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Effects of root undercutting, fertilization and thinning on seedling growth and quality of oriental beech (*Fagus orientalis* Lipsky) seedlings

Doğu kayını (Fagus orientalis Lipsky) fidanlarında kök kesimi, gübreleme ve seyreltmenin fidan gelişimi ve kalitesi üzerine etkileri

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Abstract
In this study, the effects of root undercutting, fertilization and thinning applications on th morphological characteristics of oriental beech seedlings grown in Karadağ Forest Nursery wer investigated. In 2+0 years old seedlings, the effects of treatments including by making root undercuttin and thinning (A) and by giving 50 g of ammonium nitrate fertilizer per m^2 addition to thinning (B) in Ju were examined. Moreover, quality classes of seedlings were determined on the basis of treatment According to the result of this study, significant differences were found between the morphologica characteristics of the seedlings depending on the treatments. It was determined that while there is statistical significance in terms of seedling length, sturdiness quotient, the number of side branche shoot and root fresh weight, shoot and root dry weight, shoot dry weight/root dry weight, roo percentage, Dickson quality index, there is no significance in terms of root collar diameter, fres seedling weight, dry seedling weight in 2+0 years old seedlings. According to Turkish Standard Institute's deciduous seedling standard (TS 5624/21.03.1988) prepared in March 1988, 48.8% of treatment and 76.7% of B treatment and 78.9% of the control group were found to be Class I. Accordin to Dickson quality index, the quality index values of seedlings in 2+0 A, 2+0 B and control wer determined as and 1.05, 0.74 and 0.68 respectively. In determination of Dickson quality index valu using of important parameters used for determination of seedling quality is important in terms o obtaining more accurate results.

Özet
Bu çalışmada, Karadağ Orman Fidanlığı'nda yetiştirilen Doğu kayını fidanlarında uygulanan yerinde kök kesimi, seyreltme ve gübreleme uygulamalarının morfolojik özellikler üzerindeki etkileri araştırılmıştır. Çalışmada iki yaşındaki fidanlarda Temmuz ayında kök kesimi ve seyreltme yapılarak (A) ve seyreltme yapılıp ve metrekareye 50 g amonyum nitrat gübresi verilerek (B) bu işlemlerinin etkisi incelenmiştir. Ayrıca işlemler bazında fidanların kalite sınıfları belirlenmiştir. Yapılan işlemlere bağlı olarak fidan morfolojik karakterleri arasında önemli farklılıklar tespit edilmiştir. Fidan boyu, gürbüzlük indisi, yan dal sayısı, gövde taze ağırlığı, kök taze ağırlığı, gövde kuru ağırlığı, kök kuru ağırlığı, katlılık, kök yüzdesi ve Dickson kalite indeksi bakımından 2+0 yaşlı fidanlarda yapılan işlemlerin istatistiki olarak etkisi olduğu, kök boğazı çapı, fidan taze ağırlığı ve fidan kuru ağırlığı bakımından ise işlemler arasında istatistiki olarak bir fark olmadığı tespit edilmiştir. Türk Standartları Enstitüsünün Mart 1988'de hazırlamış olduğu yapraklı ağaç fidanı standardına (TS 5624/21.03.1988) göre A işleminin %48.8'i, B işleminin %76.7'si kontrol grubunun ise %78.9'u I. sınıf çıkmıştır. Dickson kalite indeksine göre fidanların kalite indeks değerleri 2+0 A, 2+0 B ve kontrol grubunda sırasıyla 1.05, 0.74 ve 0.68 olarak belirlenmiştir. Dickson kalite indeksi değerinin belirlenmesinde fidan kalitesini belirlemede kullanılan önemli parametrelerin kullanılması daha hassas sonuçların elde edilmesi bakımından önemlidir.

INTRODUCTION

Beech, represented by 10 species in the northern hemisphere, is one of the most important species of deciduous forests. There are two naturally distributed species as oriental beech (*Fagus orientalis* Lipsky) and European beech (*Fagus sylvatica* L.) in Turkey. Oriental beech is one of the most common and economically important native deciduous tree species of Turkey. Oriental beech forests in Turkey have a total distribution of 1 899 929 ha to be 1 630 196 ha forest in normal structure and 269 733 ha forest in degraded structure (Anonymous 2015).

Oriental beech is native to the Balkans in the east, through Anatolia (Asia Minor) in the west, and to the

Caucasus, northern Iran and Crimea. Wide hybridization zones are observed between oriental and European beeches in the central east and eastern region of the Rhodope Mountains in Bulgaria and Greece. In Turkey, oriental beech is distributed in Thrace and south of the Marmara Sea and throughout the Black Sea Regions. The species can be found as both pure stands and mixed forests with conifers and other deciduous tree species. Its vertical distribution is between 200 and 2200 m above sea level (Atalay 1992, Denk et al. 2002, Gailing and Wuehlisch 2004, Kandemir and Kaya 2009, Papageorgiou et al. 2008).

