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ASSESSMENT OF PRODUCTIVITY OF *DENDROCALAMUS STOCKSII* UNDER AGROFORESTRY SITUATION IN HUMID REGION OF KARNATAKA

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ABSTRACT

Bamboo-based agroforestry is recently recognized as the potential land use system to achieve ecological stability and economic efficiency for the farming community. The study was conducted in a four-year-old *Dendrocalamus stocksii* plantation at the Main Agricultural Research Station at Iruvakki, Shivamogga district during 2022-23. The study was carried out in split-plot design with three spacings *i.e.*, T_1 (8 m × 4 m), T_2 (8 m × 6 m), and T_3 (8 m × 8 m) of *Dendrocalamus stocksii* as the main plot and presence and absences of intercrops as subplots. The results of the study demonstrated the homogeneity in biomass allocation towards the components by the culms across the spacing**.** The contribution of biomass by each age class to the clump biomass revealed that 0-1-year-old culms contributed half of the total above-ground biomass followed by two-year-old and three-year-old culms and the least was contributed by four-year-old culms. The maximum value for biomass per clump was recorded in the wider spacing of 8 m×8 m (143.7 g clump^{-1}). However, when observed among the varied age classes the biomass components, stem contributed about 64 - 73 % of the total biomass followed by the branch (17 to 22 %) and the least contribution was through the leaf (10 to 14 %) in all the age groups. Interestingly, the total above-ground biomass per hectare did not show significant differences across the spacing regime. These findings contribute to our understanding of bamboo-based agroforestry systems and provide valuable insights for optimizing plantation design and management strategies to enhance both ecological and economic benefits for farmers. Further research is warranted to explore additional factors influencing biomass dynamics and productivity in *D. stocksii* plantations, ultimately facilitating the widespread adoption of sustainable land use practices in agricultural landscapes.

***Keywords* :** Bamboo based agroforestry, productivity, biomass, age classes, spacing regime

Introduction

Agroforestry systems help to conserve agrobiodiversity by lessening pressure to clear more land for agriculture, providing habitat and supplies for local plant and animal species that are partially reliant on forests, and maintaining landscape connectivity (Schroth *et al.*, 2004). One can maximize its functionality by designing bamboo into mixed-use agroforestry complexes while integrating it with other production crops. Bamboo can be suitably grown with intercrops to enhance productivity and conserve natural resources under different agroforestry systems.

Bamboo is an extraordinary and unique woody perennial grass gaining popularity among ecologists, farmers and entrepreneurs because of its productive, sustainable and versatile nature. Bamboos have many advantages over trees, such as a relatively short period from planting to harvest and versatility of use which outmatches most tree species' ability to provide building materials and edible products for many years or even decades. They are a very fast-growing perennial plant that produces culms every year and give a very high return compared to timber trees (Sandhu *et al.,* 2010; Tewari *et al.,* 2015). The quality of strength, lightweight and flexibility make bamboo a viable alternative to tropical timbers, which are also in short supply for furniture and building material industries. Furthermore, it is claimed that bamboo produces significant biomass with calorific values comparable to those of regularly used wood biomass, such as teak and acacia (Partey *et al*., 2017).

Dendrocalamus stocksii (Munro) is one such species that has been exploited as a potential species for the bamboo-based agroforestry model. *Dendrocalamus stocksii* has medium-sized, stout solid and strong culms. Though the natural distribution of this species is in humid tropics with lateritic soil type, this species has wide adaptability and comes up well in sub-humid and semi-arid conditions under black and red soils as well. This species is a preferred one among bamboo users because of its non-thorny nature, and loosely spaced culms which facilitate easy management.

This investigation's primary objectives were to determine how spacing affects biomass output and how various culm components contribute to biomass production. By planting bamboo, the farming community may be able to increase their standard of living, as there is potential for consistent revenue from well-managed plantations and seasonal output from intercrops.

Material and Methods

The experiment was conducted in the four-year-old well managed bamboo plantation under AICRP Agroforestry trial, established in 2018. Initially, the demarcation of different aged culms was carried out using standard color code (Table 1) and subsequently, the culms were harvested to record biomass parameters to understand the influence of spacing and cultivation of intercrops on bamboo. The different spacing regimes are taken as main plot treatments (T1 - 8 m × 4 m, T2 - 8 m × 6 m and T3- 8 m × 8 m) and presence and absences of intercrops as subplot treatments for recording the biomass parameters of bamboo in three replications.

