Journal of the Faculty of Forestry, Istanbul University 2012, 62 (1): 31-45

Technical and Economical Evaluations of Maritime Pine Plantations in Western Black Sea Region of Turkey

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Abstract

In this study, technical and economical evaluations of the maritime pine (*Pinus pinaster* Aiton.) plantations, established at Bartın-Karaçaydere between the years of 1979 and 1984, were made. 60 sample plots were allocated by representing the establishment techniques of mechanization and labour. The data were collected from the plots concerning growth, yield and economics, in the year of 2003. Reasonable growth rates were obtained in maritime pine plantations, in spite of the negative conditions of inadequate mechanization techniques, wrong origin and snow damages. Mean annual volume increments were calculated as 12.3 m^3/ha and 9.8 m^3/ha for the sites prepared by mechanization and labour, respectively. The results obtained from the economical evaluations indicated that maritime pine plantations were more productive and profitable than indigenous oriental beech forest in the area as regards the criteria of Net Present Value, Internal Rate of Return and Benefit Cost Ratio.

Keywords: Maritime pine (*Pinus pinaster* Aiton.), oriental beech (*Fagus orientalis* Lipsky.), industrial plantation, growth and yield, economical analysis.

1. Introduction

The forests in the world cover an area of 3.8 billion hectares. During the period of 1990 to 1995, the forested area in industrialized countries increased annually by about 1.75 million hectares. At the same time, the area covered by natural and semi-natural forests in developing countries, decreased by 13.7 million hectares every year. This reduction was partly compensated by yearly plantations, but the net annual reduction in the forests was still 12.0 million hectares (Lanly, 1997). Harvested woods from these forests can not meet the global demand at present, and this demand will continue to increase form the foreseeable future, due to continued increases in population and income. In recent years, there has been an increased interest in the establishment of forest plantations for wood supply and forest resources. Forest plantations can reduce potential future wood shortages and provide continuity of supply for existing industrial enterprises. It is estimated that a total of something near to 2.6 billion hectares of indigenous and planted forests should provide enough wood, wood products and other forest services such as water, wildlife habitat and recreation to allow to future civilization to work well (Kanowsky, 1997; Brown, 2000; Libby, 2002).

Available forest land in Turkey is 21.2 million hectares constituting 27.2% of the total land area. As a result of destructive utilizations and interventions over centuries, productive forests cover only about 50% of total forest area and remaining 50% carries only degraded or severely degraded unproductive forest cover presently (Anonymous, 2006). These forests are renewable complex ecosystems. Depending the great range of climatic and topographic conditions prevailing in the

Received: 19.08.2011; accepted: 21.12.2011

country, forest ecosystems show great biological diversities at gene and species level. But, natural forests in Turkey has been decreased and biodiversity in forest ecosystems has been seriously threatened due to the over utilization of forest resources. It is evident that, forest resources should be managed and utilized to provide multiple products, economic, social and environmental functions and benefits on a sustainable basis for the present and future generations of the country. It is a certainty that demands on the forest lands will become greater while the population of the country will grow and the area available for forest production will decrease. Thus, there is a vital need to increase the productivity of existing forest land in Turkey for meeting the future wood demand. To achieve this, genetic improvement of forest tree species and establishment of industrial plantations with indigenous and exotic species to produce high amount of production in short rotation ages are considered as effective ways (Ürgenç, 1982; Birler, 1995; Boydak and Dirik, 1998; Tunçtaner, 2003, 2007).

Introduction of fast growing exotic species to Turkey was started in 1950's. There have been demonstrative plantations and comparative experiments at various levels conducted by several organizations. A special Project (FAO: DP/TUR/71/521) titled "Industrial Forestry Plantations" was imitated by the Government of Turkey and UNDP/FAO in 1972 and ended 1977. One of the objectives of this Project was aimed at establishing a comprehensive programme of tree improvement for exotic and fast growing indigenous species. During the Project, the numbers of the species and provenance trials were expanded in Marmara and Black Sea regions of Turkey. Some pilot plantations with promising species such as; *Pinus pinaster*, *Pinus radiata*, *Pinus brutia* and *Pinus nigra* were also established at the same regions to determine optimal cultural and managerial techniques and to make the vital decision on whether or not to proceed with the complete reforestation programmes. Valuable information has been obtained from the evaluations of these experiments and plantations. The results indicated that the most promising species were *Pinus pinaster* and *Pinus radiata* in Marmara and Black Sea regions and *Pinus pinaster* had larger potential planting area in these regions (Ürgenç, 1972; Burley, 1972; Cooling, 1977; Ürgenç and Boydak, 1982; Tunçtaner et al., 1985). Therefore, further research studies on *Pinus pinaster* have been particularly implemented in these regions, concerning growth-site interactions and provenance selection (Tunçtaner et al., 1988; Tunçtaner and Tulukçu, 1993; Boydak et al., 1995; Asan, 1998; Tunçtaner, 1998), site selection, land preparation and maintenance techniques (Tolay et al., 1988; Ayberk, 1996; Tolay, 1997; Hızal et al., 2002), growth and yield (Birler and Yüksel, 1983; Birler et al., 1996; Birler, 1998; Şener, 2001; Özcan, 2003). Some studies on economical evaluations of industrial plantations establihed with *Pinus pinaster* and some other fast growing plantations were also made (Türker, 1986; Birler, 1995; Erkan, 2002; Daşdemir and Şahin, 2005).

This paper is aimed at the evaluation of growth and yield performances of maritime pine plantations established on suitable sites in western Black Sea Region. Discussion was made on the capability of these plantations to support the relatively fast rates of growth necessary to achieve the stated objectives, comparing the former vegetation. Discussion is also made on the economical feasibility of maritime pine plantations.

