Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; SP5: 208-211

Shikha Verma
Department of Soil Science and Agricultural Chemistry, Birsa Agricultural University, Kanke, Ranchi, Jharkhand, India

Prabhakar Mahapatra
Department of Soil Science and Agricultural Chemistry, Birsa Agricultural University, Kanke, Ranchi, Jharkhand, India

Shashi Bhushan Kumar
Department of Soil Science and Agricultural Chemistry, Birsa Agricultural University, Kanke, Ranchi, Jharkhand, India

Asha Kumari Sinha
Department of Soil Science and Agricultural Chemistry, Birsa Agricultural University, Kanke, Ranchi, Jharkhand, India

Asisan Minz
Department of Soil Science and Agricultural Chemistry, Birsa Agricultural University, Kanke, Ranchi, Jharkhand, India

Kumari Prerna Deep
Department of Soil Science and Agricultural Chemistry, Birsa Agricultural University, Kanke, Ranchi, Jharkhand, India

Suryanshu Yadav
Department of Soil Science and Agricultural Chemistry, Birsa Agricultural University, Kanke, Ranchi, Jharkhand, India

Jyotiranjan Pal
Department of Soil Science and Agricultural Chemistry, Birsa Agricultural University, Kanke, Ranchi, Jharkhand, India

Arun Eby Palatty
Department of Soil Science and Agricultural Chemistry, Birsa Agricultural University, Kanke, Ranchi, Jharkhand, India

Correspondence
Shikha Verma
Department of Soil Science and Agricultural Chemistry, Birsa Agricultural University, Kanke, Ranchi, Jharkhand, India

(Special Issue- 5)
International Conference on
"Food Security through Agriculture & Allied Sciences"
(May 27-29, 2019)

Long term effect of nutrient management on biological properties of acid soil under maize-wheat cropping system

Shikha Verma, Prabhakar Mahapatra, Shashi Bhushan Kumar, Asha Kumari Sinha, Asisan Minz, Kumari Prerna Deep, Suryanshu Yadav, Jyotiranjan Pal and Arun Eby Palatty

Abstract
The present study was undertaken on the soil of on-going permanent manurial trial (PMT) during 2015-16, with maize-wheat cropping system, initiated in 1956 at Birsa Agricultural University in Jharkhand state, India. The selected treatments were T_1-$N_0P_0K_0$ (control), T_2-100%N, T_3-100%NP, T_4-100%NPK, T_5-100%NPK+Lime, T_6-Farmyard manure (FYM) alone, T_7- - ½ (N+FYM) + P $_{(A-X/2)}$ + K $_{(B-Y/2)}$ (Integrated nutrient management; INM) and T_8-Lime+N. Surface soil samples from all the treatments were collected and biological properties [soil microbial population, soil microbial biomass carbon (SMBC), dehydrogenase activity (DHA) and potential mineralizable nitrogen (PMN)] were determined and compared with the sustainability of the maize-wheat cropping system in terms of sustainable yield index (SYI). Population of bacteria and actinomycetes were favoured by application of lime/FYM in conjunction with 100% NPK as well as by FYM alone while application of only inorganic fertilizers resulted in higher fungal population. Application of lime or FYM in conjunction with NPK recorded increased SMBC, DHA and PMN over control. Continuous use of imbalanced chemical fertilizer particularly through urea alone had deleterious effect on biological properties of the soil. Highest SYI was recorded in 100%NPK+ lime treatment (0.43) followed by T7 receiving integrated application of FYM and NPK (0.36). 100% N treatment recorded the lowest and negative SYI (-0.03). The study revealed that integrated application of lime/FYM along with balanced chemical fertilizers for cereal-cereal cropping system in acid soil could be followed for maintaining the sustainability of the system as well for maintaining the soil biological health.

