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Utilization Possibility from Advanced Regeneration in Brutian Pine (*Pinus brutia* Ten.)

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ABSTRACT

Seedling Height (**SH**) and Root-Collar Diameter (**RCD**) data of one year old seedlings was collected from advanced regenerations called as seedling in the present study of seven natural stands which were no under natural regeneration practices of Brutian pine (*Pinus brutia*) to contribute natural regeneration (i.e., utilization possibility) and other forestry practices, and to compare their growth performance and quality with produced seedlings. Height, diameter at breast height and age were also measured from mother trees of the stands. Averages of height, diameter at breast height and age of mother stands were 18.9 m, 22.5 cm and 62 years, respectively. There were large differences within stand and among the stands for seedling height and root-collar diameter. Averages of height and diameter of one year seedling were 8.9 cm and 1.68 mm in polled populations, respectively. They ranged from 6.6 cm to 10.6 cm for SH, and between 0.73 mm and 2.13 mm for RCD in the stands. Positive and significant ($p<0.05$) relations between SH and RCD were found in each stand and polled stands. Percentages of cull seedlings were 67.6% for SH and 37 for RCD, while there were large differences among the stands for seedling quality according to Quality Classification of Turkish Standard Institute.

INTRODUCTION

Brutian pine (*Pinus brutia* Ten.) is one of the most important forest tree species because of its commercial wood production of Turkey by 5.85 million ha natural distributions of which 45.2% (2.7 milyon ha) to be unproductive [1]. Silvicultural practices included natural regeneration practices is the most important way in conversion of unproductive forest to productive forest. However, seedling morphology and quality produced from improved seeds artificially or utilization possibility from advanced regeneration grown naturally is an important stage in biological and economical success of conversion in forest establishment. While many studies were conducted on morphology and quality of seedling produced in nursery conditions included different seed sources an seedling type [e.g., 2, 3, 4, 5, 6, 7], limited studies were carried out on morphology of advanced regeneration [e.g., 8, 9]. Beside, quality of advanced regeneration has not been studied in the species, yet However, the quality could be an important role for decision of regeneration method and also future forestry practices such as forest tending.

This study aimed to determine morphology and quality of advanced regenerations based on seedling height and root-collar diameter to estimate their utilization possibility in natural regeneration and other forestry practices and to compare their growth performance and quality with produced seedlings.

MATERIALS AND METHODS

The study was carried out in seven natural stands sampled from southern part of Turkey of Brutian pine. Some location details of mother stands were given in Table 1. The stand had no under natural regeneration practices during the study because of rotation age of the species.

Table No. 1: Location details of studied stands.

Stands and code	Latitude (N)	Longitude (E)	Altitude (m)
Erdemli (**S1**)	36°39'07"	34°15'33"	190
İmamoğlu (**S2**)	37°20'07"	35°33'33"	250
Akören (**S3**)	37°26'35"	35°26'32"	365
Aladağ (**S4**)	37°33'24"	35°22'16"	720
Aladağ (**S5**)	37°32'28"	35°23'35"	800
Horzum (**S6**)	37°40'38"	35°53'30"	985
Kicak (**S7**)	37°35'44"	35°14'19"	1090

Morphological data included Seedling Height (**SH**) and Root-Collar Diameter (**RCD**) was collected from 100 one year advanced regenerations called as seedling in the present study in each stand of 2018. Height, diameter at breast height and age were also measured from 30 mother trees of each stand (Figure 1).

Figure No. 1: Measurement of seedling and a view from mother stand.

The seedlings were classified according to the Seedling Quality Classification of Turkish Standard Institute (TSI) [10].

Analysis of Variance (ANOVA) was used for comparison of growth characteristics of seedling and mother trees in the stands. Stands were also grouped by Duncan's multiple range test [11] for the characteristics.

Correlations among characteristics were also calculated by Pearson's correlation using Statistical Package for the Social Sciences (SPSS) statistical package program in each and polled stands.

RESULTS AND DISCUSSION

Growth characteristics of mother stands: Averages of height, diameter at breast height and age of mother stands were given in Table 2. Diameter at breast height was the lowest (22.5 cm) in the youngest (27 years) stand in S7, while S1 had the lowest tree height (18.9 m) at 64 years. Mother stands showed statistically significant ($p<0.05$) differences for the growth characteristics. They were grouped by Duncan's multiple range test (Table 2). Positive and

significant ($p \leq 0.05$) relations were found among growth characteristics of mother stands. There could be many genetical and environmental factors on the growth characteristics such as age, crown closure and altitude. For instance, rotation age changed from 60 years to 100 years in the species related to different ecological conditions based on large natural distribution (5.85 million ha) [1]. The stand had no under natural regeneration practices during the study because of rotation age of the species especially S4 and S7 (Table 2).

Table No. 2: Averages and results of Duncan's multiple range test for the growth characteristics of mother stands.

