Estimation of Site Index of Teli Garjan (*Dipterocarpus turbinatus* Gaertn. F.) in Bangladesh

M. A. Latif
Bangladesh Forest Research Institute, P. O. Box 273
Chittagong 4000, Bangladesh

Abstract

Teli garjan (*Dipterocarpus turbinatus*) is the most important indigenous species included for long term plantation programme in Bangladesh. Site indices models have been derived for the species in the plantations of Bangladesh. The selected models derived in the study could be satisfactorily used for teli garjan plantations having ages 3-60 years and site indices of 25-55 metres based on a base age or rotation of 45 years.

সারসংক্ষেপ

বাংলাদেশের বন বাগানে লাগানো স্থানীয় বৃক্ষ প্রজাতির মধ্যে তেলী গর্জন একটি অন্যতম প্রধান প্রজাতি। আলোচ্য গবেষণায় সৃজিত বাগানে তেলী গর্জন প্রজাতির গাছের সাইট ইনডেক্স মডেল নির্বাচন করা হয়েছে। ৪৫ বছর বেস বয়স অথবা আবর্তন কাল হিসাবে নির্বাচিত মডেল ৩-৬০ বছর বয়স ও ২৫-৫৫ মিটার সর্বোচ্চ উচ্চতাবিশিষ্ট বাগানের জন্য সন্তোষজনকভাবে ব্যবহার করা যাবে।

Key words : Bangladesh, *Dipterocarpus turbinatus*, site index

Introduction

Management regime, genetic variation, stand age, site quality, and stand densities are the main factors affecting growth and yield of trees. An area where trees grow and the capacity of that area to support tree growth are the two main implications of site quality in forestry. Site has been considered traditionally an independent variable in yield studies, because site quality is a term commonly referred to indicate the productive capacity of the forest area for a given species. Soil, climate, biotic and other ecological factors also affect the ability of the forest area to produce vegetation. Volume, height, and soil with few vegetation are some of the measurable units of site indicators of the forest. In forestry, the mean height of 100 dominant and co-dominant trees per hectare is used to determine the site quality. This is called a site quality index at a given age. The site index curves express the growing conditions of stands in a particular locality and predict future growth of stands that now have a specified height. The growth rate and yield of a species at different sites are estimated by laying out permanent sample plots and collecting data for analyses. It takes time from the data of establishment to the date of harvesting. Now-a-days growth and yield of different species are determined by collecting data from temporary sample plots. For the present study site indices models have been derived with the data collected from temporary and permanent sample plots.

There have been many researches conducted to determine the site quality of a

plantation. Some recent works were done by Furnival and Wilson (1970), Lignan (1980), Monoy (1981), Cacanindin (1982), Pinol *et al.* (1982), Gonzales (1985) and others.

Teli garjan (*Dipterocarpus turbinatus* Gaertn. F.) is the most important indigenous species used for long rotation plantations in Bangladesh. The species, in general, is planted in pure stands and sometimes mixed up with teak (*Tectona grandis* L.) and dhakijam (*Syzygium grande*). Very little work has been done on the estimation of growth and yield of teli garjan. Taper series have been estimated for the species (De Milde and Chowdhury 1985). Some studies on the growth and yield for the species have also been done (Ahmed and Dalmacio 1989). These studies were carried out with the data collected during the time of forest inventory of the forests of Cox's Bazar and Chittagong in 1987. They have used the mean height of 100 to 600 dominant and co-dominant trees per hectare instead of 100 trees per hectare as dominant height for estimation of site index guide equation.

The growth information of this species is not adequate and cannot be used to develop any age-growth equation (Kingston 1979). Therefore, an attempt was made in the present study to determine site indices for the species with wide range of data collected from major plantations in Bangladesh.

Material and methods

Permanent sample plots (PSP) were laid out in the available plantations. The plots were square in size with an area of 0.05 ha each. Heights of the fattest five trees were measured for estimation of the dominant height of the plots for a period of 9 years. There were only 25 permanent sample plots. Therefore, temporary sample plots (TSP) were laid out in the available plantations to supplement the data. Forest Ranges with plantations having maximum age ranges were selected. From each plantation three plots were selected at random. The plots were squares of 0.02 ha each in general. The total heights of the fattest two trees in each plot were measured. In the plantations with sparse trees, the plots were of 0.03 to 0.05 hectare so that each TSP included at least 10 trees per plot to get acceptable mean dbh and height. In such cases, heights of 3 to 5 fattest trees were taken to estimate the mean dominant height.

