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Leaf dynamics and above ground biomass growth in *Dendrocalamus longispathus* Kurz

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Abstract—Leaf production and culm growth as affected by different age groups of culms in a 10-year-old clump of *Dendrocalamus longispathus* Kurz were studied at Chittagong, Bangladesh. The total above ground biomass, bud break, branching pattern, leaf number and area produced by each age group of culms were investigated. The progressive increment of biomass-related morphometric parameters correlated optimally with the age of the clump. As the clumps become aged, the culms emerged in subsequent years were gradually taller with bigger diameter and more internodes. Leaf growth and defoliation are a dynamic process where leaf growth started in the first year of culm emergence but there is no defoliation. In 18–21-month-old culms the number and area of leaf, and biomass of branches, leaves and culm were highest; defoliation started at the end of the rainy season and continued in the winter dry season. In the third and fourth years leaf production and growth were getting low, but in the fifth and sixth years these sharply declined and ultimately the culm died. Thus harvesting of culm within 3 to 4 years of age could be an ideal management practice in the species.

Key words: *Dendrocalamus longispathus*; biomass growth; culm age; leaf area; leaf dynamics.

INTRODUCTION

Dendrocalamus longispathus Kurz is growing naturally in the forests of Sylhet, Chittagong, Chittagong Hill Tracts of Bangladesh; Assam, Manipur, Meghalaya, Mizoram, Tripura of north-east India; and Arakan and Tenasserim of Myanmar. The local communities have considered it as an economically important bamboo species. The local names of *D. longispathus* are Orah, Khag (Chittagong, Sylhet-Bangladesh), Rupai (Tripura-India), Khang (Barak Valley, Assam-India), Rawnal (Mizoram-India), Chingwa (Manipur), Waya, Talagu-wa (Myanmar). The species is also found in north, central and southern Thailand.

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The culms are commonly used for making baskets, furniture and food grain containers; they are also used in housing construction. The species is somewhat resistant to ghoon borers and comparatively stronger than most of the other naturally grown forest bamboo species. This bamboo is being used to make thatches, houses, household utensils, agricultural implements, etc. It provides raw material for paper pulp industries [1]. Sometimes culms are used as floats and rafts for timber transportation. Young shoots are edible. It is a handsome species and also cultivated as an ornamental. Culms are also used for famous bamboo dance in Chittagong hill-tracts. Considering the benefits tribal and Bangalee people sometimes also cultivate this bamboo on their homesteads in the hills and plain land near forest fringes, respectively.

D. longispathus has been described as a large tufted bamboo with branches mostly in the upper part of the culms [2]. Thin and small branches are produced on the young culm, comparatively stout branches on the older culms. The culms are glaucous-green when young, greyish green when old, and 10–18 m tall with 4–10 cm in diameter and wall thickness from tip to base is 0.2–1.8 cm [3, 4]. The internodes of young culms are covered with long persistent fragile papery sheaths. Internode length varies from 25 to 65 cm with slightly swollen nodes; the middle internodes are distinctly longer than the upper and lower ones. The nodes usually have two close ridges of root rings, mostly on lower half of a culm, root thick fleshy, 2–5 mm long on the nodes of young culms. Culm sheaths are usually long or even longer than internodes with dark-brown pubescence. Some clumps may have culm-sheaths shorter than the length of internodes. The clumps of this species grow luxuriantly in the moist fertile loamy soil mostly along the bank of the hilly streams and partially shaded fringes of the forest covers [4]. Healthy plants are rarely seen on hilltops, drier slopes and under the close canopy cover. Out of total natural bamboo forests of Bangladesh the species cover about 4–15% of the area due to its restricted occurrence in the less to undisturbed specific habitat. It is believed that the natural existence of healthy clump indicates moist condition of a forest habitat with high organic matter. In the moist hilly ranges of Tripura this bamboo species is occurring, from 15–25% of total bamboo forest, second position after *Melocanna baccifera*. Due to over-exploitation and biotic interference, availability of *D. longispathus* is decreasing. Therefore, the vegetation of this species needs proper attention and management. Very little is known about the culm and clump growth behaviour of this bamboo. The knowledge on biomass growth as affected by leaf production in culms of different ages is important to understand the development and performance of *D. longispathus* clumps in the field. This result of the study would also help in formulating the management practice of *D. longispathus* forests.

