Influence of Long Term Fertilizer Application on Soil Phosphatase Enzyme Activity and Nutrient Availability in Rice – Rice Cropping System

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Abstract

Build up of phosphorous in soil was observed under long term fertilizer experiments which were initiated in *kharif* 2000-01 on clay soil at Regional Agricultural Research Station, Acharya N.G. Ranga Agricultural University, Jagtial under All India Coordinated Research Project (AICRP) in a randomised block design for growing rice – rice cropping system involving various doses of N, NP, NPK, NPK with FYM, Zn and S. The data generated during *rabi* 2010-11 (11th crop cycle) was used to report the results. In the present study, the activities of acid phosphatase and alkaline phosphatase in soil were determined during crop growth of rice. Soil samples collected after harvest of rice were analysed for organic carbon, available N, P and K. The activity of acid and alkaline phosphatase in soil at different growth stages of rice revealed that there was an increase in enzyme activity up to active growth stages of crop and later showed decrease. The activities of acid and alkaline phosphatase were significantly higher with application of 150% NPK followed by the treatment 100% NPK +FYM @ 10 t ha^{-1}. Phosphatase activity was at its peak at 60 days after transplanting stage.

Key words: Long term, phosphatase activity, rice, fertilizers, FYM.

Usage of imbalanced fertilizers badly influences production potential and soil health. Integrated nutrient management will not only sustain the crop production but also be effective in improving soil health and enhancing nutrient use efficiency. Enzyme activities are considered as an index of microbiological activity. A better understanding of the role of these soil enzymes in the ecosystem could provide a unique opportunity for an integrated biological assessment of soils due to their crucial role in several soil biological activities, their ease of measurement, and their rapid response to the changes in soil management.

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Enzyme levels in soil systems vary in amounts primarily due to the fact that each soil type has different amounts of organic matter, composition and activity of living organisms and intensity of the biological processes. Since rice grows in the interactive ecosystem involving soil – microorganism – rice and atmosphere, rice development consequentially affect soil microorganisms and soil enzymatic activities.

Among the various enzymes, phosphatase speeds up soil organic phosphorus decomposition and improves soil phosphorous concentration, which is an important index to assess soil phosphorus bio – availability. Phosphatases are capable of catalysing hydrolysis of esters and hydrides of phosphoric acid. In soil ecosystem, these enzymes are believed to play critical roles in 'P' cycle as evidence shows that they are correlated to 'P' stress and plant growth. Apart from being good indicators of soil fertility, phosphatase enzymes play key role in the soil system (Dick and Tadatabai, 1992). Acid phosphatase provides a potential index of mineralisation of soil organic P. Keeping this in view, a study on the effect of continuous application of fertilizers on soil phosphatase enzyme activity at different growth stages of rice was taken up.

Materials and Methods

The present investigation was carried out in the on-going AICRP on Long Term Fertilizer Experiments initiated in *kharif* 2000-01 at the experimental farm of Regional Agricultural Research Station, Acharya N.G. Ranga Agricultural University, Jagtial. The experimental site is situated at Longitude 78^{o} 45' E to 79^{o} 0 E, Latitude 18^{o}45' N to 19^{o}0 N. The experimental soil at the initiation of the experiment was clayey (Inceptisol) in texture with a soil pH 8.2 (1:2 soil: water ratio), Electrical Conductivity 0.47 dSm^{-1} (1:2 soil: water ratio), organic carbon 0.79 % and 107.6, 19.6 and 364 kg ha^{-1} of available N, P and K. The mean annual total rainfall of the area is 900–1500 mm.

Based on the soil test values for available NPK, 120-60-40 kg N-P_2O_5-K_2O ha^{-1} was fixed as cent per cent optimum recommended dose. The experiment was laid out on permanent basis, the fertilizer and manure doses were then fixed as per treatments. Twelve (11+1) treatments with four replications in a randomised block design (unit plot size 12mx9m) are as follows:

T_1 – 50%NPK ,

T_2 – 100%NPK,

T_3 – 150%NPK,

T_4 – 100% NPK +HW,

T_5 – 100% NPK+$ZnSO_4$ @ 10 kg ha^{-1}(in *kharif*),

T_6 – 100% NP, T_7 – 100% N alone,

T_8 – 100% NPK+FYM@ 10 t ha^{-1}(in each *kharif*),

T_9 – 100% NPK-S,

T_{10} – FYM @ 10 t ha^{-1}(in each *kharif* and *rabi*),

T_{11} – Control (No fertilizers, No manures),

T_{12} – Fallow (No crop , No fertilizers).

