

The Effects of Different Growing Media on Seedling Characteristics of Turkish Alder (*Alnus orientalis* Decne)

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Abstract

Aim of study: This study aimed to investigate the effects of different growing media on the seedling characteristics of *Alnus orientalis*.

Area of study: Cones were collected from Bucak, Anamur and Fethiye regions in October 2022.

Material and method: Two growing media were used: a mixture of 50% forest soil, 30% peat, and 20% fertilizer, and a mixture of 50% perlite and 50% sand. The following seedling characteristics were measured: root collar diameter, height, biomass, sturdiness quotient (SQ), and Dickson quality index (DQI).

Main results: Seedling heights ranged from 12.79 cm to 18.07 cm in perlite media and from 37.63 cm to 41.80 cm in soil media. Diameters ranged from 4.30 mm to 5.32 mm in perlite media and from 9.83 mm to 11.33 mm in soil media. In soil media, no significant differences were observed among populations in terms of height, but significant differences in diameter were found. While SQ was not significantly influenced by the growing media, DQI values were significantly affected by the type of growing media.

Research highlights: The use of different growing media enables a more comprehensive evaluation of the intraspecific variation in *Alnus orientalis*.

Keywords: Biomass, Population, Seed, Dickson Quality Index, Sturdiness Quotient

Farklı Kap Ortamlarının Türk Kızılağacı (*Alnus orientalis* Decne) Fidan Karakterleri Üzerine Etkileri

Öz

Çalışmanın amacı: Bu çalışmada, farklı yetiştirme ortamlarının *Alnus orientalis* fidan özellikleri üzerine etkilerinin araştırılması amaçlanmıştır.

Çalışma alanı: Kozalaklar Ekim 2022'de Bucak, Anamur ve Fethiye bölgelerinden toplandı.

Materyal ve yöntem: Denemede, standart tüp harcı olan %50 orman toprağı + %30 torf + %20 gübre ile %50 perlit + %50 dere kumu içeren iki farklı yetiştirme ortamı kullanılmıştır. Fidanların kök boğazı çapı, boyu, biyokütle değerleri, gürbüzlük indisi (SQ) ve Dickson kalite indisi (DQI) değerleri saptanmıştır.

Temel sonuçlar: Aralık ayında boylar perlit ortamında 12.79 cm ile 18.07 cm arasında değişirken, toprak ortamında 37.63 cm ile 41.80 cm arasında değişmiştir. Çaplar ise perlit ortamında 4.30 mm ile 5.32 mm, toprak ortamında ise 9.83 mm ile 11.33 mm arasında ölçülmüştür. Toprak ortamında kızılğaç popülasyonlarında boy karakteri açısından anlamlı bir fark gözlenmezken, çap değerlerinde anlamlı farklılıklar tespit edilmiştir. İki ortamın SQ üzerinde istatistiksel olarak anlamlı bir etkisi olmadığı sonucuna varılmıştır. İki farklı yetiştirme ortamının SQ üzerinde önemli bir etkisi bulunmazken, yetiştirme ortamının DQI üzerinde etkili bir rol oynadığı görüldü.

Araştırma vurguları: Çeşitli yetiştirme ortamlarının kullanılması, *Alnus orientalis*'te tür içi varyasyonun daha kapsamlı bir şekilde değerlendirilmesine olanak sağlayacaktır.

Anahtar kelimeler: Biyokütle, Popülasyon, Tohum, Dickson Kalite İndisi, Gürbüzlük İndisi



Introduction

Turkish alder (*Alnus orientalis* Decne.) is one of the species that is not well known in Türkiye (Yılmaz, 2020). Turkish alder, which belongs to the *Alnus* genus of the *Betulaceae* family, is among the species that grow naturally in Türkiye. Turkish alder is distributed in Türkiye, Cyprus, Syria and Lebanon (Browicz, 1982; Yaltırık & Efe, 2000). Among these countries, it is most widely distributed in Türkiye. With its distribution in a narrow area in the world, Turkish alder is an endemic species for the Eastern Mediterranean (Yılmaz, 2020). It is found in the southern part of Türkiye, on the banks of streams. Although it is generally found between 0-1000 m altitude, it is distributed up to 1400 m altitude in Mersin-Sorgun. Turkish alder has a very high temperature requirement and the places where it is distributed are areas with warm, hot and very hot climates (Yılmaz & Ekici, 2011).