2. Materials and Methods

2.1. Site characteristics

The research area of 1700 ha was intensively established with maritime pine (*Pinus pinaster* Aiton.) plantations between the years of 1979 and 1984 in Bartın- Karaçaydere forest district. It was formerly covered mostly by oriental beech and some oak species (*Quercus ssp.*). The total land of the district is about 16.147 hectares and mostly covered with coppice forest consisting of the species; oriental beech (*Fagus orientalis* Lipsky.), oak (*Quercus ssp*.), hornbeam (*Carpinus betulus* L.) and chestnut (*Castanea sativa* L.). The altitudinal range of the district varies between 0-300 meters with hilly sites having 10-80% slopes. Climate is mild and humid with 1072 mm mean annual precipitation and 13.2^0 C mean annual temperature. Vegetation period is about six months and the type of the climate is stated as semi-humid. Soil is deep and slightly stony. Texture of the soil varies form sandy clay loam to sandy loam. Soil reaction (pH) is between 4.5 and 5.2 (Günay, 1983; Anonymous, 2001).

2.2. Layout of the trial sites

Maritime pine plantation area was separated into two blocks on the basis of land preparation

techniques of mechanization and labour. In each block, 30 plots, in size of 100 m^2, were taken with 250 m intervals by using systematic sampling. Apart from this, representing formal coppice vegetation three plots composed of oriental beech (*Fagus orientalis* Lipsky.) trees in different years of age were taken for comparison.

2.3. Measurements and analysis

Breast height diameters (dbh) of all trees and heights of three trees in sample plots of maritime pine plantation were measured. The ages of the mean trees for each plot were also measured. Survival percentages in the plots were determined by measuring the distances between available maritime pine trees. Site index values in the plots were determined on the basis of basal area, dominant height and ages. After that, frequency degrees of the plots were found according to the ratio of the basal area values in plots and the basal area values in the yield tables prepared for maritime pine plantations by Özcan (2003). Using the frequency degrees calculated for plots, current increment, stem volume and mean volume increment values of maritime pine trees in plots were found as the proportions of the values in the yield table (Özcan, 2003).

The evaluations on growth and yield performances of maritime pine plantations were made separately for land preparation techniques. The data were assessed as mean values since maritime pine plantations were established in different years. Oriental beech trees in comparison plots were also evaluated regarding the mean values of growth data. The values for current annual increment, stem volumes and mean annual volume increments were assessed by considering the growth and yield values stated for oriental beech forests in different ages (Atıcı, 1998).

The economic evaluations of maritime pine plantations and coppices land were made using the criteria of Net Present Value (NPV), Benefit/Cost Ratio (BCR) and Internal Rate of Return (IRR) (Türker, 1986; Erkan, 2002; Daşdemir, 2005). Some data used for economical analysis were provided from Bartın Directorate of Afforestation and Directorate of Forest Enterprise. The amounts of harvested wood products were taken from yield tables (Carus, 1998; Özcan, 2003) and sort of product tables (Sun et al., 1977; Durkaya, 2001). In this study, the criteria of NPV and BCR were calculated by using the forestry small interest ratio of 3.0% for different site index, rotation age and plantation techniques in maritime pine plantations and oriental beech forest to compare them.

3. Results

3.1. Growth performance of plantation prepared by mechanization

The ages of trees in 30 plots were determined between 19 and 24. Therefore, differences were found for mean diameter and height values of the trees in plots, depending on ages. Survival percentages calculated depending on the number of trees in plots considerably differed from each other, when it was compared with the initial 16 trees planted in 2x3 m spacing in plots. Annual current increment, stem volume and mean annual volume increment values per hectare showed significant variations depending on the plots and ages. Mean values of the growth and yield data in plots and overall mean of the plots were summarized in Table 1.

Table 1. Mean growth values for maritime pine plantations prepared by mechanization.
Tablo 1. Makineli arazi hazırlığı yapılan sahilçamı sahaları için ortalama büyüme değerleri.

