Effect of Long-term fertilization on soil enzyme activities under groundnut based cropping system

The Bioscan 12(3): 1755-1758, 2017 (Supplement on Agronomy)
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.com

EFFECT OF LONG-TERM FERTILIZATION ON SOIL ENZYME ACTIVITIES UNDER GROUNDNUT BASED CROPPING SYSTEM

P. V. GEETHA SIREESHA*, G. PADMAJA, M.VIJAY SHANKAR BABU AND P. C. RAO
Dept. of Soil Science and Agricultural Chemistry, College of Agriculture,
PJTSAU, Rajendranagar, Hyderabad - 500 030.
e-mail: geethashirisha048@gmail.com

KEYWORDS
Dehydrogenase
FYM
phosphatase
urease activity

Received on :
14.05.2017

Accepted on :
24.08.2017

***Corresponding author**

ABSTRACT

A long term field experiment on integrated nutrient management in groundnut was initiated under AICRP on Dryland Agriculture during *kharif*, 1985 at Agricultural Research Station, Ananthapur, Andhra Pradesh. The highest organic carbon content (0.67 %) was noticed in the treatment receiving FYM @ 5 t ha^{-1} (T_5). The enzyme activities *viz.,* urease (15.00μg of NH_4^+-N g^{-1} soil 2h^{-1}), dehydrogenase (63.19 μg of TPF g^{-1} soil day^{-1}) and acid (34.87 μg p-nitrophenol g^{-1} soil h^{-1}) and alkaline phosphatase (64.40 μg p-nitrophenol g^{-1} soil h^{-1}) were significantly higher in treatment T_7 (50% RD of NPK + FYM @ 4 t ha^{-1}) followed by the treatment receiving 50% RD of NPK + Groundnut shells @ 4 t ha^{-1} (14.56 μg of NH_4^+-N g^{-1} soil 2h^{-1}, 60.50 TPF g^{-1} soil day^{-1}, 32.82 and 61.94 μg p-nitrophenol g^{-1} soil h^{-1}, respectively). This study revealed that integrated application of optimum level of inorganic fertilizer, farmyard manure along could improve the biological properties of as well as the growth under groundnut – fallow cropping system.

INTRODUCTION

Soil enzymatic activities can be used as an index for soil fertility and microbial functional diversity (Maurya *et al.,* 2011) in catalyzing several biochemical reactions which are necessary for the life processes of soil micro-organisms, organic wastes decomposition, organic matter formation and nutrients cycling (Tabatabai, 1994). These are sensors of soil degradation since they combine information about microbial status and soil physicochemical conditions (Aon and Colaneri, 2001). The microbial population dynamics is governed by interactions between plant type, climate, and management practices. The enzymatic activities of a soil catalyzes the biochemical activities performed by bacteria (Sarapatka, 2003) and thereby indicates the potential of the soil to permit the basic biochemical processes necessary for maintaining soil fertility. Soil fertility is in great extent controlled by different biochemical activities of the microflora especially in the immediate surroundings of the roots, the rhizosphere, which under the influence of roots, carry a particularly dense population of microorganisms (Arancon *et al.,* 2006). Judicious use of organic manures such as FYM and farm wastes along with chemical fertilizers improves soil physical, chemical and biological properties and improves groundnut productivity. The objective of present investigation was to examine the influence of different levels and sources of fertilization on the activity of enzymes, and growth of groundnut under groundnut-fallow cropping system.

MATERIALS AND METHODS

Site description: The experiment on integrated nutrient management in groundnut was initiated under AICRP on Dryland Agriculture during *kharif*, 1985 at Agricultural Research Station, Ananthapur, Andhra Pradesh. The monthly mean maximum temperatures during the crop growth period ranged from 29.8 °C to 39.3 °C with an average of 33.5 °C, while the monthly mean minimum temperature ranged from 15.9 °C to 31.9 °C with an average of 27.4 °C. The total rainfall received during the crop growth period was 409.8 mm with a total of 19 rainy days. The mean relative humidity ranged from 37.5 to 73.8 per cent. The monthly mean sunshine hours varied from 2.2 to 9.1 h with an average of 7 h per month. The mean wind speed ranged from 8.2 to 19.3 km h^{-1} with an average of 10.8 km h^{-1}. The mean monthly evaporation was ranged from 6.4 to 11.3 mm with an average of 8.1 mm per month.

