ROTATION AGES OF KEORA (*SONNERATIA APETALA* BUCH.-HAM.) IN THE COASTAL PLANTATIONS OF BANGLADESH

M. A. Latif
R. A. Del Castillo

ABSTRACT

Keora (*Sonneratia apetala* Buch.-Ham) is the principal species in the coastal plantations of Bangladesh. Rotation ages were estimated for the species considering four important criteria. It was observed that the rotation ages vary from 6 to 21 years for site indices 18, 15, 12, 9 and 6 meters at a reference age of 12 years. Considering the different factors of raising the coastal plantations, a rotation age of 12 years for site indices 15 and 18 meters dominant height and 15 years for site indices of 6, 9 and 12 meters dominant height at the same reference age may be prescribed for keora in the coastal plantations of Bangladesh.

সারসংক্ষেপ

বাংলাদেশের উপকূলীয় চরে বনায়নের জন্য কেওড়া প্রধান প্রজাতির গাছ। আবর্তনকাল নির্ণয়ের প্রধান চারটি পদ্ধতিতে কেওড়া বাগানের আবর্তনকাল হিসাব করা হয়েছে। এই হিসাবে দেখা যায় যে, ১২ বছর বয়সে ১৮, ১৫, ১২, ৯ ও ৬ মিটার গাছের সর্বোচ্চ উচ্চতা বাগানের আবর্তনকাল ৬ হতে ২১ বছরের মধ্যে পড়ে। এই বনায়নের বিভিন্ন উদ্দেশ্য বিবেচনা করে ১২ বছর বয়সে গাছের সর্বোচ্চ ১৫ ও ১৮ মিটার হলে ১২ বছর আবর্তনকাল এবং একই বয়সে উচ্চতা ৬, ৯ ও ১২ মিটার হলে ১৫ বছর আবর্তনকাল হিসাবে গ্রহণ করা যেতে পারে।

INTRODUCTION

Plantation establishment, maintenance, and harvesting are capital investment activities in forest management. The trees must be allowed to grow for an optimal period to assure a return of the investment to the industry. The determination of the economic rotation therefore assumes an important role in forest management.

Lundgren (1973) used the land expectation value and the internal rate of return methods to determine the investment returns for managing a red pine plantation. Duerr (1960) considered the alternative rate of return method to determine financial maturity as the suitable rotation age for a timber stand. Chapman and Meyer (1947) suggested the use of net present worth or capitalized value approach for the economic rotation and cutting cycle of forest.

After a brief review of the criteria used in the determination of economic

M. A. Latif, Senior Research Officer, Bangladesh Forest Research Institute, P. O. Box 273, Chittagong, Bangladesh; R. A. Del Castillo, Professor, College of Forestry, University of the Philippines at Los Banos, College, Laguna, Philippines.

rotation or cutting cycle, Fortson (1972) and McCauley and Trimble (1972) considered the net present value and internal rate of returns as the most popular approaches.

Tomboc (1976) used the Faustmann method and net present value approach for bagras plantations managed for pulp timber production in different accessibility site class stands. Revilla (1975) has recommended the internal rate of return and the net present value approach as complementary approaches in determining the economic rotation of forest plantations.

Keora (*Sonneratia apetala* Buch. -Ham.) is the principal species planted at the coastal areas of Bangladesh. This species has been planted since 1967. The raising of keora plantations is a capital-intensive business and knowledge about its rotation age is essential in weighing different alternatives and planning strategies to optimize the benefit flow. Therefore, an attempt was made in the present study to determine the rotation age of keora in the coastal areas of Bangladesh.

METERIALS AND METHODS

The yield table generated by Latif (1989) has been used to determine the rotation ages for keora plantations in the coastal areas of Bangladesh. The mean height in metres of 100 dominant and codominant trees per hectares attained at a reference age of 12 years were used to estimate the site index of plantation area. In the present study, the following four principal criteria of finding rotation ages were considered :

1. Rotation of maximum volume production
2. Economic rotation based on net present value (NPV) single rotation
3. Economic rotation based on NPV infinite rotation
4. Economic rotation based on forest rent formula

The rotation of maximum volume production is the age at which the mean annual volume increment (MAI) is the maximum. It is the age at which the MAI and the current annual increment (CAI) are the same. The economic rotation age is the age at which the net value of cash flow is maximum.

Determination of economic rotation needed the calculation of total costs involved in the total planning horizon and benefits derived out of the investment within that period. As all costs and benefits occur at different periods, these costs and benefits were brought to a common point and were discounted to year zero by using 15% interest rate. For the determination of the rotation ages based on forest rent criterion, the benefits were not brought to the common point by using the interest rate as this was not necessary.

