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Nutrient accumulation and distribution in different bamboo species under semi-arid climatic condition of Entisol

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Abstract
A long-term field experiment initiated in the year 2018-19 at National Agricultural Research Project, was selected for conduct of present investigation during the year 2020-21 in order to determine the effect of different bamboo species on nutrient accumulation and distribution in different biomass components as a result of bamboo plantation grown on Entisol under semiarid climatic condition. In the average effect of bamboo biomass components, the nitrogen concentration was found highest in bamboo leaves (1.51% N), phosphorus and potassium concentration was significantly highest in bamboo branches (0.095% P and 0.64% K respectively), while, carbon concentration was numerically highest in bamboo stem (43.53% C). The bamboo species treatment, *Bambusa nutans* recorded significantly highest nitrogen uptake (457.83 kg ha^{-1}), whereas *Bambusa tulda* recorded the highest phosphorus and potassium uptake (49.70 and 409.77 kg ha^{-1}, respectively). The maximum carbon uptake of 27.83 t C ha^{-1} was recorded in *Bambusa nutans*. All of the tested bamboo species had shown greater amounts of nutrient accumulation in above ground biomass, *i.e.* Stem > Branches > Leaves > Leaf-litter > Rhizome > Roots, due to maximum partitioning of total biomass towards above ground components. The results indicate that the relative proportions of nutrients accumulated in different biomass components in tested bamboo species vary greatly due to variations in elemental concentrations and biomass output after 2nd year of bamboo plantation under semi-arid climatic conditions of Entisol.

Keywords: Bamboo, *Bambusa balcooa*, *bamboos*, *nutans*, *tulda*, Branches, Carbon, *Dendrocalamus asper*, *brandisii*, *strictus*, Entisol, Nutrient concentration, Nutrient uptake, Leaves, Leaf-litter, Phosphorous, Potassium, Rhizome, Roots, Stem, Semi-arid

1. Introduction
Bamboos are tall giant grasses that belong to the Bambusoideae sub-family of the Poaceae family. About 80% of the bamboo growing area are confined to South and South-East Asia (Newman *et al.*, 2007) [10]. India has the world's richest bamboo reserves, harbouring over 20 genera and 113 species occurring over an area of 15.69 million ha, which is about 12.8% of the total forest area of the country with approximately total standing biomass stock of 189 million tonnes (ISFR, 2017) [3]. Bamboo plant displays several components, including culms, branches, leaves, rhizomes, roots, nodes and buds. The belowground portion of the bamboo is known as rhizome. Bamboo bears two types of underground rhizomes (Liese, 2009) [7], the 'leptomorph type,' which grows laterally below the soil surface, extending the domain of the plant by enlarging and consolidated its area, and the 'pachymorph type,' which grows vertically, producing an interconnected rhizome system. Besides, the rhizome serves as storehouse of food and nutrients for the development of bamboos and facilitates rapid growth. Nodes and internodes, which vary in length from species to species and occur between two nodes, are found on the rhizome. The nodes of bamboo rhizome produce extensive root systems with numerous tiny lateral roots that grow horizontally. Profuse root growth helps bamboo to exploit water and nutrients from larger soil volume. Stems of bamboo termed as "culm" are the most prominent, easily recognizable and commonly used component of the plant that develops from the rhizome. Each culm have distinct and substantial nodes, that bears branch bud (primordium) which may later develop into branches and branchlets which bears leaves, flower, fruits and seeds. Buds emerge from the alternate sides of the axes on culm and rhizome of the bamboo. In the internodal section, culm buds are located marginally above the nodes and rhizome buds are seen adjacent to the nodes.

The majority of bamboo species annually produces profuse biomass that falls on surface soil, forming a dense carpet of nutrient-rich organic matter. Bamboo in addition to being a traditional source of energy, can provide a variety of ecosystem services, such as carbon sequestration (Nath *et al.*, 2015) [8]. Bamboo plants, in fact, have a dense root system that is efficient at absorbing plant available-nutrients, which explains the rapid response of bamboo to fertilization (Gao *et al.*, 2016) [2]. The uptake of nutrients and their utilization play important role in sustainability of the bamboo plantation. Due to the substantial nutrient removal in harvested biomass, site quality and production sustainability in short rotation bamboo plantations are constantly a matter of concern (Kumar *et al.*, 2005) [6]. Knowledge of the nutrient status of bamboo plantation can help in the determination of nutrient removal through harvest as well as becomes important in formulation of an appropriate nutrient management strategic approach (Upadhyaya *et al.*, 2008) [19]. However, there is a scarcity of information on the variation in nutrient stocking, distribution and utilization in different bamboo species. The objective of present study was to examine the variation in nutrients concentration and nutrient uptake in bamboo biomass components of different nutrient element in different bamboo species grown on Entisol under semi-arid climatic conditions after 2nd year of bamboo plantation.