In Turkey, oriental beech is tree species with the second largest spread among deciduous trees after *Quercus* spp. (Anonymous 2015), and plantation studies of this species are made in quite high. Plantation activities are expensive and long-term investments. Selection of appropriate species and origin and growing of quality seedlings in terms of physiological and morphological features from these seeds are the most important issues to be considered in the plantation studies (Tosun et al. 1993). Especially in areas having extreme conditions, the production of quality and suitable seedlings gains high importance in order to conduct the plantation studies in the most economical way and to reach the highest success (Üçler and Turna 2003, Yahyaoğlu and Genç 2007). Quality seedling is seedling showing high survival percentage in plantation studies and can make a very good growth in the first years, and is also being in economic balance with these advantages (Tosun et al. 1993).

One of the important factors affecting the success of plantation is the quality of seedlings, and it is possible to increase the quality of seedlings with appropriate seedbed density (Cengiz and Şahin 2002). The seedbed density has a direct effect on the diameter, height and physiological activities of the seedlings (Tolay 1987, Tonguç 2009). Sparse cultivation may have some economic losses (Saatçioğlu 1976), and it is possible to encounter weakness of seedlings in frequent cultivation (Alım ve Kavgacı 2017).

The characteristics used to determine the quality of forest tree seedlings are generally grouped into three groups as genetical, morphological and physiological characteristics (Duryea 1984, Genç 1992, Genç and Yahyaoğlu 2007). Morphological characteristics such as root collar diameter and seedling length give an idea about seedling characteristics suitable for planting (Deligöz 2012). In addition, it is generally desirable for a quality seedling to have a shoot/root ratio of less than 3 to increase the percentage of survival in the field (Grossnickle et al. 1988, Tetik 1995). It is stated that variables such as growth and survival percentage are not alone effective in determining seedling morphology, and morphological and physiological characteristics of seedling should be evaluated together (Ritchie 1984; Thompson 1985). Furthermore, the morphological and physiological characteristics of the seedlings affect the success of the land after planting (Chavasse 1980, Q'Reilly and Keane 2002).

Root growth potential, which is one of the physiological characteristics, is perhaps the most reliable feature in terms of land performance. High root growth potential of seedlings that start to develop rapidly after planting is important in terms of obtaining quality seedlings (Ritchie 1985). The survival of newly planted seedlings, the ability to survive planting shock and to develop roots depends on the white-tipped roots they form (Dirik 1990). In the study conducted in Turkish red pine, it was stated that the water intake was higher in the seedlings with white-tipped root compared to the ones without white-tipped root (Dirik 1991). In addition, some factors such as the seedling age, root cutting, irrigation, fertilization, transplanting, shading, seedling density, nursery soil characteristics are also affect the quality of the seedlings (Eyüboğlu 1979, Alım et al. 2008, Landis 2008, Tonguç and Aydın 2019). Root undercutting is one of the most important cultivation techniques that enable seedlings to achieve certain quality characteristics. With this application, it is provided that the height growth of seedlings and elongation of the roots are prevented, the formation of more compact fibrous roots is encouraged, and the shoot/root ratio is reduced by making the dormancy and hardening (Landis 2008). Although, there are several studies on the technique of seedling growing in oriental beech (Tosun et al. 2002, Güney 2009, Atik

2013, Güney et al. 2016), the current study differs from previous studies, since the root undercutting, fertilization and thinning are evaluated together.

The aim of this study is to determine the effect on the morphological characteristics of the seedlings of root undercutting, fertilization and thinning practices on the oriental beech seedlings and to determine the best application for growing quality seedlings. In addition, depending on the results obtained, it is aimed to reveal the quality classes of the seedlings and to see the change of quality classes according to the treatments. Different quality class criteria including TSI and Dickson were applied in the study and comparison of these criteria creates another objective of the study.

MATERIAL AND METHOD

Material

The study was carried out in the Karadağ Forest Nursery (1400 m) within the borders of Trabzon Regional Directorate of Forestry. The nursery where the study was carried out has a land shape of 30% slope and the composition of the soil varies between clay loam, sandy clay loam and sandy loam. The pH of the soil ranges between 3.9 and 4.8 and there is no lime in the nursery soil and it is poor in terms of phosphorus. According to the data obtained from the meteorological station closest to the nursery, annual temperature is between 3.0-11.4 °C and average temperature is 7.0 °C. The average annual rainfall is 342.7 mm, the number of rainy days is 118.3, and the number of frosty days is 97.5. As a study material, 2+0 years old oriental beech (*Fagus orientalis* Lipsky) seedlings of Trabzon origin were used. Geographical location of Karadağ Forest Nursery in Turkey is shown in Figure 1.

