Effect of Organic Manures and Fertilizers on Soil Enzymatic Activities

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(Received: 29 November 2014; accepted: 09 January 2015)

The field experiment was undertaken to investigate the long-term application of manures and fertilizers on soil microbial communities and their biological activities in the rhizosphere and bulk soil. The research was conducted at ZARS, GKVK, Bangalore. There were 10 treatments and three replications in an RCBD design. Soil enzyme activities *viz*., dehydrogenases, acid and alkaline phosphatases and urease activities were found to be significantly higher in the treatment with application of 20t of FYM ha^{-1} compared to recommended NPK alone.

Key words: Organic manures, Fertilizers, Dehydrogenase, Acid and alkaline phosphatase and urease.

Soil is a living system and has to be managed in agriculture to improve sustainability. Soil health is commonly used in a broader sense to indicate the capacity of soil to function as a vital living system to sustain biological productivity, promote environmental quality and maintain plant and animal health (Doran and Zeiss, 2000).

Soil organic matter dynamics play a major role in natural ecosystems and extensive agriculture. In intensive agricultural systems with high fertilization rates, the various organic components have potential for acting as a temporary nutrient reservoir. Organic matter is an indispensable component of soil and plays an important role in the maintenance and improvement of soil fertility and productivity. The proper management of this reservoir should make it possible to increase the efficiency of use of both soil and fertilizer nutrients. The active soil organic component comprises of soil microbial biomass and microbial metabolites and recently added labile organic inputs. Soil amendments presents a comprehensive and balanced synthesis of current knowledge pertaining to the environmental effects of soil amendments on various biotic systems, including crops,livestock,wildlife, forestry*etc*.

The plant roots provide an ecological niche for many soil microorganisms that abound soil. Carbon input by plants into soil through rhizodeposition is the primary source of soil organic matter. These exuded organic substances induce fast carbon turnover in the vicinity of the roots. The rhizosphere microorganisms utilize these substances as easily available carbon and energy sources for fast growth and reproduction. This increase in population results in increased soil microbial biomass, a temporary reservoir of labile nutrients. Further, increase in various other biological activities such as enzyme activities, mineralization capabilities, rate of nitrification, microbial diversity *etc*., will have influence on soil

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fertility. These biological parameters can also be used as effective indicators for assessing long-term soil and crop management effects on soil quality (Kaur*et al*., 2005). Keeping these points in view an attempt was made to study the influence of long term application of organic manures and fertilizers on soil enzymes activity.

MATERIALS AND METHODS

The experiment was conducted to study the effect of long-term application of manures and fertilizers on soil microbial communities and their biological activities in the rhizosphere and bulk soil. The soils were collected from the research plots applied with organic manures and fertilizers at ZARS, UAS, GKVK, Bangalore. The soil samples were air dried in shade, passed through two mm sieve and subjected to biochemical analysis in the laboratory of the Department of Agricultural Microbiology, UAS, GKVK, Bangalore.

Treatment details

1. 5t of FYM
2. 10t of FYM
3. 10t of FYM (partially decomposed)
4. 10t of FYM + mulching (glyricidia 2 t ha-1)
5. 20t of FYM
6. 17.5t of FYM + 25% rec. NPK
7. 15t of FYM + 50% rec. NPK
8. 12.5t of FYM + 75% rec.NPK
9. Rec. NPK + rec. FYM + phorate + herbicide + fungicide
10. Rec. NPK

Note:

Rec.NPK- 25:60:25 Kg/ha
Rec. FYM- 10t ha^{-1}
Phorate 10G @ 1Kg a.i ha^{-1}
Herbicide-Lasso 50 EC@2.5 l ha^{-1}
Fungicide seed treatment (**Thiram + Bavistin - each 2g kg^{-1} of seeds**).
Rhizobium seed treatment common to all plots
Replications : 3
Crop : Soybean
Plot size : 6 õ 3.6 m
Spacing : 30 õ 10 cm
Variety : MAUS-2
Design : RCBD

Soil biochemical analysis

Dehydrogenase activity

The dehydrogenase activity was determined by the procedure as given by Casida *et al*. (1964).

