Plant Archives Vol. 24, No. 2, 2024 pp. 1501-1505 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2024.v24.no.2.210

ASSESSMENT OF GROWTH PERFORMANCE OF *DENDROCALAMUS STOCKSII* UNDER AGROFORESTRY SITUATION IN HUMID REGION OF KARNATAKA, INDIA

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(Date of Receiving-22-05-2024; Date of Acceptance-11-08-2024)

ABSTRACT

The utilization of bamboo in agroforestry has gained recent recognition as a promising land-use system with the potential to enhance ecological stability and economic efficiency for agricultural communities. The present study was conducted in four years old *Dendrocalamus stocksii* plantation at 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 main plot and sub plot consists of *Curcuma longa* and *Alpinia galanga* as intercrops. The study findings indicated that *Dendrocalamus stocksii* showed superior growth performance when planted with a wider spacing, specifically at T_3 (8 m × 8 m), followed by T_2 (8 m × 6 m). In contrast, the least growth performance was observed in the closely spaced T_1 (8 m × 4 m). Therefore, this research highlights the significance of optimizing bamboo spacing to improve the overall productivity and sustainability of bamboo-based agroforestry systems. In this current study, it is suggested that a relatively wider spacing of 8 m × 8 m appears to be the most suitable geometry for establishing *Dendrocalamus stocksii*- based agroforestry in the humid region of Karnataka. This spacing is recommended for achieving better yields and overall productivity.

Key words : Bamboo based agroforestry, Spacing, Productivity.

Introduction

The increasing demand for food, fuel, timber and fodder due to the explosion of human and animal populations and depletion of available land resources necessitate increased production per unit area. Non-adaptability of high-input technology is an anomaly leading to low yields and frequent failure of crops because of scarcity of resources. Hence, it is not appropriate to depend totally on traditional agriculture which is uncertain and extremely risky, but to develop an alternate land use system such as 'agroforestry' which is more suitable, sustainable and boosts income, besides simultaneously helping in food and nutrition security and to protect the environment. Agroforestry systems also 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. Taxonomically, bamboos belong to the subfamily Bambusoideae under the family of Poaceae (Gramineae). Bamboos are widely distributed in India and provide livelihood support to millions of people and are part of various cultural and traditional celebrations in rural areas. Thus, the development of bamboo-based agroforestry systems in this framework holds great promise in augmenting the supply of bamboo. The main aim of this investigation was that the farming community might improve their living by taking up bamboo planting as there is scope for regular income from well-managed bamboo plantations and seasonal yield from the intercrops.

Materials 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 colorcode (Table 1) and subsequently, growth parameters were recorded to understand the influence of spacing and cultivation of intercrops on bamboo. The different spacing regimes are taken as main plot treatments (T_1 - 8 m × 4 m, T_2 - 8 m × 6 m and T_3- 8 m× 8 m) and presence and absences of intercrops as subplot treatments for recording the growth observations of bamboo in three replications.

Table 1 : Procedure for bamboo age demarcation.

S. 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

Experimental observations of clump parameters

a. Clump height (m): The height of the clump was recorded using a measuring pole and expressed in meters.
b. Clump girth at breast height (m): The spread of the clump is measured around the clump at breast height and recorded in meters.
c. Number of culms per clump (#): The number of culms present in the plant/clump was counted and recorded.
d. Number of different aged culms per clump (#): The number of different aged culms were identified and counted numerically. The proportion of different aged culms was carried by using the formula.

$$\text{Proportion of different aged culms per clump} = \frac{\text{Number of different aged culms}}{\text{Total number of culms per clump}} \times 100$$

e. Culm diameter at breast height (cm): Culm diameter at the breast height of all the culms was measured with the help of measuring tape.
f. Internodal length was measured by taking three internodes at the base, middle and top of a harvested culm with the help of measuring tape.
g. Light intensity (lux): The amount of light received per unit area was measured at the centre of two rows of bamboo using a lux meter.
h. Canopy density (%): The proportion of an area in the field/ground covered by the crown of clump was measured and expressed in percentage of the total area measured at the centre of two rows of bamboo using a densiometer.

