PAPER DETAILS

TITLE: Effects of altitude on some seedling quality characteristics of Carpinus betulus L. (Common Hornbeam) and Carpinus orientalis Mill. (Oriental Hornbeam)

AUTHORS: Fahrettin ATAR

PAGES: 257-265

ORIGINAL PDF URL: http://ofd.artvin.edu.tr/tr/download/article-file/1830502

Artvin Çoruh Üniversitesi Orman Fakültesi Dergisi ISSN:2146-1880, e-ISSN: 2146-698X Yıl: 2021, Cilt: 22, Sayı:2, Sayfa: 257-265



Artvin Coruh University Journal of Forestry Faculty ISSN:2146-1880, e-ISSN: 2146-698X Year: 2021, Vol: 22, Issue:2, Pages: 257-265

Effects of altitude on some seedling quality characteristics of Carpinus betulus L. (Common Hornbeam) and Carpinus orientalis Mill. (Oriental Hornbeam)

Carpinus betulus L. (Adi Gürgen) ve Carpinus orientalis Mill. (Doğu Gürgeni) fidanlarının bazı kalite özellikleri üzerine yükseltinin etkisi

Fahrettin ATAR

Karadeniz Teknik Üniversitesi, Orman Fakültesi, Orman Mühendisliği Bölümü, Trabzon

Eser Bilgisi / Article Info Araştırma makalesi / Research article DOI: 10.17474/artvinofd.954066

Sorumlu yazar / Corresponding author Fahrettin ATAR e-mail: fatar@ktu.edu.tr Geliş tarihi / Received 17.06.2021 Düzeltme tarihi / Received in revised form 10.08.2021 Kabul Tarihi / Accepted 13.09.2021 Elektronik erişim / Online available 18.11.2021 **Keywords:** Carpinus betulus Carpinus orientalis Variation Morphology Sturdiness quotient Anahtar kelimeler: Carpinus betulus Carpinus orientalis Varyasyon Morfoloji

Gürbüzlük indisi

Abstract

This study aims to determine some morphological characteristics of two-year-old common hornbeam (Carpinus betulus L.) and oriental hornbeam (Carpinus orientalis Mill.) seedling and to determine the quality classes of the seedlings according to Turkish Standards Institute's (TSI) seedling quality standards and sturdiness quotient values. As a study material, two-year-old common hornbeam and oriental hornbeam seedlings, grown from seed obtained from three different altitudes as lower (0-400 m), mid (400-800 m) and upper (800-1200 m) in the Trabzon-Maçka watershed were used. The seedlings were grown in seedbeds in open nursery conditions of Karadeniz Technical University Forestry Faculty Research and Application Greenhouse. Seedling length and root collar diameter were measured in two-year-old seedlings. The sturdiness quotient was calculated with the data of the measured seedling morphological characteristics. Quality classes were classified according to TSI seedling quality standards determined for hornbeam seedlings. The highest mean seedling length for common hornbeam was determined as 48.76 cm at the 3rd altitude level, while the highest mean seedling length for oriental hornbeam was found as 38.90 cm at the 2nd altitude level. The mean root collar diameters for were varied between 4.97-5.23 mm in common hornbeam and 4.62-5.09 mm in oriental hornbeam. As a result of variance analysis, statistically significant differences (p<0.05) among altitudes regarding seedling length and sturdiness quotient of common hornbeam. As for the oriental hornbeam, it was found that statistically significant differences on 95% confidence level in terms of seedling length and root collar diameter. In addition, significant differences between the two seedling quality assessments and consistent results were not obtained. This shows that both TSI seedling quality standards and the sturdiness quotient criteria are not sufficient by themselves to determine the quality of common hornbeam and oriental hornbeam.