The nutrients were applied through urea, single super phosphate, muriate of potash and zinc sulphate, where as DAP was used as a source of 'P' in T_9. Recommended chemical control and hand weeding measures were adopted in all the treatments except T_4 where fertilizers and only hand weeding was practiced. The crop was harvested at maturity manually. Soil samples were collected at 30, 60, 90 days after transplanting and at harvest. Acid and alkaline phosphatase activities were assayed by quantifying the amount of p-nitrophenol released and expressed as µg of p-nitrophenol released g^{-1} soil h^{-1}as described by Tabatabai and Bremner (1969).

Soil samples collected after harvest of rice were air dried, ground to pass through 2 mm sieve and then subjected to chemical analysis. For soil organic carbon, soil samples were sieved to pass through a 0.5 mm sieve. Soil organic carbon was determined by the Walkley and Black method (1934), available N by Subbaiah and Asija (1956), P by Olsen method (Olsen *et al.* 1954) and K by ammonium acetate method (Black 1965).

Results and Discussion

The results obtained on the effect of long term fertilizer application on acid phosphatase activity are presented in Table.1 Phosphatase activity (expressed as µg of p-nitrophenol released g^{-1} soil- h^{-1}) in soils collected from different treatments varied significantly during all growth stages of crop. Enzyme activity in soil increased with age of the crop up to 60 days after transplanting. These results are in conformity with those of Vandana *et al.* (2012). Acid phosphatase increase ranged from 64.3 to 90.3, 77.3 to 127.9, 67.6 to 121.3 and 48.8 to 78.1during *kharif* and 72.7 to 120.6, 169.8 to 206.1, 86.1 to 138.7 and 65.6 to 100.5 µg of p-nitrophenol released g^{-1} soil- h^{-1} at 30, 60, 90 DAT and harvest respectively during *rabi* .

Soil enzyme activities increased with increasing rate of NPK application. The highest acid phosphatase activity recorded in 150% NPK treated plot (90.3 and 120.6 µg of p-nitrophenol released g^{-1} soil- h^{-1} in *kharif* and *rabi* respectively) was on par with the application of 100% NPK along with FYM @10 t ha^{-1} (85.1 and 110.5 µg of p-nitrophenol released g^{-1} soil- h^{-1} in *kharif* and *rabi* respectively), compared to other treatments. The acid phosphatase activity was lowest in 100% N alone (64.3 and 72.7 µg of p-nitrophenol released g^{-1} soil h^{-1} in *kharif* and *rabi* respectively), indicating that balanced nutrition of crop is responsible for better proliferation of root and for maximum activity of enzymes.

The increase in activity with integrated application of organic manures along with chemical fertilizer may be attributed to the increasing population of microorganisms like bacteria, etc., due to increased availability of substrate through organic manure there by resulting in high microbial activity and release of these enzymes in to the soil. Mishra *et al,* (2008) reported that application of 100% NPK along with FYM @ 10 t ha^{-1} to maize resulted in increase in phosphatase activity.

Alkaline phosphatase activity ranged from 73.5 to 94.8, 81.8 to 135.2, 70.2 to 125.9, 52.8 to 92.6 in *kharif* and 81.7 to 126.1, 127.9 to 177.4, 85.6 to 151.4 and 69.1 to 109.4 µg of p-nitrophenol released g^{-1} soil h^{-1} at 30, 60, 90 DAT and harvest respectively in *rabi*. The activity of alkaline phosphatase was considerably higher (Fig.1 and 2) than that of acid phosphatase irrespective of treatments. Alkaline phosphatase activity increased sharply up to 60 DAT and there after declined gradually to 30 DAT level in all the treatments. The highest alkaline phosphatase activity was fo und in150% NPK treatment followed by the application of 100% NPK +FYM. In general these enzymes activities were found to be high in *rabi* than *kharif* season.

Effect on available nutrients

Long term application of variable amounts of nutrient levels either alone or in combination, and along with organic manures had profound influence on soil fertility (Table.3). After 11^{th} crop cycle soil organic carbon status increased in all the treatments, highest values were recorded with application of organic manure alone (FYM@10 t ha^{-1}) and along with chemical fertilizers (100% NPK+FYM). 150% NPK Jrecorded highest soil available N (213 kg ha^{-1}), P (42.1 kg ha^{-1} and K (349 kg ha^{-1}) 100% NPK +FYM treatment with 210, 43.2 and 326 kg ha^{-1} respectively indicating that

integrated nutrient application improves the soil fertility status equivalent to 150% NPK.

