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CONE YIELD AND GROWTH CHARACTERISTICS IN A PLANTATION OF *CUPRESSUS SEMPERVIRENS*

Nebi Bilir[1*]
[1]Isparta University of Applied Sciences, Faculty of Forestry, Isparta

Abstract

Mediterranean cypress (*Cupressus sempervirens* L.) is an important secondary forest tree species in Turkish forestry because of its high adaptation ability and resistance to different ecological condition. However, limited studies were carried out in cypress. In this study, cone numbers, tree height, diameters at breast height and at base were surveyed from 75 individuals chosen randomly at eighteen years' plantation in the species. Interaction between number of cones and growth characteristics was estimated together with fertility variation and linkage parameters (i.e. population size) to contribute management and practices of seed collection and gene conservation areas, and other forestry practices of the species. Mean cone number was 86/tree ranged from 36 to 174. Individual trees had large differences for the growth traits, while means of tree height, diameters of breast height and base were 6.1 m, 9.9 cm, and 12.6 cm, respectively. Fertility variation was 1.15 (87% of total trees, CV%=38.9), which close to typical population. Positive and significant ($p \leq 0.05$) relations were found between growth characteristics and cone production in *Cupressus sempervirens*. Tree height was better predictor in cone production than diameters.

Key Words: Diameter, fertility, height, population, reproductive.

1. Introduction

Increasing of unproductive forest area is an important environmental and commercial problem in the world. Türkiye has 23.4 million ha forests of which about 9.7 million ha (%41) are considered as unproductive (Anonymous, 2024). Forest establishment is the most important way to increase productive forest land by quality seeds extracted cones. Quality and suitability of seed sources play important roles in plantation forestry and, to improve of present unproductive and productive forest areas. It is getting importance of Mediterranean cypress or also called Italian cypress (*Cupressus sempervirens* L.) because of its using widely for different purposes such as conversion of unproductive forest area and other poor environmental conditions to productive forest because of its resistance to arid areas, and also to forest fire (Neyişci, 1996), despite the its limited natural distribution, less than 600 ha in Türkiye (Özçelik, 2006). The species is also used widely as monumental trees by two taxa (*Cupressus sempervirens var. horizontalis* and var. *pyramidalis*) in different areas of Türkiye. Mediterranean cypress had the highest diameters at base and at breast height performances compare to Black pine (*Pinus nigra* Arnold.), and Taurus cedar (*Cedrus libani* A. Rich.) in 27 years' plantation (Özbey, 2023). These advantages emphasized importance of seed collection areas for future plantation in Mediterranean cypress. However, Cypress has three gene conservation areas at 184.2 ha, and three seed plantations at 14.45 ha according to the latest forest inventory of Türkiye (Anonymous, 2024).

Mediterranean cypress is a native species to the eastern Mediterranean region such as Albania, Croatia, Greece, Türkiye, Cyprus, Lebanon, Israel, Italy and in Iran (Anşin and Özkan, 1993). *Cupressus sempervirens* grows at Taurus mountains and western part of Türkiye up to 1800 m. naturally (Kayacık, 1966; Özalp, 1991).

The species is a medium-sized coniferous evergreen tree more than 40 m tree height, and 2 m diameter, and also over 1000 years old (Anşin and Özkan, 1993; Özçelik, 2006). Estimation of the interactions among growth and reproductive traits were important tools in genetic-breeding practices such as selection and management of seed collection and gene conservation areas. However, limited studies were carried out in genetics and breeding of the species (Sabuncu, 2004; Çalıkoğlu et. al., 2010; Bilir et. al., 2017a; Özbey et. al., 2024).

***Sorumlu Yazar (Corresponding Author):** Nebi BİLİR;
Isparta University of Applied Sciences, Faculty of Forestry,
Isparta, TÜRKİYE.

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This study was conducted to estimate correlations among cone number and growth characteristics (height, diameters at breast height and base), and also cone fertility variation, and to discuss seed collection and gene conservation practices in *Cupressus sempervirens*.

2. Material and Methods

Numbers of mature cone ($\mathbf{C_N}$) (Figure 1), tree height (**H**), diameters at breast height ($\mathbf{d_{1.30}}$), and at base ($\mathbf{D_0}$) were measured at 75 individuals chosen randomly at eighteen years plantation located at latitude 37°24′ N, longitude 30°47′ E, and between 550 and 650 m. asl. of the species was sampled at southern part of Türkiye in April of 2024 (Figure 1).

Figure 1. Sampled population (left side) and mature cones (right side).

The cone fertility variation (Ψ_C) (Kang and Lindgren, 1999; Bilir, 2011) and the effective number of parents (N_C) (Kang et al., 2003) depending on the census number (N) and individual cone fertility of the i^{th} tree (Con_i) were estimated as:

$$\Psi_C = N\sum_{i=1}^{N} Con_i^2 \quad ; \quad N_p = \frac{N}{\Psi_C} \qquad (1\&2)$$

Growth characteristics and number of cones was related by phenotypic Pearson's correlation analysis at SPSS package (SPSS, 2011).