2. Material and Methods

2.1 Description of experimental field

A long term field experiment entitled, "Performance of different bamboo species on growth and yield of bamboo" was initiated in the year 2018-19 at National Agricultural Research Project, Dryland Sub-Centre (Agroforestry), M. P. K. V., Rahuri, Dist. Ahmednagar (M.S.). The same long-term field experiment was selected for conduct of present investigation during the year 2020-21 in order to determine the effect of different bamboo species on nutrient accumulation and distribution in different biomass components as a result of bamboo plantation grown on Entisol under semiarid climatic condition after 2nd year of bamboo plantation. The geographical location of experimental field is N 19º 31′ 996″ to N 19º 32′ 073″ latitude and E 74º 63′ 920″ to E 74º 64′ 042″ longitude, at the altitude of 608.4 to 616.1 meter above mean sea level. During crop growth period of different bamboo species for the year 2020-21, it was observed that the average max and min temperature ranged between 27.0 to 38.5℃ and 13.0 to 25.7℃, respectively. The total rainfall received was 1345.8 mm in 66 rainy days (15 months). The average morning and evening relative humidity ranged between 61.1 to 91.1% and 19.3 to 66.5%, respectively. The average wind speed ranged between 0.7 - 4.3 km hr^{-1}. The average bright sunshine hours and open pan evaporation ranged between 3.2 to 10.1 hrs. and 3.0 to 13.4 mm, respectively.

2.2 Experimental setup

The field experiment was laid out in Randomized Block Design comprising 3 replications and 7 treatments of different bamboo species *viz.*, T_1: *Dendrocalamus brandisii*, T_2: *Bambusa nutans*, T_3: *Bambusa balcooa*, T_4: *Dendrocalamus strictus*, T_5: *Bambusa tulda*, T_6: *Bambusa bamboos*, T_7: *Dendrocalamus asper*. The gross plot size for the field experiment was 20 m × 15 m, and the net plot size was 12 m x 09 m. The optimum spacing adopted was 4 m x 3 m so as to accommodate 833 clumps per ha. The recommended dose of chemical fertilizers, 160:40:200 kg N, P_2O_5 and K_2O ha^{-1} $year^{-1}$ was applied as split dose through commercial grade Urea, SSP and MOP, respectively.

2.3 Soil Characteristics

The soil of experimental field is grouped under Entisol order and belongs to the Rahuri soil series. The experimental soil had a sandy clay texture, was slightly alkaline in reaction (pH 8.01), had low electrical conductivity (0.21 dSm^{-1}) and calcium carbonate (3.37%), was medium in organic carbon (0.67%), low in available nitrogen (178.70 kg ha^{-1}), very low in available phosphorus (6.10 kg ha^{-1}) and very high in available potassium (403.20 kg ha^{-1}) content. The average depth of experimental soil is upto 45 cm. Experimental soil had a bulk density of 1.51 Mg m^{-3}.

2.4 Collection and analysis of plant samples

Bamboo plant samples, aboveground (stem, branches and leaves), belowground (rhizome and roots) and leaf-litter were collected, from the experimental site after the end of active growing season in the month of January, 2021 from randomly selected and identified clumps of different bamboo species. The uprooted rhizome and rootlets was washed with tap water and removed all adhered soil particles. Thereafter samples were collected and transported to laboratory, air-dried under shade and subsequently oven-dried at 65℃ and grinded through a stainless steel Willey mill to maximum fineness. The processed bamboo plant samples were used for plant analysis. Digestion of plant sample was done and used for estimation of nutrient concentration *viz.* N, P, K and C by using standard methods. Total N: Micro-Kjeldahl (Parkinson and Allen, 1975) [11], Total P: Vanadomolybdate yellow colour method in nitric acid (Jackson, 1973) [4], Total K: Flame photometry (Chapman and Pratt, 1961) [1] and Total C: Dry Combustion method (Nelson and Sommers, 1982) [9].

