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SITE QUALITY ASSESSMENT OF YOUNG CHIR PINE PLANTATIONS

D. Dalai, B. Gupta*, N. K. Gupta & O. P. Sambhar

Department of Silviculture and Agroforestry, Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.), India 173 230

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DALAI, D., GUPTA, B., GUPTA, N. K. & SAMBHAR, O. P. 2000. Site quality assessment of young chir pine plantations. Site quality assessment was made for four 19-y-old chir pine plantations around Solan Forest Division in Himachal Pradesh, India, using 3-, 4-, 5-, 6- and 7-y mean internodal lengths (height intercepts) from the breast height. Out of all the height intercepts, the 6-y height intercept showed the best result and hence was used for categorisation of sites for their site quality.

Key words: Chir pine - site quality - height intercept - internodal length - models - forest sites

DALAI, D., GUPTA, B., GUPTA, N. K. & SAMBHAR, O. P. 2000. Penilaian kualiti tapak bagi ladang chir pine muda. Penilaian kualiti tapak dilakukan terhadap empat ladang chir pine yang berumur 19 tahun di sekitar Solan Forest Division di Himachal Pradesh, India dengan menggunakan panjang ruas min 3, 4, 5, 6 dan 7 tahun (tampanan ketinggian) dari ketinggian aras dada. Daripada kesemua tampanan ketinggian, tampanan ketinggian 6 tahun menunjukkan keputusan terbaik dan dengan itu digunakan untuk mengkategorikan tapak bagi kualiti tapaknya.

Introduction

Chir pine (*Pinus roxburghii* Sargent) is one of the most important conifers of the Western Himalayas, especially in the mid-hills of Himachal Pradesh. As the extent of distribution of this species is very large, chir pine grows on a wide variety of soil and topographic conditions. This provides great contrast in site quality and tree growth and thus, the measurement of site quality is very important as it plays a pivotal role in forest management. The number of site indices for afforestation is derived either directly or indirectly (Hocker 1979). The species showing distinct annual whorls provides an alternate method known as 'height intercept', developed by Wakeley and Merrero (1958), which employs the measurement of first few internodal lengths and has been considered a quick and reliable method by Day *et al.* (1960), Beck (1971), and Brown and Stires (1981). This method has been globally used to determine site quality of young conifers, too young for the

*Author for correspondence.

conventional method of evaluating site quality, by recording age and top height, and avoids the necessity of using different age classes while assessing the site quality of any conifer forest.

The purpose of our present study was to classify the young chir pine plantations of age 19 y for their site qualities using the height intercept method. The rotation period of the species is 120 y. The height intercept method offers a direct measurement of site quality and enables early classification of young stands until they become old enough for evaluation by conventional site index method.

Material and methods

The present study was conducted in the northwestern part of India, i.e. Himachal Pradesh (H.P.), during 1996. The Solan forest division (30° 5'–31° 15' N, 76° 42'–77° 20'E), which forms the western part of southern H.P., was selected for this purpose. Information on the distribution of young chir pine plantations (< 20 y old) in the Solan forest division was collected from forest records and plantations of different ages were recorded. A maximum of four plantations of age 19 y were recorded and selected for study.

These plantations are: Thurni – Oachghat (site 1), D-192 Nabapratha beat – Sultanpur (site II), D-91 Bhawan-ki-Dhar beat – Barog (site III) and Salhari plantation – Kandaghat (site IV). These plantations are located in different ranges of the Solan forest division. Details of the four plantations are given in Table 1. The climate of Solan is mostly sub-tropical. Rain is received during the rainy as well as in the winter season. The total annual rainfall in this region is around 100 cm of which about 80% is received during the rainy season. Maximum and minimum mean monthly temperatures were recorded in May (31.2 °C) and January (3.1°C) respectively.

Table 1. Details of the study sites

Site	Name of the compartment/ plantation	Stand density (trees ha^{-1})	Aspect	Elevation (m asl)
Site I	Thurni plantation – Oachghat	360	South–West	1300
Site II	D-192 Nabapratha beat – Sultanpur	330	North–East	1300
Site III	D-91 Bhawan-ki-Dhar beat – Barog	340	North–West	1350
Site IV	Salhari plantation – Kandaghat	320	North–West	1350

