J. Bamboo and Rattan, Vol.5, Nos. 3&4, pp. 105-116 (2006)

Bambusa bambos (L.)Voss plantation in eastern India: II. Nutrient dynamics

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Abstract: Data are presented for nutrient (N, P and K) dynamics in 3- to 5-year-old *Bambusa bambos* plantations in eastern India. The nutrient concentration in the various biomass components of the bamboo was generally in the order of leaf > rhizome > root > branch > culm, with the nutrient elements in the order of N > K > P. The maximum amount of all nutrients was accumulated in the culms, followed by branches, rhizomes, leaves and roots. Considerable reduction (55-62%) in concentration of nutrients (N, P and K) in leaves occurred during senescence. The uptake of nutrients by bamboo with and without adjustment for internal recycling has been calculated separately. Annual transfer of nutrients through litter and roots to the soil was 49.2-58.7 N, 2.7-3.1 P and 40.4-48.9 K kg $ha^{-1}year^{-1}$. Annual turnover rate of nutrients on the floor of different aged bamboo plantations ranged from 69 to 93 per cent. Compartmental models for nutrient dynamics have been developed to represent the distribution of nutrient pools and net annual fluxes in 4- and 5-year-old bamboo plantations. It is concluded that bamboo plantations make an efficient use of nutrients through internal recycling and conserve nutrients by accumulation in phytomass and immobilization in the decomposing leaf mass.

Key words: Nutrient budget, litter, nutrient pool and flux, nutrient retranslocation.

INTRODUCTION

India is endowed with rich diversity of bamboos consisting of about 23 genera and over 100 indigenous species spread over an area of 10.05 million ha or about 12.8 per cent of the total forest area of the country (Jain and Biswas, 2001; Shanmughavel *et al.*, 2002). There is a need for quantitative information on nutrient cycling for sustainable production of bamboo. In a given climate, primary production is generally influenced by the availability of nutrients, which in turn, depends on the pattern and rate of their cycling (Das and Chaturvedi, 2005). Information on nutrient relations of bamboo is scarce (Tripathi and Singh, 1994; Shanmughavel *et al.*, 2002). In this paper we, therefore, present the results of a study on uptake, return, turnover and cycling of

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nutrients in *Bambusa bambos* plantations growing in the calciorthent soil of Bihar, India.

METHODS

The study area and the species characteristics of the *B. bambos* have been described in a related paper (Das and Chaturvedi, 2006). Fresh samples of different bamboo components *viz.*, culm, branch, leaf, rhizome, coarse roots (> 2 mm dia) and fine roots (< 2 mm dia), were taken from the field and brought to the laboratory. Composite samples of each component were oven dried at 80°C to a constant weight. The samples were millground. Five replicates each of 0.5 g of dry plant material were analysed for total nitrogen, phosphorus and potassium. Total nitrogen was determined by micro Kjeldahl method. Phosphorus was determined colorimetrically using spectrophotometer and K with a flame photometer.

Nutrient stock (kg ha^{-1}) in different bamboo components was computed as the sum of the products obtained by multiplying the dry weight of the components with the mean nutrient concentration. The values of nutrient stock in different components were summed to obtain total nutrient storage in bamboo plantation. Nutrient uptake (kg ha^{-1} $year^{-1}$) was computed by multiplying the value of net primary productivity of

Table 1. Mean nutrient concentration (% ± SE) in different components of *B. bambos*

Components	N	P	K
Current year bamboo			
Young shoots	2.20±0.060	0.16±0.002	1.85±0.021
Culm	1.01±0.006	0.06±0.001	0.90±0.003
Branch	1.20±0.003	0.08±0.002	1.10±0.023
Leaf	2.09±0.025	0.14±0.006	1.60±0.008
> 1-year-old bamboo			
Culm	0.57±0.003	0.04±0.002	0.55±0.005
Branch	0.72±0.007	0.05±0.001	0.68±0.003
Leaf	1.86±0.102	0.12±0.006	1.05±0.024
Rhizome	1.20±0.012	0.06±0.003	0.77±0.006
Roots	0.91±0.003	0.04±0.001	0.70±0.006
Litterfall			
Leaf	0.90±0.005	0.05±0.001	0.60±0.003
Non-leaf	0.70±0.003	0.04±0.001	0.40±0.001
Litter layer			
Fresh leaf	0.90±0.002	0.06±0.002	0.48±0.006
Partly decayed	2.50±0.043	0.12±0.004	0.40±0.001
Wood litter	0.75±0.006	0.03±0.001	0.44±0.008