2.5 Computation of nutrient uptake

The uptake of nutrient were worked out by multiplying total biomass production (Table 4) to respective concentration of N, P, K and C (Table 1 and Fig. 1) at harvest by using the following formulas.

$$\text{Macronutrient uptake (kg N, P, K ha}^{-1}) = \frac{\text{Total biomass (kg ha}^{-1}) \text{ x Nutrient concentration (\%)}}{100}$$

$$\text{Carbon uptake (t C ha}^{-1}) = \frac{\text{Total biomass (t ha}^{-1}) \text{ x Carbon concentration (\%)}}{100}$$

2.6 Biometric observation
Five representative clumps of each bamboo species were randomly selected and identified with the help of colour paint marking as suggested by Shanmughavel and Francis (2003) [14]. The biometric observations were recorded on marked clumps. Total biomass production in different bamboo species was calculated and is presented in Table 4.

3. Results and Discussion

3.1 Nutrient concentration in bamboo biomass components

The nutrient concentration in bamboo biomass components was significantly influenced by different bamboo species under semiarid climatic condition after 2nd year of plantation grown on Entisol. Considering the mean of all tested bamboo species (Table 1), concentration of N was found in the order of leaves > leaf-litter > rhizome > branches ~ roots > stem, whereas, P concentration was found in the order of branches > rhizome > leaves ~ leaf-litter > roots > stem, while K concentration was found in the order of branches > leaves > stem > leaf-litter > rhizome > roots. But, the concentration of C (Fig. 1) was in the order of Stem > Branches > Rhizome > Roots > Leaves > Leaf litter biomass component after 2nd year of bamboo plantation. The variation in nutrient content in biomass components reflects the diversity of adaptation mechanisms used by different bamboo species in low soil nutrient environment.

3.1.1 Nitrogen concentration

The bamboo species treatment, *Dendrocalamus asper* recorded highest N concentration (Table 1) in bamboo leaves and leaf-litter biomass (1.75 and 0.84% N respectively) over rest of the bamboo species except *Dendrocalamus brandisii* which was at par for the leaves N concentration (1.68 N%). The N content was found in substantially higher amount in leaves than in other organs. Werger *et al.* (2000) [20] and Kim *et al.* (2018) [5] also reported higher N content in bamboo leaves. Higher nutrient allocations in the leaves have been associated to its increased photosynthetic activity (Singh and Arvind, 2012) [15]. The treatment of *Bambusa tulda* recorded highest N concentration in bamboo branches and roots (0.70% N each) over other bamboo species. The treatment of *Dendrocalamus brandisii* recorded highest N concentration in bamboo stem and rhizome (0.70% N each) as compared to other tested bamboo species except *Bambusa balcooa* which recorded same N concentration in bamboo rhizome (0.70% N).

3.1.2 Phosphorus concentration

The T_3 *i.e. Bambusa balcooa* recorded significantly highest P concentration (Table 1) in bamboo stem, branches, leaves, rhizome and roots (0.071, 0.099, 0.078, 0.079 and 0.085% P respectively) which was statistically at par with *Bambusa tulda* for stem, branches, leaves and rhizome's P concentration (0.072, 0.094, 0.074 and 0.076% P respectively), with *Dendrocalamus strictus* for branches, leaves and rhizome P concentration (0.096, 0.076 and 0.078% P respectively), with *Dendrocalamus brandisii* for bamboo stem and branches (0.068 and 0.098% P respectively) and with *Dendrocalamus asper* for bamboo branches and leaves (0.094 and 0.075% P respectively). The treatment of *Dendrocalamus asper* recorded significantly highest P concentration in bamboo leaf-litter biomass (0.079% P) which was at par with *Dendrocalamus strictus* and *Bambusa bamboos* (0.078 and 0.076% P respectively) after 2nd year of plantation. The results are in line with the findings of Shanmughavel and Francis (2003) [14].