Frankia bacteria in the roots of alder trees enrich the soil by fixing nitrogen (Kajba & Gracan, 2003). Dense root nodules were also observed in the roots of 1-year-old *Alnus orientalis* seedlings produced in the nursery (Yılmaz & Aslan, 2013; Kavraz, 2023). Due to the presence of these nodules, alder trees are commonly used in the afforestation of sandy soils and mining areas that are deficient in organic nutrients (Tarrant & Trappe, 1971; Kurdali et al., 1990). Turkish alder is a tree species that can be used in many areas such as industrial plantation, restoration of waterfronts, rehabilitation of mine and waste areas and urban afforestation (Yılmaz, 2020). Deciduous trees like alder can improve living conditions for other species in rehabilitated areas, such as mines, by providing shade, nutrients, and organic material. Alders are also suitable for landscape applications due to their low maintenance, resistance to moist soils, and ability to quickly form windbreaks. On the other hand, it is stated that alder can be a tree that can be used for nutrient-poor soils such as mines, waste areas and stream. The use of alder species is also suitable for the restoration of riparian vegetation damaged by pressures (Jones, 2000; Bernhardt et al., 2005). There are many studies showing that alder generally increases soil fertility and aboveground biomass in mixed stands where

it is grown together (Binkley, 2003; Rothe et al., 2003).

It has been suggested to use 1+0 aged seedlings in afforestation studies to be carried out with alder (Eyüpoğlu & Atasoy, 1991). In the cultivation of alder in nurseries, it has been determined that planting density is not statistically effective on height growth, but it has a significant effect on the survival rate of the seedlings (Eyüpoğlu, 1975). Alder is grown as bare-root and container seedlings in nurseries. A study on pre-treatment effects on alder seed germination found that hot water, light, and salt treatments were statistically effective (Erdem, 2007). Seed characteristics of eastern alder from Mersin, Antalya, Denizli, and Muğla were analyzed, showing that four-week stratification increased germination, seeds germinated better at 20°C+, and two-week stratification overcame dormancy (Ekici, 2011). The germination period of alder seeds is generally reported to be between 10 and 20 days. (MacDonald, 1999). Again, the germination percentages of alder seeds varied among origins (18%-55%). The study also found that the ideal germination temperature for alder is above 20°C (Yılmaz, 2020).

Saatçioğlu (1971) determined the 1000-seed weight of *Alnus glutinosa* and *Alnus glutinosa* subsp. *barbata* as 1.4 g and 1.0 g, respectively. It is stated that the germination percentage of *Alnus glutinosa* is approximately 40%, but this percentage is generally lower due to fungal infection in the seed (Suszka et al., 1996). In a study carried out on six relict populations of common alder in the Eastern Mediterranean region the cone, seed and germination characteristics of the species were also determined (Yılmaz & Yılmaz, 2021). A study on the effect of growing media on alder seedling development found that the highest values for seedling height, diameter, lateral branches, and dry weight were in a soil+farm manure+sand mix (Kösa & Karagüzel, 2012). In this study, it was aimed to reveal the effect of perlite and soil growing media on the growth and development of 1+0-year-old seedlings belonging to Fethiye, Anamur and Bucak Turkish alder populations; the hypothesis that there is no difference in the growth

performance of the populations and seedling quality in perlite and soil media was tested.

Material and Methods

Cones of *Alnus orientalis* were collected from ten trees per population during the last week of October 2022 in the Bucak (37° 14' N, 30° 47' E), Anamur (36° 12' N, 32° 51' E), and Fethiye (36° 42' N, 29° 03' E) regions. (Kavraz, 2023). A distance of at least 50 meters was maintained between cone-collecting trees to capture genetic variation (Ürgeç, 1982). All cones were brought to the Istanbul-Göktürk Forest Nursery Directorate and the seeds were extracted from the cones. The seeds were stored at +4°C until the experiment.

On March 20, 2023, 250 seeds of three Turkish alder populations (Fethiye, Anamur, and Bucak) were sown in 18x35 cm polyethylene tubes in accordance with the random block design at the Göktürk Forest Nursery Directorate. A total of 4500 seeds were sown in 900 polyethylene tubes, 5 seeds each. No repulsive pesticide or similar chemical treatment was applied to the seeds. Two different media were used in the experiment. Standard growing media and relatively poorer growing media were used to test the development of seedlings. The standard growing media used in production practices of the Göktürk Forest Nursery Directorate, consisting of 50% forest soil + 30% peat + 20% fertilizer (hereinafter referred to as “Soil”), was used as the first media. For the second media, 50% perlite + 50% stream sand (hereinafter referred to as “Perlite”) was used. Soil analyses of two different media are given in Table 1. No additional fertilization was applied to the seedlings throughout the experiment. The seeds were kept moist by watering them every day during the

germination phase, and the polyethylene tubes were covered with cage wire to combat biotic pests.

The root collar diameter (mm) and height (cm) values of all seedlings belonging to the Turkish alder populations of Fethiye, Anamur and Bucak in soil and perlite media were measured with the using digital caliper and meter in August, September, October, November and December 2023, respectively. In December (2023), biomass measurements were made on a total of 90 randomly selected seedlings (3 populations x 2 media x 3 replicates x 5 seedlings = 90 seedlings) grown in soil and perlite media from three populations. In this context, each seedling was separated into lateral branches, stem and root parts (Figure 1) and labeled and placed in different paper bags. Samples of biomass components (lateral branches, stem and root) were dried in a drying oven at 65 °C until a uniform weight was attained. Then, the lateral branches, stem and root dry weights (g) were weighed separately with a digital scale. The total biomass was determined as the sum of the lateral branches, stem and root dry weights. The sturdiness quotient (SQ) was calculated the ratio of seedling height to root collar diameter ($SQ = h_{cm} / d_{mm}$).

