J. Bamboo and Rattan, Vol. 4, No. 3, pp. 221–230 (2005)

Also available online - www.vsppub.com

Soil properties influenced by some important edible bamboo species in the North Eastern Himalayan region, India

M. S. VENKATESH [1], B. P. BHATT [2,*], KAILASH KUMAR [1], B. MAJUMDAR [1] and KUNDAN SINGH [2]

[1] *Division of Soil Science, ICAR Research Complex for NEH Region, Umroi Road, Umiam, Meghalaya 793 103, India*
[2] *Division of Agroforestry, ICAR Research Complex for NEH Region, Umroi Road, Umiam, Meghalaya 793 103, India*

Abstract—Soil profile samples collected from 11 different locations of edible bamboo growing areas in the Meghalaya and Manipur states of the North Eastern Himalayan (NEH) region of India were analysed to study the effect of different bamboo species on soil properties. The clump density was noticed highest in *Teinostachyum wightii*, followed by *Melocanna baccifera*. The highest number of culms per clump has also been recorded in *M. baccifera*. The highest average culm height and diameter, however, was recorded in *Bambusa balcooa*. All the bamboo species showed varying effects on soil properties. The highest increase in soil pH was observed in *Dendrocalamus giganteus*, followed by *D. hookerii*. Organic carbon increased in soils under all the species of bamboo. The highest increase of available N content was recorded in *B. multiplex* (126.5 kg/ha), followed by *D. giganteus* (94.0 kg/ha). The maximum build-up of exchangeable Ca + Mg was found in *D. giganteus* and *D. hookerii*. There was a reduction in available P in most of the species, the maximum being in *D. hamiltonii* (4.4 kg P/ha), followed by *B. multiplex* (3.9 kg/ha). The highest increase of available K was observed in *D. hookerii* (207.2 kg/ha), followed by *B. multiplex*. On average, *D. giganteus*, *D. hookerii* and *B. nutans* were found to be the better species for restoring soil fertility status in humid tropics of the NEH region, India.

Key words: Bamboo species; soil properties; humid tropics; India.

INTRODUCTION

In a forest ecosystem, the physico-chemical properties of soil and its fertility status vary spatially due to change in climate, parent material, physiographic position,

*To whom correspondence should be sent. E-mail: drbpbhatt@yahoo.co.in

vegetation and biotic interference. Knowledge of variability in soil properties has contributed to optimising land use and maximising biomass production in man-made/natural forests [1]. Bamboos form the single most important commodity of forest product used by rural communities, especially in Asia and the Pacific region. The North Eastern Himalayan (NEH) region of India is one of the richest botanical regions in speciation and genetic bio-diversity in bamboos [2]. Tribal communities of the region use this potential source for shelter, furniture, handicraft, medicines and various ethno-religious purposes [3]. Besides, tender shoots of as many as 25 bamboo species are used as food by various ethnic groups in the region [4]. At present, very limited information is available on the changes in the properties of bamboo growing soils of the NEH region. In the present study, an attempt has been made to estimate soil properties within which the bamboo species grow in various locations of the region, which may eventually help in identifying the bamboo species suitable for maintenance of soil fertility status in the hilly ecosystem of the NEH region.

MATERIALS AND METHODS

Several exploration trips were made to understand the ecological status of the important bamboo species of the Meghalaya and Manipur states in the NEH region. The region lies between 21 and 30° N latitude, and 85 and 98° E longitude, which occupies an area of 18.4 million ha. The region has a difficult terrain with hilly topography, characterized by steep slopes, gorges and plateaus with less than 15% valleys. The elevation ranges from 100 m to 5600 m asl, tropical to alpine agro-climatic condition with ca. 100–6000 mm annual rainfall. This peculiar agro-climatic condition of the NEH region has supported very rich and diverse flora and fauna, including bamboo species, for which the region could account a position among the 25 hot spots of the world.

For studying growth productivity and biomass performance of the bamboo species, at least two sites were selected in every district of the study area. The quadrate method was followed to study clump, as well as culm density and to identify their rich pockets following the methodology given by Mueller-Dombois and Ellenberg [5].