3.1.3 Potassium concentration

The treatment of *Dendrocalamus asper* recorded significantly highest K concentration (Table 1) in bamboo leaves, rhizome, roots and leaf litter biomass (0.68, 0.38, 0.28 and 0.42% K respectively) which was at par with *Bambusa balcooa* for leaves K concentration (0.62% K), with *B. nutans* and *D. strictus* for rhizome's K concentration (0.34% K each), with *B. nutans*, *B. balcooa*, *D. strictus* and *B. bamboos* for roots K concentration (0.24, 0.26, 0.22 and 0.26% K respectively) and with *D. brandisii* and *D. strictus* for leaf litter biomass K concentration (0.42% K each). The treatment of *Dendrocalamus brandisii* recorded significantly highest K concentration in bamboo branches (0.74% K) which was at par with *B. nutans* (0.72% K). The treatment of *Bambusa tulda* recorded significantly highest K concentration in bamboo stem (0.65% K) which was at par with *Dendrocalamus brandisii* (0.62% K). The results are in corroborative with the findings of Seethalakshmi *et al.* (2021) [12].

3.1.4 Carbon concentration

All the tested bamboo species treatments were statistically at par with each other for carbon concentration (Fig. 1) in bamboo stem, branches, leaves, rhizome, roots and leaf litter. However the treatment of *Bambusa nutans* recorded numerically highest C concentration in bamboo stem, leaves and roots (44.70, 34.70 and 36.90% C respectively), whereas, *D. strictus*, *B. bamboos* and *D. asper* recorded numerically highest C concentration in bamboo leaf litter biomass, branches and rhizome (27.10, 44.30 and 41.30% C respectively) after 2nd year of bamboo plantation under semiarid climatic condition of Entisol. Similar findings were also reported by Tariyal *et al.* (2013) [18] and Angom *et al.* (2018).

3.2 Nutrient uptake in bamboo biomass components

The nutrient uptake in bamboo biomass components was significantly influenced by different bamboo species (Table 2-3) after 2nd year of bamboo plantation. The highest N uptake was recorded in *Bambusa nutans* (457.83 kg ha^{-1}), while *Bambusa tulda* recorded highest P and K uptake (49.70 and 409.77 kg ha^{-1} respectively), this can be attributed to their fast growth and high biomass production capacity on Entisol under semi-arid climatic condition (Table 4). Whereas, lowest N, P and K uptake was recorded in *Bambusa bamboos* (124.96, 14.64 and 100.15 kg ha^{-1} respectively). Variations in the pattern of nutrient uptake in different biomass components as observed in different bamboo species were also reported by Singh and Kochhar (2005) [16].

3.2.1 Nitrogen uptake

The total nitrogen uptake of tested bamboo species varies from 124.96 to 457.83 kg ha^{-1} (Table 2). The total nitrogen uptake of bamboo stem and leaves was significantly highest in *Bambusa nutans* (250.74 and 68.29 kg ha^{-1} respectively), whereas the total N uptake of bamboo branches, rhizome and roots were recorded highest in *Bambusa tulda* (90.40, 19.92 and 14.18 kg ha^{-1} respectively). The total nitrogen uptake of leaf litter biomass was found significantly highest in *Bambusa tulda* (29.93 kg ha^{-1}). Considering the average value of

nutrient uptake of the all tested bamboo species, bamboo stem, branches, leaves, rhizomes, roots and leaf-litter biomass contributed 54.61, 18.91, 14.92, 3.85, 2.41 and 5.29% respectively towards total N uptake after 2nd year of bamboo plantation.

3.2.2 Phosphorus uptake

The total phosphorus uptake of tested bamboo species ranged from 14.64 to 49.70 kg ha^{-1} (Table 2). The total phosphorus uptake of bamboo branches and leaves was significantly highest in *Bambusa nutans* (12.92 and 3.15 kg ha^{-1} respectively), whereas the total P uptake of bamboo stem, rhizome, roots and leaf litter were highest in *Bambusa tulda* (28.04, 2.40, 1.46 and 2.64 kg ha^{-1} respectively). Considering the average value of phosphorus uptake of the all tested bamboo species, bamboo stem, branches, leaves, rhizomes, roots and leaf-litter biomass contributed 55.78, 26.52, 6.43, 3.93, 2.58 and 4.71% respectively towards total P uptake after 2nd year of bamboo plantation grown on Entisol under semi-arid climatic condition. The results are in corroborative with the findings of Shanmughavel and Francis (2003) [14].

