Original Research Article

STUDY OF BIOLOGICAL PROPERTIES UNDER IMPORTANT CROPPING SYSTEMS IN INCEPTISOLS AND VERTISOLS OF NORTHERN TELANGANA ZONE

ABSTRACT:

An experiment was conducted during *kharif*, 2019 at Agricultural College, Polasa, Jagtial, Professor Jayashankar Telangnana State Agricultural University. The experiment was laid out in randomized block design with factorial concept (FRBD) with five replications. Soil samples were collected from four cropping systems *viz*., rice-rice (CS_1), rice-maize (CS_2), cotton-fallow (CS_3) and turmeric-sesame (CS_4) under two soil types *viz*., inceptisols (S_1) and vertisols (S_2) from surface soil (0-15cm). Selection of sites was based on continuous cultivation of the same cropping system (at least for 8 year), in Northern Telangana Zone of Telangana State.

Surface soils were analyzed for biological properties. Microbial biomass carbon, microbial biomass nitrogen, dehydrogenase and urease enzyme activity were found to be higher under vertisols and in rice-rice cropping system. Urease activity was positively correlated with available nitrogen ($Y=26.80 X + 128.2$; $R^2=0.499$) and dehydrogenase with SOC content ($Y=0.069X + 0.340$; $R^2=0.516$).

Microbial activities in soil were found higher under vertisols and in rice-rice cropping system.

INTRODUCTION

Microorganisms play a crucial part in soil nutrient cycling, maintenance of soil structure, degradation of agrochemicals and pollutants, and plant pest control (Stockdale and Brookes, 2006), hence it has often been indicated as an important component of soil fertility (Nogueira et al., 2006). Enzymatic activities in the soil highly affect nutrient cycling and organic matter decomposition (Pavel et al., 2004). Moreover, ureases are in charge of releasing inorganic N in the N-cycle (Bandick and Dick, 1999). A case study indicated that excessive cultivation decreased both microbial biomass and its activities. (Gupta and Germida, 1988).

Soil enzyme activities related to SMBC and soil organic carbon (SOC) are often used for comparison of different land use with varying SOM content (Waldrop et al. 2004; Bastida et al. 2007). Measurement of soil enzyme activities in key nutrient

cycling (C, N, and P) and oxidation–reduction processes have been used widely as a potential indicator for determining the effect of land use conversions and management practices on soil health (Acosta-Martínez et al. 2007; Pandey et al. 2014; de Medeiros et al. 2015). Therefore, an investigation of soil microbial characters and enzyme activities is critical in studying the land conversions and focusing the soil management.

MATERIAL AND METHODS

Soil Microbial Biomass Carbon

Field-moist soil samples (25.0 g) were exposed to $CHCl_3$ vapour for 24 h and extracted with 0.5 *M* K_2SO_4. A second non-fumigated set of samples was also extracted under similar conditions. The difference between C obtained from the fumigated and from the non-fumigated ones was taken to represent the microbial C-flush and converted to MBC using the relationship: MBC = 1/0.41 × C-flush (Voroney and Paul, 1984). All results are expressed on an oven-dry soil basis (105^{o}C, 24 h) and are the mean of three replicate analyses.

Microbial biomass nitrogen (MBN)

Microbial biomass nitrogen was also estimated using the same principle of microbial biomass carbon. The K_2SO_4 extractant of both fumigated and unfumigated soil was digested for 3 hr. with addition of digestion mixture and sulphuric acid. After cooling, distillation was carried out to find the nitrogen content. The difference between fumigated and unfumigated extracted nitrogen of soil divided by a calibration factor (K_{EC}) 0.38 gives the measure of microbial biomass nitrogen in soil and expressed as micro gram of microbial biomass-N per gram of dry soil.

Dehydrogenase activity (µg TPF produced g^{-1} soil h^{-1})

Five grams soil was weigh into glass tubes and mixed with 5 ml TTC solution. The tubes were sealed with rubber stopper and inoculated for 24 hours at 30^{0}C. The control contain only 5 ml tris buffer (without TTC). After incubation 40 ml acetone was added to each tube and tubes were shaken thoroughly and further incubated at room temperature for 2 hour in dark (shaking the tubes at intervals). The suspension was then filtered and optical density of clear supernatant was measured against the blank at 546 nm (red colour). The activity of dehydrogenase is expressed in µg TPF formed per gram of dry soil per day. (Thalmann, 1968).