Özet

Çalışmada iki yaşındaki adi gürgen (Carpinus betulus L.) ve doğu gürgeni (Carpinus orientalis Mil fidanlarının bazı morfolojik özelliklerinin belirlenmesi ve fidanların TSE fidan kalite standartları v gürbüzlük indisi değerlerine göre kalite sınıflarının tespit edilmesi amaçlamaktadır. Çalışma materya olarak, Trabzon-Maçka havzasının üç farklı yükseltisinden (0-400 m, 400-800 m, 800-1200 m) toplana tohumlardan yetiştirilmiş 2+0 yaşındaki Adi gürgen ve doğu gürgeni fidanları kullanılmıştır. Fidanla Karadeniz Teknik Üniversitesi Orman Fakültesi Araştırma ve Uygulama Serası açık alan fidanl koşullarında yetiştirilmiştir. İki yaşındaki fidanlarda fidan boyu ve kök boğaz çapı değerleri ölçülmüştü Ölçümü yapılan fidan morfolojik karakterine ait veriler ile gürbüzlük indisi değeri hesaplanmıştır. Ayrıc gürgen fidanı için belirlenmiş Türk Standartları Enstitüsü (TSE) fidan kalite standartlarına göre kalit sınıfları tasnifi yapılmıştır. Çalışma sonucunda, yükseltiler arasında en yüksek ortalama fidan boyu a gürgende 48.76 cm ile 3. yükseltide, doğu gürgeninde 38.90 cm ile 2. yükseltide elde edilmişti Ortalama KBÇ değerleri adi gürgende 4.97-5.23 mm, doğu gürgeninde 4.62-5.09 mm arasınd değişmektedir. Varyans analizi sonucunda, yükseltiler arasında fidan boyu ve gürbüzlük indisi açısında %95 güven düzeyinde istatistiksel olarak anlamlı farklılıklar (p<0.05) tespit edilmiştir. Doğu gürgeninc ise fidan boyu ve kök boğazı çapı bakımından %95 güven düzeyinde istatistiksel olarak anlamlı farklılıkla olduğu belirlenmiştir. Ayrıca, her iki fidan kalite değerlendirmesi arasında önemli farklılıklar meydar gelmiş ve tutarlı sonuçlar elde edilmemiştir. Buda gerek TSE fidan kalite standartlarının gereks gürbüzlük indisi kriterlerinin adi gürgen ve doğu gürgeninin fidan kalitesini belirlemede tek başlarır yeterli olamadığını göstermektedir.

1. INTRODUCTION

Turkey carries out important activities such as to increase the forest areas and sustainability from the past to present. While the forest area of Turkey was 20.199.296 ha in 1973, it reached 22.342.935 ha in 2015 and covers 28.6% of the country's surface area. However, 57% of these forests are productive and 43% are degraded. Rehabilitating degraded forest areas into productive is extremely important for the continuity of various functional benefits provided by forest ecosystems (Anonymous 2015). Forestation works with natural deciduous broadleaf species have become importance both in Europe and in Turkey (Kahveci and Tüfekçioğlu 1998, Huss and Kahveci 2009).

Since deciduous broadleaf forests provide multiple-use forest functions, protect biodiversity and serve recreational purposes, it is recommended to increase these areas (Löf et al. 2004). On the other hand, it is expected that the log prices of deciduous broadleaf forest trees will increase in the coming years (Abildtrup et al. 1997, Löf et al. 2004) and it is predicted that their growth rate will increase as the deciduous broadleaf forest trees will perform more photosynthesis as a result of global climate change (Sykes and Prentice 1996, Löf et al. 2004).

Biological and economical success of forestations, as well as the habitat conditions, it depends on the land preparation, appropriate planting technique, planting time and the use of quality seedling (Ayan 2002, Gezer and Yücedağ 2006). The quality seedlings are defined as those that meet the desired level of growth and survival after planting (Duryea 1985, Mattsson 1997). Johnson and Cline (1991) defined high quality seedlings as those that have the physical and physiological attributes that enhance their survival and produce vigorous growth after field establishment. The morphological characteristics of seedling such as length, diameter, dry weight and stemroot ratios are significantly effective in the quality of seedling planted in forestation areas (Sevik et al. 2003). Planting success can be increased by using quality seedling in forestation works, and more quantity and quality wood raw materials can be produced in a shorter time from unit areas (Bilgin 2019).

Morphological traits are the most commonly measured in seedling quality assessment as they are cheap and easy to measure (Ritchie 1984, Mexal and Landis 1990, Yahyaoğlu and Genç 2007). Unlike physiological traits, advanced equipment and advanced training are not needed to evaluate morphological traits. Among the morphological traits, seedling length and root collar diameter are the easiest to measure (Haase 2008). There are various studies in which morphological parameters are used to determine the quality of seedling of many species (Yılmaz 1995, Donahue and Upton 1996, Üçler et al. 2000, Apholo and Rikala 2003, Jacobs et al. 2005, South et al. 2005, Ayan and Tilki 2007, Manas et al. 2009, Yer and Ayan 2011, Çiçek et al. 2011, Aksu and Tilki 2015, Ivetić et al. 2016, Bilgin 2019, Ayan et al. 2020). However, there are a limited number of studies in the literature on seedling characteristics of common hornbeam and oriental hornbeam, them of our important tree species and having a wide distribution in Turkey.

The genus Carpinus includes 35-60 species with tree or shrub forms and is widely distributed in the temperate regions of the northern hemisphere (Hora 1981, Krüssman 1984). Carpinus orientalis Mill. and Carpinus betulus L. species spreads naturally in Turkey. Carpinus orientalis has a wide natural distribution area from southeast of Europe to the north of Iran (Babrov 1970). In Turkey, it spreads in North Anatolia, Eastern Anatolia, Aegean and Marmara Regions. (Yaltırık 1982, Demirci 2006). Carpinus betulus distrubuted in the Black Sea region. It also spreads locally in the Amanos Mountains (Yaltırık 1982, Anşin and Özkan 2006). Oriental hornbeam has a high drought tolerance and usually grows in dry, shallow and stony soils. Thick bark structure that reduces mortality is characteristic for this species (Shafiei et al. 2010). Due to its resistance to drought stress, it is a suitable species for rehabilitation of degraded areas (Pipinis et al. 2012). Common hornbeam is a shade tolerant species that grows best in forests with deep rich and moist soils. However, it also develops in dry and shallow soils (Browicz 1982). Oriental hornbeam wood is used extensively for local needs, in the production of tourist ornaments and as firewood (Anşin and Özkan

2006). The common hornbeam tree form, leaf color and decorative fruits have the potential to be used as an ornamental plant (Dirr 1998). It is used as sled and timber in the lathe industry, in the construction of vehicle bodies, shipbuilding and wood fuel (Anşin and Özkan 2006).

