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ISSN : 0254-8704
http : //www.jeb.co.in

J. Environ. Biol.
30(2), 179-182 (2009)
info@jeb.co.in

Effects of release cutting on the development of young natural lebanon cedar (C*edrus libani* A. Rich) stands of western Mediterranean region of Turkey

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(Received: May 26, 2007; Revised received: August 30, 2007; Accepted: September 15, 2007)

Abstract: *Release cutting is ecologically and economically one of the most important silvicultural treatments for establishing a new stand. The study was designed to determine the suitable silvicultural treatments of different spacing of thinning for release cutting on young natural lebanon cedar (Cedrus libani A. Rich) stands at the thicket stage. Studies were carried out at Bucak and Gölhisar forest districts in the Western Mediterranean region of Turkey between the years of 1999-2005. Results showed that release cutting treatment had a positive effect on diameter growth for individual trees with the 1.5 m x 3 m spacing and positively correlated with spacing of thinning. However, there was not significant effect of the thinning application on height growth of young natural Lebanon cedar stands.*

Key words: *Cedrus libani, Release cutting, Spacing, Diameter growth, Height growth*
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Introduction

Currently, Lebanon cedar is economically and ecologically one of the most common and important commercial species in Turkey with a current standing volume of approximately 27.4 million m^3 (Konukcu, 2001; Boydak, 2003; Kirdar and Ertekin, 2007). Lebanon cedar forests covers a total 417188 ha area and is mostly in the Aegean and Mediterranean geographical regions of Turkey (Boydak, 2003). This species in Taurus Mountains occurs generally above 1200 m elevation. At these elevations snow cover period ranges 1-5 months, and winds are strong. Stems must be withstand the pressures of wind and snow. Therefore, appropriate cuttings should be implemented at the thicket stage to produce well-formed trees and more diameter increment. Later thinnings are difficult because of sickly stems. The regulation of stand density affects the properties of both single trees and the whole stands (Varmola and Salminen, 2004). Kramer (1988) pointed out that release cutting plays a decisive role in development of both the quantity and quality of conifers.

Release cuttings fall into two categories in Turkey forestry *i.e.* ecologically and economically. From the ecologically viewpoint, silvicultural practices (thinnings, release cuttings *etc.*) that provide a wide variety of vegetative composition and structure in young stands should help manage for biological diversity across forested landscape (Sullivan *et al*., 2002; Hanley, 2005). Promotion of biodiversity has become an important management objective for forests over the past decade, and release cutting and thinnings is viewed as one of the most effective tools to achieve this (Sullivan *et al*., 2005). Thinning to increase diversity, however, is likely to require different strategies than thinning to maximize timber production (Weng *et al*., 2007).

The economical dimension of release cutting is emphasized in this study. Release cuttings are an integral part of even-aged stands management for efficient and profitable production of timber products. In general, release cutting starts at an early ages in softwood stands in order to increase the yields and reduce the rotation age by concentrating on growth of selected stems. As forest rotations are long, unsuitable release cutting may result in irreparable crown positions and economic losses in the future.

In central Europe, release cutting and thinning can be considered as the most important influence on forest development (Daume and Robertson, 2000), and are a major tool for stand density control to increase tree growth or improve quality on a sustainable basis (Clark *et al*., 1994; Houtzager, 2002; Zeide, 2004). Parviainen (1994) in Finland recommended that the suitable time for release cutting is when the stand height reaches to 4-5 m. Kinnunen (1986) suggested that release cutting should not be carried out until the mean height of 4-6 m.

Release cutting may also have negative effects. Too heavy thinning and spacing may result in biotic and abiotic damage (Laiho, 1987) as well as have undesirable effects on wood quality. In addition, heavy thinnings may considerably reduce the total yield obtained during a stand rotation. However, a slight growth reduction may be acceptable if it is more than compensated by larger stem diameters and earlier income from thinnings (Makinen and Isomaki, 2004). These relationships are difficult to generalize because increment responses are often highly variable depending on differences in stand density, origin, tree species, site quality, stand age and different spacing of thinning (Nowak, 1996). Consequently, regional studies are required for release cutting impact assessment in geographically distinct forest area with different silvicultural practices.

This paper presents the data of the effects of release cutting on diameter and height growth using controls, thinning with 0.75 m x

1.0 m, 1.5 m x 1.5 m, and 1.5 m x 3 m spacing in young natural Lebanon cedar stands.