Number of the plots Deneme Alanı No	Age (year) Yaş	Diameter (cm) Çap	Height (m) Boy	Number of trees Ağaç Sayısı	Survival percent. (%) Yaşama Yüzdesi	Top height (m) Üst Boy	Basal area (m^2/ha) Göğüs Yüzeyi	Basal area (Table) (m^2/ha) Göğüs Yüzeyi	Current annual inc. (m^3/ha) Cari Artım	Stem volume (m^3/ha) Gövde Hacmi	Mean annual inc. (m^3/ha) Ortalama Artım
1	24	22.8	12.5	8	50	12.5	32.7	28.8	11.8	214.4	8.9
2	23	25.7	12.1	11	69	12.1	57.1	27.9	21.9	364.1	15.8
3	22	25.2	13.7	12	75	13.7	59.9	29.0	28.1	454.0	20.6
4	24	19.7	12.4	15	94	12.4	45.7	28.8	16.5	300.0	12.5
5	22	23.9	14.0	12	75	14.0	53.8	29.0	25.3	408.4	18.6
6	21	23.5	15.2	15	94	15.0	65.1	28.9	35.1	533.5	25.4
7	20	24.7	12.3	7	44	12.3	33.5	24.8	15.6	196.1	9.8
8	22	26.2	14.3	10	63	14.4	53.9	29.0	25.3	409.0	18.6
9	24	25.1	15.9	11	69	15.9	54.4	32.6	26.6	539.3	22.5
10	23	29.9	14.4	8	50	14.4	56.2	29.9	24.8	437.7	19.0
11	24	30.7	14.3	5	31	14.3	37.0	30.9	15.3	294.7	12.3
12	23	30.2	13.9	9	56	13.9	64.5	29.9	28.5	502.4	21.8
13	24	25.8	12.0	4	25	12.0	20.9	28.8	7.6	137.2	5.7
14	23	27.1	14.6	5	31	14.6	28.8	30.9	13.7	249.2	10.8
15	23	23.6	13.8	5	31	13.8	21.9	29.9	9.7	170.4	7.4
16	23	27.9	13.9	6	38	13.9	36.7	29.9	16.2	285.9	12.4
17	23	37.6	15.2	1	6	15.2	11.1	30.9	5.3	95.9	4.2
18	23	27.5	15.1	12	75	15.1	71.3	30.9	33.9	615.9	26.8
19	19	27.3	13.2	8	50	13.2	46.8	24.8	24.7	290.8	15.3
20	19	30.8	12.8	3	19	12.8	22.4	24.8	11.8	138.8	7.3
21	19	24.1	12.7	8	50	12.7	36.5	24.8	19.3	226.6	11.9
22	20	22.5	7.6	2	13	7.6	8.0	17.6	3.1	33.7	1.7
23	20	22.0	12.2	8	50	12.2	30.4	24.8	14.1	177.8	8.9
24	20	24.8	13.6	4	25	13.6	19.3	26.9	10.3	137.9	6.9
25	22	25.2	13.6	5	31	13.6	24.9	29.0	11.7	189.2	8.6
26	21	24.4	11.9	5	31	11.9	23.4	25.9	10.1	141.7	6.8
27	19	22.4	13.5	4	25	13.5	15.8	25.7	9.0	109.2	5.8
28	20	29.4	13.6	4	25	13.6	27.2	26.9	14.4	193.8	9.7
29	20	25.5	13.4	4	25	13.4	20.4	25.9	10.1	131.7	6.6
30	20	22.2	13.2	5	31	13.2	19.4	25.9	9.6	124.8	6.2
Mean	21	25.9	13.4	7.2	45	13.4	36.6	27.8	17.0	270.1	12.3

3.2. Growth performance of plantation prepared by labour

Plantation works were started at mechanized land in the beginning, but later carried out at some areas prepared by labour for not suitable for mechanization. Therefore ages of such these plantations were generally younger than the former ones. Annual current increment, stem volume and mean annual volume increment values per hectare showed significant variations depending on the plots and ages. Mean values of the growth and yield data in plots and overall mean of the plots were summarized in Table 2.

Table 2. Mean growth values for maritime pine plantations prepared by labour.
Tablo 2. İşgücü ile arazi hazırlığı yapılan sahilçamı sahaları için ortalama büyüme değerleri.

Number of the plots Deneme Alanı No	Age (year) Yaş	Diameter (cm) Çap	Height (m) Boy	Number of trees Ağaç Sayısı	Survival percent. (%) Yaşama Yüzdesi	Top height (m) Üst Boy	Basal area (m^2/ha) Göğüs Yüzeyi	Basal area (Table) (m^2/ha) Göğüs Yüzeyi	Current annual inc. (m^3/ha) Cari Artım	Stem volume (m^3/ha) Gövde Hacmi	Mean annual inc. (m^3/ha) Ortalama Artım
1	22	23.3	13.2	8	50	13.2	34.1	28.0	14.9	233.9	10.6
2	22	26.9	13.2	5	31	13.2	28.4	28.0	12.4	194.9	8.9
3	19	28.7	13.3	5	31	13.2	32.3	24.8	17.1	200.9	10.6
4	16	18.5	7.1	15	94	7.1	40.3	9.8	25.5	139.9	8.7
5	16	26.5	11.4	6	38	11.4	33.1	19.9	20.0	163.0	10.2
6	21	24.0	12.9	6	38	12.9	27.1	27.0	12.6	180.0	8.6
7	21	25.4	9.2	4	25	9.2	20.3	22.1	7.6	96.3	4.6
8	21	20.7	9.2	4	25	9.2	13.5	22.1	5.1	64.0	3.0
9	21	21.8	9.1	5	31	9.1	18.7	22.1	7.0	88.7	4.2
10	16	19.3	8.7	7	44	8.7	20.5	16.1	10.7	80.1	5.0
11	16	19.2	8.6	8	50	8.6	23.2	16.1	12.1	90.6	5.7
12	16	19.8	9.1	7	44	9.1	21.6	16.1	11.2	84.3	5.3
13	17	21.7	13.2	11	69	13.2	40.7	22.3	24.6	233.5	13.7
14	17	21.9	12.8	10	63	12.8	37.7	22.3	22.8	216.2	12.7
15	17	23.4	13.0	9	56	13.0	38.7	22.3	23.4	222.2	13.1
16	17	23.3	11.3	10	63	11.3	42.6	20.1	22.7	201.5	11.9
17	17	22.4	12.8	8	50	12.8	31.5	22.3	19.1	181.0	10.6
18	18	29.4	12.3	5	31	12.3	33.9	22.5	18.0	184.0	10.2
19	18	20.8	12.2	8	50	12.2	27.2	22.5	14.4	147.4	8.2
20	18	23.8	12.2	6	38	12.2	26.7	22.5	14.1	144.7	8.0
21	18	24.4	13.1	10	63	13.1	46.8	23.6	26.4	279.4	15.5
22	18	25.4	12.3	8	50	12.3	40.5	22.5	21.4	219.8	12.2
23	17	20.9	12.1	10	63	12.1	34.3	21.2	19.4	178.0	10.5
24	17	23.3	12.9	8	50	12.9	34.1	22.3	20.7	195.8	11.5
25	17	21.8	13.3	8	50	13.3	29.9	22.3	18.1	171.4	10.1
26	17	20.9	12.8	8	50	12.8	27.4	22.3	16.6	157.5	9.3
27	17	19.2	12.2	8	50	12.2	23.2	21.2	13.1	120.2	7.1
28	17	22.2	12.0	14	88	12.0	54.2	21.2	30.7	281.2	16.5
29	17	20.5	12.2	12	75	12.2	39.6	21.2	22.4	205.5	12.1
30	17	23.3	13.2	10	63	13.2	42.6	22.3	25.8	244.7	14.4
Mean	18	22.7	11.7	8	51	11.7	32.2	21.6	17.7	173.4	9.8