The resulting net cash flow values could be positive or negative depending on the magnitude of costs, revenues, interest rates, and time parameters. Site quality was considered in the analyses. The economic rotation for keora was determined for use as fuelwood.

The formulae used to calculate the rotation ages based on different criteria are given below :

NPV single rotation :

$$NPV_1 = \frac{P \times V(t) - C \times (1+i)^t}{(1+i)^t}$$

NPV infinite rotation :

$$NPVa = \frac{P \times V(t) - C \times (+i)^t}{(1+i)^{t-1}}$$

Forest rent : $FR_t = Max_t ((PxV(t) - Cost)/t)$

where, NPV_1 = net present value based on single rotation

NPV_a = net present value based on infinite rotations

FR_t = forest rent at age t,

C = establishment and maintenance costs,

P = price per unit yield or stumpage value,

V(t) = volume yield at age t,

i = interest rate, and

t = rotation age in years.

Since NPV does not tell about the rate of return to investment, internal rates of return (IRR) were calculated for rotation ages at which NPV were maximum at the recommended interest rate. This was done by trial and error with the help of the following formula :

$$IRR = Lo + (Li - Lo) \times \frac{\text{NPV at Lo interest rate}}{\text{Absolute difference between NPV at lower and higher interest rates}}$$

where, Lo = lower interest rate at which NPV is positive

Li = higher interest rate at which NPV is negative

Establishment and Maintenance Costs : Straight-forward cost data for the establishment and maintenance of keora plantations (C) in the coastal areas of Bangladesh is available in the plantation journals. The costs are the same for all localities.

A sum of taka 1013/ha is available to carry out the tending operations like cleaning and thinning at the seventh year of the plantation while, on the average, a sum of taka 900/ha may be recovered by selling the materials obtained from the tending operation. Therefore, a sum of net Tk. 113/ha is required for cleaning/thinning. The tending operation is being carried out in some selected and well-stocked plantations only. The cost data for different forestry operations are given below :

Activity	Cost per ha (Taka)
Nursery	544
Planting including all operations	1483
Vacancy filling	
1st year	568
2nd year	507
3rd year	445
Cleaning/thinning 7th yr (net)	113
Maintenance and supervision cost each year	50

*US 1$ = Tk 32.90

Stumpage Value : Stumpage value (P) refers to the monetary value of a standing timber or the whole stand considering the site. Under the present management system, all harvesting activities are being carried out by a private party. The Forest Department liquidates the forest resources through public auction. The price of fuelwood, poles, and pulpwood is set at Taka 150/- cu. m. for the present study which is stumpage price. No harvesting, transportation, or marketing costs are considered.

It is not easy to give a monetary value to benefits like shelterbelts, contributions to acceleration of land accretion, and establishment of land suitable for agriculture. Again, the monetary value given to any of these benefits may vary according to the importance given to each of them. Therefore, no financial values were considered other than the timber yield.

Interest Rate : In Bangladesh, 15% interest rate is being considered in analyzing all development projects (Anon., 1985). In addition to this, interest rates of 10, 12, 14, 16 and 18 per cent were tried to observe the effect of interest rate on rotation age.

RESULTS AND DISCUSSIONS

The rotation ages based on maximum volume production NPV single rotation, NPV infinite rotation, and forest rent formula were determined. The summary of the calculation are presented in Table 1.

Rotation age is dependent on the magnitude of costs, revenues and interest rates. It may be changed if any of these variables are being changed. To observe the effect of interest rates on rotation age, interest rates of 10, 12, 14, 16 and 18 per cent were tried (Table 2).

Table 1. Rotation ages (years) of keora grown in the coastal areas of Bangladesh at different site indices based on different criteria

Criterion	Site indices				
	6	9	12	15	18
Maximum volume production	14	12	10	8	7
NPV single rotation	10	9	8	8	7
NPV infinite rotation	12	11	9	7	6
Forest rent	21	17	14	11	8

Table 2. Rotation ages (years) at different interest rates for keora in coastal areas of Bangladesh

Criterion	Interest rate	Site indices				
		6	9	12	15	18
NPV single rotation	10	12	11	10	9	8
	12	11	10	9	8	7
	14	10	9	9	8	7
	15	10	9	8	8	7
	16	10	9	8	7	7
	18	9	8	8	7	6
NPV infinite rotation	10	14	12	10	8	6
	12	13	11	9	8	6
	14	13	11	9	7	6
	15	12	11	9	7	6
	16	12	11	9	7	6
	18	12	10	8	7	6

The results show that for both NPV single rotation and NPV infinite rotation criteria, the rotation ages are lengthened or shortened by 1 or 2 years compared to the same estimated at 15% interest rate.