Method

Three different treatments were performed on 2+0 years old oriental beech seedlings. These applications are as follows.

A: In July, root undercutting (at 20 cm deep from soil level) and thinning (50% of the seedlings were removed from the seedbeds) were made.

B: Thinning was made, there is no fertilization in first year, In the fifth month of the second year, 50 g of 33 ammonium nitrate fertilizer per m^2 was made.

C (Control): Routine application of the nursery without root undercutting and thinning is considered as control.

The experiment was designed in a randomized complete block design with three replications. The location and order of replications for each treatment were randomly determined. Other than root undercutting, thinning and fertilization, cultural applications (irrigation, weed control) were carried out according to the routine work program of the Karadağ Forest Nursery. Undercutting of roots was made by passing the root undercutting knife attached to the tractor under the seedbed parallel to the soil surface.

Figure 1. Geographical location of Karadağ Forest Nursery

The morphological characteristics of 1+0 year-old oriental beech seedlings were determined. Removal of 2+0 years old seedlings was carried out on 30 seedlings from each replication of each treatment. Measurements of root collar diameter (RCD), seedling length (SL), the number of side branches (NSB), shoot fresh weight (SFW), root fresh weight (RFW), shoot dry weight (SDW), root dry weight (RDW), fresh seedling weight (FSW) and dry seedling weight (DSW) were made. Using these measurement values, shoot dry weight/root dry weight (SDW/RDW), root percentage (RP: RDW/DSW), sturdiness quotient (SQ: SL/RCD) and Dickson quality index (DQI: (DSW)/(SQ)+(SDW/RDW)) were determined for each seedling. Dickson quality index is a formula used to determine the quality of forest tree seedlings and it is developed by Dickson et al. in 1960. It is reported that seedlings are considered as high quality if they are close to and higher than 1 (Aslan 1986), which explains the potential power of seedlings for field performance (Mañas 2009). Ruler that the measurement accuracy is 0.1 cm was used for length measurements, electronic caliper that measurement accuracy is 0.01 mm was used for diameter measurements, and digital scales with a measurement accuracy of 0.001 g was used for weight measurements.

Data were analyzed by SPSS 23 package program. In order to determine the effects of root undercutting, thinning and fertilization on the basic morphological characteristics of oriental beech seedlings, variance analysis (one-way ANOVA) and Duncan's test were performed for each morphological character. In addition, seedlings belonging to thinning and root undercutting treatments were evaluated according to Turkish Standards Institute's deciduous seedling standard (TS 5624/21.03.1988) prepared in March 1988 (Anonymous 1988) and Dickson quality index values (Dickson et al. 1960).

RESULTS AND DISCUSSION

Morphological characteristics of seedlings

The averages of the morphological characteristics of oriental beech seedlings in 1+0 year-old and the mean of the morphological characters measured after root undercutting, fertilization and thinning interventions applied to oriental beech seedlings of 2+0 years old are given in Table 1.

Table 1. Differences between morphological characteristics of oriental beech seedlings applied different treatments (Mean±SE)

Morphological Characteristics	1+0 year-old	Treatments (2+0 years old)			F	*p*
		A	B	C		
SL (cm)	20.31±4.86	28.93±7.49 **a**	36.89±8.60 **b**	34.82±7.64 **b**	24.35	0.000*
RCD (mm)	4.73±0.72	6,97±1.39 **a**	6.81±1.62 **a**	6.64±1.36 **a**	1.128	0.325
SQ	4.32±0.91	4.20±0.88 **a**	5.49±0.90 **b**	5.32±1.04 **b**	49.72	0.000*
NSB	0.53±0.72	2.60±1.69 **b**	2.64±1.84 **b**	1.81±1.39 **a**	7.255	0.001*
SFW (g)	1.45±0.55	4.76±2.37 **a**	6.73±4.01 **b**	6.00±3.14 **b**	8.460	0.000*
RFW (g)	2.44±0.85	7.65±3.60 **b**	6.64±3.89 **ab**	6.43±3.03 **a**	3.100	0.047*
FSW (g)	3.89±1.29	12.42±5.70 **a**	13.38±7.65 **a**	12.43±6.01 **a**	0.649	0.523
SDW (g)	0.57±0.21	2.26±1.04 **a**	2.76±1.69 **b**	2.42±1.33 **ab**	3.040	0.049*
RDW (g)	0.69±0.26	2.86±1.14 **b**	2.12±1.31 **a**	1.89±0.94 **a**	17.73	0.000*
DSW (g)	1.26±0.43	5.12±2.00 **a**	4.88±2.89 **a**	4.31±2.21 **a**	2.692	0.070
SDW/RDW	0.89±0.42	0.81±0.27 **a**	1.34±0.32 **b**	1.29±0.29 **b**	88.31	0.000*
RP	0.55±0.08	0.56±7.55 **b**	0.43±6.18 **a**	0.44±8.69 **a**	107.18	0.000*
DQI	0.25±0.09	1.05±0.42 **b**	0.74±0.45 **a**	0.68±0.37 **a**	20.66	0.000*

*p<0.05 (There is a statistically significant difference.)

