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Effect of Integrated Application of Organic and Inorganic Fertilizers on Soil Biological Properties in Coastal Alluvial Soils of Andaman Islands

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Abstract

The use of organic fertilizers has been proposed to enhance soil quality and carbon sequestration in comparison to inorganic fertilizers. A field experiment was conducted during dry months (January to April) of 2016 and 2017 at Field crops Experimental Research Farm, ICAR- CIARI, Port Blair to study the effect of integrated application of organic and inorganic fertilizers for maize-greengram intercropping in coastal plains. The experiment was carried out in Factorial randomized block design (FRBD) with three replications each consisting of two main plots and eight subplot treatments. The main plots treatments include maize, green gram intercropping at 1:1 and 2:2 ratios, while subplots have 8 nutrient applications. The results indicated that the application of organics alone or in combination with inorganic fertilizers and biofertilizer significantly enhanced the rate of soil respiration and enzyme activities. The rate of average soil respiration and enzyme activities was significantly enhanced under organic (N2) and INM treatments compared to inorganic alone (N1) indicating higher soil microbial activity. The study underlined the need for a nutrient management strategy that involves organic and biofertilizers in combination with inorganic fertilizers for nutrient exhaustive crops like maize.

Key words: *Maize-green gram intercropping, nutrient source, soil respiration, soil enzymes*

Introduction

Soil is a very complex system and its quality is central to the sustainability and productivity of agricultural production. There are many strategies of farming in agriculture, such as fertilizer application, inter cropping, conservation agriculture, crop residue recycling, manure or organic application which are significantly influencing the soil quality and productivity in any agricultural ecosystems. Integrated nutrient management (INM) is one such strategy that aims at achieving efficient use of chemical fertilizers in conjunction with organic manures. The crop productivity increases from the combined application of chemical fertilizers and organic manures, besides contributing to the improvement of physical, chemical and biological properties, soil organic matter and nutrient status. The integrated application of chemical and biofertilizer significantly improved the soil quality by increasing soil porosity, water holding capacity, soil organic matter, macro and micro nutrients in the soil. The use of biofertilizer and compost significantly improved soil bacterial and fungal population in the soil, thereby increasing the soil health (Saha *et al*., 2010).

Application of organic manures influences crop growth and yield, either directly by supplying nutrients or indirectly by modifying the soil physical properties. Proper organic matter management is the main challenge to preserve the quality of the soils. However, it is difficult to quantify the changes in soil organic matter as small amounts should be quantified against a large background. In contrast, biochemical indicators such soil enzymes are more sensitive to changes in soil properties due to any change in management effects. Hence, their measurements are largely utilized as indicators of management effect on soil health and biological fertility. Soil enzymes predominantly hydrolases, play a major role in carbon, nitrogen, and phosphorus cycles and oxido-reductases, contribute to decomposition of organic compounds. Measurement of such enzyme activities reflect the intensity and direction of various biochemical processes in soil environment, which reflects any changes in the environment or soil management as such (Wang *et al*., 2015).

Maize is one of the important cereal crop grown in the Islands during Rabi season under rainfed or minimal irrigation facilities. The productivity of the crop mainly depends on proper nutrient management practices. Acid soils coupled with limited availability of chemical fertilizers affect the productivity of the crop in the Islands. Integrating chemical fertilizers with organic manures was quite promising, in maintaining higher productivity. The inclusion of green gram as intercrop and application of vermicompost, biocompost and FYM significantly increased growth attributes, yield parameters and yield of individual crops (Ashish Dwivedi *et al*., 2015). As there is no such studies under Island condition, the present work was undertaken to study the effect of organic sources with different levels of inorganic fertilizer applied to maize – green gram cropping system on the biological properties under Island condition.

Materials and methods

The experiments were carried out at Field Crops Experimental Farm, ICAR- Central Island Agricultural Research Institute, Port Blair during January to April in 2016 & 2017. The experimental site is located in valley plains and subjected to water stagnation and flash flooding during the rice-growing season, while water availability is limited during dry months (January - March/ April). The maize (var. Vivek 27) was intercropped with green gram (var CARI Mung1) during dry period under rainfed condition with small amount of supplemental irrigation during critical crop growth stages. The soil at the experimental site was an Entisol with sandy clay loam texture having a bulk density (1.42 Mg m^3). The soils are slightly acidic (pH 6.0), non saline (EC 0.02 dS m^{-1}), and contained 3.7 g kg^{-1} of organic carbon, 163 kg ha^{-1} of available N, 14.8 kg ha^{-1} P and 256 kg ha^{-1} ammonium acetate K.