Keywords: Acid soil, lime, FYM, soil microbial biomass carbon, dehydrogenase activity, potential mineralizable nitrogen, sustainable yield index

Introduction
The concept of soil health deals with integrating the physical, chemical and biological components of the soil. The soil quality is strongly influenced by the microbiological mediated processes. Soil microbes play an important role in nutrient cycling, decomposition of organic matter, mineralization of organic forms of element, bioremediation of toxic wastes and various other biochemical reactions which influences the soil fertility and plant growth. Changes in soil properties due to different nutrient management practices can significantly affect the biological properties of soils, some of them being extremely sensitive to soil management; and hence some soil biological properties can be used as indirect indicators of appropriate soil management and good soil quality (Gurjar *et al.* 2017) [6]. There are reports which suggest that application of fertilizers on continuous basis has resulted in the changed composition and functions of soil microorganisms (Dong *et al.* 2014) [3]. Application of organic manure improves the microbial condition of soil (Babu *et al.* 2007) [1]. There are reports suggesting that conjunctive use of organic manure with chemical fertilizers improve the population of microbes and enzymatic activities (Mallikarjun and Maity, 2018) [10]. A knowledge of soil biological properties is thus important for maintaining soil quality, plant health, soil resilience, soil fertility and soil sustainability. The present investigation was therefore conducted to

determine the long term effect of different nutrient management practices on biological properties of soil under maize-wheat cropping system in an acid soil after 60 cycles of cropping.

Materials and Methods

The present investigation was conducted on permanent manurial trial (PMT) with maize-wheat cropping system on an acidic red loam soil at Birsa Agricultural University, Kanke, Ranchi (85^0 19' East longitudes, 23^0 17' North latitude 625 m above the mean sea level) in Jharkhand state, India. The soil of the experimental site is acidic red loam. The experiment consisted of fourteen treatments, each replicated thrice in randomized block design (RBD) having individual plot size of $10m^2$. Out of 14 treatments under PMT, only eight treatments were selected for this study. The selected treatments were T_1 –$N_0P_0K_0$ (Control), T_2 -100 % N, T_{3-} 100 % NP, T_{4-} 100 % NPK, T_{5-}100 % NPK + Lime, T_{6-} FYM, T_{7-} ½ (N+FYM) + P $_{(A-X/2)}$ + K $_{(B-Y/2)}$ (INM) and T_{8-} Lime + N. The recommended dose of fertilizer for maize and wheat were 110-90-70 kg N-P_2O_5-K_2O/ha supplied through urea, single superphosphate and muriate of potash, respectively. In lime treated plot lime was supplied as per lime requirement (LR) once in four years. In T_6 FYM was applied @22 ton ha^{-1} 15 days before sowing of each crop. In treatment T7, A and B stand for full dose of P and K i.e. 90 kg P_2O_5 and 70 Kg K_2O ha^{-1}, respectively. X and Y represent the amount of P and K present in full dose of FYM applied on N basis to meet 110 kg N ha^{-1}. The amount of N, P and K contained in FYM were taken into consideration in adjusting the final dose when applied in conjunction with fertilizers. In INM plot, 50% of N was substituted through FYM and NPK @ of 55kg N ha^{-1} as urea + 55.6 kg P_2O_5 ha^{-1} as SSP + 42.9 kg MOP ha^{-1} was supplied. Surface (0–15cm) soil samples were collected from each plot after the harvest of maize (2015-16). A part of the representative soil sample was air dried, crushed and passed through 2 mm sieve. Other part was stored in refrigerator for determination of soil microbial biomass carbon (SMBC). Soil microbial biomass carbon (SMBC) was estimated using chloroform fumigation extraction method (Vance *et al.* 1987) [15]. Dehyrogenase in the soils was measured by triphenyl tetrazolium chloride method (Klein *et al.* 1971) [8]. Potential minralizable nitrogen (PMN) was determined by anaerobic incubation method (Keeney 1982) [7]. Soil microbial population (bacteria, actinomycetes and fungi) was determined by serial dilution as per standard methods. The data sets were processed for analysis of variance as applicable to randomized block design using least significant difference as described in Gomez and Gomez (1984) [5]. Treatment means were compared at 5% level of significance. The sustainability of the maize-wheat cropping system for the years of experimentation (1960-65, 1966-75, 1976-85, 1986-95, 1996-05 and 2006-15) was measured in terms of sustainable yield index (SYI).