Data on available phosphorous indicates that (Table. 5) available 'P' in treatment 100% NP was 25.8 kg ha^{-1} whereas in treatment receiving 100% N, it was 18.6 kg ha^{-1}. Use of 100% NP over 100% N significantly improved the available P status of the soil. A significant reduction in 'P' was observed under N alone (3.6% depletion from the initial) due to removal of 'P' by the crop in the absence of external source of 'P' (Verma *et al*., 2012).

Conclusions

From the study, it can be concluded that acid phosphatase and alkaline phosphatase activities in soil were significantly increased with application of increased rate of nutrients from 50% recommended dose to 150% of recommended dose of fertilizers. Activity of alkaline phosphatase was higher than acid phosphatase. Enzyme activity increased sharply up to 60 DAT and thereafter decreased gradually to 30 DAT level. Continuous application of fertilizers resulted in build up of available 'P' in soil under long term fertilizer experiments.

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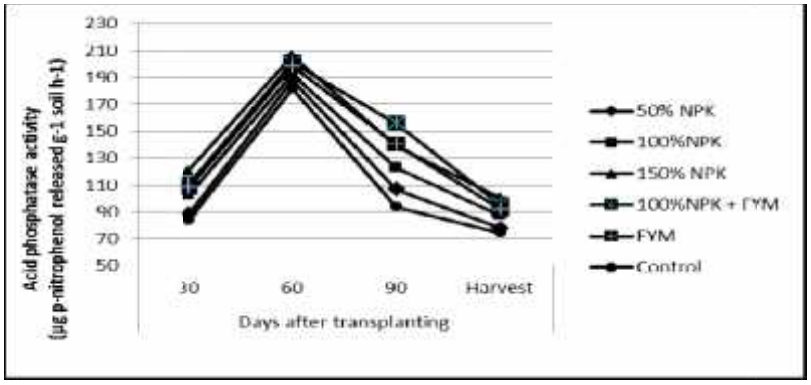

Fig.1 Changes in soil acid phosphatase activity (µg p-nitrophenol released g^{-1} soil h^{-1}) at various growth stages of rice (*rabi*).

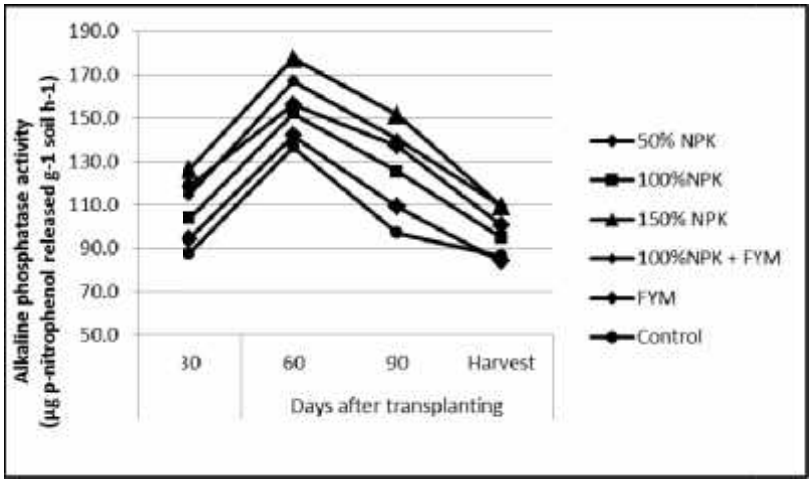

Fig.2 Changes in soil alkaline phosphatase activity (µg p-nitrophenol released g^{-1}soil h^{-1}) at various growth stages of rice (*rabi*).

