160.00	68.75	68.00	111.35	110.20
T_9	166.75	165.25	79.49	78.50	135.97	135.28	167.84	161.75	80.30	79.25	136.85	134.58
T_{10}	165.95	166.99	80.50	84.12	112.80	111.50	165.25	164.25	85.25	84.50	133.82	130.28
T_{11}	170.00	170.00	80.16	84.55	135.80	134.25	171.25	168.25	85.25	84.50	133.25	130.28
T_{12}	140.50	140.00	66.15	65.45	120.30	119.25	141.48	140.00	67.50	66.00	121.34	120.45
SE $\pm$	14.56	13.80	11.62	9.40	11.40	14.27	15.15	13.30	5.10	6.83	12.92	11.65
CD at 5 %	30.21	28.62	24.10	18.80	23.60	29.60	30.30	27.60	10.58	14.17	26.80	24.18

Table 11. Influence of integrated nutrient management treatments on alkaline phosphatase activity (p nitrophenol g^{-1} soil h^{-1}) in rice-rice cropping system at 15-30 cm

Treatments	2005-06						2006-07					
	Transplanting		Panicle initiation		Harvesting		Transplanting		Panicle initiation		Harvesting	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
T_1	85.34	87.43	56.17	57.23	92.35	90.54	86.43	87.21	53.71	53.90	42.5.3	73.15
T_2	130.49	131.14	61.25	63.58	120.32	122.32	128.41	129.43	58.58	59.24	117.33	118.35
T_3	125.52	130.25	61.25	63.58	120.32	122.32	130.25	130.32	60.46	61.62	119.23	119.90
T_4	135.86	136.68	63.62	64.26	124.43	125.35	133.68	134.25	61.25	62.51	121.32	121.80
T_5	136.86	139.57	63.62	64.26	131.70	132.72	135.57	135.75	62.25	62.51	128.85	128.80
T_6	180.50	181.05	92.54	93.45	171.26	172.60	156.36	157.63	80.46	80.58	138.85	139.25
T_7	182.65	184.66	94.31	95.00	174.32	172.60	152.45	154.51	85.96	86.00	134.23	134.86
T_8	152.83	184.66	93.40	92.45	105.67	172.60	141.39	142.36	76.28	77.00	102.11	103.38
T_9	155.57	155.83	72.14	62.28	155.69	122.26	141.75	144.05	70.48	60.58	95.88	96.12
T_{10}	160.59	165.85	73.62	74.24	131.70	130.97	141.79	141.65	72.25	72.35	102.81	103.38
T_{11}	162.61	166.15	85.61	81.16	131.70	131.89	138.48	138.82	72.25	73.05	100.00	100.12
T_{12}	132.45	133.54	62.52	63.25	114.32	115.23	125.54	126.00	63.28	64.61	100.00	100.12
SE $\pm$	13.79	16.98	6.11	4.63	11.86	13.76	15.26	14.24	3.24	3.78	19.57	19.05
CD at 5 %	28.60	35.20	12.68	9.60	24.60	28.55	31.65	29.54	6.72	7.85	40.60	39.52

Table 12. Influence of integrated nutrient management treatments on dehydrogenase activity (µg TPF g^{-1} soil 24 h^{-1}) in rice-rice cropping system at 0-15 cm

Treatments	2005-06						2006-07					
	Transplanting		Panicle initiation		Harvesting		Transplanting		Panicle initiation		Harvesting	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
T_1	13.65	13.45	12.68	12.50	9.52	9.43	13.83	13.54	12.75	12.61	9.69	9.55
T_2	14.05	13.85	13.13	13.40	10.12	10.00	14.16	13.96	13.78	13.53	10.22	10.73
T_3	14.10	13.92	13.42	13.40	11.33	11.12	14.21	14.04	13.62	13.66	11.44	11.25
T_4	14.95	14.26	13.76	13.65	11.50	11.36	15.85	14.99	13.81	13.77	11.67	11.35
T_5	17.82	17.63	16.82	16.75	11.75	11.45	17.15	17.74	16.90	16.78	11.82	11.56
T_6	20.66	20.04	20.76	20.66	15.50	15.2	20.76	20.25	20.15	20.64	15.68	15.29
T_7	21.64	21.00	21.85	21.54	16.26	16.12	21.75	21.10	22.00	20.69	16.38	16.10
T_8	19.80	19.56	20.04	19.97	14.95	14.75	19.90	19.62	20.16	21.65	15.04	14.20
T_9	20.25	19.87	20.45	20.25	14.51	14.62	20.38	20.00	20.64	19.92	14.68	14.35
T_{10}	22.05	21.63	22.50	20.25	17.25	17.00	22.15	21.78	22.73	20.35	17.45	17.65
T_{11}	22.76	22.00	23.12	22.24	18.14	18.00	22.85	22.16	23.08	23.00	18.34	18.12
T_{12}	16.44	16.05	16.37	16.0	11.50	11.26	16.62	16.10	16.05	16.15	11.41	11.28
SE $\pm$	1.67	2.21	2.58	2.39	1.57	1.66	1.37	1.55	2.34	1.68	1.08	1.01
CD at 5 %	3.46	4.58	5.36	4.85	3.26	3.44	2.84	3.21	4.85	3.49	2.25	2.10

