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Distribution of nutrition elements in different bamboos in bamboo based agroforestry plantation –A comparative study

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Abstract

This paper describes the results from a bamboo plantation (i.e. *D. asper*, *D hamiltonii* and *B balcooa*) grown in the Bamboo based Agroforestry system at Dr YS Parmar University of Horticulture and Forestry, Nauni - Solan under mid hill conditions of HP. Bamboos with a high production and wide utilization has been planted in large scale in southern China and India but little information about bamboo nutrition is available. The objective of this study was to reveal the dynamics of nutrition with growing time and the distribution of nutrition in different organs. It was found that the nutrition concentration of the whole plant generally declined with time owing to a dilution effect with the result of quickly increasing the biomass. The leaf, branch, stem, root and rhizome concentration of nitrogen (N), phosphorus (P), and potassium (K) changed regularly, generally declined with the age. The concentrations of calcium (Ca) and magnesium (Mg) in bamboo leaf, branch, stem, root and rhizome appeared to be opposite to those of N, P, and K in corresponding plant parts. The abundance of nutrition in leaves, branches, and stems of bamboo followed the order of N>K>Mg> P > Ca, K>N>Mg>P>Ca, and K>N>Mg> P> Ca, respectively. However in below ground parts the nutrients in root and rhizome of bamboo followed the order of N>K> P > Mg > Ca and N> K> Mg > P > Ca respectively.

Keywords: Bamboo, plant nutrients, dynamics, *D. asper*, *D hamiltonii* and *B balcooa*.

Introduction

Bamboo is a fascinating arbores cent grass. For centuries, bamboos have played an important part in the daily life of the people in many tropical countries, particularly in Asia. India has the World's richest resources of bamboo, claiming about 130 species occurring over an area of 10.05 million ha, which is about 12.8% of the total forest area of the country (Sharma, 1987). However, bamboo resource in the natural habitat is dwindling, due to over exploitation, gregarious flowering, shifting cultivation and extensive forest fires. A sustained availability can be ensured only by elaborate bamboo cultivation (Shanmughavel and Francis, 1995) [16]. More recently, curiosity about the peculiar plants with their widespread distribution, rapid rate of growth and multipurpose uses has grown. Studies on the effect of container size on seedling growth in a number of species point to the effect of container size on growth performance of *Bambusa arundinaceae* indicate that shoots and length of the plant were not influenced by container size (Chacko and Jayaraman, 1998) [4]. Performance of bamboo seedlings in nursery with varying spacing and fertility levels has been studied (Kondas *et al*, 1973; Suzuki and Narita 1975; Kim *et al*, 1976; Patil and Patil, 1988) [11, 18, 10, 13]. Observations on growth and development of forest bamboos were reported (Hasan, 1975; Caracallas *et al,* 1988) [6]. However reports on growth and nutrient dynamics of bamboos in a social forestry is limited (Seshadri, 1985; Balaji, 1991; Shanmughavel, 1995) [14, 1, 16]. Therefore, an elaborate study was carried out on the performance of bamboo based agroforestry plantation in mid hill of HP at Dr YS Parmar UHF, campus, Nauni-Solan, India.

Material and method

Study site

The study was carried out in first agro-climatic zone-I of Himachal Pradesh at experimental field of Department of Silviculture and Agroforestry (30º 51’ N latitude and 76º 11’ E longitude and elevation; 1200m amsl) at Nauni, Dr YS Parmar University of Horticulture and Forestry, Nauni-Solan, Himachal Pradesh.

Climatic and Edaphic factors

The climate of study area varies within different altitudinal ranges. This zone affected by all three extreme climatic conditions, high temperature in summers (18 to 35 ºC), very low in winter (5 to 21 ºC) and heavy rainfall in rainy season. The mean annual rainfall varies from 1400 to 1800 mm and most of which concentrated during July-August, receiving about 80 per cent of total annual rainfall. This zone having distinct type of soil viz., brown, alluvial and grey brown with the composition of sandy loam and clay loam.

Sampling of Bamboo

For plant nutrient estimation, 3 clumps were randomly selected from each clump three culms of each age class i.e. < 1 year, 1-2 year and > 3year were felled. Three age-classes: <1 year, 1–3 years and >3 year. Age was identified in the field based on the indicators used by Wimbush (1945) [20] and Banik (1993) [2]. After felling the sample culms were subdivided into leaves, branches and stem. Sub samples from each component were brought to the laboratory in plastic bags. The sub samples were then oven dried at 103ºC to constant weight. Then the samples were grinded into powder form for further analysis.