3. Results and Discussion

3.1. Cone Production and Fertility Variation

Sampled individuals had high variation for cone production and the growth traits. Mean cone number was 86 per tree, while it ranged from 36 to 174 in the individuals. The most abundant eight trees (10% of total sampled individuals) produced about 20% of total cone production in the plantation (Figure 2). Mean cone number was 72 in eleven years of the plantation (Bilir et al., 2017a). It indicated importance of age of plantation in cone yield. However, there could be many environmental or genetical effects in these variations. It was reported that some a-biotic and biotic (e.g., age, year, climate) effects have been reported as effective on variation of reproductive characters (Bila, 2000; Kang, 2001; Prescher, 2007; Varol et al., 2017; Yazıcı, 2024; Bilir and Yazıcı, 2024). For instance, severe drought effected on reproductive characteristics of seed orchards of *Pinus brutia* Ten. and *Cedrus*

libani A. Rich. (Varol et al., 2017). Therefore, it was needed to collect more ertility data for detail conclusion for selection of seed collection areas. Large variation in fertility among trees were found in natural and plantation populations of many plant species (e.g., El-Kassaby, 1995; Bila and Lindgren, 1988; Kang et al., 2003; Bilir et al., 2005 and 2023a; Park et al., 2017; Yazıcı and Bilir, 2017 and 2023; Bilir and Kang, 2021).

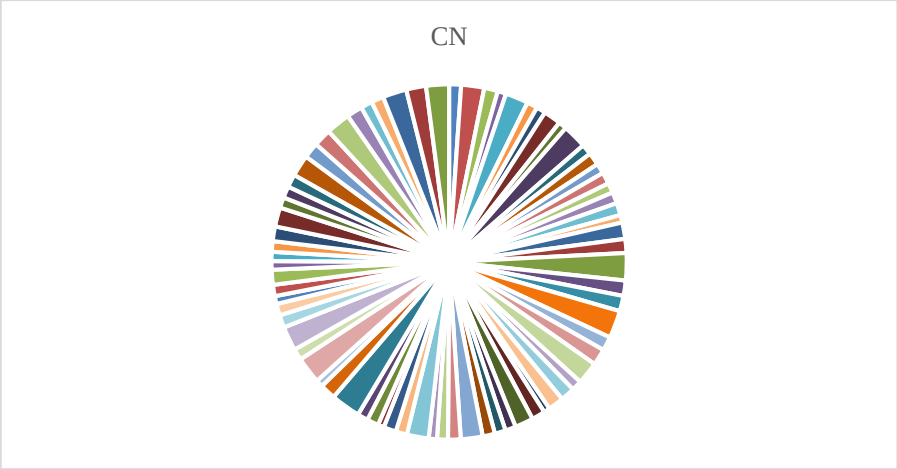

Figure 2. Individual cone production in the plantation.

Estimated fertility variation which was 1.15 (87% of total trees, CV%=38.9) could have been expected level for foresters as a target population (Ψ<3, CV%<140) (Kang, 2001; Kang and Bilir, 2021) based on close to equally contributions of the plantation. The cone fertility variation (Ψ_C) could be also corraleted with coefficient of variation in cone fertility (CV_C) as: $\Psi_C = CV^2_C + 1$ (Kang and Lindgren, 1999; Bilir, 2011). The results were well accordance with parental-balance curve in the plantation was shown by means of cumulative gamete contribution in Figure 3.

Effective population size mirrored by effective number of parents (N_p) was 65.2 (87% of number of individuals. Genetic diversity (*GD*) of seeds have been correlated with effective number of parents (N_p) as (Kang and Lindgren, 1998): $GD=1-0.5/N_p$. It indicated of number of observed trees. The surveyed plantation could be considered as a seed source depending on higer *GD* (0.992). However, my study was carried out by one-year data belong to limited number of trees of a plantation. So, future data collection in the same and other populations should be taken into consideration.