MATERIALS AND METHODS

The study was conducted during the months of December 1989 and January 1990 on a full-grown 10 years and 6 months old seed origin clump of *D. longispathus* Kurz

grown at bambusetum, Bangladesh Forest Research Institute (BFRI), Chittagong. Ten clumps of this bamboo species were raised at BFRI bambusetum (Line Number 15) by planting seedlings in 1979 germinated from seeds produced in a mother clump flowered during 1978–1979 at the same bambusetum. The land of the bambusetum is with coarse, loamy acidic (pH around 5.5) soil under the influence of tropical monsoon climate, having a range of annual air temperature of 10–35°C and total annual rainfall of 2500–3000 mm.

Culms produced in the clumps were marked every year by different colour paints on the internodes to recognise the year of emergence. The number of culms in each age group could be identified and counted as every year newly emerged culms in the clumps were marked with a different specific colour of permanent paints. The colour and bands used to mark the culms in the corresponding year of emergence can be seen in Table 1.

Accordingly the planted clumps were more than 10 years of age during the study period (in December 1989 and January 1990). The culms emerged in the first, second and third year after plantation were not available in the clump during the study period (the clump was 10 years old) as they were dead, rotten and decayed. Only culms of seven age groups were available in the clumps. These culms were designated as Gr-1 to Gr-7 on the basis of age and year of emergence (Table 1).

The culms of each age group were collected by cutting with a saw at the basal node near the ground from a randomly selected clump and immediately the following measurements were recorded. Ten fresh leaves were randomly collected from each of large, medium and small size groups of leaves produced in the same culm. The area of a leaf was measured by tracing the leaf margin on millimetre graph paper. Then the mean value of leaf area was calculated. The total amount of leaf area in a

Table 1.
Designated culm age groups in relation to the year of emergence in different ages of clump in *Dendrocalamus longispathus* under study

Culm age groups	Culms		Clump age (year) at the year of culm emergence
	Age (months)	Year of emergence (as marked by colours)	
Gr-1	6–9	1989 (One red band and a cross)	10
Gr-2	18–21	1988 (One yellow band and a cross)	9
Gr-3	30–33	1987 (Three yellow bands)	8
Gr-4	42–45	1986 (Three black bands)	7
Gr-5	54–57	1985 (Three white bands)	6
Gr-6	66–69	1984 (Three red bands)	5
Gr-7	78–81	1983 (Two black bands)	4
		1982 (Two yellow bands)	
		1981 (Two white bands)	
		1980 (Two red bands)	

culm was estimated by multiplying the mean value with the total number of leaves present in the same culm.

The fresh weight of culms, branches and leaves were separately taken. Oven-dry weight (biomass) of the leaves, branches and culm were taken separately by storing each of them in different jute bags at temperature 103 ± 2°C in an oven until the attainment of constant weight.

The culm height and diameter of each age group were also measured. The culm diameter were measured at basal, mid and tip internodes. The total numbers of internodes, number of branches and leaves in a culm of each age group were counted.

All the measurements/counting were replicated in three culms of each age group.

RESULTS AND DISCUSSION

Culm biomass growth and expression of morphometric character

The culms emerged (Gr-1) from the 10-year-old clump showed maximum growth of morphometric parameters like culm height, internode number, culm diameter and biomass like culm weight, compared to the other six age groups (Table 2). It was also noticed that the culm completed its full growth on height, diameter and internode number within about 2–3 months after its emergence in the monsoon rain (from May onwards). Although these culms (Gr-1) were heavy they showed the lowest dry/green matter content ratio as they were youngest (6–9 months old) and contained more water than those of older culm groups (Table 2). The oldest culms (78–81 months, Gr-7) remaining in the clump emerged at an early age (4 year old) of the clump. These were found to be smallest in height and diameter with minimum weight.