Table 2. Nutrient stocks (kg ha^{-1} ± SE) in different components of *B. bambos*

Age (years)	Nutrient	Leaf	Branch	Culm	AGB*	Rhizome	Root	BGB'	Total
3	N	69.10 ±4.25	353.76 ±50.02	867.66 ±42.98	1290.52 ±58.97	177.12 ±9.87	11.38 ±1.65	188.50 ±8.76	1479.02 ±76
	P	4.54 ±0.28	25.80 ±1.87	54.92 ±4.10	85.26 ±6.93	8.86 ±0.87	0.50 ±0.03	9.36 ±0.76	94.62 ±7.43
	K	46.42 ±3.43	327.97 ±49.76	801.76 ±54.90	1176.15 ±39.98	113.65 ±7.74	8.75 ±0.11	122.4 ±8.56	1298.55 ±32.02
4	N	81.18 ±5.82	424.13 ±57.08	1057.34 ±68.07	1562.65 ±65.05	216.12 ±8.62	13.56 ±0.86	229.68 ±21.90	1792.33 ±57.67
	P	5.33 ±0.52	30.93 ±3.34	66.92 ±5.98	103.18 ±8.52	10.81 ±0.58	10.60 ±0.82	11.41 ±0.13	114.59 ±8.76
	K	54.53 ±2.08	393.20 ±39.25	977.03 ±61.09	1424.76 ±87.19	138.68 ±4.61	10.43 ±1.08	149.03 ±22.34	1573.79 ±76.07
5	N	97.22 ±8.03	524.26 ±59.68	1320.88 ±74.08	1942.36 ±78.89	270.24 ±42.61	16.65 ±1.37	286.89 ±39.85	2229.25 ±81.08
	P	6.38 ±0.21	38.23 ±2.51	83.60 ±8.90	128.21 ±11.41	13.51 ±0.89	0.73 ±0.02	14.24 ±0.87	142.45 ±5.62
	K	65.30 ±3.54	486.03 ±52.61	1220.56 ±69.86	1771.89 ±88.90	173.40 ±13.95	12.81 ±0.12	186.21 ±13.98	1958.10 ±98.34

*AGB: Aboveground biomass; 'BGB: Belowground biomass.

different components with their respective nutrient concentration. Values of nutrient uptake by the components of bamboo were summed up to estimate total uptake by the plantation. The amounts of nutrients transferred to the plantation floor via litterfall were calculated. The turnover rate (k) for each element on the plantation floor was calculated as $k = A/(A+F)$ where, A is the amount of nutrient added to the plantation floor by litterfall and F is the nutrient content of the lowest value of floor litter in the annual cycle (Lodhiyal *et al.*, 1995). Turnover time (t) was calculated as the reciprocal of the turnover rate (k).

Consistently every year, in the months of September and December, 100 each of green (mature) and senescent leaves were taken for nutrient retranslocation estimates. Since, rainfall is negligible in the region when leaves senesce, the effect of leaching on nutrient loss from the leaves is likely to be negligible.

Three soil samples were collected at random from each of the three permanent plots during October in 2000, 2001 and 2002 from four depths (0-15, 15-30, 30-45 and 45-60 cm). The samples from within a plot were thoroughly mixed to yield one composite sample per plot. Large pieces of plant materials were removed and the soil was sieved through a 2 mm mesh screen. Available N was estimated by alkaline permanganate method (Chopra and Kanwar. 1982). Available P_2O_5 was extracted in a mild H_2SO_4

Table 3. Reduction in nutrient concentration (% ± SE) during senescence in foliage of *B. bambos*

Foliage	N	P	K
Foliage attached green	1.98±0.044	0.13±0.006	1.33±0.021
Attached senescent non-green	0.90±0.025	0.05±0.002	0.60±0.020
Relative change (%)	- 54.5	- 61.5	- 54.9

(0.002 N solution) by shaking for 30 min followed by the development of blue colour, which was measured using spectrophotometer. Available K_2O was extracted with neutral 1 N NH_4OAc using soil to extractant ratio of 1:5. The potassium in the extract was determined with the help of flame photometer as described by Jackson (1967).