The research aims to determine some morphological characteristics of two-year-old common hornbeam and oriental hornbeam seedlings which grown from seeds obtained from different altitudes and to decide the quality classes of the seedling according to the Turkish Standards Institute seedling standards and sturdiness quotient.

2. MATERIAL AND METHOD

2.1. Material

As a study material, two-year-old common hornbeam and oriental hornbeam seedlings, grown from seeds obtained from three different altitudes (0-400 m, 400-800 m, 800-1200 m) of the Trabzon-Maçka watershed were used (Figure 1). Seeds were collected during the optimum seed maturation period in early October. Seeds were harvested from a total of 90 trees (3 altitude levels × 15 trees × 2 species). The harvested seeds were labeled according to the altitude levels they were collected from by putting them separately into bags. Afterwards, they were separated from the pericarps by hand and empty and rotten seeds were removed. Filled seeds were identified through floatation in 96% alcohol. Seeds were sown using line sowing method (75 seeds in each sowing line), by a randomised sampling design, in nursery seedbeds (using 10.0 cm sowing line spacing across 1.0 m wide seedbeds) in October. All nursery operations were performed as uniformity as possible (i.e. irrigation, shading, weed control, maintenance, etc.). The seedlings were grown in seedbeds in open nursery conditions of Karadeniz Technical University Forestry Faculty Research and Application Greenhouse. According to the climate data between 1927-2019 in the province of Trabzon where the nursery is located, the annual average temperature is 14.7 and the total annual precipitation is 829.6 mm (Table 1).



Figure 1. The geographical locations of the altitudes where seeds were collected

	Climate Period (1927-2019)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	7.4	7.2	8.3	11.7	15.8	20.1	22.9	23.3	20.3	16.6	12.9	9.5
2	10.7	10.7	11.9	15.5	19.1	23.1	25.9	26.5	23.7	20.0	16.5	12.9
3	4.6	4.3	5.4	8.6	12.9	17.0	19.9	20.3	17.3	13.6	10.0	6.7
4	2.6	3.2	3.4	4.3	5.5	7.0	5.9	5.6	4.9	4.5	3.6	2.6
5	11.8	11.7	12.6	12.4	12.3	10.3	7.6	8.3	10.4	11.8	11.3	12.0
6	82.9	64.6	58.4	56.9	52.1	51.8	35.6	48.0	78.6	115.4	99.6	85.7

1. Avg. Temperature (°C); 2. Avg. Highest Temperature (°C); 3. Avg. Lowest Temperature (°C); 4. Avg. Sunshine Time (hour); 5. Avg. Number of Rainy Days; 6. Monthly Total Precipitation Avg. (mm)

2.2. Method

In the study, morphological characteristics were measured on a total of 900 seedlings (2 species × 3 altitudes × 3 replications × 50 seedlings). Seedling length and root collar diameter were measured in two-year-old seedlings. The sturdiness quotient was calculated with the data of the measured seedling morphological characteristics.

Seedling Length (SdL): It is the length value from root collar to the top of the terminal shoot. It was measured by use a meter with precision of ± 0.1 cm.

Root Collar Diameter (RCD): It is the value measured just above the uppermost root on the seedling stem. It was measured by use a digital caliper with precision of \pm 0.01 mm.

Sturdiness quotient (SQ): The sturdiness quotient refers to the ratio of the height of the seedling to the root collar diameter and expresses the vigour and robustness of the seedling (Thompson 1985, Aldhous 1994, Jaenicke 1999).

$$SQ=SdL(mm)/RCD(mm)$$
 (1)

The seedling were classified as quality seedling (SQ<50), medium quality seedling (50<SQ<60) and low quality seedling (SQ>60) by using the SQ values (Yahyaoğlu and Genç 2007). In addition, seedlings were classified according to Turkish Standards Institute's (TSI) deciduous seedling standards (TS 5624/21.03.1988) (Anonymous 1988). TSI quality standards of hornbeam seedlings are given in Table 2.

Table 2. Quality classes of hornbeam according to Turkish Standards

 Institute

Classes	Classes Minimum length		Minimum RCD according to seedling							
			lengths (mm)							
	(cm)	20	30	40	50	75	100			
I	30	-	4	5	6	7	8			
Ш	20	3	3	4	5	6	7			

The coefficient of variation of seedling morphological characters were also evaluated depending on the altitude. The coefficient of variaton (CV) was calculated as follows:

$$CV\% = \left(\frac{\sigma}{\mu}\right) \times 100$$
(2)

where σ is standard deviation, μ is the overall mean (Bland and Altman 1996).

