The Occurrence of Heart Rot on *Abies nordmanniana* subsp. *bornmülleriana* Mattf. Trees in relation to Altitude

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Abstract

Fir is the taxon subjected to the selection systems in Turkish forestry. In selection forests, target diameter is the main criterion for planning and management. In this study the aim is to determine the formation and level of the heart rot and target diameter depending on aspect and altitude for *Abies nordmanniana* subsp. *bornmülleriana* Mattf. For this purpose, the fir trees with maximum diameters were cut and the situation of heart rot at various altitude levels (900-1,200 m, 1,200-1,500 m, and 1,500-1,800 m) and aspects was determined. The formation of heart rot starts at low altitudes and this defect was found nearly on all fir trees of target diameter of 60 cm which is commonly used in practical Turkish forestry. Target diameter of 60 cm was considered as usable at the altitude of 1,200 m and even higher, at 1,500 m and even more, the usable target diameter is more than 60 cm, as heart rot was not found in the sample trees with target diameters about 70-80 cm. In addition to this, heart rot was detected less in fir trees located on the south-facing slopes than on the north-facing slopes. The correlation coefficient between the basal diameter and heart rot was 0.631; it was 0.638 in the fir trees on the north-facing slopes and 0.696 on the south-facing slopes. According to these results, the target diameter of fir trees, which are dominant in selection forests, must be planned considering the altitude and aspect.

Key words: *Abies nordmanniana* subsp. *bornmülleriana*, target diameter, heart rot

Introduction

Abies species are economically valuable because of many features like timber, pulp and paper, oils, and resins. In addition, some species are used for ornamental purposes (Anşin and Özkan, 1997; Esteban et al., 2010). Turkey's total forest area is 21,389,783 ha of which 626,647 ha is formed by fir species (*Abies nordmanniana*, *A. bornmülleriana, A. equi-trojani*, *A. cilicica*) (Anonymous, 2006).

Uneven-aged forests require more intensive interventions. For this reason, selection systems are applied in the uneven-aged forests. The forests composed of shade-tolerant species such as fir are the most suitable for selection systems (Saatçioğlu, 1979; Ata, 1995; Genç, 2004). Also Ata (1995) stated that both pure and mixed (dominated by fir) fir forests are suitable for selection systems in Turkey forests. The main purpose of selection cutting method is the preservation of the best quality stems and maintenance of an uneven-aged stand structure.

Çepel (1995) stated that fir forests show highly variable physiographic factors, especially altitude. As a matter of fact altitude is an important physiographic variable, influencing local ecological conditions. Depending on the changes in altitude, microclimatic and soil conditions also change dramatically. Generally, fir reaches its optimum development between 1,000-1,500 m altitude (Saatçioğlu, 1969; Ata, 1975; Bozkuş, 1987).

The basic criterion in selection forests is the removal of the trees reaching the target diameter. Therefore, the amount of trees reaching this diameter affects the allowable cut and removal of these individuals from the stand by operator. So, the target diameter is the most important factor for determining the level of intervention in the selection forests. However, there is no study for different ecological conditions. According to Eraslan (1992), the target diameter must be 60 cm and the General Directorate of Forestry use the same value for all ecological conditions. According to forestry practitioners, the target diameter should be higher than 60 cm in the optimum ecological range. In less favorable conditions, the heart rot was found in most of the trees reaching the target diameter and it affects all parts of trees. Consequently, the target diameter of fir trees should be lower than 60 cm outside their optimum ecological conditions.

Fir trees reaching the target diameter have high proportions of heart rot and are not usable for economical valuation. So, determining the formation of heart rot is very important for deciding upon the target diameter. For these reasons, this study aims to determine the formation and level of the heart rot in Bornmülleriana fir depending on aspect and altitude.

Material and Method

Material

A. n. subsp. *bornmulleriana* is an endemic taxon in Turkey. It is distributed in the Black Sea Region, the estuary of Kızılırmak River between Uludağ East Black Sea Region and Kocaeli Basin. In the West Black Sea Region, the fir occurs as forest tree at a distance of 8-10 km from the seaside and it could be found inside at 140-150 km.