3.3. Growth performances of control plots covered by oriental beech coppice

Growth and increment values of oriental beech control plots in the vicinity of maritime pine plantation area were determined. Current annual increment, stem volume and annual volume increment values per hectare were calculated. Mean values of the growth and yield data in plots and overall mean of the plots were summarized in Table 3.

Table 3. Mean growth values for oriental beech trees in control plots.
Tablo 3. Kayın kontrol alanlarına ait ortalama büyüme değerleri.

Number of the plots Deneme Alanı No	Age (year) Yaş	Diameter (cm) Çap	Height (m) Boy	Number of trees Ağaç Sayısı	Top height (m) Üst Boy	Basal area (m^2/ha) Göğüs Yüzeyi	Basal area (Table) (m^2/ha) Göğüs Yüzeyi	Current annual inc. (m^3/ha) Cari Artım	Stem volume (m^3/ha) Gövde Hacmi	Mean annual inc. (m^3/ha) Ortalama Artım
1	31	9.8	12.8	27	12.8	20.4	26.0	8.7	178.2	5.7
2	33	12.7	13.2	18	12.7	22.8	31.1	6.8	229.5	6.9
3	30	8.5	13.2	28	13.3	15.9	19.4	8.5	98.4	3.3
Mean	31	10.3	13.1	24.3	12.9	19.7	25.5	8.0	168.7	5.3

3.4. The results of economical analysis

The purpose of the maritime pine plantations at Bartın-Karaçaydere is to produce high amount of industrial wood in a considerably short rotation age. Rotation ages of maritime pine plantation were determined as 25 years for good sites and 35 years for bad sites. These periods for oriental beech are 100 and 120 respectively. Economic analysis was made regarding the two site classes as good and bad.

3.4.1. Assessment of expenses for plantation investments

The costs of plantations were determined on the basis of the prices in 2003 for various activities in establishment expenses carried out by Afforestation Directorate at Bartın. The calculated costs for maritime pine and oriental beech are given in Table 4.

Table 4. Plantation costs based on tree species and plantation techniques (US$/ha).
Tablo 4. Ağaç türü ve plantasyon teknolojisi itibariyle ağaçlandırma maliyetleri (US$/ha).

Activities Faaliyetler	Type of the activity İşin Çeşidi	Plantation techniques Labour İşgücü	 Mechanization Makine
Establishment	Land clearing	248	285
	Soil preparation	300	212
	Planting	81	81
	Border	35	35
	Service roads	11	11
I-Total establishment expenses		675	623
Maintenance	Supplementary planting	31	31
	Weed control, hoe	49	49
	Shoot control	60	60
II-Total maintenance expenses		139	139
III-Total establishment and maintenance expenses (I+II)		815	763
IV- Cost of seedling	Maritime pine (Çm)	101	101
	Oriental beech (Kn)	1.457	1.457
V- Plantation cost (III+IV)	Maritime pine (Çm)	915	863
	Oriental beech (Kn)	2.272	2.221
VI-General management Expenses (V x 0,15)	Maritime pine (Çm)	137	129
	Oriental beech (Kn)	341	333
Plantation expenses Total General (V+VI)	Maritime pine (Çm)	1.052	993
	Oriental beech (Kn)	2.613	2.553

3.4.2. Assessments of NPV, IRR and BCR for plantation investments

NPV and IRR values for maritime pine plantations were calculated depending on the yield tables data (Özcan, 2003) and sort of product tables (Durkaya, 2001) for the plantation techniques of labour and mechanization. Rotation ages of maritime pine plantations were accepted as 25 years for good sites and 35 years for bad sites. One thinning was considered in 15th and 20th year for good and bad site respectively.

NPV and IRR values for oriental beech were calculated on the basis of the yield tables (Carus, 1998) and sort of product tables (Sun et al., 1977) for all alternatives. Rotation ages were considered 100 years for good site and 120 years for bad site. Thinnings with 10 year periods were accepted between the years of 20 and 110 for good and bad site respectively. NPV and BCR values were calculated by using the forestry small interest ratio of 3.0% for all alternatives. IRR, the ratio of reduced values of total incomes and expenditures of project into present time was calculated, and then the discount rate making this ratio to (0) was found. Consequently, regarding the above principles, the assessment of NPV, IRR and BCR were calculated for the alternatives and the results were given in Table 5.

Table 5. NPV, IRR and BCR values for tree species, site index, rotation and plantation techniques.
Tablo 5. Ağaç türü, bonitet, idare süresi ve plantasyon tekniği itibariyle NBD, İKO ve FMO değerleri.

