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Effect of Integrated Use of Organic and Inorganic Sources of Nutrients and Biofertilizers on Soil Enzyme Activities in Maize – Onion Cropping System

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A field experiment was conducted in *kharif* (maize) and *rabi* (onion) during 2009-10 to study the effect of integrated use of organic and inorganic sources of nutrients and biofertilizers on enzyme activities in maize-onion cropping system in Alfisols of Hyderabad. The results revealed that application of 75% RDF along with 25% N or P substituted through vermicompost or poultry manure with addition of azotobacter or phosphorus solubilising bacteria recorded higher activities of soil urease, dehydrogenase and acid and alkaline phosphotases. However in *rabi* onion grown in two different situations like fertilized and unfertilized, the results revealed that the fertilized onion recorded maximum activity of enzymes when compared to unfertilized one. Within fertilized and unfertilized onion INM treatments showed highest activity of enzymes compared to other treatments.

Key words : Dehydrogenase, Maize, Onion, Urease and Phosphotase enzyme activities

Enzymes in soil are biologically significant as they are involved in the transformation, cycling of mineral elements and influence their availability to plants. The activity of soil enzymes is influenced by the nature, age of crop and addition of fertilizers and manures. The enzyme activity is considered as an index of microbial activity. Interest in soil enzyme activity has increased recently since it is believed to reflect the potential capacity of a soil to perform nutrient transformations.

Enzyme activities are very much influenced by the addition of organic manures due to increase in soil microbial activity. Available NPK and organic carbon content have a strong positive relationship with all the enzymes. Higher rates of NPK fertilization enhanced the activities of soil enzymes and the effect was more pronounced with organic manures in combination with fertilizers. (Singaram and Kamalakumari, 1995 and Reddy, 2002).

Till date not much attention has been paid to the nutrient management aspects of this cropping sequence barring a few attempts on individual crops. Hence the present investigation was carried out to study the effect of organic manures along with inorganic fertilizers and biofertilizers on soil biological properties in maize-onion cropping system.

MATERIAL AND METHODS

A field experiment was conducted during *kharif* (maize) on Alfisols at College Farm, College of Agriculture, Rajendranagar, Hyderabad. The experimental soil was sandy loam, neutral in reaction (pH 7.3), non saline (EC 0.22 dSm^{-1}), low in organic carbon (0.49%), low in alkaline $KMNO_4$ extractable N (186 kg ha^{-1}), medium in available P (23.27 kg ha^{-1}) and high in available K (395 kg ha^{-1}). The urease, dehydrogenase and acid and alkaline phopshotase activities of the initial soil were 37.5 µg of NH_4^+ N released g^{-1} soil h^{-1} , 80.16 µg of TPF produced g^{-1} soil d^{-1} , 102.54 µg of p-nitrophenol released g^{-1} soil h^{-1}, and 105.41 µg of p-nitrophenol released g^{-1} soil h^{-1} respectively. The experiment was laid out in randomized block design consisting of twelve treatment combinations each replicated thrice. The treatments consisted control (T_1); three inorganic N and P levels namely 50% N and P through RDF (T_2), 75% N and P through RDF (T_3) and 100% N and P through RDF (T_4) and integrated nutrient management treatments *viz.,* 75% N through RDF + 25% N through poultry manure (T_5), 75% N through RDF + 25% N through poultry manure + azotobacter (T_6), 75% N through RDF + 25% N through vermicompost (T_7), 75% N through RDF + 25% N through vermicompost + azotobacter

(T_8), 75% P through RDF + 25% P through poultry manure(T_9), 75% P through RDF + 25% P through poultry manure + phosphorus solubulising bacteria(T_{10}), 75% P through RDF + 25% P through vermicompost (T_{11}), 75% P through RDF + 25% P through vermicompost + phosphorus solubulising bacteria (T_{12}).In *rabi* season onion grown in strip plot design, all the plots were divided into two halves. Fertilizers were not applied to one half to know the residual effect on onion grown during *rabi* after harvest of maize crop. In another half a common dose of 75 percent of recommended dose of N, P and K fertilizers were applied to onion crop for all the treatments to know the cumulative effect.