RESULTS AND DISCUSSION

Nutrient concentration

Nutrient concentration within the plant component showed little difference with the age of the plantation and therefore, pooled data on nutrient concentration are presented. The mean nutrient concentration varied widely amongst the components (Table1). The relative concentration of nutrients, in diminishing order was: N > K > P. Young shoots and leaves of bamboo had greater concentration of all nutrients. All aboveground components of the current year bamboo shoots showed 1.1-1.8 times greater nutrient concentration than the corresponding components of culms aged more than a year. The concentration of nutrients in the various biomass components was generally in the order of leaf > rhizome > root > branch > culm. These results are in general agreement with those obtained from *Bambusa vulgaris* plantation (Shanmughavel *et al.*, 2002) and *Dendrocalamus strictus* plantation (Tripathi and Singh, 1994). The leaf component is metabolically most active and accumulates maximum amount of nutrients (Das and Chaturvedi, 2005).

Nutrient stocks in plantation

On a per hectare basis, the nutrient stock of the standing bamboo increased with plantation age, because of an increase in dry matter accumulation. The total nutrient stocks in the 5-year-old plantation were about 1.5 times greater than that of the 3-year-old plantation (Table 2). Among the different bamboo components, the greatest nutrient stocks resided in culms due to their high proportion of biomass, although culms had the lowest nutrient concentration. These findings are in accordance with the findings of Veda (1960) for *Melocanna baccifera* and Tripathi and Singh (1994) for *D. strictus*. The relative contributions of different components to the nutrient stocks in bamboo were generally in the order: culm > branch > rhizome > leaf > root. The nutrient stocks in the above and belowground biomass were in the order of N > K > P.

Table 2. Nutrient stocks (kg ha^{-1} ± SE) in different components of *B. bambos*

Age (years)	Nutrient	Leaf	Branch	Culm	AGB*	Rhizome	Root	BGB*	Total
3	N	69.10 ±4.25	353.76 ±50.02	867.66 ±42.98	1290.52 ±58.97	177.12 ±9.87	11.38 ±1.65	188.50 ±8.76	1479.02 ±76
	P	4.54 ±0.28	25.80 ±1.87	54.92 ±4.10	85.26 ±6.93	8.86 ±0.87	0.50 ±0.03	9.36 ±0.76	94.62 ±7.43
	K	46.42 ±3.43	327.97 ±49.76	801.76 ±54.90	1176.15 ±39.98	113.65 ±7.74	8.75 ±0.11	122.4 ±8.56	1298.55 ±32.02
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	P	5.33 ±0.52	30.93 ±3.34	66.92 ±5.98	103.18 ±8.52	10.81 ±0.58	10.60 ±0.82	11.41 ±0.13	114.59 ±8.76
	K	54.53 ±2.08	393.20 ±39.25	977.03 ±61.09	1424.76 ±87.19	138.68 ±4.61	10.43 ±1.08	149.03 ±22.34	1573.79 ±76.07
5	N	97.22 ±8.03	524.26 ±59.68	1320.88 ±74.08	1942.36 ±78.89	270.24 ±42.61	16.65 ±1.37	286.89 ±39.85	2229.25 ±81.08
	P	6.38 ±0.21	38.23 ±2.51	83.60 ±8.90	128.21 ±11.41	13.51 ±0.89	0.73 ±0.02	14.24 ±0.87	142.45 ±5.62
	K	65.30 ±3.54	486.03 ±52.61	1220.56 ±69.86	1771.89 ±88.90	173.40 ±13.95	12.81 ±0.12	186.21 ±13.98	1958.10 ±98.34

*AGB: Aboveground biomass; *BGB: Belowground biomass.

different components with their respective nutrient concentration. Values of nutrient uptake by the components of bamboo were summed up to estimate total uptake by the plantation. The amounts of nutrients transferred to the plantation floor via litterfall were calculated. The turnover rate (k) for each element on the plantation floor was calculated as $k = A/(A+F)$ where, A is the amount of nutrient added to the plantation floor by litterfall and F is the nutrient content of the lowest value of floor litter in the annual cycle (Lodhiyal *et al.*, 1995). Turnover time (t) was calculated as the reciprocal of the turnover rate (k).

