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Full Length Research Paper

The effect of *Viscum album* L. on annual diameter increment of *Pinus nigra* Arn.

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In this study, the influence of infestation by mistletoe (*Viscum album* L. subsp. *austriacum* (Wiesb.) on the annual diameter increment of Anatolian black pine (*Pinus nigra* Arn. subsp. *pallasiana* (Lamb.) Holmboe) in Goksun district (Kahramanmaras province, Turkey), was investigated. Differences among annual diameter increment measured in nine growing years between 1992 and 2000 were significantly (P < 0.001) affected by the infestation of the mistletoe. The percent decrease in the annual diameter increment of infested trees ranged between 36 and 50% depending upon the years. In conclusion, the annual diameter increments of Anatolian black pine trees were reduced by about 41% within 9 years due to infestation by the mistletoe.

Key words: Anatolian black pine, annual diameter increment, mistletoe, Turkey.

INTRODUCTION

Pinus nigra Arn. subsp. *pallasiana* (Lamb.) Holmboe, one of the most common subspecies of black pine, is known as Anatolian black pine. This species shows wide natural distribution in Balkans, Thrace, Crimea, Carpathians and Turkey (Yucel, 1998; Anşin et al., 2005) and covers an area of about 4.2 million hectares (20% percent of all forest areas) in Turkey. The distribution of this species depends upon exposure and climatic conditions and it generally grows in boreal exposures and deep soils. Its growth is seriously affected by pest organisms (Kanat, 1999; Kanat et al., 2004; Anonymous, 2008) and the parasitic/hemiparasitic floweradial plants such as mistletoe, *Viscum album* L., a hemiparasitic floweradial plant (Ergun and Deliorman, 1995).

Worldwide, mistletoes include 900 species in 65 genera of Loranthacea family, and 400 species in 7 genera of Viscacea family (Barlow, 1983). In Turkey, there are three subspecies of the Loranthaceae and the most common one of which is *V. album* subsp. *austriacum* (Wiesb.) which is investigated here (Ergun and Deliorman, 1995). Mistletoe seeds are disseminated by various methods and diverse agents. It was observed early on that berry-eating birds played a crucial role in distributing the seed of this plant (Calder, 1983). Infection of mistletoe to trees mainly spreads through birds, which first eat the seeds of mistletoe on trees and then the seeds spreads on the other trees through feces of birds.

Mistletoes cause a great deal of damage in forests, orchards, plantations and ornamentals worldwide. Mistletoes impair growth and host vigor, reduce wood quality, quantity and seed crop production. Infected trees are often predisposed to insect attacks or killed directly by mistletoes (Hawksworth, 1978; Hawksworth, 1980). It also reduces male and female flowers' production on different host trees. The parasite develops special adaptation for mineral nutrition by using its sucking roots, which leads to reduced growth of the host plant.

Effects of dwarf mistletoes on a stand depend on a combination of factors: intensity of infection, stand density, stand structure and composition. For a given intensity of infection, effects are most pronounced in dense stands. For example, in 60-year-old stand of *Pinus contorta* with moderately heavy infestations estimated volume reduction is about 10, 20 or 30% for stands of growing stock level (Hawksworth et al., 1996). Dooling and Eder (1981) reported 35% of all the surveyed lodgepole pine stands in Montana infested with dwarf

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mistletoe. Johnson et al., (1981) found that in Colorado and Wyoming, 47 and 55%, respectively, of the surveyed lodgepole pine stands were infested. Annual volume yield reduction estimates in Montana forests averaged 0.70 m^3/ha and ranged from 0.43 to 1.30 m^3/ha. For six national forests in Colorado, Johnson et al., (1980) reported that annual lodgepole pine volume yield reductions averaged 0.62 m^3/ha and ranged from 0 to 0.82 m^3/ha. Eroglu and Usta (1993) reported that annual volume increment of *Pinus sylvestris* growing in Turkey was reduced by 33 - 56% for 5 -15 years due to the infestation of mistletoe, *V. album* subsp. *austriacum*. It was also reported that the growth of mistletoe on *Pinus sylvestris* played an important role in chemical composition.