3.2.3 Potassium uptake

The total potassium uptake of tested bamboo species varies from 100.15 to 409.77 kg ha^{-1} (Table 2). The total potassium uptake of bamboo stem, branches, rhizome, roots and leaf litter was significantly highest in *Bambusa nutans* (253.17, 105.90, 12.33, 5.67 and 13.99 kg ha^{-1} respectively), whereas, the total K uptake of bamboo leaves were highest in *Bambusa nutans* (25.72 kg ha^{-1}). Considering the average value of potassium uptake of the all tested bamboo species, bamboo stem, branches, leaves, rhizomes, roots and leaf-litter biomass contributed 61.82, 24.41, 6.84, 2.37, 1.22 and 3.36% respectively towards total K uptake of after 2nd year of bamboo plantation grown on Entisol under semi-arid climatic condition. Singh and Rai (2013) [17] also reported higher potassium uptake by different bamboo species.

3.2.4 Carbon uptake

The total carbon uptake of tested bamboo species varies from 8.57 to 27.83 t C ha^{-1} (Table 3). The highest carbon uptake in above ground components was found in *Bambusa nutans* (17.79, 5.95 and 1.54 t C ha^{-1} in stem, branches and leaves respectively). Whereas, carbon uptake in below ground components was found highest in *Bambusa tulda* (1.26 and 0.68 t C ha^{-1} in rhizome and roots respectively). Shanmughavel and Francis (2001) [13] also reported higher amounts of nutrient stocking in the above ground components of different bamboo species. Among the tested bamboo species, on an area basis *Bambusa nutans* recorded highest carbon uptake (27.83 t C ha^{-1}), closely followed by *Bambusa tulda* (26.68 t C ha^{-1}). Whereas, on culm basis *Bambusa bamboos* recorded significantly highest carbon uptake (982.36 g C culm^{-1}), which was followed by *Dendrocalamus strictus* and *Bambusa balcooa* (938.03 and 801.38 g C culm^{-1} respectively) (Table 3). The contribution of bamboo stem, branches, leaves, leaf-litter, rhizome and root component towards total carbon uptake was 64.73, 21.21, 5.23, 2.73, 3.84 and 2.27% respectively, after 2nd year of bamboo plantation grown on Entisol under semi-arid climatic condition.

Table 1: Nutrient concentration (NPK) in bamboo biomass components

Treatment	Nutrient concentration in bamboo biomass components (%)																	
	Above ground components									Below ground components						Leaf-litter biomass		
	Stem			Branches			Leaves			Rhizome			Roots					
	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
T1- *D. brandisii*	0.70	0.068	0.62	0.63	0.098	0.74	1.68	0.070	0.42	0.70	0.071	0.26	0.56	0.068	0.20	0.70	0.073	0.42
T2- *B. nutans*	0.63	0.065	0.56	0.63	0.091	0.72	1.54	0.071	0.58	0.63	0.072	0.34	0.56	0.067	0.24	0.70	0.072	0.34
T3- *B. balcooa*	0.56	0.071	0.54	0.56	0.099	0.66	1.33	0.078	0.62	0.70	0.079	0.28	0.63	0.085	0.26	0.70	0.071	0.36
T4- *D. strictus*	0.49	0.062	0.48	0.56	0.096	0.56	1.40	0.076	0.58	0.63	0.078	0.34	0.56	0.074	0.22	0.63	0.078	0.42
T5- *B. tulda*	0.56	0.072	0.65	0.70	0.094	0.62	1.40	0.074	0.46	0.63	0.076	0.32	0.70	0.072	0.28	0.77	0.068	0.36
T6- *B. bamboos*	0.56	0.067	0.50	0.56	0.092	0.52	1.47	0.071	0.64	0.56	0.075	0.28	0.63	0.079	0.26	0.77	0.076	0.36
T7- *D. asper*	0.56	0.062	0.46	0.56	0.094	0.49	1.75	0.075	0.68	0.63	0.071	0.38	0.56	0.065	0.28	0.84	0.079	0.42
Mean	0.58	0.067	0.54	0.60	0.095	0.64	1.51	0.074	0.57	0.64	0.075	0.32	0.60	0.073	0.25	0.73	0.074	0.38
S.Em +	0.01	0.001	0.01	0.01	0.002	0.01	0.02	0.001	0.02	0.01	0.002	0.01	0.01	0.001	0.02	0.01	0.001	0.01
CD at 5%	0.02	0.004	0.05	0.03	0.006	0.03	0.07	0.004	0.07	0.03	0.006	0.03	0.03	0.004	0.07	0.03	0.004	0.05