Plant chemical analysis

For the estimation of total nitrogen, plant material **(**stem, leaf, branch, rhizomes and root) was digested in the concentrated sulphuric acid in the presence of a digestion mixture of following composition:

K2SO$_4$ 400 parts

$CuSO_4$ 20 parts

HgO 3 parts

Selenium Powder 2 parts

After digestion, the N was determined by Micro-Kjeldahl method

For the estimation of total P, K, Ca and Mg, wet digestion of the plant sample was carried out in di-acid mixture consisting nitric acid and perchloric acid in the ratio of 4:1 and the final volume of the digest was made to 100ml with distilled water. Total P in the digest was determined by Vanado-molybdate yellow method using Ultra Spectophotometer while K, Ca and Mg were estimated using Atomic Absorption Spectophotometer.

Result and discussion

Nutrition accumulation regularity and the pattern of distribution in different plants are generally affected by the type and age of the species (Ovington, 1968) [12]. Table 1-5 present the dynamics of N, P, K, Ca and Mg concentrations in leaf, branch, stem, root and rhizome of bamboo from current year age to age 3. Similar trends for N, P and K concentrations have been observed in leaves, branches and stems of different bamboo species. In stem organ of bamboo, the concentration of N (196.31 Kg ha^{-1}) P (36.59 Kg ha^{-1}), and K (220.25 Kg ha^{-1}) was significantly higher in *D. asper* and lower in *B balcooa* among species, likewise among age classes in current year i.e. A_1 bamboo stem the higher concentration of N, P and K was 189.79, 33.16 and 218.27 Kg ha^{-1} respectively whereas the lower abundance was detected in 3 year old bamboo stem. Likewise in branch component of bamboo, the concentration of N (125.54 Kg ha^{-1}) P (20.64 Kg ha^{-1}), and K (168.33 Kg ha^{-1}) was significantly higher in *D. asper* and lower in *B balcooa* among species, likewise among age classes in two year i.e. A_2 bamboo branch the higher concentration of N, P and K was 122.22, 17.88 and 165.66 Kg ha^{-1} respectively whereas the lower abundance was detected in 3 year old bamboo branch. The concentration of N (192.49 Kg ha^{-1}) P (28.35 Kg ha^{-1}), and K (137.62 Kg ha^{-1}) was significantly higher in leaf component of bamboo of *D. asper* and lower in *B balcooa* among species, likewise among age classes in two year i.e. A_2 bamboo leaf the higher concentration of N, P and K was 190.01, 24.75 and 130.33 Kg ha^{-1} respectively whereas the lower abundance was detected in 3 year old bamboo leaf. The concentration of N (94.34 Kg ha^{-1}) P (22.61 Kg ha^{-1}), and K (67.15 Kg ha^{-1}) was significantly higher in root component of bamboo of *D. asper* and lower in *B balcooa* among species, likewise among age classes in current year i.e. A_1 bamboo root the higher concentration of N, P and K was 91.71, 20.40 and 64.95 Kg ha^{-1} respectively whereas the lower abundance was detected in 3 year old bamboo root. In rhizome component of bamboo, the concentration of N (99.41 Kg ha^{-1}) P (10.99 Kg ha^{-1}), and K (65.84 Kg ha^{-1}) was significantly higher in *D. asper* and lower in *B balcooa* among species, likewise among age classes in current year i.e. A_1 bamboo rhizome the higher concentration of N, P and K was 96.13, 9.48 and 64.28 Kg ha^{-1} respectively whereas the lower abundance was detected in 3 year old bamboo rhizome. These results are supported by Embaye *et al*, 2004.The maximum concentrations occurred in young year old bamboo due to the fast growth of the bamboo. It is well known that nutrition uptake by plants usually goes to the fast growing part or parts. Since the largest amount of nutrition in old bamboo is being transported to the new bamboo growth (1-year old), the nutrition in the old bamboo plant was getting lower, and the green leaf turned yellow. The old leaves fell down and the new leaves grew out in the next year when the bamboo were at age 2, 4, and 6 and no new bamboos growing out at that year. Therefore bamboo leaves are generally renewed every other year. The special genetic characteristics of bamboo (new bamboo and new leaves will grow out every other year but not in the same year) induced the result that nutrition in bamboo leaf did not increase steadily with time as other plants, but fluctuate with lower concentrations during the year of new bamboo generating and relative higher at the rest. Leaves are the main organ for organic matter producing in most of the plants (Huang and Chen, 1991) [8]; therefore, concentrations in leaves would be more sensitive to changes caused by environment and by other coexisting plants. However, branches and stems acting as storage organs contain less nutrition and more cellulose and semi-cellulose, especially older bamboos. That is why a decline for N, P, K, Ca and Mg with age in branches and stems was observed. These results are in line with Jiasen *et al,* 2009 [9].

