J. Bamboo and Rattan, Vol.6, Nos. 3&4, pp. 215-222 (2007)

Domestication of *Dendrocalamus brandisii* in upland paddy fields in Coorg, Karnataka

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Abstract: The feasibility of *Dendrocalamus brandisii* cultivation in abandoned paddy fields in Coorg, Karnataka was assessed through a financial analysis using indicators like Net Present Value (NPV), Benefit Cost (B/C) ratio and Land Expectation Value (LEV) at different discount rates. Comparisons were made with other possible landuses including ginger monocropping and bamboo intercropping at different spacings, to determine the financially optimal farming practice in such areas. Results revealed that all the landuse options discussed were feasible in financial terms since they had NPV values higher than zero and B/C ratios greater than one at 10 per cent and 15 per cent discount rates. *D. brandisii* at 6 m x 6 m spacing intercropped with ginger had the highest NPV and LEV which may primarily be attributed to low input costs associated with bamboo farming and higher market value of the produce over a longer period. The constraints in popularizing the species in Coorg and the prospects of value addition for enhancing the income of primary stakeholders are also examined.

Key words: *Dendrocalamus brandisii*, domestication, financial indicators, benefit-cost analysis, value-addition

INTRODUCTION

Coorg District in Karnataka State covering a land area of 4,104 km^2 is one of the well-wooded districts in India with 80 per cent of its land area under tree cover. Natural forests cover 48 per cent of the forested landscape while private coffee plantations cover the remaining 32 per cent. In the non-forested area, paddy cultivation is the prominent landuse (18% of total area). But in recent times, the area under paddy is progressively getting reduced due to unsustainable yield levels, non-remunerative prices and paucity of labour. Thus paddy lands are increasingly being converted to other landuses mainly ginger cultivation. Locally acceptable perennial species like *Dendrocalamus brandisii* have the potential to fill this vacuum, provided the economics and marketing work out to be favourable.

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In Karnataka, bamboo covers an area of about 492,500 ha constituting about 12 per cent of the forest area. *Dendrocalamus strictus* is present in about 60 per cent of the bamboo area (about 300,000 ha), *Bambusa bambos* in about 30 per cent (150,000 ha) and other species in remaining 10 per cent of the area in the State (NABARD, 2005). In forested areas of Coorg district, these bamboo species occur naturally and there is a long tradition of using bamboo for edible shoots, farming requirements, handicrafts and cottage industry. *D. brandisii* was introduced in the District in 1915, and has since been preferred for cultivation in homesteads by enterprising farmers mainly due to its large size, straight growth habit and thorn-less nature unlike other local bamboo species. In addition to traditional uses such as for ladders and for basket weaving, this species is currently used widely for fencing poles for ginger cultivation in upland paddy fields. The culms of this species are smooth and around 25 m tall with a diameter of 13-30 cm, wall thickness of 1.7-3 cm and internodal length of 30-60 cm, thus making it an attractive species for integration in various farming systems.

The distribution of *D. brandisii* in India has been well documented, studies assessing the productivity and economics of cultivation of this species in different agro-climatic zones of the Country are scarce even though similar studies are available for other bamboo species. Shanmughavel (1995) assessed the productivity of a trial plantation of *B. bambos* and found that the average number of culms increased from 5 culms per clump in the first year to 8, 12, 14, 16 and 17 in the subsequent years and biomass increased from 17.5 kg to 70.1 kg from second to sixth year. Tewari (1981), Chaturvedi (1986), Shanmughavel (1995) and Torane *et al.* (1996) worked out the economics of bamboo plantations and obtained Benefit-Cost ratios higher than one at different discount rates. Shanmughavel and Peddappaiah (2000) recommended intercropping of soybean (*Glycine max*) and turmeric (*Curcuma longa*) in initial stages of *B. bambos* plantations in tropics due to Land Equivalent Ratio of 1.2, which shows that the productivity of one ha of land under intercropping is equivalent to that of 1.2 ha under the monocropping system.

The widening gap between demand and supply in the coming years will necessitate large-scale private plantations of bamboo, thereby offering immense opportunities for domesticating *D. brandisii* in the State. The present paper assesses the viability of *D. brandisii* cultivation through a financial analysis using indicators like Net Present Value (NPV), Benefit Cost (B/C) ratio and Land Expectation Value (LEV) at different discount rates (sensitivity analysis) and explores the potential for its wide scale domestication in abandoned upland paddy fields of Coorg.