low at the lower depth of 15-30 than the top 0-15 cm depth of the soil in all the treatments (Table 7). The application of different proportions of recommended dose of fertilizers and that adopted by the farmers enhanced the urease enzyme activity consistently at the transplanting and panicle initiation stage of the crop in *kharif* as well as *rabi* seasons during the two years. The influence of integrated nutrient management supply by substituting 25 or 50 % N recommended fertilizer was not consistently superior to the effect of fertilizers at every stage of crop growth during the two years.

Phosphomonoesterases

Acid phosphatase (EC 3.1.3.2)

The activity of *p* nitrophenol per g soil h^{-1} was very low in the unfertilized soil (Table 8). The application of different proportions of recommended fertilizer dose or that adopted by the farmers significantly increased the activity of this enzyme at every stage of observation in *kharif* and *rabi* during 2005-06 and 2006-07. The integrated nutrient management by the substitution of 50 % N fertilizer through FYM and application of 50 % recommended fertilizers in *kharif* followed by the application of recommended dose of fertilizers in *rabi* season further increased the enzyme activity significantly more than the fertilizers. The release of *p* nitro phenol g^{-1} soil h^{-1} was much less in the 15 – 30 cm soil depth (Table 9) than in the upper surface layer irrespective of treatments, season or year of the study. The substitution of 50 or 25 % N fertilizers with FYM in *kharif* season was the most outstanding treatment.

Alkaline phosphatase (EC 3.1.3.1)

The activity of alkaline phosphatase reduced abrupt at panicle initiation than at transplanting and harvesting stage of rice both in *kharif* and *rabi* seasons in two years (Table 10). Activity of alkaline phosphatase was significantly low in unfertilized soil at transplanting, panicle initiation and harvesting stage of rice in *kharif* 2005 in contrast to the high activity in the soil fertilized with 50 % recommended dose of nutrients. Among the three organic sources of nutrients, FYM was very effective. The substitution of 50 % N fertilizer with this organic manure significantly increased the activity of alkaline phosphatase enzyme. The enzyme alkaline phosphatase was less active in the 15-30 than 0-15 cm soil depth with no regard to the stage of crop growth, season or year (Table 11).

Table 13. Influence of integrated nutrient management treatments on dehydrogenase activity ($\mu g\ g^{-1}$ soil 24 h^{-1}) in rice-rice cropping system at 15-30 cm.