Soil sampling

Composite soil profile samples from three different depths (0–20, 20–40 and 40–60 cm) were collected from 11 different locations of Manipur and Meghalaya states from bamboo plantations of 8–10 years of age (Table 1). Five random profile samples from each bamboo species plantation were collected with soil auger. Depth-wise samples were thoroughly mixed to draw one composite sample for each depth from each species. Similarly composite profile samples were collected from the adjoining site of each bamboo plantation site, to serve as control. The soil

Table 1.
Details of locations of soil sampling, NEH Region, India

Location	Altitude (m asl)	Bamboo species	Soil order
Bishnupur, Manipur	680	*Bambusa balcooa*	Ultisol
Burnihat, Meghalaya	310	*B. multiplex*	Ultisol
Nongstain, Meghalaya	1780	*B. nutans*	Ultisol
Umran, Meghalaya	850	*B. pallida*	Ultisol
Imphal, Manipur	750	*Dendrocalamus giganteus*	Inceptisol
Imphal, Manipur	710	*D. sikkimensis*	Inceptisol
Imphal, Manipur	710	*D. longispathus*	Inceptisol
Nongpoh, Meghalaya	650	*D. hamiltonii*	Ultisol
Upper Shillong, Meghalaya	1700	*D. hookerii*	Ultisol
Nongpoh, Meghalaya	560	*Melocanna baccifera*	Ultisol
Bishnupur, Manipur	680	*Teinostachyum wightii*	Ultisol

type and parent material for control site, as well as the site of ecological study at each place were similar. The control sites at all the locations were without any major intense canopy vegetation but sparsely covered with small annual grasses and shrubs.

Analytical procedure

The collected samples were air-dried and ground to pass through a 2-mm sieve and the analysis was carried out using the procedure of Jackson [6]. Soil pH was analysed in 1 : 2 soil/water suspension. Organic carbon was analysed by the chromic acid oxidation method of Walkley and Black [6]. Available N was determined by the alkaline permanganate method [8] using a Pelican semi-automatic nitrogen analyser. Available P was extracted by Bray and Kurtz extractant No. 2 and the P in the extract was estimated by the ascorbic acid method of John [7]. Available K was extracted from the soil by neutral 1 M ammonium acetate and estimated by flame photometry. Exchangeable Ca and Mg were estimated using the EDTA versanate titration method. The results were expressed on oven-dry basis.

RESULTS AND DISCUSSION

Growth of bamboo species

Soil samples were collected from natural stands of different edible bamboo species. The range of distribution of the species varied from 310 to 1780 m asl (Table 1). An ecological survey for important bamboo species has been conducted. On average, the density was found to be highest in *T. wightii* and lowest in *D. giganteus*. Culm number/clump also varied between species and it was found to be highest in *D. hamiltonii* and lowest in *D. longispathus*. The average culm height, diameter at breast height (DBH) and basal diameter were recorded to be highest in *B. balcooa*, the lowest culm height and DBH was noticed in *T. wightii*, and basal diameter in

B. multiplex. The number of internodes also varied between species; *B. balcooa* and *D. hamiltonii* were the species which had, respectively, the highest and lowest number of internodes. The highest internodal length on the other hand was recorded in *D. hamiltonii*, followed by *D. giganteus*. The lowest internodal length was recorded in *B. multiplex*. Among various species, *B. multiplex* and *T. wightii* had thinner culms as compared to other species. On average, the highest total bamboo cover per ha of area was recorded in *T. wightii*, followed by *M. baccifera*. The lowest bamboo area was recorded in *B. balcooa*. The highest total standing biomass was recorded in *M. baccifera*, followed by *B. balcooa*. The lowest biomass was recorded for *T. wightii* (Table 2).

All species are major edible species of the region, except *B. multiplex* and *B. nutans*, which have been found to be semi-edible species. *B. pallida* is mainly used for construction purposes. On average, the harvesting of young edible shoots was estimated as ca. 1859, 1095, 1080, 650, 326, 273, 5 and 21 tonnes/year, respectively, for *D. hamiltonii*, *D. giganteus*, *D. sikkimensis*, *M. baccifera*, *D. hookerii*, *B. balcooa*, *D. longispathus* and *T. wightii* in the NEH region [4]. Genus *Dendrocalamus* accounted for 77% of the total sales of bamboo shoots in the region (data not shown).