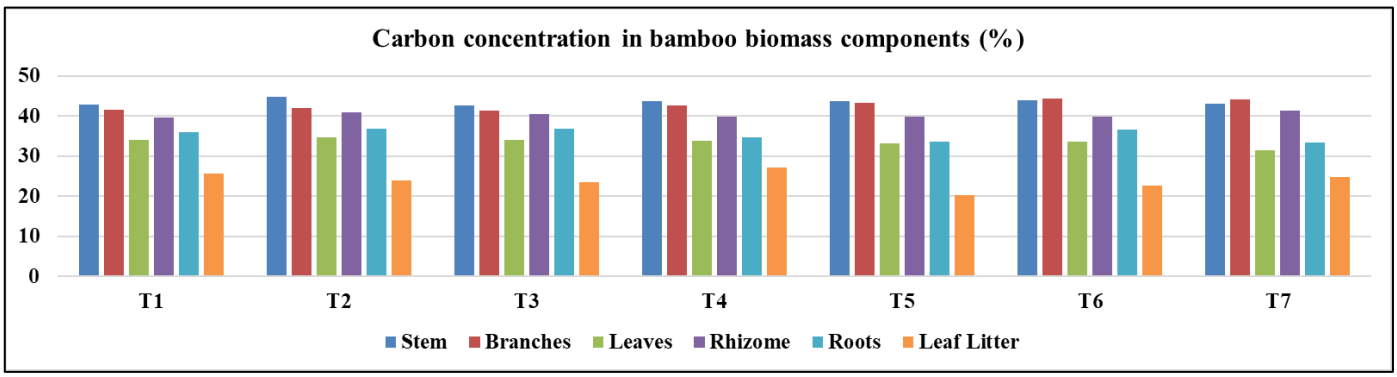

Fig 1: Carbon concentration in bamboo biomass components

Table 2: Nutrient uptake (NPK) in bamboo biomass components

Tr. No	Treatment	Nutrient uptake in bamboo biomass components (kg ha^{-1})																	Total nutrient uptake (kg ha^{-1})		
		Above ground components									Below ground components						Leaf-litter biomass					
		Stem			Branches			Leaves			Rhizome			Roots								
		N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
T_1	*D. brandisii*	155.5	15.1	137.7	59.4	9.24	69.8	54.9	2.29	13.7	14.1	1.4	5.2	7.6	0.9	2.7	16.7	1.7	10.0	**308.3**	**30.7**	**239.3**
T_2	*B. nutans*	250.7	25.8	222.8	89.4	12.9	102.2	68.2	3.15	25.7	16.8	1.9	9.1	11	1.3	4.7	21.3	2.2	10.3	**457.8**	**47.3**	**375.0**
T_3	*B. balcooa*	78.76	9.99	75.9	26.0	4.60	30.6	18.8	1.11	8.80	5.68	0.64	2.2	3.0	0.4	1.2	7.20	0.7	3.70	139.5	17.4	122.6
T_4	*D. strictus*	90.51	11.4	88.6	32.2	5.53	32.2	21.9	1.19	9.08	5.52	0.68	2.9	3.4	0.4	1.3	6.89	0.8	4.59	160.5	20.1	138.9
T_5	*B. tulda*	218.1	28.0	253.1	90.5	12.1	105.9	56.9	3.01	18.7	19.9	2.4	12	14	1.4	5.6	29.9	2.6	13.9	429.4	49.7	409.7
T_6	*B. bamboos*	77.57	9.28	69.2	20.1	3.31	18.7	16.2	0.78	7.06	3.18	0.43	1.5	2.3	0.3	0.9	5.50	0.5	2.57	124.9	14.6	100.1
T_7	*D. asper*	92.95	10.2	76.3	31.9	5.35	27.9	33.0	1.42	12.8	7.23	0.81	4.3	4.5	0.5	2.3	11.0	1.0	5.50	180.7	19.4	129.2
	Mean	137.4	15.7	132.0	49.9	7.59	55.3	38.6	1.85	13.7	10.3	1.1	5.4	6.6	0.7	2.7	14.0	1.3	7.25			
	S.Em +	1.91	1.20	3.02	0.79	1.23	3.08	0.20	0.12	1.85	0.21	0.11	0.5	0.3	0.1	0.1	1.23	0.1	0.21			
	CD at 5%	5.95	3.76	9.41	2.47	3.84	9.61	0.64	0.37	5.76	0.68	0.34	1.6	0.9	0.4	0.3	3.84	0.3	0.68			