Since NPV does not tell the rate of return to investment, IRR were calculated for rotation ages at which NPV were maximum at recommended interest rate. The computed IRR are shown in Table 3.

considering the other objectives of the project which suggest that the plantations to be maintained as long as possible, liquidation of the plantation falling in site indices 15 and 18 may be deferred for few more years.

The mean annual volume increment (MAI), NPV and soil rent within expected rotation age range have been summerised in table 4. It is observed from table 4, that NPV is negative for lower site indices where financial value has been

Table 3. Internal rate of return at rotation ages for keora in the coastal areas of Bangladesh

Criterion	Site indices				
	6	9	12	15	18
NPV Single rotation					
Rotation age	10	9	8	8	7
IRR	3.0	6.5	11.1	17.4	26.0
NPV infinite rotation					
Rotation age	12	11	9	7	6
IRR	5.3	7.9	11.4	17.0	27.9

From Table 3, it is observed that IRR is greater than the recommended interest rate for site indices 15 and 18 while it is lower for site indices 6, 9 and 12. Hence, considered only for timber yield. If it could be in a position to consider financial values for other benefits, then that could increase or change the rotation ages.

Table 4. Summary of the data for the determination of rotation age for keora in the coastal areas of Bangladesh

Criterion and units of measurement	Values at site indices				
	6	9	12	15	18
Age range (years)	10-15	10-15	10-15	10-12	10-12
Volume yield (m^3/ha/yr)	5.6-3.8	5.1-5.0	7.1-6.7	10.1-9.6	14.2-13.2
NPV single rotation (Tk)	-2166 to-2493	-1620 to - 2151	-850 to -1696	237 to - 276	1770 t0 921
NPV infinite rotation (Tk)	-2877 to -2843	-2152 to -2452	-1129 to -1933	314 to-339	2351 to 1133
Forest rent (Tk)	184 to 327	405 to 512	717 to 759	1156 to 1148	1777 to 1681

Keora is a pioneer species for plant succession in the mangroves and gradually die out on higher ground. Again, keora is attacked by insect borer. Hence, there is a limitation of age to allow the species to grow.

The mean annual volume increments (MAI), NPV and soil rent do not differ so much within the age range of 10-15 years for site indices 6, 9 and 12 and 10-12 years for site indices 15 and 18.

Considering all these factors, a rotation age of 12 years for site indices 15 and 18 meters dominant height at a reference age of 12 years and 15 years for site indices of 6, 9 and 12 meters dominant height at the same reference age may be prescribed for keora in the coastal plantations in Bangladesh.

But still it is necessary to consider again whether this period is sufficient to stabilize the land for agriculture. Another vital question is whether all lands should be ultimately devoted to agriculture or whether part of the plantation should be retained as a protective measure against cyclones and tidal waves. To find suitable answers to these questions, there is a need to create a study group involving different disciplines.

REFERENCES

Anon. 1985. Staff Appraisal Report. Bangladesh Second Forestry Project. World Bank.

Chapman, H. H. and W. H. Meyer. 1947. Forest valuation. Mcgraw-Hill Book Co., New York.

Duerr, W. A. 1960. Fundamentals of forestry economics. McGraw-Hill Book Inc. New York.

Fortson, J. C. 1972. Which criterion? Effect of choice of the criterion on forest management plans. For. Sci. 18(4) : 292-297

Latif, M. A. 1989. Growth/yield prediction model and rotation ages of keora (*Sonneratia apetala* Buch.-Ham.) plantations in Bangladesh. Unpublished M. S. Thesis. College of Forestry, University of the Philippines at Los Banos, Laguna.

Lundgren, A. 1973. Cost price, a useful way to evaluate timber growing alternatives. USDA. Forest Service Paper NC-95.

Mc Cauley, O. D. and G. R. Trimble, Jr. 1972. Forestry returns evaluated for uneven-aged management in two appalanchian woodlots. USDA For. Serv. Res. pap NC-244. NE For. Expt. Stn. Upper Darby.

Revilla, A. V. Jr. 1975. A yield prediction model of natural benquet pine Stands. Sylvatrop, For. Res. J. 1 : 116-127.

Tombac, C. C. 1976., Growth, yield and economic rotation of Bagras pulptimber in PICOP plantations. M. S. Thesis, University of the Philippines at Los Banos, College, Laguna.