Urease activity (µg NH_4^+ released g $soil^{-1}$ h^{-1}):

This method is based on determination of NH_3 released other incubation of soil with urea solution for 2 hours at 30^0C (Tabatabai and Bremner, 1972). Five gram of soil was taken in duplicate in 50 ml volumetric flask. 0.2 ml toluene and 9 ml of THAM buffer (pH- 9 ; 0.05M) were added to it. The flasks were swirled for few second to mix the content. Then 1 ml of 0.2 M urea solution was added and swirled again for a few second. The flasks were then stoppered and placed in an incubator at 30^0C for 2 hours. After 2 hours the stoppers were removed and approximately 35 ml of KCl – Ag_2SO_4 solution was added and the flasks were swirled for a few seconds and allowed to stand until the contents have cooled to room temperature. The volume of the flasks was made upto mark (50 ml) by addition of KCl – Ag_2SO_4 solution. The flasks were stoppered and inverted several times to mix the contents. To perform control, the above procedure was followed, but 1 ml 0.2M urea solution was added after the addition of 35 ml KCl-$AgSO_4$ solution.

A 40 ml aliquot of the suspension was pipetted out into 100 ml distillation flask and 0.2g MgO was added to it for the determination of NH_4-N in the resulting soil suspension. The content of the flask was then distilled for 15 minutes and the distillate was collected in a 50 ml conical flask containing 5 ml of 2 per cent boric acid indicator solution. The distillate was then titrated with 0.005(N) H_2SO_4. The urease activity is expressed as micro gram NH_4 – N per gram dry soil per hour at 30^0C.

3.5 Statistical analysis

The data were analysed using analysis of variance (ANOVA) – two way classification. Two factor factorial ANOVA was used to determine the existence of interaction effect between soil orders and cropping systems. Simple correlation coefficient was also developed to evaluate relationships between the response variables using the same statistical package. The 5% probability level was regarded as statistically significant.

Results and discussion

Biological properties:

The higher content of soil organic carbon, the more active the soil microorganisms. Microorganisms accelerate the degradation of OM, which is reflected in soil respiration and release of carbon dioxide from the rizosphere (Zhang *et al*., 2010). Results on the effect of cropping systems and soil type on biological properties are in the Table. 4.7.

4. 4. 1. Dehydrogenase activity

Activity of dehydrogenase reflects oxidative activity of soil microflora and is a good indicator of microbial activity (Nannipieri e*t.at.,* 1990; Velmourougane *et al*., 2013). Activity of dehydrogenase enzyme was significantly higher in vertisol (2.71 µg TPF g^{-1} hr^{-1}) over inceptisol (2.25 µg TPF g^{-1} hr^{-1}). The results were in the same line with Prasad *et al.,* 2013. The greater amount of organic carbon, nutrients and stimulated microbial activity (Velmourougane *et al*., 2013) in Vertisols might have contributed for the increase in dehydogenase activity compared to inceptisol.

Different cropping systems were found to have significant effect on dehydrogenase activity. Irrespective of soil order, dehydrogenase activity was found in the decreasing order of $CS_1 > CS_2 > CS_4 > CS_3$ with the activity of 3.52, 2.65, 2.27 and 1.48 µg TPF g^{-1} hr^{-1}, in respectively in surface soils. It was found that dehydrogenase activity was highest in CS_1, as biological activity was found highest in rice ecology. Under CS_1 very labile pool of SOC was higher which might have used as feed for micro organism (Casida, 1977 and Zaman *et al*., 2002) and enhances soil enzymatic activity. Relationship between SOC and dehydrogenase activity was positively correlated, is shown in the Fig. 1. Similar correlation was also observed by Bergstrom *et al*., 1998 and Roldan *et al*., 2005. Soil organic carbon has been considered as an indicator of soil quality, because of its character of nutrient sink and source that can enhance soil physical and chemical properties, and also promote biological activity (Salazar *et al.,* 2011) and highest carbon and biological activity were found in rice ecology when compared to other cropping systems.

Interactional effect of soil type and cropping system were found to be non significant.