Experimental set up

The experiment was laid out in the Factorial Randomized Block Design (FRBD) with three replications each consisting of eight treatments. The main plots has two treatments maize, green gram intercropping at 1:1 and 2:2 ratio, while subplots have 8 nutrient applications and the treatment details are given in table 1

Table1 Nutrient combinations of Maize based cropping system

Treatment	Treatment Combination
N1	Recommended dose of fertilizer (100%)
N2	100% RDM through Organic manure (33% FYM +33% VC +33% PM)
N3	50% RDN through Urea + 50% N through Farm Yard Manure
N4	50% RDN through Urea + 50% N through Vermi Compost
N5	50% RDN through Urea + 50% N through Poultry Manure
N6	25% RDN through Urea + 50% N through Farm Yard Manure + 25% Gliricidia + Azotobactor
N7	25% RDN through Urea + 50% N through Vermi Compost +25% Gliricidia + Azotobactor
N8	25% RDN through Urea + 50% N through Poultry Manure+ 25% Gliricidia + Azotobactor

* RDF- Recommended dose of fertilizers (120:80:60 NPK for maize) RDN- Recommended dose of N, FYM- Farm yard manure, VC- vermicompost, PM- poultry manure

Nutrient content of organics

The organic manures used in the study were characterized for major nutrient concentration using standard methods. Total organic carbon (TOC) was measured after igniting the sample in muffle furnace at 550°C for 6 hrs as a difference between dry weight and ash content. Total N was measured by the method of Bremner and Mulvaney, 1982. Total P and K were extracted in diacid mixture of HNO_3 and $HClO_4$ in 4:1 v/v ratio by wet digestion method. Then, the total P was measured by spectrophotometer and K by flame photometer.

Table 2 The nutrient content of the organic manures used in the study

Parameter	FYM	Poultry manure	Vermicompost	Gliricidia
Total carbon (%)	46.3	36.2	32.5	42.2
Total nitrogen (%)	0.8	2.1	2.9	3.9
Total phosphorus (%)	0.1	1.2	2.6	0.9
Total potassium (%)	0.8	1.1	0.7	0.6
C:N ratio	59.4	17.4	11.2	10.9

Soil sampling and analysis

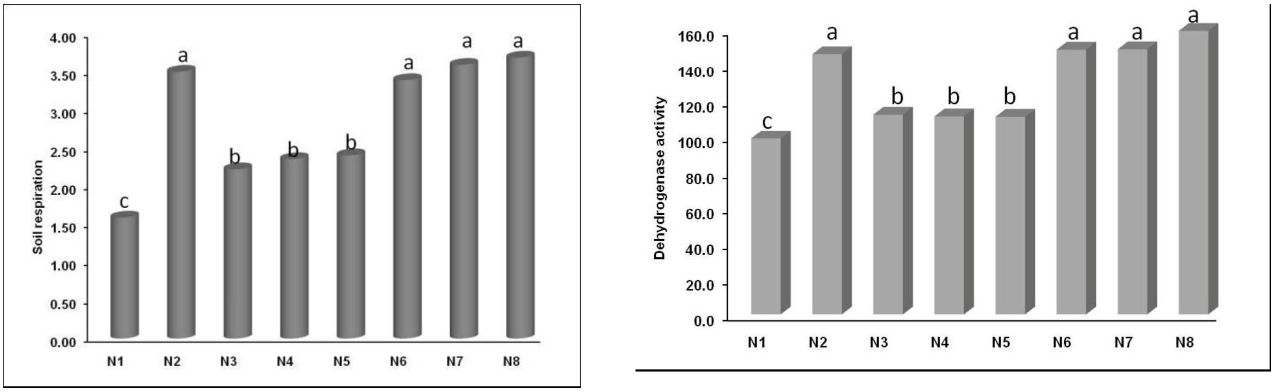
Surface soil samples were collected after harvest of maize and green gram from a depth of 0-15 cm with the help of soil auger from 5 different points within the individual replicated plots of respective treatments and pooled together. 250 g of the samples was preserved at temperature below 0°C until analysis. Remaining samples were air dried and used for soil moisture estimation. The soil pH was measured in 1:2.5 soil water suspensions. The organic carbon and available N were determined by wet oxidation and Kjeldhal method respectively. The soil respiration was estimated by following the methods of Salamanca *et al*. 2002. While soil enzymes viz., dehydrogenase, phosphatase and urease activities were quantified by the method prescribed by Tabatabai (1994) and the results were reported on oven dry basis.

Statistical analysis

The variance analysis was done for the data by the method suggested in Gomez and Gomez (1984). The significance of different sources of variations was tested by error mean square of Fisher and Snedecor's 'F' test at probability level of 0.05. Fisher and Yate's tables were consulted for the determination of least significant difference (LSD) at 5% level of significance. The value standard error of mean (SEm+) and the LSD was used to compare the difference between the treatment means.