Experimental design and treatments: This experiment was laid out in a randomized block design with seven treatments replicated thrice. The treatment details during *kharif* was as follows

T_1 – Control (No fertilizers and Manures)

T_2 – 100% RD of NPK (20-40-40 N, P_2O_5, K_2O kg ha^{-1}) + $ZnSO_4$ @50 kg ha^{-1}

T_3 – Groundnut shells @ 4 t ha^{-1}

T_4 – FYM @ 4 t ha^{-1}

T_5 – FYM @ 5 t ha^{-1}

T_6 – 50% RD of NPK (10-20-20 N, P_2O_5, K_2O kg ha^{-1}) + T_3

T_7 – 50% RD of NPK (10-20-20 N, P_2O_5, K_2O kg ha^{-1}) + T_4

The recommended fertilizer dose (20-40-40 kg N, P_2O_5 and K_2O ha^{-1}) was applied in the form of urea, diammonium phosphate and muriate of potash, respectively. Farmyard manure was applied one week before sowing of crops as per the treatments.

Soil sample analysis

The initial soil was sandy loam, neutral in reaction pH 6.6 (Jackson, 1973), non saline in nature EC 0.15 dS m^{-1} (Jackson, 1973), medium in organic carbon OC 0.5 % (Walkley and Black (1934), low in available N 139 kg ha^{-1} (Subbiah and Asija (1956), high in available P 44.2 kg ha^{-1} (Olsen *et al.*, 1954) and medium in available K 155 kg ha^{-1} (Jackson, 1973). Urease activity was assayed by quantifying the rate of release of NH_4^+ from the hydrolysis of urea as described by Tabatabai and Bremner (1972). Dehydrogenase activity in the soil was determined by the procedure given by Casida *et al.* (1964). The method involved spectrophotometric determination of the Tri Phenyl Formazon (TPF) produced when soil is treated with Triphenyl Tetrazolium Chloride (TTC). The acid and alkaline phosphatase activity was 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).

Statistical analysis

The data on the observations made were analyzed statistically by applying the technique of analysis of variance for randomized block design as suggested by Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

Soil properties

The decrease or increase in soil reaction from the initial value (6.6) is attributed to relative uptake of anions and cations by plants. The pH values of 1:2.5 soil water suspensions ranged from 6.0 to 6.8 under *kharif* indicating slightly acidic to neutral in reaction. Pulse crops have the ability to reduce the pH of the soil in the rhizosphere and make the micro environment favourable for nutrient availability Nambiar (1985). The EC in soil water extract of different treatments varied from 0.24 to 0.30 dS m^{-1}. The soil organic carbon ranged from 0.45 to 0.67 % after harvest of groundnut. All the treatments showed higher organic carbon content than the initial value (0.5). The highest organic carbon content was noticed in the treatments receiving FYM @ 5 t ha^{-1} (T_5) followed by T_4, T_7 and T_6 with organic carbon content of 0.67, 0.65, 0.61 and 0.60 %, respectively (Table 1).

All the treatments were recorded higher available nitrogen content than initial level of nitrogen (139.0 kg ha^{-1}). Treatment receiving 50% RD of NPK + T_4 showed highest available N (178.9 kg ha^{-1}) followed by T_6 (174.9 kg ha^{-1}). All the treatments were found to be non significant with each other. Though the groundnut is a legume crop, available N status decreased over initial level and remained low in all the treatments in spite of the application of recommended dose of N and use of organics. Among different treatments, T_7 recorded significantly higher content of available phosphorus (64.8 kg ha^{-1}). The appreciable build up in available P in soil with organic manure and inorganics may be attributed to the influence of organic manure in increasing the labile P through complexing of cations like Ca^{2+} and Mg^{2+} which are responsible for fixation of phosphorus. Application of 50% RD of NPK + T_4 was resulted in significantly increased potassium (354.8 kg ha^{-1}) and found significant over others. The beneficial effect of FYM on available potassium may be ascribed to the reduction in potassium fixation and release of potassium due to interaction of organic matter (Balwinderkumar *et al.*, 2008).