The Dickson Quality Index (QI) was calculated based on Equation (1) (Dickson et al., 1960);

$$DQI = \frac{F(g)}{h + \frac{S(g)}{R(g)}} \quad (1)$$

In equation (1), *F* represents the total seedling dry weight (g), *h* the seedling height (cm), *d* the root collar diameter (mm), *S* the above-ground dry weight (g), and *R* the root dry weight (g).

Table 1. Soil analysis results of soil and perlite growing media

Media	Sand (%)	Silt (%)	Clay (%)	pH	EC (uS/cm)	CaCO ₃ (%)	Organic matter (%)
Soil	64.6	17.8	17.6	7.12	161.7	0.51	6.1
Perlite	98.6	0.8	0.6	7.29	86.2	0.01	0.4

Statistical Analysis

Mean values and standard errors were used to represent seedling characters. Analysis of variance (ANOVA) was utilized to examine

the differences among treatments, followed by Tukey’s post hoc test for pairwise mean comparisons at a significance threshold of $p < 0.05$. All statistical analyses were

conducted using SPSS software (SPSS, 2010). The ANOVA model used in the experiment is given in Equation (2);

$$Z_{ijkm} = \mu + P_i + O_j + A_k + PO_{ij} + PA_{ik} + OA_{jk} + POA_{ijk} + e_{mijk} \quad (2)$$

In equation (2), the model components represent the following:

Z_{ijkm} = Phenotypic value of the seedling,
 μ = Average of the measured character,
 P_i = Effect caused by populations,
 O_j = Effect caused by media,
 A_k = Effect caused by months,
 PO_{ij} = Population x media interaction,
 PA_{ik} = Population x month interaction,
 OA_{jk} = media x month interaction,
 e_{mijk} = Experimental error



Figure 1. Development of lateral branches, stem and root organs in Turkish alder seedlings grown in soil (left) and perlite (middle) media. Nodule formations on the roots of 1+0-year-old Turkish alder (*Alnus orientalis*) seedlings (right) (Photo: G. Kavraz, 2023).

Results

The effect of population x media interaction on height ($p=0.000$) and diameter ($p=0.000$) in the seedlings was found to be significant. The effect of population x month interaction on height ($p=0.360$) and diameter ($p=0.987$) was found to be insignificant. The effect of media x population x month triple interaction on height was found to be insignificant ($p=0.319$) while it was found to be significant ($p=0.004$) on diameter (Table 2). The height and diameter values of alder populations in perlite and soil media by months are given in Table 3. In December, the maximum average height in soil and perlite

media was determined as 41.8 cm and 18.07 cm in Anamur population, respectively. The maximum average root collar diameter was determined as 5.32 mm in perlite media in Anamur and 11.33 mm in soil media in Bucak population.

The Tukey Post Hoc test results of the average height and diameter values of alder populations in perlite and soil media by months are shown in Figure 2. In soil media, it was observed that Fethiye and Bucak populations formed separate groups in terms of height values in September. It was found that the statistical difference determined in terms of height disappeared in October,

November and December and all populations were gathered in the same group (Figure 2). In perlite media, all populations were gathered in the same group in terms of height and root collar diameter. In soil media, Fethiye and Bucak populations were gathered in different groups in terms of root collar diameter values in December (Figure 2). The Tukey post hoc test results for the monthly average height and diameter increases of alder populations in

perlite and soil media are shown in Figure 3. While the populations were gathered in a single group in perlite media in terms of height increases in the September-August period, Fethiye and Bucak were gathered in different groups in soil media. It was observed that this statistical difference between the populations disappeared in other periods (Figure 3).

Table 2. Results of variance analysis (ANOVA) on the effects of perlite and soil media on the height (h) and root collar diameter (d) of *Alnus orientalis* seedlings

Variable		Variation source			
		df	MS	F	P
Media	h	1	193551.459	2048.814	0.000
	d	1	6786.781	1434.53	0.000
Population (Pop)	h	2	596.111	6.310	0.002
	d	2	1.951	0.412	0.662
Month	h	4	40311.757	426.715	0.000
	d	4	3331.052	704.090	0.000
Media * Pop	h	2	1420.433	15.036	0.000
	d	2	96.916	20.485	0.000
Media * Month	h	4	6800.734	71.988	0.000
	d	4	365.886	77.338	0.000
Pop * Month	h	8	103.847	1.099	0.360
	d	8	1.044	0.221	0.987
Media*Pop*Month	h	8	109.774	1.162	0.319
	d	8	13.564	2.867	0.004
Error	h	2218	94.470		
	d	2218	4.731		

