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Comparative assessment of soil properties under commercial tree plantations

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Abstract
Bulk and rhizosphere soils were collected from tree plantations *viz*., *Acacia leucophloea*, *Melia dubia* and *Pongamia pinnata*. Among the tree plantations, *A. leucophloea* recorded the lowest pH. The lowest electrical conductivity of 0.21 dSm^{-1} and bulk density value of 1.05 Mg m^{-3} was recorded under pungam plantation indicating higher uptake of soluble salts. The water soluble carbon content of bulk and rhizosphere soils were the highest in *P. pinnata* plantation. The highest value of soil microbial biomass carbon was registered under *A. leucophloea* plantation. In the rhizosphere soil C: N ratio of 25.11 was recorded in pungam plantation indicating the highest C content in rhizosphere of pungam plantation. The rhizospheres of *P. pinnata* plantation accumulated higher water soluble carbon and hence supported higher microbial biomass. The results imply that fast growing *M. dubia* and leguminous N fixing *P. pinnata* plantations could be recommended for restoration of degraded lands for enhancing soil quality.

Keywords: bulk soil, rhizosphere, soil property, carbon, microbial biomass

Introduction
Rhizosphere is the zone surrounding roots of plants. In this zone, there are complex interactions between plants, soil microorganisms and soil components. The soils strongly adhering to the roots and within the space explored by the roots was considered as the rhizosphere soil (Garcia *et al*., 2005) [4]. Plant species and soil type substantially affect the structure and function of microbial populations associated with the rhizosphere (Prescott and Grayston 2013) [12].

The activity of plant roots has an impact on the physicochemical conditions as well as on the biological activity in the surrounding rhizosphere compartment and *vice versa*. These processes determine availability and cycling of nutrients; solubility of toxic elements for plants and microorganisms, thereby creating the rhizosphere as a unique micro ecosystem, which can exhibit completely different properties compared with the bulk soil, not directly influenced by the activity of roots. The main purpose of this study was to investigate the soil properties of rhizosphere and bulk soil in tree plantations *viz*., *A. leucophloea*, *M. dubia* and *P. pinnata* and to assess the various soil carbon forms.

Materials and Methods
Tree species *viz*., *A. leucophloea*, *M. dubia* and *P. pinnata* of uniform age (4 y, height ~ 10 m) were identified for the study. The individual tree plantation occupying one acre area was selected for the study. Soil samples were collected from rhizosphere and non-rhizosphere region of six randomly selected trees under each species. From the tree base, pits were formed to a depth of 2 m to collect soil samples of rhizosphere region. The soil samples were analyzed for soil pH (soil: water suspension ratio of 1: 2.5), electrical conductivity (soil : water suspension ratio of 1:2.5),bulk density (Jackson,1973), organic carbon (Walkley and Black,1934), water soluble carbon (Burford *et al*., 1975) [3], microbial biomass carbon (Vance *et al*.,1987) and total nitrogen (Bremner and Mulvaney, 1982) [2]. The relevant soil physico-chemical parameters were determined in air-dried soils ground to pass a 2 mm sieve.

Results and Discussion
Soil pH and electrical conductivity
In rhizosphere soils, the pH value was lower as compared to non-rhizosphere soils. This general trend of soil acidification by trees has been observed under a variety of circumstances (Sinha *et al*., 2009) [15] and attributed to the release of H^+ ions from the respiration of plant

Roots/soil microorganisms (Hinsinger *et al*., 2006) [7] or release of acidic exudates (Hagen-Thorn *et al*., 2004) [6].
The pH value ranged from 6.21 - 6.34 in rhizosphere soils (Table 1) as compared to 6.33 -6.39 in bulk soil (Table 2). Among the tree plantations, *A. leucophloea* recorded the lowest pH of 6.21 indicating the predominance of acidic exudates in the rhizosphere.