The data were analysed by SPSS 23.0 statistical package program. In the study, analysis of variance (one-way ANOVA) was performed to reveal the statistical significance of the differences in the morphological characteristics of the seedling depending on the different altitudes. In case of significant differences as a result of variance analysis, groups were determined by Duncan test.

3. RESULTS AND DISCUSSION

Morphological characteristics of common hornbeam and oriental hornbeam seedlings are shown in Table 3. In the common hornbeam, the seedling length was between 6.00 to 132.00 cm with a mean value of 44.03 cm. The value of root collar diameter ranged from 0.95 to 14.05 mm, the mean of seedling length was 5.13 mm. Sturdiness quotient was from 29.52 to 178.95, the mean of sturdiness quotient was 86.40. In the oriental hornbeam, the value of seedling length was from 6.00 to 105.00 cm, the mean value was 36.48 cm. The root collar diameter were between 0.90 to 13.20 mm with a mean value of 4.78 mm. The sturdiness quotient in all altitudes ranged from 17.98 to 266.67, with a mean value of 78.30. The values of the measured morphological characteristics varied in both species depending on the increase in altitude. The seedlings belonging to the 1st altitude level had the lowest seedling length (41.43 cm and 34.77 cm for Carpinus betulus and Carpinus orientalis, respectively) in both species. The highest seedling length was obtained at the 3rd altitude level with 48.76 cm in common hornbeam and at the 2nd altitude level with 38.90 cm in the oriental hornbeam. It was determined that the sturdiness quotient of common hornbeam increase depending on the increase in altitude.

The changing of coefficients of variation of the measured morphological characteristics depending on the altitude was determined. The CV of most of seedling morphological characteristics was high in the 3rd altitude level (Figure 2).

			C. betulus			C. Orientalis	
		1st Altitude	2nd Altitude	3rd Altitude	1st Altitude	2nd Altitude	3rd Altitude
		(0-400 m)	(400-800 m)	(800-1200 m)	(0-400 m)	(400-800 m)	(800-1200 m)
SdL	Mean	41.43	41.90	48.76	34.77	38.90	35.76
	Std. dev.	19.95	20.20	25.50	18.20	17.82	19.06
	Std. error	1.72	2.25	2.56	1.48	1.03	1.57
	Min	12.00	6.00	6.00	7.00	6.00	8.00
	Max	100.00	106.00	132.00	100.00	105.00	102.00
RCD	Mean	5.23	4.97	5.20	4.62	5.09	4.63
	Std. dev.	1.96	2.26	2.51	1.97	1.96	1.91
	Std. error	0.16	0.25	0.26	0.16	0.11	0.15
	Min	1.41	0.95	1.37	0.90	0.96	1.14
	Max	14.05	11.35	13.00	9.96	13.20	11.28
SQ	Mean	79.96	85.02	94.23	77.94	79.02	77.94
	Std. dev.	23.46	20.21	26.50	30.37	27.99	30.12
	Std. error	2.02	2.26	2.66	2.48	1.61	2.48
	Min	34.00	29.52	41.96	26.77	30.36	17.98
	Max	178.95	133.90	169.88	233.96	266.67	260.09

Table 3. Statistical data regarding the morphological characteristics of the seedlings



Figure 2. The CV of seedling morphological characteristics

As a result of variance analysis, it was determined that statistically significant differences on 95% confidence level (p<0.05) among altitudes regarding seedling length and sturdiness quotient of common hornbeam. As for the oriental hornbeam, it was found that statistically significant differences on 95% confidence level in terms of seedling length and root collar diameter (Table 4). Groups formed by the altitudes for each morphological characteristics were determined by Duncan's test. Accordingly, among the altitudes, there were 2 groups for seedling length and sturdiness quotient in common hornbeam. 3 groups for the seedling length and 2 groups for the root collar diameter occurred in the oriental hornbeam (Figure 3).

Table 4. The results of variance analysis regarding the morphological characteristics

	C. be	tulus	C. Orientalis		
	F	Р	F	Р	
SdL	3.615	0.028	3.075	0.047	
RCD	0.374	0.688	4.137	0.016	
SQ	10.746	0.000	0.102	0.903	



Figure 3. The result of Duncan test regarding the morphological characteristics

When the relationships between the measured seedling characteristics were examined, it was found strong positive correlations between the seedling length and root collar diameter of both species. The correlation coefficient between seedling length and root collar diameter in common hornbeam and oriental hornbeam were determined as $R^2 = 0.69$ and $R^2 = 0.51$, respectively (Figure 4).