4. 4. 2. Urease activity

Soil types had significant impact on the activity of urease enzyme. Greater urease activity was recorded in vertisols (3.32 µg NH_4-N g^{-1} hr^{-1}) than inceptisols (2.58) as biological activities are more in verisols than inceptisols Prasad *et al.,* 2013.

In cropping systems, rice-rice (CS_1) has maintained higher amount of urease activity followed by $CS_2 > CS_4 > CS_3$ with the activity of 3.84, 3.62, 2.41 and 1.92 µg NH_4-N g^{-1} hr^{-1} respectively. Biogenic elements were more in Rice-Rice cropping system compared to other systems (Strachel, 2016) which helps in increase of microbial properties, such as urease (Strachel, 2016, Saiya-Cork *et al*. 2002, and Wang *et al*. 2008). Ureases participate in ammonification, during which ammonia is

released from urea, amino acids, and purine bases. Soil fertility and productivity depend on soil organic matter, which is a reserve of nutrients and is very important in nutrient cycling (Bai *et al*., 2018) as well as improves soil physical, chemical, and biological properties (Bhattacharya *et al*., 2010). Processes associated with organic matter transformations in soil occur with the participation of soil microorganisms and their enzymes (Schimel *et al*., 2004)

Interactional effect of cropping system and soil types were found to have a profound influence on urease activity. CS_1 cropping system maintained higher urease activity followed by CS_2, CS_4 and CS_3 in inceptisol. Similar trend was followed in vertisols too. Nitrogen content in soil had positive influence on urease activity. With higher the content of nitrogen in soil more will be the urease activity, such results were also found with (Strachel, 2016, Saiya-Cork *et al*. 2002; Wang *et al*. 2008). Relationship between urease with available nitrogen content was positively correlated ($Y=26.80\ X + 128.2$; $R^2=0.499$), is shown in the Fig. 1. Nitrogen stimulates soil microorganisms which produce more soil enzymes when biogenic elements become more available (Strachel *et al.*, 2016). As urease is the enzyme that catalyzes hydrolysis of urea to CO_2 and NH_3, which is a vital process in the regulation of N supply to plants after urea fertilization (Balota *et al.*, 2010).

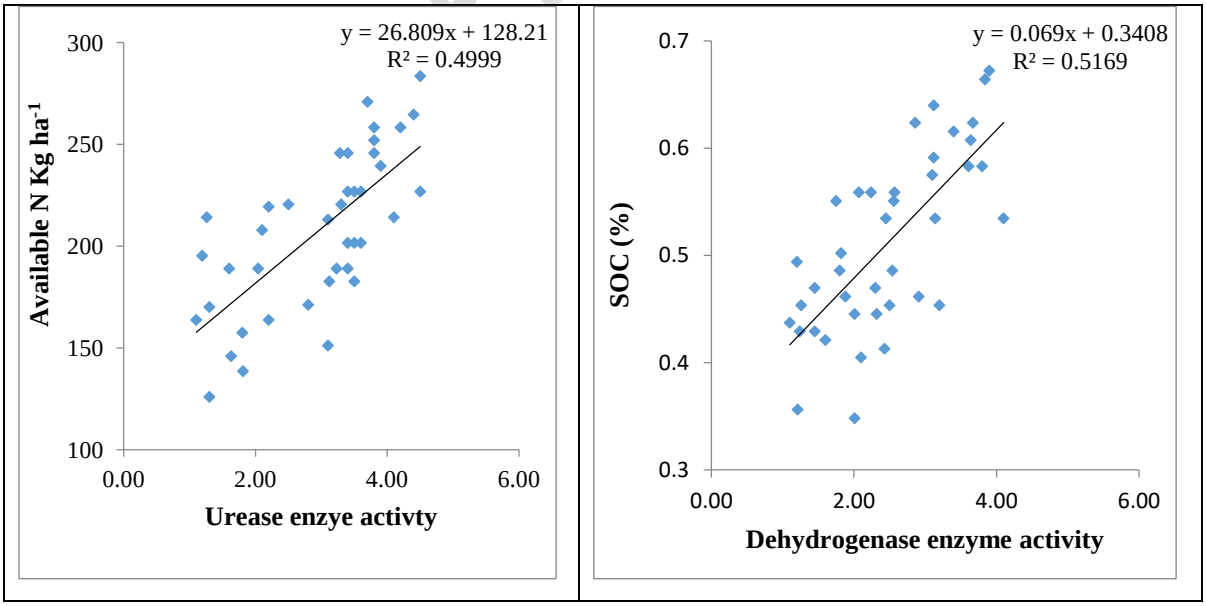

Fig. 1 relationship between soil available nitrogen and urease enzyme activity and SOC and dehydriogenase activity.