As can be seen in Table 1, while there were statistically significant effects in terms of SL, SQ, NSB, SFW, RFW, SDW, RDW, SDW/RDW, RP and DQI depending on applied treatments in 2+0 years old seedlings, there was no statistically significant effect in terms of RCD, FSW and DSW.

Although there was a partial increase in RCD in the seedlings that were applied thinning, there wasn't a statistically significant difference. Seedling length had

higher values in seedlings that were made thinning and root undercutting. According to the results of the study, it was seen that the treatments caused a partial increase in total fresh and dry weight of the seedlings compared to the control treatment, but there was no statistically significant difference. However, when evaluated on the basis of shoot and root weights, it is understood that the treatments have significant effects. As a matter of fact, in the control treatment, RFW and RDW were 6.43 and 1.89 g, respectively, while the values in A treatment were 7.65 and 2.86 g, respectively. While SFW and SDW were 6.00 and 2.42 g respectively in the control treatment, these values were 6.73 and 2.76 g respectively in the B treatment.

In general, it is stated that the seedlings grown at low sowing density develop larger diameter and heavier roots and shoots as dry weight, the seedling length and shoot/root ratio are not always affected by the seedling density (Duryea 1984). In the species of *Picea orientalis* (L.) Link (Eyüboğlu 1988), *Robinia pseudoacacia* L. (Cengiz and Şahin 2002, Semerci et al. 2008), tree of heaven (Cengiz and Şahin 2002) and *Elaeagnus angustifolia* L. (Gülcü and Çelik Uysal 2010) in different studies, it was found that the low seedling density increases root collar diameter and seedling weight, but it does not affect seedling length. In some studies, it was reported that the seedbed density for *Acer negundo* L. are only effective on the root development potential in terms of morphological and physiological characteristics of seedlings (Deligöz 2012), it has positive effects on seedling length, root collar diameter and seedling weight for *Juglans nigra* L. and *Quercus rubra* L. (Schultz and Thompson 1997), it has also statistically significant effects on seedling length, root collar diameter, shoot dry weight and root dry weight for 1+0 year-old *Crataegus monogyna* Jacq. seedlings (Bayar and Deligöz 2016).

Root undercutting treatment increased the fresh and dry root mass in 2+0 years old oriental beech seedlings, while fertilization treatment increased the fresh and dry shoot mass. Consequently, while the percentage of dry root weight is increased in the seedlings applied thinning and root undercutting, the rates of SDW/RDW decrease. Johnsen et al. (1988) reported that being high of root percentage is an important factor in the living success of seedlings with root system rich in capillary roots.

In the B treatment, it was determined that the rates of SDW/RDW increased. In order for a quality seedling to increase the living percentage in the field, it is generally desirable that the shoot/root ratio is less than 3 (Grossnickle et al. 1988, Tetik 1995). In the present study, the values of SDW/RDW were found to be less than 3 for all treatments. In a study conducted to determine the effect on the development of seedlings in the first year of different rates of biohumus applied to oriental beech, it has been determined that seedlings grown from seeds waiting for 12 and 24 hours in 0.5 ml biohumus solution grow the most in terms of both seedling length and root collar diameter (Güney et al. 2010).

Although the seedling length was lower in the A treatment than the control, FSW was about the same as the control and DSW was higher than the control. This can be explained by the increase in total seedling weight due to the fibrous roots caused by root undercutting (Table 1). Studies on oriental beech seedlings express the necessity of making root undercuttings in order to eliminate root thinning in oriental beech seedlings and to form appropriate root systems. However, it is stated that the seedlings that root cuttings have been made must stay in the seedling beds for one more year in order to improve their root systems (Şimşek 1994).

While the mean value of the sturdiness quotient in 1+0 year-old seedlings were found to be 4.32, it was determined as 4.20 in A treatment, 5.49 in B treatment and 5.32 in control treatment in 2+0 years old seedlings. Due to the positive effect of B treatment on seedling length, the highest SQ value was obtained in this application. Seedling length and root collar diameter have a significant effect on both percentages of survival and seedling growth after planting. Seedlings having high values in terms of seedling length and root collar diameter are generally superior to the others with regard to survival percentage and development in the field (Rose et al. 1990, Yahyaoğlu and Genç 2007). In the study carried out in Taurus cedar, it was determined that seedling quality classes have an important effect on the

development of seedlings in the field (Eler et al. 1993).