Consistently every year, in the months of September and December, 100 each of green (mature) and senescent leaves were taken for nutrient retranslocation estimates. Since, rainfall is negligible in the region when leaves senesce, the effect of leaching on nutrient loss from the leaves is likely to be negligible.

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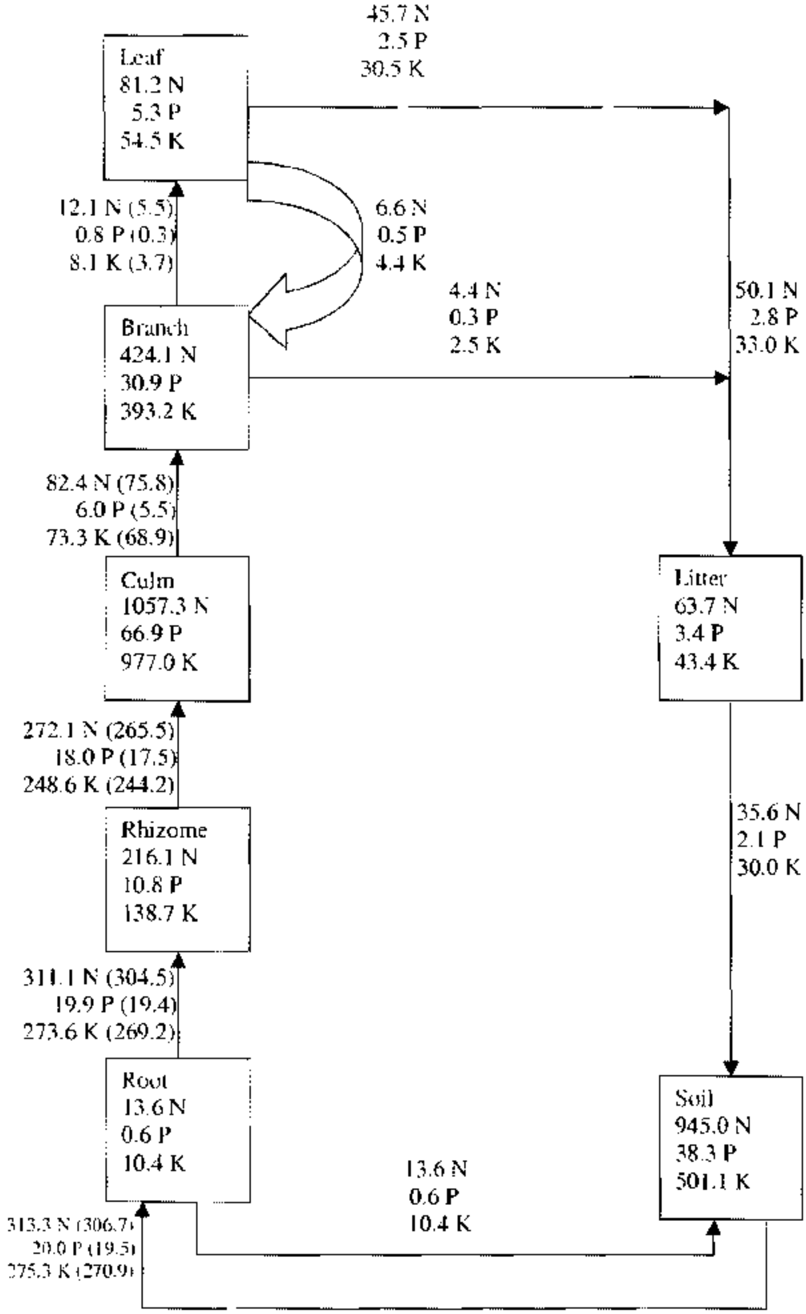

Figure 1. Compartmental model of 4-year-old *B. bambos* plantation showing the distribution and cycling of nitrogen (N), phosphorus (P) and potassium (K). Rectangles represent compartment for standing state of nutrients and arrows represent flow rate of nutrients from one compartment to the next compartment. Curved left arrow represents retranslocation of nutrients. Units are kg ha^{-1} for compartment and kg ha^{-1} $year^{-1}$ for flows between compartments. Values in parentheses indicate adjustment for internal cycling.