Results and Discussion

Soil microbial population

Application of chemical fertilizers alone significantly reduced the population of both bacteria and actinomycetes as compared to control as evident from the table 1; probably due to the acidic nature of the fertilizers. However, application of lime/FYM along with chemical fertilizers as well as FYM alone increased the population of bacteria and actinomycetes. This might be due to the favorable effect of lime on soil pH and addition of FYM resulted in increase in organic matter which act as a substrate for stimulation of bacterial growth. Application of lime favours neutral pH and add Ca which is conducive for bacterial growth. Application of only inorganic fertilizers resulted in higher fungal population as compared to lime/FYM along with chemical fertilizers due to low soil pH which is preferred by the fungi. The results are in agreement with the findings of Vineela *et al.* (2008) [16] and Tao *et al.* (2015) [14].

Table 1: Microbial population of acid soil as influenced by long term nutrient management practices under maize – wheat cropping system

Treatment	Bacteria ($x10^6$cell g^{-1} soil)	Fungi ($x10^3$propagules g^{-1} soil)	Actinomycetes ($x10^6$cell g^{-1} soil)
Control	14.8	10.0	10.3
100% N	11.8	12.6	8.6
100% NP	11.1	12.9	8.8
100% NPK	10.1	13.1	9.1
100% NPK + Lime	18.3	12.2	12.2
FYM	18.1	12.0	12.0
INM	16.5	10.7	10.7
Lime + N	16.5	10.7	10.7
CD (P = 0.05)	1.62	1.42	1.34
CV (%)	6.31	6.85	7.5

Soil microbial biomass carbon (SMBC)

Soil microbial biomass carbon (SMBC) is a measure of the carbon contained within the living component of soil organic matter. Highest value of soil microbial biomass carbon was recorded in INM plots (363.7ppm) which was significantly higher over control and at par with the treatments FYM alone, 100%NPK+ lime and 100% NPK (Table 2). Low values of SMBC were observed in treatments receiving imbalanced fertilization which was at par with control. Lower level of crop productivity over the years due to continuous mining of nutrients in absence of any external source of plant nutrients in control; inadequate use of nutrients in treatments receiving imbalanced fertilization led to consequent reduction in biomass carbon due to limited substrates in the form of root exudates and thus restricted microbial activity. Balanced dose of inorganic fertilizer showed increased microbial biomass carbon which may be due to the formation of more root exudates due to higher crop productivity. FYM alone as well as conjoint use of inorganic fertilizers and organic materials (INM) showed increase in microbial biomass carbon. Manure application aids in direct incorporation of organic matter, better root growth and more addition of plant residues and provides favorable environment for enhanced microbial activity. Application of lime with balanced NPK also recorded higher SMBC probably due to ameliorating effect of lime providing better environment conducive for microbial growth and NPK application providing easily accessible nutrient for the growth of microbes. These results are in accordance with the findings Gogoi *et al.* (2010) [4] and Nath *et al.* (2012) [11].

Potential mineralizable nitrogen (PMN)

Potential mineralizable nitrogen can be defined as the fraction of organic nitrogen converted to plant available (or mineral) forms under specific conditions of temperature, moisture, aeration, and time. Determining levels of PMN can provide an estimate of available N in the soil. Potential mineralizable nitrogen varied from 55.6 ppm in control to 78.6 ppm in

100% NPK + lime treatment as evident from table 2. Supplementing lime along with balanced NPK application recorded the highest PMN content probably due to the ameliorating effect lime providing a better environment conducive for microbial growth and NPK application providing easily accessible nutrient for the growth of microbes.

Dehydrogenase activity (DHA)