In the A treatment where SL was lower and RCD was higher, the SQ value was lower (Table 1). In a study investigating the effects of vermicompost on morphological characteristics of 1+0 year-old oriental beech seedlings at different planting densities, it was determined that vermicompost had significant effects on development, and growth increased as planting density decreased. Vermicompost giving the best results was used in the study and the sturdiness quotient of the seedlings planted at 10 cm intervals was obtained as 3.08 on average (Atik 2013). While developing new roots, new seedlings planted in the field are not yet sufficiently photosynthetic. Therefore, they meet the nutrients they need from their carbohydrate reserves. Furthermore, the positive effect of carbohydrate content is very important, especially in newly planted bare rooted seedlings. It has been reported that the low density of seedlings improves carbohydrate reserves in seedlings, hence increases resistance and will be able to provide the better development in the field with more nutrient reserves of seedlings (Duryea 1984, Lavender 1984, Wang 1998, Deligöz 2012).

Distribution of seedlings to quality classes

Distribution of oriental beech seedlings, where root undercutting, fertilization and thinning applications are applied according to the standard prepared by Turkish Standards Institute for deciduous tree seedlings (TS 5624) (Anonymous 1988) and Dickson quality index values (Dickson et al. 1960) are given in Table 2.

Table 2. Quality classes of Turkish Standards Institute (TSI) and Dickson quality index (DQI) values in oriental beech seedlings of 1+0 and 2+0 years old

	Quality Classes (TSI)						DQI
	I		II		Non-standard		
	NS*	%	NS	%	NS	%	
1+0	4	4.4	45	50	41	45.6	0.25
2+0 A	44	48.8	38	42.2	8	8.9	1.05
2+0 B	69	76.7	21	23.3	0	0	0.74
2+0 C	71	78.9	17	18.9	2	2.2	0.68

*NS: The number of seedlings

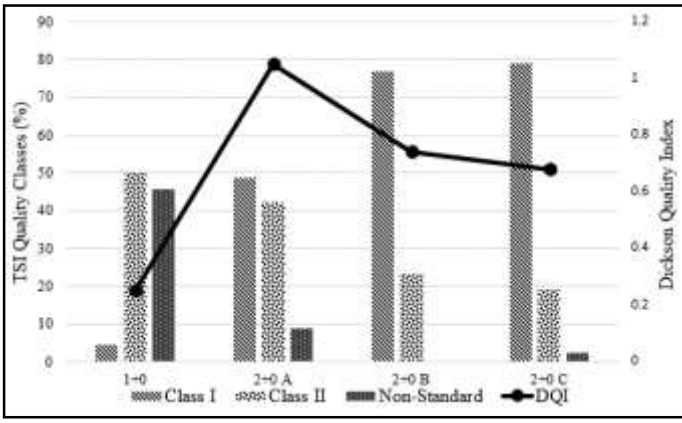

Figure 2. Comparative graph of TSI quality classes and DQI values

As can be seen in Figure 2, according to the TSI quality classification, the percentage of Class I in 2+0 years old seedlings was highest in the control group, followed by 2+0 B treatment, 2+0 A treatment and 1+0, respectively. According to Dickson quality index, the highest value in 2+0 years old seedlings occurred in A treatment (1.05), followed by B treatment (0.74), and control treatment (0.68) took the last place. In the 1+0 year-old seedlings, the DQI value was found to be 0.25. As it can be seen from these data, seedlings with low quality value according to TSI standards can be higher than Dickson quality index. This result can be explained by the fact that only the seedling length and root collar diameter were taken as a criterion in the deciduous tree seedlings standards prepared by TSI (TS 5624) and no age criterion was given for this. In determining Dickson quality index value, it is important to use more important parameters such as sturdiness quotient, the ratio of shoot dry weight/root dry weight and dry seedling weight depending on seedling length and root collar diameter in order to obtain more accurate results.

Similar to the results obtained in our study, in a study examining the effects of seedbed density of on seedling morphology for *Juniperus oxycedrus* L. subsp. *oxycedrus*, it was stated that although there was no difference between some morphological characters depending on the density, the control group had the lowest DQI value (Alım and Kavgacı 2017).

Dickson quality index was determined between 0.44 and 1.29 in another study in which the effect of thinning and

root undercutting application on morphological characters was investigated in Anatolian black pine. According to the results of the study, different thinning and root cutting applications were effective on seedling morphology and it was stated that the lowest Dickson quality index value was in the control treatment (Çetinkaya and Deligöz 2012). In a study conducted on *Juniperus foetidissima* Wild. seedlings, it was stated that the seedbed density had significant effects on root collar diameter, seedling length, shoot, root and seedling dry weight, shoot/root ratio, root percentage, sturdiness quotient and Dickson quality index (Özüberk and Deligöz 2016).

