



# Height and diameter performances in afforestation of Taurus cedar and Crimean juniper seedlings: A case study from southern Turkey

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## Abstract

The present study was carried out in 16<sup>th</sup> year afforestation sampled from southern Turkey of Taurus cedar (*Cedrus libani* A. Rich) and Crimean juniper (*Juniperus excelsa* Bieb.). Variation, competition and correlation were examined based on seedling height and stem diameter at base data collected from two samples areas 500 m<sup>2</sup> each. Growth performances were different at the areas for the species, while averages of Taurus cedar (223.6 for height and 65.3 mm for stem diameter at base) had higher than Crimean juniper (106 cm and 58.5 mm) in total areas. The results emphasized importance of species selection in afforestation. Significant ( $p < 0.05$ ) differences between areas and species were found according to results of analysis of variance. Positive and significant phenotypic correlation ( $p < 0.05$ ,  $r > 0.52$ ) was estimated between the characteristics in both species and areas. It could be used for tending in afforestation areas.

## Keywords

Diameter; Height; Plantation; Species; Variation

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## 1 Introduction

Turkey has 9.6 million ha unproductive forest demanded to afforestation practices in total 23.4 million ha forest (Anonymous 2025). Taurus cedar (*Cedrus libani* A. Rich) and junipers (*Juniperus* sp.) mainly (~82%) Crimean juniper (*Juniperus excelsa* Bieb.) covers 2.2 million ha which of 1.45 million ha is unproductive (Anonymous 2025). Afforestation is an important practice in forestry to conversion of unproductive forests to productive by planting or sowing. The species are used widely in afforestation practices because of their commercial wood product and adaptation ability to different ecological areas. For instance, Taurus cedar occurs from 500 m to 2400 m (Boydak 2003). Boydak (2003) reported that it grows over 1000 years old by impressive size such as diameter at breast height 2.49 m and tree height 46 m. Crimean juniper is also native

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at different environments of different countries such as Albania, Greece, Macedonia, Bulgaria, Cyprus, Syria, Lebanon, Azerbaijan, Crimea, Russia at between 500 m and 2700 m (Farjon 2005). It has drought, heat and cold tolerant characteristics (Özbey and Bilir 2024). The species are used widely in Turkish afforestation practices because of the advantages (Anonymous 2025). These advantages are getting importance of the species to be used at large afforestation areas. However, many biotic and abiotic factors could impact on afforestation practices (i.e., Bilir et al. 2018; Yazıcı 2018; Yazıcı and Turan 2016; Yazıcı et al. 2022). Besides, the species was compared for growth characteristics in limited studies (i.e., Eser 2025).

Taurus cedar and Crimean juniper were compared based on seedling height and stem diameter at base of 16<sup>rd</sup> year afforestation to contribute afforestation and other forestry practices such as selection of the species in this study.

## 2 Materials and methods

The mixed afforestation or also called plantation area by Taurus cedar and Crimean juniper the species was established by 2-years container seedlings of the species at 2.5 x 3 m spacing at southern Turkey. Two areas (A1 and A2), each of 500 m<sup>2</sup> (50 x 10 m) were sampled (Table 1, Figure 1) for data collection in total 8.5 ha afforestation in the location. The areas were tried to select close to each other (about 500 m distance each other) to minimize impact of habitat conditions based on target of this study.

Height (H) and stem diameter at base (D<sub>0</sub>) were measured in all seedlings at each sampled area at end of 16<sup>rd</sup> year in 2024.

Table 1. Some geographic details and number of seedlings of the sampled areas.

Areas	Latitude (N)	Longitude (E)	Altitude (m)	Aspect	N*	
					<i>C. libani</i>	<i>J. excelsa</i>
A1	37°50'32"	30°38'50"	1162	South-west	44	43
A2	37°50'36"	30°38'51"	1163	South-west	39	43

\*: Number of seedlings at the areas.

The areas and species were compared for the height and stem diameter at base by following linear model of analysis of variance as:

$$Y_{ij} = \mu + P_j + e_{ij}$$

Where  $Y_{ij}$  is the observation from the  $j^{th}$  seedling of the  $i^{th}$  species,  $\mu$  is overall mean,  $P_i$  is the random effect of the  $i^{th}$  species, and  $e_{ij}$  is random error.

Phenotypic correlations ( $r_p$ ) between height and stem diameter at base were estimated in each species as (Falconer, 1989):

$$r_p = \frac{COV_{f(x,y)}}{\sqrt{\sigma^2_{f(x)}} \sqrt{\sigma^2_{f(y)}}}$$

Where  $COV_{f(x,y)}$  is the phenotypic covariance between the characteristics x and y,  $\sigma^2_{f(x)}$  and  $\sigma^2_{f(y)}$  are the phenotypic variances for characteristics x and y, respectively. Results were processed using Statistical Package for the Social Sciences (SPSS 2011).



Figure 1. A view of sample areas.

### 3 Results and discussion

Species showed different performances for the areas, while Taurus cedar (223.6 for height and 65.3 mm for stem diameter at base) had higher growth performances than Crimean juniper (106 cm and 58.5 mm) in total area (Table 2, Figure 2). Similar growth performances were also reported in plantation practices at different locations of the species based on the characteristics and similar age by Eser (2025).

Large differences were found among seedlings within sample area and species. For instance, seedling heights of Crimean juniper were between 48 cm and 180 cm in A1, and between 64 cm and 370 cm in A2. Taurus cedar and seedling height had higher variation than Crimean juniper and diameter at base (Table 2).

Table 2. Averages ( $\bar{x}$ ) and coefficients of variations (CV%) for the characteristics of the species and areas.