The mean height of the fattest trees measured were taken as dominant height of the stand. The ages of the trees were recorded from the plantation journals by subtracting the date of plantation from the date of measurements. For the selection of the best suited site index guide models, models were tested subject to the satisfaction of the statistical and biological requirements. Statistical requirements included the analyses of variance, coefficient of determination (R^2) and adjusted R^2. The biological requirement was that the yield curves should be sigmoid. Validations of the models were also done by using data from 30 separate sample plots. This was done by comparing the estimated and observed values, applying the chi-square test of goodness of fit and paired t-test. This was also compared with 45 degree line test by plotting the observed values and the predicted value in the graph. The site index models or equations derived so far may be rewritten in the form :

1) $H = b_0 A^{b1}$ (i)

2) Schumacher model, modified by adding a constant

$H = b_0 * \exp(b_1 A^{-k})$ (ii)

for a particular site index

$S = H^{b1} (Ac^{-k} - A^{-k})$ (iii)

3) Chapman-Richards model

$H = b_2 * (1 - e^{-b_1 * A}) b_3$ (iv)

for a particular site index

$S = H (1 - e^{-bA}0)/(1 - e^{-BA})^c$ (v)

4) Lars strand equation

$$H = \frac{A}{(b_0 + b_1 A)^3} \quad \text{(vi)}$$

where,

b_0 = intercept
b_1 = slope
b_2 = asymptote
b_3 = inflection point
H = mean total height in metres of 100 dominant and co-dominant trees per hectare
A = age of the plantation in years
S = Site Index (dominant height at reference age)
A_0 = reference age or rotation age
e = base of natural logarithms
k = constant selected on the basis of lowest residual sum of squares whose value varies between 0.2 to 2.0

Model (i) gives more or less sigmoid curves but sometimes they tend to be straight lines if there are insufficient data for the two extremes, for younger and older ages. Model (ii) considers the problem of concavity of the growth curve. The tree growth rate is slow in the intital ages of establishment and subsequently the rate becomes higher followed by gradually slower and slower and ultimately it approximates a steady state. This results in the formation of a curve concave in the younger ages and convex at the older ages. To take care of the growth performance in the older ages, the logistic model 3 is being used. It takes care of both concavities at the younger ages and convexity at the older ages.

Results and discussions

The site index Model (ii) was found to be suitable for teli garjan in the forests of Bangladesh. The specific form of the equation is given by :

$$\log(H) = 5.90445 - 5.95239 / A^{02}$$

The coefficient of determination (R^2=0.871) of the selected site index model explains about 87.1% of the total variations. The site index guide curve is given in Fig. 1.To obtain the site index for each plot, a reference age or rotation of 45 years was used and the specific equation is given by :

Figure 1. Site index guide curve for *Dipterocarpus turbinatus* in plantations of Bangladesh.

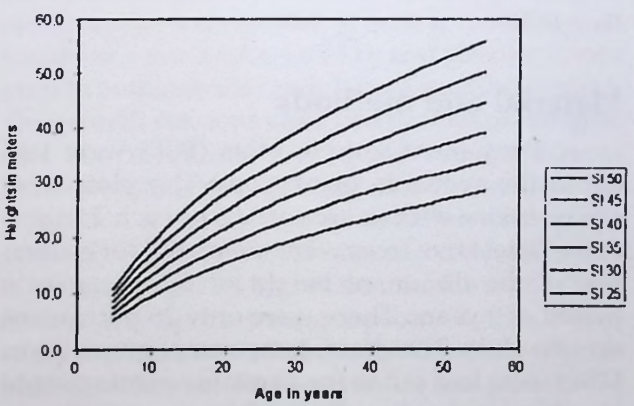

Figure 2. Height growth curves for *Dipterocarpus turbinatus* in plantations of Bangladesh.

Table 1. Height growths for *Dipterocarpus turbinatus* in plantations of Bangladesh.