Table 1: Soil physical and chemical properties of tree plantations (Rhizosphere soil)

Tree plantations	Soil pH	Electrical conductivity (d S m^{-1})	Bulk density (Mg m^{-3})	Particle density (Mg m^{-3})	Porosity (per cent)
A. leucophloea	6.21	0.30	1.33	2.30	42.0
M. dubia	6.34	0.28	1.11	2.10	47.2
P. pinnata	6.30	0.23	1.05	2.23	53.0
CD(p=0.05)	0.45	0.07	0.22	0.54	1.75

The accumulation of soluble salts was higher in *A. leucophloea* plantations both in rhizosphere (Table 1) and bulk soil (Table 2). The lowest electrical conductivity of 0.21 d S m^{-1} was recorded under pungam plantation indicating higher uptake of soluble salts by pungam.

Table 2: Soil physical and chemical properties of tree plantations (Bulk soil)

Tree plantations	Soil pH	Electrical conductivity (d S m^{-1})	Bulk density (Mg m^{-3})	Particle density (Mg m^{-3})	Porosity (per cent)
A. leucophloea	6.39	0.28	1.66	2.64	37.0
M. dubia	6.37	0.24	1.42	2.58	45.0
P. pinnata	6.33	0.21	1.17	2.30	49.0
CD(p= 0.05)	0.39	0.05	0.16	0.40	1.58

Soil physical properties

Soil physical properties have long been considered to exert great influence on the distribution, growth and development of trees. Tree cover in turn, influences the improvement of physical properties of soil (Rathod and Devar, 2003) [14].
In the rhizosphere soil samples the maximum bulk density value of 1.33 Mg m^{-3} was recorded in *A. leucophloea* plantation and the minimum bulk density value of 1.05 Mg m^{-3} was recorded in pungam plantation (Table 1). Low value of bulk density indicate the higher amount of organic matter in *P. pinnata* plantations through litter fall.
The maximum bulk density of 1.66 Mg m^{-3} and particle density of 2.64 Mg m^{-3} was recorded in the bulk soil under *A. leucophloea* plantation and the minimum soil bulk density value of 1.17 was recorded under *P. pinnata* plantation (Table 2).Decrease in soil density and increase in porosity (49-53 per cent) under pungam plantations could be due to the presence of more decomposed litter cover in soils.

Soil carbon fractions

Among the tree plantations, the highest oxidizable organic carbon content of 7.86 g kg^{-1} and 7.12 g kg^{-1} were recorded in rhizosphere (Table 3) and bulk soils (Table 4) under *M. dubia* plantation and the lowest oxidizable organic carbon content of 6.24 - 6. 78 g kg^{-1} was recorded under pungam plantation.
The water soluble carbon content of rhizosphere and bulk soils were the highest in *P. pinnata* plantation (0.65 and 0.42 g kg^{-1}) and the lowest water soluble carbon content was recorded under *M. dubia* plantation (0.31 g kg^{-1}). A substantial proportion of carbon fixed during photosynthesis by higher plants (20-60%) can be translocated below ground (Grayston *et al*. 2001) [5].

Table 3: Soil carbon fractions in rhizosphere soils

Tree Plantations	Oxidizable Organic Carbon(g kg^{-1})	Water Soluble Carbon (g kg^{-1})	Microbial Biomass Carbon (mg kg^{-1})
A. leucophloea	7.08	0.46	0.65
M. dubia	7.86	0.54	0.61
P. pinnata	6.78	0.65	0.59
CD(p=0.05)	0.55	0.05	0.08

Similar to SOC, the water soluble carbon levels were also markedly higher in the tree rhizosphere compared to the bulk soil. Water soluble carbon has been proposed as an indicator of carbon available to soil microorganisms (Boyer and Groffman, 1996) [1] and greater levels in the tree rhizosphere suggested release of labile C from roots to soil via sloughed cells and root and mycorrhizal exudates.