Results and Discussion

Growth performance of *Dendrocalamus stocksii in* agroforestry practices

The growth parameters of four-year-old *D. stocksii* were measured and analyzed. The data presented in Table 2 revealed that the clump height of *D. stocksii* at the age of four did not differ significantly, implying that height growth is independent of spacing. The values ranged from 8.06 m under closer spacing to 8.37 m under wider spacing. The results were in accordance with the study of Bachpai *et al*. (2017) in *Dendrocalamus strictus* and *Pseudoxynanthera stocksii* and Manasa (2023) *Dendrocalamus brandisii*. Contrary to the present results, Kittur *et al*. (2019) reported a decrease in clump height with increasing spacing of bamboo at the age of seven. Prasath *et al.* (2014) observed increased clump height with increased spacing in *Bambusa vulgaris* var. *Vulgaris*.

Further, the significant effect of spacing on Clump girth, culm diameter, internodal length, and number of

Table 2 : Important growth and stand parameters of *D. stocksii* under different spacing.

Treatments	Clump height (m)	Clump girth (m)	Canopy density (%)	Light intensity (×100 lux)
T_1 (8 m × 4 m)	8.02	4.45[a]	94.00(75.82)[c]	190.85[a]
T_2 (8 m × 6 m)	8.13	4.94[b]	92.41(74.01)[b]	225.92[ab]
T_3 (8 m × 8 m)	8.30	5.83[c]	90.73(72.27)[a]	261.00[b]
S. Em (±)	**0.15**	**0.15**	**0.51**	**13.55**
CD (0.05)	**NS**	**0.45**	**1.53**	**40.65**
With intercrop (S1)	8.14	5.04	92.09(73.67)	237.25
Without intercrop (S2)	8.16	5.12	92.74(74.37)	215.23
S. Em (±)	**0.19**	**0.14**	**0.44**	**11.44**
CD (0.05)	**NS**	**NS**	**NS**	**NS**
T1× S1	7.75	4.36	93.42(75.14)	226.52
T1× S2	8.29	4.54	94.53(76.48)	156.37
T2× S1	8.19	4.99	92.99(74.65)	208.97
T2× S2	8.07	4.90	91.83(73.39)	242.30
T3× S1	8.48	5.74	89.72(71.30)	274.97
T3× S2	8.13	5.91	91.69(73.25)	247.03
S. Em (±)	**0.21**	**0.22**	**0.70**	**8.12**
CD (0.05)	**NS**	**NS**	**NS**	**24.36**

culms per clump was evident in the present study. The wider spacing of 8 m ×8 m has recorded maximum values for clump girth, culm diameter, internodal length, and number of culms per clump (Table 3). The increased value of growth parameters in wider spacing may be attributed to the availability of higher growing space compared to closer spacing, which has limitations for growing space. This can be corroborated with the data recorded on canopy density and light intensity presented in Table 2, where the interception of light under wider spacing was significantly higher (251.30 ×100 lux). Light, being a major contributor to photosynthesis leads to increased biomass accumulation with its increased availability. This has resulted in 31.52 per cent increased clump girth and 40.6 per cent increase in the number of culms under wider spacing compared to closer spacing. This has manifested in the increased number of culms under varied age classes which might have a greater impact on the number of harvestable culms (3.90). Similar results were reported by Patil and Mutanal (2017) in marihal bamboo the culm diameter and harvestable culms were higher in wider spacing (4 m × 5 m) compared to closer spacing. Raveendran *et al.* (2010) have reported the higher number of culms per clump at a wider spacing in *Ochlandra travancorica.* The total number of 0–1-year-old culms was higher in wider spacing due to growing space availability to emerge a greater number of new culms (Darabant *et al.*, 2014). Manasa (2023) reported the maximum value for the number of culms per clump, and clump girth in wider spacing of 5 m × 5 m in *Dendrocalamus brandisii*.

The data on culm diameter and internodal length revealed a decreasing trend of individual culm diameter with age classes (Table 3). This can be attributed to the fact that, the higher moisture content in the younger culms compared to older culms. As age progresses the culms lose their moisture content and thickening of their inner walls leading to decreased moisture, leading to reduced culm diameter and increased strength for construction and making furniture. Further, the positive correlation between the bamboo clump age and clump growth might have also played a role in the increased culm diameter of

Table 3 : Culm and culm characteristics of *D. stocksii* under different spacing.