Table 1. Influence of soil types and cropping systems on soil microbial biomass

carbon (µg C g^{-1} soil), microbial biomass nitrogen (µg NH_4^+ g^{-1} soil), dehydrogenase (µg TPF g^{-1} hr^{-1}) and urease (µg NH_4-N g^{-1} hr^{-1}) enzyme activities

Soil order	MBC	MBN	Dehydrogenase	Urease
S_1	116.15	9.16	2.25	2.58
S_2	132.41	11.21	2.71	3.32
Sem	4.73	0.35	0.09	0.09
CD@5%	13.71	1.00	0.27	0.27
Cropping System				
CS_1	141.14	11.64	3.52	3.84
CS_2	123.24	10.63	2.65	3.62
CS_3	98.73	8.86	1.48	1.92
CS_4	134.02	9.60	2.27	2.41
Sem	9.00	0.49	0.13	0.13
CD@5%	26.07	1.42	0.38	0.39
Interactions				
S_1CS_1	130.74	10.78	3.32	3.65
S_1CS_2	119.15	9.82	2.25	3.44
S_1CS_3	88.58	7.91	1.32	1.52
S_1CS_4	126.12	8.11	2.12	1.71
S_2CS_1	151.55	12.49	3.72	4.04
S_2CS_2	127.31	11.45	3.05	3.80
S_2CS_3	108.85	9.80	1.64	2.32
S_2CS_4	141.94	11.08	2.43	3.12
Sem	9.47	0.69	0.18	0.19
CD@5%	NS	NS	NS	0.55
CV	17.03	15.20	16.50	14.28

S_1- Inceptisols, S_2- Vertisols, CS_1- Rice-Rice, CS_2- Rice-Maize, CS_3- Cotton –Fallow, CS_4- Turmeric-Sesame, SE m: Standard error of mean, CD: Critical difference, CV: Critical Variance

4. 4. 3. Microbial Biomass Carbon

Microbial biomass carbon (MBC) content in surface soils was significantly higher in vertisols (132 µg C g^{-1} soil) than inceptisols (116 µg C g^{-1} soil) the results were in agreement with Prasad *et al* 2013. The high clay and organic matter contents in vertisols might have contributed for higher MBC values compared to inceptisols.

Different cropping systems were found to have significant effect on MBC. MBC was in the range of 89 to 152 µg C g^{-1} soil MBC values was found highest in CS_1 (141 µg g^{-1}) followed by CS_4 (134 µg g^{-1}), CS_2 (123 µg g^{-1}) and CS_3 (99 µg g^{-1}). Higher MBC values are commonly found in cropping systems that include high residue-producing crops (Omay *et al*. 1997), crops with intensive root growth and root

density (Stone and Buttery 1989; Perfect *et al*. 1990). Thus CS_1 has found to maintain significantly higher MBC values than other cropping systems this may be due to the amount of crop residues, the proportion of easily decomposable organic compounds returned to the soil, root density and microclimate in rice-rice cropping systems (Moore *et al*. 2000).

Interactional effect of soil types and cropping system were found to be non significant.

4. 4. 4. Microbial Biomass Nitrogen

Microbial biomass nitrogen (MBN) content in surface soils was significantly higher in vertisols (11.21 µg NH_4^+ g^{-1} soil) than inceptisols (9.16 µg NH_4^+ g^{-1} soil). The result is also in accordance with Prasad *et al.,* 2013. The high clay and organic matter contents in vertisols might have contributed for higher MBN values compared to inceptisols.