Age (years)	Height in metres at site indices						
	25	30	35	40	45	50	55
05	5.4	6.5	7.5	8.6	9.7	10.8	11.9
06	6.3	7.5	8.8	10.1	11.3	12.6	13.8
07	7.1	8.6	10.0	11.4	12.8	14.3	15.7
08	7.9	9.5	11.1	12.7	14.3	15.9	17.5
09	8.7	10.4	12.2	13.9	15.7	17.4	19.1
10	9.4	11.3	13.2	15.1	17.0	18.8	20.7
11	10.1	12.1	14.2	16.2	18.2	20.2	22.3
12	10.8	12.9	15.1	17.2	19.4	21.6	23.7
13	11.4	13.7	16.0	18.3	20.6	22.8	25.1
14	12.0	14.4	16.8	19.3	21.7	24.1	26.5
15	12.6	15.2	17.7	20.2	22.7	25.3	27.8
16	13.2	15.8	18.5	21.1	23.8	26.4	29.0
17	13.8	16.5	19.3	22.0	24.8	27.5	30.3
18	14.3	17.2	20.0	22.9	25.7	28.6	31.4
19	14.8	17.8	20.7	23.7	26.7	29.6	32.6
20	15.3	18.4	21.5	24.5	27.6	30.6	33.7
21	15.8	19.0	22.1	25.3	28.5	31.6	34.8
22	16.3	19.6	22.8	26.1	29.3	32.6	35.9
23	16.8	20.1	23.5	26.8	30.2	33.5	36.9
24	17.2	20.7	24.1	27.6	31.0	34.5	37.9
25	17.7	21.2	24.7	28.3	31.8	35.3	38.9
26	18.1	21.7	25.4	29.0	32.6	36.2	39.8
27	18.5	22.2	26.0	29.7	33.4	37.1	40.8
28	19.0	22.7	26.5	30.3	34.1	37.9	41.7
29	19.4	23.2	27.1	31.0	34.9	38.7	42.6
30	19.8	23.7	27.7	31.6	35.6	39.5	43.5
31	20.2	24.2	28.2	32.3	36.3	40.3	44.4
32	20.5	24.7	28.8	32.9	37.0	41.1	45.2
33	20.9	25.1	29.3	33.5	37.7	41.9	46.0
34	21.3	25.6	29.8	34.1	38.3	42.6	46.9
35	21.7	26.0	30.3	34.7	39.0	43.3	47.7
36	22.0	26.4	30.8	35.2	39.6	44.0	48.4
37	22.4	26.8	31.3	35.8	40.3	44.7	49.2
38	22.7	27.3	31.8	36.4	40.9	45.4	50.0
39	23.1	27.7	32.3	36.9	41.5	46.1	50.7
40	23.4	28.1	32.8	37.4	42.1	46.8	51.5
41	23.7	28.5	33.2	38.0	42.7	47.5	52.2
42	24.1	28.9	33.7	38.5	43.3	48.1	52.9
43	24.4	29.2	34.1	39.0	43.9	48.7	53.6
44	24.7	29.6	34.6	39.5	44.4	49.4	54.3
45	25.0	30.0	35.0	40.0	45.0	50.0	55.0
46	25.3	30.4	35.4	40.5	45.6	50.6	55.7
47	25.6	30.7	35.9	41.0	46.1	51.2	56.3
48	25.9	31.1	36.3	41.5	46.6	51.8	57.0
49	26.2	31.4	36.7	41.9	47.2	52.4	57.6
50	26.5	31.8	37.1	42.4	47.7	53.0	58.3

$$\log(S) = \log(H) + 5.90445/A^{0.2} - 2.780026$$

where, S is the site index of an individual plot at a base age of 45 years.

The selected models satisfied all the above mentioned statistical criteria. The predicted values were plotted against age for different site indices. The growth curves were sigmoid. The growth curves also showed that at a given stand age, higher growth is expected on better sites. The computed chi-square, t-value, slope and absolute deviation percent were 6.07, 1.21, 44.4 and 8.4 respectively. The height growth curves are given in Fig. 2. The dominant heights for different site indices were estimated and are given in Table 1. The results of the study can safely be used for stand ages of 3 to 60 years and site indices from 25 to 55 metres at a reference age of 45 years.

References

Ahmed, I. U. and Dalmacio, M. V. 1989. *Growth and Yield of Garjan*. Working Paper No. 23, FAO/UNDP Project BGD/85/085, Assistance to the Forestry Sector Phase-II, Bano Bhaban, Mohakhali, Dkaha. 42 pp.

Cacanindin, D. C. 1982. *Tree Volume, Yield and Economic Rotation of Kaatoan Bangkal Plantations in Agusan del Norte*. M. S. Thesis, University of the Philippines at Los Banos, College, Laguna. 94 pp.

De Milde, R. and Chowdhury, J. A. 1985. *Taper Series for Volume Calculation*. Working Paper No. 6B, FAO/UNDP Project BGD/74/017, Assistance to the Forestry Sector, Bano Bhaban, Mohakhali, Dhaka. 21 pp.

Kingston, B. 1979. *A Compendium of Mensuration Statistics*. Field Document No. 7, UNDP/FAO Project BGD/72/005, Bangladesh Forest Research Institute, Chittagong. 72 pp.

Furnival, G. M. and Wilson, R. M. 1970. *System of Equations for Predicting Forest Growth and Yield*. School of Forestry and Environmental Studies, Yale University. 17 pp.

Gonzales, L. L. 1985. *Growth and Yield Prediction Model for Teak (*Tectona grandis *Linn.) Plantations*. M. S. Thesis, Univresity of the Philippines at Los Banos, College, Laguna.

Lignan, L. B. 1980. *Growth and Yield Prediction for Yemane Plantations in the Philippines*. M. S. Thesis, University of the Philippines at Los Banos, College, Laguna. 105 pp.

Monoy, R. E. 1981. *A Yield Prediction Model for Giant Ipil-ipil* (Leucaena leucocephala *Lam. De Wit.*). M. S. Thesis, College of Forestry, University of the Philippines at Los Banos, College, Laguna. 68 pp.

Pinol, A. A.; Uriate, M. T. and Torres, F. G. 1982. *Growth/Yield Prediction and Economic Rotation of* Albizia falcataria *on Selected Plantations in Mindanao*. Technical Paper, FORI, College, Laguna. 55 pp.