Soil pH and bases

Soils under different bamboo species were strongly acidic and mean profile pH ranged from 3.72 to 5.05. In soil under *D. longispathus* the lowest pH was recorded, followed by *T. wightii* and *D. sikkimensis*. The highest pH was found in *Bambusa nutans*. There was an increase in soil pH of *D. giganteus*, *D. hookerii*, *D. sikkimensis* and *B. nutans* by 0.49, 0.26, 0.15 and 0.14 units, respectively, compared to their respective control values, whereas a decrease of 2.15, 0.68, 0.38, 0.21 and 0.17 units was observed in *D. hamiltonii*, *B. pallida*, *D. longispathus*, *T. wightii* and *M. baccifera* accordingly. In general, sub-surface soil horizons exhibited higher pH than surface soil, except in *B. nutans*, *D. giganteus*, *B. balcooa* and *T. wightii*. Soils of *D. hookerii* and *D. giganteus* stands were richer in available Ca and Mg status than the soils of other species. Exchangeable Ca and Mg contents of the soils under *B. nutans*, *B. multiplex*, *D. giganteus*, *D. hookerii*, *B. balcooa* and *D. sikkimensis* increased over respective controls, while in other species there was a decline in exchangeable Ca and Mg content. A drastic reduction in exchangeable Ca and Mg contents from 4.95 to 0.97 and 1.18 to 0.75 cmol (p+)/kg, respectively was observed in *D. hamiltonii*. This drastic reduction in pH and exchangeable bases might be due to its higher base requirement. This is in conformity with the results reported by Singh [9] in soils of Arunachal Pradesh. Changes in pH *vis-à-vis* the base status of the soils under different bamboo species might be due to the differential uptake of Ca and Mg and their replenishment to the soil through leaf litter with varying base content and root residue decomposition [9]. Since Ca and Mg are found to be the dominant elements in the leaf return to the forest floor, this may have resulted in higher values of these elements into the soil [10] (Table 3).

Table 2.
Growth and biomass performance of some important bamboo species of NEH region, India

Bamboo species	Density (Clump/ha)	No. of culms/clump	Culm height (m)	DBH (cm)	Basal diameter (cm)	No. of internodes	Internodal length (cm)	Bamboo cover (m^2/ha)	Total standing biomass (t/ha)
Bambusa balcooa	38.02 ± 12.77	23.50 ± 2.12	15.4 ± 1.56	6.39 ± 0.69	8.20 ± 1.01	38.67 ± 5.51	24.65 ± 0.92	891.83±211.96	42.1±3.5
B. multiplex	75.00 ± 7.07	21.5 ± 3.54	10.07 ± 0.41	1.74 ± 0.21	1.98 ± 0.35	31.33 ± 3.05	16.53 ± 1.12	929.25 ± 61.95	10.5±2.4
B. nutans	36.85 ± 8.22	25.00 ± 2.83	13.15 ± 0.35	4.06 ± 0.02	4.42 ± 0.09	28.67 ± 3.21	49.30 ± 0.28	3081.45±486.35	21.6±2.4
B. pallida	18.17 ± 4.48	27.50 ± 2.12	12.70 ± 0.28	4.79 ± 0.11	5.62 ± 0.34	24.00 ± 1.73	49.67 ± 3.06	1948.55±302.64	9.8±1.1
Dendrocalamus giganteus	15.70 ± 2.93	24.00 ± 2.83	14.65 ± 0.35	5.81 ± 0.29	6.18 ± 0.31	29.00 ± 2.65	50.57 ± 2.14	2256.17±297.44	29.4±2.4
D. hamiltonii	29.0 ± 1.41	32.00 ± 2.83	12.40 ± 2.55	3.52 ± 0.20	3.87 ± 0.11	22.50 ± 0.03	51.50 ± 3.54	2575.49 ± 88.81	29.2±3.2
D. hookerii	23.58 ± 2.01	23.50 ± 3.54	11.15 ± 0.35	4.81 ± 0.36	5.29 ± 0.09	30.33 ± 1.15	46.67 ± 2.52	2105.25±126.75	13.0±2.3
D. longispathus	16.15 ± 5.44	20.50 ± 2.12	13.75 ± 3.32	4.46 ± 0.04	5.21 ± 0.02	31.00 ± 1.00	43.77 ± 0.49	992.17±236.24	8.5±0.7
D. sikkimensis	21.54 ± 2.17	26.50 ± 3.54	9.75 ± 0.64	4.22±0.38	5.11±0.11	29.33±0.58	42.47±0.60	951.14 ± 67.94	14.5±1.2
*Melocanna baccifera**	47.50 ± 0.50	28.33 ± 4.72	9.80 ± 0.57	4.67 ± 0.66	5.07 ± 1.01	31.67 ± 0.58	34.77 ± 1.87	4750.00±100.00	50.4±0.9
*Teinostachyum wightii**	49.0 ± 6.3	26.50 ± 0.71	8.15 ± 1.06	1.46 ± 0.31	3.32 ± 0.60	29.25 ± 5.12	34.40 ± 5.05	6414.22±583.11	2.4±1.1