In each plantation, five sample plots, each of 0.1-ha area, were demarcated and five trees were selected randomly in every sample plot for observation. In all 100 trees in the four sites were selected for site quality evaluation. The total height of each tree was measured using a Spiegel Relaskop. The height of the trees up to 3, 4, 5, 6 and 7 internodes was determined by a graduated staff and these values were computed to determine different height intercepts, viz. X_3, X_4, X_5, X_6 and X_7. The data were regressed by taking the total height (m) as the dependent variable and mean internodal length (cm) of 3, 4, 5, 6 and 7 internodes (height intercepts) from the breast height as the independent variable. The following linear, curvilinear and log-linear models were used to derive the relationships:

Linear model : $Y = a + bX$
Curvilinear model : $Y = a + bX + cX^2$
Log-linear model : $LnY = a + bLnX$

where

Y = total height of tree
X = X_3, X_4, X_5, X_6 and X_7 (which represent mean of 3, 4, 5, 6 and 7 internodal lengths in centimeter respectively from breast height and
LnY = natural log of total height of tree

Results and discussion

All the curvilinear models were found to be non-significant when tested by *t*-test. However, the linear and log-linear models were significant. Among the different linear and log-linear models tested for X_3, X_4, X_5, X_6 and X_7 height intercepts, the mean of six internodal lengths, i.e. X_6, showed maximum adjusted R^2 value (Table 2). A linear and log-linear model having highest adjusted R^2, i.e. $Y = 4.1950 + 0.0606\ X_6$ (adjusted $R^2 = 0.4769$) and $LnY = 0.7956 + 0.3661\ LnX_6$ (adjusted $R^2 = 0.4678$) were further tested to determine the best model out of the two. The log-linear model was transformed into linear form using standard procedure. The adjusted R^2 value so obtained was 0.4656 which was still less than the adjusted R^2 value of the linear model (0.4769). On that basis, the linear model was considered and selected finally as the best fit model for determination of site quality as given below:

$$\text{Height}_{19} = 4.1950 + 0.0606\ X_6, \text{ (adjusted } R^2 = 0.4769) \quad (0.0064)$$

where Height_{19} = total height (m) of the tree at age 19 y
X_6 = mean internodal length for the first six internodes taken from the breast height

Table 2. Allometric relationships between total height (Y) and 6-y height intercepts (X_3, X_4, X_5, X_6 and X_7) of 19-y-old chir pine trees

Sr. No.	Model	Adjusted R^2
	Linear models	
1.	$Y = 4.7656 + 0.0492X_3$ (0.0062)	0.3792
2.	$Y = 4.4384 + 0.0553X_4$ (0.0064)	0.4273
3.	$Y = 4.3209 + 0.0579X_5$ (0.0064)	0.4428
4.	$Y = 4.1950 + 0.0606X_6$ (0.0064)	0.4769
5.	$Y = 4.1785 + 0.0617X_7$ (0.0067)	0.4588
	Curvilinear models	
6.	$Y = 5.1059 + 0.0376X_3 + 0.00009X_3^2$ (0.0405) (0.0003)	0.3733*
7.	$Y = 5.8141 + 0.0424X_4 + 0.0001X_4^2$ (0.0440) (0.0003)	0.4160*
8.	$Y = 4.6463 + 0.0466X_5 + 0.00009X_5^2$ (0.0430) (0.0003)	0.4374*
9.	$Y = 4.3875 + 0.0538X_6 + 0.00005X_6^2$ (0.0490) (0.0004)	0.4662*
10.	$Y = 4.3179 + 0.0567X_7 + 0.00004X_7^2$ (0.0521) (0.0004)	0.4533*
	Log-linear models	
11.	$LnY = 1.0628 + 0.2977LnX_3$ (0.0394)	0.3069
12.	$LnY = 0.9304 + 0.3309LnX_4$ (0.0405)	0.3987
13.	$LnY = 0.8709 + 0.3466LnX_5$ (0.0399)	0.4292
14.	$LnY = 0.7956 + 0.3661LnX_6$ (0.0390)	0.4678
15.	$LnY = 0.7824 + 0.3705LnX_7$ (0.0402)	0.4582

* not significant as tested by *t*-test.

X_3 = mean internodal lengths of first 3 internodes from breast height.
X_4 = mean internodal lengths of first 4 internodes from breast height.
X_5 = mean internodal lengths of first 5 internodes from breast height.
X_6 = mean internodal lengths of first 6 internodes from breast height.
X_7 = mean internodal lengths of first 7 internodes from breast height.