Treatments	Total culms (#)	Number of different aged culms/clump				Culm dbh (cm)				Internodal length (cm)			
		0-1 year	1-2 year	2-3 year	3-4 year	0-1 year	1-2 year	2-3 year	3-4 year	0-1 year	1-2 year	2-3 year	3-4 year
T_1(8 m × 4 m)	31.58 (5.62)[a]	11.09 (3.33)[a]	10.05 (3.17)[a]	7.95 (2.82)	2.40 (1.55)[a]	3.50[a]	2.88[a]	2.37[a]	1.57[a]	25.38[a]	22.95[a]	20.96[a]	18.71[a]
T_2(8 m × 6 m)	37.33 (6.11)[b]	14.36 (3.79)[b]	11.70 (3.42)[b]	8.12 (2.85)	2.99 (1.73)[b]	3.64[b]	3.00[b]	2.47[b]	1.76[b]	31.81[b]	28.76[b]	26.74[b]	24.64[b]
T_3(8 m × 8 m)	43.56 (6.60)[c]	18.15 (4.26)[c]	12.46 (3.53)[b]	9.00 (3.00)	3.92 (1.98)[c]	3.82[c]	3.06[b]	2.55[b]	1.84[b]	36.67[c]	34.00[c]	31.76[c]	29.62[c]
S. Em (±)	**0.16**	**0.09**	**0.09**	**0.07**	**0.04**	**0.04**	**0.03**	**0.03**	**0.03**	**0.188**	**0.192**	**0.185**	**0.188**
CD (0.05)	**0.48**	**0.26**	**0.25**	**NS**	**0.10**	**0.10**	**0.09**	**0.08**	**0.09**	**0.524**	**0.536**	**0.516**	**0.524**
With intercrop (S1)	36.24 (6.02)	13.99 (3.74)	11.02 (3.32)	8.12 (2.85)	2.89 (1.70)	3.63	2.98	2.45	1.74	31.10	28.34	26.27	24.08
Without intercrop (S2)	38.56 (6.21)	14.75 (3.84)	11.76 (3.43)	8.58 (2.93)	3.03 (1.74)	3.69	2.98	2.48	1.71	31.53	28.85	26.75	24.34
S. Em (±)	**0.13**	**0.09**	**0.08**	**0.06**	**0.04**	**0.04**	**0.03**	**0.03**	**0.02**	**0.52**	**0.51**	**0.50**	**0.51**
CD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
T1× S1	28.52 (5.34)	9.86 (3.14)	9.18 (3.03)	7.08 (2.66)	2.25 (1.50)	3.37	2.84	2.30	1.55	24.90	22.39	20.53	18.23
T1× S2	34.81 (5.90)	12.32 (3.51)	11.02 (3.32)	8.88 (2.98)	2.56 (1.60)	3.46	2.92	2.43	1.60	25.86	23.48	21.37	19.17
T2× S1	37.09 (6.09)	14.36 (3.79)	11.63 (3.41)	8.25 (2.87)	2.76 (1.66)	3.64	3.02	2.48	1.82	31.57	28.66	26.57	24.44
T2× S2	37.45 (6.12)	14.29 (3.78)	11.76 (3.43)	8.01 (2.83)	3.28 (1.81)	3.62	2.97	2.47	1.71	32.04	28.86	26.90	24.82
T3× S1	43.56 (6.60)	18.23 (4.27)	12.32 (3.51)	9.18 (3.03)	3.76 (1.94)	3.67	3.07	2.56	1.84	36.64	33.79	31.54	29.39
T3× S2	43.56 (6.60)	18.06 (4.25)	12.53 (3.54)	9.00 (3.00)	4.04 (2.01)	3.80	3.04	2.53	1.83	36.69	34.20	31.98	29.85
S. Em (±)	**0.22**	**0.28**	**0.13**	**0.11**	**0.06**	**0.05**	**0.04**	**0.04**	**0.04**	**0.34**	**0.35**	**0.36**	**0.35**
CD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

the younger culms than the older culms. Darabant *et al.* (2014) reported that the moisture content of culms of *Bambusa beecheyana* decreased with an increase in culm age, indicating that older culms are more useful for energy production.

Conclusion

The analysis of *D. stocksii* performance in the study indicates that there are significant differences in key growth parameters of bamboo, including clump girth, culm diameter, internodal length, number of different-aged culms per clump, total number of culms per clump, proportion of different-aged culms per clump and light intensity. The study examined three spacing regimes and the results show that wider spacing of bamboo leads to significantly higher values in these growth parameters. This suggests that the spacing between *D. stocksii* plants has a substantial impact on their growth, with wider spacing being associated with more favorable conditions for the observed growth parameters. Hence, wider spacing of 8 m ×8 m is suitable and recommended for *D. stocksii* under agroforestry practices for better growth and productivity.

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