The organic sources and biofertilizers were applied at the time of field preparation. The soil samples were collected after final harvest of each crop and analyzed for soil enzyme activities by following standard methods (Tabatabai and Bremner, 1972, Casida *et al*., 1964 and Eirazi and Tabatabai, 1977).

RESULTS AND DISCUSSION

Enzyme activities after harvest of Maize

The urease activity was substantially influenced by different treatments. The initial soil sample released 37.5 µg NH_4^+ g^{-1} soil h^{-1} and it was increased to 40.06 µg NH_4^+ g^{-1} soil h^{-1}in the unfertilized soil after the harvest of maize. The application of increasing level of N and P fertilizers improved urease activity. The soil fertilized with the recommended level of 120 kg N and 60 kg P_2O_5 ha^{-1} released 50.16 µg NH_4^+ - N g^{-1} soil h^{-1}. The substitution of 25% inorganic N or P with organic nutrients through poultry manure or vermicompost enabled the soil to release significantly larger quantity of urease activity(61.20 µg NH_4^+ - N g^{-1} soil h^{-1}). The addition of azotobacter or phosphorus solubilising bacteria along with the manures was not beneficial.

The dehydrogenase activity of soil showed that it released 80.16 µg TPFg^{-1}soil d^{-1} before the commencement of the experiment. It increased with increase in the level of fertilizer application from 88.16 µg TPF g^{-1} soil d^{-1} in the unfertilized control to 105.20 µg TPF g^{-1} soil h^{-1} by the addition of 120 kg N and 60 kg P_2O_5 ha^{-1}. The dehydrogenase activity accelerated substantially by the integrated nutrient management treatments. It was observed that 132.20 to 138.10 µg TPF g^{-1} soil d^{-1} was released by the soils treated with the integrated source of nutrients.

The urease and the dehydrogenase activity increased with the fertilizer application at the recommended level of 120 kg N and 60 kg P_2O_5 ha^{-1}. The integrated nutrient management treatments stimulated these activities and further enhanced their release significantly over the use of inorganic fertilizers. Increase in the urease and dehydrogenase activity due to addition of organic matter is also reported by several workers(Pallab et al., 1990, Reddy 2002, Singaram and Kamalakumari 1995).Therefore integrated nutrient management treatments are a step forward since the increased urease activity due to the addition of organic manures influence the availability of plant utilizable forms of nitrogen. This enzyme catalyses the hydrolysis of urea to ammonia. This is subsequently transformed to NH_4^+ and NO_3^- ions.

The acid phosphatase activity showed that the initial sample released 102.54 µg p- nitrophenol g^{-1} soil h^{-1}. The alkaline phosphatase showed that the 105.41 p- nitrophenol was released g^{-1} soil h^{-1}. The values of both the components were relatively high in the soil without the application of fertilizers. They increased with the level of N and P fertilizers up to the recommended level. The influence of integrated nutrient management treatments was similar to the recommended level of fertilizers. Several workers reported higher phosphatase activity in rhizosphere than non rhizosphere soils (Pallab et *al*., 1990).

Enzyme activities after harvest of Onion

The urease and dehydrogenase activity of the soil increased due to fertilizer application only to onion or both maize and onion in the cropping system compared to their respective initial values of 37.5 and 80.16 µg g^{-1} soil h^{-1} NH_4^+ -N and TPF g^{-1} soil d^{-1}.The soil treated with fertilizers only to onion recorded 40.28 µg NH_4^+ -N g^{-1} soil h^{-1} and 85.45 µg TPF g^{-1} soil d^{-1}. These enhanced significantly to 45.35 and 94.46 µg due to the cumulative influence of recommended level of N and P fertilizer application to maize and 75% supply of NPK to onion. The cumulative influence of integrated nutrient management treatments to maize and fertilizer application to onion improved both the urease and dehydrogenase activity by releasing

Table 1. Effect of different fertility management treatments on enzyme activity in soil after harvest of maize.

