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Seedling Quality and Morphology in Seed Sources and Seedling Type of Brutian Pine (*Pinus brutia* Ten.)

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Abstract This study was carried out on 1+0 year containerized and bare root seedlings originated from a seed stand and a seed orchard of Brutian Pine (*Pinus brutia* Ten.) at Dursunbey Forest Nursery of Turkey. Findings of present investigation may contribute to better nursery practices, productive plantation establishment, and genetic improvement of the species. Seedling height and root-collar diameter were examined on 100 seedlings chosen randomly from each seed source and seedling type at the end of the growing period. Seedling quality and relation between the characteristics were also investigated. Averages of seedling height and root-collar diameter were 12.5 cm and 2.74 mm in the polled seed sources and seedling type, respectively. While containerized seedling showed better performance than bare root seedlings, seed stand was better than seed orchards for observed characters. There were significant differences ($p \leq 0.05$) among seedling type and seed source based on results of variance analysis. Distribution of seedlings changed for quality classes, characters, seed sources and seedling types. The both classification was suitable for the seedlings according to results of Discriminant analysis. There were positive and significant ($p \leq 0.05$) relations between the characters based on results of correlation analysis. Results of the study were discussed for nursery practice of the species. Results of the study could be combined by field performance.

Keywords: *Brutian pine, height, root-collar diameter, origin, morphology*

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1. Introduction

Turkish forests cover about 21.7 million ha, of which about 11.6 million ha (%53.3) are considered to be productive forests [1]. Brutian pine (*Pinus brutia* Ten.) has the largest natural distribution in Turkish forestry by 5.8 million ha of which 45.2% to be unproductive. The natural range of the species is low and mid altitude of Mediterranean countries such as Greeks, Cyprus, Turkey, Georgia, Iran, Russia and Ukraine. Outside of the natural range it has been used for afforestation in countries of western and central areas of the Mediterranean Sea, Australia, Pakistan and Tajikistan [2] because of its adaptability to dry or unirrigated areas.

Seedling quality is one of most important factor in plantation forestry, conversion of unproductive forest to productive forest, and to increase quality of present productive forest area. It is getting importance of the species and seedling quality based on global warming which is one of the most important environmental problems in whole the world. Seedling morphology and physiology are very important for the regeneration and, economical and biological successes of plantations in arid areas [3].

This study was conducted to examine the seedling morphology and to compare quality and morphology of a seed stand and a seed orchard seedlings. The results of the study are discussed based on nursery practices, plantation forestry, and genetic-breeding of the species, and also for warming.

2. Material and Methods

Data on seedling height (**SH**) and root-collar diameter (**RCD**) were collected on 1+0 year containerized ($\mathbf{C_{seedling}}$) and bare root ($\mathbf{BR_{seedling}}$) seedlings, grown at Dursunbey Forest Nursery of Turkey (latitude 39° 32' 50" 40°52'N, longitude – 28° 39' 24" E, altitude 400 m), originated from a seed stand (S_{stand}) and a seed orchard ($S_{orchard}$) of Brutian Pine (*Pinus brutia* Ten.). 100 seedlings were chosen randomly in each seed sources ($S_{stand\ \&}\ S_{orchard}$) and seedling types ($\mathbf{C_{seedling}}$ & $\mathbf{BR_{seedling}}$) at the end of growing period of 2014.

The seedlings were classified according to the "Broadleaved Forest Tree Seedlings Classes" of the Turkish Standard Institute ($\mathbf{TSI_{class}}$) [4] (Table 1), and to New Quality Classification ($\mathbf{NQ_{class}}$) created by averages ($\bar{x}$) and standard deviation (S) of seedling height and root-collar diameter ($\bar{x} \pm S$) [5] for each seedling type

(Table 1). The quality classes were examined by **Discriminant analysis**.

Table 1. Seedling quality classes of Turkish Standard Institute (TSI_{class}) and New Quality Classification (NQ_{class})

Quality classes	SH (cm)	RCD (mm)	SH+RCD
		TSI_{class}	
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
		NQ_{class} - $BR_{seedling}$	
First class	13≤	2.8≤	13≤ SH + 2.8≤RCD
Second class	13> SH ≥8	2.8> RCD ≥1.95	13> SH ≥8 + 2.8> RCD ≥1.95
Cull	8>	1.95>	8>SH + 1.95> RCD
		NQ_{class} - $C_{seedling}$	
First class	18≤	3.6≤	18≤ SH + 3.6≤RCD
Second class	18> SH ≥11	3.6> RCD ≥2.7	18> SH ≥11+ 3.6> RCD ≥2.7
Cull	11>	2.7>	11>SH + 2.7> RCD

Seedling height and root-collar diameter were also related by Pearson's correlation analysis using SPSS statistical package program [6]. Besides, differences among seed sources and seedling types were observed by Analysis of Variance (ANOVA) for the seedling height and root-collar diameter. They were compared by Duncan's multiple range test [7].

3. Results and Discussion

3.1. Seedling Morphology

Containerized seedlings showed better performance than bare root seedlings for the seedling height and root collar diameter, while seed stand seedlings had lower performance than that of seed orchard opposite to expectation (Table 2). Turkish seed orchards have been established with about 30 clones originated from plus trees from a single seed stand [8]. The studied seed orchard was also established by 30 clones selected from a seed stand. The opposite expectation could be derived from these originations.