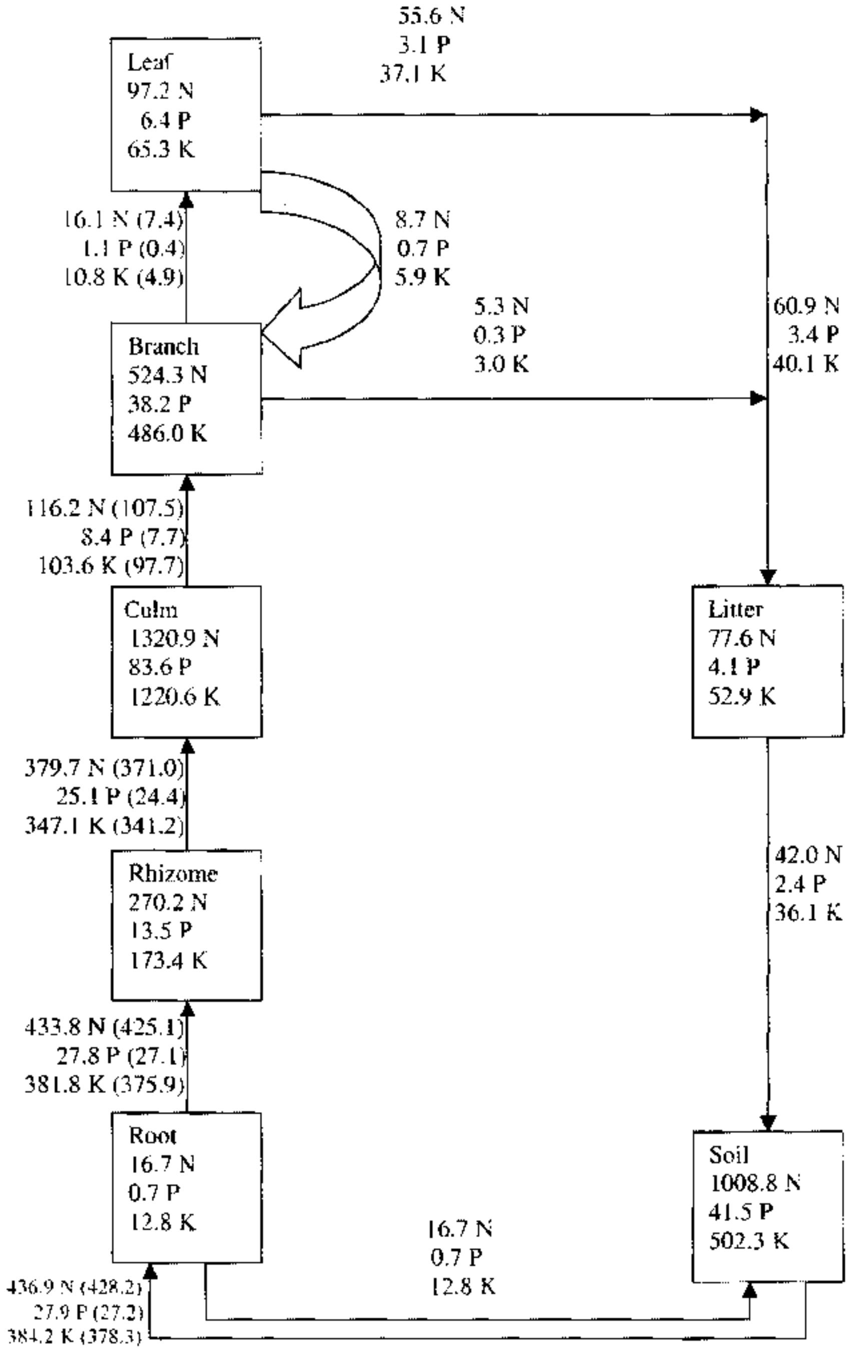

Figure 2. Compartmental model of 5-year-old *B. bambos* plantation showing the distribution and cycling of nitrogen (N), phosphorus (P) and potassium (K). Rectangles represent compartment for standing state of nutrients and arrows represent flow rate of nutrients from one compartment to the next compartment. Curved left arrow represents retranslocation of nutrients. Units are kg ha^{-1} for compartment and kg ha^{-1} $year^{-1}$ for flows between compartments. Values in parentheses indicate adjustment for internal cycling.