Acid and alkaline phosphatase activity

The acid and alkaline phosphatase activities were estimated as per the procedure given by Eivazi and Tabatabai (1977).

Urease activity

The urease activity was determined by following the method outlined by Eivazi and Tabatabai (1977).

RESULTS AND DISCUSSION

Dehydrogenase activity

The dehydrogenase activity as influenced by the long-term application of manures and fertilizers in the rhizosphere and bulk soils is presented in table-1. The dehydrogenase activity was found to be significantly higher due to the application of 20t of FYM ha^{-1}(90.30 mg TPF g^{-1} soil day^{-1}) before sowing as compared to all other treatments. However, it was on par with the application of 17.5t of FYM + 25% rec. NPK (87.83mg TPF g^{-1} soil day^{-1}), 15t of FYM + 50% rec. NPK (86.75mg TPF g^{-1} soil day^{-1}),12.5t FYM + 75% rec. NPK (85.34mg TPF g^{-1} soil day^{-1} respectively)andrec. NPK + rec. FYM + phorate + herbicide + fungicide (83.51 mg TPF g^{-1} soil day^{-1}).The least dehydrogenase activity (58.57mg TPF g^{-1} soil day^{-1}) was noticed due to the application of rec. NPK.

The application of 20t of FYM ha^{-1} at 45 DAS recorded significantly higher dehydrogenase activity in the rhizosphere and non-rhizosphere soils (520.17mg TPF g^{-1} soil day^{-1} and 410.33mg TPF g^{-1} soil day^{-1}respectively). It was found to be on par with the application of17.5t FYM + 25% rec. NPK (499.06mg TPF g^{-1} soil day^{-1} and 402.37mg TPF g^{-1} soil day^{-1} respectively), 15t of FYM + 50% rec. NPK (496.77mg TPF g^{-1} soil day^{-1} and 397.00 mg TPF g^{-1} soil day^{-1} respectively), 12.5t of FYM + 75% rec. NPK (494.67 and 393.63 mg TPF g^{-1} soil day^{-1} respectively) and rec. NPK + rec. FYM + phorate + herbicide + fungicide (492.70 mg TPF g^{-1} soil day^{-1} and 391.23 mg TPF g^{-1} soil day^{-1}) respectively. The lowest dehydrogenase activity (160.43mg TPF g^{-1} soil day^{-1} and 110.30 mg TPF g^{-1} soil day^{-1}) was found with rec. NPK.

The dehydrogenase activity in the rhizosphere and non-rhizosphere soils at harvest

Table 1. Effect of organic manures and fertilizers on dehydrogenase activity (mg TPF g^{-1} soil day^{-1})

Treatments	Before sowing	45 DAS		At harvest	
		Rhizosphere	Non Rhizosphere	Rhizosphere	Non Rhizosphere
T1. 5t of FYM	60.40^{c}	209.87^{d}	180.33^{d}	134.13^{d}	98.53^{d}
T2. 10t of FYM	67.65^{b}	307.70^{bc}	279.47^{b}	207.53^{b}	158.77^{b}
T3. 10t of FYM (Partially decomposed)	65.47^{bc}	280.27^{c}	222.67^{c}	172.40^{c}	120.63^{c}
T4. 10t of FYM + Mulching (Glyricidia 2 t ha^{-1})	68.47^{b}	312.27^{b}	282.32^{b}	212.50^{b}	160.60^{b}
T5. 20t of FYM	90.30^{a}	520.17^{a}	410.33^{a}	390.53^{a}	296.37^{a}
T6. 17.5t of FYM + 25% rec. NPK	87.83^{a}	499.06^{a}	402.37^{a}	379.87^{a}	285.53^{a}
T7. 15t of FYM + 50% rec. NPK	86.75^{a}	496.77^{a}	397.00^{a}	376.10^{a}	282.40^{a}
T8. 12.5t of FYM + 75% rec. NPK	85.34^{a}	494.67^{a}	393.63^{a}	375.57^{a}	280.50^{a}
T9. Rec. NPK + rec. FYM + Phorate + Herbicide + Fungicide	83.51^{a}	492.70^{a}	391.23^{a}	372.13^{a}	278.23^{a}
T10. Rec. NPK	58.57^{c}	160.43^{e}	110.30^{e}	120.53^{d}	92.80^{d}
SEM±	2.33	9.90	6.62	6.63	6.55
CD at 5%	6.93	29.40	19.65	19.68	19.45