Thus, 6-y mean internodal length (X_6) starting from the breast height was the best estimator for the site quality of chir pine trees of age 19 y. Though the other mean internodal lengths, i.e., X_3, X_4, X_5 and X_7, also showed significant results, their significance values were less compared to that for X_6. Beyond X_6 the precision of determination was found to decrease. Five-year growth intercept method for

site quality assessment has been used by many scientists around the world (Wakeley & Marrero 1958, Day *et al.* 1960, Beck 1971). Fewer than the first three internodal lengths starting from the breast height are usually less precise due to year to year variations in growth (Smith & Ker 1956) and hence were not taken into consideration. The internodal length taken from the breast height was preferred to the internodal length from the base of the tree, because height up to the breast height is often affected by irregular growth of seedlings due to fluctuating environmental conditions, weed competition, stock quality, planting methods, injuries, etc. (Ferree *et al.* 1958, Day *et al.* 1960, Brown & Stires 1981) and may not be the true manifestation of the site quality.

In the present study, the total height of the trees in the four sites varied from 5 to 10.5 m. On the basis of the 6-y height intercept, a wide variation in height intercept of the 19-y-old chir pine trees was recorded in four sites. The values ranged from 35 to 98 cm (Figure 1), which shows that the chir pine trees of the same age grow differently in different sites revealing differences in site quality. Keeping in view the significant difference in the 6-y height intercept of trees in the four sites, a broad classification was done to classify the chir pine sites as: poor—sites showing less than 45 cm height intercept (site I), average—sites showing height intercept between 45 and 60 cm (sites II & III), and good—sites showing more than 60 cm height intercept (site IV). A similar classification for site quality differentiation has been given by Applegate and Gilmour (1988) for chir pine in Nepal, and Sahu (1997) in Himachal Pradesh, India.

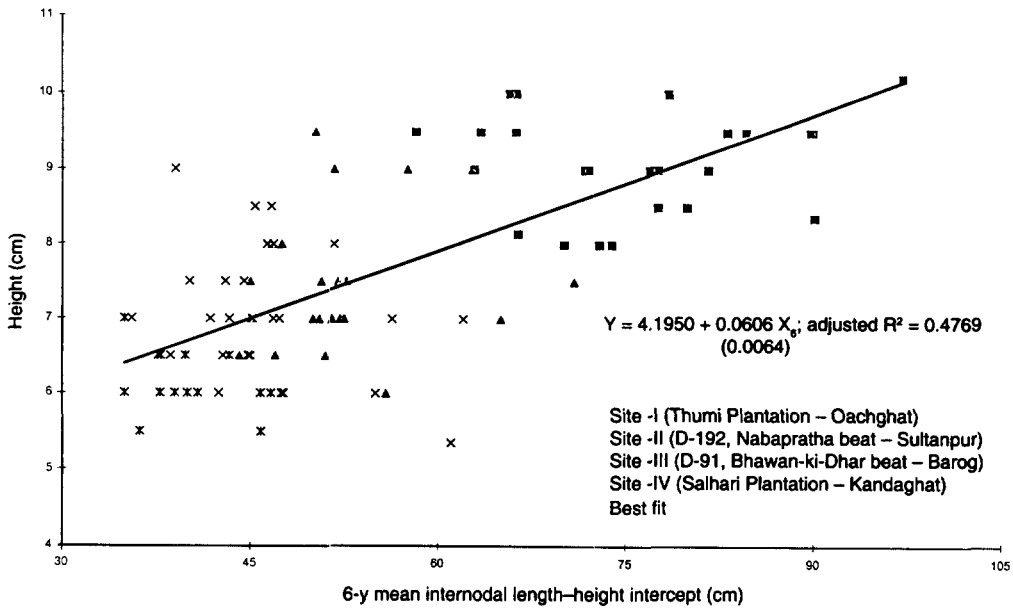

Figure 1. Relationship between 6-y height intercept and height at age 19 y of chir pine plantations

Conclusion

The height intercept method for categorising site quality of young chir pine plantations is simple and quick compared to the frequently used age–height curve method, which requires mid-rotation aged stands and is time consuming. The results obtained in the present study clearly indicate that 6-y mean internodal length can be reliably used for an early assessment of site quality. It gives an indication of the performance of the young chir pine trees growing at different sites in the years to come. Moreover, this method can be used to determine the site quality of the chir pine plantations which have grown for only 6 y beyond the breast height and are too young for categorisation by the conventional method. However, the validity of site quality classification done by the height intercept method needs to be substantiated by taking observations through the conventional method.

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