Treatments	Urease (µg of NH_4^+-N released g^{-1} soil h^{-1})	Acid phosphatase (µg of p-nitrophenol released g^{-1} soil h^{-1})	Alkaline phosphatase (µg of p-nitrophenol released g^{-1} soil h^{-1})	Dehydrogenase (µg of TPF* g^{-1} soil d^{-1})
T_1: Control (No fertilizers)	40.06	112.06	124.50	88.16
T_2: 50% N, P through RDF	45.26	113.16	123.03	100.16
T_3: 75% N, P through RDF	46.20	114.24	125.06	103.30
T_4:100% N, P through RDF(120-60 Kg N, P_2O_5 ha^{-1})	50.16	115.13	128.23	105.20
T_5: 75% N through RDF + 25% N through Poultry manure	58.16	117.15	130.16	132.20
T_6: 75% N through RDF + 25% N through Poultry manure + Azotobacter	60.20	117.16	130.29	135.06
T_7: 75% N through RDF + 25% N through Vermi compost	61.19	120.21	130.28	137.16
T_8: 75% N through RDF + 25% N through V.C. + AZB	61.20	120.06	130.25	138.10
T_9: 75% P through RDF + 25% P through P.M.	58.26	119.25	130.54	133.23
T_{10}: 75% P through RDF + 25% P through P.M. + Phosphorus solubilising bacteria	59.20	120.04	131.12	135.36
T_{11}: 75% P through RDF + 25% P through V.C	59.16	121.12	130.24	136.23
T_{12}: 75% P through RDF + 25% P through V.C + P.S.B.	61.15	121.14	131.36	137.20
SEm±	1.45	2.08	1.42	1.87
CD(P=0.05)	4.27	6.15	4.20	5.53

TPF* = Triphenyl formazon

significantly larger quantity of NH_4^+ -N and TPF. Substantially low quantity of 32.14 µg NH_4^+ -N g^{-1} soil h^{-1} and 66.06 µg TPF were recorded g^{-1} soil d^{-1} in the unfertilized check. The corresponding values increased significantly to 34.61 and 69.03 µg due to the residual effect of fertilizer application to maize. The release of TPF increased further due to the integrated nutrient management treatments.

The activity of acid phosphotase and alkaline phopshotase enzymes reduced in the soil after the harvest of the fertilized onion preceded by the unfertilized maize compared to their initial values (Table 2). This activity improved with increase in the level of fertilizers up to the recommended level of 120 kg N and 60 kg P_2O_5 ha^{-1} to maize and application of recommended level of 75% NPK to onion as compared to their initial level. Application of low levels of phosphorus to maize in the maize-onion cropping system was not sufficient to maintain the activity of these enzymes. Therefore, the soil require sufficient supply of phosphorus to maintain this biological activity.

The cumulative influence of integrated nutrient management treatments to maize and fertilizer application to onion was highly prominent to significantly increase the soil biological activity by releasing significantly larger quantity of urease, dehydrogenase, acid and alkaline phosphatase enzymes as compared to the fertilizer application to both the crops. Increasing level of phosphorus is known to improve the growth and development of roots which in turn release the enzymes in larger quantities (Pallab *et al*., 1990).The additional advantage of further improvement in biological

Table 2. Influence of fertility management treatments in maize onion cropping system on enzymatic activity in soil after harvest of onion.