The soil dehydrogenase activity (DHA) provides correlative information on the biological activity and microbial population in soil. It is considered to exist as integral parts of intact cells. They are not residing extracellular in the soil. Measurement of dehydrogenase represents immediate metabolic activities of soil microorganism at the time of the test. A good correlation has been reported between microbial biomass and soil DHA by Chander *et al*. (1977) [2]. Perusal of the data on dehydrogenase activity (Table 2) revealed that application of lime along with NPK recorded the highest DHA (18.33 µg TPF formed day^{-1} g^{-1} of soil) which was significantly superior to rest of the treatments. It may be attributed to the ameliorating effect of lime on soil pH which is conducive for enhanced micriobial growth and development and balanced inorganic fertilizers provide easily accessible nutrient for microbes which might have resulted in increased metabolic activity. Application of FYM in conjoint use with inorganic fertilizers showed significant increase in dehydrogenase activity as compared to inorganic fertilizers and control. Higher accumulation of soil organic carbon, additional supply of both primary and micronutrients, better physical condition of soil, better root growth and thus increased availability of substrate for dehydrogenase activity due to addition of organic source *viz* FYM and the easily accessible nutrient for microbes due to supply of inorganic fertilizers might be responsible for increased dehydrogenase activity. The treatment receiving only FYM was significantly superior to control, 100%N and 100% NP. Rai and Yadav (2011) [12] also showed that DHA activity was more in soil treated with organic sources either solely or combined with inorganic fertilizers as compared to NPK treatment. 100 per cent N treatment recorded the lowest dehydrogenase activity. Application of lime together with N alone significantly enhanced the DHA as compared to 100% N which clearly demonstrates the favorable effect of lime on activity of microbes in acid soils.

Table 2: Soil microbial biomass carbon (SMBC), dehydrogenase activity (DHA) and potential mineralizable nitrogen (PMN) of acid soil as influenced by long term nutrient management practices under maize – wheat cropping system

Treatment	SMBC (ppm)	DHA (µg TPF formed day^{-1} g^{-1} of soil)	PMN (ppm)
Control	233.9	7.17	55.6
100% N	228.7	6.67	58.3
100% NP	276.0	7.83	65.3
100% NPK	331.9	8.33	70.3
100% NPK + Lime	305.3	18.33	78.6
FYM	305.7	10.67	67.3
INM	363.7	12.08	62.4
Lime + N	226.8	10.83	57.5
CD (P = 0.05)	69.28	2.61	9.33
CV(%)	13.93	14.57	8.27

Sustainable Yield Index (SYI)

Sustainable yield index (SYI) helps to establish the minimum guaranteed yield that can be obtained relative to maximum observed yield. crop yields, whereas deviation from 1 indicates losses to sustainability (Reddy *et al*. 1999). Table 3 shows the sustainability of the maize-wheat cropping system for the years of experimentation (1960-65, 1966-75, 1976-85, 1986-95, 1996-05 and 2006-15). The treatment receiving continuous application of lime in conjunction100% NPK recorded the highest SYI (0.43). Sustainable yield index (SYI) followed the following order: Lime+ NPK (0.43) >INM (0.36) > FYM (0.28) > Lime + N (0.24) > NPK (0.11) > NP (0.06) = Control (0.06) > N (-0.03). Continuous application of only nitrogenous fertilizer might have limited the availability of other essential nutrients due reduced soil pH. Proper liming of the acid soil increases soil pH and reduces exchangeable acidity, thereby, enhancing the crop productivity and sustainability. Integrated application of FYM along with balanced chemical fertilizer recorded 227% increase in SYI as compared to 100% NPK. This may be attributed to the positive effects of FYM on physical, chemical as well as biological properties of the soil. Organic manure enhances the organic carbon status of the soils as well as increases the nutrient regime by supplying micronutrients in addition to primary nutrients in due course of time, while the chemical fertilizer fulfill the immediate requirement of the crop. This suggests that the productivity of maize-wheat system could be sustained by integrated use of lime or FYM and chemical fertilizers. In acid soils, use of chemical fertilizers or FYM alone cannot sustain the desired level of sustainability in the long run. Kumari *et al*. (2013) [9] also reported the similar results.

Table 3: Effect of long term nutrient management practices on sustainable yield index (SYI) of maize – wheat cropping system

Treatment	Maize-wheat system
Control	0.06
N	-0.03
NP	0.06
NPK	0.11
Lime + NPK	0.43
FYM	0.28
INM	0.36
Lime + N	0.24

Conclusions

Long term application of NPK in conjunction with lime / FYM as well as FYM alone significantly influenced soil microbial biomass carbon, dehydrogenase activity and potential mineralizable nitrogen over control. Integrated use of balanced chemical fertilizer along with lime or FYM also positively influenced the microbial population Continuous use of imbalanced chemical fertilizer particularly through urea alone had deleterious effect on biological properties of the soil. The higher values of sustainable yield index (SYI) were obtained in the treatments receiving lime/FYM along with NPK as compared to rest of the treatments. Application of chemical fertilizers or FYM alone in acid soils are not viable options for enhancing and sustaining crop production under maize-wheat cropping sequence. So, the study suggests that integrated application of lime/FYM along with balanced chemical fertilizers for cereal-cereal cropping system in acid soil could be followed for maintaining the sustainability of the system as well for maintaining the soil biological health in the long run.