* Clump density of these species was recorded on the basis of per 100 m^2 area.

Table 3.
Soil properties of some important bamboo species of NEH Region, India

Species	Soil depth (cm)	Soil pH	Organic C (g/kg)	Exch. Ca^{2+} (cmol (p+)/kg)	Exch. Mg^{2+} (cmol (p+)/kg)	Available nutrients		
						N (kg/ha)	P (kg/ha)	K (kg/ha)
Bambusa balcooa	0–20	4.31 (4.30)	22.2 (22.0)	1.50 (1.30)	1.50 (1.30)	250.9 (240.0)	0.67 (3.10)	95.2 (101.5)
	20–40	3.92 (3.90)	12.3 (11.0)	1.30 (1.00)	0.60 (0.50)	203.8 (210.0)	2.35 (2.58)	59.9 (120.5)
	40–60	3.85 (3.80)	10.5 (6.0)	0.95 (0.64)	0.65 (0.95)	156.8 (105.0)	1.06 (2.00)	66.1 (99.0)
	Mean	4.03 (4.00)	15.0 (13.0)	1.25 (0.98)	0.92 (0.85)	203.8 (185.0)	1.36 (2.56)	73.7 (107.0)
B. multiplex	0–20	4.68 (4.76)	23.4 (24.6)	0.60 (0.25)	0.70 (0.65)	313.6 (150.5)	2.13 (4.59)	320.3 (203.8)
	20–40	4.77 (4.81)	19.2 (25.5)	0.85 (0.10)	0.85 (0.20)	250.9 (100.4)	2.74 (6.72)	310.8 (116.5)
	40–60	4.76 (4.70)	12.0 (30.9)	0.45 (0.15)	1.00 (0.45)	188.2 (122.3)	2.97 (8.18)	277.8 (125.4)
	Mean	4.74 (4.76)	24.0 (18.2)	0.63 (0.17)	0.85 (0.43)	250.9 (124.4)	2.61 (6.50)	303.0 (148.6)
B. nutans	0–20	5.25 (5.06)	27.6 (18.3)	2.05 (0.35)	0.35 (0.30)	360.6 (210.1)	3.25 (5.15)	333.8 (321.0)
	20–40	5.15 (4.94)	15.0 (14.4)	1.15 (0.25)	0.30 (0.15)	172.5 (185.0)	2.97 (2.46)	210.0 (204.5)
	40–60	4.75 (4.73)	20.4 (12.9)	0.85 (0.30)	0.10 (0.10)	266.6 (166.2)	2.46 (2.24)	182.6 (169.7)
	Mean	5.05 (4.91)	21.0 (15.2)	1.35 (0.30)	0.25 (0.18)	266.6 (187.1)	2.89 (3.28)	242.1 (231.7)
B. pallida	0–20	3.87 (4.75)	21.0 (14.4)	1.20 (2.10)	1.25 (1.30)	219.5 (141.1)	0.50 (2.18)	67.8 (209.4)
	20–40	3.96 (4.77)	17.4 (10.5)	0.25 (1.65)	0.20 (2.30)	141.1 (141.1)	2.63 (2.63)	44.2 (272.4)
	40–60	4.28 (4.64)	12.6 (11.1)	0.30 (1.50)	0.35 (1.30)	141.1 (203.8)	3.86 (2.86)	45.9 (260.0)
	Mean	4.04 (4.72)	17.0 (12.0)	0.58 (1.75)	0.60 (1.63)	167.2 (162.0)	2.33 (2.56)	52.6 (247.3)
Dendrocalamus giganteus	0–20	4.41 (3.98)	24.3 (13.2)	2.45 (1.25)	0.55 (1.10)	235.2 (172.5)	4.87 (1.85)	289.5 (116.5)
	20–40	4.40 (3.75)	17.7 (8.1)	1.90 (0.60)	1.85 (0.55)	235.2 (141.1)	2.02 (1.96)	203.3 (143.4)
	40–60	4.22 (3.83)	16.5 (6.6)	2.20 (0.95)	3.05 (0.30)	203.8 (78.4)	1.51 (1.62)	209.4 (155.7)
	Mean	4.34 (3.85)	19.5 (9.3)	2.18 (0.93)	1.82 (0.65)	224.7 (130.7)	2.80 (1.81)	234.1 (138.5)
D. hamiltonii	0–20	4.33 (6.36)	11.1 (11.7)	0.60 (6.60)	0.55 (1.30)	256.1 (216.4)	0.95 (9.18)	315.8 (321.4)
	20–40	4.46 (6.56)	9.0 (8.4)	1.50 (4.50)	0.55 (1.10)	206.1 (159.9)	0.45 (3.70)	202.7 (318.1)