Tree species Ağaç Türü	Site index Bonitet	Rotation (year) İdare Süresi	Plantation techniques Teknoloji	NPV (US$/ha) NBD	IRR (%) İKO	BCR (ratio) FMO
Maritime pine	Good	25	Mechanization	6.923	13.09	7.97
			Labour	6.863	12.78	7.53
	Bad	35	Mechanization	1.057	5.43	2.06
			Labour	998	5.22	1.95
Oriental beech	Good	100	Mechanization	-452	2.85	0.82
			Labour	-511	2.83	0.80
	Bad	120	Mechanization	-1.977	1.78	0.23
			Labour	-2.036	1.76	0.22

4. Discussion

4.1. Growth and yield

Maritime pine is one of the most important exotic species imported to Turkey so far. Therefore, some demonstrative and industrial plantations have been established in coastal sites of Marmara and Black Sea regions since 1975. Economical importances of the species for industrial plantations in coastal sites of temperate regions have been reported by many writers (Ürgenç, 1972; Burley, 1972; Cooling, 1977; Birler, 1982; Tunçtaner, 1990). In this framework, the plantation site at Bartın-Karaçaydere was established in the period of 1979-1984. The results obtained from the research area showed that there were no significant effects of mechanization practices on growth characteristics and survival, since proper land preparation and maintenance techniques were not applied in plantation area. In most instances, reforestation involves the conversion or replacement of a vegetation type currently of low productivity, although the site itself may not be inherently poor. The reason for undertaking the reforestation of these areas by conversion is the pressing need for industrial softwood timber and the fact that such sites represent a very considerable but inadequately developed asset in their present condition. Intensive forestry operations including complete land clearing and thorough soil working are increasingly being recognized as essential in order to optimize growth rates and ensure efficient production of the required quantity and quality of wood. Some research information obtained from intensively managed Maritime pine plantations in Marmara and Black Sea regions were reported (Tunçtaner et al., 1985; Tolay

et al., 1988; Tolay, 1997; Tunçtaner, 1998; Ayberk et al., 1998; Hızal et al., 2002).

In research area, growth rates of the plots showed great differences depending on site quality, plantation techniques, survival and age of trees. Slight differences were found between the overall mean values of survival, growth and yield characteristics of the plots representing plantation techniques of mechanization and labour (Table 1 and 2). Likewise, the results of a lot of research studies, indicated that survival, growth and yield characteristics of Maritime pine plantations had important differences depending on their local conditions (Lemoine, 1969; Destremau et al., 1976; Duarte et al., 1991; Belghazi and Romane, 1993; Akgül, 2010). The growth performances (such as, increament-growth, policyclizm, false and annual ring) of Maritime pine plantations were investigated in a study comprising the bio-climatic classes (classified by Emberger) in Turkey. The three different bio-climatic classes were determined as 'rainy', 'less rainy' and 'semi-drought'. According to these bio-climatic classes it was reported that the great differences were determined on the growth of Maritime pine plantations. It was also stated that the dryer the climate the longer the age on which mean annual increment reached maximum (Akgül, 2010). It is known that, this situation affects the application of silvicultural maintenance treatments and rotation age. Bartın-Karaçaydere research area is located at low altitudes (0-300 m) of the rainy bio-climatic class having suitable conditions for growth and rotation age. Another study on daily diameter growth in the Landes region of France showed that the growth of Maritime pine stands were better in the moist and hot micro-climatic conditions (Guinaudeau, 1966). The best growth of Maritime pine plantations in Sardinya was observed in moist areas of lower altitudes. The lowest survival rate of the trees was determined in 625 m altitude (Giannini et al., 1992). Similar results on growth and age of application of silvicultural maintenance treatments in Maritime pine plantations were also reported (Editions du Present, 1997; Bailly, 1990; Şener, 2001; Akgül, 2010).

Some of the trees have been taken out of the plantation in some years, since they have been seriously affected from snow damages in winters. Therefore, low average survival percentage values of the plots were calculated as 45% and 51% for plantations prepared by mechanization and labour respectively. The reason of this poor survival has been considered as an origin problem. Research studies showed that Corsican provenances of the species are more resistant against snow damages than the Land provenances (Tunçtaner et al., 1985, 1988; Aktaş, 2003). The Land origin of the species were extensively used in research area, therefore most of the plots have low survival, whereas a few plots have very high survivals (94%) in mechanized plantation established with Corsican provenances.

Mean annual increment of the plots in mechanized area is 12.3 m^3, whereas it is 9.8 m^3 in plantation established by labour. The mean annual increment of intensively managed Maritime pine plantations in Marmara region was anticipated as 15.3 m^3 for 26 year rotation age (Grut, 1976). The results obtained from the research plots in Black Sea and Marmara regions showed that, the mean annual increment of Maritime pine varied between 8-23 m^3 in 20-23 year rotation age (Tunçtaner, 1998). According to the yield study of Maritime pine plantations in Turkey, mean annual increment for good sites was determined as 16.6 m^3 in 27 year of age (Özcan, 2003). In a study on yield of Maritime pine stands in Uruguay, the mean annual increment was determined 10.7m^3 for 37 years (Bonilla and Beckmann, 1964).

At Bartın-Karaçaydere plantation site, average stand volume of Maritime pine was found as 286.9 m^3/ha for mechanized land whereas this figure was 177.3 m^3/ha for the land prepared by labour in 19-24 years. In the yield table of Maritime pine plantations in Turkey, this was reported as 438 m^3/ha for 27 years (Özcan, 2003). According to the yield studies of Maritime pine plantations in different countries, average stand volume of very dense plantations for 27 years was determined as 1143 m^3/ha in the Capetown region of the Republic of South Africa (Theron, 1967), 192 m^3/ha for 28 years in the Southwest France (Decourt and Lemoine, 1969) and 467 m^3/ha for 37 years in Uruguay (Bonilla and Beckmann, 1964). The average stand volume of oriental beech forest in 31 year of age was found as 167.3 m^3/ha. Good growth of Maritime pine plantation has also been recorded at İzmit-Kerpe as compare with oriental beech coppice (Birler et al., 1996); the stand volumes of Maritime pine plantation and oriental beech coppices were found as 128.8 m^3/ha and 97.5 m^3/ha in 15 years respectively. This indicates that, the productivity of degraded hardwood forests and coppice sites may have been raised by conversion using intensive plantation techniques in some areas.