Table 1: Procedure for bamboo age demarcation

Sl. No.	Culm age	Color code	Identification characters
1	0-1 year	Red	Younger culms usually have green surfaces, more intact culm sheaths near the ground, and more light-coloured bristles on the sheath ring around nodes
2	1-2 years	Yellow	Culms will have higher girth and culm sheath will be present in the upper region
3	2-3 years	Blue	Older culms will be in the centre of the clump and will have white spots on the outer wall
4	3-4 years	Green	The culms in the centre with more prominent lenticels are ready for harvesting

The color-coded age demarcation technique was carried out for culm identification. For each sub-treatment, three clumps per replication were selected for felling, hence total 54 clumps were harvested. The identified and harvested culms were used for biomass estimation. The different culm components such as pole, branches, and leaves were separated. The fresh weight of each component was measured separately. A subsample of known quantity was brought to the laboratory and oven dried at 70°C to a constant weight, and the dry weight of each component was weighed in the digital balance. The ratio of the dry and fresh weight of different components was computed and used to determine the dry weight of different components. The total above-ground biomass was determined by summing up the weight of all culm components and extrapolated to per hectare basis.

Biomass of various components of culms per clump was calculated by dividing the weight of the component in a clump by total biomass of the clump.

$$\text{Moisture \%} = \frac{\text{Fresh weight (g)} - \text{Dry weight (g)}}{\text{Fresh weight (g)}} \times 100$$

$$\text{Dry matter (kg)} = \frac{\text{Dry weight of the sample (g)}}{\text{Fresh weight of the sample (g)}} \times \text{Fresh wt. of the clump (kg)}$$

Results and Discussion

The data depicted in Table 2 revealed the proportion of different components of culms in clump at varied age classes and spacing regimes. The data revealed the homogeneity in biomass allocation towards the components by the culms across the spacing**.** However, when observed among the age classes (Fig. 1) the biomass components stem contributed about 64 - 73 % of the total biomass followed by the branch (17 to 22 %) and the least contribution was through the leaf (10 to 14 %) in all the age groups. The production of leaves reduces with age with 3–4-year culms recording the lowest proportion of leaves. It was in accordance with the observations in *Dendrocalamus longispathus* that the fresh weight of leaf biomass was at its maximum in the 2-year-old culms (per culm number of leaves 6,975, oven dry weight of leaves 1.15 kg) and then it decreased about 30 % and remains somewhat static in the third and fourth years (Banik 2000; Banik and Islam 2005). Similar results were reported by Kittur *et al.* (2015) that among the biomass components, the stem had better biomass accumulation than other components.

The contribution of biomass by each class to the clump biomass revealed that 0-1-year-old culms contributed half of the total above-ground biomass followed by two-year-old and three-year-old culms and the least was contributed by four-year-old culms (Table 3). This can be attributed to the higher number and size (culm diameter) of these age classes in the clump. The results were corroborated by Thokchom and Yadava, (2017) who opined that above-ground biomass is a function of size, age, and density of culms and reported a higher contribution of the current year and one-year-old culms for above-ground stand biomass.

The maximum value for biomass per clump was recorded in the wider spacing of 8 m×8 m (143.7 g clump^{-1}). However, the total above-ground biomass per hectare did not show significant differences across the spacing regime. The increased number of clumps per hectare under closer spacing has compensated for the reduced individual clump biomass production leading to a similar biomass production per hectare as that of wider spacing. The study indicates the selection of bamboo spacing depending on the market requirements for the smaller and larger-sized culms. The non-significant values for the above-ground biomass per hectare indicate that wider spacing with minimum economic investment can result in the same production capacity as that of closer spacing with an increased clump number. Kittur *et al.* (2015) reported that clump-wise biomass was highest in the wider spacing and closer spacing recorded maximum biomass per hectare.

The contribution of each component to the stand biomass is depicted in Table 3. The data revealed that the contribution of leaf mass for above-ground biomass ranged from 12.38 per cent to 12.75 per cent, the contribution of branch ranged from 21.20 per cent to 22.28 per cent and stem contribution ranged from 64.97 percent to 66.68 percent. Devi *et al.* (2018) reported that the contribution of culm, leaf and branch to the total above-ground biomass of *M. baccifera* was 73.03 %, leaf 15.81 % and branch 11.16 %, while for *Bambusa tulda* was 80.52 %, 10.16 % and 9.32 %, respectively.