Table 2. Effect of organic manures and fertilizers on acid phosphatase activity in soil (g PNP g^{-1} soil)

Treatments	Before sowing	45 DAS		At harvest	
		Rhizosphere	Non Rhizosphere	Rhizosphere	Non Rhizosphere
T1. 5t of FYM	10.73^{c}	18.92^{c}	12.99^{c}	17.65^{c}	11.86^{c}
T2. 10t of FYM	16.17^{b}	28.27^{b}	18.67^{b}	22.23^{b}	18.30^{b}
T3. 10t of FYM (Partially decomposed)	14.50^{b}	20.60^{c}	15.70^{bc}	19.81^{bc}	13.63^{bc}
T4. 10t of FYM + Mulching (Glyricidia 2 t ha^{-1})	16.57^{b}	28.95^{d}	19.07^{b}	23.22^{b}	18.63^{b}
T5. 20t of FYM	29.40^{a}	43.03^{a}	34.61^{a}	36.93^{a}	32.57^{a}
T6. 17.5t of FYM + 25% rec. NPK	27.20^{a}	42.27^{a}	32.36^{a}	35.66^{a}	31.44^{a}
T7. 15t of FYM + 50% rec. NPK	26.80^{a}	40.24^{a}	32.16^{a}	35.55^{a}	29.10^{a}
T8. 12.5t of FYM + 75% rec. NPK	26.23^{a}	39.21^{a}	30.90^{a}	34.12^{a}	28.31^{a}
T9. Rec. NPK + rec. FYM + Phorate + Herbicide + Fungicide	26.20^{a}	39.03^{a}	30.14^{a}	33.60^{a}	26.53^{a}
T10. Rec. NPK	8.40^{c}	14.47^{d}	11.50^{c}	13.77^{d}	9.96^{c}
SEM±	1.08	1.36	1.75	1.32	2.05
CD at 5%	3.22	4.05	5.19	3.92	6.08

Note: Rec. NPK- 25:60:25 Kg ha^{-1}, Rec. FYM- 10t ha^{-1}, Phorate 10G @ 1Kg a.i ha^{-1}, Herbicide-Lasso 50 EC@2.5 l ha^{-1}, Fungicide seed treatment (Thiram + Bavistin - each 2g kg^{-1} of seeds), *Rhizobium* seed treatment common to all plots.

was found to be significantly higher due to the application of 20t of FYM ha^{-1}(390.53mg TPF g^{-1} soil day^{-1} and 296.37mg TPF g^{-1} soil day^{-1} respectively) compared to all other treatments. However, it was on par with the application of 17.5t of FYM + 25% rec. NPK (379.87mg TPF g^{-1} soil day^{-1} and 285.53mg TPF g^{-1} soil day^{-1}), 15t of FYM + 50% rec. NPK (376.10mg TPF g^{-1} soil day^{-1} and 282.40 mg TPF g^{-1} soil day^{-1}) and 12.5t of FYM + 75% rec. NPK (375.57mg TPF g^{-1} soil day^{-1} and 280.50 mg TPF g^{-1} soil day^{-1}) and rec. NPK + rec. FYM + phorate + herbicide + fungicide (372.13 mg TPF g^{-1} soil day^{-1} and 278.23 mg TPF g^{-1} soil day^{-1}) respectively in the rhizosphere and non-rhizosphere soils. The lowest activity was found to be with rec. NPK (120.53mg TPF g^{-1} soil day^{-1} and 92.80 mg TPF g^{-1} soil day^{-1}).