4.2. Economic evaluation

NPV of maritime pine plantation in good site for 25 year rotation age, were found as 6.923 US$/ha and 6.863 US$/ha for the alternatives of mechanization and labour respectively with % 3 discount rate. In another study, NPV of this species was reported as 15.192 $/ha for 35 year rotation with 4% discount rate (Durkaya, 2001). NPV of oriental beech forest in good site for 100 year rotation were found as -452 US$/ha for mechanization and -511 US$/ha for labour.

In this study, IRR values of maritime pine plantations in good site for 25 year rotation were found as 13.09% for mechanization and 12.78% for labour. In another study, IRR value for maritime pine plantations for 30 year rotation was calculated as 7.14% and 7.35% for the alternatives of labour and mechanization + labour (Türker, 1986). The profitability of industrial plantation in Marmara Region is examined for two alternatives: in coppice by means of complete mechanized soil preparation, and in marquis with mechanized preparation of gradoni. It is estimated that the former alternative can yield a real (inflation-free) rate of return of 14.0% when inputs are valued at 'actual' costs and 15.0% when they are valued at social costs, and that under similar conditions the latter alternative can yield 10.0% and about 10.5 % respectively (Grut, 1976).

IRR values for oriental beech in good site for 100 year rotation were found as 2.85% for mechanization and 2.83% for labour. In another study, IRR value for oriental beech was found as 2.49% for labour (Türker, 1986). According to the results, it is found out that, a plantation investment can be assessed with 2.85% maximum interest rate in 100 year.

Maximum BCR values of maritime pine and oriental beech were calculated as 7.97 and 0.82 respectively, for good site and mechanization techniques. Rotation ages were accepted as 25 years for maritime pine and 100 year for oriental beech. In this case, it can be economically said that the investment for industrial plantation with maritime pine at Bartın-Karaçaydere might be considered a right decision since the calculated BCR value is bigger than 1.0. Similar economical parameters were also obtained from a study made for maritime pine plantation in Marmara and Western Black Sea regions in the conditions of good site, 30 year rotation and 5% discount rate; the values of NPV, IRR and BCR were reported as 6.948 US$/ha, 13.98% and 2.96 respectively (Birler, 1998). At Bartın-Karaçaydere plantation, higher NPV, IRR and BCR values were determined for mechanization techniques comparing with labour. Therefore, these results are also consistent with the results obtained from technical evaluations regarding growth and yield.

Here, the economic evaluations were made for the only wood raw material. However, there are many benefits of plantation investments. One of them is carbon sequestration and its economic value is much greater (Kula, 2010). Should also be noted that economic values of wood raw material is an underestimation in the many benefits of plantation investments. Therefore, it will be useful taking into consideration many variables and making comprehensive analysis when deciding to invest in plantation.

5. Conclusion

The establishment of mechanized industrial plantations of fast growing forest tree species is concentrated in the Marmara, Black Sea, Aegean and Mediterranean coastal regions of Turkey. The Marmara and western Black Sea regions are considered to be priority locations for maritime pine plantations due to generally favorable site conditions and proximity to major wood using industries. Industrial plantations of fast growing coniferous species have a vital role to play assisting the General Directorate of Forest to meet the requirements of industry. The purpose of such plantations should be the production of soft wood timber for pulping and other industrial use in a short rotation age. Maritime pine is the most important exotic species used in such plantations, particularly in Marmara and Black Sea regions.

In this framework, 1.700 hectares of maritime pine plantations were established at Bartın-Karaçaydere between the years of 1979 and 1984. Generally the Land origin of the species was used at plantation site. Mechanization techniques have applied at suitable sites, but the evaluation of results indicated that land clearing, preparation and maintenance operations were not properly practiced and plantation have partly invaded by coppice vegetation. However, for the majority of medium to very good quality rock-free sites, involving the conversion of degraded coppice or forest crops, complete uprooting, clearing and brushpiling by a dozer-type crawler tractor and front-mounted

clearing rake is a satisfactory and versatile technique. This operation may be done on slopes to about 40-45 percent. Because, this is the limit for following mechanized soil preparation. Consequently, it may be said that, the main reason of low survival rates in the sample plots at Bartın-Karaçaydere is inadequate mechanization techniques. Wrong origin and snow damages are the other effective factors. In spite of these negative conditions, reasonable growth rates were obtained in maritime pine plantation. Mean annual volume increment is 12.3 m^3/ha in mechanized land. This figure is 9.8 m^3/ha for the sites prepared by labour. Mean annual increment of the oriental beech is calculated as 5.3 m^3/ha, in the sample plots representing coppice vegetation.

The economical evaluations for maritime pine plantation and oriental beech forest at Bartın-Karaçaydere were also made. The results indicated that, maritime pine plantations were more productive and profitable comparing oriental beech forest as regards the criteria of NPV, IRR and BCR. Maximum IRR value (13.09%) was obtained for maritime pine plantations in the conditions of good site, 25 year rotation and mechanized preparation. Therefore, at Bartın-Karaçaydere and similar sites, establishment of maritime pine plantations should be considered as a good alternative to coppice forests. Western Black Sea region has vast areas of degraded forest which at present yield little other than firewood. The shortage of industrial timber is increasing year by year. It therefore makes good economic sense to convert the degraded forest to industrial plantations and such conversion wood seem to yield an attractive rate of return. It has been recognized that, intensive forestry operations including land clearing and soil cultivation are essential to optimize survival and growth rates and ensure efficient production of required quantity of wood.

