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Research article

CULTIVATION PROSPECTS OF *DENDROCALAMUS ASPER* BACKER.FOR EDIBLE SHOOTS IN SEMIARID AND HUMID TROPICS OF PENINSULAR INDIA

Sowmya Chandramouli[a,*], M.R. Jagadish[b],and SyamViswanath[a]

[a]Tree Improvement and Genetics Division, Institute of Wood Science and Technology,18th cross Malleswaram, Bangalore – 560003

[b]Ashoka Trust for Research in Ecology and the Environment (ATREE), Royal Enclave, Srirampura, Jakkur, Bangalore- 560064

* Corresponding author: sowmya.chandramouli@gmail.com

ABSTRACT: *Dendrocalamus asper* also known as 'Sweet Bamboo' is the most widely accepted species globally for edible shoots. The prospects of cultivation of *D.asper* in humid tropics and semiarid conditions of peninsular India was assessed using various financial indicators and through quantitative and qualitative analysis of juvenile shoots. Growth parameters in on-farm field trials by IWST, Bangalore suggest that this species grows well in humid tropical conditions as compared to semi-arid conditions in Peninsular India. In semiarid conditions in Hosakote, Bangalore on an average 16 shoots were produced in a five year old clump with the average shoot diameter of 18±1.1mm and extractable volume of > 0.75 kg. In humid tropical conditions in Thithimathi, Kodagu, *D. asper* clumps of same age produced around 25 shoots. The average shoot diameter was 55±2mm at the end of fifth year which translated into higher volume (> 2kg) of edible portion in harvested shoots. In *D.asper,* 30% extraction of the total new shoots emerging from the fifth year was ideal. There was no difference in nutritional composition of the species between semiarid and humid tropics in terms of protein, carbohydrates, crude fibre and fat.Financial indicators at different discount rates (10%, 12% and 15%) suggest that cultivation of *D.asper* for shoot production may be a profitable venture in humid tropics with a high equivalent annual net income (EAI) around 7.6 – 9 lakhs as compared to a lower EAI in semiarid conditions (0.22 to 0.59 lakhs).

Key words: *Dendrocalamus asper* Backer, edible shoots, semiarid conditions, humid tropical conditions, Peninsular India

INTRODUCTION

Bamboo has been gaining increased global attention as an alternative horticulture/plantation crop with multiple uses and benefits, providing mankind with various resources. A lesser known fact of bamboos is utilization of its juvenile shoots as a food item. Most bamboo species produce edible shoots but less than 100 species out 1200 species recorded world wide are utilized for shoots. National Mission for Bamboo Application (NMBA) has identified 20 fast growing multi-purpose species for India, of which 10 species are considered edible. So far in India, exploitation of shoots has been confined mostly to North-east. In China, shoots have been exploited as a traditional forest vegetable for more than 2500 years and has been explicitly used in the traditional South Asian cuisine for many centuries. Of all species *Phyllostachys pubescens* (Moso) has been largely cultivated and utilized for shoots in China. India, has second largest diversity of bamboo species next to China with 130 species in 18 genera. Around 90% of the species diversity is found in North-east India. Various native species from other parts of India and exotic species from outside India have been introduced in Peninsular India in the past few decades. Though many species of bamboo are being cultivated, there is not much emphasis on exploitation of these commercial plantations for edible shoots. This may be attributed to lack of awareness on the nutritional potential of edible shoots and the lack of information on the potential of bamboo as edible shoots. In India, despite the fact that it is the second largest producer of bamboo shoots after China, not much attention has been given to its neutraceutical properties.

This may be primarily due to lack of awareness regarding the edible characteristics of the shoots and lacunae in R&D. The high returns from bamboo plantations has attracted people to raise plantation in abandoned agricultural lands and tea/coffee estates where availability of labour is a major constraint [1]. Studies conducted by IWST, Bangalore, to identify appropriate bamboo species for cultivation in Peninsular India revealed that *Bambusa balcooa, B.bambos, B.nutans, Dendrocalamus asper, D. strictus, D.stocksii* and *Guadua angustifolia* could be exploited for edible shoots in tropical humid conditions while species like *Bambusa balcooa, B.bambos, B.nutans* and *Dendrocalamus strictus* were more suited in semiarid conditions.Though there are studies on the productivity and economics aspects of various other native bamboo species but not much study has been done on *D.asper*.

