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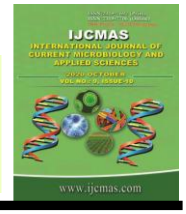

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Study of Soil Organic Carbon and Microbial Population Dynamics under different Bamboo Species in Mollisols of Terai Region of Uttrakhand, India

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A B S T R A C T

The present study was undertaken at the experimental site situated at Agroforestry Research Centre, Haldi of G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. Bamboo as species has many economical and ecological benefits. Soil samples collected under six different bamboo species namely *Dendrocalamus hamiltonii, Bambusa nutans, Dendrocalamus asper Bambusa bambos Bambusa balcooa and Dendrocalamus strictus* showed significant increase in microbial population and soil organic carbon (SOC) than open plot (control). Maximum bacterial (67.87×10^6 cfu g^{-1}) and actinomycetes (53.17×10^5 cfu g^{-1}) population was showed under *D. hamiltonii*. Microbial populations and soil organic carbon (SOC) stock also showed significant correlation.

Introduction

Bamboo as the superb species has been coined with different names across globe like Vietnamese call it 'My Brother', the Chinese 'Friend of the people' and in India it is widely called 'Green Gold' 'Poor Men's Timber' 'Cradle to Coffin timber' etc[1]. About 125 indigenous and 11 exotic species of bamboo belonging to 23 genera are reported in country. Species like Bambusa and Dendrocalamus are found in tropical conditions where as Arundinaria occur in temperate regions. *Dendrocalamus strictus* is found predominantly in dry deciduous forest while *Bambusa bambos* flourishes best in moist deciduous forests[2]. Bamboo is an economically important plant and has been introduced in many places in country to protect and restore ecosystems. Bamboo's special biological characteristics and growth habits enable bamboo forests to serve ecological and environmental functions such as land rehabilitation, water conservation and control of soil erosion[3]. Soil microbes also known as 'natural soil engineers' are of different types like bacteria, actinomycetes, fungi, protozoa, nematodes etc are responsible for many biochemical reactions nitrogen fixation, organic matter decomposition, humus formation, nitrification, aggregate stabilization etc[4]. Microbial diversity is an important way to gauge soil fertility[5]. Soil organic carbon (SOM) is the amount of carbon content that is stored in soil. Soil organic carbon (58% of soil organic matter) is one of the main factors affecting the storage and supply of nutrients in soil, soil microbial population as microbes use organic carbon as their energy source[6-7]. The soil microorganisms containing about 2-3% of soil organic carbon (SOC) (6). Soils with high soil organic carbon (SOC) usually have higher microbial biomass[8]. Forest soils have been reported to accumulate considerably higher carbon than other land uses such as savannas and agro-ecosystems[9].Under bamboo forests, soil enzymatic activities and microbial communities were considerably higher than in the soil from the barren land[10]. Due to rapid growth rate, the species has considerable ability to sequester carbon in soil[9]. So the present study was conducted to investigate dynamics of soil organic carbon (SOC) stock and soil microbial population under different bamboo species in mollisols of Terai area of Uttrakhand.

Materials and Methods

The present study was undertaken at the experimental site situated at Agroforestry Research Centre, Haldi of G.B. Pant University of Agriculture and Technology, Pantnagar, Distt. Udham Singh Nagar, Uttarakhand. Pantnagar in year 2017-2018 at bamboo plantation established at 2005. Experiment was done by taking 7 treatments having three replications which include 6 species of bamboo namely *Dendrocalamus hamiltonii*, *Bambusa nutans*, *Dendrocalamus asper Bambusa bambos Bambusa balcooa Dendrocalamus strictus* spaced at 5 x 5 m spacing and a control (an open area without any crop). For soil microbial population, the analysis was done up to 20 cm depth of soil and for soil organic carbon (SOC) stock up to 60 cm depth. The soil samples were dried under shade, finely processed and sieved through a 0.2 mm sieve for removing any minute root remains and other minute pieces of litter, debris etc. For counting soil microbial population "Serial dilution plate technique" was used[11]. After colonies development in plates, colonies were counted and their multiplication by respective dilution factor gave number of viable cells per gram soil. Soil Organic Carbon (SOC) Stock = B.D × O.C × Depth of soil Where, B.D = bulk density (g/cm3) of soil. O.C = organic carbon content (%) in soil and expressed in tonnes/hectare. The organic carbon content (%) of soil determined by modified Walkley and Black (1934) method[12] as described by Jackson (1967) method[13].