Acknowledgements

This paper was produced from the project (TOVAG-3113) titled “Batı Karadeniz Bölgesi Sahilçamı (*Pinus pinaster* Aiton.) Ağaçlandırmalarında Büyümeye Ilişkin Teknik ve Ekonomik Değerlendirmeler (Bartın-Karaçaydere Örnek Çalışması)”. We are grateful to the Scientific and Technological Research Council of Turkey (TUBİTAK) for supporting this study. We also thank to the Directorate of Bartın Forest Enterprise and Directorate of Afforestation and Erosion Control for their valuable assistances.

Journal of the Faculty of Forestry, Istanbul University 2012, 62 (1): 31-45

Batı Karadeniz Bölgesi Sahilçamı Ağaçlandırmalarında Teknik ve Ekonomik Değerlendirmeler

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Kısa Özet

Bu makalede Bartın-Karaçaydere serisinde 1979-1984 yılları arasında tesis edilen sahilçamı (*Pinus pinaster* Aiton.) plantasyonlarının teknik ve ekonomik bir değerlendirmesi yapılmıştır. Bu kapsamda farklı arazi hazırlığı tekniklerinin (makine ve işgücü) uygulandığı plantasyon alanlarından toplam 60 adet deneme alanı alınmıştır. Deneme alanlarında ölçüm ve tespitler 2003 yılında gerçekleştirilmiştir. Yapılan ölçüm ve tespit sonuçlarına göre, sahilçamı plantasyonlarının yanlış mekanizasyon tekniklerinin uygulanmasına, hatalı orijin seçimine ve kar zararına rağmen büyüme ve ürün verimi yönünden memnun edici düzeyde olduğu ortaya çıkmıştır. Buna göre makineli arazi hazırlığı yapılan plantasyon alanında yıllık ortalama artım 12,3 m^3/ha, insan gücü ile arazi hazırlığı yapılan plantasyon alanında ise yıllık ortalama artım 9,8 m^3/ha olarak tespit edilmiştir. Diğer taraftan Net Bugünkü Değer, İç Kârlılık Oranı ve Fayda/Maliyet Oranı kriterlerine göre gerçekleştirilen ekonomik analizler sonucunda, yörede farklı yıllarda tesis edilen sahilçamı plantasyonlarının, araştırma alanının doğal türü olan doğu kayını (*Fagus orientalis* Lipsky.) ormanlarına göre daha verimli ve kârlı bir yatırım olduğu belirlenmiştir.

Anahtar Kelimeler: Sahilçamı, Doğu Kayını, endüstriyel plantasyon, büyüme ve hasılat, ekonomik analiz

1. Giriş

Ormanlar sağladıkları ürün ve hizmetler ile toplum yaşamının sağlık ve kalitesine katkı sağlayan en önemli doğal kaynakların başında gelmektedir. Bu nedenle, ormanların çeşitli nedenlerle tahrip edilmesinin önlenmesi ve devamlılıklarının sağlanması üzerinde önemle durulması gereken çevre sorunlarından birisidir. Ülkemiz 21,2 milyon ha alan ile zengin bir orman kaynağına sahip olmakla birlikte, bu kaynağın yaklaşık olarak %50'si verimli, % 50'si ise verimsiz niteliktedir (Anonymous, 2006). Bu nedenle, verimli doğal ormanlarımızın devamlılığının sağlanması ve bozuk nitelikli orman kaynaklarımızın da ıslah edilerek verimli hale getirilmesi hem sahip olduğumuz biyolojik çeşitliliğin korunması hem de orman ürünleri sektörünün ihtiyaç duyduğu hammaddenin sürekli olarak sağlanması açısından önem taşımaktadır. Bu kapsamda verim güçleri özellikle meydana gelen yangınlar, usulsüz yararlanmalar ve hatalı teknik uygulamalar nedeniyle azalmış olan doğal orman kaynaklarımız üzerindeki faydalanma baskısının azaltılması, bu kaynakların gelecek nesillere aktarılması yönünden alınacak önemli tedbirlerden birisidir. Bu doğrultuda odun hammaddesine duyulan yüksek talebin uygun yetişme ortamı koşullarına sahip alanlarda, uygun orijinler ile tesis edilecek endüstriyel plantasyonlardan karşılanması doğru bir uygulama olacaktır (Cooling, 1977; Birler, 1995; Boydak ve Dirik, 1998). Nitekim, Yeni Zelanda'da doğal orman kaynaklarından yapılan aşırı yararlanmalar nedeniyle bu kaynaklarda ortaya çıkan ciddi azalmalar nedeniyle söz konusu bu ülke için egzotik bir tür olan Radiata Çamı (*Pinus radiata* D. Don) ile 1,5 milyon ha alanda tesis edilen endüstriyel plantasyonlardan yılda toplam 15 milyon metreküp ürün elde edilmekte ve bu ürünün yaklaşık %50'si ihraç edilerek değerlendirilmektedir (Ayberk ve Ark., 1998). Ülkemiz ormanlarında da yetişme ortamı koşulları açısından hızlı gelişen yerli ve

Received: 19.08.2011; accepted: 21.12.2011

yabancı türler ile endüstriyel plantasyonların kurulmasına uygun alanlar bulunmaktadır. Bu nedenle ülkemizde TUR71/521 nolu FAO destekli proje ile başlayan endüstriyel plantasyon çalışmalarına devam edilmelidir.