In the present study, the dehydrogenase activity was found to be highest due to the application 20t of FYM ha^{-1}. The activity of dehydrogenases is considered as an indicator of the oxidative metabolism in soils and thus of the microbiological activity. The dehydrogenase activity in soil reflects the functioning of microbial redox systems that are involved in the oxidation of soil organic matter. Hence, it has been frequently used for assessing management influences on soil quality (Gil-sotres*et al*., 2005). The dehydrogenase activity is thought to reflect the total range of oxidative activity of soil microflora and may be a good indicator of microbial activity (Nannipieri*et al*., 1990).

Acid phosphatase activity

The influence of long-term application of manures and fertilizers on acid phosphatase activity in the rhizosphere and bulk soils is presented in table-2. The acid phosphatase activity was found to be significantly higher due to the application of 20t of FYM ha^{-1} (29.40 mg PNP g^{-1} soil) before sowing compared to all other treatments. It was on par with the application of 17.5t of FYM + 25% rec. NPK(27.20mg PNP g^{-1} soil), 15t of FYM + 50% rec. NPK (26.80mg PNP g^{-1}soil), 12.5t of FYM + 75% rec. NPK (26.23mg PNP g^{-1} soil) and rec. NPK + rec. FYM + phorate + herbicide + fungicide (26.20 mg PNP g^{-1} soil respectively). The least acid phosphatase activity was found to be in control treatment with rec. NPK (8.40mg PNP g^{-1} soil).

The acid phosphatase activity was found to be significantly higher at 45 DAS in the application of 20t of FYM ha^{-1}(43.03mg PNP g^{-1} soil and 34.61mg PNP g^{-1} soil)in the rhizosphere soil compared to non-rhizosphere soil respectively compared to all other treatments. However, it was on par with the application of 17.5t of FYM + 25% rec. NPK (42.27mg PNP g^{-1} soil and 32.36mg PNP g^{-1} soil), 15t of FYM + 50% rec. NPK (40.24mg PNP g^{-1} soil and 32.16mg PNP g^{-1} soil), 12.5t of FYM + 75% rec. NPK (39.21mg PNP g^{-1} soil and 30.90 mg PNP g^{-1} soil) and rec. NPK + rec. FYM + phorate + herbicide + fungicide (39.03 mg PNP g^{-1} soil and 30.14 mg PNP g^{-1} soil) respectively in both rhizosphere and non- rhizosphere soils. The lowest acid phosphatase was recorded in control treatment with rec. NPK (14.47mg PNP g^{-1} soil and 11.50 mg PNP g^{-1} soil).

The acid phosphatase activity as found to be significantly higher at harvest due to the application of 20t of FYM ha^{-1} in the rhizosphere soil (36.93mg PNP g^{-1} soil) compared to non-rhizosphere soil (32.57mg PNP g^{-1} soil) respectively compared to all other treatments. It was on par with the application of 17.5t of FYM + 25% rec. NPK (35.66mg PNP g^{-1} soil and 31.44mg PNP g^{-1} soil), 15t of FYM + 50% rec. NPK (35.55mg PNP g^{-1} soil and 29.10 mg PNP g^{-1} soil), 12.5t of FYM + 75% rec. NPK (34.12mg PNP g^{-1} soil and 28.31 mg PNP g^{-1} soil) and rec. NPK + rec. FYM + phorate + herbicide + fungicide (33.60 mg PNP g^{-1} soil and 26.53 mg PNP g^{-1} soil respectively) in both rhizosphere and non-rhizosphere soils. The least acid phosphatase activity was found in the treatment with rec. NPK in both rhizosphere and non-rhizosphere soils (13.77mg PNP g^{-1} soil and 9.96 mg PNP g^{-1} soil respectively).