Figure 4. The relationship between RCD-SdL in common hornbeam and oriental hornbeam seedlings

TSI standards suitability of the seedlings was evaluated according to the seedling length and root collar diameter criteria. It was determined that 72.7% of the common hornbeam is in the 1st quality class, 18.0% is in the 2nd and 9.3% of the seedlings are discarded. It was found that 58.4% of the oriental hornbeam is in the 1st quality class, 28.0% is in the 2nd quality class, and 13.6% of the

seedlings are discarded. According to the sturdiness quotient, 87.6% of common hornbeam seedling and 72.1% of oriental hornbeam seedlings were in the low quality seedling class (Table 5). Also, depending on the altitude, it was determined that the quality classes of the seedlings belonging to the 1st altitude for both species had the lowest value.

		Quality classes of TSI (%)				SQ (%)			
		I	Ш	Non-standard		Quality	Medium Quality	Low Quality	
	1st Altitude	68.7	23.9	7.5		6.0	13.4	80.6	
C. betulus	2nd Altitude	73.8	13.8	12.5		3.8	5.0	91.3	
	3rd Altitude	75.8	16.2	8.1		3.0	6.1	90.9	
	Mean	72.7	18.0	9.3		4.2	8.2	87.6	
	1st Altitude	53.3	29.3	17.4		14.0	16.7	69.3	
C. orientalis	2nd Altitude	66.6	26.4	7.0		11.7	13.4	74.9	
	3rd Altitude	55.8	28.6	16.6		10.2	17.7	72.1	
	Mean	58.4	28.0	13.6		12.0	15.9	72.1	

 Table 5. Quality classification according to TSI standards and sturdiness quotient for species

In the first studies of seedling quality classification were used seedling length as the criterion (Yahyaoğlu and Genç 2007). Depending on the habitat conditions of the forestation area, it is reported that more successful results are obtained after planting sometimes high length, sometimes low length and even rarely mediumlength seedlings. For this reason, the most suitable seedling length depends significantly on the ecological conditions prevailing in the forestation area. In a study conducted by Semerci (2002), while a positive correlation was found between seedling length and survival success, some researchers stated that there was a negative correlation between these two parameters (Larsen et al. 1986, Tuttle et al. 1987, Dirik 1991). Also, it is notified that the root collar diameter is a more important criterion in the seedling quality classification than the seedling length (Şimşek 1987, Yahyaoğlu and Genç 2007). Cleary and Greaves (1979) reported that the root collar diameter is an important parameter that indicates the strength of the seedling. Within the scope of the study, the highest mean seedling length for common hornbeam was determined as 48.76 cm at the 3rd altitude, while the highest mean seedling length for oriental hornbeam was found as 38.90 cm at the 2nd altitude. The mean seedling lengths were determined as 44.03 cm in common hornbeam and as 36.48 cm in oriental hornbeam. The mean root collar diameters were varied between 4.97-5.23 mm in common hornbeam and 4.62-5.09 mm in oriental hornbeam. Ayan et al. (2020) was determined that the average height of 3+0 year-old common hornbeam seedling was 70.8 cm and the average RCD was 6.70 mm. In a study conducted on the oriental beech, it was found significantly differences seedling length and root collar diameter in terms of populations (Gülseven et al. 2019). In a study investigating the four-year growth performance of common hornbeam seedlings by Atar et al. (2018), they stated that there were significant differences in seedling heights and root collar diameters according to populations. Similar results were found by Atar and Turna (2018) on *Castanea sativa*, by Hatipoğlu (2013) on *Carpinus orientalis*, by Yahyaoğlu et al. (2012) on the *Pinus pinea* and by Güney (2009) on the *Fagus orientalis*. Aksu and Tilki (2015) reported that the origin and seed size were effective on the morphological characteristics of the *Quercus pontica* seedling.

Genç (1992) stated that another criterion used as seedling quality classification is the sturdiness quotient, the lower the SQ value is a desired feature in terms of the quality of the seedling and the planting success is higher. According to Aphola and Rikala (2003), all origins of the seedling with a SQ<50 are evaluated in the quality seedling class. Gülseven et al. (2019) stated to the SQ value of all the studied populations was less than 50 in on seedling belonging to different oriental beech populations. In the study conducted on one-year-old oak seedlings was notified that the highest SQ value was obtained in control seedling grown routinely as 39.6% and the lowest SQ value was obtained in containerized seedlings as 28.7% (Kestek 2012). In another study, it was stated that the SQ values of Quercus brantii Lindley differ according to the planting spacing and the values varied between 43 and 53 (Çanakçı 2011). In a research conducted by Bilgin (2019), the SQ values were found as 39.11 for Pinus pinea seedling, 36.84 for Quercus ithaburensis seedling, and 23.79 for Quercus cerris seedlings. In other study investigating the morphological characteristics of some deciduous broadleaf forest tree seedling, it was reported that 100% of mountain maple, 93.3% of oriental beech and 97.8% of common hornbeam according to SQ values

were in the category of low-quality seedling (Ayan et al. 2020).