METHODOLOGY

The profitability of *D. brandisii* cultivation to primary stakeholders was assessed through a Benefit-Cost Analysis (BCA) following Friday *et al.* (2000) and Purushothaman (2005). BCA takes into account all expenditures incurred and revenues generated under a project in order to assess the ability of the project to meet its financial obligations and to assess the incentives to producers (Purushothaman, 2005). The criteria used for assessment include Net Present Value (NPV), Benefit-Cost (B/C) ratio and Land Expectation Value (LEV). Besides examining the viability of raising bamboo monoculture plantation, a comparison with other possible landuses in unused paddy fields in Coorg including intercropped bamboo plantations was also conducted to determine the financially optimal landuse there. The following feasible alternative landuses were identified through detailed discussions with farmers and consultations with experts from College of Forestry, Ponnampet, Coorg.

D. brandisii monoculture

Traditionally *D. brandisii* has been grown in homesteads along farm boundaries or in isolated patches in Coorg. But preliminary survey of homestead cultivation in Coorg revealed lack of scientific management practices and harvesting schedules, which are essential pre-requisites in cultivation of *D. brandisii*. Scientifically managed block plantations of *D. brandisii* can be a viable alternative in upland paddy fields. At 6 m x 6 m spacing, around 278 bamboo plants can be accommodated in 1 ha. Costs incurred include labour and materials costs for initial plantation establishment, fencing, plant protection chemicals, fertilizer inputs, weeding, etc. In subsequent years, input costs are less apart from those for annual marking of culms and harvesting of mature culms. The harvestable yield varies from an average of 2 culms/clump in the third year to 10 or more culms/clump from eighth year up to 40 years. Each harvested culm is valued at Rs. 50 to 55 at current farm gate prices.

Ginger monocrop

The warm, humid climate of Coorg is conducive for the cultivation of ginger (*Zingiber officinale*), an important spice. In Coorg, ginger rhizomes are planted in May, before the advent of monsoon and crop is harvested generally after 8 months. About 600 beds of 15 cm height, 1 m width and 10 m length can be prepared leaving 50 cm between beds. Ginger cultivation is highly input intensive and requires at least 25-30 tonnes/ha of compost, 50 kg/ha of NPK and 10-15 tonnes/ha of leaf mulch as per current practices followed in Coorg. Leaf mulch is considered essential to enhance germination of seed rhizomes and to prevent washing off of soil during heavy rains. Yield varies from 15,000-22,500 kg/ha and prices are highly remunerative though fluctuating. However, ginger being a nutrient-depleting crop, cannot be cultivated in consecutive years and a rotation of 5 years is followed in Coorg with paddy cultivation in the intervening periods.

Bamboo intercropped with ginger

Generally intercropping is difficult in plantations of bamboo due to the fast and luxuriant growth of culms. But in well-managed bamboo plantations where culms are regularly harvested, shade tolerant species like ginger can be cultivated in beds between bamboo rows. In block plantations with bamboo at 6 m × 6 m spacing, four rows of 10 beds each can be raised between bamboo rows in the initial year. As bamboo matures, light availability to intercrops is reduced in the subsequent years and only one more rotation of ginger may be possible in the fifth year. When the spacing between bamboo rows is increased to 10 m (6 m × 10 m spacing), intercropping may be possible for longer periods. In such a situation, four rotations, up to 15th year may be possible, though the number of ginger bed rows may decrease progressively, from six in first year to one in 15th year. Intercropping offers better returns due to multiple yields, when both the crops are managed properly; thereby avoiding competition between them. The high litter output of bamboo is an added advantage, since bamboo leaf litter can be used for mulching in ginger beds, which is essential in Coorg.

Financial analysis

Since the financial returns are delayed for four years, it becomes imperative to judge the viability of bamboo plantation through appropriate financial analysis, taking the time value of money into account. The indicators used for financial analysis include Net Present Value (NPV), Benefit-Cost ratio (B/C ratio) and Land Expectation Value (LEV). Various costs and benefits associated with different landuse practices described for a specific time period were identified initially. Since *D. brandisii* has a life span of 40-50 years and is expected to keep producing culms at least for 40 years, the time period taken for analysis was 40 years. Secondary data were collected from College of Forestry, Ponnampet, local markets and non-governmental agencies like Kodagu Model Forest Trust (KMFT) to identify and quantify costs and benefits. Major costs incurred in these farming systems include labour and material inputs in planting, protection and harvest. Benefits accrued include the economic products like bamboo culms and ginger rhizomes, which are sold in the open market. Costs and benefits were valued at farm gate or nearest market prices and discounted at 10 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 is the benefits in year t, C the costs in year t, and r is the selected discount rate, following Nair (1993).

