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Seed source effect on quality and morphology of Turkish red pine (*Pinus brutia* Ten.) seedlings

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Abstract

This study was carried out to compare quality and morphology in 1+0 year containerized seedlings of Turkish red pine (*Pinus brutia* Ten.) originating from a seed stand and a seed orchard based on height and root-collar diameter. Averages of seedling height and root-collar diameter were 13.8 cm and 2.63 mm in orchard seedlings, while they were 14.8 cm and 4.56 mm in stand seedlings, respectively. There were significant differences ($p \leq 0.05$) between seed sources for the characters according to result of ANOVA. Stand seedlings were better quality than that of orchard seedlings according to quality classification of Turkish Standard Institute. Positive and significant ($p \leq 0.05$) relations were found between the characters in both seed sources based on results of correlation analysis. Results of the study were discussed for nursery practices, plantation forestry, and genetic-breeding of the species.

Keywords

Pinus brutia; Seedling; Seed stand; Seed orchard

Contents

1 Introduction

Turkish red pine, or also called Brutian pine (*Pinus brutia* Ten.), has the largest natural distribution in Turkish forestry by 5.8 million ha (26.7 of total Turkish forest area) of which 45.2% are unproductive (Anonymous 2015). The main natural range of the species is low and mid altitude of Mediterranean countries and outside of the natural range such as Australia, Pakistan, and Tajikistan (Cabi 2014) because of tolerance to dry or unirrigated areas. Improved seedling included quality and morphology are most important criterions in forest establishment and conversion of unproductive forest to productive forest, and to increase quality of present productivity of forest area by afforestation, reforestation, artificial regeneration and restoration. Ivetić and Devetaković (2016) reported that extreme weather conditions

and low precipitation during the growing season will cause high mortality of seedlings after planting based on climate change. They also reported reforestation programs must take projections of climate change into consideration. Seedling morphology and physiology have an important role for regeneration and, economical and biological successes of plantations in arid areas (Dutkuner and Bilir 2011), and reforestation programs. For instance, many studies (i.e., Thompson 1985; Mexal and Landis 1990; Grossnickle 2012) showed the relationship between seedlings morphological attributes and planting success. However, studies on seedling quality and morphology from different seed sources are very limited in *Pinus brutia*. Seed orchards, are one of the important seed sources for forest plantations, established with clones or seedlings, collected from plus trees selected phenotypically from natural stands or plantations, while seed stands are selected phenotypically from natural forests. 68 seed orchards were established by 3026 clones at 479 ha in *Pinus brutia,* while 82 seed stands were selected at 12208 ha of the species (Bilir 2013).

This study was conducted to examine the seedling morphology and quality to compare a seed stand and a seed orchard seedlings to contribute nursery practices, forest establishment, and genetic-breeding of the species.

2 Materials and Methods

Seedling height (SH) and root-collar diameter (RCD) of 1+0 year containerized seedlings were studied on 150 seedlings, chosen randomly in each stand and orchard source at the end of the growing period of 2015, grown at The Osmaniye Forest Nursery of Turkey (latitude 37° 40' N, longitude 30°15 E, altitude 120 m). The seedlings originate from a seed orchard ($S_{orchard}$) and a seed stand (S_{stand}) (latitude 36° 20' N, longitude 35°57 E, altitude 385 m) of Brutian pine. The seed orchard was established with clones selected plus trees phenotypically from the studied seed stand.

The seedlings were classified according to the "Coniferous Forest Tree Seedlings Classes" of Turkish Standard Institute (Anonymous 1988) (Table 1).

Table 1. Seedling quality classes of Turkish Standard Institute.

Quality classes	SH (cm)	RCD (mm)	SH+RCD
First class	12≤SH	2≤RCD	12≤SH + 2≤RCD
Second class	12> SH ≥10	-	12>SH ≥10 + 2≤RCD
Cull	10>SH	2>RCD	10>SH + 2>RCD

Relation between seedling height and root-collar diameter was tested by calculating Pearson's correlation coefficient, using SPSS statistical program package (Ozdamar 1999). Seed sources were compared by the following linear ANOVA model for the characters:

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

Where Y_{ij} is the observation from the j^{th} seedling of the i^{th} seed source, μ is overall mean, P_i is the random effect of the i^{th} seed source, and e_{ij} is random error.

