Research Paper Economics

Optimal Rotation of Teak Plantation

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ABSTRACT

Teak is native to the Indian subcontinent. Its timber quality surpasses almost all others of its category and the same is suitable for multifarious usage. This fast growing species is worthy of study as candidate for forest economics. The Present paper considers the question of optimal rotation of the stand in a model stylized forest based on Faustmann's model. The results of analysis confirm that a rotation period of 16 to 22 years is optimum.

Keywords : Teak Forest, Faustmann's Formula, Optimal Rotation, Logistic Curve

Introduction

Teak – the Tectona Grandis – is globally famous for its timber quality which is suitable for a wide variety of applications as in furniture, flooring, doors and windows, ply wood, building boats etc. This species is originally native to India, Myanmar, Thailand and Laos. Generally, teak is a fast growing tree and occurs almost every where in India, where the best and the fastest growing specimens flourish in well irrigated and properly drained deep alluvial soils as found in the peninsular regions, while plantations in the fertile eastern regions is a great possibility. However, the plants do not grow in acidic soils.

Teak timber is famous for its excellent strength and durability and considering the high price the timber can fetch, plantations of small size may also be economically viable. Harjeet [1] considers this as a 100 % safe and profitable business and mentions plantation of 1000 saplings per acre (i.e., 2500 saplings/Hectare).

The quality of seeds, soil characteristics, drainage and topography mainly control the excellence and the rate of growth in the teak plantations. Romeijn [2] reports the yield potential in an investment programme in teak plantations in Costa Rica. The results are depicted in Fig.1. The growth of the tree continues for many years, but after attaining the age of 30 years, the growth, as reported by Centeno [3], reaches a near saturation value, of about 119 % of the 20 years value. This extrapolation has been incorporated in Fig.1.

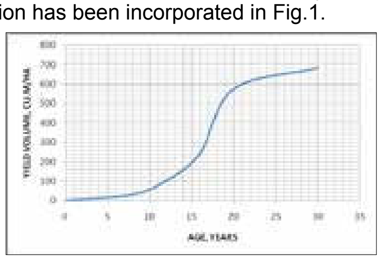

FIG. 1 YIELD POTENTIAL (Extrapolated Romeijn Data)

Economics of Exploitation

Plantations of teak, in addition to their value in business, are also valuable as amenity resource that is important for supporting the biodiversity and improving the environment.

The theory of optimal commercial exploitation was considered by Faustmann as early as 1849. He derived formulae for the optimal rotation age considering discounted cash flow. If V(t) be the growth function expressed as yield volume per hectare, R = the discount rate, and the ratio $\beta =$ Price of Timber per Unit Volume/ Cost of planting, per rotation, then Faustmann's optimal rotation [4] formula can be reproduced as under:

$$\frac{\dot{V}(\tau)}{V(\tau)-\beta} = \frac{R}{1-\exp(R\tau)} \quad \ldots \quad \ldots(1)$$

Where τ = Age at the end of rotation.

Hanley et.al. [4] discuss an analysis of optimal rotation based on equation (1).

Logistic Growth Function

The growth curve of plants is generally fitted into a sigmoidal function (or the S- curve) that is well known as Richard's curve. A generalized logistic function of this type is given below [5]:

$$Y(T) = A_1 + \frac{A_2 - A_1}{1 + A_3 \exp(-A_4(T-\tau))^{A_5}} \quad \ldots \quad \ldots(2)$$

Where, Y = Weight, size, height, etc.

A_1 = Lower asymptote

A_2= Upper asymptote

A_4 = Growth rate

T = Time

τ = Time for max growth (if $A_3.A_5=1$) .

A Stylized Teak Forest

As a pilot project, we propose a small stylized forest of 1 hectare size where 2500 teak saplings are planted. The location of this model forest is chosen in the fertile Burdwan district of West Bengal in the vicinity of a canal. However, a loss of trees at 10% will be usual. The equation for the growth curve, in relation to Romeijn data, is chosen as under:

$$v(T) = \frac{A}{[1+\exp(B-CT)]^D} \quad (3)$$

Where, A = 700; B= 4.0; C=0.2298 and D=1.11
T= Time in years (Age of the tree)

v = Volume of teak wood in m^3/hectare.
Equation (3) is a simplified version of equation (2).

The Volume – Time plot of the teak plantation is shown in Fig. 2.

FIG. 2 THE GROWTH FUNCTION
Figures and Tables

Fig. 3 shows the time path of the LHS (Left Hand Side of eq. (1), the upper curve with larger average downward slope) and the RHS (Right Hand Side of eq.(1), the lower curve with smaller average downward slope) for R=0.1 and β =1. Their intersection point marks the graphical solution of the highly non-linear equation (1). This occurs at a rotation age τ = 16.65 years (Fig. 3). The rough graphical results are fine tuned by the *interval bisection method* [6]. For better visibility of the point of intersection, we used a multiplier of 900 in the ordinates in figure 3.

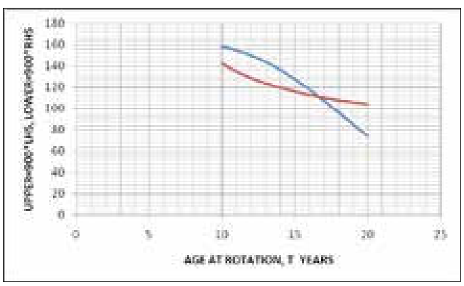

FIG. 3 THE OPTIMUM AGE OF ROTATION

Table 1 lists the Rotation Age (τ) value against some suggested values of β and R.

Table 1. Optimal Age of Rotation
For various β and R values

τ (yrs)	β	R
22.15	1	0.025
22.17	2	0.025
22.19	4	0.025
20.35	1	0.05
20.37	2	0.05
20.40	4	0.05
16.65	1	0.1
16.72	2	0.1
16.78	4	0.1

Table. 1 very clearly depicts that the Rotation Age (τ) increases with β and decreases with R. The variation in τ, however, is not very sensitive to β.

Income Earning from Rotation
We take the representative value of the Rotation Age = 16.65 years as depicted in fig. 3 (β =1 and R=0.1). The timber volume is 330 Cu. m per hectare (Fig. 2) which is the assumed size of the forest. Considering a tree loss of 10%, the net harvest volume = 297 Cu. m. At a price of Rs. 59,000 per Cu. m of timber, the net earning per rotation is Rs.1,75,2300. This result is amazing.

Discussions
The intent of the paper is to highlight how Faustmann's model formalizes the process of analytical decision making in forest economics. The results for optimal rotation period (or harvesting), for various discounted rates of cash flow (R) and price-to-planting cost ratio (β) as in Table 1, show that the optimal rotation period is 16 to 22 years and these tend to corroborate the practice adopted by plantation owners. It is documented that maintenance of a stylized teak forest can be a very profitable business.

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