Stand growth of *P. sylvestris* in Sürmene-Çamburnu was reduced by 8.5 -16.5% (Eroğlu, 1993). While the percentage of dead trees due to mistletoes in this forest was 1 - 2% in ten years ago, it was 3.5% in last year (Eroğlu and Başkaya, 1995). Increment loss due to intensive mistletoes was 20% in trees (Sekendiz, 1984) and 32% in pine trees (Unger, 1992). So far, the scientists have been studying on the effects of the mistletoe on the various properties of trees (Glatzel, 1983; Thomson et al., 1984; Knutson and Tinnin, 1986; Hawksworth and Geils, 1990; Hosman, 1993; Sterba, 1993). However, a few studies have addressed the effect of the mistletoe, *V. album* subsp. *austriacum*, on the annual diameter increment (Sekendiz, 1984; Unger, 1992; Eroğlu, 1993).

Therefore, the aim of this study was to investigate the influence of damage caused by *V. album* subsp. *austriacum* on the annual diameter increment of Anatolian black pine trees grown in the region of Kahramanmaraş, the Eastern Mediterranean part of Turkey.

MATERIALS AND METHODS

Study area

The study was carried out on Anatolian black pine naturally growing in the forest of Yazıkoy village (Goksun District, Kahramanmaraş province, Turkey, latitude, 380 021 N; longitude, 360 301 E; altitude, 1300 m). Stand structure in study area is Anatolian black pine, mature development stage (20 - 35.9 cm diameter at the breast height) and medium coverage (41-70% crown closure). It is pure and naturally regenerated stand. It covers approximately 38 hectare (ha) and most of the area are affected by mistletoes. The site class is V in which soil depth and productivity is low. In other words, the research area has poorer soil properties (as soil depth, organic matter, etc.). The mean diameter and the height of 50 - 60 years pine trees growing in the study area (for both infested and control trees) varied between 25 - 35 cm and 19 - 22 m, respectively. The mean volume of the stand is 100.957 m^3 per hectare and the mean volume increment is 2.531 m^3 (Anonymous, 1991 - 2010). The number of trees in a hectare of the study area is about 464. Any silvicultural prescription such as thinning and tending was not carried out in study area from 1990 to 1999. However, tending felling was fulfilled at the end of the 1999.

The mistletoes were first observed in 1990 in the study area. Any treatments such as mechanical, biological and chemical were not carried out for mistletoes until 1994. However, the mistletoes grown on the Anatolian black pine trees were cut by tree pruner in the study area and removed from the stand in the winter season of growing year of 1994. Yet, new infestation was seen on trees after 1996 and they were not removed from the trees. The infestation was mainly observed on the branches and partially on the stem of the trees.

Both infested and control trees were selected from the same stand structure and have the same properties such as stand type, crown closure, site index, altitude and aspect. Besides, infested trees were selected according to the following criteria; diameter at breast height (DBH) between 20 and 30 cm, living crown length, silvicultural prescription and tree ages. Two hundred trees (100 infested and 100 controls) were randomly selected from the study area and these trees were distributed over the whole of the study area. Trees had 7 -10 mistletoes visible from the ground to be considered as infested. The trees of the control group bear no mistletoes visible from the ground. Meteorological data belonging to the study area were presented in Figure 1.

Calculation of annual diameter increment

The annual diameter increments of the pine trees were measured for nine growing years from 1992 to 2000. For the determination of annual diameter increment for the Anatolian black pine trees, increment cores were first taken by Pressler increment borer. Increment cores were extracted at the breast height (1.30 m) from one side of each tree (infested and control) parallel to the topographic contour. Cores were inserted into labeled plastic straws that were thermally sealed to prevent moisture loss. The measurements were done by using a Zeiss Winkel apparatus (Dendrometer 2000, made in Finland) with 0.01 mm precision on each core for the period 1992 to 2000. Annual diameter increment (ADI) and percent decrease in annual diameter increment (PDADI) were determined as follows:

$$ADI = (D_2 - D_1) \quad \text{(mm)}$$

Where; D_2 is the diameter of the pine tree measured at the end of the vegetation period of each year and D_1 is the diameter of the tree measured at the beginning of vegetation period of each year.

$$PDADI = (ADI_c - ADI_i) / ADI_c x100 \quad (\%)$$

Where; ADI_i is annual diameter increment for the pine trees defoliated by mistletoe and ADI_c is annual diameter increment for the control pine tree.