This study was conducted in the optimum range of fir, in selection forests at 900-1,750 m altitude, part of Daday Forest Chiefdom and Ballıdağ Forest Chiefdom.

The sample areas were selected at 900-1,200 m, 1,200-1,500 m, and 1,500-1,800 m altitude levels, on highly fertile sites. The sample trees were obtained from the middle of these altitudes. The sample areas were selected in fir stands dominated by Bornmülleriana fir (80%) and located under optimum ecological conditions.

30 sample trees was obtained from the selected three different altitude levels; five Bornmülleriana fir trees with the thickest diameters in the north-facing and south-facing slopes of each altitude levels were also selected. Position of sample trees was obtained from different sample areas located in the lower, middle and upper part of slope. The selected sample trees were checked and no diseases, injuries, insect attacks were found on them.

Method

Selected sample trees were cut close to the ground level then measured. The center of cut trees and location of heart rot, proportion of healthy wood and bark thickness in each tree aspect were determined. SPSS 13.0 software was used for calculating the correlation between the basal diameter and amount of heart rot and identifying the influence of aspect class from the obtained data for three altitude levels.

In this study, we aimed at determining the effect of altitude on the onset of heart rot. In this respect, using the obtained data, sample trees from each altitude class were tabulated considering the „aspect" factor. Subsequently solely the „altitude" factor was used.

Results

The measurements carried out in sample trees from the north-facing and south-facing slopes are shown at Table 1.

Table 1. Average results for the north-facing and south-facing slopes

Altitude (m)/Aspect	North	South
900-1,200 m	76.85	55.25
1,200-1,500 m	107.03	94.90
1,500-1,800 m	98.65	90.10

The average basal diameters and heart rots for each altitude classes are shown in Table 2; the average diameter and heart rots for both aspect and altitude are shown in Table 3; the types of heart rot are shown in Fig. 1.

Fig. 1. Types of heart rot (healthy wood, spongy wood, rotten wood)

Table 2. Average diameter and heart rots for each altitude level

Aspects	Altitude (m)	Thickness	North (cm)	South (cm)	East (cm)	West (cm)	Total (cm)
Mean values of lower altitude level (900-1,200 m)							
North	1020	Bark	1.7	2.7	1.5	1.6	3.75
		Wood	26.8	32.5	26.6	34.3	60.10
		Rotten	**5.2**	**7.2**	**3.4**	**10.2**	**13.00**
		TOTAL	**33.7**	**42.4**	**31.5**	**46.1**	**76.85**
South	1052	Bark	1.7	1.5	1.8	1.8	3.4
		Wood	20.6	25.8	23.8	24.2	47.2
		Rotten	**2**	**3.2**	**2.4**	**1.7**	**4.65**
		TOTAL	**24.3**	**30.5**	**28**	**27.7**	**55.25**
900-1,200 m General mean	**1036**	Bark	**1.7**	**2.1**	**1.65**	**1.7**	**3.58**
		Wood	**23.7**	**29.15**	**25.2**	**29.25**	**53.65**
		Rotten	**3.6**	**5.2**	**2.9**	**5.95**	**8.83**
		TOTAL	**29**	**36.45**	**29.75**	**36.9**	**66.05**
Mean values of medium altitude level (1,200-1,500 m)							
Aspects	**Altitude (m)**	**Thickness**	**North (cm)**	**South (cm)**	**East (cm)**	**West (cm)**	**Total (cm)**
North	1367.8	Bark	4.7	2	1.6	2.1	3.60
		Wood	40.8	39.8	34.6	39.3	77.25
		Rotten	**11.3**	**14.4**	**11.9**	**10.9**	**26.18**
		TOTAL	**56.8**	**56.2**	**48.1**	**52.3**	**107.03**
South	1404.8	Bark	1.3	1.8	1.6	1.8	3.25
		Wood	55.5	41.5	44.6	39.2	90.40
		Rotten	**0.6**	**0.6**	**0.6**	**0.7**	**1.25**
		TOTAL	**57.4**	**43.9**	**46.8**	**41.7**	**94.90**
1,200-1,500 m General mean	**1386.3**	Bark	**3**	**1.9**	**1.6**	**1.95**	**3.425**
		Wood	**48.15**	**40.65**	**39.6**	**39.25**	**83.83**
		Rotten	**5.95**	**7.5**	**6.25**	**5.8**	**13.72**
		TOTAL	**57.1**	**50.05**	**47.45**	**47**	**100.97**
Mean values of high altitude level (1,500-1,800 m)							
Aspects	**Altitude (m)**	**Thickness**	**North (cm)**	**South (cm)**	**East (cm)**	**West (cm)**	**Total (cm)**
North	1685.8	Bark	2.8	2.3	2.6	2.3	5.00
		Wood	50.5	47.1	50.3	39.4	93.65
		Rotten	**0**	**0**	**0**	**0**	**0,00**
		TOTAL	**53.3**	**49.4**	**52.9**	**41.7**	**98.65**
South	1687.4	Bark	1.7	2	2	2.1	3.90
		Wood	46.1	41	48.3	37	86.20
		Rotten	**0**	**0**	**0**	**0**	**0,00**
		TOTAL	**47.8**	**43**	**50.3**	**39.1**	**90.10**
1,500-1,800 m General mean	**1686.6**	Bark	**2.25**	**2.15**	**2.3**	**2.2**	**4,45**
		Wood	**48.3**	**44.05**	**49.3**	**38.2**	**89.925**
		Rotten	**0**	**0**	**0**	**0**	**0,00**
		TOTAL	**50.55**	**46.2**	**51.6**	**40.4**	**94.375**