According to the sturdiness quotient in this study, only 11.5% of common hornbeam seedlings are in the quality and medium quality class, and 88.6% of them are in the low quality class that is not suitable for use. 83.4% of common hornbeam seedlings were in 1st class, 6.3% of them were in 2nd class in terms of TSI standards, and only 10.3% of the seedlings were considered as substandard seedling. For oriental hornbeam seedlings, it was determined that 72.8% of the seedlings were in low quality according to the sturdiness quotient, but 88.7% of them were in the 1st and 2nd classes according to TSI standards. It was occurred significant differences between the two seedling quality assessments and consistent results were not obtained. This shows that both TSI seedling quality standards and the sturdiness quotient criteria are not sufficient to determine the seedling quality of common hornbeam and oriental hornbeam.

REFERENCES

- Abildtrup J, Riis J, Jellesmark TB (1997) The reservation price approach and internationally efficient markets. J. For. Econ. 3:229-246
- Aksu Y, Tilki F (2015) Orijin ve tohum büyüklüğünün Quercus pontica fidanlarının yaşama yüzdesi ve morfolojik özellikleri üzerine etkisi. Artvin Çoruh Üniversitesi Orman Fakültesi Dergisi 16(2):216-226.
- Aldhous JR (1994) Nursery policy and planning. Forest Nursery Pratice. In JR Aldhous and WL Mason (Eds.), Forestry Commission Bulletin, London, U.K. 111 pp 1-12

Anonymous (1988) TSE Yapraklı orman ağacı fidanları. TS 5624, Ankara

- Anonymous (2015) Türkiye Orman Varlığı Kitabı. Orman ve Su İşleri Bakanlığı, Orman Genel Müdürlüğü, Geçmişten Bugüne Ulusal Orman Alanlarımızın Durumu, Yayınlar, Ankara
- Anşin R, Özkan ZC (2006) Tohumlu Bitkiler (Spermatophytha) Odunsu Taksonlar. KTÜ Orman Fakültesi, Genel Yayın No: 167, Fakülte Yayın No: 19, Trabzon
- Apholo P, Rikala R (2003) Field performance of silver-birch plantingstock grown at different spacing and in containers of different volume. New Forests 25:93-108
- Atar F, Turna İ (2018) Fruit and seedling diversity among sweet chestnut (Castanea sativa Mill.) populations in Turkey. Šumarski list 142(11-12):611-619
- Atar F, Atar E, Bayraktar A, Turna İ (2018) Growth performance in seedlings of common hornbeam (Carpinus betulus L.) in nursery conditions. International Congress on Engineering and Life Sciences, 26 - 29 Nisan, Kastamonu
- Ayan S, Tilki F (2007) Morphological attributes of oriental spruce (Picea orientalis (L.) Link.) seedlings grown in peat-based media amended with natural zeolite. Acta Agronomica Hungarica 55:363-373