By using SPSS 12.0 statistical program, independent t test was applied to determine if significant differences between annual diameter increment of infested and control trees exist or not. Furthermore, the analysis of variance was applied to determine whether or not there were significant differences in years between 1992 and 2000 for both control trees and infested trees.

RESULTS AND DISCUSSION

The mean annual diameter increment for both infested and control trees are shown in Figure 2 and descriptive information of infested trees by years is given in Table 1. As indicated in this figure, obvious differences in the annual diameter increment among the growing years for

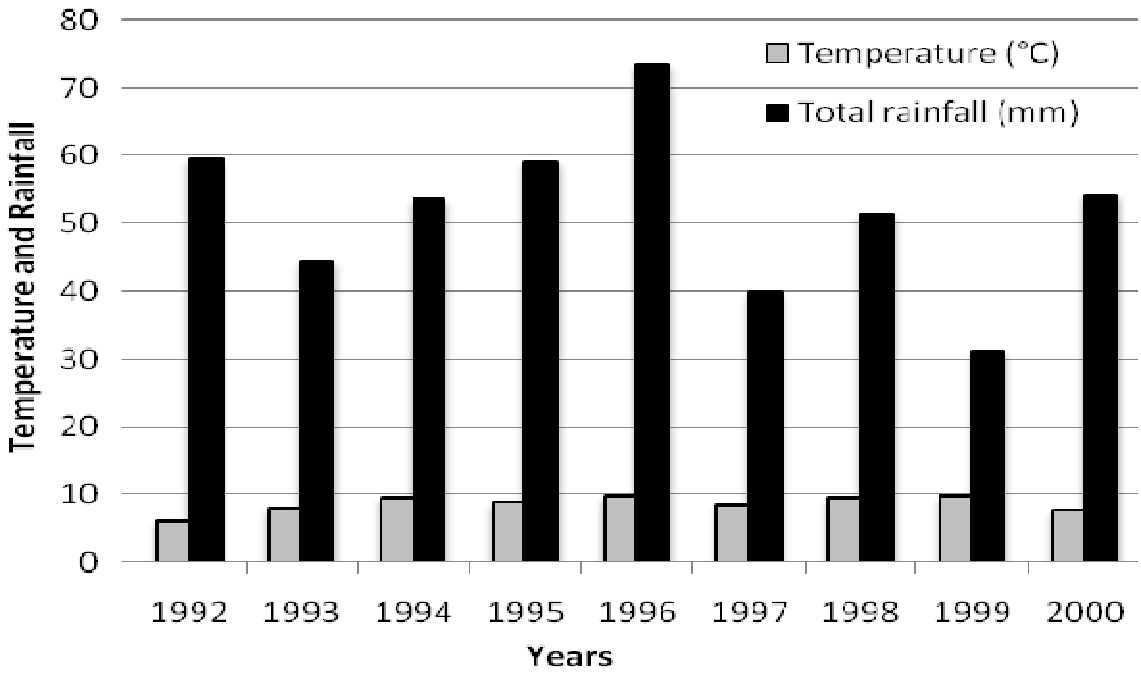

Figure 1. Mean temperature and total precipitation for the study area from the years ranging from 1992 to 2000.