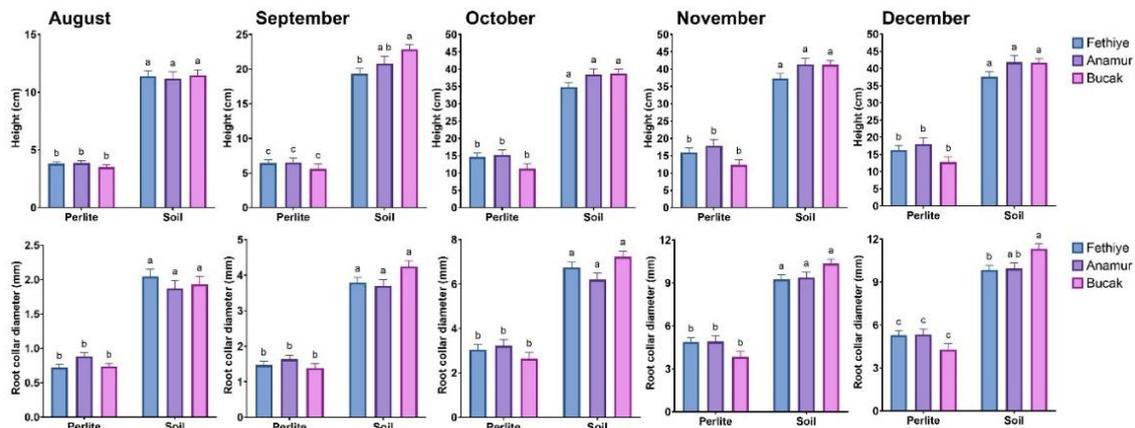


Figure 2. Distribution of height (cm) and diameter (mm) values of seedlings of *Alnus orientalis* populations (Fethiye, Anamur and Bucak) in perlite and soil media across different months and Tukey post hoc test results (\pm standard error). Same letters in the graphs for different months and measurement parameters are not statistically different ($p < 0.05$)

Table 3. Average height and diameter values (\pm standard error) of *Alnus orientalis* populations (Fethiye, Anamur and Bucak) in perlite and soil media by months. Minimum and maximum values are shown in parentheses

Month	Populations	Perlite		Soil	
		Height (cm)	Diameter (mm)	Height (cm)	Diameter (mm)
August	Fethiye	3.81 \pm 0.16 (0.80-11.80)	0.72 \pm 0.04 (0.12-2.62)	11.41 \pm 0.43 (1.70-22.80)	2.05 \pm 0.11 (0.31-5.54)
	Anamur	3.86 \pm 0.23 (1.20-13.30)	0.88 \pm 0.05 (0.21-1.84)	11.17 \pm 0.58 (1.10-22.80)	1.87 \pm 0.12 (0.20-5.34)
	Bucak	3.51 \pm 0.22 (0.60-14.50)	0.74 \pm 0.05 (0.28-2.33)	11.45 \pm 0.50 (1.30-23.40)	1.93 \pm 0.12 (0.24-5.73)
September	Fethiye	6.43 \pm 0.48 (1.50-24.80)	1.47 \pm 0.11 (0.27-5.23)	19.32 \pm 0.76 (3.30-42.80)	3.79 \pm 0.15 (0.88-8.97)
	Anamur	6.55 \pm 0.63 (1.50-26.50)	1.63 \pm 0.12 (0.30-4.13)	20.83 \pm 1.03 (2.00-34.50)	3.70 \pm 0.18 (0.47-8.34)
	Bucak	5.59 \pm 0.71 (1.10-29.80)	1.38 \pm 0.12 (0.51-5.31)	22.83 \pm 0.67 (7.00-36.40)	4.24 \pm 0.16 (1.33-11.61)
October	Fethiye	14.66 \pm 1.16 (2.40-46.40)	3.05 \pm 0.23 (0.36-9.46)	34.80 \pm 1.25 (8.60-67.70)	6.75 \pm 0.26 (1.78-14.52)
	Anamur	15.25 \pm 1.47 (2.40-43.80)	3.22 \pm 0.27 (0.83-9.23)	38.44 \pm 1.67 (5.40-69.60)	6.19 \pm 0.29 (0.55-12.44)
	Bucak	11.25 \pm 1.48 (1.80-55.10)	2.64 \pm 0.28 (0.62-11.41)	38.78 \pm 1.16 (8.60-60.20)	7.23 \pm 0.25 (2.19-14.03)
November	Fethiye	15.99 \pm 1.26 (2.80-53.50)	4.89 \pm 0.32 (0.79-12.17)	37.28 \pm 1.40 (9.00-70.00)	9.24 \pm 0.34 (2.29-17.14)
	Anamur	17.83 \pm 1.84 (2.60-68.50)	4.91 \pm 0.40 (1.18-11.15)	41.35 \pm 1.87 (5.40-81.00)	9.37 \pm 0.40 (0.83-20.00)
	Bucak	12.36 \pm 1.53 (2.00-55.10)	3.84 \pm 0.38 (0.72-14.92)	41.27 \pm 1.24 (9.90-66.50)	10.35 \pm 0.31 (4.21-16.67)
December	Fethiye	16.33 \pm 1.28 (3.00-54.00)	5.29 \pm 0.32 (0.93-12.96)	37.63 \pm 1.42 (9.00-70.00)	9.83 \pm 0.35 (2.50-17.67)
	Anamur	18.07 \pm 1.85 (2.60-69.00)	5.32 \pm 0.41 (1.22-11.36)	41.80 \pm 1.90 (5.40-84.00)	9.95 \pm 0.39 (1.86-20.00)
	Bucak	12.79 \pm 1.56 (2.00-55.10)	4.30 \pm 0.40 (0.73-15.45)	41.66 \pm 1.24 (11.00-67.00)	11.33 \pm 0.34 (5.53-17.89)