Table 1: Long-term effects of INM on physico-chemical and chemical properties of soil after harvest of groundnut-fallow system at Ananthapur

Treatments	pH	EC(dS m^{-1})	OC (%)	Avail. N	Avail. P	Avail. K
T_1 – Control	6.0	0.3	0.45	133.8	36.5	127.2
T_2 – 100% RD of NPK + $ZnSO_4$ @ 50 kg ha^{-1}	6.1	0.25	0.58	170.5	51	290.2
T_3 – Groundnut shells @ 4 t ha^{-1}	6.2	0.26	0.58	149.6	44.8	212.3
T_4 – FYM @ 4 t ha^{-1}	6.7	0.28	0.65	166.4	48.6	249.4
T_5 – FYM @ 5 t ha^{-1}	6.8	0.28	0.67	171.7	49.3	268.2
T_6 – 50% RD of NPK + T_3	6.4	0.24	0.6	174.9	55.1	343.7
T_7 – 50% RD of NPK + T_4	6.4	0.24	0.61	178.9	64.8	354.8
Initial	6.6	0.15	0.5	139	44.2	155
CD (P=0.05)	0.27	NS	0.05	NS	16.4	33.55
SEm +	0.13	0.06	0.02	7.23	5.25	10.77

Table 2: Long-term effects of INM on enzyme activities of the soils under groundnut-fallow cropping system at Ananthapur

Treatments	Acid phosphatase (μg p-nitrophenol g^{-1} soil h^{-1})	Alkaline phosphatase	Dehydro genase (μg of TPF g^{-1} soil day^{-1})	Urease (μg of NH_4^+ -N g^{-1} soil $2h^{-1}$)
T_1 – Control	16.10	33.4	23.64	6.38
T_2 – 100% RD of NPK + $ZnSO_4$ @ 50 kg ha^{-1}	24.15	46.59	47.53	10.5
T_3 – Groundnut shells @ 4 t ha^{-1}	30.35	59.63	53.69	12.88
T_4 – FYM @ 4 t ha^{-1}	29.93	60.01	57.49	12.38
T_5 – FYM @ 5 t ha^{-1}	29.75	59.54	58.65	13.25
T_6 – 50% RD of NPK + T_3	32.82	61.94	60.5	14.56
T_7 – 50% RD of NPK + T_4	34.87	64.4	63.19	15
CD (P=0.05)	2.68	3.87	4.83	1.17
SEm +	0.9	1.24	1.6	0.38

Table 3: Simple correlations between different organic carbon and soil enzyme activities

Variables			r-values
Organic carbon	vs	Acid phosphatase	0.788
Organic carbon	vs	Alkaline phosphatase	0.840
Organic carbon	vs	Dehydrogenase	0.895
Organic carbon	vs	Urease	0.798

Effect on Enzyme activity

Different levels of inorganic fertilizers alone or supplemented by FYM in combination with and without groundnut shells significantly influenced the activity of dehydrogenase (DH), acid phosphatase (ACP) and alkaline phosphatase (ALP) enzymes in the rhizosphere soil of peanut. The effect of different treatments evaluated interms of activiy of urease, dehydrogenase and acid and alkaline phosphatase are presented in table 2.

Urease (μg of NH_4^+-N g^{-1} soil $2h^{-1}$)

Urease activity ranged from 6.38 to 15.0 μg of NH_4^+ released g^{-1} soil $2h^{-1}$ at harvest of groundnut. The highest urease activity was recorded in the treatment of 50% RD of NPK + T_4 (T_7) followed by T_6 (50% RD of NPK + T_3) and T_5 (FYM @ 5 t ha^{-1}), T_3 (Groundnut shells @ 4 t ha^{-1}), T_4 (FYM @ 4 t ha^{-1}) and T_2 (100% RD of NPK + $ZnSO_4$ @ 50 kg ha^{-1}) with urease activity of 14.56, 13.25, 12.88, 12.38 and 10.50 μg of NH_4^+ released g^{-1} soil $2h^{-1}$, respectively. The lowest urease activity was recorded in control. However, T_7 showed significantly increased urease activity than all the other INM treatments. Significant positive correlation between urease and organic carbon observed (r = 0.798, Table 3). Leguminous plants have the potential for biological nitrogen fixation and this could have stimulated the increased activity of enzymes (urease and phosphatase) involved in nitrogen and phosphorus cycle. Cropping significantly increase the activity of acid and alkaline phosphatase in the soil compared to their activity in soils of fallow lands. Similar results were observed by Bhadoria *et al.* (2011). Maestre *et al.* (2011) reported a decrease in the urease activity with addition of inorganic N whereas crop residues and organic manure additions increased its activity. Enzyme activities of soils are usually correlated with their organic carbon. Higher levels of organic carbon stimulate microbial activity, and therefore enzyme synthesis (Meena *et al.,* 2013).