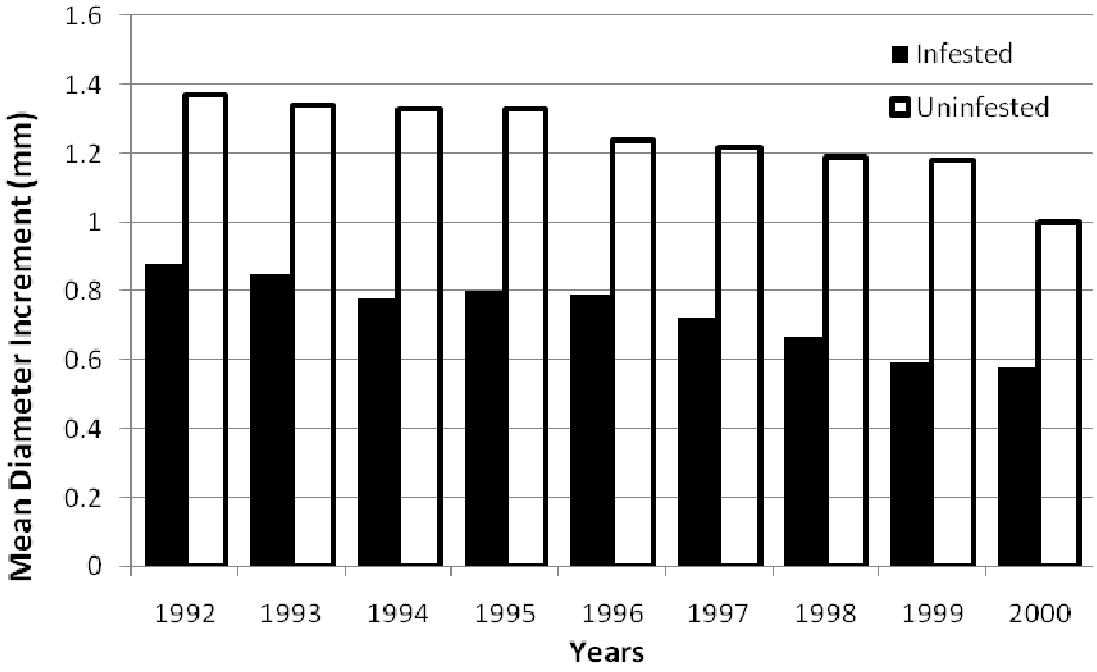

Figure 2. Mean annual diameter increment (ADI) for infested and control Anatolian black pine trees from the years ranging from 1992 to 2000.

the infested pine trees as well as control were determined. As can be seen in this figure, the values of the mean annual diameter increment of the infested pine trees are greatly lower than those of control ones for all the growing years, revealing that annual diameter increment of the pine trees was seriously affected by the

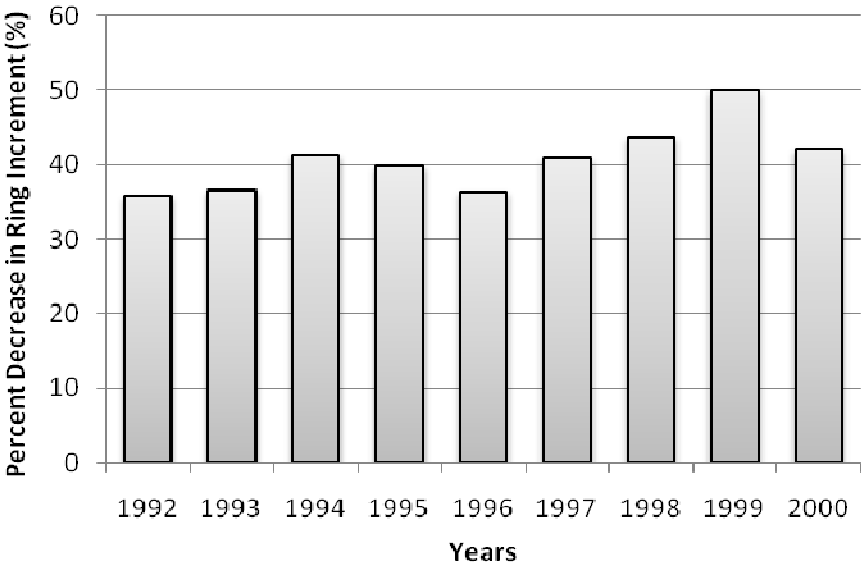

Figure 3. Percent decrease in mean annual diameter increment (PDADI) of trees infested by *Viscum album* from the years ranging from 1992 to 2000.

Table 1. The descriptive information of infested trees.