It was observed that Fethiye and Bucak populations were gathered in two different groups in terms of root collar diameter increase in the December-August period. While the highest average root collar diameter increase was seen in Bucak population in soil media, Bucak population made the least

increase in perlite media (Figure 3). While the Anamur population made the highest average height increase in all periods in perlite media, the Anamur population made the highest average height increase in soil media in all periods (except September-August) (Figure 3).

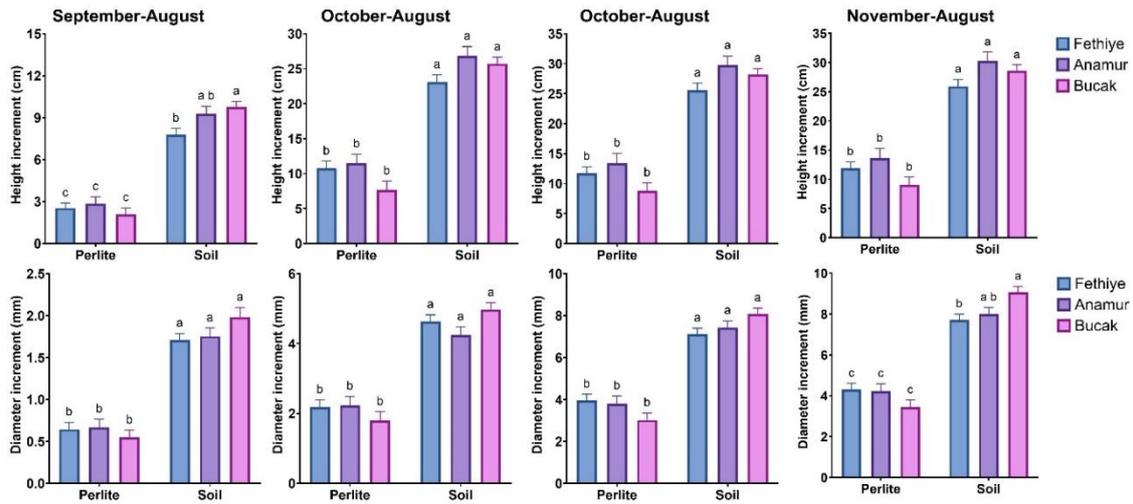


Figure 3. The height (cm) and diameter (mm) increment values of seedlings of *Alnus orientalis* populations (Fethiye, Anamur and Bucak) in perlite and soil media across different periods and Tukey post hoc test results (\pm standard error). Same letters in the graphs for different months and measurement parameters are not statistically different ($p < 0.05$)

The dry weights of lateral branches, stem and roots of alder populations in soil and perlite media are given in Figure 4. While the belowground biomass of alder populations in perlite media is approximately four times the aboveground biomass, root biomass of alder seedlings grown in soil media is approximately two times the aboveground biomass (Figure 4). It was observed that the Bucak population had the lowest biomass (lateral branches, stems, roots, total biomass) among all alder populations in perlite media. While the aboveground biomass of seedlings from the Fethiye population in perlite media

was the highest, the biomass of seedlings from the Anamur population was higher in belowground biomass. However, there was no statistical difference between the Fethiye and Anamur populations. It was observed that the Bucak population had the lowest biomass (lateral branches, stems, roots, total biomass, aboveground biomass) among all alder populations in soil media. However, no statistical difference was found between the populations in terms of lateral branches, stems, roots and total biomass. It was observed that the biomass of the seedlings belonging to the Fethiye population was the highest in the soil media (Figure 4).