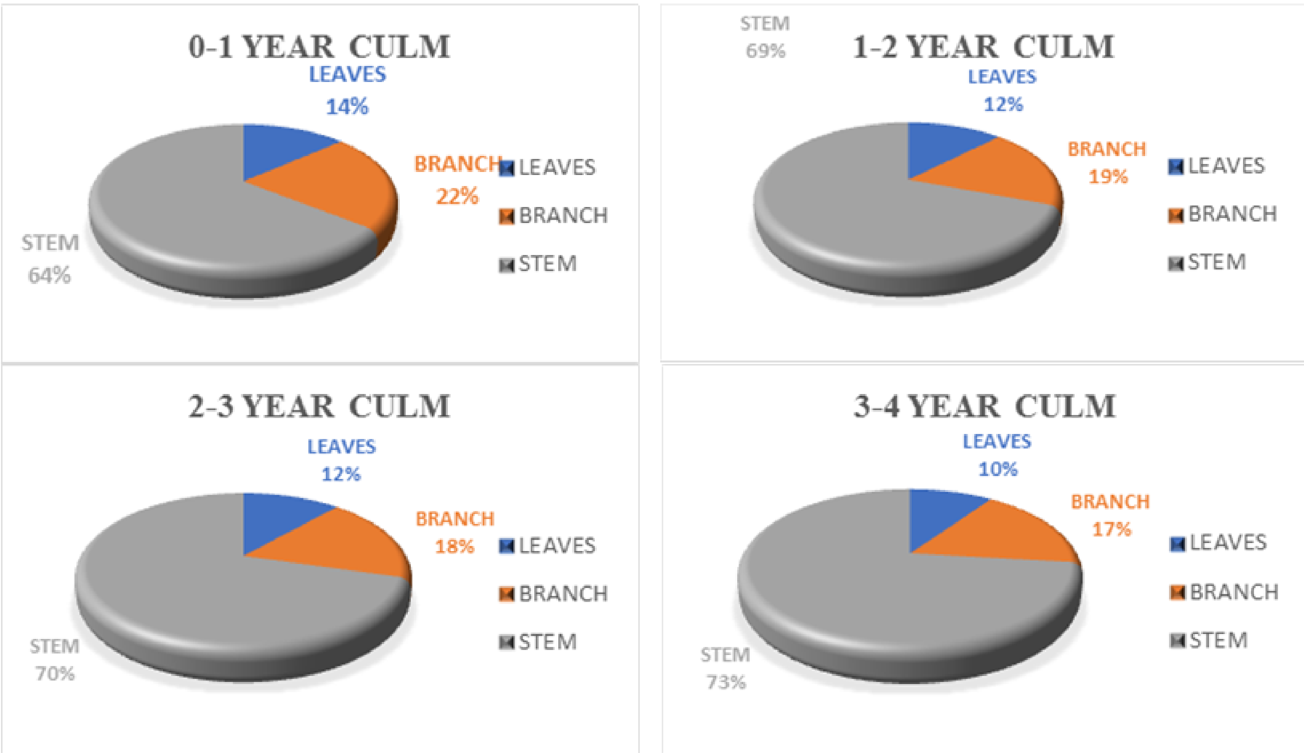

Fig. 1: Components of different age culms in each clump

Table 2 : Biomass of various components of culms under different spacing

Treatments	Total above ground biomass			Leaf		Branch		Stem	
	Culms (#)	Biomass (Kg clump^{-1})	Biomass (Kg ha^{-1})	Biomass (Kg clump^{-1})	Biomass (Kg ha^{-1})	Biomass (Kg clump^{-1})	Biomass (Kg ha^{-1})	Biomass (Kg clump^{-1})	Biomass (Kg ha^{-1})
T_1(8 m × 4 m)	33.21 (5.76) ^{a}	69.80 ^{a}	21860.80	8.65 ^{a}	2707.22	15.58 ^{a}	4633.41	45.63 ^{a}	14277.86
T_2(8 m × 6 m)	51.08 (7.15) ^{b}	117.40 ^{b}	22414.91	14.98 ^{a}	2834.33	26.16 ^{b}	4875.72	76.34 ^{b}	14947.17
T_3(8 m × 8 m)	64.21 (8.01) ^{b}	143.70 ^{b}	24426.17	18.17 ^{b}	3114.95	29.70 ^{b}	5441.64	95.83 ^{b}	15869.57
S. Em (±)	**0.25**	**8.17**	**1402.53**	**1.71**	**219.46**	**1.65**	**328.66**	**5.15**	**957.88**
CD (0.05)	**0.97**	**32.06**	**NS**	**6.73**	**NS**	**6.46**	**NS**	**20.24**	**NS**
With intercrop (S1)	46.79 (6.84)	109.70	22220.90	13.76	2865.92	23.11	4765.20	71.81	14589.78
Without intercrop (S2)	50.54 (7.11)	111.00	23580.35	14.10	2905.08	24.51	5201.99	73.42	15473.28
S. Em (±)	**0.09**	**2.86**	**1196.84**	**0.70**	**180.29**	**1.05**	**278.05**	**2.02**	**814.75**
CD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
T1× S1	28.88 (5.37)	58.60	18339.37	7.46	2335.32	13.46	4212.89	37.73	11791.17
T1× S2	37.85 (6.15)	81.10	22367.92	9.84	2718.16	17.69	4622.91	53.62	14649.44
T2× S1	50.68 (7.17)	103.50	22461.90	14.03	2917.97	26.08	4643.90	70.44	14888.49
T2× S2	51.47 (7.12)	110.62	22990.91	15.92	2950.51	26.25	5423.49	77.21	15005.86
T3× S1	64.92 (8.06)	138.62	23861.43	18.91	3311.93	29.77	5538.57	92.22	16089.69
T3× S2	63.50 (7.97)	134.58	23382.23	17.43	3079.12	29.63	5459.80	93.42	16164.55
S. Em (±)	**0.27**	**8.88**	**1901.28**	**1.917**	**297.67**	**2.09**	**458.82**	**5.72**	**1283.07**
CD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 3: Above ground biomass of different aged culms under different spacing