Results and Discussion

The result of present study (Table 1 and fig. 1) showed that fungi population was recorded maximum and significantly highest in *D. nutans* (102.10 × 10^4 cfu g^{-1}) and minimum was recorded in open plot (53.57 × 10^4 cfu g^{-1}). The trend of fungi population was followed by the order: *B. nutans > D.hamiltonii > D. strictus > B. bambos > B. balcooa > D. asper* > open. The range of bacteria in soil under different bamboo species was ranged from 35.90 × 10^6 cfu g^{-1} soil to 67.87 × 10^6 cfu g^{-1}. *D. hamilltonii* was recorded maximum and significantly highest bacterial population (67.87 × 10^6 cfu g^{-1}) and minimum was recorded in open plot (35.90 × 10^6 cfu g^{-1}).The trend of bacterial population was followed by the order: *D. hamiltonii > B. nutans > B. balcooa > D. strictus > B. bambos > D. asper* > open. The results showed that range of actinomycetes was varied from 29.45 ×10^5 cfu g^{-1} soil to 53.17 × 10^5 cfu g^{-1}. The actinomycetes population was recorded maximum and significantly highest in *D. hamiltonii* (53.17 × 10^5 cfu g^{-1}) and minimum actinomycetes population was recorded in open plot (29.45×10^5 cfu g^{-1}) which was significantly lowest than the other bamboo species (Table 2 and Fig. 2).

Table.1 Microbial population under different bamboo species and in open

Bamboo Species	**No of colony g-1 soil**		
	Fungi ($\times 10^4$ cfu)	**Actinomycetes ($\times 10^5$ cfu)**	**Bacteria ($\times 10^6$ cfu)**
D. hamiltonii	101.57	53.17	67.87
B. nutans	102.10	50.44	64.77
D. asper	82.65	37.95	52.30
B. bambos	94.52	44.80	58.92
B. balcooa	88.82	43.94	62.62
D. strictus	96.90	41.61	61.72
Open	53.57	29.45	35.90
C D at 5%	3.024	1.053	1.922

Table.2 Soil organic carbon stock (t/ha) under different bamboo species and in open plot

Treatment	**Soil Organic Carbon Stock (t/ha)**		
	0-30 cm	**30-60 cm**	**Mean**
D. hamiltonii	50.40	36.57	43.48
B. nutans	51.15	36.16	43.65
D. asper	47.60	30.65	39.12
B. bambos	47.88	32.58	40.23
B. balcooa	48.56	34.56	41.56
D. strictus	48.64	32.38	40.51
Open plot	28.15	20.37	24.26
C D at 5%	1.492	0.866	1.051

Table.3 Correlation coefficient between microbial population and soil organic carbon (SOC) stock under different bamboo species

	Fungi population	**Actinomycetes population**	**Bacteria population**	**Soil carbon stock**
Fungi population	1.00	**0.850****	**0.853***	0.805^{NS}
Actinomycetes population		1.000	**0.886**	**0.939****
Bacteria population			1.000	**0.908***
Soil carbon stock				1.000