Alkaline phosphatase activity

The alkaline phosphatase activity as influenced by the long-term application of manures and fertilizers in the rhizosphere and bulk soils is presented in table-3. The alkaline phosphatase activity was found to be significantly higher due to the application of 20t of FYM ha^{-1} (13.00 mg PNP g^{-1} soil) before sowing compared to all other treatments. However, it was on par with the application of 17.5t of FYM + 25% rec. NPK, (12.43mg PNP g^{-1} soil), 15t of FYM + 50% rec. NPK (12.03mg PNP g^{-1} soil), 12.5t of FYM + 75% rec. NPK (11.33mg PNP g^{-1} soil) and rec. NPK + rec.

Table 3. Effect of organic manures and fertilizers on alkaline phosphatase activity (g PNP g^{-1} soil)

Treatments	Before sowing	45 DAS		At harvest	
		Rhizosphere	Non Rhizosphere	Rhizosphere	Non Rhizosphere
T1. 5t of FYM	6.87^{bc}	14.57^{c}	13.77^{cd}	13.96^{cd}	9.90^{bc}
T2. 10t of FYM	8.34^{bc}	19.47^{b}	18.17^{b}	17.22^{bc}	10.86^{bc}
T3. 10t of FYM (Partially decomposed)	7.50^{bc}	16.74^{bc}	15.57^{bc}	15.69^{bc}	10.31^{bc}
T4. 10t of FYM + Mulching (Glyricidia 2 t ha^{-1})	8.48^{b}	19.87^{b}	18.94^{b}	17.87^{b}	11.57^{b}
T5. 20t of FYM	13.00^{a}	31.23^{a}	26.73^{a}	24.73^{a}	15.77^{a}
T6. 17.5t of FYM + 25% rec. NPK	12.43^{a}	30.73^{a}	26.01^{a}	23.58^{a}	14.62^{a}
T7. 15t of FYM + 50% rec. NPK	12.03^{a}	30.00^{a}	24.62^{a}	22.93^{a}	14.24^{a}
T8. 12.5t of FYM + 75% rec. NPK	11.33^{a}	29.77^{a}	24.30^{a}	21.40^{a}	13.90^{a}
T9. Rec. NPK + rec. FYM + Phorate + Herbicide + Fungicide	11.00^{a}	27.80^{a}	23.32^{a}	21.33^{a}	13.80^{a}
T10. Rec. NPK	6.23^{c}	13.33^{c}	11.40^{d}	10.70^{d}	9.07^{c}
SEM±	0.68	1.30	1.16	1.16	0.66
CD at 5%	2.03	3.86	3.45	3.43	1.97

Table 4. Effect of organic manures and fertilizers on urease activity (g NH_4 -1 g^{-1} soil $2hr^{-1}$)

Treatments	Before sowing	45 DAS		At harvest	
		Rhizosphere	Non Rhizosphere	Rhizosphere	Non Rhizosphere
T1. 5t of FYM	70.75^{c}	114.75^{cd}	87.44^{bc}	104.93^{bc}	81.54^{cd}
T2. 10t of FYM	77.80^{b}	127.44^{bc}	95.19^{bc}	111.44^{bc}	88.62^{bc}
T3. 10t of FYM (Partially decomposed)	76.53^{b}	118.47^{bcd}	90.60^{bc}	107.83^{bc}	85.49^{bc}
T4. 10t of FYM + Mulching (Glyricidia 2 t ha^{-1})	78.31^{b}	131.24^{b}	96.95^{b}	114.81^{b}	90.95^{b}
T5. 20t of FYM	90.60^{a}	173.13^{a}	123.77^{a}	154.75^{a}	111.54^{a}
T6. 17.5t of FYM + 25% rec. NPK	90.31^{a}	169.74^{a}	121.93^{a}	147.41^{a}	109.10^{a}
T7. 15t of FYM + 50% rec. NPK	88.29^{a}	167.35^{a}	116.85^{a}	146.73^{a}	108.83^{a}
T8. 12.5t of FYM + 75% rec. NPK	86.51^{a}	163.35^{a}	114.28^{a}	144.50^{a}	106.19^{a}
T9. Rec. NPK + rec. FYM + Phorate + Herbicide + Fungicide	86.47^{a}	159.08^{a}	113.63^{a}	143.42^{a}	104.99^{a}
T10. Rec. NPK	62.47^{d}	108.45^{d}	83.98^{c}	98.85^{c}	74.86^{d}
SEM±	1.41	4.99	3.76	4.47	2.46
CD at 5%	4.19	14.82	11.16	13.27	7.32