Table 3. Average diameter and heart rots for both aspect and altitude

Altitude level	Mean altitude (m)	Thickness	North (cm)	South (cm)	East (cm)	West (cm)	Total (cm)
900-1,200 m General mean	1036	Bark	1.7	2.1	1.65	1.7	3.58
		Wood	23.7	29.15	25.2	29.25	53.65
		Rotten	**3.6**	**5.2**	**2.9**	**5.95**	**8.83**
		TOTAL	**29**	**36.45**	**29.75**	**36.9**	**66.05**
1,200-1,500 m General mean	1386	Bark	3	1.9	1.6	1.95	3.43
		Wood	48.15	40.65	39.6	39.25	83.83
		Rotten	**5.95**	**7.5**	**6.25**	**5.8**	**13.72**
		TOTAL	**57.1**	**50.05**	**47.45**	**47**	**100.97**
1,500-1,800 m General mean	1687	Bark	2.25	2.15	2.3	2.2	4.45
		Wood	48.3	44.05	49.3	38.2	89.93
		Rotten	**0**	**0**	**0**	**0**	**0.00**
		TOTAL	**50.55**	**46.2**	**51.6**	**40.4**	**94.38**

According to Table 3, the average basal diameter of sample trees at low altitude level is 66.05 cm, of which the heart rot counts for 8.83 cm on average. The average basal diameter of sample trees at middle altitude level is 100.97 cm, with the average diameter of heart rot of 13.72 cm. Finally, the average basal diameter of sample trees at the high altitude level is 94.375 cm without any trace of heart rot. Northern and south-western sections of selected sample trees are shown in Fig. 2.

