# Effect of using harvesting residues as a nursery media on seedling weight in Brutian pine (*Pinus brutia* Ten.)

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## Abstract

Effects of harvesting residues (needle, bark and branch) on fresh and dry weights of two-year bare root seedlings originated from a seed stand and a seed orchard were examined in Brutian pine (*Pinus brutia* Ten.) to contribute nursery practices of the species and to estimate utilization possibility of the residues. Averages of seedling fresh and dry weights were 9.24 g and 3.36 g, respectively in polled treatments and origins. Results of analysis of variance showed significant differences ($p \le 0.05$) among the treatments and between seed sources for the fresh and dry weights. Total averages of water content were 61.20% in root, 64.69% in stem and 63.75% in fresh weight of full seedling. Seed orchard seedlings had higher water content in root, stem and full seedling than seed stand seedlings opposite to fresh and dry weights. Averages of water content ranged from 60.39% (control treatment) to 65.94% (bark treatment) in full seedling of polled treatments and seed sources.

## Keywords

Nursery; *Pinus brutia*; Seedling quality; Water content

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## 1 Introduction

Global warming is one of the most important environmental problems that negatively affect the survival of current forests and the establishment by aridity of new forests. For instance, Ivetić and Devetaković (2016) reported that extreme weather events and low precipitation during the growing season could cause high mortality of seedlings after planting based on climate change. It was also suggested that reforestation programs should take projections of climate change into consideration

(Ivetić and Devetaković 2016). It is getting importance optimal using of water sources in forest establishment from nursery to plantation (i.e re-planting), and optimal utilization from the forest area and its products.

Harvesting residues (also called waste material), logging residues, cutting residues, and slash or foliage (Alma and Çetin 2002; Ateş et al. 2007; Mañas et al. 2009; Eker 2011) are important forest products, especially for use in Brutian pine (*Pinus brutia* Ten.) which cover about 22% of total Turkish forest area, around 5.8 million ha (Anonymous 2015). However, although the potential of available residues is 5 to 7 Mt (million tonnes) for Turkey (Anonymous 2009), the supply and use of residues is very low because of the indefiniteness on cost and system components such as where chipping is to be done, which chipper types are used, how many logging residues are left in the stand to supply etc. (Eker 2011). The residues, used limitedly by different industries in other countries, have large amount after wood harvesting. It is used for energy production, animal and poultry feeds or additive for animal feeds, paper, board, chemical, fertilizer and cosmetic industries in many countries (Ateş et al. 2007). However, limited studies were carried out to investigate utilization possibility of harvesting residues in nursery practices such as growing media (e.g., Solbraa 1986; Smith 1992; Wright et al. 1999; Hernández-Apaolaza et al. 2005; Mupondi et al. 2006; Mañas et al. 2009) in different forest tree species, and in Brutian pine (Çetinkaya and Bilir 2017; Çetinkaya 2020). The aim of this study was to estimate the effect of incorporating harvesting residues into the soil media on fresh and dry weights, and water content in two-year bare root Brutian pine seedlings and to determine utilization possibility of the residues in nursery practices based on water economy. The results of the study are also discussed with water economy used by the seedlings based on global warming.

## 2 Materials and methods

The study was carried out in Pos-Kicak (Adana) forest nursery located at southern part of Turkey (37°34'40'' N latitude, 35°12'45'' E longitude, 980 m altitude). Three distinct sources of harvesting residues were used as incorporated media into soil: first - needle (N), second - bark (BA) and third - branches (BR) of Brutian pine from natural regeneration areas of the species in 2017.

Two-year bare root seedlings originated from a seed orchard (SO, 37°06'55" N latitude, 35°48'30'' E longitude, 30 m altitude) and a natural seed stand (SS, 37°34'30" N latitude, 35°24'30'' E longitude, 745 m altitude) were used in the study. Seed beds were treated by each residue (500 g/m$^2$) as three replicates together with control (C) treatment before sowing in April of 2018. At the end of the second year growing period in 2019, a number of 200 seedlings from each seed source treatment were lifted (Figure1). Root and stem part of sampled seedlings were separated on root collar after cleaning at the laboratory. Root (RFW), stem (STFW) and full seedling fresh weights (SFW) were weighed for treatments and seed sources. Dry weights of root (RDW), stem (STDW) and full seedling (SDW) were weighed after drying in an oven at 105 ± 2°C for 24 hours according to treatments and seed sources. Water contents for root (WR), stem (WST), and full seedlings (WS) were calculated by difference between fresh and dry weights.