Table 4: Soil carbon fractions in bulk soils

Tree Plantations	Oxidizable Organic Carbon (g kg^{-1})	Water Soluble Carbon (g kg^{-1})	Microbial Biomass Carbon (mg kg^{-1})
A. leucophloea	6.60	0.39	0.52
M. dubia	7.12	0.31	0.50
P. pinnata	6.24	0.42	0.51
CD(p=0.05)	0.81	0.07	0.10

Microbial biomass carbon

The soil microbial biomass carbon ranged from 0.59-0.65 mg kg^{-1} in rhizosphere soil with the highest value under *A. leucophloea* plantation (Table 3) while it ranged from 0.50-0.52 mg kg^{-1} in bulk soil with the highest value of 0.65 mg kg^{-1} under *A. leucophloea* plantation (Table 4). Rhizosphere soil often has greater microbial biomass and different microbial community compositions (Sorensen 1997) [16]. This may be due to the effects of plants on rhizosphere soil. Exudates and deposits from plant roots supply organic nutrients for microorganisms and greatly affect their abundance and activity. The rhizosphere: bulk soil ratio for components of the microbial population is widely used to evaluate the degree of rhizosphere effect (Morgan *et al*. 2005) [10].

Because soil microbial biomass is considered a temporally integrated measure of labile C, differences in rhizosphere and bulk soil can be attributed to differences in the amount of root-derived C (Phillips and Fahey, 2008) [11], stimulatory effects of nutrients on the rhizosphere microbes and increased C flux in the rhizosphere.

The tree species, however, varied markedly in their effects on microbial biomass levels possibly due to variation in the levels of exudates, secretions, sloughed cells and other debris from fine roots to soil or due to differences in organic matter composition (McMillan *et al*., 2007) [9].

Total nitrogen

Root-induced stimulation of N mineralization has been reported for seedlings and mature trees in forest soils (Phillips and Fahey, 2008) [11]. The accumulation of mineral N and N mineralized in the rhizosphere was, however, related to tree species. Total N content in the rhizosphere soil (Table 5) was the highest (0.05%) in *M. dubia* plantation indicating the N mineralization pattern of leaf litter. The total N content of bulk soil (Table 6) was the highest in *M. dubia* plantation (0.02%) and the lowest was recorded under *P. pinnata* plantation (0.01%).

Greater levels were observed in the *Gliricidia sepium* rhizosphere possibly because it is a leguminous tree capable of fixing N. Higher rates of N mineralization in the rhizosphere of N fixing trees and varied effects of tropical trees on N accumulation in soils is well documented (Sinha *et al*., 2009) [15].

Table 5: Total N content (%) and C: N ratio of rhizosphere soils

Tree plantations	Total N (%)	Organic Carbon (%)	C:N Ratio
Acacia leucophloea	0.038	0.718	18.63
Melia dubia	0.052	0.786	15.11
Pongamia pinnata	0.027	0.767	25.11
CD(p=0.05)	0.09	0.15	

C: N ratio

In the rhizosphere soil, C: N ratio of 25.11 was recorded in pungam plantation while it was minimum (15.11) in *M. dubia* plantation. The C: N ratio was maximum (24.55) in bulk soil under *M. dubia* plantation and in *P. pinnata* plantation, the value of C: N ratio was 22.40. (Table.6). this indicate the highest C content in rhizosphere of pungam plantation. This confirmed the finding that soils under N fixing trees accumulate C faster than other types of trees (Resh *et al*., 2002) [13].

Table 6: Total N content (%) and C: N ratio of bulk soils

Tree plantations	Total N (%)	Organic carbon (%)	C:N ratio
Acacia leucophloea	0.027	0.660	24.44
Melia dubia	0.029	0.712	24.55
Pongamia pinnata	0.010	0.624	22.40
CD(p=0.05)	0.05	0.27	

The study further indicated that the rhizosphere soils under tree species are more active and root exudates have a profound influence on the soil properties. Consequently, each tree species may modify the conditions in the rhizosphere in order to maximize nutrient acquisition from organic matter. The rhizospheres of *P. pinnata* plantation accumulated higher water soluble carbon and hence supported higher microbial biomass. The results imply that fast growing *M. dubia* and leguminous N fixing *P. pinnata* plantations could be recommended for restoration of degraded lands for enhancing soil quality.