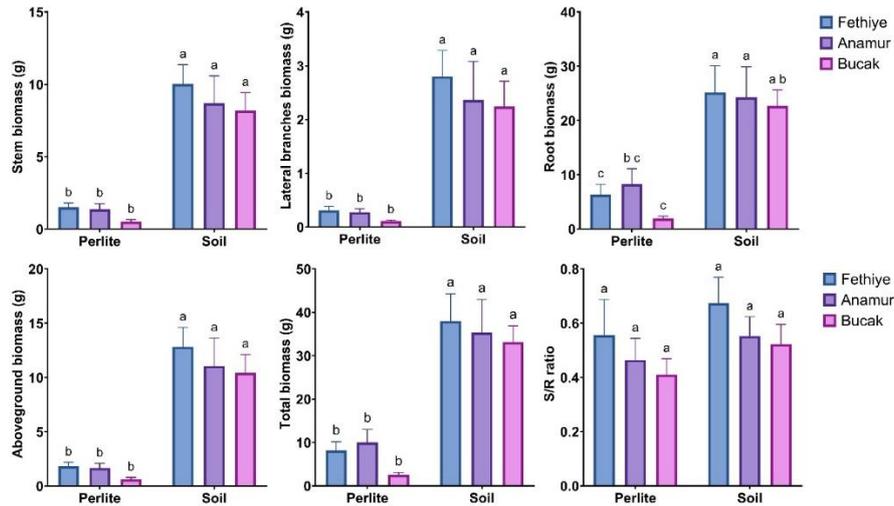


Figure 4. Tukey Post Hoc test results (\pm standard error) of average stem, lateral shoot, root and total biomass of different Turkish alder populations (Fethiye, Anamur and Bucak) in soil and perlite media. S/R ratio indicates the ratio of above-ground biomass to root biomass. The same letters in the graphs for each measurement parameter are not statistically different ($p < 0.05$)

The changes in SQ and DQI in perlite and soil media according to months are shown in Figure 5. In perlite media, it was observed that Fethiye was higher in terms of SQ in August, September and October. In soil media, Anamur was statistically higher than other populations in terms of SQ in October, November and December. When examined in terms of quality index, it was observed that the populations in both media formed the only group in which there was no statistical difference. In all months, the average SQ values of the populations in perlite and soil

media were similar to each other and there was no significant difference. While the lowest DQI value in perlite media was seen in Bucak population, the lowest DQI value in soil media was seen in Anamur population. However, the populations did not show statistical differences in terms of DQI based on media (Figure 5). The average DQI value of the populations in perlite media was quite lower than the DQI value in soil media (Figure 5). This showed that the growing media influenced DQI values.

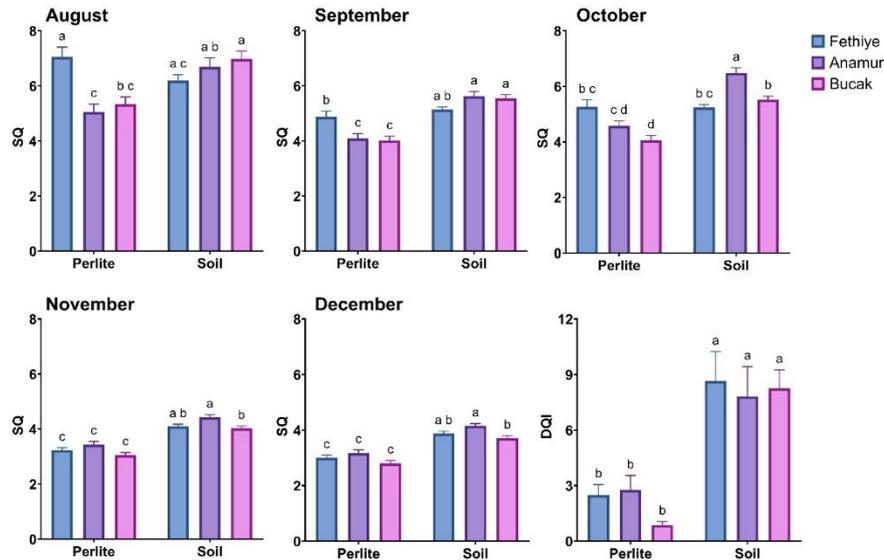


Figure 5. Tukey Post Hoc test results (\pm standard error) of sturdiness quotient (SQ) and Dickson quality index (DQI) values of different Turkish alder populations (Fethiye, Anamur and Bucak) in soil and perlite media at different times. $SQ = \text{Height}/\text{root collar diameter}$ ratio. Dickson quality index (DQI) = $[\text{seedling dry weight}/(\text{height}/\text{diameter} + \text{above ground dry weight}/\text{root dry weight})]$. The same letters in the graphs for each measurement + month are not statistically different ($p < 0.05$)

