Research Article

PHOSPHORUS MICROBIOLOGY UNDER ORGANIC FARMING SYSTEM

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KEY WORDS:
Organic farming, Tea garden, Phosphate solubilization

ARTICLE INFO
Received on: 17.11.2017
Revised on: 28.02.2018
Accepted on: 18.03.2018

ABSTRACT
The problem in organic farming system is acute with nutrient element like phosphorus as it cannot be gained through biological acquisition as that of biological nitrogen fixation Microbiologically driven P-transformations are vibrant under organic farming systems A research work was conducted to study the microbiological potentiality of phosphorus transformation under organic production systems. To understand transformation of phosphorus, soils were sampled from older established certified organic tea gardens under two agro-ecological zones of Brahmaputra and Barak Valley of Assam. Soils of conventional tea gardens of those regions were also collected and treated as control to understand the edge of organic husbandry over conventional ones. A set of microbiological parameters leading to mineral phosphate solubilization including phosphate solubilizing microbial load, their solubilizing capacity, enzyme activities, mineralization rate, microbial biomass phosphorus, immobilization potential were assessed under each system. Organically managed tea gardens stimulated higher phosphate solubilizing microbial load, % of mineral phosphate solubilisation capacity reaches as high as 64% while in case of conventional tea gardens it is only 22%, more net accumulation of phosphorus and better enzyme activities leading to higher organic phosphorus mineralization in organic tea gardens.

INTRODUCTION

Organic farming is an integrated evaluation of all possible organic sources and practices synthesized for a particular eco-system with the sole aim of strengthening crop husbandry. All the processes involved in soil-plant relations should be synchronized with natural processes such as decomposition, nitrification, phosphorus solubilization and mineralization and many other microbial activities to achieve the desirable level of productivity.(Joshi *et al*.,2011) Organic farming is one of the widely used methods, which is thought of as the best alternative to avoid the ill effects of chemical farming. Organic agriculture is now becoming a promising practice globally. In recent times, the need for organic farming is increasingly felt in view of consumer's concern for residue free food items for better health . As such, the demand for organic husbandry is progressively increasing for quality products and sustaining the productivity with the increase in biological buffering of soil. Organic production potentially affects a number of soil properties, including soil organic matter(SOM) content, microbial activity, microbial community structure, soil aggregation, water-holding content, and soil chemistry, which could potentially affect P availability (Stockdale et al., 2001). The question of replenishment of phosphorus levels in organic agricultural systems is indeed as one of the main challenges for the long-term productivity of organic farms. The importance of P- nutrition holds specific significance for acid soil areas like Assam. Recycling of soil native phosphorus- microbiologically exploited P pool and external sources like composted-P, poultry droppings etc. are the better alternative sources to overcome the problem of P nutrition in P- deficient soils .Providing adequate levels of P for plant grow depends on both microbial activity to mineralize organic P forms and solubilization of insoluble inorganic P. Under this background soils of established and certified organic tea (*Camellia sinensis*) gardens were analyzed to evaluate phosphate solubilising bacterial load under different organic production systems, to assess and understand the microbiological and biochemical processes leading to P-transformation in organic farming soils and to explore microbiologically exploited potential P-pools in organic farming soils and their characterization, quantification etc.

MATERIALS AND METHODS

Soil samples were collected from different agro-climatic conditions with different cropping sequences and management practices followed in Tea Gardens of Assam. Soil samples were collected from different organic and inorganic Tea Estate of Assam. Organic Tea Estates included Belseri Tea Estate, Chardwar Tea Estate, Jalinga Tea Estate, Kalachera Tea Estate and the inorganic Tea Estates include Irrongmora Tea Estate, Rose Candy Tea estate. Soils samples were collected at the depth of 0-15(cm) by means of spade from 15 to 20 well distributed spots, moving in zigzag manner from each of the sampling site after scrapping off the surface litter. The basic detail characteristics of the sampling sites i.e., tea gardens are described in the Table 1. The collected soil samples were air dried, grinded and passed through 2.0 mm nylon sieve and analyzed for different parameters following the standard protocol (Table 2). At Conceptual level, the organic farming aims at achieving the regeneration and continuance of natural processes of plant growth in a given eco-system by making the eco-system as a self –sustainable system. The organic farming aims at making crop husbandry as self – supporting and self sustainable activity in a given eco-system rather than its dependence on outside inputs. Organic farming is an integrated evaluation of all possible organic sources and practices synthesized for a particular eco-system with the sole aim of strengthening crop husbandry. All the processes involved in soil-plant relations should be synchronized with natural processes such as decomposition, nitrification, phosphorus solubilization and mineralization and many other microbial activities to achieve the desirable level of productivity.