Note: Rec. NPK- 25:60:25 Kg ha^{-1}, Rec. FYM- 10t ha^{-1}, Phorate 10G @ 1Kg a.i ha^{-1}, Herbicide-Lasso 50 EC@2.5 l ha^{-1}, Fungicide seed treatment (Thiram + Bavistin - each 2g kg^{-1} of seeds), *Rhizobium* seed treatment common to all plots.

FYM + phorate + herbicide + fungicide (11.00 mg PNP g^{-1} soil respectively). The lowest alkaline phosphatase activity was found to be in the treatment with rec. NPK (6.23mg PNP g^{-1} soil).

The application of 20t FYM ha^{-1} at 45 DAS recorded significantly higher alkaline phosphatase activity in the rhizosphere and non-rhizosphere soils (31.23mg PNP g^{-1} soil and 26.73mg PNP g^{-1} soil respectively). However, it was on par with the application of 17.5t of FYM + 25% rec. NPK (30.73mg PNP g^{-1} soil and 26.01mg PNP g^{-1} soil), 15t of FYM + 50% rec. NPK (30.00mg PNP g^{-1} soil and 24.62mg PNP g^{-1} soil), 12.5t of FYM + 75% rec. NPK (29.77mg PNP g^{-1} soil and 24.30mg PNP g^{-1} soil) and rec. NPK + rec. FYM + phorate + herbicide + fungicide (27.80 mg PNP g^{-1} soil and 23.32 mg PNP g^{-1} soil respectively) in both rhizosphere and non rhizosphere soils. The least alkaline phosphatase activity was found in control treatment with rec. NPK (13.33mg PNP g^{-1} soil, 11.40mg PNP g^{-1} soil.

The alkaline phosphatase activity at harvest in the rhizosphere and non-rhizosphere soils was found to be significantly higher due to application of 20t FYM ha^{-1}(24.73mg PNP g^{-1} soil and 15.77 mg PNP g^{-1} soilin the rhizosphere soil compared to non-rhizosphere soil respectively compared to all other treatments. It was on par with 17.5t of FYM + 25% rec. NPK (23.58mg PNP g^{-1} soil and 14.62mg PNP g^{-1} soil), 15t of FYM + 50% rec. NPK (22.93mg PNP g^{-1}soil and 14.24 mg PNP g^{-1} soil), 12.5t of FYM + 75% rec. NPK (21.40mg PNP g^{-1} soil and 13.90 mg PNP g^{-1} soil) and rec. NPK + rec. FYM + phorate + herbicide + fungicide (21.33 mg PNP g^{-1} soil and 13.80mg PNP g^{-1} soil respectively in both rhizosphere and non-rhizosphere soils. The lowest alkaline phosphatase activity was found due to application of rec. NPK (10.70mg PNP g^{-1} soil and 9.07 mg PNP g^{-1} soil).