3 Results and Discussion

3.1 Seedling morphology

Stand seedlings showed higher growth performance especially for root-collar diameter than orchard seedlings (4.56 mm compared to 2.63 mm), opposite to expectations (Table 2). Similar results were reported for the same species by Dilaver et al. (2015). Root collar diameter is a seedling attribute that forecasts survival and growth (Thompson 1985; Mexal and Landis 1990; Mattsson 1996). Turkish seed orchards have been established with about 30 clones originating from plus trees of a single seed stand (Anonymous 2001). The studied seed orchard was established by 30 clones originating from the studied seed stand, and this can explain results in this study. Bilir et al. (2004) reported that the number of 30 clones could hardly deliver entire gene diversity of the base population into the seed orchard. It showed the importance of plantations to transmit present gene diversity by reproductive materials to next generations as discussed by Lindgren (2016) and Ivetić et al. (2016).

Table 2. Averages ($\overline{x}$),range and standard deviation (S) for seedling height (SH) and root collar diameter (RCD) of seedlings from seed stand and seed orchard.

	S_{stand}		$S_{orchard}$	
	SH	**RCD**	**SH**	**RCD**
$\overline{x}$	14.8	4.56	13.8	2.63
Range	8.0-32.0	2.64-6.71	8.0-22.0	0.82-4.96
S	4.14	1.10	2.25	0.89

Results of the analysis of variance showed significant (*p<0.01*) differences between seed sources in both seedling height and root-collar diameter. For instance, seedling heights ranged 8.0 and 32.0 cm in seedlings originating from seed stand, and between 8.0 and 32.0 cm in seedlings originating from seed orchard. This result was well in accordance with the results on the same species (Dilaver et al. 2015), and on *Pinus pinea* (Bilir et al. 2010). Seedlings originating from seed stand seedlings had higher variation than orchard seedling for both attributes (Tab. 2). These results emphasize the importance of individual selection rather than mass selection in seed collection. There was positive and significant (*p≤0.05, r=0.508&0.496*) relation between SH and RCD similarly to previous reports on seedlings of forest tree species (Morris et al. 1990; Dilaver et al. 2015).

3.2 Seedling quality

Seedlings originating from seed stand were better quality according to Turkish Standard Institute than seedlings originating from seed orchard as previously reported by Dilaver et al. (2015). For instance, all seedlings originating from seed stand were in first class for root-collar diameter, compared to 68.7% of seedlings originating from seed orchard (Table 3).

Table 3. Distribution (%) of seedlings to quality classes from different seed sources.

	SH			RCD			SH+RCD		
	First class	**Second class**	**Cull**	**First class**	**Second class**	**Cull**	**First class**	**Second class**	**Cull**
S_{stand}	89.3	8.7	2.0	100.0	-	-	89.3	8.7	2.0
$S_{orchard}$	87.4	9.3	3.3	68.7	-	31.3	64.7	32.0	3.3

Root collar diameter had to be at least 2 mm for all species, ages and seedling types in quality classifications of Turkish Standard Institute for better quality seedlings (Anonymous 1988). However, it was known that seedling morphology could change according to age, species and seedling type (Kizmaz 1993; Bilir, 2002; Gezer et al. 2000; Eler et al. 1993; Dilaver et al. 2015) as well as nursery practice regime (Yazici et al. 2011; Yazici and Babalik 2011). Aside from that, it was reported that root-collar diameter was a better measure of seedling quality than shoot height (Chavasse 1977; Dey and Parker 1997; Ivetić et al. 2013).

4 Conclusions

Field performance of seed sources should be combined with nursery performance to draw an accurate conclusion. Root collar diameter is one of the most important morphological characters in seedling quality to tolerance to arid areas as known, while seedling height is an easily measurable criterion in forestry practice. New quality classification should be improved for age group and seedling types, and species especially for root- collar diameter. It should be tested by field performance supported by physiological characters.

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