Discussion

A wide variety of growing media are used in container seedling cultivation. Growing media are generally prepared with soil, peat, perlite, vermiculite, rotted bark, sand, manure, wood shavings and their mixtures in certain proportions (Boydak & Çalışkan, 2021). Peat, which is not a sustainable source, is still predominantly used in forest nurseries. Therefore, experiments are being carried out on alternative container media. For example, coconuts are used as an alternative media to grow oak seedlings, but the deficiencies in coconut need to be compensated for by fertilization (Mariotti et al., 2020). The successful establishment of seedlings is closely associated with the morphological and physiological traits specific to the species (Wilson & Jacobs, 2006; Pinto et al., 2011; Dumroese et al., 2016). There is a strong relationship between the development of morpho-physiological traits and nursery practices (Haase & Davis, 2017; Pemán et al., 2017). In the context of potted seedling production, the efficacy of the growing medium constitutes a pivotal factor in determining the quality of the resulting seedlings. (Landis et al., 2014; Barrett et al., 2016). An ideal growing substrate should

ensure an optimal equilibrium between air-filled porosity and water-holding capacity, thereby promoting efficient root growth and facilitating effective nutrient uptake (Barrett et al., 2016). It has been determined that the best shoot-root development in European beech seedlings occurs in peat-perlite media where compaction of the growing media is low. Therefore, compaction of the medium also affects seedling development and quality (Pajak et al., 2022). Furthermore, the substrate should possess a high exchange capacity and be cost-effective to ensure practical applicability in large-scale cultivation (Tsakalidimi & Ganatsas, 2016). In this study, the population \times medium interaction on height ($p=0.000$) and diameter ($p=0.000$) in alder seedlings was found to be significant. On the other hand, the population \times month interaction did not show a significant effect on height ($p=0.360$) and diameter ($p=0.987$). The triple interaction environment \times population \times month was not found to be significant on height ($p=0.319$) but had a significant effect on diameter ($p=0.004$).

In this study, the height and diameter values in perlite and soil media were between 13-16 cm, 4-5 mm and 38-42 cm, 10-11 mm, respectively. The average height and diameter

values in 1+0-year-old European beech saplings grown in peat-perlite mixture were determined as 45 cm and 5 mm (Pajak et al., 2022). The height and diameter values of 1+0-year-old *Quercus robur* saplings grown in media consisting of peat and coconut fibers were determined as 46-58 cm and 10-12 mm, respectively. Again, in the same experiment, it was found that the height and diameter values in *Q. pubescens* saplings varied between 22-37 cm and 9-11 mm, respectively, and the height and diameter values in *Q. ilex* saplings varied between 35-53 cm and 8-9 mm, respectively. It was observed that oak saplings grown in peat medium were taller than those grown in coconut fibers (Mariotti et al., 2020). In addition, Mariotti et al. (2020) showed that the size and nutrient content of the seed rather than the quality of the growing media are effective in the first growth phase of different oak seeds.

The height and diameter values of 2+0-year-old black pine seedlings grown in a substrate mixture consisting of 50% peat and 50% moistened bark and beech and fir sawdust were determined as 9-10 cm and 3-4 mm, respectively (Ivetic & Skoric, 2013). From this, it is seen that the height and diameter values of different species of seedlings differ in different potting mixes. In addition, in this study, the Bucak population made the lowest height increase in all months in perlite media, while the Bucak population made the highest height increase in soil media in August, September and October. This situation revealed the importance of testing different growing media in revealing intraspecific variation. It is interesting that biofertilizer applications are partially effective on seedling height and root collar diameter and that such applications should be investigated in different species (Parlak et al., 2018).

In this study, it was observed that the biomass amounts in organs other than roots of alder populations did not differ statistically in perlite and soil media. In general, it was observed that alder seedlings grown in soil media had more above and below ground biomass than those grown in perlite media. The reason for this can be said to be related to the amount of organic matter in the media. In addition, when forest soil was added to the growing media, it was observed that the root/stem ratios of Douglas fir saplings

increased due to the mycorrhiza effect (Kazantseva et al., 2009). Significant differences were observed in stem, fine root, and total biomass across the mixtures, with varying ratios of individual components (leaves, stem, and fine roots) to total biomass (Çakıroğlu, 2024). The fact that the mycorrhiza effect in forest soil was not revealed is one of the limitations of this study. In 1+0-year-old European beech saplings grown in peat-perlite mixture, above ground biomass (stem+shoot) and root dry weights were determined as 2.26 g and 1.13 g, respectively (Pajak et al., 2022).

In this study, it was determined that the belowground biomass of alder seedlings in perlite media was approximately four times the aboveground biomass, while the belowground biomass of alder seedlings grown in soil media was approximately twice the aboveground biomass. In a study examining the effects of different growth environments on the growth of alder seedlings, it was determined that the seedling height, diameter, number of lateral branches, root and stem dry weight values were the highest in the soil+farm manure+sand mixed media (Kösa & Karagüzel, 2012). Alternatively, fertilization applied during cultivation may modify the seedlings' physiological and morphological attributes, potentially interacting with the substrate's chemical properties. Such effects can influence various attributes, including biomass accumulation in both shoots and roots (Poorter et al., 2012), leaf morphological and physiological traits (Domínguez et al., 2012; Pemán et al., 2017), root system architecture and functionality (Pemán et al., 2017), as well as seedling survival and performance under field conditions (Grossnickle, 2012; Cortina et al., 2013; Grossnickle & MacDonald, 2018). Hence, modifying fertilization regimes and the growing environment may provide a means to enhance seedling quality (Ovalle et al., 2016) and improve the performance of transplanted seedlings (Oliet et al., 2011). Mixtures containing vermicompost have improved the overall growth parameters, biomass production, and root development of maritime pine seedlings, and resulted in significant changes in nitrogen and carbon values (Sariyeva, 2025).