The highest activity of phosphatases was found to be due to the application of organic manures. The phosphatases are important, because they provide P for plant uptake by releasing PO_4 from immobile organic P. The acid phosphatase activity was much higher than alkaline phosphatase activity for all the treatments, which may be due to the acidic reaction of these soils. Both the acid and alkaline phosphatase activities were higher under FYM applied plots and least in the rec. NPK. Increased phosphatase activity could be responsible for the hydrolysis of organically bound phosphate into free ions, which are then taken up by plants. The plants utilize organic P fractions from the soil by the phosphatase activity enriched in the soil–root interface (Yosefi*et al*., 2011). This suggests that the increased phosphatase activity in the treatment with FYM application increased the available-P content in soils in the present study.

Urease activity

The effect of long-term application of manures and fertilizers on urease activity in the rhizosphere and bulk soils is presented in table-4. The urease activity was found to be significantly higher due to the treatment 20t of FYM ha^{-1} (90.60 mg NH_4^{-1} g^{-1} soil $2hr^{-1}$) before sowing compared to all other treatments. It was on par with the application of 17.5t of FYM + 25% rec. NPK (90.31mg NH_4^{-1} g^{-1} soil $2hr^{-1}$), 15t of FYM + 50% rec. NPK (88.29mg NH_4^{-1} g^{-1} soil $2hr^{-1}$), 12.5t of FYM + 75% rec. NPK (86.51mg NH_4^{-1} g^{-1} soil $2hr^{-1}$) and rec. NPK + rec. FYM + phorate + herbicide + fungicide (86.47 mg NH_4^{-1} g^{-1} soil $2hr^{-1}$) respectively. The least urease activity was found to be in control treatment with rec. NPK (62.47mg NH_4^{-1} g^{-1} soil $2hr^{-1}$).

At 45 DAS, the urease activity in the rhizosphere and non-rhizosphere soils was found to be significantly higher due to the application of 20t of FYM ha^{-1}(173.13mg NH_4^{-1} g^{-1} soil $2hr^{-1}$ and 123.77mg NH_4^{-1} g^{-1} soil $2hr^{-1}$ respectively) compared to all other treatments. However, it was on par with 17.5t of FYM + 25% rec. NPK (169.74mg NH_4^{-1} g^{-1} soil $2hr^{-1}$ and 121.93mg NH_4^{-1} g^{-1} soil $2hr^{-1}$),15t of FYM + 50% rec. NPK (167.35mg NH_4^{-1} g^{-1} soil $2hr^{-1}$ and 116.85mg NH_4^{-1} g^{-1} soil $2hr^{-1}$), 12.5t of FYM + 75% rec. NPK (163.35mg NH_4^{-1} g^{-1} soil $2hr^{-1}$ and 114.28mg NH_4^{-1} g^{-1} soil $2hr^{-1}$) and rec. NPK + rec. FYM + phorate + herbicide + fungicide (159.08 mg NH_4^{-1} g^{-1} soil $2hr^{-1}$ and 113.63 mg NH_4^{-1} g^{-1} soil $2hr^{-1}$) respectively in both rhizosphere and non-rhizosphere soils. The least urease activity was due to the application of rec. NPK (108.45mg NH_4^{-1} g^{-1} soil $2hr^{-1}$ and 83.98mg NH_4^{-1} g^{-1} soil $2hr^{-1}$).