Results and discussion

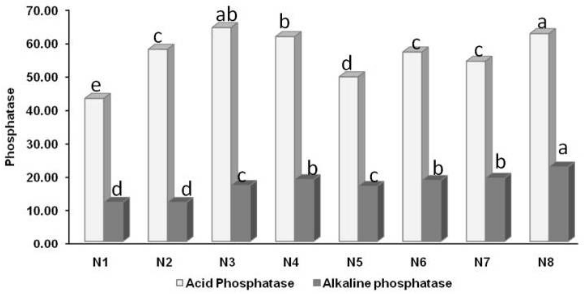
Measuring the activities of soil enzymes is a common approach for estimating soil quality (Gil-Sotres *et al*. 2005). The results indicated no significant influence of different cropping systems on soil biological properties. However, significant differences were observed between different nutrient treatments. The effect of different sources of nutrients under maize-green gram intercropping on soil respiration and enzyme activities was depicted in Fig1. The rate of average soil respiration (Fig. 1a) was significantly enhanced under organic (N2) and INM treatments compared to inorganic alone (N1) indicating higher soil microbial activity. The increase was consistent with the increasing substitution of organic application. Similar to rate of soil respiration, soil enzymatic activities significantly varied with different sources of nutrient supply. Irrespective of the cropping system, the dehydrogenase activity (Fig. 1b) was significantly higher in treatments, where 25% RDN is supplied through urea and remaining N is supplied by organics like poultry manure, green leaf manure, vermicompost in varying combinations along with *Azotobactor* (N6, N7 & N8) and only organic sources of nutrients were applied (100% RDN through organics, N2). The availability of organics with priming effect induced by inorganic urea might have favoured higher microbial activity resulting in higher dehydrogenase activity. And it is considered to be one of the best indicators of overall microbial activity because it occurs only within living cells unlike other extracellular enzymes (Masciandaro *et al*., 2001).



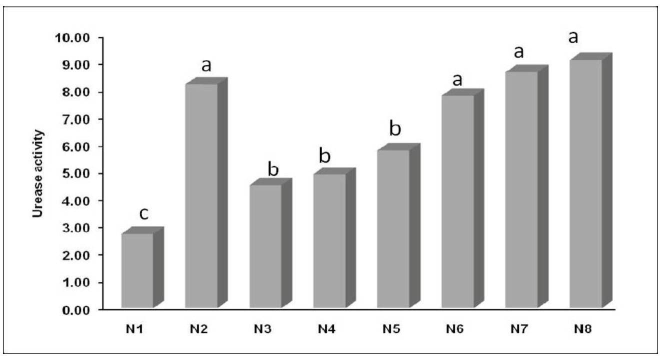
1a Soil respiration (µg CO_2 C g^{-1} soil hr^{-1}) b Dehydrogenase activity (µg TPF g^{-1} soil $24hr^{-1}$)

Fig. 1. Effect of treatments on soil biological properties under maize-green gram system

Hydrolysis of organic P compounds in soil is essential for P uptake by plants and microorganisms, which is mediated by phosphatase enzymes. The activities of soil acid and alkaline phosphatases were affected by different nutrient treatments (Fig. 2a).



2a. Acid and Alkaline phosphatase (µmol p- Nitrophenol g-1 hr-1)



2b. Urease (µmol NH3 -N/g soil/hr)

Fig. 2. Effect of different treatments on soil enzymes important for nutrient mobilization

In general acid phosphatase activity is much higher in all the treatments owing to soil acidity. The addition of organic materials increased the soil acid phosphatase activities when compared to inorganic fertilizer application alone which is similar to observations reported by Dick 1992.

Nitrogen mineralization is an important reaction in soils for supplying sufficient N for plant growth. As urease plays an important role in the hydrolysis of urea, it is widely used as an indicator for evaluating changes in soil quality due to soil management practices. The urease activity (Fig. 2b) was higher in organic treated soils than soils applied with fertilizers alone (N1). As observed for dehydrogenase activity, the urease activity was highest in soils N2, N6, N7 and N8 wherein higher quantity of organics was applied. The lesser application of urea will act as stimulant for microbial growth while organics might have facilitated the slow release of nutrients which might be the reason for higher urease activity in N6 to N8, where the 100% RDN through urea and 50% RDN through urea recorded significantly lower urease activity. Significantly lower mean urease activity (2.71 µmol NH3 -N/g soil/hr) occurred in N1 where only chemical fertilizers were applied. This could be due to the application of organic matter leading to increased supply of nutrients to soil microorganisms and increased enzymatic activities, including urease activity (García *et al.* 1994; Ed-Haun Chang *et al.*2010). The increased soil respiration and enzyme activities of organics applied soils may be the consequence of both microbial growth and stimulation of microbial activity by enhanced resource availability, as well as of changes in microbial community composition (Iovieno *et al.*2009).