CONCLUSION

Success in plantation studies is directly proportional with being proper to the quality standards of the seedlings used. In the plantation studies carried out in forest, mostly the technical problems are the subject and the seedling is in the second degree. Using quality seedlings, degraded areas need to be transformed into productive forests. In this case, the first task should be to develop a standardization of seedlings. In this study, it was aimed to grow seedlings that can make the best increment with different root undercutting, fertilization and thinning interventions to be applied to the seedlings and to obtain material that meets the quality criteria. In other words, growing of seedlings that is high field success in plantation studies with the most suitable root undercutting, fertilization and thinning application determined in the study was aimed. In addition to this, the seedlings can make a good growth by continuing actively own life in the first years, and are in economic balance with these advantages.

According to the standards prepared by Turkish Standards Institute for deciduous tree seedlings, seedlings in Class I were the highest in the control group, while the control group had the lowest value according to Dickson quality index. TSI's results without using too many criteria in the classification can give misleading results. For this reason, usage the criteria which are important for the seedlings while determining the quality criterion, and especially making classification by determining criteria according to the purpose of seedling cultivation will be very important in terms of application.

In the new researches in order to obtain quality seedlings, the most suitable seedling density should be determined by making thinning interventions according to the tree species in each nursery and the site conditions where the nursery is located. In addition, thinning studies must be supported with root undercuttings in order to obtain seedlings with larger root diameter and healthy root system. Especially in areas where there is a problem of ground cover, fertilization in the nursery is important for the areas where the usage of tall seedlings is required, in order to give positive results in overcoming this problem. In this respect, the applications such as root undercutting time, thinning time and density, fertilizer type, quantity and time should be studied according to nursery conditions, species used and production purpose, and the results obtained should be supported with field trials.

REFERENCES

Alım E, Kavgacı A (2017) Eğirdir orman fidanlığı'nda diken ardıcı (*Juniperus oxycedrus*) fidan yetiştirme sıklığının fidan morfolojisine etkileri. Ormancılık Araştırma Dergisi 4(1):01-11

Alım E, Şahin M, Gültekin HC (2008) Fidan sıklığının Badem (*Prunus amygdalus* L.) fidanlarının morfolojik özellikleri üzerine etkisi. Batı Akdeniz Ormancılık Araştırma Enstitüsü Dergisi 9(1): 29-41

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

Anonymous (2015) Orman Varlığımız. T.C. Orman ve Su İşleri Bakanlığı Orman Genel Müdürlüğü, Ankara

Aslan S (1986) Kazdağı Göknarı (*Abies eguitrojani* Ascher et Sinten)'nın Fidanlık Tekniği Üzerine Çalışmalar. Ormancılık Araştırma Enstitüsü Yayını, Teknik Bülten Serisi No:157, Ankara

Atalay I (1992) The Ecology of Beech (*Fagus orientalis* Lipsky) Forests and TheirRegioning in Terms of Seed Transfer. Ankara, TR: Forest Tree Seeds and Tree Breeding Research Directorate Publishing

Atik A (2013) Effects of Planting Density and Treatment with Vermicompost on the Morphological Characteristics of Oriental Beech (*Fagus orientalis* Lipsky.). Compost Science & Utilization 21:87-98

Bayar E, Deligöz A (2016) Alıç (*Crataegus monogyna* Jacq.) fidanlarının morfolojisi ve kök gelişme potansiyeli üzerinde yetiştirme sıklığının etkisi. SDÜ Türkiye Ormancılık Dergisi 17(1):7-11

Cengiz Y, Şahin M (2002) Bazı yapraklı ağaç fidanlarının yetiştirilmesinde ekim sıklığının büyüme üzerine etkileri. Batı Akdeniz Ormancılık Araştırma Enstitüsü Dergisi 4:123-136

Chavasse CGR (1980) Planting stock quality: A Review of Factors Affecting Performance. N.Z. Journal of Forestry 25:145-171

Çetinkaya D, Deligöz A (2012) *Pinus nigra* Arn. subsp. *pallasiana* (Lamb.) Holmboe'nda yerinde kök kesimlerinin fidan morfolojisi üzerindeki etkisi. Bartın Orman Fakültesi Dergisi 14:49-58

Deligöz A (2012) Ekim Sıklığının *Acer negundo* L. fidanlarının morfolojik ve fizyolojik özellikleri üzerine etkisi. Bartın Orman Fakültesi

Dergisi 14(21):11-17

Denk T, Grimm G, Stogerer K, Langer M, Hemleben V (2002) The Evolutionary History of *Fagus* in Western Eurasia: Evidence from Genes, Morphology and the Fossil Record. Plant Systematics and Evolution 232:213-236

Dickson A, Leaf AL, Hosner F (1960) Quality appraisal of white spruce and white pine seedling stock in nurseries. Forestry Chronicle 36:10-13

Dirik H (1990) Dikim şoku. İstanbul Üniversitesi Orman Fakültesi Dergisi 40:105-116

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

Duryea ML (1984) Nursery Cultural Practices, Impacts on Seedling Quality, Forest Nursery Manual Production of Bareroot Seedlings. Duryea State Universty, 146-149, 153-158, 160-161