References

1. Babu MVS, Reddy CM, Subramanyam A, Balaguravaiah D. Effect of integrated use of organic and inorganic fertilizers on soil properties and yield of sugarcane. Journal of the Indian Society of Soil Science. 2007; 55:161-166.
2. Chander K, Goyal S, Mundra MC, Kapoor KK. Organic matter, microbial biomass and enzyme activity of soils under different crop rotations in the tropics. Biology and Fertility of Soils. 1977; 24:306-310
3. Dong W, Zhang XY, Dai XQ, Fu XL, Yang FT, Liu XY, *et al*. Changes in soil microbial Community composition in response to fertilization of paddy soils in subtropical China. Applied Soil Ecology. 2014; 84:140-147.
4. Gogoi B, Barua NG, Baruah TC. Effect of integrated supply of nutrients on soil microbial biomass carbon in an Inceptisol of Assam. Journal of the Indian Society of Soil Science. 2010; 58:241-244.
5. Gomez KA, Gomez AA. Statistic al Procedures for Agricultural Research. John Wiley and Sons, New York, 1984.
6. Gurjar GN, Swami S, Telkar SG, Meena NK, Kant K, Kumar R. Soil Biological Properties and Their Importance in Agricultural Production. Biomolecule reports, 2017, 1-5.
7. Keeney DR. Nitrogen Availability Indices. In: Methods of Soil Analysis, Part 2: Chemical and Microbiological Properties (CA Black; *et al*., eds.). American Society of Agronomy Madison, Wisconsin, USA, 1982, 711-733.
8. Klein DA, Loh TC, Goulding RL. A rapid procedure to evaluate dehydrodenase activity of soils low in organic matter. Soil Biology and Biochemistry. 1971; 3:385-387.
9. Kumari G, Thakur SK, Kumar N, Mishra B. Long term effect of fertilizers, manure and lime on yield sustainability and soil organic carbon status under maize (*Zea mays*)-wheat (*Triticum aestivum*) cropping system in Alfisols. Indian Journal of Agronomy. 2013; 58(2):152-158.
10. Mallikarjun M, Maity SK. Effect of Integrated Nutrient Management on Soil Biological Properties in Kharif Rice. International Journal of Current Microbiology and Applied Sciences. 2018; 7(11):1531-1537
11. Nath DJ, Ozah B, Baruah R, Barooah RC, Borah DK, Gupta M. Soil enzymes and microbial biomass carbon under rice-toria sequence as influenced by nutrient management. Journal of the Indian Society of Soil Science. 2012; 60:20-24.
12. Rai TN, Yadav J. Influence of inorganic and organic nutrient sources on soil enzyme activities. Journal of the Indian Society of Soil Science. 2011; 59(1):54-59.
13. Reddy DD, Subba Rao A, Reddy Sammi K, Takkar PN. Yield sustainability and phosphorus utilization in soybean-wheat system on Vertisols in response to integrated use of manure and fertilizer phosphorus. Field Crops Research. 1999; 62:181-190.
14. Tao R, Liang Y, Wakelin SA, Chu G. Supplementary chemical fertilizer with an organic component increases soil biological function and quality. Applied Soil Ecology. 2015; 96:42-51.
15. Vance ED, Brookes PC, Jenkinson DS. An extraction method for measuring soil microbial biomass carbon. Soil Biology and Biochemistry. 1987; 19:703-707.
16. Vineela C, Wani SP, Srinivasarao C, Padmaja B, Vittal KPR. Microbial properties of soils as affected by cropping and nutrient management practices in several long-term manurial experiments in the semi-arid tropics of India. Applied Soil Ecology. 2008; 40:165-173.