Table 3.
(Continued)

Species	Soil depth (cm)	Soil pH	Organic C (g/kg)	Exch. Ca^{2+} (cmol (p+)/kg)	Exch. Mg^{2+} (cmol (p+)/kg)	Available nutrients N (kg/ha)	P (kg/ha)	K (kg/ha)
	40–60	4.54 (6.85)	9.6 (6.9)	0.80 (3.75)	1.15 (1.15)	135.2(125.6)	1.18 (3.02)	172.5 (287.8)
	Mean	4.44 (6.59)	9.9 (9.0)	0.97 (4.95)	0.75 (1.18)	199.1(167.3)	0.86 (5.30)	230.3 (309.1)
D. hookerii	0–20	5.03 (4.53)	25.2 (11.1)	2.55 (0.50)	2.05 (0.40)	235.2(166.2)	2.30 (2.24)	460.3 (211.7)
	20–40	5.12 (4.68)	15.3 (8.4)	2.50 (0.30)	1.45 (0.40)	203.8(138.0)	2.74 (1.46)	351.7 (206.1)
	40–60	4.42 (4.60)	16.5 (13.5)	2.60 (0.65)	1.00 (0.40)	125.4(125.4)	3.02 (2.46)	396.5 (169.1)
	Mean	4.86 (4.60)	19.0 (11.0)	2.55 (0.48)	1.50 (0.40)	188.1(143.2)	2.69 (2.05)	402.8 (195.6)
D. longispathus	0–20	3.47 (3.80)	26.1 (24.0)	0.85 (0.89)	1.35 (1.00)	188.2(140.5)	1.85 (5.20)	104.7 (100.0)
	20–40	3.80 (4.30)	26.4 (23.0)	0.85 (0.87)	1.00 (1.10)	172.5(130.6)	1.62 (4.50)	91.8 (109.9)
	40–60	3.89 (4.20)	23.4 (18.0)	1.05 (1.48)	0.50 (1.20)	109.8(109.3)	0.95 (1.90)	212.8 (101.5)
	Mean	3.72 (4.10)	25.3 (21.5)	0.92 (1.08)	0.95 (1.10)	156.8(126.8)	1.47 (3.86)	136.4 (103.8)
D. sikkimensis	0–20	3.80 (3.68)	23.1 (12.8)	0.95 (0.75)	0.45 (0.30)	203.8(182.3)	3.71 (4.85)	105.8 (106.5)
	20–40	3.95 (3.75)	15.6 (10.1)	0.70 (0.60)	0.80 (0.55)	94.1(101.1)	1.74 (1.98)	70.0 (103.4)
	40–60	3.92 (3.80)	14.4 (7.6)	0.45 (0.35)	1.00 (0.30)	109.8(69.5)	2.63 (2.65)	71.7 (105.0)
	Mean	3.89 (3.74)	14.7 (10.2)	0.70 (0.57)	0.75 (0.38)	135.9(117.6)	3.36 (3.16)	82.50 (105.0)
Melocanna baccifera	0–20	4.61 (5.36)	23.4 (5.4)	1.45 (1.40)	1.50 (0.75)	235.2(219.5)	1.40 (2.46)	211.1 (396.5)
	20–40	4.82 (4.50)	18.9 (5.4)	0.70 (1.05)	1.35 (1.00)	188.2(200.7)	1.74 (1.23)	166.9 (101.9)
	40–60	4.90 (4.99)	13.5 (6.3)	0.70 (0.75)	0.55 (0.55)	109.8(197.6)	2.02 (1.68)	117.0 (67.2)
	Mean	4.78 (4.95)	18.6 (5.7)	0.95 (1.07)	1.13 (0.77)	177.7(205.9)	1.72 (1.79)	165.0 (188.5)
Teinostachyum wightii	0–20	3.94 (4.00)	25.5 (21.0)	1.00 (0.90)	0.15 (0.30)	172.5(130.6)	2.07 (4.58)	159.0 (210.0)
	20–40	3.75 (3.90)	22.2 (21.0)	0.45 (0.50)	0.15 (0.30)	125.4(111.80)	1.79 (2.50)	86.8 (140.0)
	40–60	3.63 (4.04)	14.1 (14.0)	0.30 (0.40)	0.30 (0.30)	109.8(105.0)	1.34 (1.50)	75.0 (100.0)
	Mean	3.77 (3.98)	20.6 (18.6)	0.58 (0.60)	0.20 (0.30)	135.9(115.8)	1.73 (2.86)	106.9 (150.0)