2. Materyal ve Metot

Bu araştırma Bartın-Karaçaydere serisinde 1979-1984 yılları arasında 1700 ha alanda tesis edilen sahilçamı (*Pinus pinaster* Aiton.) endüstriyel plantasyon sahasında gerçekleştirilmiştir. Alanda doğal olarak doğu kayını, gürgen, kestane ve bazı meşe türleri bulunmaktadır. Araştırma alanının rakımı 0-300 m, eğimi ise % 10-80 arasında değişmektedir. Karaçaydere serisi her mevsimi yağışlı Batı Karadeniz alt iklim tipinin etkisi altında olup, yıllık ortalama yağış 1072 mm, ortalama sıcaklık 13,2°'dir. Yörede vejetasyon süresi 6 aydır. Toprak derin olup, iskelet muhtevası az taşlıdır. Toprak türü ise genel olarak kumlu-balçık ve killi-kumlu-balçıktır (Günay, 1983; Anonymous, 2001).

Araştırma kapsamında incelene sahilçamı plantasyonlarının, ağaçlandırma projesinde ve arazide yapılan ön etütler neticesinde iki farklı arazi hazırlığı tekniği uygulanarak tesis edildiği belirlenmiştir. Buna göre, Karaçaydere serisindeki sahilçamı plantasyon alanının yarısı makineli, diğer yarısı ise eğimin artması nedeniyle işçi gücü ile arazi hazırlığı yapılarak tesis edilmiştir. Bu kapsamda, iki farklı arazi hazırlığı gerçekleştirilen alandaki sahilçamı bireylerinin gelişimi ve plantasyon başarısını belirlemek için araştırma alanı 2 bloka ayrılmış ve her bir blokta 250 m mesafe ile 0,10 ha (10 x 10m) büyüklüğünde 30 adet olmak üzere sistematik olarak toplam 60 adet örnekleme alanı alınmıştır. Bu örnekleme alanlarında boy, göğüs yüksekliği çapı, yaş, ağaç sayısı gibi değişkenler ölçüm ve tespit edilmiştir. Diğer taraftan sahilçamı plantasyonlarının ortalama hacmi ve ortalama yıllık artımını hesaplamak için Özcan (2003) tarafından yapılan araştırmadan yararlanılmıştır. Yörenin doğal yapraklı türü olan doğu kayının hacim ve artım değerlerini belirlemek için gövde analizleri yapılmış ve gövde analizlerinden elde edilen sonuçlara göre hacim ve artım tabloları düzenlenmiştir.

Sahilçamı plantasyonları ile doğu kayını baltalıklarına ilişkin ekonomik analizlerin gerçekleştirilmesinde Net Bugünkü Değer (NBD), İç Kârlılık Oranı (İKO) ve Fayda/Maliyet Oranı (FMO) gibi ekonomik kriterler kullanılmıştır (Geray, 1986; Erkan, 2002; Daşdemir, 2005).

3. Sonuç ve Tartışma

Bu araştırmadan elde edilen bulgulara göre, mekanizasyon ile arazi hazırlığı yapılan sahilçamı plantasyon alanında yıllık ortalama artım 12,3m^3/ha, işçi gücü ile arazi hazırlığı yapılan alanda ise yıllık ortalama artım 9,8 m^3/ha'dır. Diğer taraftan makineli arazi hazırlığı yapılan sahilçamı plantasyon alanında ortalama meşcere hacmi 286,9 m^3/ha, işçi gücü ile arazi hazırlığı yapılan alanda ise bu oran 177,3 m^3/ha'dır. Ayrıca yörenin doğal yapraklı türü olan doğu kayını meşcerelerinde yapılan ölçüm sonuçlarına göre 31 yaşındaki doğu kayını meşceresinde ortalama meşcere hacmi 167,3 m^3/ha olarak belirlenmiştir.

Araştırma kapsamında gerçekleştirilen ekonomik analizler sonucunda, iyi yetişme ortamı koşullarında, 25 yıllık idare süresinde ve makineli arazi hazırlığı yapılarak gerçekleştirilen sahilçamı plantasyonlarının NBD, İKO ve FMO değerlerinin doğu kayınından ve diğer seçeneklerden oldukça yüksek olduğu (Tablo 5) anlaşılmıştır. Bu nedenle çeşitli olumsuzluklara rağmen yörede yapılacak sahilçamı plantasyonlarının araştırma alanının doğal türü olan doğu kayını ormanlarına göre daha verimli ve kârlı bir yatırım olduğu sonunca varılmıştır.

Bu araştırmayla yörede uygulamada ağaçlandırma yatırımlarında karşılaşılan ağaç türü, yer, idare süresi ve teknoloji seçimi konularına bilimsel yoldan çözüm getirilmeye çalışılmıştır. Özellikle sahilçamı gibi hızlı gelişen yabancı türlerle plantasyon sahaları kurulmadan önce sürekliliğin sağlanması, biyolojik ve ekonomik açıdan en iyi sonuçların elde edilmesi için bakım, koruma, silvikültürel rejim ve pazarlama konularında kapsamlı ve çok yönlü araştırmaların yapılması, ekonomik ve ekolojik bakımdan üstün ve güvenilir sonuçlar elde edildikten sonra, geniş sahalarda ağaçlandırmalara girişilmesi uygun olacaktır.

Teşekkür

Bu çalışma, "Batı Karadeniz Bölgesi Sahilçamı (*Pinus pinaster* Aiton.) Ağaçlandırmalarında Büyümeye Ilişkin Teknik ve Ekonomik Değerlendirmeler (Bartın-Karaçaydere Örnek Çalışması)" başlıklı (TOVAG-3113) projeden üretilmiştir. Bu çalışmaya desteklerinden dolayı Türkiye Bilimsel ve Teknolojik Araştırma Kurumu (TUBİTAK) 'na teşekkürlerimizi sunarız. Aynı zamanda Bartın Orman İşletmesi Ağaçlandırma ve Erozyon Kontrol Genel Müdürlüğüne değerli katkılarından dolayı teşekkür ederiz.

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