However, the trends of Ca and Mg in leaf were opposite to those of N, P, and K (table 1-5). In stem organ of bamboo, the concentration of Ca (18.66 Kg ha^{-1}) and Mg (38.76 Kg ha^{-1}) was significantly higher in *D. asper* and lower in *B balcooa* among species, likewise among age classes in 3 year i.e. A_3 bamboo stem the higher concentration of Ca and Mg was 16.63 and 34.87 Kg ha^{-1} respectively whereas the lower abundance was detected in current year bamboo stem. In branch component of bamboo, the concentration of Ca (14.57 Kg ha^{-1}) and Mg (30.41 Kg ha^{-1}) was significantly higher in *D. asper* and lower in *B balcooa* among species, likewise among age classes in 3 year i.e. A_3 bamboo stem the higher concentration of Ca and Mg was 16.63 and 34.87 Kg ha^{-1} respectively whereas the lower abundance was detected in 2 year bamboo stem while bamboo were devoid of branch in current year. In leaf component of bamboo, the concentration of Ca (16.65 Kg ha^{-1}) and Mg (33.65 Kg ha^{-1}) was significantly higher in *D. asper* and lower in *B balcooa* among species, likewise among age classes in 3 year i.e. A_3 bamboo leaf the higher concentration of Ca and Mg was

16.09 and 29.78 Kg ha^{-1} respectively whereas the lower abundance was detected in 2 year bamboo stem while bamboo were devoid of leaf in current year. In root organ of bamboo, the concentration of Ca (7.95 Kg ha^{-1}) and Mg (14.41 Kg ha^{-1}) was significantly higher in *D. asper* and lower in *B balcooa* among species, likewise among age classes in 3 year i.e. A_3 bamboo root the higher concentration of Ca and Mg was 7.42 and 12.04 Kg ha^{-1} respectively whereas the lower abundance was detected in current year bamboo root. In rhizome organ of bamboo, the concentration of Ca (6.68 Kg ha^{-1}) and Mg (21.81 Kg ha^{-1}) was significantly higher in *D. asper* and lower in *B balcooa* among species, likewise among age classes in 3 year i.e. A_3 bamboo root the higher concentration of Ca and Mg was 6.39 and 17.23 Kg ha^{-1} respectively whereas the lower abundance was detected in current year bamboo rhizome.

The lower concentrations of Ca and Mg in stem, branch, leaf, root and rhizome were detected in current year bamboo organs, with the maximum at year 3. A small decrease in concentrations from age 1 to 2 was observed, which may be due to the results of the dilution effect. Calcium and Mg are not easy to transport from one part to another and they are difficult to reuse in the plant. It was proven that Ca and Mg accumulated with plant age (Tian, 1989) [19]. Therefore, a higher concentration would be observed in the old part of the plant. The nutrition in the 1-year bamboo mainly came from the old bamboo rather than uptake from soil owning to its weak root system. Calcium and Mg were taken up passively via transpiration from soil to leaf and less removable, and their concentrations in new plant with fewer roots were often lower than the old plant. The accumulating tendency of Ca and Mg were observed in branches and stems, which are not renewed every other year (Figures 3C and 3D; Figures 4C and 4D), this finding was comparable to results from other types of trees (He and Meng, 1987) [7].

Table 1: Effect of different bamboo species and age on plant nutrient accumulation in stem organ of bamboo.