Dendrocalamus asper Backer, native of Indonesia, also known as sweet bamboo is one of bamboo species which is recognized world wide for the culinary value of its shoots.This exotic bamboo species, which was introduced in India around 15 years ago, has been well recognized for its multifarious uses. The species grows best in rich and heavy soils of humid regions from lowlands to 1500 m altitude. It also grows well in semiarid conditions under good mangement practices. Apart from being used as edible shoots, it is also used in making good quality furniture, musical instruments, containers, household utensils, handicrafts and in paper making. It is considered as structural timber due to its fairly good physical and mechanical properties. Hence the species may be truly considered as a multipurpose among bamboo species, since mature culms from plantations raised for shoot production, can be used for other purposes as well. The paper throws light on the cultivation potential of *D.asper* for edible shoots as a profitable venture in humid tropics and the nutritional benefits from shoots.

METHODOLOGY

Study area and its general features

Dendrocalamus asper plantations in two contrasting locations in Karnataka were chosen for the study viz. Hosakote, Bangalore and Thithimathi, Kodagu. The sites selected for the present study were, Thithimathi, Kodagu (Humid tropics) and Hosakote, Bangalore (Semiarid) fall within a latitude of 12°13'44.67" and 13°06'08.20" N and the longitude of 76°00'51.21" and 77°50'44.04" E. Sites were located at an altitude of 851 and 892 m a.m.s.l with a mean annual rainfall of 1396.46 mm and 651.52 mm. The site at Thithimathi, Kodagu was an abandoned paddy field having clayey loam soil having pH 7.41 and low soil organic carbon (SOC) (0.44%) with 94.76, 6.23 and 279.47 kg $ha^{-1}$of N, P and K respectively. Secondary nutrient concentration was 0.92, 0.22 and 15.60 ppm of Ca, Mg and S. The site at Hosakote, Bangalore was an abandoned forest land with maximum area covered with *Lantana camera* and few scattered trees of native species such as *Pongamia pinnata, Azadirachta indica* and *Tamarindus indica*. The soil was red lateritic having a pH 5.80 and low SOC (0.49%) with 102.96, 4.65 and 90.92 kg $ha^{-1}$of N, P and K respectively. The concentration of secondary nutrients were 0.89, 0.16 and 7.91 ppm of Ca, Mg and S respectively.Trials of *D.asper* were established with a spacing of 5X5m in 2005 in RCBD with three replications and 16 plants per replicate.

Growth studies

Observations were taken from six year old *D.asper* clumps planted at the same time in both locations at 5x5m spacing. Height of the clump (m), number of shoots/culms emerged and culm diameter (mm) at fifth internode were recorded from six year old clumps in both the locations. The data obtained were subjected to factorial analysis of variance (ANOVA) [2].

Nutritional analysis

New culms or juvenile shoots in bamboos usually develop with the beginning of the rainy season in June/July, during which the young edible shoots are harvested. The shoot is actually a culm that emerges from the ground in full diameter and contains nodes and inter nodes in a vertically miniaturized form and the young shoots are tightly clasped with overlapping sheaths that have to be removed to extract the edible part. Shoots are normally harvested 7-14 days after the emergence from the ground and when the shoot height is about 15-30 cm. The outer sheath was removed and the inner creamy white portion was used for the analysis. The nutritional analysis was done for shoots collected from both the locations using different standard methods. The moisture content was estimated by drying the sample at 100°C for 6 -8 hours in hot air oven [3], total protein was calculated by estimating the nitrogen present in the sample[4], fat content was estimated by soxhlet extraction with petroleum ether [3], carbohydrate content was estimated by spectrophotometric method [3], crude fibre content was estimated by alternate acid and alkali treatment of fat free samples [3] and total ash content was estimated by charring the sample at 600°C for 5 hours in a muffle furnace [3]. The data obtained was subjected to statistical analysis.