The urease activity in the rhizosphere and non-rhizosphere soils at harvest was found to be significantly higher due to the treatment which received 20t of FYM ha^{-1}(154.75mg NH_4^{-1} g^{-1} soil $2hr^{-1}$ and 111.54 mg NH_4^{-1} g^{-1} soil $2hr^{-1}$respectively) compared to all other treatments. It was on par with the application of 17.5t of FYM + 25% rec. NPK (147.41mg NH_4^{-1} g^{-1} soil $2hr^{-1}$ and 109.10mg NH_4^{-1} g^{-1} soil $2hr^{-1}$),15t of FYM + 50% rec. NPK (146.73mg NH_4^{-1} g^{-1} soil $2hr^{-1}$ and 108.83 mg NH_4^{-1} g^{-1} soil $2hr^{-1}$), 12.5t of FYM + 75% rec. NPK (144.50mg NH_4^{-1} g^{-1} soil $2hr^{-1}$ and 106.19 mg NH_4^{-1} g^{-1} soil $2hr^{-1}$) and rec. NPK + rec. FYM + phorate + herbicide + fungicide (143.42 mg NH_4^{-1} g^{-1} soil $2hr^{-1}$ and 104.99 mg NH_4^{-1} g^{-1} soil $2hr^{-1}$) respectively in both rhizosphere and non-rhizosphere soils. The least activity was found in control treatment with rec. NPK (98.85mg NH_4^{-1} g^{-1} soil $2hr^{-1}$ and 74.86 mg NH_4^{-1} g^{-1} soil $2hr^{-1}$).

The urease activity was found to be significantly higher in FYM applied treatments. Similar increase in urease activity due to amendment of cowdung, farm residues and green manure crops like sesbania has been reported by (Chakrabarti*et al*., 2000). Dilly *et al*. (2007) reported that addition of soil with organic N stimulated the heterotrophic microbial activity resulting in the activity of hydrolytic enzymes.

Smith and Powlson (2003) also reported that the presence of readily-available organic N (manure) stimulated the urease activity. These results uphold the observations in this study. Further, the least urease activity was due to the application of rec. NPK.

REFERENCES

1. Casida, L. E., D. A. Klein and T. Santro, Soil dehydrogenase activity. *Soil Sci*., 1964; **98**: 371-376.
2. Chakrabarti, K., Sarkar, B., Chakraborty, A., Banik P. and Bagchi, D. K., Organic recycling for soil quality conservation in a sub-tropical plateau region.*J. Agron. Crop Sci*., 2000; **184**: 137-142.
3. Dilly, O., Munch J. C. and Pfeiffer, E. M., Enzyme activities and litter decomposition in agricultural soils in northern, central, and southern Germany.*J. Plan. Nutri. Soil Sci*., 2007; **170**: 197–204.
4. Doran, J. W. and Zeiss, M. R., Soil health and sustainability: managing the biotic component of soil quality. *Appl. Soil Ecol.*, 2000; **15**: 3–11.
5. Eivazi, F. and Tabatabai, M.A., Phosphates in soils. *Soil Biol. Biochem*., 1977; **9**: 167–172.
6. Gil-sotres, F., Trasar-cepeda, C., Leirós, M. C. and Seoane, S., Different approaches to evaluating soil quality using biochemical properties. *Soil Biol. Biochem*., 2005; **37**: 877–887.
7. Kaur, K., Kapoor, K. K. and Gupta, A. P., Impact of organic manures with and without mineral fertilizers on soil chemical and biological properties under tropical conditions. *J. Plan. Nutri. Soil Sci*., 2005; **168**: 117–122.
8. Mohammadi, K., Amir Ghalavand, Majid Aghaalikhani, Gholamreza Heidari and Yousef Sohrabi, Introducing a sustainable soil fertility system for chickpea (*Cicerarietinum* L.). *Afri. J. Biotech*., 2011; **10**: 6011-6020.
9. Nannipieri, P., Grego, S. and Ceccanti, B., Ecological significance of the biological activity in soil. *Soil Biochem*.,1990; **6:** 293–355.
10. Smith, P. and Powlson, D. S., Sustainability of soil management practices – a global perspective. In: Abbott LK, Murphy DV (eds) Soil biological fertility – A key to sustainable land use in agriculture. Kluwer Academic Publishers, ordrecht, Netherlands, 2003; 241–254.
11. Yosefi, K., Galavi, M., Ramrodi, M. and Mousavi, S. R., Effect of bio-phosphate and chemical phosphorus fertilizer accompanied with micronutrient foliar application on growth, yield and yield components of maize. *Aust. J. Crop Sci*., 2011; **5**: 175-180.