Fertilized(cumulative)	Urease (µg of NH_4^+-N released g^{-1} soil h^{-1})	Acid phos-phatase	Alkaline phos-phatase	Dehydrogenase (mg of TPF* g^{-1} soil d^{-1})
		(µg of p-nitrophenol released g^{-1} soil h^{-1})		
T_1: Control (No fertilizers)	40.28	86.24	96.10	85.45
T_2:50% N, P (RDF)	41.45	94.92	98.13	89.10
T_3:75% N, P (RDF)	42.26	95.76	99.00	90.25
T_4:100% N, P through RDF (120-60 Kg N, P_2O_5 ha^{-1})	45.35	101.57	104.35	94.46
T_5:75% N (RDF) + 25% N Poultry manure	46.24	104.50	107.16	96.24
T_6: 75% N (RDF) + 25% N Poultry manure + azotobacter	46.28	105.06	108.10	96.58
T_7: 75% N (RDF) + 25% N Vermicompost	46.25	107.10	108.16	96.40
T_8: 75% N (RDF) + 25% N V.C. + AZB	46.29	108.03	108.16	96.60
T_9: 75% P (RDF)+ 25% P P.M.	46.24	105.16	108.17	96.54
T_{10}: 75% P (RDF) + 25% P P.M. + Phosphorus solubilising bacteria	46.31	107.06	110.10	96.45
T_{11}: 75% P (RDF) + 25% P V.C	46.25	105.16	110.10	96.52
T_{12}: 75% P RDF + 25% P V.C + P.S.B.	46.25	107.50	111.16	96.52
Unfertlized (Residual)				
T_1: Control (No fertilizers)	32.14	68.30	72.01	66.06
T_2:50% N, P (RDF)	34.21	69.06	74.16	67.13
T_3:75% N, P (RDF)	34.56	70.10	75.06	68.30
T_4:100% N, P through RDF(120-60 Kg N, P_2O_5 ha^{-1})	34.61	74.30	76.30	69.03
T_5:75% N (RDF) + 25% N Poultry manure	35.24	75.20	84.03	85.06
T_6: 75% N (RDF) + 25% N Poultry manure + azotobacter	35.28	76.13	84.16	86.20
T_7: 75% N (RDF) + 25% N V.C	35.20	77.06	85.33	87.20
T_8: 75% N (RDF) + 25% N V.C. + AZB	35.28	77.16	85.13	88.20
T_9: 75% P (RDF)+ 25% P P.M.	35.24	76.10	86.30	86.10
T_{10}: 75% P (RDF) + 25% P P.M. + P.S.B.	35.24	77.16	87.06	87.30
T_{11}: 75% P (RDF) + 25% P V.C	35.25	77.30	87.16	87.20
T_{12}: 75% P RDF + 25% P V.C + P.S.B.	35.25	78.03	88.13	87.20
Effect of kharif treatments at same levels of rabi treatments				
SEm±	0.28	0.70	0.68	0.48
CD(P=0.05)	0.81	2.05	1.99	1.40
Effect of rabi treatments at same or different levels of kharif treatments				
SEm±	1.92	4.24	3.15	2.06
CD(P=0.05)	NS	NS	NS	6.03

TPF* = Triphenyl formazon

activity was probably due to the addition of organic manures in the integrated nutrient management treatments that serve as a source for increased microbial activity which exude the enzymes and further aid in still better development of the root system through better soil aggregation and other physical properties (Singaram and Kamalakumari, 1995).

The inherent soil nutrients were not sufficient to support good development of the roots of maize and onion. Therefore the urease, acid and alkaline phosphatase and dehydrogenase activity recorded a substantial reduction. This gap narrowed off through the residual effect of increase in level of N and P fertilizers to maize. The integrated nutrient management treatments further narrowed down this gap for acid and alkaline phosphatase and the dehydrogenase enzyme but not urease through their residual effect. This study highlight the importance of adequate fertilizer application both to maize and onion in the cropping system while a part substitution of 25% N or P through the poultry manure or vermicompost to maize in *kharif* and 90-60-75 kg ha^{-1} NPK applied through fertilizers to onion is the strategic option to be adopted to preserve these enzymes which aid in the release of unavailable forms of nutrients in the readily available forms for utilization by the crop.

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