* Significant at 5% probability
** Significant at 1% probability

Fig.1 Microbial population under different bamboo species and in open

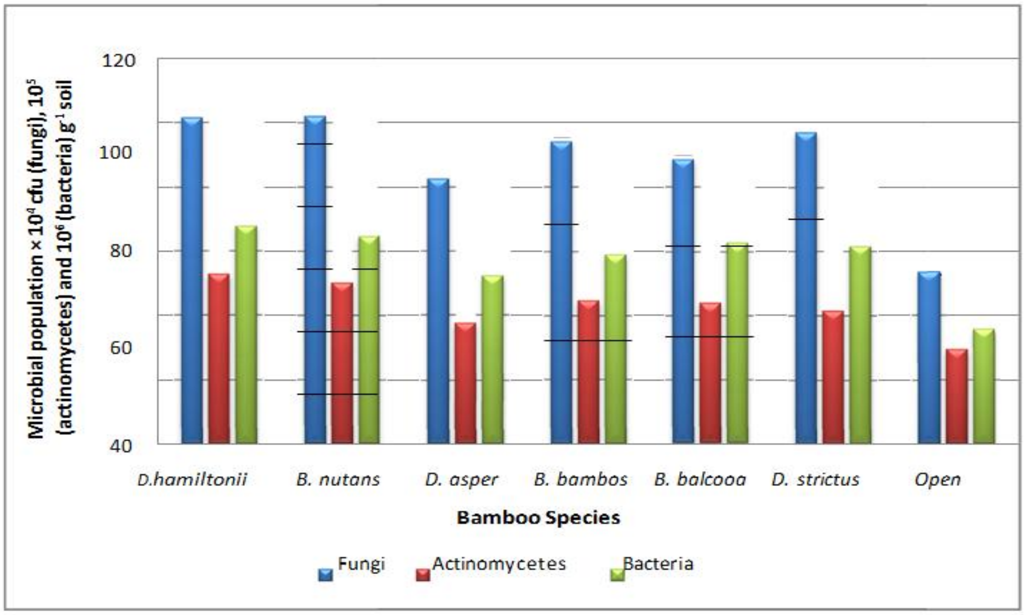
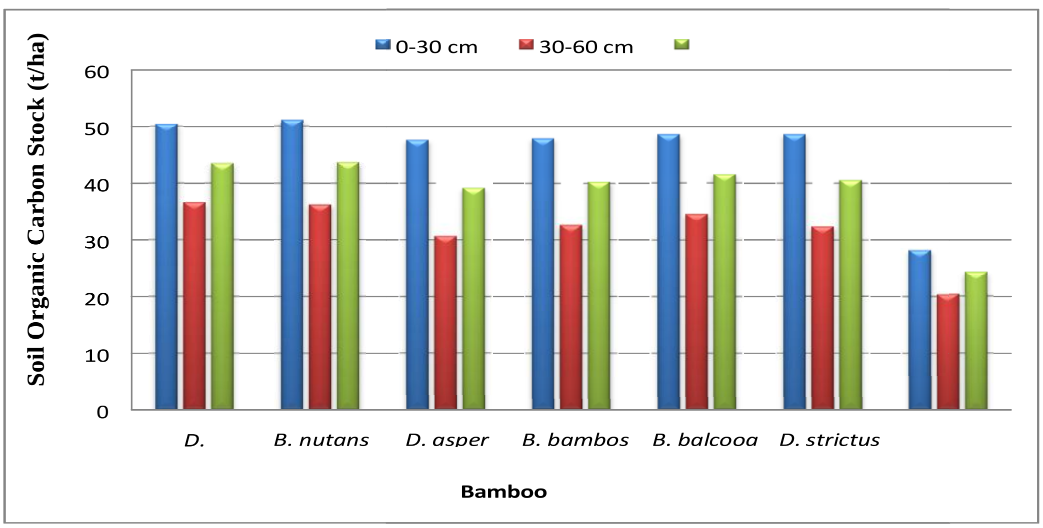


Fig.2 Soil organic carbon stock (t/ha) under different bamboo species and in open



The trend of actinomycetes population was followed by the order: *D. hamiltonii*> *B. nutans* > *B. bambos* > *B. balcooa* > *D. strictus* > *D. asper* > open. The above findings are in line with Tu *et al.*, (2014) who reported that planting bamboo might help to increase soil microbial and enzyme activities and enrich soil fertility[10] and Pandey *et al.*, 2012 reported that fungal succession in plantation sites greatly differed from sites without plantation due to the presence of organic materials[14]. The soil organic carbon (SOC) stock was significantly higher under the different bamboo species in comparison to the open plot and also decreased with increase in successive soil depth. The SOC stock for the surface layer (0-30 cm), maximum (51.15 t/ha) was found under *B. nutans* which was significantly highest and minimum (28.15 t/ha) was observed in open plot. For subsurface soil layer (30-60 cm), maximum (33.57 t/ha) SOC stock was observed under *D. hamiltonii* and minimum (20.37 t/ha) under open plot. The results supported by similar findings of Richards *et al.,* 2007 reported high SOC stock under the loop pine plantation (254t/ha) compared to the pasture land (211 t/ha)[15]. Similarly, Satyawali (2014) also reported highest SOC stock on the surface soil (0-30 cm) followed by middle layer (30-60 cm) and lower layer (60-90 cm) for high density plantations of *Eucalyptus hybrid* and *Melia azedarach*[16]. The table 3 and fig. 3 showed soil organic carbon (SOC) stock having significant correlation with all parameters except fungi population. Actinomycetes population and soil organic carbon (SOC) stock reported highest correlation (r=0.939**) coefficient.

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