Table 3: Carbon uptake in bamboo biomass components

Tr. No.	Treatment	Carbon uptake in bamboo biomass components (t C ha^{-1})						Total carbon uptake (t C ha^{-1})	Total carbon uptake (kg C ha^{-1})	Total C uptake (g C culm^{-1})
		Above ground components			Below ground components		Leaf litter biomass			
		Stem	Branches	Leaf	Rhizome	Root				
T_1	*D. brandisii*	9.53	3.91	1.11	0.80	0.49	0.61	16.46	16460	545.76
T_2	*B. nutans*	17.79	5.95	1.54	1.10	0.73	0.73	27.83	27830	447.97
T_3	*B. balcooa*	6.01	1.92	0.48	0.33	0.18	0.24	9.16	9160	801.38
T_4	*D. strictus*	8.07	2.45	0.53	0.35	0.21	0.30	11.90	11900	938.03
T_5	*B. tulda*	17.02	5.59	1.35	1.26	0.68	0.79	26.68	26680	540.08
T_6	*B. bamboos*	6.08	1.60	0.37	0.23	0.14	0.16	8.57	8570	982.36
T_7	*D. asper*	7.15	2.51	0.60	0.47	0.27	0.32	11.33	11330	690.77
	Mean	10.24	3.42	0.85	0.65	0.38	0.45			
	S.Em +	0.61	0.22	0.08	0.06	0.03	0.04			
	CD at 5%	1.92	0.68	0.25	0.19	0.10	0.14			

Table 4: Biomass production in different bamboo species

Tr. No.	Treatment	Biomass production (t ha^{-1})						Total biomass (t ha^{-1})	Total biomass (kg ha^{-1})	Total biomass (kg culm^{-1})
		Above ground Components			Below ground components		Leaf litter biomass			
		Stem	Branches	Leaves	Rhizome	Roots				
T_1	*D. brandisii*	22.22	9.43	3 27	2.02	1.36	2.39	40.69	40690	1.34
T_2	*B. nutans*	39.80	14.20	4.43	2.68	1.97	3.06	66.15	66150	1.77
T_3	*B. balcooa*	14.06	4.65	1.42	0.81	0.48	1.03	22.45	22450	1.96
T_4	*D. strictus*	18.47	5.76	1.57	0.88	0.61	1.09	28.38	28380	2.23
T_5	*B. tulda*	38.95	12.91	4.07	3.16	2.03	3.89	65.01	65010	1.31
T_6	*B. bamboos*	13.84	3.60	1.10	0.57	0.38	0.71	20.21	20210	2.31
T_7	*D. asper*	16.60	5.70	1.89	1.15	0.82	1.31	27.56	27560	1.67
	Mean	23.42	8.04	2.54	1.61	1.09	1.93			
	S.Em +	0.74	0.25	0.18	0.10	0.10	0.12			
	CD at 5%	2.32	0.80	0.57	0.34	0.32	0.38			

4. Conclusion

The N, P and K concentration in bamboo stem, branches, leaves, rhizome, roots and leaf-litter biomass was ranged between 0.49-0.70, 0.56-0.70, 1.33-1.54, 0.56-0.70, 0.56-0.70 and 0.63-0.84% N respectively, 0.062-0.071, 0.092-0.099, 0.070-0.078, 0.071-0.079, 0.065-0.085 and 0.068-0.079% P respectively and 0.48-0.65, 0.49-0.74, 0.42-0.68 0.26-0.38, 0.20-0.28 and 0.34-0.42% K respectively. Whereas, carbon concentration in bamboo stem, branches, leaves, rhizome, roots and leaf litter was ranged between 42.70-44.70, 41.30-44.30, 31.50-34.70, 39.50-41.30, 33.30-36.90 and 20.30-27.10% C respectively after 2nd year of bamboo plantation. Considering the average value of nutrient uptake of the all tested bamboo species, bamboo stem, branches, leaves, rhizomes, roots and leaf-litter biomass contributed 54.61, 18.91, 14.92, 3.85, 2.41 and 5.29% respectively to total N uptake, 55.78, 26.52, 6.43, 3.93, 2.58 and 4.71% respectively to total P uptake and 61.82, 24.41, 6.84, 2.37, 1.22 and 3.36% respectively to total K uptake of bamboo. While, the contribution of stem, branches, leaves, leaf-litter, rhizome and root component in total carbon uptake was 64.73, 21.21, 5.23, 2.73, 3.84 and 2.27% respectively after 2nd year of bamboo plantation grown on Entisol under semiarid climatic condition.

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