Table 1: Changes in soil acid phosphatase activity (µg p-nitrophenol released g^{-1} soil h^{-1}) at various growth stages of rice during *kharif*

Treatments	***Days after transplanting (kharif)***			
	30	**60**	**90**	**Harvest**
50% NPK	74.6	92.2	88.2	52.1
100%NPK	80.8	110.4	101.3	67.0
150% NPK	90.3	127.9	121.3	78.1
100%NPK + HW	82.5	110.5	100.7	65.5
100%NPK + Zn	83.2	107.6	99.9	64.2
100%NP	65.6	80.7	74.1	55.5
100%N	64.3	77.3	67.6	48.8
100%NPK + FYM	85.1	116.7	112.5	75.5
100%NPK - S	81.9	100.8	103.6	62.3
FYM	87.4	104.2	100.6	74.5
Control	73.1	89.1	80.8	61.1

Fallow	82.9	100.9	98.0	76.8
S.Em+	4.0	7.2	5.5	4.6
CD (0.05)	8.2	14.7	11.2	9.5
CV (%)	7.2	10.1	8.1	10.2

Table 2: Changes in soil acid phosphatase activity (µg p-nitrophenol released g^{-1} soil h^{-1}) at various growth stages of rice during *rabi*

Treatments	***Days after transplanting (rabi)***			
	30	**60**	**90**	**Harvest**
50% NPK	88.1	187.9	106.7	77.8
100%NPK	102.2	192.0	122.9	87.4
150% NPK	120.6	206.1	138.7	100.5
100%NPK + HW	102.1	191.5	126.7	91.2
100%NPK + Zn	105.3	194.2	126.9	89.6
100%NP	78.5	177.0	91.5	70.1
100%N	72.7	169.8	86.1	65.6
100%NPK + FYM	110.5	201.1	155.6	95.4
100%NPK - S	101.3	194.0	129.4	89.6
FYM	107.9	198.2	140.2	92.0
Control	83.8	181.9	93.5	74.5
Fallow	100.1	191.5	138.1	95.7
S.Em+	4.4	6.6	6	4.6
CD (0.05)	8.9	13.5	12.2	9.3
CV (%)	6.3	4.9	7.1	7.6

Table 3: Changes in soil alkaline phosphatase activity (µg p-nitrophenol released g^{-1} soil h^{-1}) at various growth stages of rice during *kharif*

Treatments	***Days after transplanting(kharif)***			
	30	**60**	**90**	**Harvest**
50% NPK	82.2	86.1	94.0	78.6
100%NPK	87.9	97.6	100.0	82.3
150% NPK	94.8	135.2	125.9	92.6
100%NPK + HW	83.1	97.1	99.0	78.9
100%NPK + Zn	82.6	94.1	99.1	86.1
100%NP	79.9	85.9	79.8	59.2
100%N	73.5	81.8	70.2	52.8
100%NPK + FYM	91.9	123.4	105.1	88.7
100%NPK - S	85.2	99.5	102.0	82.4
FYM	82.2	102.7	104.8	88.5
Control	83.7	85.5	87.5	62.2
Fallow	89.3	110.3	105.3	85.4
S.Em+	3.9	4.4	4.9	3.5
CD (0.05)	7.9	8.9	10.1	7.1
CV (%)	6.5	6.2	7.2	6.3

Table 4: Changes in soil alkaline phosphatase activity (µg p-nitrophenol released g^{-1} soil h^{-1}) at various growth stages of rice during *rabi*

Treatments	*Days after transplanting(rabi)*			
	30	**60**	**90**	**Harvest**
50% NPK	94.2	142.0	109.1	83.9
100%NPK	103.8	152.0	125.2	94.9
150% NPK	126.1	177.4	151.4	109.4
100%NPK + HW	102.0	153.6	121.9	96.8
100%NPK + Zn	103.7	149.8	123.1	93.9
100%NP	85.6	132.0	96.7	76.9
100%N	81.7	127.9	85.6	69.1
100%NPK + FYM	114.7	167.0	140.1	109.3
100%NPK - S	100.9	151.6	123.7	94.6
FYM	118.5	156.1	137.0	100.6
Control	87.6	136.6	97.0	86.4
Fallow	114.8	157.8	131.6	103.2
S.Em+	3.3	3.9	3.3	2.4
CD (0.05)	6.7	7.9	6.8	4.9
CV (%)	4.5	3.6	3.9	3.6

Table 5: Soil fertility status after harvest of rice (After 11th crop cycle)

Treatments	Organic carbon (%)	Available Nitrogen (kg ha^{-1})	Available Phosphorous (kg ha^{-1})	Available Potassium (kg ha^{-1})
50% NPK	0.81	204	29.5	320
100%NPK	0.8	185	31.1	322
150% NPK	0.81	213	42.1	349
100%NPK + FYM	1.01	210	43.2	326
FYM	1.04	247	38.2	316
Control	0.8	191	20.3	309
CD (0.05)	0.16	NS	6.7	NS