Stem																				
Species	**Total N(kg/ha)**				**Total P(kg/ha)**				**Total K (kg/ha)**				**Total Ca(kg/ha)**				**Total Mg(kg/ha)**			
	A1	**A2**	**A3**	**MEAN**	**A1**	**A2**	**A3**	**MEAN**	**A1**	**A2**	**A3**	**MEAN**	**A1**	**A2**	**A3**	**MEAN**	**A1**	**A2**	**A3**	**MEAN**
Dendrocalamus asper	196.81	196.36	195.77	196.31^{a}	37.08	36.59	36.11	36.59^{a}	221.19	220.77	220.25	220.74^{a}	18.10	18.62	19.26	18.66	38.26	38.68	39.34	38.76^{a}
Dendrocalamus hamiltonii	193.44	192.95	192.47	192.96^{b}	35.26	34.78	34.41	34.82^{b}	220.38	219.89	219.61	219.96^{b}	16.33	16.71	17.23	16.76	34.78	35.29	35.82	35.30^{b}
Bambusa balcooa	179.11	178.58	178.09	178.59^{c}	27.15	26.75	26.33	26.74^{c}	213.24	212.71	212.19	212.71^{c}	12.37	12.89	13.41	12.89	28.33	28.81	29.44	28.86^{c}
MEAN	189.79^{a}	189.30^{a}	188.78^{a}		33.16^{a}	32.71^{a}	32.28^{b}		218.27^{a}	217.79^{a}	217.35^{b}		15.60	16.07	16.63		33.79	34.26	34.87	
CD 5%																				
Age				NS				NS				0.58				0.67				NS
Species				1.02				0.78				0.58				0.67				0.97
Age x Species				NS				NS				NS				NS				NS

Table 2: Effect of different bamboo species and age on plant nutrient accumulation in branch organ bamboo

Branch																				
Species	Total N(kg/ha)				Total P(kg/ha)				Total K(kg/ha)				Total Ca(kg/ha)				Total Mg(kg/ha)			
		A2	A3	MEAN	A1	A2	A3	MEAN	A1	A2	A3	MEAN	A1	A2	A3	MEAN	A1	A2	A3	MEAN
Dendrocalamus asper	-	125.75	125.34	125.54^{a}	-	20.88	20.40	20.64^{a}	-	168.60	168.05	168.33^{a}	-	14.38	14.76	14.57^{a}	-	30.18	30.63	30.41^{a}
Dendrocalamus hamiltonii	-	122.41	122.00	122.21^{b}	-	19.53	19.16	19.34^{b}	-	166.63	166.22	166.43^{b}	-	12.97	13.79	13.38^{b}	-	28.06	28.62	28.34^{b}
Bambusa balcooa	-	118.52	117.96	118.24^{c}	-	13.23	12.86	13.05^{c}	-	161.76	161.18	161.47^{c}	-	10.09	10.57	10.33^{c}	-	22.40	22.88	22.64^{c}
MEAN	-	122.22^{a}	121.76^{a}		-	17.88^{a}	17.47^{a}		-	165.66^{a}	165.14^{a}		-	12.48	13.04		-	26.88	27.38	
CD 5%																				
Age				NS				NS				NS				NS				NS
Species				0.91				0.89				1.33				1.08				1.10
Age x Species				NS				NS				NS				NS				NS

Table 3: Effect of different bamboo species and age on plant nutrient accumulation in leaf organ of different bamboo species

Leaf																				
Species	**Total N(kg/ha)**				**Total P(kg/ha)**				**Total K(kg/ha)**				**Total Ca(kg/ha)**				**Total Mg(kg/ha)**			
	A1	**A2**	**A3**	**MEAN**	**A1**	**A2**	**A3**	**MEAN**	**A1**	**A2**	**A3**	**MEAN**	**A1**	**A2**	**A3**	**MEAN**	**A1**	**A2**	**A3**	**MEAN**
Dendrocalamus asper	-	192.71	192.26	192.49	-	28.59	28.10	28.35	-	137.86	137.38	137.62	-	16.42	16.87	16.65	-	33.41	33.89	33.65
Dendrocalamus hamiltonii	-	191.44	190.92	191.18	-	26.96	26.44	26.70	-	134.89	134.37	134.63	-	16.06	16.53	16.29	-	29.47	29.85	29.66
Bambusa balcooa	-	185.87	185.33	185.60	-	18.70	18.07	18.39	-	118.26	117.73	118.00	-	14.38	14.86	14.62	-	25.21	25.62	25.41
MEAN	-	190.01	189.51		-	24.75	24.20		-	130.33	129.83		-	15.62	16.09		-	29.36	29.78	
CD 5%																				
Age				NS				NS				NS				NS				NS
Species				0.98				0.10				0.21				1.22				0.76
Age x Species				NS				NS				NS				NS				NS

Table 4: Effect of different bamboo species and age on plant nutrient accumulation in root of bamboo.