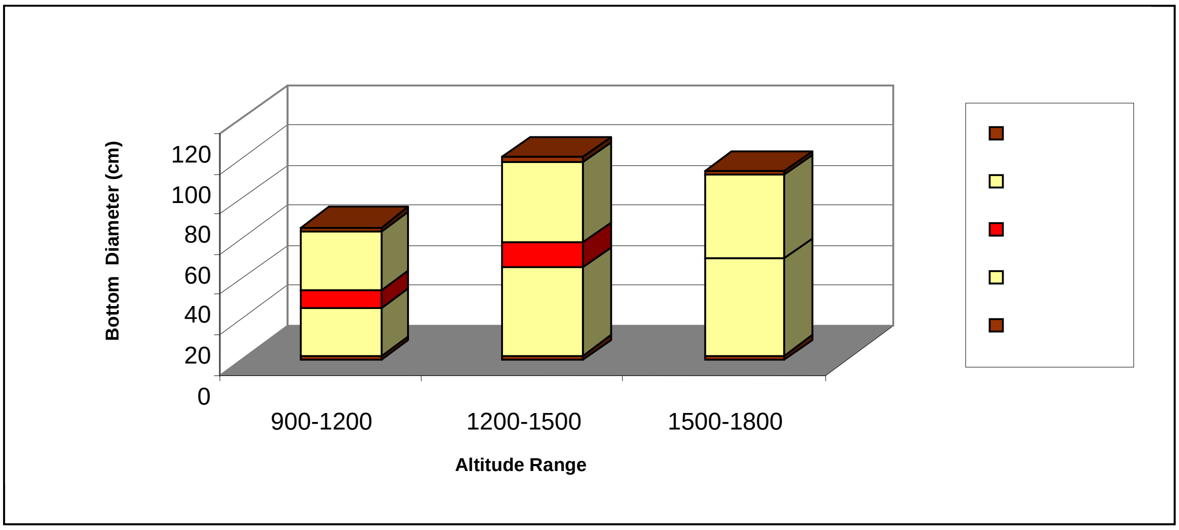

Fig 2. Section of selected sample trees from different altitudes levels

In Fig. 2 sample trees selected from middle altitude level are thicker than sample trees from high altitude level. So, sample trees selected from middle altitude level have more heart rot. The values of healthy wood were calculated with formula: total bottom diameter minus heart rot value. This situation is shown in Fig. 3.

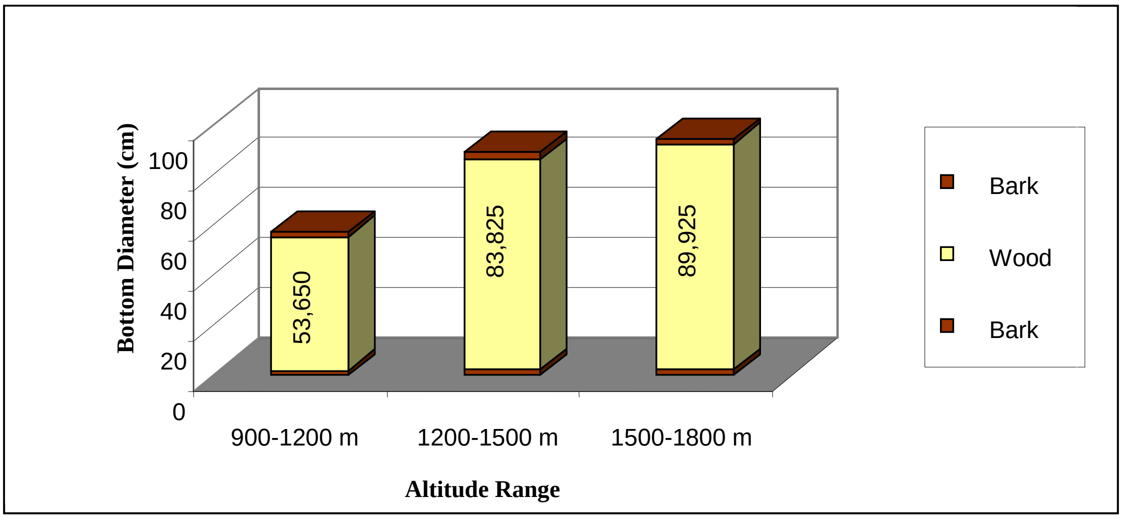

Fig. 3. Average values of healthy wood depending on altitude level

In Fig. 2, there is no difference between the healthy wood of sample trees from different altitudes levels. The average values of healthy wood of sample trees are 53.65 cm at low altitudes, 83.825 cm at middle altitudes, and 89.925 cm at high altitudes. The statistical relationship between basal diameter and heart rot is shown in Fig. 4.