Seedlings with a low shoot/root (S/R ratio) ratio have reduced mortality rates in arid environments (Franco et al., 2006; Mañas et al., 2009). According to Mañas et al. (2009), an elevated shoot dry weight (high photosynthetic reserve content) contributes to improved seedling vitality and a higher survival rate post-planting. A thicker stem will contribute to increased resistance to transplanting shock since it will form a larger root system (Grossnickle & MacDonald, 2018). S/R ratio is an important index since it is related to seedling survival (Franco et al., 2006). A poorly developed root system fails to supply adequate water to the aerial parts, thereby limiting the plant's capacity to sustain vigorous growth (Johkan et al., 2010). In this study, the lowest S/R ratio was observed in Bucak population seedlings in both growing environments.

This study reveals that differences in growing media do not have a significant effect on S/R ratio. Therefore, it should be noted that direct comparison of S/R ratios of seedlings grown in different media may not be appropriate in evaluating alder seedling quality. It is expected that quality seedlings will show high growth performance and survival rate after planting. Seedling quality affects seedling vitality, growth and survival after planting. In addition, seedling quality is largely affected by cultivation techniques and environmental conditions. Considering the effect of seedling quality on survival, growth and productivity of trees, this quality should be determined before planting. No significant difference was observed between the average sturdiness quotient (SQ) values of the populations in perlite and soil media in all monthly periods, and it was concluded that these two environments did not have a statistically significant effect on SQ. While the lowest Dickson quality index (DQI) value was recorded in Bucak population in perlite media, this value was at the lowest level in Anamur population in soil environment. However, when the DQI values of the populations in each media were compared, no statistically significant difference was detected. On the other hand, the average DQI values of the populations in perlite media were found to be significantly lower compared to soil media. This result reveals that the cultivation media plays an effective role on DQI. In addition, this study

emphasizes that the SQ values of seedlings in the same growing environment should be analyzed comparatively, and the DQI should also be determined in this process.

SQ<5 is considered as good seedling, 5<SQ<6 is considered as medium seedling and SQ>6 is considered as weak seedling (Yahyaoğlu & Genç, 2007). A low sturdiness quotient (SQ) reflects a more resilient plant morphology, enhancing its likelihood of survival, particularly under windy or arid environmental conditions (Boydak & Çalışkan, 2021). Manas et al. (2009) determined the SQ value between 4.6-6.0 in maritime pine seedlings in different growing media and found that different environments had no significant effect on SQ. In this study, the average SQ values of the seedlings were determined as 3 and 4 (December values) in perlite and soil media, respectively. It was observed that the SQ value changed statistically in different applications (root cutting, fertilization and thinning) applied to *Fagus orientalis* seedlings (2+0) (Güney et al., 2020).

The DQI is widely accepted as a measure that defines the potential strength of seedlings for growth and survival percentage (field performance). It is generally accepted that a higher value is better (Mañas et al., 2009). Eyüboğlu (1979), suggested that the SQI value is an effective measure in evaluating the physiological status of the plant and that this ratio should be a maximum of 3 to ensure the success of plant cultivation in extreme climatic conditions and arid areas. In this study, the average DQI values were determined as 2 and 8 in perlite and soil media, respectively. Zengin et al. (2024) found the DQI value of Anatolian chestnut seedlings (1+0) between 0.8 and 2.2 in different growing media. It was observed that the influence of seed size on seedling quality in Eastern Black Sea oak became more pronounced as seedling size increased (Aksu & Tilki, 2016). These findings suggest that soil media significantly enhances seedling quality, and DQI can serve as a reliable indicator for selecting suitable growing conditions, especially for afforestation efforts in challenging environments.

Conclusions

This study examined the effects of perlite and soil media on the growth of *Alnus*

orientalis seedlings from Fethiye, Anamur, and Bucak populations. Seedlings grown in perlite exhibited lower height, diameter, and biomass compared to those in soil media. Since perlite media alone produces low biomass due to lack of organic matter and leads to production loss in unit areas, it is recommended that it should not be used alone but added to the media mixture.

The Anamur population showed the highest growth rates, while Fethiye exhibited the greatest biomass, especially in soil. Perlite media resulted in a higher root-to-shoot biomass ratio, but soil media promoted better seedling quality (DQI). Further testing of various growing media is recommended to better understand intra-specific variation. Additionally, research on propagation techniques and conservation strategies is crucial for ensuring the species' long-term survival and seed production.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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