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Site Index for Teak (*Tectona grandis* Linn. F.) in Forest Plantations of Bangladesh

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ABSTRACT

Site is an important factor, which gives an idea how a particular tree species perform over different sites. Among the different asymptotic models developed for age and height data, the Chapman-Richards generalization of Bertalanffy's growth model was found to be the most suitable for *Tectona grandis* grown in Bangladesh. This model was diverted in the form of site index (SI), which gave the top height of a stand at a given reference age for different sites. The reference age was considered as 40 years. The maximum top height was observed at 23 m and the minimum was 3.5 m. Two site classes were developed through the "guide curve method". The lower limit and the upper limit of these curves (top height) at the reference age of 40 years were 20 and 22 m, respectively and the classes were placed at 2 m interval at the reference age.

Key Words: Teak; Bangladesh; Site classes; Top height; Reference age

INTRODUCTION

Teak (*Tectona grandis* Linn. F.) has always been the principal species in the plantation programs of Bangladesh. More than 70% of total plantation in hill forests is composed of teak (Rahman, 1982). Teak is not indigenous to Bangladesh. The species was introduced from Myanmar (former Burma) during 1871 at Sita pahar Range, Kaptai forests of Chittagong Hill Tracts. Till 1998, 216000 hectares were raised by teak.

Site is an important phenomenon in both natural and plantation forests, which is reflected by the growth and the development of a forest stand. Edaphic and climatic are the two main factors influencing the characters of a site in plantation. In forestry studies, the site quality has been evaluated with the help of different indices. There is no single index based directly on environmental parameters, which show sufficient precision in forest management and modeling. Wood production may be the best indicator of site productivity, but measuring volume production is a difficult task and it is not comfortable to use an easier method (Vanclay, 1994).

The objective of this study was to develop a site index system and site classes for *Tectona grandis* with special to the forest plantations in Bangladesh.

MATERIALS AND METHODS

Study areas and data collection. The study areas used for this investigation were Chittagong and Sylhet forest divisions, where teak (*Tectona grandis*) was the main plantation species. Chittagong forest division lies between 21° 50′and 23° 00′ North Latitude and 91°30′and 92° 10′ East Longitude. It falls under the agro-ecological regions of Chittagong coastal flood plain. Chittagong Hills is a broad plain, cut by rivers draining into the Bay of Bengal that rises to a final chain of low coastal hills, mostly below 200 m, that attain a maximum elevation of 300 m. The Sylhet forest division lies between 23° 55′and 25° 02′ North Latitude, and 90° 55′and 92°30′ East Longitude. The Sylhet hills are low with an altitudinal range from 50 to 150 m. It falls under Eastern Surma Kusiyara flood plain.

Since the sampled areas were plantations i.e. in several occasions the trees were planted in rows, square plot design were used to demarcate the sampling plots. In a beat, age was stratified i.e. sampling was done in different age groups in a beat. To have a meaningful mean and variance that are the components of population mean and variance, every stratum (age) must have a minimum of two sampling units (Philip, 1996). Therefore, minimum of five sampling units were chosen for each age group. Sampling units were chosen randomly and the size of a sampling unit was 20 m × 20 m. Total 50 temporary sample plots were taken from both study areas. In sloping side, during the plot establishment the slope correction was carried out.

Stand height. In even-aged stands the most used site quality assessment is through *site index*, the dominant stand height attained at a given reference age. It gives an idea how a particular tree species performs over different sites. Stand height can be used as an estimator of site productivity of a stand which is good enough to reflect the maximum potential height on that site (Vanclay, 1994). Height growth

is relatively independent of stand density and thus much not affected by thinning (Gadow & Hui, 1999).

RESULTS AND DISCUSSION

In this study, different asymptotic models were applied for the whole height-age data points, to get the best fit. In this work, top height is defined as the average height of 100 largest diameter trees per hectare of a stand. Table I shows the summary of different asymptotic and fitted models for age and top height (refers to dominant height). The most appropriate model was then used to predict the site index at a given stand and dominant height. Fitted models for top height and age relationship of *Tectona grandis* in Bangladesh is shown in Table I.

Equation 1 is the Chapman and Richards's generalization of Bertalanffy's growth model. This model is rather popular and commonly used in even-aged plantations. Also it has proved to be the best fitted model among the others.

The reference age used in site index is often confused and sometimes chosen arbitrarily with several reference ages for a particular species (Gadow & Bredenkamp, 1992). The reference age used for *Tectona grandis* in Bangladesh is 40 years to gain financial maturity. This rotation age is compatible with economic demand of forestry.