Economics of *D.asper* cultivation

The profitability of *D.asper* cultivation for shoot production and culm production was assessed through a Benefit – Cost Analysis (BCA) following [5] and [6].The financial returns from plantations raised for shoots production were estimated three years after planting. It becomes imperative to judge the viability of bamboo plantations through appropriate financial analysis, taking the time value of money into account. *D.*asper has a life span of around 40 years and is expected to keep producing shoots at least for 40 years, hence the time period taken for analysis was kept at 40 years. The number of harvestable shoots per clump is calculated based on observation of growth in each of the two locations considering that 30% of the emerging shoots are retained for clump sustenance. The indicators used for financial analysis include Net Present Value (NPV), Benefit Cost (B/C) ratio, Internal rate of return (IRR) and Equivalent Annual Income (EAI) at three different discount rates. BCA takes into account all the major costs incurred including labour, site preparation, pitting, soil working, fertilization, cost of planting material, transport, irrigation, fencing, watch and ward, protection etc. In subsequent years, the input costs include the harvesting of emerging shoots/culms, infrastructure and labour for processing of shoots, annual marketing etc. Costs and benefits were valued at farm gate or nearest market prices and discounted at 10 per cent, 12 per cent and 15 per cent based on prevailing interest rates. Discounted net benefits were added up to calculate NPV using the formula,

$$NPV = \sum_{t=0}^{T} (B_t - C_t) / (1 + r)^t$$

Where B_t is the benefits in year t, C_t is the costs in year t and r is the selected discount rate and t is the time period [7]. IRR is calculated by finding the discount rate that makes NPV equal to zero and was calculated by using following equation,

$$IRR\ \% = L + \frac{NPV_L}{NPV_L - NPV_H} \times (H - L)$$

Where L is the lower discount rate, H is highest discount rate, NPV_L is the net present value results for the lower discount rate and NPV_H is the net present value results for the higher discount rate.

Equated annual income (EAI) gives NPV converted into the annual amount for 40 years rotation period which was calculated using the formula

$$EAI = NPV \frac{i(1+i)^n}{(1+i)^n - 1}$$

Where 'n' is the number of years in rotation

$$\text{Benefit-Cost Ratio} = \frac{\text{Total discounted benefits}}{\text{Total discounted costs}}$$

RESULTS AND DISCUSSION

Growth performance

Studies conducted by IWST, Bangalore, to identify appropriate bamboo species for commercial cultivation in Peninsular India revealed that *Bambusa balcooa, B.bambos, B.nutans, Dendrocalamus asper, D. strictus, D.stocksii* and *Guadua angustifolia* could be exploited for edible shoots in tropical humid conditions while species like *Bambusa balcooa, B.bambos, B.nutans* and *Dendrocalamus strictus* were more suited in semiarid conditions.

Field trials by IWST in Hosakote, Bangalore reveal that *Dendrocalamus asper* can be exploited for edible shoots throughout the year with supplementary irrigation and can be a profitable commercial venture. The growth in Kodagu was found to be contrasting to the average growth observed in Hosakote. The maximum clump height reached at the end of sixth year in Kodagu was around 10m whereas the clups reached a height of only 3m in Hosakote. In semiarid conditions in Hosakote, on an average 16 shoots were produced in a five year old clump with the average shoot diameter was around 18±1.1mm.

In humid tropical conditions, *D. asper* clumps of same age produced around 25 shoots with an average shoot diameter of 55±2mm (Fig 1). With appropriate irrigation, a species like *Dendrocalamus asper* can also be exploited even in semiarid conditions. The typical "shooting season" of this species rarely exceeds two months which may be extended by modifying the cultivation and management practices since it is an intensively managed process. The shoots have to be harvested within two weeks of emergence when they reach 30-40cm height. Continuous monitoring is essential as to harvest the shoots at the appropriate time to get the maximum volume of edible portion. After harvest, deterioration of shoot quality is rapid especially if the outer sheath is removed. Hence transportation of shoots from the harvesting site to the processing unit has to be well coordinated.Initial results of the studies underway at IWST, Bangalore suggests that the shooting season of *D.asper* could be extended from July to December by management.