Dehydrogenase (μg of TPF g^{-1} soil day^{-1})

The results related to dehydrogenase activity revealed that highest activity (63.19 μg of TPF g^{-1} soil day^{-1}) was noticed in the treatment receiving 50% RD of NPK + T_4 (T_7) whereas lowest activity was observed in control (23.64μ g of TPF g^{-1} soil day^{-1}) (Table 2). However, T_6 and T_7 were on par with each other and T_7 was significantly higher than T_2, T_3, T_4 and T_5.

The organic material is the rich source of organic carbon which activated the enzymes like dehydrogenase etc. A clear positive relationship between soil dehydrogenase activity and soil C was also reported by Leirós *et al.* (2000). This result is in agreement with Lee *et al.* (2004), who reported that soil treated with vermicompost and manures showed higher level of dehydrogenase activity as compared to mineral fertilizers applied soil. The increase in dehydrogenase activity after additions of FYM along with fertilizers to soils is generally attributed to the fact that enzyme activities directly associated to organic matter and to microbial response to soluble sugars of the added substances. Inhibition of dehydrogenase activity with higher doses of mineral fertilizers were also reported by Ranjith *et al.,* 2015.

Acid and Alkaline Phosphatase (μg p-nitrophenol g^{-1} soil h^{-1})

The data pertaining to acid phosphatase activity revealed that T_7 (FYM 50% RD of NPK + T_4) showed highest 34.87 μg p-nitrophenol released g^{-1} soil h^{-1} at harvest of groundnut and the lowest 13.10 μg p-nitrophenol released g^{-1} soil h^{-1} in T_1 (control). However T_6 and T_7 were on par with each other (Table 2). The data pertaining to alkaline phosphatase activity revealed that T_7 (50% RD of NPK + T_4) showed highest 64.40 μg p-nitrophenol released g^{-1} soil h^{-1} at harvest of groundnut and the lowest activity 33.40 μg p-nitrophenol released g^{-1} soil h^{-1} was observed in T_1 (control). A positive correlation was observed with organic carbon (r = 0.788 and r = 0.840, respectively for both acid and alkaline phostphatases.

Phosphatases are capable of catalysing hydrolysis of esters and anhydrides of phosphoric acid. The evidence shows that their activities are correlated with P stress and plant growth. Phosphatase is an enzyme present in all the microorganisms and increase in phosphatase activity was mainly due to an increase in microbial biomass. Temporal sequence in activity of this enzyme may be attributed to the differential production rates which may be influenced by the physiological age of different groups of microorganisms present in the soil (Srinivas *et al.*, 2000 and Ramalakshmi, 2011). The importance of organic carbon in nutrient cycling was evident that fact that the enzyme activity quantified in the present study showed positive correlation with organic carbon (Table 3). This indicates that organic material significantly increases the enzymatic activity in soil. Several studies have observed inverse relationships between inorganic P availability and phosphatase activity (DeForest *et al.,* 2012).

ACKNOWLEDGEMENTS

I gratefully acknowledge the Acharya N.G. Ranga Agricultural University, Government of Andhra Pradesh and Professor Jayashankar Telangana State Agricultural University Government of Telangana for their financial assistance provided in the form of stipend during my Ph.D. programme.

REFERENCES

Aon, M. A. and Colaneri, A. C. 2001. Temporal and spatial evolution of enzyme of enzymatic activities and physic-chemical properties in an agricultural soil. *Applied Soil Ecology*. **18:** 255-270.

Arancon, N. Q., Edwards, C. A. and Bierman, P. 2006. Influences of vermicomposts on field strawberries: Part 2. Effects on soil microbiological and chemical properties. *Bioresource Technology*. **97:** 831-840.

Balwindarkumar, Gupta, R. K. and Bhandari, A. L. 2008.Soil fertility changes after long-term application of organic manures and crop residues under rice-wheat system. *.J. the Indian Society of Soil Science*. **56(1):** 80-85.