Table 1. Characteristics of the sampling sites

Name of the Garden and company	Jalinga	Kalachera	Belseri	Chardwar	Rose candy	Irrongmara
Name of the place/ district	Dwarbund	Dwarbund	North Bank	North Bank	Dwarbund	North Bank
block	Chaklabil	Chaklabil	Tejpur	Tejpur	Chaklabil	Tejpur
Name of the state	Assam	Assam	Assam	Assam	Assam	Assam
Agro-ecological Zone	Barak Valley	Barak Valley	Brahmaputra valley	Brahmaputra valley	Barak Valley	Brahmaputra valley
Textural Class	Sandy Loam	Sandy Loam	Sandy Clay Loam	Sandy Clay Loam	Sandy Loam	Sandy Clay Loam
pH of soil	4.10-5.0	4.10-5.0	4.10-5.10	4.10-5.10	4.10-5.10	4.10-5.10
EC(ds/m)	0.5-0.8	0.6-0.8	0.3-0.5	0.4-0.5	0.6-0.8	0.6-0.8
Status	Organic	Organic	Organic	Organic	Conventional	Conventional
Accredited by	LACON (India)	LACON (India)	LACON (India)	LACON (India)	-	-
Year of starting of organic gardening	2006	2006	2007	2007	-	-

Table 2. Parameters analysed

Chemical attributes	Methods Used	Biological attributes	Methods Used
Soil pH	Sorensen(1924)	Microbial biomass P	"Fumigation extraction method" developed by Brookes et al(1982)
Oxidisable organic C	Walkley and Black method (1930)	Phytase activity	Ames (1966).
		P solubilizing Power	Olsen's modified Ascorbic Acid method

RESULTS AND DISCUSSION

Status of phosphate solubilising microbial load

It was observed that organically managed tea garden soils harboured significantly higher microbial population as compared to conventional tea garden irrespective to agro-ecological zone. It was also worked out that organic tea husbandry equally influenced the abundance of phosphate solubilizing bacteria, fungi and acitinoimycetes. However, organic tea garden, Belsri under Brahmaputra Valley reared maximum number of bacteria and fungi .Whereas, under Barak Valley, Jalinga tea garden soils harboured maximum number of bacteria, fungi and actinomycetes population. On an average, Belseri tea garden soil registered 40.76% and 49.06% increase in bacteria and fungi population over conventional tea garden Irrangmara. Whereas, jalinga tea garden soils harboured 69.67% and 84.49% more bacterial and fungal population over conventional Rose Candy tea garden of that agroecological zone (Table 3).

Table 3. Phosphate solubilising microbial load under organic and conventional tea gardens of Assam

Site	Bacteria (CFUX10^5)	Fungi (CFUX10^3)	Actinomycetes (CFUX10^4)
Belseri	39.60a	10.36a	26.73bc
Chardwar	29.67b	8.71ab	22.03c
Irrangmara	28.13b	6.95bc	27.2bc
Jalinga	32.30b	9.04ab	40.1a
Kalachera	26.37b	9.21ab	22.53bc
Rose Candy	19.04c	4.9c	23.3b

Means followed by a different letter are significantly different at $p \leq 0.05$ by Duncan's multiple range test.

Phosphate Solubilisation Power

It was noticed that irrespective of location agroecological zone, age of organic garden and management packages, organically managed gardens secured significantly higher insoluble inorganic phosphate solubilizing power of soils (Fig. 1 and 2). Reduction in mineral phosphate solubilization across conventional tea gardens may be explained by the fact that p-solubilization activity of microorganisms is affected by the presence of soluble phosphate (Mikanova and Novakova, 2002) used as phosphatic chemical fertilizers in conventional tea gardens. Goldstein and Liu (1987) have indicated that mineral phosphate solubilizing activity in genetically coded in a gene cluster on plasmids of the microorganisms possessing this activity.