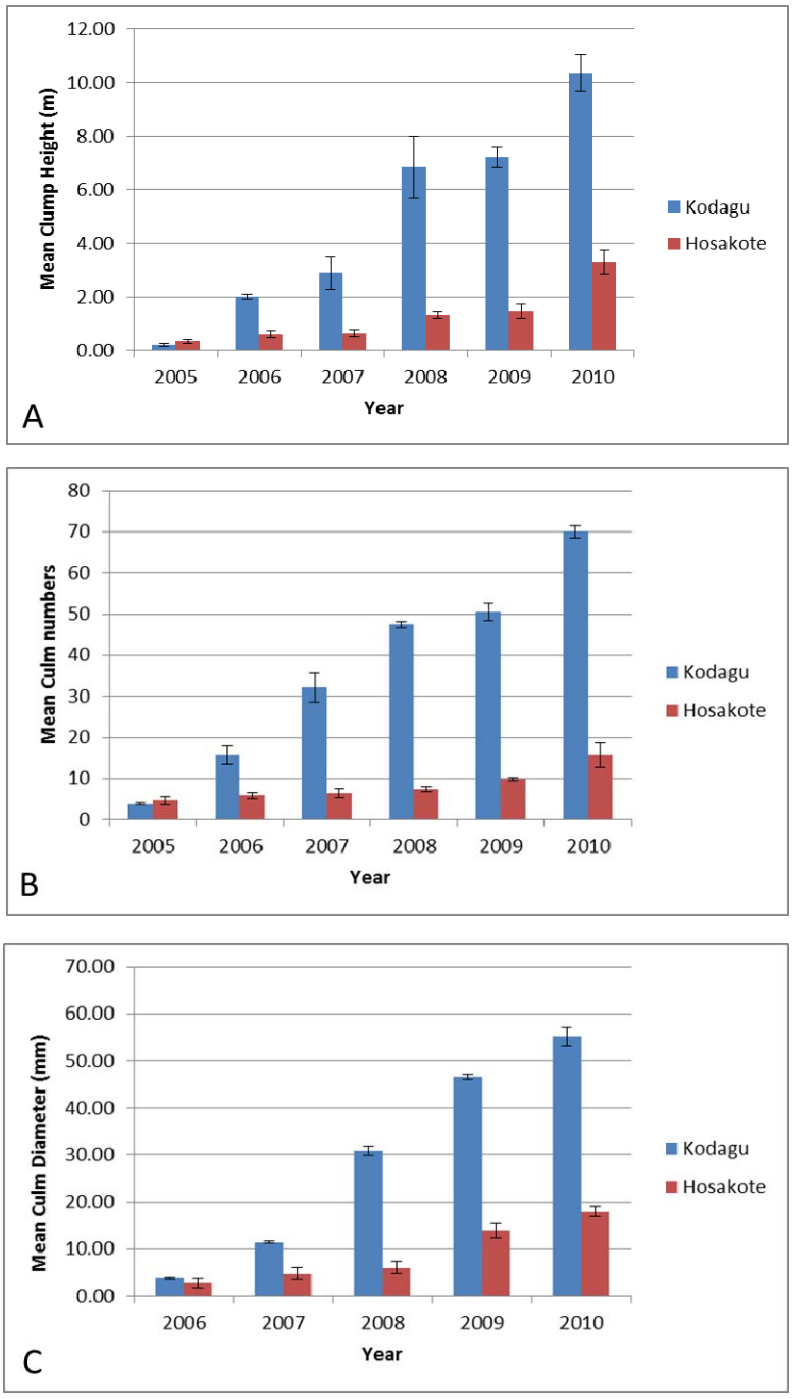

Fig 1: Comparison of growth parameters in humid tropical (Kodagu) conditions and semi-arid (Bangalore) A. Mean clump height, B. Mean culm number, C. Mean culm diameter