Bhadoria, P. B. S., Basu, M. and Mahapatra, S. C. 2011. Study of microbial population and enzyme activities in intercropped peanut rhizosphere with different nutrient application. *British Biotechnology J.* **1(2):** 29-45.

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

DeForest, J. L., Smemo, K. A., Burke, D. J., Elliott, H. L. and Becker, J. C. 2012. Soil microbial responses to elevated phosphorus and Ph in acidic temperate deciduous forests. *Biogeochemistry*. **109:** 189- 202.

Jackson, M. L. 1973.. *Soil Chemical Analysis*. Oxford IBH Publishing House, Bombay. 38.

Lee, J. J., Park, R. D., Kim, Y. W., Shim, J. H., Chae, D.H., Rim, Y.S. and Kyoon, B. 2004. Effect of food waste compost on microbial population, soil enzyme activity and lettuce growth. *Bioresource Technology*. **93:** 21-28.

Leirós, M. C., Trasar-Cepeda, C., Seoane, S. and Gil-Sotres, F. 2000. Biochemical properties of acid soils under climax vegetation (Atlantic oakwood) in an area of the European temperatehumid zone (Galicia, NW Spain): general parameters. *Soil Biology and Biochemistry*. **32:** 733-745.

Maestre, F. T., Puche, M. D., Guerrero, C. and Escudero, A. 2011. Shrub encroachment does not reduce the activity of some soil enzymes in Mediterranean semiarid grasslands. *Soil Biol. & Biochem.* **43:** 1746-1749.

Maurya, B. R., Vimal, S. and Dhyani, P. P. 2011. Enzymatic activities and microbial population in agri-soils of Almora district of central Himalaya as influenced by altitudes. *Internat. J. Soil Science.* **6:** 238-248.

Meena, V. S., Maurya, B. R., Verma, R., Meena, R.S., Jatav, G.K., Sunita, K. and Meena, S. K. 2013. Soil microbial population and selected enzyme activities as influenced by concentrate manure and inorganic fertilizer in alluviam soil of Varanasi. *The Bioscan*. **8(3):** 931-935

Nambiar, K. K. M. 1985. *All India Co-ordinated Research Project on Long-term Fertilizer Experiments*. Indian Council of Agricultural Research, New Delhi. 111.

Olsen, S. R., Cole, C.V., Watanabe, F. S. and Dean, L. A. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. *Circular of United States Department of Agriculture*. pp. 939.

Panse, V. G and Sukhatme, P.V. 1978. Indian Statistical methods for agricultural workers I.C.A.R., New Delhi

Ramalakshmi, Ch. S., Rao, P. C., Sreelatha, T., Padmaja, G., Madhavi, M., Rao, P.V and Sireesha, A. 2013. Effect of nutrient management (INM) on humic substances and micro nutrient status in submerged rice soils. *J. Rice Research*. **6(1):** 57-65.

Ranjith, M., Sridevi, S., Venkata Ramana, M. and Rao, P. C. 2015. Soil enzyme activity, soil microbial communities, microbial biomass carbon changes and seed cotton yield under different nutrient management practices in *Bt* cotton. *The Bioscan*. **10(4):** 1499-1504

Šarapatka, B. 2003. Phosphatase activities in agrosystem soils. Ph.D. Thesis, Swedish Univ. of Agric. Sci., Uppsala, Acta Universitatis Agriculturae Sueciae Agraria, Czech Republic.

Srinivas, D., Raman, S and Rao, P. C. 2000. Influence of plant cover on acid and alkaline phosphatase activity in two soils of Andhra Pradesh. *The J. Research ANGRAU*. **28(4):** 40-47.

Subbiah, B. V and Asija, C. L. 1956. A rapid procedure for the estimation of available nitrogen in soils. *Current Science*.PP. 25- 32.

Tabatabai, M. A. 1994. Soil enzymes In: Weaver RW, Angle JS and Bottomley PS (Eds.) Methods of soil analysis, part 2. Microbiological and biochemical properties. SSSA Book Series No. 5. *Soil Sci. Soc. Am. Madison, Wis.* pp. 775-833.

Tabatabai, M.A and Bremner, J.M. 1969. Use of *p*-nitrophenol 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.

Walkley, A and Black, C. A. 1934. Estimation of organic carbon by chromic acid titration method. *Soil Science*. **37:** 29-38