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Construction of a growth model to predict the individual stem volume of *Tectona grandis* L.f. (Teak) in Sri Lanka

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Stem volume is one of the most important variables in commercial forestry since all the management decisions are taken on the volume production of trees. Also volume is the most difficult variable to measure and therefore it has to be predicted using a reliable method. Therefore, a growth model was newly constructed in this study to predict the individual stem volume of teak (*Tectona grandis* L.f.) planted as even-aged monocultures in Sri Lanka.

In order to construct the model, data were collected from 11 plantations in dry zone (Anuradhapura, Hambatota and Puttlam Forest Divisions) and intermediate zone (Kurunegala Forest Division). The selected plantations vary in age from 27 to 44 years. Stratified random sampling was used to collect the data with 0.02 ha circular sample plots. It was decided to use the Newton's formula for volume calculations and for this reason, the standing tree stems were divided into 3-5 sections and end diameters, mid diameter and length of each section were measured. The final section was assumed as a cone. The stem volume was then calculated by adding all the section volumes together. In addition to that, breast height diameter, total height and crown height were also measured. Using those data, tree volume, basal area and top height were calculated which were necessary for the analysis.

A theoretical model was developed to predict the individual tree volume using the relationship of tree volume with form factor, basal area and total height. Three site factors and four transformations which are biologically accepted were used to enhance the quality of the models. When tested for the site differences using top height/age index, five classes were identified from the 11 plantations. At the first stage of analysis, the data of each site class were fitted separately to the basic model structures. As a result, eight common models were identified for all five site classes with R^2 over 91.0 and good standard residual distributions. However, the regression parameters were different for different site classes even for the same model structure.

In order to eliminate the difficulty of using different parameter sets for different site classes, data collected from all plantations were pooled and fitted at the second stage to the selected eight models and new parameter sets were estimated. Then the normal residuals were calculated separately for five site classes using those models and tested using one way ANOVA. Only one model indicated the non-significant residuals for all site types, i.e., $v^{1/2} = 0.5730\,(basal\ area * total\ height)^{1/2} + 0.0235\,[1/(top\ height / age)]$. That model indicated negligible bias (-0.002) and very high modelling efficiency (0.91). When validated with the reserved data which were not used for model building, it indicated a good distribution of normal residuals. Finally it was concluded that the selected model proved its ability of predicting the unbiased volume of individual teak stems of all site classes in Sri Lanka and therefore it is recommended to use in the field.

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Estimation of change of taper with age for *Tectona grandis* L. f. (Teak)

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Taper is the change of diameter over a specified length along the tree stem, which varies not only by species and site type, but also by diameter at breast height (dbh), height and other tree growth parameters. Taper is important for the foresters to estimate the upper stem diameters especially in volume calculations.

The main objective of the present study was to find out the variation of taper with different ages for *Tectona grandis* L. f. (teak). For this reason, three teak plantations of 22, 27 and 35 years of age were selected from the Block 01 in Kotagoda plantation, Ampara Forest Division. Selection of these three plantations from a single Block was done to minimise the effect of the site quality on tree growth. Data were collected from randomly laid out 14 circular plots of 0.05 ha. The trees in sample plots were measured for dbh, total height and sectional diameters at 5m and 10m along the stem.

In order to estimate the taper variation, the equation developed by Kozak *et al* (1969) for Douglas fir in Western Colombia was used. This equation is given below and it is considered as one of the best models developed to estimate the upper stem tree diameters.

$d^2 / dbh^2 = b_0 + b_1(h/H) + b_2(h^2/H^2)$;

where d = diameter at height h and

H = total height

At the first stage, the data were fitted to the selected equation separately for each age and the regression parameters were estimated separately without changing the basic structure of the original equation.

It was observed that the parameter b_0 and b_2 were positive values and increased from age 22 to 27 and then decreased from that to age 35. The parameter b_1 was a negative value which decreased from age 22 to 27 and then increased from that to age 35.

When the results were examined further, it was observed that the taper is decreasing with the age proving that the teak tree stems become more conical with the age, i.e., the diameter difference increases with age for a fixed length along the stem.

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Predicting the optimal rotation length of Teak plantations using a simulation model

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The traditional problem in Forest Economics has been mainly dealt with the estimation of optimal rotation length for sustainable management. However, given the limitation of the availability of time series data on growth and management in forest plantations in Sri Lanka, such estimations are not feasible. Against this background, this study attempted to develop a simulation model and predict rotational interval of teak plantation under different management conditions.

A field survey was conducted to identify the plantation related parameters in the Kurunegala District. Meantime, a simulation model was developed with Microsoft Visual Basic and Microsoft Excel using the equations specified in the Teak Management Plan (1997) to supplement the field data. The past data obtained from the Forest Department was used to parameterize the model. Using the age and the height of a plantation at a particular time, the model was capable of predicting the plantation related parameters such as dbh and timber volume over the time.

According to the values predicted by the simulation model, four different categories were identified based on the site index, which represents the level of growth of a stand. Rotational interval was estimated using the Faustman rotational model at different discount rates. Thereby it was estimated that the rotational intervals for the four categories at discount rates 10%, 15% and 20% as 19, 17 and 15 years respectively. The internal rate of return obtained through the simulation was above the market rate of 12%. Though the model yielded shorter rotational intervals than the present field values, the approach could be used in future with more reliable field data.