Year	Mean ADI	Std. deviation
1992	0.88	0.36
1993	0.85	0.37
1994	0.78	0.29
1995	0.80	0.31
1996	0.79	0.33
1997	0.72	0.28
1998	0.67	0.26
1999	0.59	0.19
2000	0.58	0.08

Table 2. The results of independent t test.

Year	t	Significant level (2-tailed)
1992	-9.18	.000
1993	-9.91	.000
1994	-12.70	.000
1995	-12.13	.000
1996	-10.49	.000
1997	-12.71	.000
1998	-13.85	.000
1999	-6.84	.000
2000	-26.12	.000

attack of mistletoe

Figure 3 shows the percent decrease in mean annual diameter increment (PDADI) of pine trees infested by the mistletoe for nine growing years. The PDADI values of the pine trees due to the mistletoe infestation vary from 36% to 50% for the nine growing years, from 1992 to 2000. The mean PDADI was about 41% for the same growing years. The highest PDADI (about 50%) arising from the attack of mistletoe is for the year of 1999, followed by 44% in 1998, 42% in 2000, 41% in 1994 and 1997, 40% in 1995, 37% in 1993 and 36% in 1996 and1992, respectively. The results of independent t test for the annual diameter increment of both control and infested pine trees are presented in Table 2. As can be seen from this table, all the growing years differ statistically from each other. This means that annual diameter increment in the pine trees are significantly reduced by the attack of the mistletoe at the significant level of $P < 0.001$.

The analysis of variance was applied to determine whether or not there were significant differences in years between 1992 and 2000 for both control trees and infested trees (Table 3). According to result of the analysis of variance, a significant difference was determined for all the growing years at a 95% confidence level in both control and infested trees and thus the Duncan test was applied to years which are different from each other (Table 4). While all the years were different from each other for control trees, there were five groups in infested trees. There was no difference within group. However, there were differences among groups. No significant differences were found in the annual diameter increments of the infested trees between 1999 and 2000; 1994, 1995

Table 3. The analysis of variance for annual diameter increment data of control and infested Anatolian black pine trees.

Year	Sum of squares	DF	Mean square	F	Significance
Infested	9.21	8	1.20	14.030	.000
Control	11.20	8	1.40	8.764	.000

Table 4. The Duncan test results for infested Anatolian black pine trees.

Years	Groups (subset for alpha= .05)				
	1	2	3	4	5
2000	0.582				
1999	0.591				
1998		0.672			
1997			0.721		
1994				0.780	
1996				0.788	
1995				0.800	
1993					0.851
1992					0.882

and 1996; 1992 and 1993. Annual diameter increments of the control trees were continuously decreased from 1992 to 2000. Annual diameter increment of infested trees did not almost changed between 1994 - 1996 and 1999 - 2000 while it was generally decreased. This can be ascribed to the removal of the mistletoe by mechanical treatment (using branch pruner) applied in 1994, as reported by officer working in the forest directorate of the study area (Yazıkoy village) and this situation affected decrease in annual diameter increment positively. Annual diameter increment of control trees decreased this period (1994 -1996 and 1999 -2000) while annual diameter increment of infested trees did not decrease. This fact can be attributed to mechanical treatment affecting annual diameter increment positively. In fact, there were no significant differences in the annual diameter increments of the infested trees between 1994, 1995 and 1996 according to Duncan test. Besides, tending felling carried out in 1999 positively affected to annual diameter increment of infested trees and for this reason, annual diameter increments in 1999 and 2000 were not statistically significant.

DISCUSSION

The results indicated that annual diameter increment of Anatolian black pine was significantly ($P < 0.01$) infested by the mistletoe in nine different growing years, between 1992 and 2000. The percent decrease in mean annual diameter increment (PDRI) was found to be between 27 and 41% relying on the growing years. It could be said that the mean annual diameter increment of Anatolian black pine trees was reduced by about 36% in nine years owing to infestation by the mistletoe.

The percentage of annual diameter loss due to mistletoes should change according to tree species, stand type, stand age, site index, intensity and quantity of mistletoes. Mistletoes negatively affected annual diameter increment and also played an important role in chemical composition of trees. Required harvesting scheduling, silvicultural prescriptions and mechanical, biological and chemical treatments should be designated to eliminate negative effects of mistletoes.

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