Treatments	2005-06						2006-07					
	Transplanting		Panicle initiation		Harvesting		Transplanting		Panicle initiation		Harvesting	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
T_1	12.00	11.80	12.05	12.00	9.05	8.15	12.56	11.90	12.75	12.15	9.80	8.20
T_2	13.50	13.06	13.75	3.28	9.58	9.08	14.10	13.12	14.25	13.35	10.58	9.12
T_3	13.58	13.08	13.80	13.28	1065	10.00	14.18	13.22	14.38	13.60	11.38	10.12
T_4	13.90	1.25	14.15	13.22	10.74	10.00	14.30	13.22	14.58	13.60	11.38	10.12
T_5	16.15	15.88	17.27	16.09	10.56	10.15	16.70	15.91	17.12	16.00	11.38	10.18
T_6	18.26	17.88	19.20	18.15	14.30	12.50	18.81	17.83	19.25	18.25	15.00	13.55
T_7	19.14	18.00	20.30	18.26	14.45	13.96	19.75	58.11	20.15	18.28	15.00	13.55
T_8	18.63	18.15	19.35	18.31	13.85	12.98	19.15	18.15	19.80	18.25	14.28	13.55
T_9	18.75	20.00	19.45	18.46	13.35	15.83	19.35	18.26	20.15	18.25	14.28	15.80
T_{10}	20.80	20.50	21.30	20.35	16.50	15.97	21.35	20.10	22.14	20.48	17.05	16.15
T_{11}	21.25	20.50	22.18	20.78	16.25	15.97	22.00	20.50	22.50	20.45	17.05	16.15
T_{12}	15.25	14.50	16.12	14.68	10.61	10.12	16.00	14.50	26.50	14.25	11.38	10.00
SE $\pm$	0.60	0.52	0.46	0.42	0.81	0.75	0.64	0.89	0.80	0.65	0.89	1.02
CD at 5 %	1.24	1.08	0.96	0.87	1.68	1.56	1.32	1.85	1.66	1.35	1.85	2.12

The treatment effects were significant and followed similar trend to that of upper layer.

Dehydrogenase (EC 1.1.1.1)

The increase in the activity of dehydrogenase enzyme detected in the fertilized than the unfertilized soil was not significant at transplanting, panicle initiation and harvesting of rice – rice cropping system during 2005-06 (Table 12). However, the substitution of N fertilizer with FYM, paddy straw or *Glyricidia* and the application of recommended dose of fertilizers significantly increased the activity of dehydrogenase as compared to the unfertilized soil continuously during the two cycles of rice-rice cropping system. The best organic source to improve the dehydrogenase activity both in the top and lower layer of the soil was *Glyricidia.* It was relatively low in the 15-30 cm depth than in the top with no regard to the treatment, season or year of the experiment (Table 13) and followed the trend as of top layer. The dehydrogenase activity was not promoted by the application of different levels of fertilizers in the top layer. The decrease in dehydrogenase activity by chemical fertilization may be due to poor physical conditions and lack of organic substrates in soils.

Conclusion

In general, the effect of different integrated nutrient management treatments did not increase the microbial biomass significantly over the complete reliance on fertilizing the crop with optimum nutrient requirement. The influence of FYM, paddy straws as well as *glyricidia* was superior on enzymatic activity when combined with fertilizers.

LITERATURE CITED

Casida L E, Klein D A and Santro J 1964 Soil dehydrogenase activity. *Sol Science,* 98: 371-376

Kang G S, Beri V, Sindhu B S and Rupela O P 2005 A new index to assess soil quality and Sustainability of wheat-based cropping systems. *Bio Fertile Soils,* 41: 389-398.

Jaggi W 1976 Die Bestinmmung der CO_2 – Bilding als MaB der bodenbiolgischen Aktivitat. *Schw Landw Forsch,* 15: 371-380.

Saha N, Das A C and Mukherjee D 1995 Effect of decomposition of organic matter on the activities of microorganism and avalibility of nitrogen, phosphorous and sulphur in soil. *Journal of the Indian Society of Soil Science,* 43(2): 210-215.

Selvi D, Santhy P, Dhakhinamoothy M and Maheswari M 2004 Microbial population and biomass on Rhizosphere as influenced by continuous intensive cultivation and fertilization in an inceptisol. *Journal of the Indian Society of Soil Science,* 52 (3): 254-257

Sharma A C and Bordoloi P K 1994 Decomposition of organic matter in soils in relation to mineralization of carbon and nutrient availability. *Journal of the Indian Society of Soil Science,* 42 (2):199-203.

Sharma M P and Gupta J P 1998 Effect of organic materials on yields and soil properties in maize – wheat cropping system. *Indian Journal of Agricultural Sciences,* 68(11): 715-717.

Sparling G P and West A W 1988 A direct extraction method to estimate soil microbial biomass in soils following recent additions of wheat straw and characterization of the biomass that develops. *Soil Biology and Biochemistry,* 22: 685-694.

Tabatabai M A and Bremner J M 1969 Use of P nitro phenyl phosphate for assay of soil Phosphatase activity. *Soil biology and Biochemistry,* 1: 301-307.

Tabatabai M A and Bremner J M 1972 Assay of urease activity in soils. *Soil Biology and Biochemistry,* 4: 479-487.

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