Materials and Methods

The sample plots were established within the boundary of Bucak and Golhisar Forest districts (Fig. 1) at an elevation of 1290 m to 1310 m and elevations of 1520-1540 m above sea levels. Climate and soil characteristics are similar on both districts and part of interior Mediterranean site region (Kantarci, 1991). The climate of lakes district is defined Mediterranean climate by Çepel and Kalay (1992). The most important characteristics of this climate are dry and hot in summer and rainy and mild in winter. Forests of this region are defined as "arid forests" due to its long dry period. The effects of Mediterranean climate can changes in a short distance. Mean annual precipitation is between 600-1200 mm and is related to elevation. The mean annual temperature is 18°C, (10°C in winter and 28-30°C in summer). The bedrock is generally calcareous and soil is characterized as red or reddish brown Mediterranean forest soils (Zech and Cepel, 1972). Scarascia-Mugnozza *et al.* (2000) stated that the natural vegetation of the Mediterranean region is closely related to the typical features of Mediterranean climate.

Measurements in sample plots followed requirements for accurate forest mensuration (Juodvalkis *et al*., 2005). The study was only carried out in selected representative areas of Bucak and Gölhisar divisional forest between the years of 1999-2005, where Lebanon cedar shows the good growth.

The experiments were laid out in a randomized blocks design with three replications. The spacing of thinning (control, 0.75 m x 1.0 m, 1.5 m x 1.5 m, and 1.5 m x 3 m spacing thinning) was randomly distributed to parcels in blocks. Buffer zones between treatments were about 1.5 m. The sample plots were based not only on area but also on number of stems. The mean size of sample plots was approximately 100 m^2 and nearly square. The border of sample parcels were marked using corner stakes according to treatment, including 30 numbered trees (galvanized labels) nearest to center of the parcel. Height was measured with a telescopic measuring rod, to the nearest 1 cm, and diameter at breast height (dbh) was measured to the nearest 1 mm accuracy with a caliper. Each numbered stem was marked by circle with oil paint at the height of 1.3 m, and during each inventory stem dbh was measured at this point in same two perpendicular directions within 1 mm accuracy. On each plots, approximate stand age was determined by the annual ring number in cutting stems from dominant trees and the mean stand age was 10-12 years. Genc (2001) indicated that Lebanon cedar forms the thicket stage at about 10 to 15 years of, and that the main objective for these stands is balancing the stem distribution and establishing a one storied structure.

For 0.75 m x 1.0 m spacing thinning, about 35% of stems were removed form respective parcels. The 1.5 m x 1.5 m spacing thinning removed about 55% of stems, and the 1.5 m x 3.0 m 76%. One plot in each block was left as a control, from which only dead

Fig. 1: Location of the sample plots in lake district of Turkey

trees were removed. Poorly developed trees and the largest individuals which were suppressing other well-developed productive trees were cut.

$$\text{Increment percent values } (P_v\% = (\frac{V_e - V_b}{V_b})x100$$

where V_e = volume at the end of period; V_b = volume at the beginning of period) data were analyzed to evaluate the effect of silvicultural treatments on diameters at breast height and total tree heights using the one-way analysis of variance. Mean values were compared with the Dunnett's test (2-tailed) at a 5% level of significance to analyze significant differences between each silvicultural treatment and the control (Dunnett, 1955).

Results and Discussion

The analysis showed that the silvicultural treatments of 1.5 m x 1.5 m, and 1.5 m x 3 m spacing of thinning was significant at 0.05 level for diameter growth in Bucak and Golhisar districts (Table 1 and 2). No other differences were statistically significant.

The findings showed that silvicultural treatments (spacing of thinning) had meaningful effect on diameter growth as is directly related to the degree of thinning. Similar findings have been reported by others (Makinen and Isomaki, 2004; Ozdemir *et al*., 1987; Voorhis, 1990; Varmola *et al*., 2004; Juodvalkis *et al*., 2005). However, Trimble (1973) indicated that the application carried out in yellow-poplar and black cherry stands in central Appalachians spacing of thinning had no effect on diameter growth. However, the results of many other studies are similar to this study as regards the effect of stand density on the diameter growth of pine species following release cutting.