Assuming that the land will continue under the same landuse into perpetuity, annuity formulae were used to find a final end value as liquidation value (LV).

LV for annual crops =Net benefits in the end year/r

LV for perennial systems= Net benefits in the end year/ $(1+r)^{20} - 1$

This LV was added to the net benefits of the end year and discounted to compute NPV (Purushothaman, 2005).

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

Land Expectation Values (LEV) were used to convert NPV to an annual basis (Friday *et al.*, 2000) to compare bamboo cultivation whose returns are delayed, with other landuses which can provide annual income, assuming that bamboo is planned to grow in perpetuity.

$$\text{LEV} = \text{NPV}\ \frac{(1+r)^n}{(1+r)^n-1}$$

where n = selected time period and r = selected discount rate

RESULTS AND DISCUSSION

Financial analysis

All projects with NPV greater than zero and B/C ratio greater than 1 are assumed to be financially viable (Nair, 1993). Since all the landuse options discussed earlier have NPV values higher than zero and B/C ratios greater than 1 at both the discount rates, they can be considered feasible in financial terms. Bamboo at 6 m × 6 m spacing intercropped with ginger had the highest NPV (Rs. 497,517.94 at 10% and Rs. 146,927.09 at 15%) and LEV (Rs. 206,194.12 at 10% and Rs. 147,477.66 at 15%) (Table 1).

Table 1. Financial analysis of different farming systems in one hectare of upland paddy field in Coorg District at different discount rates

Sl. No.	Type of farming system	NPV (Rs.)		B/C ratio		LEV		Overall ranking
		10%	15%	10%	15%	10%	15%	
1	Ginger sequentially inter-cropped with paddy	201638.27	146927.09	1.48	1.52	206194.12	147477.66	4
2	*D. brandisii* (Block plantation at 6 m x 6 m spacing)	406195.18	207422.39	3.75	2.92	415372.80	208199.60	2
3	*D. brandisii* + Ginger (Block plantation at 6 m x 6 m spacing)	497517.94	272016.02	3.10	2.40	508758.90	273035.33	1
4	*D. brandisii* + Ginger (Block plantation at 6 m x10 m spacing)	358283.10	226332.79	2.71	2.27	366378.20	227180.93	3

The high NPV and LEV may be attributed to low input costs associated with bamboo farming and sustained yield with high market value for a substantially longer period. Intercropping with bamboo reduces input cost of ginger cultivation, mainly the mulching cost due to copious contribution of leaf litter from bamboo. Studies on litter fall of *Bambusa bambos* report litter production in the range of 15.4, 17.0 and 20.3 tonnes/ha in 4-, 5- and 6-year-old plantations respectively (Shanmughavel *et al.*, 2000). Though data on litter production of *D. brandisii* in Coorg are not available, it is expected to be more than that of *B. bambos* since the leaves of the species are broader and have more luxuriant growth habit. Hence the litter output is expected to be sufficient to meet the mulch requirement of ginger, thereby increasing the profits from ginger intercropping. In terms of B/C ratio, this option ranks second (3.10 at 10% and 2.4 at 15%) after bamboo monocropping at 6 m × 6 m, which has B/C ratios of 3.75 (10%) and 2.92 (15%). When NPV and B/C ratios are at variance, NPV criterion is given preference (Gittinger, 1982). Hence, bamboo at 6 m × 6 m spacing intercropped with ginger can be considered the best in the financial perspective. When bamboo spacing is increased to 6 m × 10 m to accommodate more ginger rotations, the NPV plunges to Rs. 358,283.10 (at 10 %) and Rs. 226,332.79 (at 15%), while B/C ratio falls to 2.71 (at 10%), 2.27 (at 15%) and LEV to 366,378.20 (10%) and 227,180.93 (15%). Lower financial indicators show that compromising on number of bamboo culms to accommodate more intercropped ginger rotations is not a prudent option. Bamboo monoculture comes second in terms of NPV and first in terms of B/C ratio due to low costs and high benefits accrued. But at 15 per cent discount rate, this option has lower NPV and LEV than bamboo intercropped with ginger at 6 m × 10 m spacing and hence, is expected to be less preferred by farmers aiming at immediate returns rather than long-term benefits. Ginger cultivation has the lowest values for all financial indicators owing to high input costs and intense nutrient depleting nature of the crop, which makes continuous cultivation impossible. Paddy which is grown in between ginger rotations, does not improve the financial gains due to its high labour costs, especially due to increased cost of land preparation for paddy cultivation following ginger cultivation.