Eler Ü, Keskin S, Örtel E (1993) Toros sediri (*Cedrus libani* A. Rich.) fidanlarında kalite sınıflarının belirlenmesi üzerine araştırmalar. Orm. Arş. Enst. Yayınları, Teknik Bülten No:238-241, Ankara, 81-105

Eyüboğlu AK (1988) Fidanlıkta değişik sıklık derecelerinde yetiştirilmiş, şaşırtılmış ve şaşırtılmamış doğu ladini (*Picea orientalis* (L.) Link) fidanlarının arazideki durumları. Ormancılık Araştırma Enstitüsü, Teknik Bülten No:201, Ankara, 16 s

Eyüboğlu AK (1979) Fidan. Ormancılık Araştırma Enstitüsü Dergisi 25(2):31-67

Gailing O, Wuehlisch G (2004) Nuclear markers (AFLPs) and chloroplast microsatellites differ between *Fagus sylvatica* and *F. orientalis*. Silvae Genetica 53:105-110

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

Genç M, Yahyaoğlu Z (2007) Kalite Sınıflamasında Kullanılan Özellikler ve Tespiti. In: Yahyaoğlu Z, Genç M (eds) Fidan Standardizasyonu, Standart Fidan Yetiştirmenin Biyolojik ve Teknik Esasları. Süleyman Demirel Üniversitesi Yayınları, No:75, Isparta, pp 355-465

Grossnickle SC, Arnott JT, Major JE (1988) A stock quality assessment procedure for characterizing nursery-grown seedlings. In: Forest Nursery Association of British Columbia and Inter Mountain Forest Nursery Association Meeting. Vernon, B.C., Canada, pp 77-88

Gülcü S, Çelik Uysal S (2010) Kuş iğdesinde (*Elaeagnus angustifolia* L.) yetiştirme sıklığının fidan morfolojik özelliklerine etkisi. Süleyman Demirel Üniversitesi Orman Fakültesi Dergisi A(2):74-81

Güney D (2009) Doğu kayınında (*Fagus orientalis* Lipsky) bazı coğrafik varyasyonların morfogenetik olarak belirlenmesi. Karadeniz Teknik Üniversitesi Fen Bilimleri Enstitüsü Doktora Tezi, Trabzon, 173 s

Güney D, Kulaç Ş, Turna İ, Yahyaoğlu Z. (2010) Different biohumus effects on growth performance of oriental beech (*Fagus orientalis* Lipsky) seeds. I. Uluslararası Türk-Japon Çevre ve Ormancılık Sempozyumu. Trabzon

Güney D, Turna İ, Bayraktar A, Seyis E, Atar E (2016) Comparison of differently originated oriental beech (*Fagus orientalis* Lipsky) seedling growth in field. Biological Diversity and Conservation 9:10-18

Johnsen KH, Feret PP, Seiler JR (1988) Comparison of Greenhouse and Environmentally Controlled Growth Room Root Growth Potential Testing of 2+0 Eastern White Pine Seedlings. New Forests 2:139-143

Kandemir G, Kaya Z (2009) Technical Guidelines for Genetic Conservation and Use for Oriental Beech (*Fagus orientalis*). EUFORGEN, Bioversity International, Rome, Italy, 1-6

Landis TD (2008) Root Culturing in Bareroot Nurseries. Forest Nursery Notes Winter

Lavender DP (1984) Plant Physiology and Nursery Environment: Interaction Affecting Seedling Growth. In: Duryea ML, Thomas DL (eds) Forest Nursery Manual: Production of Bareroot Seedlings, Martinus Nijhoff Dr. W. Junk Publishers, TheHague/Boston/Lanchester for Forest Research Laboratory, Oregon State University, Corvallis, pp 133-141

Mañas P, Castro E, Heras J (2009) Quality of Maritime Pine (*Pinus pinaster* Ait.) Seedlings Using Waste Materials as Nursery Growing Media. New Forests 37:295-311

Özüberk ŞD, Deligöz A (2016) Kokulu Ardıç (*Juniperus foetidissima* Wild.) Fidanlarının Morfolojisi, Kök Gelişme Potansiyeli ve Karbonhidrat İçeriği Üzerinde Yetiştirme Sıklığının Etkileri. SDÜ Fen Bilimleri Enstitüsü Dergisi 20(2):369-375

Papageorgiou AC, Vidalis A, Gailing O, Tsiripidis I, Hatziskakis S, Boutsios S, Galatsidas S, Finkeldey R (2008) Genetic Variation of Beech (*Fagus sylvatica* L.) in Rodopi (N.E. Greece). European Journal of Forestry Research 127:81-88

Q'Reilly C, Keane, M (2002) Plant Quality: What You See is Not Always What You Get. Coford Connects Reproductive Material No:6, 4 p