Equation 1 (in Table I) can be rewritten and used as a height growth predictor. Then using the rewritten equation 5, the top height to be (H_2) at a projected age t_2 can be predicted for a given top height H_1 at the age t_1.

$$H_2 = H_1\left[\frac{1-e^{-0.03679\cdot t_2}}{1-e^{-0.03679\cdot t_1}}\right]^{1.080} \qquad (5)$$

By substituting the variable t in equation 1 with the site index reference age, the site index (SI) can be derived. It is often assumed that only the asymptote or scale parameter α varies with site index, while the slope of the growth curve as determined by parameters β and γ is the same for all site indices. The curves for all site indices having the same shape under this assumption are called as anamorphic curves (Gadow & Bredenkamp, 1992). Therefore, the general equation for site index can be given as follows:

$$SI = \alpha\left[1-e^{-0.03679\times t}\right]^{1.080} \qquad (6)$$

Then, the equation 5 can be rewritten as equation 7, considering 40 as the reference age. This can be used to describe the height development over age for a given site index.

$$SI_{40} = H\frac{\left[1-e^{-0.03679\times 40}\right]^{1.080}}{\left[1-e^{-0.03679\times t}\right]^{1.080}} \qquad (7)$$

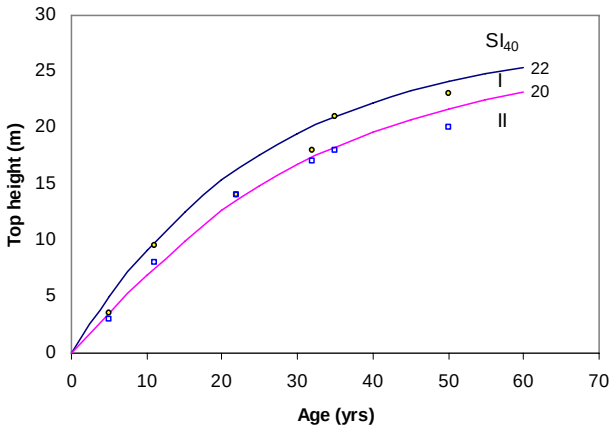
Site index is an important parameter in Silvicultural studies. Therefore, developing site classes is a primary tool for management practices, which are closely related with site factor. For example, developing volume tables i.e. volume tables are developed for different site classes. This concept is difficult to discuss or explain because; different countries use their own system. For instance in Germany, the yield table developed by Assmann-Franz is based on the top height, is used (Sivananthawerl, 2001). In British yield tables, the site classes are based on mean annual increment (MAI) (Van Laar & Akca, 1997). In this study, site classes

Table 1. Fitted models for top height and age relationship of *Tectona grandis* in Bangladesh

Models	Model parameter values			R^2
	α	β	γ	
Chapman and Richards: $H = \alpha\left[1-e^{-\beta\cdot t}\right]^{\gamma}$ (1)	27.96	0.03679	1.08075	0.99
Cilliers-Van Wyk: $H = \alpha\left[1-e^{-\beta(t-\gamma)}\right]$ (2)	28.03	0.03556	0.78409	0.99
Lundqvist: $H = \alpha\left[e^{-\beta\cdot t^{-\gamma}}\right]$ (3)	62.53	5.81385	0.45311	0.99
Gompertz: $H = \alpha\cdot\beta^{\gamma^t}$ (4)	17.98	0.00001	0.71420	0.86

where
H = Top height (m)
t = Age (yrs)
α, β, γ = Model parameter
(α is an asymptote or scale parameter of dependent variable, β scales the time axis, while γ offers the shape of the curve)

Fig. 1. Site classes and site index curves for *Tectona grandis* in Bangladesh (the reference age is 40 years)



are based on top height. Fig. 1 shows the site classes and the curves are leveled from 20 to 22, where the level refers to top height attained at a reference age of 40 years thus indicates the site index. These curves are anamorphic and derived through the "guide curve method".

In this study, site classes were divided into two classes. Class (I) referred the best site quality and class (II) having moderate quality. In Bangladesh, *Tectona grandis* is grown in more or less similar site conditions. If the classes are not placed so widely, it is easy for a Beat Forest Officer or Range Forest Officer (RFO), to classify the stands (beat & blocks) under different classes for management purposes.

CONCLUSION

Two site classes were developed on the data available on *Tectona grandis* grown in Bangladesh. Among these two site classes, class one (I) had the best site quality over site class (II).

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