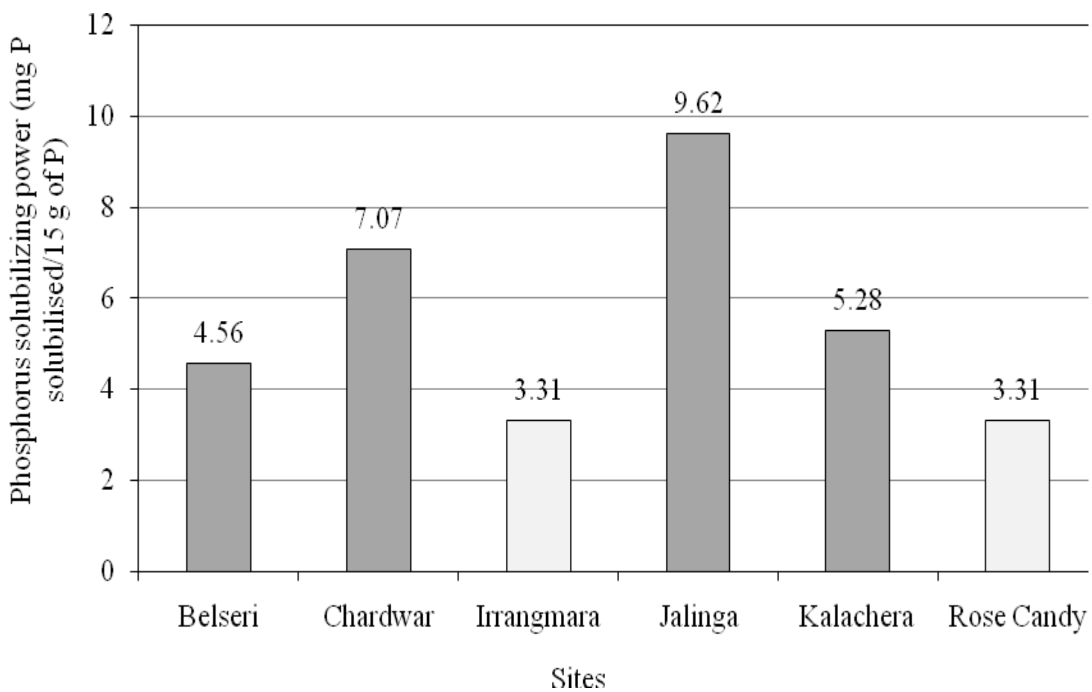

Fig. 1. Phosphate solubilizing power of different organic and conventionally managed tea gardens of Assam

Activities of acid phosphatise, alkaline phosphatise and phytase activity

Acid phosphatise, alkaline phosphatase and phytase activities were significantly increased under organic tea husbandry over conventional tea gardens in all the locations. This increased activity indicates persistence of relatively higher degree of organic phosphorus mineralization in organically produced tea gardens than conventional gardens. This is because acid phosphatase is considered as a potential biomarker for organic phosphorus mineralization under acidic soil conditions. Organic P is a major component of soil P, making up 20-80% of the total P in the surface layers of soil (Dalal, 1977). A major constituent of organic P in soil is phytate (inositol hexa and pentaphosphates), which can account for up to half of the total organic P present (Dalal, 1977). Hence, it is an important source of plant available phosphate in agriculture, in general, organic agriculture in particular. Results demonstrated that organically produced tea garden soils exhibited a significantly higher order of phytase activity over its counterpart conventional tea garden soils in all locations and under different management practices.

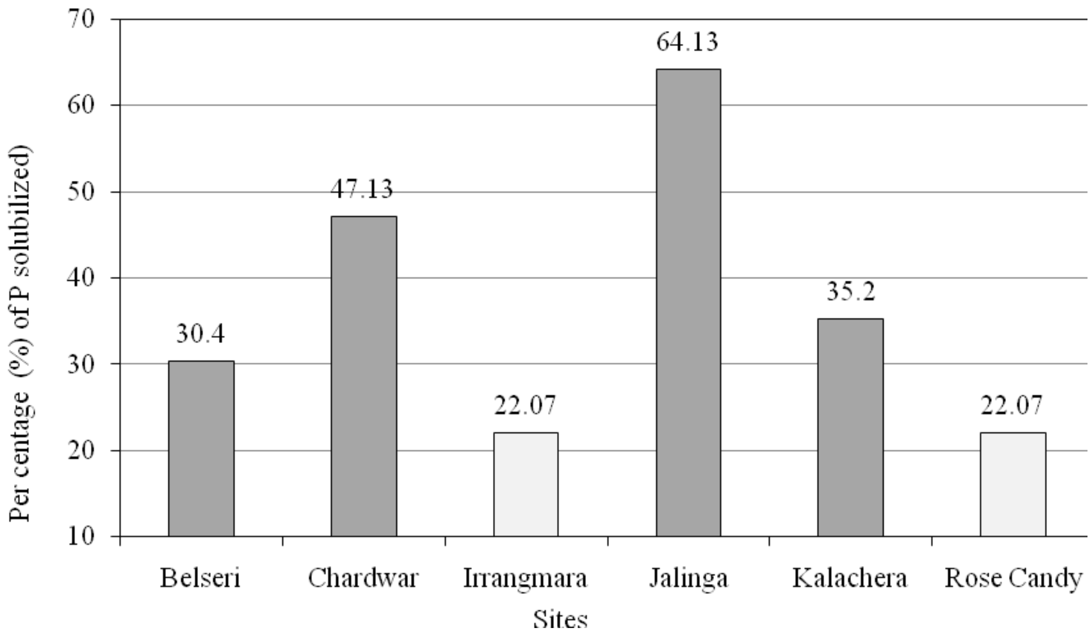

Fig. 2. Percent of P solubilised in different organically and conventionally managed tea gardens of Assam