Table 4. Uptake of nutrients by different components of *B. bambos*

Age (years)	Nutrient	Gross uptake/net uptake (kg ha⁻¹year⁻¹ ± SE)							
		Leaf	Branch	Culm	ABG	Rhizome	Root	BGP	Total
4	N	12.08 ±1.09 (5.50 ±0.2)*	70.37 ±3.26	189.68 ±23.21	272.13 ±28.96 (265.55 ±20.09)	39.00 ±1.95	2.18 ±0.06	41.18 ±2.12	313.31 ±35.62 (306.73 ±31.21)
	P	0.79 ±0.03 (0.30 ±0.03)	5.13 ±0.23	12.00 ±0.87	17.92 ±1.54 (14.43 ±0.63)	1.95 ±0.05	0.10 ±0.02	2.05 ±0.12	19.97 ±1.97 (19.48 ±1.25)
	K	8.11 ±0.68 (3.66 ±0.07)	65.23 ±4.87	175.27 ±38.09	248.61 ±34.08 (244.16 ±38.75)	25.03 ±1.48	1.68 ±0.09	26.71 ±1.24	275.32 ±25.76 (270.87 ±28.96)
5	N	16.04 ±0.72 (7.30 ±0.06)	100.13 ±30.08	263.54 ±41.24	379.71 ±41.04 (370.97 ±38.96)	54.12 ±2.04	3.09 ±0.16	57.21 ±2.89	436.92 ±34.87 (428.18 ±37.08)
	P	1.05 ±0.05 (0.40 ±0.01)	7.30 ±0.08	16.68 ±2.21	25.03 ±2.21 (24.38 ±2.69)	2.70 ±0.23	0.13 ±0.02	2.83 ±0.12	27.86 ±2.71 (27.21 ±2.87)
	K	10.77 ±0.81 (4.86 ±0.09)	92.83 ±10.21	243.53 ±36.21	347.13 ±33.08 (341.22 ±20.07)	34.72 ±2.91	2.38 ±0.07	37.10 ±1.87	384.23 ±29.07 (378.32 ±39.09)

* Values in parentheses are net nutrient uptake after adjustment for internal recycling.

The increase in nutrient content of standing bamboo with stand age has a direct bearing on the total biomass of plantation (Tandon *et al.*, 1991). In the present plantation, branches and foliage, which together represented about 25 per cent of total biomass (Das and Chaturvedi, 2006), generally contained about 40 per cent of total nutrients. Thus, leaving behind branches and leaves at the site at the time of harvest, would reduce the nutrient cost. Additionally, the slash left on the ground would act as mulch, helping to improve soil conditions.

Table 5. Nutrient return (kg ha^{-1} $year^{-1}$ ± SE) through litterfall in *B. bambos* plantation

Age (Years)	Components	Nutrient return (kg ha^{-1} yr^{-1}) N	P	K
3	Leaf	41.58±4.86	2.31±0.12	27.72±1.28
	Non –leaf	3.08±0.29	0.18±0.02	1.76±0.07
	Total	44.66±5.26	2.49±0.32	29.48±2.03
4	Leaf	45.72±5.07	2.54±0.36	30.48±2.43
	Non-leaf	4.41±1.09	0.25±0.03	2.52±0.26
	Total	50.13±3.78	2.79±0.56	33.00±2.42
5	Leaf	55.62±4.71	3.09±0.74	37.08±2.98
	Non-leaf	5.32±0.98	0.30±0.02	3.04±0.32
	Total	60.94±4.98	3.39±0.87	40.12±3.98

Retranslocation of nutrients and nutrient uptake

A considerable reduction in concentration of nutrients occurred in leaves during senescence indicating nutrient retranslocation to other parts of the plant. On an average, the concentration of nutrients in leaves decreased between 54.5 and 61.5 per cent (Table 3). Evidently, a significant amount of nutrients is recycled internally. This degree of retranslocation of nutrient is believed to be more common in nutrient poor habitats (Ernst and Tolsma, 1989) and the elements normally in short supply for plants are efficiently redistributed before senescence of leaves (Staff and Berg, 1981). The translocation of nutrients from the senescent parts is considered to be an adaptation to minimise the nutrient loss and to meet the nutrient demand of new growth (Fife and Nambiar, 1982). Such a nutrient conserving mechanism used by *B. bambos* may lead to a degree of independence from soil as nutrient source but it also means reduced transfer of nutrients through litter, a factor which may favour poor nutrient availability and tight cycling of nutrients in the ecosystem.