Stands	Height (m)*	Diameter at breast height (cm)	Age (year)
S1	18.9-a	44.8-c	64-c
S2	23.1-b	44.3-c	58-c
S3	25.0-bc	43.7-c	82-d
S4	26.6-c	42.6-c	35-b
S5	25.0-bc	40.6-bc	86-d
S6	24.7-bc	37.5-b	82-d
S7	19.8-a	22.5-a	27-a
Total	23.3	39.4	62

*; The same letters showed not significantly different at $p>0.05$.

Growth characteristics of seedlings: Large differences were found within stand and among the stands for seedling height and root-collar diameter (Table 3). Averages of height and diameter of one year seedling were 8.9 cm and 1.68 mm in polled populations, respectively. They ranged from 6.6 cm (S1) to 10.6 cm (S3) in SH and between 0.73 mm and 2.13 mm in RCD (Table 3, Figure 2). They were also between 2.3 cm and 25.0 cm for SH and between 0.12 mm and 5.77 mm for RCD in individual seedling of polled stands (Table 3).

Seedling could be defined artificially produced for plantation purpose or naturally grown regeneration materials from seed trees. It was the main material in plantation, regeneration and other forest establishment purposes. Besides, seedling played important roles in economic and biological success of the establishment from seed harvest to plantation. However, it emphasized that there could be utilization possibility of advanced regenerations (also called as seedling in the present study) in natural forests for low cost of forest establishment. Averages of seedling height and root-collar diameter were found 8.2 cm and 3.97 mm in one year bare-root seedlings of Brutian pine, respectively [2]. While, they were 18.4 cm and 4.86 mm in one

year bare-root seedlings, and 14.79 cm and 4.56 mm in one year containerized seedlings of the species, respectively [4]. Averages of seedling height and root-collar diameter were reported 12.5 cm and 2.74 mm in polled one year bare-root containerized seedlings in Brutian pine [3].

Table No. 3: Averages, ranges and results of Duncan's multiple range test of SH and RCD in the stands.

Stands and code	Growth characteristics			
	SH (cm)		RCD (mm)	
	Average*	Ranges	Average	Ranges
S1	6.6-a	3.0-12.0	1.98-d	0.50-4.10
S2	7.1-a	2.3-15.0	1.37-b	0.29-3.70
S3	10.6-d	5.0-20.0	2.36-e	0.79-5.77
S4	10.2-cd	4.0-25.0	0.73-a	0.12-3.28
S5	9.5-c	5.1-14.7	1.65-c	0.76-2.63
S6	10.2-cd	6.0-18.0	2.13-d	089-3.60
S7	8.0-b	4.2-18.6	1.51-bc	0.23-4.67
Total	8.9	2.3-25.0	1.68	0.12-5.77

*; The same letters showed not significantly different at $p>0.05$

These results were generally higher than results of the present study except of some individual growth performance. However, present study were carried out in natural stands which were not applied natural practices such as selection of mother trees phenotypically opposite to seedlings produced selected trees or populations reported in early studies [2, 3, 4]. These results showed that there could be utilization possibility from some advanced regenerations during natural regeneration practices.

Results of analysis of variance showed statistically significant ($p<0.05$) differences among the stands for SH and RCD. Stands had larger variation in root-collar diameter than seedling height based on Duncan's multiple range test (Table 3).

There were statistically significant ($p<0.05$) relations between SH and RCD in each stand ($r=$ *0.350* in S1, *0.602*, *0.781*, *0.701*, *0.628*, *0.691* and *0.468* in S7) and polled stands (*0.432*). It was also reported in early studies carried out in Brutian pine [e.g., 2, 3, 4].