Ozdemir *et al*. (1987) noted that silvicultural treatments had no significant effect on height growth of young brutian pine

Table - 1: Comparison of silvicultural treatments for diameter growth in Bucak

ANOVA				
Source	**DF**	**Mean square**	**F**	**p**
Block	2	0.1230		
Treat	3	1.5067	10.04	0.009
Error	6	0.1500		
Total	11			

Dunnett's multiple comparisons				
Treatment	**Mean**	**Difference**	**Critical d value**	**Significant**
1	2.2583	-	2.971	-
2	2.6583	0.4000	2.971**	No
3	3.3250	1.0667	2.971*	Yes
4	3.8583	1.6000	2.971*	Yes

Treatment 1: Control, 2: 0.75 m x 1.0 m spacing thinning, 3: 1.5 m x 1.5 m spacing thinning, 4: 1.5 m x 3.0 m spacing thinning, p was significant at 0.01, Yes: Significantly different at alpha= 0.05, No: Not significantly different at alpha= 0.05

Table - 2: Comparison of silvicultural treatments for diameter growth in Gölhisar

ANOVA				
Source	**DF**	**Mean square**	**F**	**p**
Block	2	0.1900		
Treat	3	2.2500	27.00	0.001
Error	6	0.0833		
Total	11			

Dunnett's multiple comparisons				
Treatment	**Mean**	**Difference**	**Critical d value**	**Significant**
1	2.6375	-	2.971	-
2	3.0042	0.3667	2.971**	No
3	3.7042	1.0667	2.971*	Yes
4	4.6042	1.9667	2.971*	Yes

Treatment 1: Control, 2: 0.75 m x 1.0 m spacing thinning, 3: 1.5 m x 1.5 m spacing thinning, 4: 1.5 m x 3.0 m spacing thinning, p was significant at 0.01, Yes: Significantly different at alpha= 0.05, No: Not significantly different at alpha= 0.05

Table - 3: Comparison of silvicultural treatments for height growth in Bucak

ANOVA				
Source	**DF**	**Mean square**	**F**	**p**
Block	2	0.1027		
Treat	3	0.4726	3.19	0.0934
Error	6	0.1482		
Total	11			

Dunnett's multiple comparisons				
Treatment	**Mean**	**Difference**	**Critical d value**	**Significant**
1	1.4173	-	2.971	-
2	1.5773	0.1600	2.971**	No
3	2.2673	0.8500	2.971**	No
4	1.4606	0.0433	2.971**	No

Treatment 1: Control, 2: 0.75 m x 1.0 m spacing thinning, 3: 1.5 m x 1.5 m spacing thinning, 4: 1.5 m x 3.0 m spacing thinning, p was not significant at 0.05, No: Not significantly different at alpha=0.05

Table - 4: Comparison of silvicultural treatments for height growth in Golhisar

ANOVA				
Source	**DF**	**Mean square**	**F**	**p**
Block	2	2.2022		
Treat	3	0.2505	0.72	0.5723
Error	6	0.3491		
Total	11			

Dunnett's multiple comparisons				
Treatment	**Mean**	**Difference**	**Critical d value**	**Significant**
1	2.0419	-	2.971	-
2	2.4919	0.4500	2.971**	No
3	2.2052	0.1633	2.971**	No
4	2.6885	0.6467	2.971**	No

Treatment 1: Control; 2: 0.75 m x 1.0 m spacing thinning; 3: 1.5 m x 1.5 m spacing thinning; 4: 1.5 m x 3.0 m spacing thinning; p was not significant at 0.05, No: Not significantly different at alpha=0.05

stands in Mediterranean region of Turkey. The studies on planted Douglas-fir, Pacific Northwest of North America found that thinning did not effectively enhance heights growth (McDonald and Tucker, 1989). As presented in Tables 3 and 4, silvicultural treatments had not significant effect on height growth in the present study.

As a result; release cutting is an important silvicultural treatment (spacings of thinning) for establishing the new stand and development of quality and quantity, and it must be done in timely manner. In order to determine the appropriate silvicultural treatment, the production target and rotation age must be taken into consideration. It is apparent from this study that different diameter growth of young lebanon cedar stands occurs at different levels of spacing (silvicultural treatments). The six years results of this study showed that the highest increment in dbh was obtained from the treatment of 1.5 m x 3 m spacing of thinning. The effect of treatment was not significant on height growth. However, in order to obtain most conclusive results, it will be necessary to carry out long term studies for getting the actual forest yields (Johnstone, 1969; Marsh and Burges, 1973).

Acknowledgments

This study was supported by the grant of Süleyman Demirel University BAPYB (Project number 225). The authors wish to extend their thanks to the authorities of the Regional Forest Service of Isparta for the valuable assistance provided during the ground survey and Harry V. Wiant Jr., for his helpful review comments of the earlier drafts of the manuscript.

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