Amount of nutrient uptake is usually directly proportional to the size of net primary production. In the present study, hence, the gross uptake and net uptake (after adjustment for retranslocation of nutrients from senescing leaves) of *B. bambos* increased with the age of the plantation (Table 4).

Nutrients in litterfall and litter layer

Leaf litter mostly showed greater nutrient concentrations than wood litter (Table 1). The bulk transfer of aboveground nutrients to the soil through litterfall occurred in the cool dry part of the year. Nutrients returned through litterfall to the floor in plantation increased with the age of the plantation (Table 5). The order of nutrient return to the floor of the plantation was: N > K > P. Of the total nutrient return through litterfall, 91-94 per cent is returned to the plantation floor through leaf litter.

Table 6. Nutrient content (kg ha^{-1} ± SE) in litters of plantation floor of *B. bambos*

Age (years)	Floor litter Components	Rainy			Winter			Summer		
		N	P	K	N	P	K	N	P	K
3	Fresh leaf	1.08	0.07	0.58	14.22	0.95	7.58	19.80	1.32	10.56
		±0.07	±0.002	±0.02	±1.09	±0.04	±0.72	±1.12	±0.06	±1.02
	Partly decayed	40.00	1.92	6.40	37.75	1.81	6.04	13.75	0.66	2.20
	litter	±5.76	±0.03	±0.14	±2.42	±0.04	±0.98	±1.09	±0.02	±0.08
	Wood litter	5.55	0.22	3.26	5.40	0.22	3.17	5.63	0.23	3.30
		±0.12	±0.04	±0.08	±0.21	±0.03	±0.08	±0.23	±0.02	±0.24
	Total	46.63	2.21	10.24	57.37	2.98	16.79	39.18	2.21	16.06
		±6.74	±0.08	±0.82	±4.21	±0.25	±1.25	±3.70	±0.07	±1.98
4	Fresh leaf	1.44	0.10	0.77	14.58	0.97	7.78	20.52	1.37	10.94
		±0.09	±0.01	±0.01	±1.43	±0.07	±0.15	±2.97	±0.04	±0.72
	Partly decayed	42.5	2.04	6.80	39.00	1.87	6.24	20.50	0.98	3.28
	litter	±6.85	±0.06	±0.75	±3.35	±0.02	±0.12	±3.45	±0.07	±0.12
	Wood litter	5.70	0.23	3.34	5.55	0.22	3.26	5.70	0.23	3.34
		±0.41	±0.01	±0.07	±0.18	±0.01	±0.12	±1.07	±0.02	±0.71
	Total	49.64	2.37	10.91	59.13	3.06	17.28	46.72	2.58	17.56
		±6.12	±0.12	±0.97	±8.92	±0.92	±1.17	±5.24	±0.09	±1.54
5	Fresh leaf	1.98	0.13	1.06	16.38	1.09	8.74	21.06	1.40	11.23
		±0.04	±0.02	±0.07	±1.45	±0.09	±0.98	±2.21	±0.02	±1.42
	Partly decayed	47.02.26	7.52	43.50	2.09	6.96	27.50	1.32	4.40	
	litter	±6.23	±0.07	±0.89	±4.87	±0.91	±0.29	±3.54	±0.04	±0.09
	Wood litter	5.93	0.24	3.48	5.63	0.23	3.30	5.85	0.23	3.43
		±0.71	±0.03	±0.75	±0.72	±0.02	±0.08	±0.53	±0.03	±0.09
	Total	54.91	2.63	12.06	65.51	3.41	19.00	54.41	2.95	19.06
		±8.42	±0.09	±1.29	±8.70	±0.09	±1.09	±5.31	±0.07	±1.72

Of the annual nutrient uptake (net) by *B. bambos* plantation, 14.2-16.3 per cent for N, 12.5-14.3 per cent for P and 10.6-12.2 per cent for K are returned to the soil through litterfall.