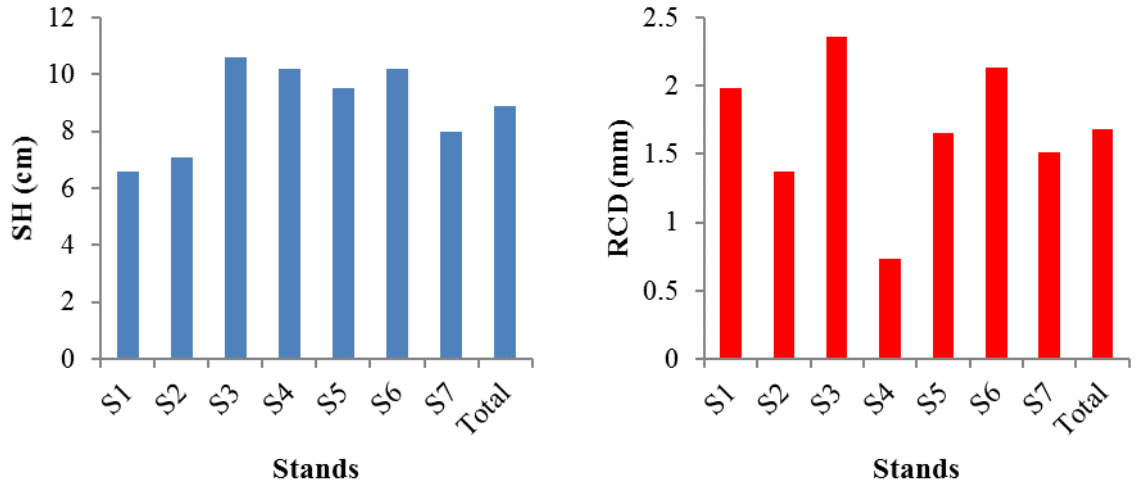

Figure No. 2: Averages of SH and RCD in stands.

Seedling quality: Percentages of cull seedlings were 67.6% for SH and 37 for RCD, while there were large differences among the stands for seedling quality according to Quality Classification of TSI (Table 4, Figure 3). S3 had the highest first class seedlings for SH (34%) and RCD (63%), while ratios of cull seedlings were the highest for SH in S1 (93%) and for RCD in S4 (94%) (Table 4). It could be said that 32.4% and 33% of seedlings had quality for SH and RCD, respectively (Table 4). The results showed importance of local natural regeneration practices.

Table No. 4: Quality classes of TSI for one year Brutian pine seedlings and their distribution (%).

Stands	SH (cm)			RCD (mm)	
	First class (12 ≤SH)	Second class (12> SH ≥10)	Cull (10> SH)	First class (2 ≤RCD)	Cull (2 > RCD)
S1	1	6	93	62	38
S2	4	13	83	8	92
S3	34	16	50	63	37
S4	33	13	54	6	94
S5	17	22	61	23	77
S6	25	27	48	51	49
S7	8	8	84	18	82
Total	**17.4**	**15.0**	**67.6**	**33.0**	**67.0**

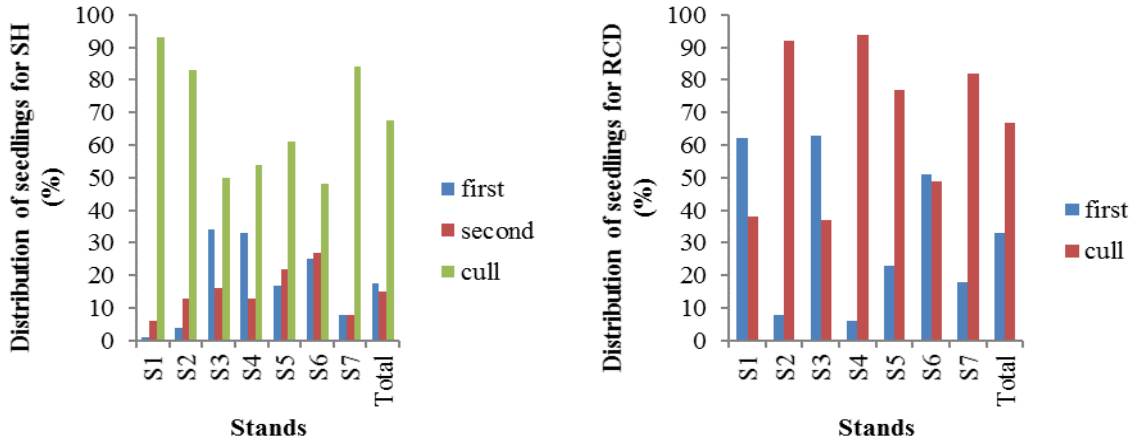

Figure No. 3: Distribution (%) of seedlings to quality classes for the characteristics.

It was reported that 29.5% first class and 42%cull for one year seedlings produced from nursery conditions of the species, while they were 82.5% and 17.5% for RDC according to Quality Classification of Turkish Standard Institute [3]. All seedlings were in high quality classification of Turkish Standard Institute for root-collar diameter in the seedling types, while it was 90% of seedlings for seedling height in one year bare-root seedlings of Brutian pine in an another nursery condition [4]. 74% of seedlings were cull/unsuitable for SH and no any cull seedlings for RCD in one year bare-root seedlings of the species in TSI [2]. The differences could be explained by genetical structure of mother trees and environmental conditions of nursery such as nursery practices and location of mother stands.

In the present study growth data were collected from one year advanced regenerations. Therefore, it could be early to draw accurate conclusion for utilization possibility from advanced regenerations seedlings. It is needed to collect more data on the growth characteristic in future years. However, results of the study could be used in regeneration stage such as thinning. These results showed that there could be utilization possibility from some advanced regenerations for natural regeneration practices.

Significant ($p<0.05$) relations between SH and RCD showed that SH could be used in forestry practice in thinning for its easy application.

The results of the study emphasized importance of local natural regeneration practices based on differences of genetical and environmental conditions.

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