As the clumps become aged the culms emerged in subsequent years were gradually taller with more internodes and bigger diameter. So the culms emerged in

Table 2.
Internode numbers, height and diameter, weight and dry/green weight ratio in seven culm age groups of *D. longispathus*

Culm age groups	Internodes per culm (total)	Culm height (m)	Culm diameter (cm)			Culm weight (kg)		Dry/green weight ratio
			Base	Middle	Tip	Green	Dry	
Gr-1	44	15.93	7.83	5.15	0.33	18.53	8.56	0.46
Gr-2	37	14.13	6.82	4.61	0.69	13.45	6.90	0.51
Gr-3	41	14.15	6.30	4.58	0.81	12.20	6.32	0.51
Gr-4	34	12.10	5.06	4.05	0.75	8.40	4.27	0.50
Gr-5	30	10.33	4.71	3.67	0.62	5.76	3.29	0.57
Gr-6	27	8.89	3.65	3.19	0.89	4.13	2.40	0.58
Gr-7	29	8.43	4.30	3.09	0.42	2.65	2.06	0.77

a year always showed increase in height and diameter growth than those emerged in the last year (from culms of Gr-7 to Gr-1).

Bud break and branching

Generally an emerging culm grows rapidly by elongation of internodes and reaches full size in 2–3 months and the nodal branch buds remains completely covered with papery culm sheaths. The branch buds first start sprouting from the buds produced in the upper culm nodes and gradually moves towards the base, leaving 9–12 nodal buds that remain unsprouted. The branch on the culm node completes development usually around the middle of November. That is, the newly emerged culms do not produce branches up to 4–5 months. The delicate culm tips are frequently damaged or broken and always vulnerable to wind and wild animals (especially the squirrels).

The branches developed on the nodes of newly emerged culms (Gr-1) are usually with very few secondary and lateral branches. The branches showed highest biomass growth in the next year (Gr-2), that is, the second year of growth. The dry matter content (including dry/green ratio) in the branches was always found to be higher in older culms (Gr-2 to Gr-6). No branch was available to assess biomass in the older culms of Gr-7, where culms were dead and most of the branches dropped from the culms. The culms emerged (that is, culms of Gr-1) in the 10-year-old clumps were comparatively tall with maximum number of nodes and internodes; and consequently each of these culms produced more number of branches (Table 3).

Leaf number, area and culm biomass growth

In 18–21-month-old culms (Gr. 2) we found the highest values: the number of leaves per culm was 6975, the leaf area per culm was 39.12 m^2, the total biomass yield per culm of green and dry leaves were 2.085 kg and 1.150 kg (Table 4). The number of leaves usually increased with the increasing of secondary and lateral branches. It was found that biomass of both branches and leaves were highest in Gr-2 culms (Tables 3 and 4), as they possessed maximum amount of leaves (number and area). The leaf growth and defoliation were found to be a dynamic process

Table 3.
Branch number, weight and dry/green weight ratio per culm of seven age groups in *D. longispathus*

Culm age groups	Branch number	Branch weight (kg)		Dry/green weight ratio
		Green	Oven-dried	
Gr-1	32	2.23	1.01	0.45
Gr-2	27	3.11	1.75	0.56
Gr-3	28	2.32	1.33	0.57
Gr-4	21	2.10	1.14	0.54
Gr-5	21	1.32	0.82	0.62
Gr-6	20	0.89	0.51	0.60
Gr-7	23	—	—	—

Table 4.
Leaf number, area and weight per culm and dry/green weight ratio in *D. longispathus* as affected by age

Culm age group	Number of leaves per culm	Leaf area per culm (m^2)	Total leaf weight (kg)		Dry/green weight ratio
			Green	Dry	
Gr-1	1406	6.74	0.67	0.308	0.46
Gr-2	6975	39.12	2.085	1.150	0.55
Gr-3	4790	22.70	1.441	0.750	0.52
Gr-4	4877	17.94	1.155	0.615	0.53
Gr-5	1755	11.33	0.475	0.275	0.57
Gr-6	907	3.51	0.29	0.141	0.48
Gr-7	—	—	—	—	—

where leaf growth started on the first year of culm emergence but there was no defoliation. In the second year of growth branch and leaf on culm were the highest; defoliation started at the end of rainy season and continued in the winter to dry season. In the third and fourth years leaf production and growth were getting low but in the fifth and sixth years these sharply declined. The higher leaf defoliation was observed following the fifth year and at the end of the sixth year leaf defoliation sharply declined and ultimately the culm died.