Characteristics	<i>C. libani</i>				<i>J. excelsa</i>			
	A1		A2		A1		A2	
	$\bar{x}$	CV%	$\bar{x}$	CV%	$\bar{x}$	CV%	$\bar{x}$	CV%
H (cm)	113.4	26.5	209.0	33.5	110.6	29.7	236.5	42.3
D <sub>0</sub> (mm)	62.3	19.7	62.4	20.8	55.0	16.6	67.7	30.7

Similar variations were also reported in afforestation areas of Taurus cedar (i.e., Bilir 2004; Bilir et al. 2018; Yazıcı 2018; Yazıcı et al. 2022) and Crimean juniper (Eser 2025) at various stand structure and ages. But it is known that many biotic and abiotic factors including seedling quality (Eler et al. 1993; Eser 2021) could be effective on growth performances of afforestation practices. In this study, it was assumed that sampled areas had similar habitat conditions such as geographic, climatic and edaphic characteristics due to close to each other.

Areas showed similar ( $p>0.05$ ) performances within species opposite to significant ( $p<0.05$ ) differences between areas and species according to results of analysis of variance. It was well in accordance with results of the species (Eser 2025). They indicated importance of local practices and species selection in forestry practices.

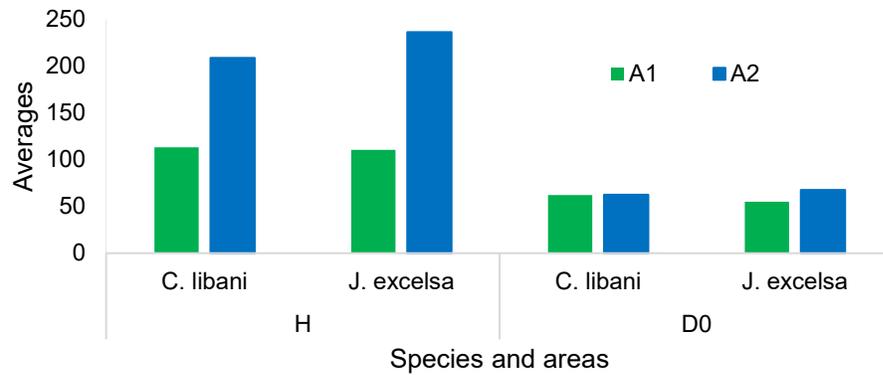


Figure 2. Averages of the characteristics for the species and areas.

Positive and significant phenotypic correlation ( $p < 0.05$ ,  $r > 0.52$ ) was estimated between the characteristics in both species and areas (Fig. 3). Positive and significant phenotypic correlation ( $p < 0.05$ ) were also found in afforestation of Taurus cedar (i.e., Bilir 2004; Bilir et al. 2018; Yazıcı 2018; Yazıcı et al. 2022) and Crimean juniper (Eser 2025), and also seedlings of Crimean juniper at nursery stage (i.e., Eser and Gülcü 2019; Eser 2021; Özbey and Bilir 2024). The correlations could be a guide for future studies because of higher  $R^2$ .

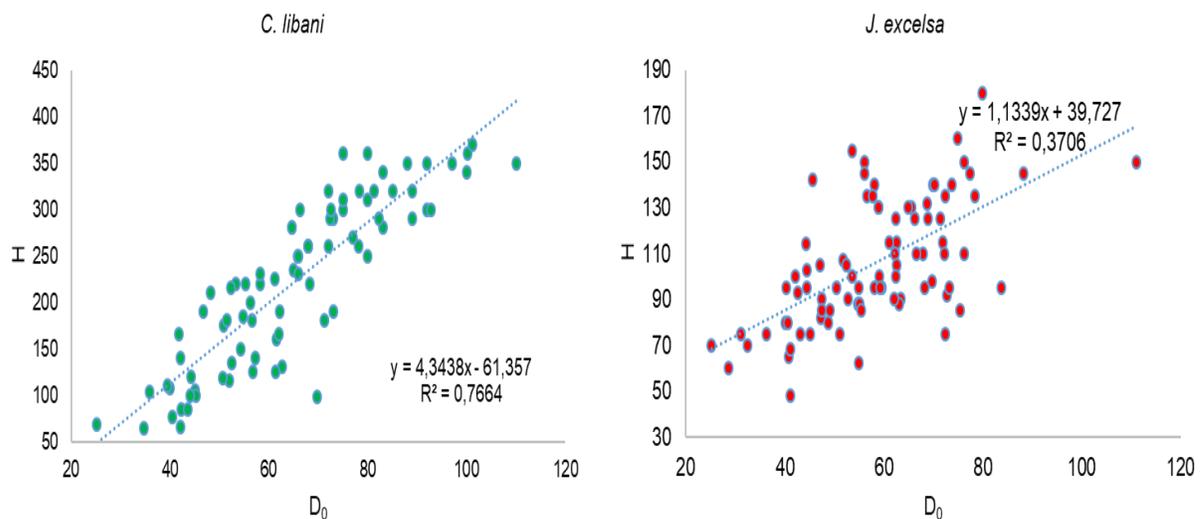


Figure 3. Relations between seedling height and stem diameter at base in the species.

## 4 Conclusions

Performances of seedling height and stem diameter at base varied for the areas and species, while averages of the performances were higher in Taurus cedar than Crimean juniper in total areas. The present study was carried out in 16<sup>rd</sup> year afforestation of the species. Due to large distribution area and long rotation age of the species, new studies could be suggested at different provenance, area and

characteristics. However, results of the study obtained from juvenile afforestation could be used at local forestry practices.

## 5 Acknowledgements

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