Following model of multiple analyses of variance (MANOVA) was used for comparison of characteristics for the treatments and seed sources. The treatments were also grouped by Duncan's multiple range test for the characteristics (Duncan 1955).

$$Y_{ijk} = \mu + P_i + S_j + P(S)_{i(j)} + e_{ijk}$$

where $Y_{ijk}$ is the observation from the $k^{th}$ seedling of $i^{th}$ treatment of $j^{th}$ seed source, $\mu$ is overall mean, $P_i$ is the effect of the i seed source, $S_j$ is the effect of $j^{th}$ treatment, $P(S)_{i(j)}$ is the effect of interaction between seed source and treatment, $e_{ijk}$ is random error.

Phenotypic correlations among characters were also estimated.

Figure 1. Seedling sample of *Pinus brutia* from Pos-Kicak (Adana) forest nursery.

## 3 Results and discussion

### 3.1 Fresh weights

Averages of seedling fresh weights were 8.05 g in SO seedlings and 10.42 g in SS seedlings (Table 1, Figure 2). Control treatment had the lowest fresh weight for stem and full seedling in both seed sources, while it was needle treatment (N, 1.89%) in seed orchard seedlings and branch treatment (BR, 2.51%) in seed stand seedlings (Table 1, Figure 2). Besides, bark treatment (BA) showed the highest fresh weight performances in total treatments and seed sources.

As seed from Table 1 and Figure 2, seedling of seed stands was heavier than seed orchard seedlings. The results were well accordance with early studies carried out on seedling height and root collar diameter (Dilaver et al. 2015; Yılmazer and Bilir 2016; Bilir and Çetinkaya 2018) opposite to Çercioglu and Bilir (2016). Significant differences ($p<0.05$) among the treatments and between seed sources were found by results of MANOVA for the fresh weights. RFW and STFW were in six homogenous groups by Duncan's multiple range test. The statistically significant ($p<0.05$) differences were reported in other seedling morphological characteristics between containerized and bare root seedlings, and between seed orchard and seed stand seedlings (e.g., Dilaver et al. 2015; Yılmazer and Bilir 2016; Çercioglu and Bilir 2016; Bilir and Çetinkaya 2018), and also among treatments (Çetinkaya, 2020) in Brutian pine.

Table 1. Seedling sample of *Pinus brutia* from Pos-Kicak (Adana) forest nursery.

| **Treatments** | | **SO** | | | **SS** | | | **General** | |
|---|---|---|---|---|---|---|---|---|---|
| | RFW | STFW | SFW* | RFW | STFW | SFW | RFW | STFW | SFW* |
| C | 2.22 | 4.26 | 6.48 | 2.71 | 6.03 | 8.74 | 2.47 | 5.15 | 7.61 |
| BR | 2.51 | 5.83 | 8.34 | 2.51 | 7.50 | 10.01 | 2.51 | 6.67 | 9.12 |
| N | 1.89 | 6.40 | 8.29 | 2.77 | 7.83 | 10.60 | 2.33 | 7.12 | 9.45 |
| BA | 2.05 | 7.02 | 9.07 | 3.31 | 8.99 | 12.30 | 2.68 | 8.01 | 10.67 |
| Total | 2.17 | 5.88 | 8.05 | 2.83 | 7.59 | 10.42 | 2.50 | 6.74 | 9.23 |