Values in parentheses indicate the soil properties in adjacent control plots, i.e., without bamboo cover.

Organic carbon

Organic carbon content increased in all the soils under different bamboo species over control and ranged from 0.99% (*D. hamiltonii*) to 2.53% (*D. longispathus*). Maximum increase in organic carbon (1.29%) was observed in *M. baccifera*, followed by *D. giganteus* (0.49%) and *D. hookerii* (0.26%). In general, perennials have the ability to maintain soil organic matter through supply of litter and root residues and certain species enhance the nitrogen status of soil [11]. Differences in the organic carbon content under various species may be due to addition of varying amounts of leaf litter and root residues to the soils. Surface soils recorded a higher organic carbon content than sub-surface ones, which may be because of higher accumulation of litter fall and decomposition in surface layer (Table 3).

Available nutrients

The highest available N content was recorded in *B. nutans* (266.6 kg/ha), followed by *B. multiplex* (250.9 kg/ha). Similar to organic carbon, surface soils recorded higher available N than in sub-surface horizons. The effect of bamboo species on soil available N content was positive and maximum increase in available N was observed in *B. multiplex* (126.5 kg/ha), followed by *D. giganteus* (94.0 kg/ha). Increase in N mineralization in bamboo soils was also reported earlier by Raghubanshi [12]. Available N content of the soils under different species almost followed the trend of organic carbon (Table 3).

Mean available P content in soils under different bamboo species was very low and ranged from 0.86 to 3.36 kg/ha, which may be due to highly acidic reaction of the soils. There was a decrease in available P under bamboo plantation in case of most of the species, except *D. giganteus*, *D. hookerii* and *D. sikkimensis*, where a slight build-up in available P content was noticed. Maximum reduction in available P was recorded in *D. hamiltonii* and *B. multiplex* species (4.44 and 3.89 kg P/ha, respectively). Reduction in P content in these species when compared to their control plots might be due to their high requirement of P, as evident by high P content of bamboo shoots [9]. On average, surface soils recorded more available P than sub-surface soils, whereas available P was more in subsurface layer of the remaining profiles (Table 3). This variation may be due to difference in rooting pattern of bamboo species, mining of P from various depths, leaching behaviour of soils and clay and sesqui - oxide contents in the soils (personal observations).