Nutritional composition of *D.asper*

The observations on shoot quantity indicate that the average shoot diameter was > 35mm at the end of fifth year which translated into higher volume (> 2 kg) of edible portion in harvested shoots in humid tropical conditions. In *D.asper,* 30% of shoot harvest from the fifth year was found to be ideal.Shoots with maximum quantity of edible portion are produced from the fifth year onwards. There are lot of opportunities for exploitation of bamboo shoots as an alternate source of nutrition during rainy season when other vegetables are scarce to come by.

The main nutrients in bamboo shoots are protein, carbohydrates, amino acids, minerals, fat, sugar, fiber, and inorganic salts. The shoots have a good profile of minerals, consisting mainly of potassium (K), calcium (Ca), manganese (Mn), zinc (Zn), chromium (Ch), copper (Cu), iron (Fe), and lower amounts of phosphorus (P), and selenium (Se) [8,9]. Fresh shoots are a good source of thiamine, niacin, vitamin A, vitamin B6, vitamin C and vitamin E [10,11,8]. Composition of nutrients like carbohydrates, proteins, vitamins and dietary fibers may vary considerably among different species and also on conditions of growth. Thus it becomes imperative to understand the nutrient composition of a particular bamboo species growing in a particular region to exploit its edible potential. Studies on the basic nutritional composition of *D.asper* shoots from semi-arid condition and tropical humid conditions reveal that the composition did not seem to vary between both the locations in terms of protein (2.36 g/100g; 2.71g/100g), carbohydrates (5.02 g/100g; 5.71g/100g) , crude fibre (0.71g/100g; 0.77g/100g) and fat (0.09g/100g; 0.1g/100g) (Table 1). For a balanced diet, the recommended dietary allowance (RDA) for protein is 0.8 g/kg of body weight for adults. In a study conducted on 14 bamboo species, the protein content in the juvenile shoots ranged from 2.31 to 3.72 g/100 g fresh weight [12]. The protein content in *D.asper* is on par with species commonly consumed in the North-east and consuming shoots will supply a generous amount of protein essential for the body. The RDA of an adult person per day for protein, dietary fibre and minerals is more or less met from around 100gms of bamboo shoots. Hence, daily consumption of shoots can be expected to be beneficial to the human body in so many ways besides helping in balanced nutrition. This is an indication that *D.asper* has immense potential to be promoted as highly nutritious vegetable and encouraged for commercial cultivation for edible shoots in Peninsular India similar to any other horticulture crop.

Table 1: Nutritional composition of *D.asper* in two contrasting agro climatic zones in Karnataka

Location	Agroclimatic zone	Moisture %	Protein g/100g of fresh wt	Carbohydrates g/100g of fresh wt	Fat g/100g of fresh wt	Crude fibre g/100g of fresh wt	Ash %
Hosakote	**Semiarid conditions**	91.8±1.04	2.36±0.13	5.02±0.10	0.09±0.01	0.71±0.014	0.87±0.11
Kodagu	**Tropical humid conditions**	94.73±0.46	2.71±0.04	5.17±0.05	0.10±0.003	0.77±0.005	0.93±0.11

Table 2: Financial analysis of *Dendrocalamus as per* plantations for shoot production in tropical humid conditions (Kodagu) and semiarid conditions (Hosakote) at different discount rates (Rs in lakhs*)

Location	Agroclimatic zone	Discount rates	Net Present Worth (NPV)	Benefit cost Ration (B/C)	Internal rate of Returns (IRR)	Equated annual Income (EAI)
Kodagu	**Tropical humid**	10%	88,08,708	6.21	63%	9,00,773
		12%	69,72,005	5.84	60%	8,45,729
		15%	50,98,292	5.33	56%	7,67,609
Hosakote	**Semiarid**	10%	5,81,895	1.33	8%	59,504
		12%	3,64,060	1.24	6%	44,161
		15%	1,49,980	1.12	3%	22,581