*SFW=RFW+STFW

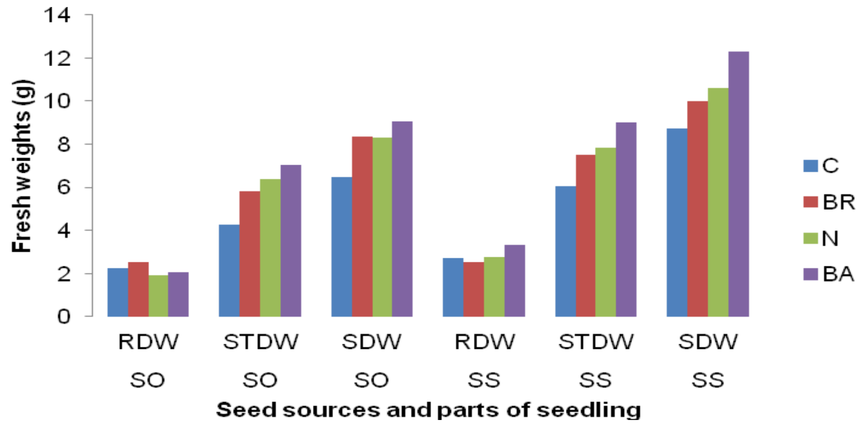


Figure 2. Averages of fresh weights (g) for the treatments and seed sources.

## 3.2 Dry weights

Total average of seedling dry weight was ranged from 2.51 g (C treatment of SO) to 4.45 g (BA treatment of SS) (Table 2, Figure 3). It could be said that control treatment showed generally lowest dry weight performances, while BA treatment had highest dry weights in each seed source and polled origin except of RDW of SO (Table 2, Figure 3). It could be also seen that dry weights were higher in SS seedlings than SO seedlings in all treatments, and part of the seedlings. The differences among the treatments and between sources was also supported by results of analysis of variance ($p<0.05$). Çetinkaya (2020) found significant ($p<0.05$) differences for seedling height and root collar of two-year seedlings among treatments in Brutian pine.

Table 2. Averages of dry weights (g) for the treatments and seed sources.

| Treatments | | SO | | | SS | | | General | |
|---|---|---|---|---|---|---|---|---|---|
| | RDW | STDW | SDW* | RDW | STDW | SDW | RDW | STDW | SDW* |
| C | 0.82 | 1.69 | 2.51 | 1.10 | 2.44 | 3.54 | 0.96 | 2.07 | 3.03 |
| BR | 0.91 | 1.63 | 2.54 | 1.07 | 2.70 | 3.77 | 0.99 | 2.17 | 3.16 |
| N | 0.74 | 2.06 | 2.80 | 1.03 | 2.98 | 4.01 | 0.89 | 2.52 | 3.41 |
| BA | 0.90 | 2.37 | 3.27 | 1.28 | 3.17 | 4.45 | 1.09 | 2.77 | 3.86 |
| Total | 0.84 | 1.94 | 2.78 | 1.12 | 2.82 | 3.94 | 0.98 | 2.38 | 3.36 |

*SDW=RDW+STDW

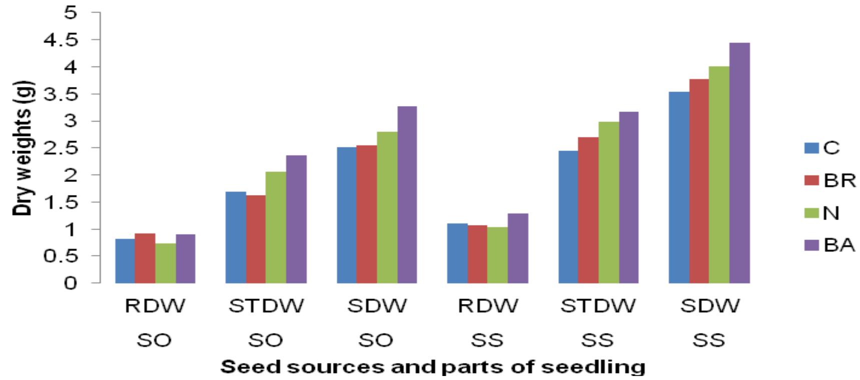


Figure 3. Averages of dry weights (g) for the treatments and seed sources.

Results of correlation analysis showed positive and significant correlation (*p<0.05, r=0.624*) was found between RDW and STDW in polled treatments and origins. The correlation between RDW and STDW was well accordance with results of two-year stone pine seedlings (Dutkuner and Bilir 2011).