- Ayan S (2002) Tüplü doğu ladini (Picea orientalis (L.) Link.) fidanı büyüme ortamları özellikleri ve üretim tekniğinin belirlenmesi. Doğu Karadeniz Ormancılık Araştırma Enstitüsü, 11, 72 s, Trabzon
- Ayan S, Gedik F, Yer Çelik EN, Gülseven O, Yılmaz E, Akın Ş, Özel H (2020) Bazı geniş yapraklı orman ağacı fidanlarının morfolojik özellikleri. Bartın Orman Fakültesi Dergisi 22(1):245-255
- Bilgin S (2019) Fıstıkçamı (Pinus pinea L.), palamut meşesi (Quercus ithaburensis Decne. subsp. macrolepis (Kotschy) Hedge and Yalt.) ve saçlı meşe (Quercus cerris L.) fidanlarının fidan kalite özelliklerinin belirlenmesi. Türkiye Ormancılık Dergisi 20(4): 297-304
- Bland JM, Altman DG (1996) Statistics notes: measurement error proportional to the mean, British Medical Journal 313, 106.
- Bobrov EG (1970) Carpinus L., In Flora of the U.S.S.R., Keter Press, Jerusalem, Israel, ed. N. Landau, 5, 202-207
- Browicz G (1982) Chronology of Trees and Shrubs in South-west Asia and Adjacent Regions. Polish Scientific Publishers, Warszawa-Poland, pp 172
- Çanakçı ZE (2011) İran palamut meşesinde ekim sıklığı ve derinliğinin bazı morfolojik fidan özellikleri üzerine etkisi. Artvin Çoruh Üniversitesi Fen Bilimleri Enstitüsü Yüksek Lisans Tezi, Artvin, 45 s
- Çiçek E, Çiçek N, Tilki F, (2011) Four-year field performance of Fraxinus angustifolia Vahl. and Ulmus laevis Pall. seedlings grown at different nursery seedbed densities. Res J For 5:89-98
- Cleary BD, Zaerr JB (1984) Guidelines for measuring plant moisture stress with a pressure chamber. PMS Instrument Co., 2750 N. W. Royal Oaks Drive, Corvallis, Oregon 97330, 15, USA
- Demirci A (2006) Silvikültürün Temel İlkeleri, KTÜ Orman Fakültesi, Ders Notları Serisi No: 83, Trabzon
- Dirik H (1991) Kızılçam (Pinus brutia Ten.)'da bazı önemli fidan karakteristikleri ile dikim başarısı arasındaki ilişkiler. İstanbul Üniversitesi Fen Bilimleri Enstitüsü Doktora Tezi, İstanbul, 116 s
- Dirr MA (1998) Manual of woody landscape plants; their identification, ornamental characteristics, culture, propagation and uses, 5 th Ed., Stipes Publishing L.L.C., Champaign, Illinois, U.S.A., pp 1187
- Donahue JK, Upton JL (1996) Geographic variation in leaf, cone and seed morphology of Pinus greggii in navite forests. Forest Ecology and Management 82(1-3):145-157
- Duryea ML (1985) Evaluating seedling quality: importance to reforestation. In: Proceedings of a workshop: Evaluating seedling quality: principles, procedures, and predictive abilities of major tests. Workshop held October 16–18, 1984. Corvallis: Forest Research Laboratory, Oregon State University. ISBN 0-87437-000-0
- Genç M (1992) Doğu Ladini (Picea orientalis (L.) Link.) fidanlarına ait bazı morfolojik ve fizyolojik özelliklerle dikim başarısı arasındaki ilişkiler. KTÜ Fen Bilimleri Enstitüsü Doktora Tezi, Trabzon, 284 s
- Gezer A, Yücedağ C (2006) Ormancılıkta ekim ve dikim yoluyla ağaçlandırma tekniği. SDÜ Orman Fakültesi Yayınları. No: 63, Isparta
- Gülseven O, Ayan S, Özel HB, Yer EN (2019) Farklı doğu kayını (Fagus orientalis Lipsky.) populasyonlarına ait fidanların morfolojik ve fizyolojik karakteristikleri. Türkiye Ormancılık Dergisi 20(3):180-186
- Güney D (2009) Doğu kayını'nda (Fagus orientalis Lipsky) bazı coğrafik varyasyonların morfogenetik olarak belirlenmesi. Karadeniz Teknik Üniversitesi Fen Bilimleri Enstitüsü Doktora Tezi, Trabzon, 173 s
- Haase DL (2008) Understanding forest seedling quality: measurements and interpretation tree planters. Notes 52(2):24–30
- Hatipoğlu E (2013) Doğu gürgeni (Carpinus orientalis Miller) 'nde yükseltiye bağlı olarak bazı morfolojik karakterlerin ve çimlenme

özelliklerinin araştırılması. Karadeniz Teknik Üniversitesi Fen Bilimleri Enstitüsü Yüksek Lisans Tezi, Trabzon, 107 s

- Hora B (1981) The Oxford Encyclopedia of Trees of the World, Oxford Unviersity Press, Oxford, U.K. pp 288
- Huss J, Kahveci O (2009) Türkiye'de doğaya yakın yapraklı orman işletmeciliği. OGEM-VAK yayını
- Ivetić V, Grossnickle S, Škorić M (2016) Forecasting the field performance of Austrian pine seedlings using morphological attributes. iForest 10:99–107
- Jacobs DF, Salifu KF, Seifert JR (2005) Relative contribution of initial root and shoot morphology in predicting field performance of hardwood seedlings. New For. 30: 235–251
- Jaenicke H (1999) Good tree nursery practices: practical guidelines for research nurseries. ICRAF, Nairobi, pp 8–15
- Johnson JD, Cline ML (1991) Seedling quality of southern Pines. Chapter 8: forest regeneration manual. Edited by Duryea ML, Dougherty PM. Volume 36 of series Forestry Sciences. pp 143–159
- Kahveci O, Tüfekçioğlu U (1998) Ülkemizde hızlı gelisent türlerle yapılan çalışmaların değerlendirilmesi. Hızlı gelişen türlerle yapılan ağaçlandırma çalışmalarının değerlendirilmesi ve yapılacak çalışmalar, Orman Bakanlığı. Ankara
- Kestek D (2012) Sapsız meşe türünde yapılan seyreltmenin fidanların bazı morfolojik kalite kriterleri üzerine etkisinin araştırılması, Artvin Çoruh Üniversitesi Fen Bilimleri Enstitüsü Yüksek Lisans Tezi, Artvin, 53 s
- Krüssmann G (1984) Manual of Cultivated Broad-Leaved Trees and Shrubs. Vol. 1, A-D, Timber Press, Inc, Portland, Oregon, U.S.A., p 448
- Larsen HS, South DB, Boyer JM (1986) Root growth potential, seedling morphology and bud dormancy carreiate with survival of lob-lolly pine seedlings planted in December in Alabama. Tree Physiology 1(41):253-263
- Löf M, Thomsen A, Madsen P (2004) Sowing and transplanting of broadleaves (Fagus sylvatica L., Quercus robur L., Prunus avium L. and Crataegus monogyna Jacq.) for afforestation of farmland. Forest Ecology and Management 188(1-3) 113-123
- Manas P, Castro E, De las Heras J (2009) Quality of maritime pine (Pinus pinaster Ait.) seedlings using waste materials as nursery growing media. New Forests 37:295-311
- Mattsson A (1997) Predicting field performance using seedling quality assessment. New For. 13:227–252
- Mexal JG, Landis TD (1990) Target seedling concepts: height and diameter. In: Rose R, Campbell SJ, Landis TD, editors. Proceedings, Western Forest Nursery Association, Aug 13-17
- Nyoka BI, Kamanga R, Njoloma J, Jamnadass R, Mng'omba S, Muwanje S (2018) Quality of tree seedlings produced in nurseries in Malawi: an assessment of morphological attributes. Forests Trees and Livelihoods 27(2):103-117
- Pipinis E, Milios E, Kiamos N, Mavrokordopoulou O, Simiris P (2012) Effect of stratification and pre-treatment with gibberellic acid on