References

1. Boyer JN, Groffman PM. Bioavailability of water extractable organic carbon fractions in forest and agricultural soil profiles. Soil Biol. Biochem. 1996; 28:783-790.
2. Bremner JM, Mulvaney CS. Nitrogen-total. In Methods of Soil Analysis, Part 2, Chemical and Microbiological Properties, 2nd edn (Eds Page A.L, Miller R.H. and Keeney D.R Madison, WI: American Society of Agronomy.), 1982, 595-624.
3. Burford JR, Bremner JM. Relationship between the denitrification capacities of soils and total, water-soluble and readily decomposable soil organic matter. Soil Biology and Biochemistry. 1975; 7:389-394.
4. Garcia C, Roldan A, Hernandez T. Ability of different plant species to promote microbiological processes in semiarid soil. Geoderma. 2005; 124:193-202.
5. Grayston SJ, Griffith GS, Mawdsley JL, Campbell CD Bardgett RD. Accounting for variability in soil microbial communities of temperate upland grassland ecosystems. Soil Biol. Biochem. 2001; 33:533-551.
6. Hagen-Thorn A, Callesen I, Armolaitis K, Nihlgard B. The impact of six European tree species on the chemistry of mineral topsoil in forest plantations on former agricultural land. For. Ecol. Manage. 2004; 195:373-384.
7. Hinsinger P, Plassard C, Jaillard B. Rhizosphere: A new frontier for soil biogeochemistry. J Geochem. Explor. 2006; 88:210-213.
8. Jackson ML. Soil Chemical Analysis, Constable and Co. Ltd. Prentice Hall of India Pvt. Ltd. New Delhi. 1973, 10-114.
9. McMillan R, Quideau SA, Mackenzie MD, Biryukova O. Nitrogen mineralization and microbial activity in oil sands reclaimed boreal forest soils. J Environ. Qual. 2007; 36:1470-1478.
10. Morgan JAW, Bending GD, White PJ. Biological costs and benefits to plant–microbe interactions in the rhizosphere. Journal of Experimental Botany. 2005; 56:1729-1739.
11. Phillips RP, Fahey TJ. The influence of soil fertility on rhizosphere effects in northern hardwood forest soils. Soil Sci. Soc. Am. J. 2008; 72:453-461.
12. Prescott CE, Grayston SJ. Tree species influence on microbial communities in litter and soil: current knowledge and research needs. Forest Ecology and Management. 2013; 309:19-27.
13. Resh S, Binkley D, Parrotta J. Greater soil carbon sequestration under nitrogen fixing trees compared with Eucalyptus species. Ecosystems. 2002; 5:217-231.
14. Rathod R, Devar KV. Effect of different plantations on soil physical properties, Karnataka journal of agricultural science. 2003; 16(3):487-488.
15. Sinha S, Masto RE, Ram LC, Selvi VA, Srivastava NK, Tripathi RC *et al.* Rhizosphere soil microbial index of tree species in a coal mining ecosystem. Soil Biol. Biochem. 2009; 41:1824-1832.
16. Sorensen J. The rhizosphere as a habitat for soil microorganisms in Van Elsas JD, Trevors JT, Wellington

EMH (eds.) Modern Soil Microbiology. Marcel Dekker Inc, New York. 1997, 21-45.
17. Vance ED, Brookes PC, Jenkinson DS. An extraction method for measuring soil microbial biomass C. Soil Biol. Biochem. 1987; 19:703-707.
18. Walkley A, Black IA. An examination of Degtjareff method for determining soil organic matter, and proposed modification of the chromic acid titration method. Soil Science. 1934; 37:29-38.