Ritchie GA (1984) Assessing Seedling Quality. In: Duryea ML, Landis TD (eds) Forestry Nursery Manual Production of Bareroot Seedlings. Forest Research Laboratory, Oregon State University, Corvallis, pp 243-260

Ritchie GA (1985) Root Growth Potential: Principles, Procedures and Predictive Ability. In: Duryea ML (ed) Proceedings: Evaluating Seedling Quality: Principles, procedures, and predictive abilities of major tests. Forest Research Laboratory, Oregon State University, Corvallis, pp 93-105

Rose R, Carlson WC, Morgan P (1990) The Target Seedling Concept, Target Seedling Symposium: Proceedings, Combined Meeting of the Western Forest Nursery Associations, August 13-17, 1990, Reseburg, Oregon, (rose, R., Campbell, S.J., Landis, T.D., eds), USDA Forest Serv. General Technical Report RM:200, p 1-8

Saatçioğlu F (1976) Fidanlık Tekniği. İstanbul Üniversitesi Orman Fakültesi Yayınları, Yayın No: 223, İstanbul

Schultz RC, Thompson JR (1997) Effect of Density Control and Undercutting on Root Morphology of 1+0 Bareroot Hardwood Seedlings: Five-year Field Performance of Root-graded Stock in the Central USA. New Forests 13:301-314

Semerci A, Güner ŞT, Çömez A, Celik N, Karataş R, Koray EŞ, Genç M, Tuncer E, Güner D (2008) Yetiştirme Sıklığının Yalancı Akasya Fidanlarının Bazı Morfolojik ve Fizyolojik Özellikleri ile Dikim Başarısına Etkileri: Eskişehir örneği. İç Anadolu Ormancılık Araştırma Enstitüsü Yayınları No: 285, 2

Şimşek Y (1994) Kaliteli Kayın (*Fagus orientalis* Lipsky.) Fidanı Yetiştirme Tekniği Araştırma Sonuçları. Ormancılık Araştırma Enstitüsü Yayınları, Teknik Rapor Serisi No:56,7-30

Tetik M (1995) Sarıkamış Fidanlığında Ekim Sıklığının Sarıçam (*Pinus sylvestris* L.) Fidanlarının Kalitesine ve Dikimdeki Başarısına Etkisi. Orm. Arş. Ents. Yayınları, Teknik Bülten Serisi No:244, Ankara, 28 s

Thompson EB (1985) Seedling Morphological Evaluation- What you can tell by looking. Ed: Duryea, M.L. Proceedings: Evaluating Seedling Quality: Principles, procedures, and predictive abilities of major tests. Forest Research Laboratory, Oregon State University, Corvallis

Tolay U (1987) Yapraklı Tür Orman Ağaçları Fidanlık Tekniği. Kavak ve Hızlı Gelişen Orman Ağaçları Araştırma Enstitüsü, Teknik Bülten, İzmit

Tosun S, Özbay Z, Tetik M (1993) Sarıçam (*Pinus sylvestris* L.) Fidanlarının Kalite Sınıflarının Belirlenmesi Üzerine Araştırmalar. Orm. Arş. Enst. Yayınları, Teknik Bülten No:238-241, Ankara, pp 37-79

Tonguç F (2009) Effects of Seedbed Density on *Pinus elliottii* Seedlings

Under Simulated Greenhouse Conditions. Artvin Çoruh Üniversitesi Orman Fakültesi Dergisi 10(2):95-101

Tonguç, F, Aydın M (2019). Radikula ve Yerinde Kök Kesimi Uygulamalarının Siirt-Pervari Orijinli Ceviz Fidanlarında (*Juglans regia*) Bazı Fidan Kalite Özelliklerine Etkisi. Iğdır Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 9(3), 1683-1691.

Tosun S, Özbay Z, Serin M, Karatepe H (2002) Doğu kayını (*Fagus orientalis* Lispky.) ve meşe (*Quercus petraea* (Matt.) Lieb, *Q. hartwissiana* Stev.) türlerinde boylu fidan üretimi ve plantasyon tekniğinin araştırılması. Batı Karadeniz Ormancılık Araştırma Enstitüsü Müdürlüğü Teknik Bülten No:6

Üçler AÖ, Turna İ (2003) Ağaçlandırma Tekniği Ders Notları. KTÜ Orman Fakültesi, Yayın No:69, Trabzon

Wang Y (1998) Low Temperature Effects on Physiologieal Characteristics of Dormant White Spruce (*Picea glauca*) Bareroot Seedlings. Doctor thesis, Edmonton, Alberta, 129 p

Yahyaoğlu Z, Genç M (2007) Fidan Standardizasyonu, Standart Fidan Yetiştirmenin Biyolojik ve Teknik Esasları. SDÜ Orman Fakültesi Yayın No:75, Isparta, 555 s