Conclusion

The results showed that application of organic manures and Azotobacter in combination with inorganic fertilizers promoted soil respiration and soil enzyme activities. As the microbial activity indicated by soil respiration and dehydrogenase activity was limited by the reduced supply of organic substrates in soil applied with the chemical fertilizers alone, a nutrient management strategy that involves organic and biofertilizers in combination with inorganic fertilizers is essential for nutrient exhaustive crops like maize under Island condition.

References

Ashish Dwivedi, Ista Dev, Vineet Kumar1, Rajveer Singh Yadav, Mohit Yadav, Dileep Gupta, Adesh Singh, & S. S. Toma (2015). Potential role of maize-legume intercropping systems to improve soil fertility status under smallholder farming systems for sustainable agriculture in India. International Journal of Life Sciences Biotechnology and Pharma Research, 4(3):145-157

Bremner, J.C. & Mulvaney C.S. (1982). Nitrogen –Total. In: Methods of soil analysis, Part 2, 2nd Ed.A.L. Page *et al*., eds.. Agronomy 9:595-622.

Dick, R.P. (1992). A review: long-term effects of agricultural systems on soil biochemical and microbial parameters. Agric. Ecosys. Environ., 40, 25–36.

Ed-Haun Chang , Ren-Shih Chung & Fei-Neng Wang (2008). Effect of different types of organic fertilizers on the chemical properties and enzymatic activities of an Oxisol under intensive cultivation of vegetables for 4 years, Soil Science and Plant Nutrition, 54:4, 587-599, DOI: 10.1111/j.1747-0765.2008.00264.x

García, C., Hernandez, M.T., Costa, F. & Ceccanti, B. (1994). Biochemical, parameters in soil regenerated by addition of organic wastes. Waste Manage. Res., 12, 457–466.

Gil-Sotres, F., Trasar-Cepeda, C., Leiros, M.C. & Seoane, S. (2005). Different approaches to evaluating soil quality using biochemical properties. Soil Biol. Biochem., 37, 877–887.

Iovieno, P., Morra, L., Leone, A., Pagano, L. & Alfani, A. (2009). Effect of organic and mineral fertilizers on soil respiration and enzyme activities of two Mediterranean horticultural soils. Biol Fertil Soils (2009) 45:555–561

Masciandaro, G., Ceccanti, B., Benedicto, S. & Lee, H. (2001). Humic substances to reduce salt effect on plant germination and growth. *Commun. Soil Sci. Plant Anal*., **33**, 3–4.

Masciandaro, G., Ceccanti, B., Benedicto, S. & Lee, H. (2001). Humic substances to reduce salt effect on plant germination and growth. Commun. Soil Sci. Plant Anal., 33, 3–4.

Nayak, D.R., Jagadeesh, B. & Adhya, T.K. (2007). Long-term application of compost influences microbial biomass and enzyme activities in a tropical Aeric Endoaquept planted to rice under flooded condition. Soil Biol Biochem 39:1897–1906. doi:10.1016/j.soilbio.2007.02.003

Saha, R,V.K., Mishra, B., Majumdar, K., Laxminarayana, & Ghosh, P.K. (2010). Effect of Integrated Nutrient Management on Soil Physical Properties and Crop Productivity under a Maize (Zea mays)–Mustard (Brassica campestris) Cropping Sequence in Acidic Soils of Northeast India. Communications in Soil Science and Plant Analysis 41(18) :

Salamanca, E., Raubuch, M. & Joergensen, R.G. (2002). Relationships between soil microbial indices in secondary tropical forest soils. Appl Soil Ecol 21:211–219

Tabatabai, M.A. (1994). Soil enzymes. In: Weaver RW, Angle S, Bottomley P, Bezdicek D, Smith S, Tabatabai A, Wollum A (eds) Methods of soil analysis, Part 2, microbiological and biochemical properties. SSSA, Madison, pp 775–833

Wang, R.Z., Dorodnikov, M., Yang, S., Zhang, Y.Y., Filley, T.R., Turco, R.F., Zhang, Y.G., Xu, Z.W., Li, H. & Jiang, Y. (2015). Responses of enzymatic activities within soil aggregates to 9-year nitrogen and water addition in semi-arid grassland. Soil Biol. Biochem. 81, 159–167.

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