Different cropping systems were found to have significant effect on MBN. The values of MBN ranged from 8.85 to 11.64 µg NH_4^+ g^{-1} soil . MBN values were found highest in CS_1 (11.64 µg NH_4^+ g^{-1} soil) followed by CS_2 (10.63 µg g^{-1}), CS_4 (9.6 µg g^{-1}) and CS_3 (8.86 µg g^{-1}). Thus MBN count was higher in CS_1 as this systems has more substrate production when compared to other systems above. The microbial biomass C and N pools will increase in one cropping system relative to another only if microbes have access to sufficient substrates and non-growth requirements have been satisfied. Therefore, greater microbial biomass in diversified cropping systems may be a consequence of increased substrate availability, where greater retention and recycling of C and N enhance available substrate to support microbial growth and biosynthesis (Geyer *et al*., 2016).

Interactional effect of soil types and cropping system were found to be non significant.

SUMMARY AND CONCLUSION

Microbial biomass carbon contributed 2.25 to 2.90 % to SOC. Biological properties *viz*., microbial biomass carbon, nitrogen, dehydrogenase and urease enzyme activities of soils showed higher values under vertisols over inceptisols. Under cropping systems compared rice- rice cropping system showed significantly higher biological activities in soil. Lowest activities were recorded in cotton- fallow

croppig system. Urease was positively correlated with available nitrogen and dehydrogenase was positively correlated with SOC content. Microbial activities in soil were found higher under vertisols and in rice-rice cropping system.

LITERATURE CITED

Geyer, K.M., Kyker-Snowman, E., Grandy, A.S and Frey, S.D., 2016. Microbial carbon use efficiency: accounting for population, community, and ecosystem-scale controls over the fate of metabolized organic matter. *Biogeochemistry.* 127:173–188.

Prasad, P. George, J. Masto, R.E., Rout, T.K., Ram, L.C and Selvi, V.A., 2013. Evaluation of Microbial Biomass and Activity in Different Soils Exposed to Increasing Level of Arsenic Pollution: A Laboratory Study. *Soil and Sediment Contamination.* 22(5): 483-497.

Moore, J.M., Klose, S and Tabatabai, M.A. 2000. Soil microbial biomass carbon and nitrogen as affected by cropping systems. *Biology and Fertility of Soils.* 31:200-210.

Stone, J.A and Buttery, B.R. 1989. Nine forages and the aggregation of a clay loam soil. Canadian Journal of Soil Science. 69: 165-169.

Perfect, E., Kay, B.D., Van Loon, W.K.P., Sheard, R.W and Pojasok, T. 1990. Factors influencing soil structural stability within a growing season. *Soil Science Society of American Journal*. 54: 173-179.

Omay, A.B., Rice, C.W., Maddux, L.D and Gordon, W.B. 1997. Changes in soil microbial and chemical properties under long-term crop rotation and fertilization. Soil Science Society of American Journal. 61: 1672-1678.

Balota, E.L and Chaves, J.C. 2010. Enzymatic activity and mineralization of carbon and nitrogen in soil cultivated with coffee and green manures. *Revista Brasileira de Ciência do Solo*. 34: 1573-1583.

Strachel. R., Wyszkowska, J and Baćmaga. M. 2016. The Influence of Nitrogen on the Biological Properties of Soil Contaminated with Zinc. *Bull Environ Contam Toxicol.* 2017; 98(3): 426–432.

Saiya-Cork, K.R, Sinsabaugh, R.L and Zak, D.R., 2002. The effects of long term nitrogen deposition on extracellular enzyme activity in an Acer saccharum forest soil. *Soil Biology and Biochemistry.* 34(9):1309–1315.

Wang, Q.K., Wang, S.L and Liu, Y.X. 2008. Responses to N and P fertilization in a young Eucalyptus dunnii plantation: microbial properties, enzyme activities and dissolved organic matter. Applied Soil Ecology. 40(3): 484-490.

Wang, Y., Fu, B., Lu, Y., Song, C and Luan, Y. 2010. Local-scale spatial variability of soil organic carbon and its stock in the hilly area of the Loess Plateau, China. *Quality Research*. 73: 70-76.

Schimel, J.P and Bennett, J. 2004. Nitrogen mineralization: Challenges of a changing paradigm. Ecology. 85, 591–602.

Bhattacharyya, T., Pal, D.K., Chandran, P., Mandal, C., Ray, S.K., Gupta, R.K. and Gajbhiye, K.S. 2004. Managing Soil Carbon Stocks in the Indo-Gangetic Plains, India, RWC-CIMMYT, New Delhi. 44.