R	R Square	Adjusted R Square	Std. Error of the Estimate
.631	.399	.354	9.410
.638	.408	.309	11.879
.696	.485	.399	2.985

The independent variable is cap.

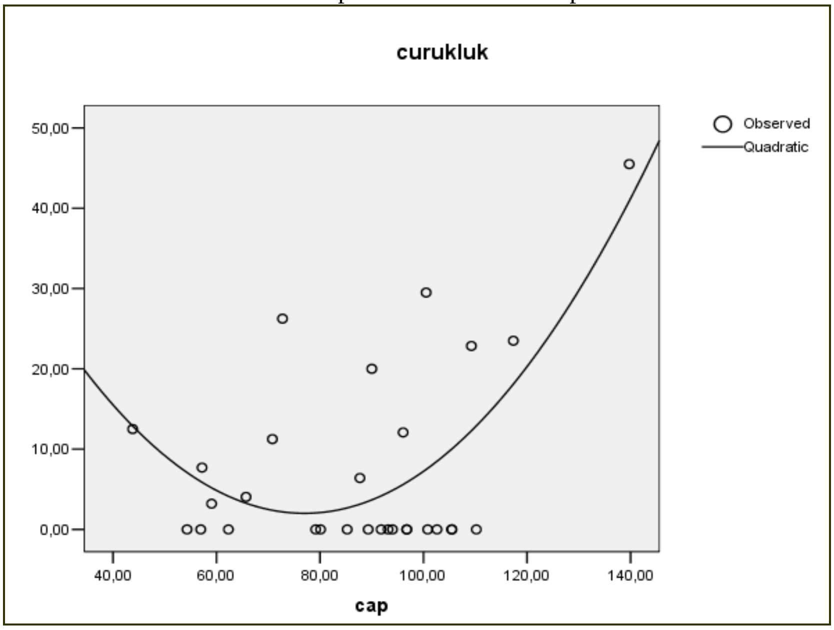

Fig. 4. Relationship between basal diameter and heart rot

The relation between basal diameter and heart rot on north-facing slopes is shown in Fig. 5. The relation between basal diameter and heart rot on south-facing slopes is shown in Fig. 6.