Root																				
Species	**Total N(kg/ha)**				**Total P(kg/ha)**				**Total K(kg/ha)**				**Total Ca(kg/ha)**				**Total Mg(kg/ha)**			
	A1	**A2**	**A3**	**MEAN**	**A1**	**A2**	**A3**	**MEAN**	**A1**	**A2**	**A3**	**MEAN**	**A1**	**A2**	**A3**	**MEAN**	**A1**	**A2**	**A3**	**MEAN**
Dendrocalamus asper	95.06	94.72	94.34	94.70[a]	23.15	22.59	22.08	22.61[a]	67.15	66.67	65.85	66.56[a]	7.49	7.93	8.42	7.95[a]	14.06	14.40	14.78	14.41[a]
Dendrocalamus hamiltonii	92.80	92.41	92.07	92.43[b]	21.58	21.03	20.59	21.07[b]	66.25	65.75	65.19	65.73[a]	7.33	7.80	8.31	7.81[a]	12.40	12.85	13.18	12.81[b]
Bambusa balcooa	87.26	86.76	86.23	86.75[c]	16.45	15.93	15.48	15.95[c]	61.44	60.94	60.43	60.94[b]	4.63	5.07	5.53	5.08[b]	7.38	7.78	8.15	7.77[c]
MEAN	91.71[a]	91.30[b]	90.88[a]		20.40[a]	19.85[a]	19.38[b]		64.95[a]	64.45[a]	63.82[b]		6.48	6.93	7.42		11.28	11.68	12.04	
CD 5%																				
Age				NS				0.75				NS				0.50				NS
Species				0.89				0.75				0.96				0.50				0.81
Age x Species				NS				NS				NS				NS				NS

Table 5: Effect of different bamboo species and age on plant nutrient accumulation in rhizome of bamboo.

Rhizome																				
Species	**Total N(kg/ha)**				**Total P(kg/ha)**				**Total K(kg/ha)**				**Total Ca(kg/ha)**				**Total Mg(kg/ha)**			
	A1	**A2**	**A3**	**MEAN**	**A1**	**A2**	**A3**	**MEAN**	**A1**	**A2**	**A3**	**MEAN**	**A1**	**A2**	**A3**	**MEAN**	**A1**	**A2**	**A3**	**MEAN**
Dendrocalamus asper	100.07	99.40	98.76	99.41[a]	11.47	10.99	10.51	10.99[a]	66.31	65.79	65.41	65.84a	6.18	6.66	7.18	6.68[a]	21.43	21.78	22.23	21.81[a]
Dendrocalamus hamiltonii	97.18	96.82	96.41	96.81[b]	9.44	8.81	8.11	8.79[b]	65.44	64.96	64.53	64.97[b]	5.72	6.10	6.51	6.11[a]	19.42	19.79	20.29	19.83[b]
Bambusa balcooa	91.14	90.56	90.16	90.62[c]	7.52	7.19	6.78	7.16[c]	61.11	60.64	60.20	60.65[c]	4.62	5.00	5.47	5.03[b]	8.20	8.68	9.17	8.68[b]
MEAN	96.13[a]	95.60[a]	95.11[a]		9.48[a]	9.00[a]	8.47[b]		64.28[a]	63.80[a]	63.38[b]		5.51	5.92	6.39		16.35	16.75	17.23	
CD 5%																				
Age				0.77				NS				NS				NS				NS
Species				0.77				0.84				0.74				0.86				0.71
Age x Species				NS				NS				NS				NS				NS

Conclusion

The nutrition concentration of the whole plant generally declined with the time during the bamboo growing period in 1 to 3 years old bamboo culms owing to the dilution effect with the result of quickly increasing the biomass. The concentration of N, P, and K in leaf, branch, stem, root and rhizome generally declined with age. The changing tendency of Ca and Mg in bamboo leaf, branch, stem, root and rhizome just appeared to be opposite to those of N, P, and K in corresponding plant parts. The abundance of nutrition was greater in the stem than in leaf and branch. A relative large total storage of nutrition was found in *D asper* than rest of the species in bamboo plantation. This study shows that bamboos follow a strategy of faster uptake and storage of essential elements. Hence, necessary precautions need to be observed during exploitation of large scale plantations of *D. asper* to nutrient loss and maintain the soil fertility. Nevertheless, it can be recommended as a species for bamboo plantations in agroforestry.

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