seed germination of two Carpinus species. Seed Science and Technology 40:21-31

- Ritchie GA (1984) Assessing seedling quality. In: Duryea ML, Landis TD, editors. Forest nursery manual: production of bareroot seedlings. The Hague: Martinus Nijhoff Publishers, pp 243–259
- Semerci A (2002) Sedir (Cedrus libani A. Rich.) fidanlarına ait bazı morfolojik ve fizyolojik karakteristikler ile iç anadolu'daki dikim başarısı arasındaki ilişkiler, İç Anadolu Ormancılık Araştırma Müdürlüğü, Teknik Bülten No: 279, Ankara, 142 s
- Şevik H, Ayan S, Demircioğlu N, Sıvacıoğlu A (2003) Kastamonu Gölköy orman fidanlığı çıplak köklü geniş yapraklı orman ağacı fidanlarının TSE normlarına göre değerlendirilmesi. Gazi Üniversitesi Orman Fakültesi Dergisi 3(2):233-245
- Shafiei AB, Akbarinia M, Jalali G, Hosseini M (2010) Forest fire effects in beech dominated mountain forest of Iran. Forest Ecology and Management 259:2191-2196
- Şimşek Y (1987) Ağaçlandırmada kaliteli fidan kullanma sorunları, Ormancılık Araştırma Enstitüsü Dergisi 33(65):5-29
- South DB, Harris SW, Barnett JP, Hainds MJ, Gjerstad DH (2005) Effect of container type and seedling size on survival and early height growth of Pinus palustris seedlings in Alabama U.S.A. For Ecol Manage. 204:385–398
- Sykes MT, Prentice IC (1996) Climate change, tree species distribution and forest dynamics: A case study in the mixed conifer/northern hardwood Zone of Europe. Clim. Change 34:161-177
- Thompson BE (1985) Seedling morphological evaluation- What you can tell by looking. Evaluating seedling quality: Principles, procedures, and predictive abilities of major tests, M.L. Duryea (ed.), Forest Research Laboratory, Oregon State University, Corvallis, OR, 59-71
- Tuttle CL, South DB, Golden MS, Meldahl RS (1987) Relationship between initial seedling height and survival and growth of loblolly pine seedlings planted during a droughty year. Southern Journal of Applied Forestry 11(3):139-143
- Üçler AÖ, Gülcü S, Bilir N (2000) Anadolu karaçamı ve kızılçam'da tohum kaynağı-morfolojik fidan kalitesi ilişkileri. Bildiri Özetleri Kitapçığı s, 39. II. Ulusal Fidancılık Sempozyumu, Eylül, İzmir
- Yahyaoğlu Z, Genç M (2007) Fidan Standardizasyonu. Standart Fidan Yetiştirmenin Biyolojik ve Teknik Esasları, SDÜ Orman Fakültesi Yayın, 75, 555 s
- Yahyaoğlu Z, Güney D, Turna İ, Atar F (2012) Fıstıkçamı (Pinus pinea L.)'nda bazı morfolojik özelliklere bağlı varyasyonların belirlenmesi. KSÜ Doğa Bilimleri Dergisi 234-239
- Yaltırık F (1982) Flora of Turkey and Aest Eagen Island, Universty Press, Edinburgh., Ed. P.H. Davis, 7, p 684
- Yer EN, Ayan S (2011) Eskişehir Orman Fidanlık Koşullarında Yetiştirilen Çıplak Köklü Toros Sediri ve Anadolu Karaçam Fidanlarının Gelişim Dönemleri. K.Ü. Orman Fakültesi Dergisi 11(2):219-227
- Yılmaz M (1995) Karaçam Fidanlarının kalite sınıflarının belirlenmesi üzerine araştırmalar, Ormancılık Araştırma Enstitüsü Yayınları 238-241:5-37.