### 3.3 Water content

Stem part of the seedling had higher water content 66.61% in SO, 62.56% in SS, and 64.69% in polled origins (Table 3, Figure 4). Opposite to fresh and dry weights performances, water content of SO seedlings had higher in root, stem and full seedling than that of SS for all treatments except of BA treatment in root (Table 3, Figure 4). It was also seen from the Table (3) and Figure (4) control treatment (C) had the lowest water content in stem and full seedling for all treatments. The results emphasized importance of the treatments included harvesting residues, and its using potential for water economy in nursery practices. Beside, it was showed SO seedlings had higher water absorbition from the soil than SS seedlings, and also residues kept the soil water. Average water content was higher in stem (51%) than that of root (40.3%) in two-year Stone pine (*Pinus pinea* L.) seedlings (Dutkuner and Bilir 2011). The contents were 51.0% in stem, 40.3% in root and 48.7% in full seedlings of Taurus cedar (*Cedrus libani* A. Rich.) (Yıldız 2005). In another study in Taurus cedar, it was reported 61.1% in root, 62.7% in stem and 61.9% in full seedlings (Bilir 1997). Dutkuner and Bilir (2011) were also reported higher than 0.7 clonal repeatability for water content in stone pine.

Table 3. Averages of water content (%) in treatments and seed sources.

| Treatments | SO | | | SS | | | General | | |
|---|---|---|---|---|---|---|---|---|---|
| | WR* | WST | WS | WR* | WST | WS | WR* | WST | WS |
| C | 63.06 | 60.33 | 61.27 | 59.41 | 59.54 | 59.50 | 61.24 | 59.94 | 60.39 |
| BR | 63.75 | 72.04 | 69.54 | 57.37 | 64.00 | 62.34 | 60.56 | 68.02 | 65.94 |
| N | 60.85 | 67.81 | 66.22 | 62.82 | 61.94 | 62.17 | 61.84 | 64.88 | 64.20 |
| BA | 56.10 | 66.24 | 63.95 | 61.33 | 64.74 | 63.82 | 58.72 | 65.49 | 63.89 |
| Total | 60.94 | 66.61 | 65.25 | 60.23 | 62.56 | 61.96 | 61.20 | 64.69 | 63.75 |

*WR%= (1-RDW/RFW)·100; WST%= (1-STFW/STDW)·100; WS%= (1-SFW/SDW)·100

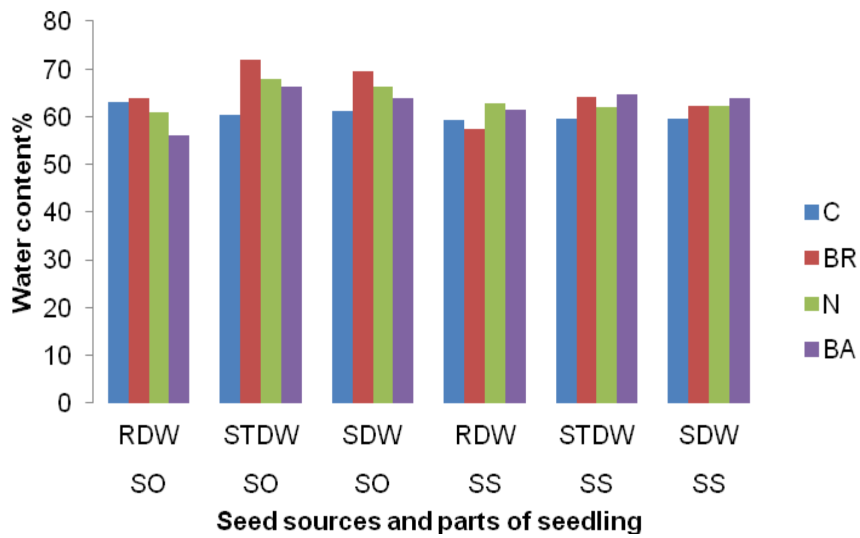


Figure 4. Averages of water content (%) for the treatments and seed sources.

## 4 Conclusions

Results of the study showed utilization possibility of harvesting residues in nursery practices especially to decrease water using in seedling producing and other forestry practices. However, nursery stage of the treatments was investigated, and also field performance of the treatments should be also examined in future studies. An amount of the residues in a period was used in the present study, combination of harvesting residues and different periods such as during germination or one year ago before sowing.

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