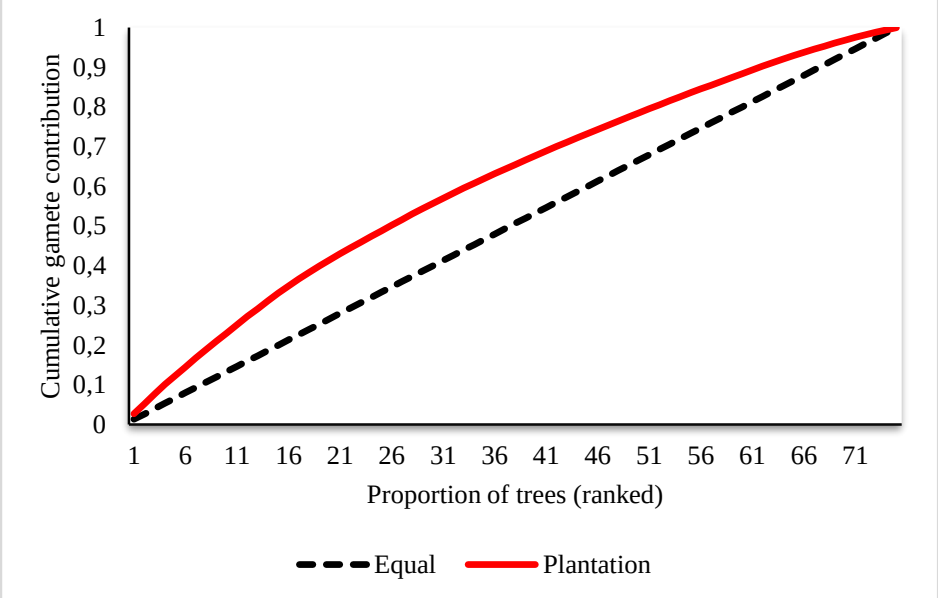

Figure 3. Parental-balance curves of the individuals.

3.2. Growth Traits

Averages, ranges and coefficient of variations of the growth traits were given in Table 1. As seen from the Table 1, the individuals showed large differences for growth traits. Means of growth traits were 8.9 m for tree height, 36.1 cm for diameter at base, and 27.3 cm for diameter at breast height in 27 years' plantation of Mediterranean cypress (Özbey, 2023). Özbey (2023) also reported high variation among individuals for the traits. Means were 5.1 m for tree height, 11.1 cm and 8 cm for diameters at breast height and at base in eleven years of the plantation (Bilir et al., 2017a). They were also reported large difference for morphology among seedlings (Uslu and Bilir, 2020), and growth traits among provenances and among individuals within provenance at field stage of the species (Sabuncu, 2004; Çalıkoğlu et. al., 2010; Özbey et.al., 2024) or other forest tree species (i.e., Bilir et al., 2023b). The differences emphasized more importance of individual selection than mass selection for higher growth performances, and successful plantation, and other forestry practices. They could be also a reflector of high genetic diversity in *Cupressus sempervirens*. It indicated importance of selection practices in the species.

Table 1. Means, ranges and coefficient of variations (CV) for tree height (**H**), diameters at breast height ($\mathbf{d_{1.30}}$), and at base ($\mathbf{D_0}$) in the plantation

	H (m)	**(D_0) (cm)**	**$d_{1.30}$ (cm)**
Mean	6.1	12.6	9.9
Ranges	5.1-7.5	6.8-19.8	5.4-17.2
CV%	8.84	24.8	29.8

3.3. Interactions of Cone Production and Growth Traits

Significant and positive correlations were found among the traits except of between H and $d_{1.30}$ (Table 2). However, tree height was better predictor for cone production than diameters due to higher correlation coefficient and R^2 value.

Table 2. Correlations among the cone number (C_N), tree height (**H**), diameters at breast height ($\mathbf{d_{1.30}}$), and at base ($\mathbf{D_0}$).

r	**C_N**	**H**	**$d_{1.30}$**
H	$.505^{**}$ ($R^2 = 0.255$)	-	
$d_{1.30}$	$.382^{**}$ ($R^2 = 0.146$)	$.224^{NS}$	-
D_0	$.383^{**}$ ($R^2 = 0.147$)	$.271^{*}$	$.957^{**}$

*; Correlation is significant at the 95% significance. **; Correlation is significant at the 99% significance. ^{NS}; Correlation is not significant.

Similar relations were also reported among growth traits in in 27 years' plantation of Mediterranean cypress (Özbey, 2023). The relations could be a guide for forestry practices. Correlations between reproductive and growth traits could change for various populations of tree species. For instance, while positive and significant correlations were reported among growth and reproductive characters in *Pinus sylvestris* L. (Burczyk and Chalupka, 1997; Bilir et al., 2006), in *Picea abies* (L.) Karst. (Nikkanen and Ruotsalainen, 2000), in *Cedrus libani* (Yazıcı and Bilir, 2017; Çatal et al., 2018), it was negative in *Pinus sylvestris* (Nikkanen and Velling, 1987) and in *Pinus taeda* L. (Schmidtling, 1981). Height, diameter at breast height and crown diameter were positively significantly ($p \leq 0.05$) correlated by cone production in *Pinus nigra* subsp. *pallasiana* var. *pyramidata* (Bilir et al., 2017b) and in *Pinus sylvestris* (Bilir et al., 2006). So, the results indicated that the relations could change for populations and species. The relations could bu used in management practices of seed collection areas or other forestry purposes of *Cupressus sempervirens*.

4. Conclusions

One plantation and one-year data of the cone and growth data was examined in the present study. Cone production is a monitor of seed yield. Future studies in different natural and artificial populations, characteristics (e.g., seed production) and ages should be carried to give large conclusions. However, results of the study such as relations among the traits could be used local area of the species for various forestry practices.

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