Partly decayed litter on plantation floor showed 2.8 times more N and 2 times more P concentration compared with the fresh leaf litter, while K concentration of fresh leaf of litter layer was 1.2 times more than that of partly decayed litter. This shows a strong immobilization of N and P by partly decayed leaf litter. This is supported by a study by Tripathi and Singh (1992) in dry tropical bamboo savanna. Wood litter was

Table 7. Turnover rate (k, year^{-1}) and turnover time (t, year) of nutrients on the floor of *B. bambos* plantation

Nutrient	Age of the plantation (years)		
	3	4	5
Nitrogen			
k	0.76	0.71	0.69
t	1.32	1.41	1.45
Phosphorus			
k	0.79	0.74	0.72
t	1.27	1.35	1.39
Potassium			
k	0.93	0.91	0.90
t	1.08	1.10	1.11

poorest with respect to N and P. The floor nutrient mass of different aged bamboo plantation is shown in Table 6. The turnover rate of nutrients on the plantation floor decreased, while turnover time increased with the age of the plantation (Table 7).

Nutrient cycling

Compartmental models of nutrient cycling in *B. bambos* plantation are presented in Figures 1 and 2. Net annual fluxes between compartments are given on arrows (kg ha^{-1} year^{-1}). Compartments show average nutrient pools (kg ha^{-1}). The soil to a depth of 60 cm is considered as a reservoir for the nutrients. Contents of N, P and K shown in the soil pools are available fractions and slightly increased with the age of plantation. The direction of nutrient flux from soil to foliage indicates a one-way movement, although it is realized that as the nutrients are utilized by the foliage in organic matter synthesis, they are redistributed among different components at varying rates, giving rise to internal cycling. Nutrients transferred through litterfall to the soil, therefore, were less than foliage content. The total amount of nutrient retranslocation from the senescing leaves of the bamboo increased with the plantation age from 6.6 N, 0.5 P and 4.4 K kg ha^{-1}year^{-1} in 4-year-old to 8.7 N, 0.7 P and 5.9 K kg ha^{-1}year^{-1} in 5-year-old plantation. The recycling supports a portion of the production of new foliage, diminishing the demand from soil (Rawat and Singh, 1988). Thus, the actual amount of uptake from the soil pool for foliage of 4-year-old plantation was reduced to 5.5 N, 0.3 P and 3.7 K kg ha^{-1}year^{-1}. Similarly, foliage of the 5-year-old plantation actually received 7.4 N, 0.4 P and 4.9 K kg ha^{-1}year^{-1} from the soil pool.

The soil compartment received nutrients consequent to release by decomposition of litter and roots. This release from litter amounted to 69-91 per cent of the nutrients contained in annual litter. On the basis of a turnover time of less than one year, the fine roots returned about 39 per cent N, 29 per cent P and 35 per cent K compared with the aboveground litterfall. Total release (litter + roots) accounted for 13.7-16.0 per cent N, 11.4-13.8 per cent P and 12.9-14.9 per cent K of the total net uptake of nutrients by the bamboo plantation. The nutrient budget indicated the retention of 79-82 per cent N, 83-85 per cent P and 84-86 per cent K in the standing biomass of bamboo over the annual cycle. Retention of nutrients by the bamboo plantation over the annual cycle is in conformity with the aggressing nature of the system as indicated by the net primary production of *B. bambos* (Das and Chaturvedi, 2006).

CONCLUSION

The present study provides basic information on nutrient storage, uptake and dynamics of 3- to 5-year-old plantations of *B. bambos* growing in calciorthent soils of the north-west alluvial plains of Bihar. The plantations make efficient use of N, P and K through internal cycling and conserve these nutrients in rhizomes, culm and roots to meet the nutrient demand of newly emerging bamboo shoots in summer. The retranslocation of nutrients before litterfall increases the nutrient-use efficiency of the ecosystem. In bamboo plantations, while the shoot harvest results in substantial nutrient export, the increased belowground allocation of nutrients following the harvest probably contributes to the resilience of *B. bambos*, which reaches maturity within a short period of 4-5 years.

ACKNOWLEDGEMENT

Thanks are due to the Indian Council of Agricultural Research, New Delhi for supporting this study through the AICRP on Agroforestry.

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