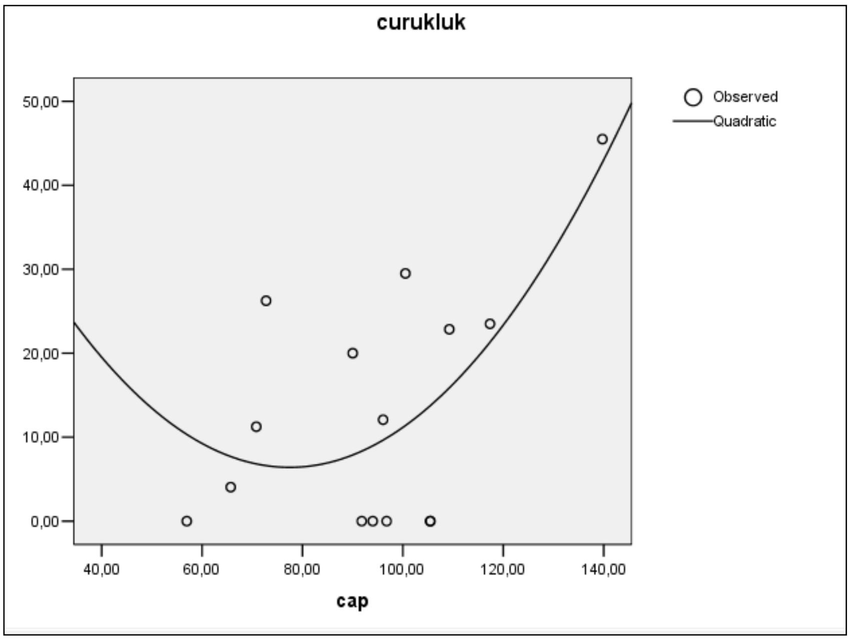

Fig 5. Relation between basal diameter and heart rot on north-facing slopes

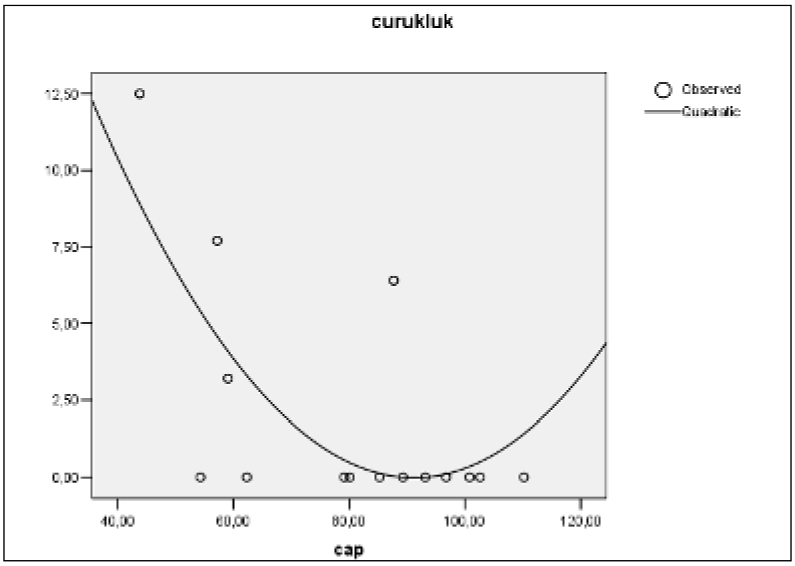

Fig. 6. Relation between basal diameter and heart rot on south-facing slopes

Conclusions and Suggestions

According to forestry district regulations, forest products take into account only the healthy wood after removing the heart rot part. Therefore, in this study, only the healthy wood part was evaluated. The average healthy wood value is 60.1 cm at low altitude level on north-facing slopes and 47.2 cm on south-facing slopes. The average value of healthy wood of sample trees is 53.66 cm at low altitudes and 83.83 cm at middle altitudes. The average value of healthy wood is 77.25 cm at middle altitude level on north-facing slopes and 94.9 cm on south-facing slopes. The sample trees collected in high altitude level have no heart rot. The average value of healthy wood is 93.65 cm at high altitude level on north-facing slopes and 86.2 cm on south-facing slopes.

The basal diameter of sample trees collected at 1,036 m mean elevation is 66.05 cm and the heart rot part is 8.825 cm. The basal diameter of sample trees collected at 1,386 m mean elevation is 100.965 cm and the heart rot part is 13.71 cm. The basal diameter of sample trees collected at 1,687 m mean elevation is 94.37 cm and sample trees collected at this high altitude level have no heart rot.

In the present forest management plans, the target diameter is not determined according to different site index classes therefore the 60 cm target diameter is used in all situations. For this reason, at low altitudes fir trees which have not reached this value and are not useable for economical valuations in accordance with the instructions of General Directorate of Forest are abandoned in the forest. In the optimum ecological conditions (sites) for fir, the 60 cm target diameter remains low. According to Saatçioğlu (1969), Ata (1975), Bozkurt (1987), fir forests show their best growth at 1,000-1,500 m elevation. Consequently one should propose the increase of target diameter in these sites and altitudes because the 60 cm target diameter can produce maximum economic losses.

During this study, the sample trees from 1,300 m upwards show a high level of diameter increment (wide growth rings). However, in nearby 1000 m altitude observed that growth to a halt. At the same time; in 1000 m altitude, from 60 cm limit diameter, sample trees can be said about increase of annual ring several mm but in 1600 m altitude this value is 2-3 cm. These results should be considered when determining the target diameter. In fir forests, this contribution can provide important insights for making the operation more profitable.

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