Bai, Z., Casparia, T., Gonzaleza, M. R, Batjesa, N.H., Mäderb, P., Bünemannb, E.K., de Goedec, R., Brussaardc, L., Xud, M and Ferreirae, C.S. 2018. Effects of agricultural management practices on soil quality: A review of long-term experiments for Europe and China. *Agriculture, Ecosystem & Environment*. 265: 1-7.

Salazar, S., Sanchez, L., Alvarez, J., Valverde, A., Galindo, P., Igual, J., Peix, A., Santa Regina, I., 2011. Correlation Among Soil Enzyme Activities Under Different Forest System Management Practices. *Ecological Engineering.* 37: 1123-1131.

Bergstrom, D.W., Monreal, C.M and King, D.J., 1998. Sensitivity of soil enzyme activity to conservation practices. *Soil Science Society of America Journal.* 62, 1286-1295.

Zaman, M., Cameron, K.C., Di, H.J and Inubushi, K., 2002. Changes in mineral N, microbial and enzyme activities in different soil depths after applications of dairy shed effluent and chemical fertilizer. *Nutrient Cycling in Agroecosystems*. 63: 275-290.

Casida, L.E. 1977. Microbial metabolic activity in soil as measured by dehydrogenase determinations. *Applied and Environmental Microbiology*. 34: 630-636.

Velmourougane, K., Venugopalan, M.V., Bhattacharyya, T., Sarkar, D., Pal. D.K., Sahu, A., Ray, S.K. , Nair, K.M., Prasad, J and Singh, R.S. 2013. Soil dehydrogenase activity in agro-ecological sub regions of black soil regions in India. *Geoderma.* 197-198: 186-192.

Nannipieri, P., Gregos, S. and Ceccanti, B. 1990. "Ecological significance of the biological activity in soil". Smith, J. L. and Paul (eds) - *Soil Biochemistry*. 6: 293-354.

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

Waldrop MP, Zak DR, Sinsabaugh RL (2004) Microbial community response to nitrogen deposition in northern forest ecosystems. Soil Biol Biochem 36(9):1443–1451

Bastida F, Moreno JL, Hernández T, García C (2007) The long-term effects of the management of a forest soil on its carbon content, microbial biomass and activity under a semi-arid climate. Appl Soil Ecol 37(1-2):53–62

Acosta-Martínez V, Mikha MM, Vigil MF (2007) Microbial communities and enzyme activities in soils under alternative crop rotations compared to wheat-fallow for the Central Great Plains. Appl Soil Ecol 37(1-2):41–52

Pandey D, Agrawal M, Bohra JS (2014) Effects of conventional tillage and no tillage permutations on extracellular soil enzyme activities and microbial biomass under rice cultivation. Soil Tillage Res 136:51–60

de Medeiros EV, Notaro KA, de Barros JA, Moraes WS, Silva AO, Moreira KA (2015) Absolute and specific enzymatic activities of sandy entisol from tropical dry forest, monoculture and intercropping areas. Soil Tillage Res 145:208–215

Gupta, V. V. S. R., and Germida, J. J. (1988). Distribution of microbial biomass and its activity in different soil aggregate size classes as affected by cultivation. Soil Biol. Biochem. 20, 777–786. doi: 10.1016/0038-0717(88)90082-X

Bandick, A. K., and Dick, P. P. (1999). Field management effects on soil enzyme activities. Soil Biol. Biochem. 31, 1471–1479. doi: 10.1016/S0038-0717(99)00051-6

Pavel, R., Doyle, J., and Steinberger, Y. (2004). Seasonal pattern of cellulase concentration in desert soil. *Soil Biol. Biochem.* 36, 549–554. doi: 10.1016/j.soilbio.2003.10.024

Nogueira, M. A., Albino, U. B., Brandao-Junior, O., Braun, G., Cruz, M. F., Dias, B. A., et al. (2006). Promising indicators for assessment of agroecosystems alteration among natural, reforested and agricultural land use in southern Brazil. *Agr. Ecosyst. Environ.* 115, 237–247. doi: 10.1016/j.agee.2006.01.008

Stockdale, E. A., and Brookes, P. C. (2006). Detection and quantification of the soil microbial biomass impacts on the management of agricultural soils. J. Agric. Sci. 144, 285–302. doi: 10.1017/S0021859606006228