Table 4. Acid phosphatase, alkaline phosphatase and phytase enzyme activity of different organic and conventionally managed tea gardens of Assam

Site	Acid Phosphatase Activity (µg p-np/g/hr)	Alkaline Phosphatase Activity (µg p-np/g/hr)	Phytase Activity (µ mole Pi released/sec/g)
Belseri	1080.56a	179.34a	26.23b
Chardwar	749.69c	137.97b	30.86a
Irrangmara	452.04e	124.42c	17.63d
Jalinga	582.98d	126.64c	17.63d
Kalachera	800.66b	142.17b	22.23c
Rose Candy	438.09e	101.48d	17.38d

Means followed by a different letter are significantly different at $p \leq 0.05$ by Duncan's multiple range test.

Mineralization rate, mineralization potential, net mineralization, immobilization potential and microbial biomass phosphorus

Mineralization rate, mineralization potential, net mineralization, immobilization potential and microbial biomass phosphorus of different organic and conventionally managed tea gardens of Assam were significantly higher in all of the organic tea garden soils compared to those in inorganic tea garden soils (Table 5). This is the line with the observation of Oehl *et al.* (2004) who also registered pronounced P mineralization under bio-organic and biodynamic production systems as compared to conventional farming receiving chemical fertilizers. In present study sites, compost, Farm yard manure(FYM), vermicompost and concentrates like, mustard and neem oil cake were routinely used for nutrition of tea plants and sustaining soil fertility Thus, an account of mineralization potential will be an advantage for proper P management in organic systems. Quantitative information on the release of available inorganic P by this process is difficult to obtain because any mineralized P gets rapidly sorbed (Oehl *et al.*, 2004).

The Microbial Biomass Phosphorus in soils of organic tea gardens were within the range of 3.09-4.95% of total P of different soils studied. These values are within the range reported by Chen *et al.* (2000) where MBP accounted for 0.7 to 8.4% of the total P in soils. Results obtained in present investigation are in conformity with the above finding. However, the variations in microbial biomass size might be due to differences in microbial community structure and availability of P in soils. Microbial biomass P is regarded as easily mineralizable P fraction of soils. A substantial amount of P is stored in their biomass often in excess of their physiological requirements. While calculating the immobilization potential of P on the basis of MBP it was exhibited that on an average a flux of 7-8 kg P $ha^{-1}y^{-1}$ was immobilized in microbial biomass. These ranges are in the conformity with the finding of Brooks *et al*. (1984).

Table 5. Mineralization rate, mineralization potential, net mineralization, immobilization potential and microbial biomass phosphorus of different organic and conventionally managed tea gardens of Assam

Site	Mineralization Rate (µg/ kg / day)	Mineralization Potential (kg/ha)	Net mineralization (kg/ha)	Immobilization potential (kg/ha)	MBP (µg /g)
Belseri	0.049c	39.35	33.09	6.26	28.46c
Chardwar	0.057b	45.77	38.54	7.23	32.88b
Irrangmara	0.019e	15.26	11.49	3.77	17.14e
Jalinga	0.04d	32.12	24.47	7.65	34.76a
Kalachera	0.067a	53.80	46.88	6.92	31.46b
Rose Candy	0.019e	15.26	10.65	4.61	20.96d

Means followed by a different letter are significantly different at $p \leq 0.05$ by Duncan's multiple range test.

CONCLUSION

Organically managed tea garden soils harboured significantly higher microbial population, insoluble inorganic phosphate solubilizing power as compared to conventional tea garden soil irrespective to agro-ecological zone. Again, acid phosphatise, alkaline phosphatase and phytase activities and mineralization rate, mineralization potential, net mineralization, immobilization potential and microbial biomass phosphorus were significantly increased under organic tea husbandry over conventional tea gardens in all the locations irrespective of management practices adopted in gardens. Hence, it can be concluded that organic farming has the opportunity to sustain soil biological health and improve P nutrition of tea gardens in acid soils of Assam.

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How to cite this article?
Dey, D. and N. Saha. 2018. Phosphorus microbiology under organic farming system. *Innovative Farming*, **3**(1): 19-23.