Table 2. Averages and results of Duncan's multiple range test of the seedling height (SH) and root-collar diameter (RCD) for seed sources and seedling types

	SH			RCD		
	$BR_{seedling}$	$C_{seedling}$	Mean	$BR_{seedling}$	$C_{seedling}$	Mean
S_{stand}	$11.4^{b,*}$	14.2^{c}	12.8	2.43^{b}	3.09^{c}	2.76
$S_{orchard}$	9.8^{a}	14.5^{c}	12.1	2.31^{a}	3.14^{c}	2.72
Mean	10.6	14.4	12.5	2.37	3.12	2.74

*; the same letters are significantly different (p>0.05);

There was differences for the characters among seed sources and seedling types and within them (Table 2). For instance, seedling heights were between 5 cm and 18.4 cm in bare root seedlings. It varied from 7 cm to 21 cm in seed stand seedling. This result was well in accordance with the results from many forest tree species [9].

Seedling height had higher variance than root collar diameter in all seed sources and seedling type. In the present study, height and diameter data were collected from only one year old seedlings. Therefore, it was needed to collect more data on field performance of seed sources and seedling type to draw accurate discussion.

Results of the analysis of variance showed significant ($p<0.01$) differences in both seedling height and root-collar diameter. Seed sources and seedling types were grouped by Duncan's multiple range test (Table 2) after determination of the differences for the characters. According to results of Duncan's multiple range test, Seed sources and seedling types were at three groups for both SH and RCD. Beside, while containerized seedlings of the seed sources were at the same group, bare root seedlings were at different groups for the seed sources (Table 2). Containerized seedlings had higher for seedling height and root collar diameter than that of bare root seedlings, while seed stand showed generally higher performance than seed orchard (Table 2).

There were positive and significant ($p\leq0.05$) relations between the characters based on results of correlation analysis in seedling types and seed sources. Generally, positive and significant ($p\leq0.05$) relations were reported in seedlings of forest tree species [10].

3.2. Seedling Quality

Distribution of seedlings changed for quality classes, characters, seed sources and seedling types (Table 3). Containerized seedlings had the highest first class seedling for both SH (78%) and RCD (99.5%) for quality classes of TSI_{class}, while they were generally at second class of NQ_{class} (Table 3). It could be also said containerized seedlings had generally better quality than bare root seedlings (Table 3).

Table 3. Distribution (%) of seedlings to quality classes for seed sources and seedling type

	SH			RCD			SH+RCD		
	First class	Second class	Cull	First class	Second class	Cull	First class	Second class	Cull
TSI_{class}- $BR_{seedling}$	29.5	28.5	42	82.5	-	17.5	29.5	28.5	42
TSI_{class}- - $C_{seedling}$	78	14.5	7.5	99.5	-	0.5	78	14.5	7.5
NQ_{class} - $BR_{seedling}$	14.5	78.0	7.5	13	73	14	6.0	78.5	15.5
NQ_{class} - $C_{seedling}$	15	70	15	12	70.5	17.5	6.5	70.5	23

The quality classes were examined by **Discriminant analysis**. The both classification was suitable for the seedlings according to results of the analysis (Table 4). Predictions of seedlings were higher than 84% for **TSI_{class}** and than 90% for **NQ_{class}** (Table 4).

Table 4. Results of Discriminant analysis

Original groups	Predicted group membership (Count-%)			
	1	2	3	Total
	TSI_{class}			
SH (93.8%)*				
1	195-90.7	20-9.3	0	215
2	0	86-100	0	86
3	0	5-5.1	94-94.9	99
RCD (94.5%)				
1	364-100	0	-	364
2	22-61.1	14-38.9	-	36
SH+RCD (84.5%)				
1	162-75.3	53-24.7	0	215
2	0	86-100	0	86
3	0	9-9.1	90-90.9	99
	NQ_{class} - $BR_{seedling}$			
SH (95%)				
1	27-93.1	2-6.9	0	29
2	1-0.6	155-99.4	0	156
3	0	7-46.7	8-53.3	15
RCD (95.5%)				
1	24-92.3	2-7.7	0	26
2	0	145-99.3	1-0.7	146
3	0	6-21.4	22-78.6	28
SH+RCD (96%)				
1	9-75.0	3-25.0	0	12
2	2-1.3	155-98.7	0	157
3	0	3-9.7	28-90.3	31
	NQ_{class} - $C_{seedling}$			
SH (100%)				
1	30-100.0	0	0	30
2	0	140-100	0	140
3	0	0	30-100	30
RCD (96.5%)				
1	20-83.3	4-16.7	0	24
2	1-0.7	138-97.9	2-1.4	141
3	0	0	35-100	35
SH+RCD (91%)				
1	10-76.9	3-23.1	0	13
2	5-3.5	130-92.2	6-4.3	141
3	0	6-13.0	40-87.0	46

*; % of original grouped cases correctly classified.

Root collar diameter was accepted at least 2 mm for all species, ages and seedling types in quality classifications of Turkish Standard Institute for quality seedlings [4]. However, it was known that seedling morphology could be changed according to age, species and seedling type [11,12,13,14].

4. Conclusions

Containerized seedlings of seed stand should be growthed for successful plantation. However, field performance of seed sources, seedling type, and quality classes should be combined to draw accurate conclusion.

Root- collar diameter was one of the most important morphological characters in seedling quality to resistance to arid areas as known. So, new quality classed should be improved for age groups and species especially for root-collar diameter combined by field performance of the quality classes and physiological characters.

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