Constraints and prospects in *D. brandisii* domestication

Planting material

Financial analysis emphasizes the viability of *D. brandisii* cultivation as an attractive alternative in abandoned paddy fields in Coorg and shows that when intercropped with ginger is a profitable venture that can be undertaken in such fields. But adequate supply of quality planting material (QPM) of *D. brandisii* has been a major constraint in popularizing this species. Preliminary trials by IWST, Bangalore to address this issue has focused on selection of Candidate Plus Clumps (CPCs) of *D. brandisii* based on morphological and physical properties and macropropagation of material from CPCs for producing QPM. Preliminary macropropagation trials, carried out using full culm cuttings, split (half) culm cuttings, branch cuttings without rhizome and branch cuttings with rhizomatous nodes revealed that rhizomatous branch cuttings gave maximum success in rooting (90%) within 15 days in sand medium in 1 m x 10 m propagation beds.

In vitro propagation, a rapid method for propagation of true-to-type planting material of selected genotypes can be a cost-effective method of large-scale production of QPM of *D. brandisii*. But studies have been very few in this regard. *In vitro* regeneration of *D. brandisii* through axillary shoot proliferation was reported to be characterized by low rate of shoot multiplication (Kumar *et al.*, 1999). Attempts are currently being made at IWST to develop protocols for rapid mass production of QPM through axillary shoot proliferation and somatic embryogenesis from CPCs and to evaluate the growth performance of such micropropagated plants.

Marketing and value-addiiton

Marketing and disposal of bamboo culms have been identified to be one of the major bottlenecks in bamboo sector in Karnataka. To facilitate large-scale cultivation of bamboo and enhance systematic commercialization, relaxation of the current laws on harvest restrictions and transit permits is urgently needed. Though bamboo has been exempted from permits in Coorg District, felling restrictions and transit permits continue to exist in other Districts hampering the free movement of the produce and establishment of good market linkages. Hence policy reforms pertaining to harvesting and transport of bamboo throughout the State are needed to strengthen this sector.

Returns from *D. brandisii* cultivation to stakeholders can be enhanced through value addition of the harvested culms, thereby providing incentives to farmers to undertake cultivation in a big way. The morphological features of its culms make the species ideally suited for making incense sticks. Estimates show that one culm of *D. brandisii* can fetch a revenue of about Rs. 200 when used for making incense sticks, whereas selling of a single culm locally will fetch Rs. 50 to 55 only. The market volume for incense sticks is estimated to be in the order of 4,000-8,000 tonnes per annum (Jagadish and Raghunandan, 2006). Mysore, adjoining Coorg, is one of the biggest markets and depends on bamboo supplies mainly from the North-eastern India. Similarly, medars (traditional craftsmen) who use bamboo for making handicrafts, also rely on supplies from Maharashtra and North-eastern states. The Mysore Paper Mill, which uses bamboo to meet up to 10 per cent of its raw material requirement, is expected to have a demand of 50,100 tonnes of bamboo in 2010 (Manjunath *et al.*, 2006). If proper linkages are established, Coorg has potential to fill these gaps through domestication of *D. brandisii*. Another exciting prospect lies in production and processing of bamboo shoots for edible purposes (Amarananjundeswara *et al.*, 2004). Shoots of *D. brandisii* have low fat and are a good source of soft fibre. But its value as an edible material is not properly recognized in Coorg even though pickles made from *B. bambos* are traditionally an important delicacy in Kodagu cuisine. Bamboo shoot processing ventures can be encouraged through innovative programmes involving self help groups.

CONCLUSIONS

The study concludes that proper supply of QPM, exposure to scientific management practices, value addition, and proper awareness of the economics of bamboo cultivation as well as development of marketing linkages can significantly help in domestication of *D. brandisii* in Coorg.

ACKNOWLEDGEMENT

We acknowledge National Mission on Bamboo Applications for financial assistance and Kodagu Model Forest Trust for logistic support.

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