***1USD= 61.45 INR Nov 2014**

Profitability of *D.asper* cultivation

The economics of *D.asper* plantation for shoot productions was worked out and the detailed financial indicators at different discount rates are presented in Table 2. Apart from the costs incurred in the systems maintained for culm production, additional recurring costs incurred include compost, soil working, irrigation, tending, cleaning, harvesting and processing of shoots and watch and ward and one-time cost for establishment of on-site infrastructure facility for processing of shoots. The fertilization is replaced by application of compost since the plantation is raised for edible shoots. To facilitate better emergence of shoots, soil working and saucer pit enlargement should be done twice every year throughout as compared to the plantations maintained for culm production. The observations on growth have indicated that *D. asper* has the potential to produce 25 – 30 emerging shoots in the fifth year in Kodagu and around 14-16 shoots in Hosakote. However, an average of 25 extractable shoots/ clump/ year in Kodagu and 15 extractable shoots/ clump/ year in Hosakote from fifth year onwards have been taken for financial analysis taking into account out of which 30 % of the shoots may have to be retained and allowed to grow to culm size for the future sustenance of the clump. Around 750 gm of edible portion from shoots in Hosakote and around 2000gm of edible portion from shoots in Kodagu can be extracted if the shoots are harvested at the right size after removal of the sheath and nodal portions. This can be processed and sold at a minimum rate of Rs.80/kg at farm gate prices. Potential revenue of Rs. 14.4 lakh year^{-1} can be expected from fifth year onwards from approximately 9000 juvenile shoots after accounting 10% mortality of clumps in humid tropics and around Rs.3.24 lakh year^{-1}can be expected from approximately 5400 juvenile shoots after accounting 10 % mortality of clumps in semiarid conditions. Over a 40 year period of the plantation at different discount rates like 10 %, 12 % and 15 %, the net present value (NPV) is 88.08, 69.72 and 50.98 lakhs in humid tropics and 5.81, 3.64 and 1.50 lakhs in semi-arid conditions. However, the benefit cost ratio is 6.24, 5.84 and 5.33 in humid tropics and 1.33, 1.24 and 1.12 in semi-arid conditions respectively for the same discount rates. The internal rate of return (IRR) at the same discount rates is 63%, 60% and 56% in humid tropics as compared to 8%, 6% and 3% in semi-arid conditions. Equivalent annual net income (EAI) of 9, 8.45 and 7.67 lakhs can be reasonably expected from the sale of young shoots over a 40 year period of plantation in humid tropics while the EAI in semi-arid conditions is as low as 0.59, 0.44 and 0.22 lakhs.The results revealed that cultivation of *D.asper* for shoot production is a highly profitable venture in humid tropics but may not be commercially viable in semi-arid conditions considering the financial indicators (Table 2).

CONCLUSION

D. asper is considered as one of the top five bamboo species used for edible purposes. The juvenile shoots are proven to have better nutritive properties and have high potential for the massive commercial production of shoots in humid tropics with more number of emerging shoots and high extractable volume. Edible bamboo shoots may be highly nutritious but lack of information on the various aspects is a limiting factor. Considering these inherent health and economic benefits of bamboo shoots and their potential for utilization as a health food and also good growth performance, in present perspective, *D. asper* plantations can be raised exclusively for shoot production in humid tropical conditions.Cultivation of *D.asper* in semi-arid conditions for shoot production may not be profitable since field trials also indicate that the growth without management is poor as compared to humid tropics. Canned and preserved bamboo shoots currently dominate international trade, but due to increased consumer demand for non processed food, it is projected that the share of fresh shoots will significantly increase in the near future.The essential requirement for successful exploitation of shoot production technology is the availability of bamboo bio resource and technical and entrepreneurial skills in managing shoot-producing bamboo plantation. Appropriate processing and marketing technology with forward and backward linkages may increase awareness and consumer acceptance bamboo shoots as a health food. If properly utilized, this enormous untapped resource can help to meet the increasing demand for food and nutrition mainly in the rural areas.

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