Mean available K content in soils ranged from 52.6 to 402.8 kg/ha. It was in the medium to high ($>$150 kg/ha) range in the soils of most bamboo species, except *B. balcooa*, *D. sikkimensis*, *B. pallida* and *D. longispathus*, where it was in the low range ($<$150 kg/ha). Available K increased in soils of *D. hookerii*, *B. multiplex*, *D. giganteus*, *D. longispathus* and *B. nutans* by 207.2, 154.4, 95.6, 32.6 and 10.4 kg/ha, respectively, compared to their control values, and in rest of the species it decreased (Table 3). The differential effect of bamboo species on soil available K may be due to the differences in K uptake by bamboo species, and K content and decomposition rate of leaf litter. The high K content in the leaves of *D. hookerii* and *D. giganteus* may be responsible for the high K build-up in these species [9]. Bamboo plays an important role in conservation of K due to its ability for rapid uptake and accumulation of K in the living biomass [13]. K content was higher in the rooting zone (0–20 cm) than in rhizome zone. Among the nutrients, N and K showed the highest increase suggesting their higher returns to soil followed by P. These observations are in line with the findings of Joshi *et al.* [14] and Shanmughavel and Francis [15]. Thus, it could be inferred from this study that *D. giganteus*, followed by *D. hookerii* and *B. nutans*, has been found to be the better species for improving and maintaining the fertility status of acid soils in the NEH region.

Acknowledgements

The authors are thankful to the Director of the institute for providing facilities to conduct the work. Thanks are also due to Indian Council of Agricultural Research (ICAR), Govt. of India, New Delhi, for financial assistance.

REFERENCES

1. J. S. Samra, J. Richer, H. S. Gill and Anlanf, Spatial dependence of soil sodicity and tree growth in Natric Hapludalf, *Soil Science Society of America Journal* **54**, 1228–1233 (1990).
2. K. Haridasan, N. B. Singh and M. L. Deori, Bamboos in Arunachal Pradesh — The present status, *Journal of Tropical Forest* **3** (4), 298–310 (1987).
3. K. R. Solanki, K. M. Bujarbaruah and B. P. Bhatt, Bamboo: A potential resource for agroforestry and social forestry with special reference to N.E.H. region. Technical Bulletin, ICAR Research Complex for NEH Region, Umiam, Meghalaya, India (2004).
4. B. P. Bhatt and K. M. Bujarbaruah, Potential edible bamboo species of N.E.H. region: Production potential, cost-benefit analysis, nutritional security and management strategies. Technical Bulletin, ICAR Research Complex for NEH Region, Umiam, Meghalaya, India (2004).
5. Mueller-Dombois D. and H. Ellenberg, *Aims and Methods of Vegetation Ecology*. Wiley, New York, NY (1974).
6. M. L. Jackson, *Soil Chemical Analysis*. Prentice Hall of India (Pvt.), New Delhi (1973).
7. M. K. John, Colorimetric determination of phosphorus in soil and plant materials with ascorbic acid, *Soil Science* **109**, 214–220 (1970).
8. B. V. Subbiah and G. L. Asija, A rapid procedure for determination of available N in soils, *Current Science* **25**, 259–263 (1956).
9. K. A. Singh, Boon of bamboo resources in North East India, in: *Resource Management Perspective of Arunachal Agriculture*, K. A. Singh (Ed.), pp. 69–112. ICAR Research Complex for NEH Region, A.P. Centre, Basar, Arunachal Pradesh, India (2002).
10. S. Nath, B. Singh, P. K. Das, S. K. Ganguly and S. K. Banerjee, Soil characteristics of conifer plantations versus natural forest in the eastern Himalaya, *Indian Journal of Tropical Agriculture* **4**, 221–227 (1986).
11. A. D. Noble and P. J. Randall, *How Trees Affect Soils — A Report for the Rural Industries Research and Development Corporation*. RIRDC, Kingston (1998).
12. A. S. Raghubanshi, Effect of bamboo harvest on dynamics of nutrient pools, N mineralization and microbial biomass in soil, *Biology and Fertility of Soils* **18**, 137–142 (1994).

13. O. P. Toky and P. S. Ramakrishnan, Role of bamboo (*D. hamiltonii*) in conservation of potassium during slash and burn agriculture (*Jhum*) in north eastern India, *Journal of Tree Science* **1** (1–2), 17–26 (1982).
14. A. P. Joshi, R. C. Sundriyal and D. C. Bahini, Nutrient dynamics of a lower Siwalik bamboo forest in the Garhwal Himalaya, India, *Journal of Tropical Forest Science* **3** (3), 238–250 (1991).
15. P. Shanmughavel and K. Francis, Balance and turn over of nutrients in a bamboo plantation (*Bambusa bambos*) of different ages, *Biology and Fertility of Soils* **25** (1), 69–74 (1997).