Ueda [5] measured the fresh weight of leaves collected from 1-, 2- and 3-year-old culms of a *Melocanna baccifera* clump in Assam and observed higher production of leaf biomass (1.10 kg per culm) in 2-year-old culms compared with 1-year (0.70 kg) and 3-year-old culms (0.60 kg). Similarly, Fu [6] observed higher biomass yield of branches and leaves in 2-year-old culms produced in adult clump of *Phyllostachys pubescens* raised from seed. The highest leaf biomass and surface growth were obtained in 18–21-month-old (Gr-2) culms produced in adult 10-year-old clumps of *D. longispathus* (Table 5 and Fig. 1). The progressive increment of biomass-related morphometric parameters continued to express optimally with the age of clump.

The younger bamboo culms are more active, have vigorous rhizomes and produce more culms while culms older than 3 to 4 years seem to be physiologically weak and buds on the rhizome and culm are either dead or inactive. Banik [4] reported that in different bamboo species (*Melocanna baccifera*, *D. longispathus*, *Bambusa balcooa*, *B. tulda* and *B. vulgaris*, etc.) generally 5-year-old culm contains lower amounts of leaves, resulting in less contribution to the photosynthesis and the overall health of the clump. Consequently, culms attaining more than 3 to 4 years of age may be harvested from the clump. The details of above quantitative growth study in *D. longispathus* clumps also support the conclusion that felling of culms may be started after 3 to 4 year of age. Thus it also prescribes the selective felling of only older culms in a clump of a bamboo species. Harvesting trials on bamboo plantation of *B. bambos* indicated that selective cutting of those culms older than three years increases their production but clear felling killed the bamboo plants [7].

Table 5.
Total above ground growth of a *D. longispathus* clump in relation to culm and clump age

Culm age group (clump age)	Culm number	Leaf number	Leaf area (m^2)	Total green culm biomass (kg)
Gr-1 (10 years)	16	22 496	107.84	342.88
Gr-2 (9 years)	11	111 600	430.32	215.52
Gr-3 (8 years)	11	52 690	219.70	164.68
Gr-4 (7 years)	13	63 401	233.22	139.03
Gr-5 (6 years)	10	17 550	113.30	70.55
Gr-6 (5 years)	10	9 070	35.10	49.30
Gr-7 (4 years)	10	0*	0*	26.50
Total	81	1 281 207	1169.48	1008.66

*Leaves were not found on the 4-year-old culm when observed at 10 years of clump age.

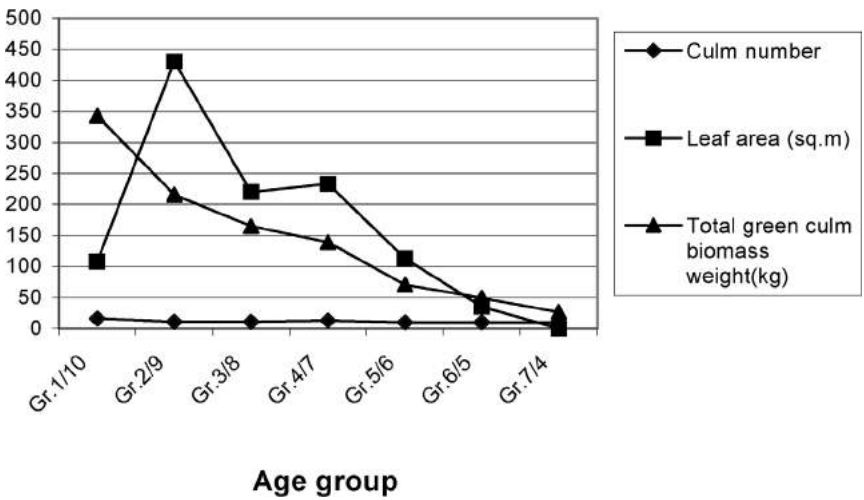

Figure 1. Above ground biomass in relation to culm number and total leaf area produced in different culm age group of a *D. longispathus* clump.

CONCLUSIONS

Optimum expression of the inherent character of *D. longispathus* is achieved in clumps about 10 years of age, but it is obvious that site and clump management plays an important role. In the third and fourth years of culm age leaf production both in number and area along with culm biomass growth are getting low and, subsequently, in the fifth and sixth years these sharply decline; therefore, more than 3–4-year-old culms are to be cut selectively. This seems to be important base information for clump management in *D. longispathus* to obtain sustainable yield.

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