Treatments	0-1 year		1-2 year		2-3 year		3-4 year	
	Biomass (Kg clump^{-1})	Biomass (Kg ha^{-1})	Biomass (Kg clump^{-1})	Biomass (Kg ha^{-1})	Biomass (Kg clump^{-1})	Biomass (Kg ha^{-1})	Biomass (Kg clump^{-1})	Biomass (Kg ha^{-1})
T_1(8 ×4 m)	41.10 ^{a}	12877.90	19.00 ^{a}	5951.05	8.80 ^{a}	2753.46	0.89 ^{a}	278.40
T_2(8 ×6 m)	68.70 ^{b}	12887.27	32.30 ^{b}	6304.43	15.05 ^{b}	2907.39	1.40 ^{b}	291.12
T_3(8 ×8 m)	82.60 ^{b}	14282.45	40.40 ^{c}	6723.27	18.64 ^{b}	3129.33	2.02 ^{c}	315.83
S. Em (±)	**5.29**	**812.72**	**1.96**	**392.80**	**1.09**	**220.46**	**0.06**	**25.41**
CD (0.05)	**20.78**	**NS**	**7.71**	**NS**	**4.30**	**NS**	**0.23**	**NS**
With intercrop (S1)	65.10	13752.35	31.20	6590.80	14.21	2961.09	1.32 a	276.12
Without intercrop (S2)	63.20	12946.06	30.00	6061.70	14.10	2899.03	1.56 b	314.11
S. Em (±)	**1.83**	**695.16**	**0.67**	**339.09**	**0.50**	**181.04**	**0.06**	**105.87**
CD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.21**	**NS**
T1× S1	47.20	12885.26	22.90 ^{b}	6288.86 ^{ab}	10.02	2837.36	0.82	248.97
T1× S2	35.10	10982.09	15.10 ^{a}	4729.08 ^{a}	7.57	2370.73	0.96	257.48
T2× S1	72.00	13594.07	34.30 ^{cd}	6319.99 ^{b}	16.45	2909.72	1.20	280.07
T2× S2	65.40	12889.27	30.30 ^{bc}	6310.50 ^{b}	13.64	2905.06	1.60	299.32
T3× S1	82.60	14970.82	40.50 ^{d}	7173.02 ^{b}	18.65	3421.29	1.80	333.27
T3× S2	82.60	14773.70	40.30 ^{d}	7136.04 ^{b}	18.62	3136.19	2.25	351.60
S. Em (±)	**5.75**	**1107.83**	**2.13**	**522.07**	**1.26**	**303.36**	**0.096**	**33.41**
CD (0.05)	**NS**	**NS**	**7.56**	**1566.22**	**NS**	**NS**	**NS**	**NS**

Conclusion

The present research findings provide valuable insights into the dynamics of biomass allocation in bamboo-based agroforestry systems and underscore its potential, particularly focusing on *Dendrocalamus stocksii* plantations, as a sustainable land use system for achieving ecological stability and economic efficiency within farming communities. The research demonstrates homogeneity in biomass allocation across different spacing configurations, with younger culms making significant contributions to total above-ground biomass. Wider spacing shows promise for maximizing biomass per clump, while stems consistently constitute the majority of biomass across all age classes. These findings offer valuable insights for optimizing bamboo agroforestry practices, highlighting its role in promoting sustainable land management practices and enhancing agricultural productivity.

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