Academic Analysis and Discussions in Agriculture, Forestry and Fisheries

Editor: Assist. Prof. Derya GÜLOĞLU



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MORPHOLOGICAL CHARACTERISTICS AND QUALITY CLASSIFICATION OF *Picea orientalis* (L.) LINK SEEDLINGS AT DIFFERENT AGES

Fahrettin ATAR[1]

Ali BAYRAKTAR[2]

1. INTRODUCTION

In Turkey, significant efforts have been made from the past to the present to increase and sustain the presence of forests. The forest coverage in our country was 20,199,296 hectares in 1973 and reached 22,933,000 hectares by 2020, encompassing 29.4% of the country's landmass. However, 44% of these forests are normal, while 56% are characterized as degraded forests. The transformation of degraded forest areas back into efficient and productive ones, both qualitatively and quantitatively, holds paramount importance for the continuity of various functional benefits provided by forest ecosystems (Anonymous, 2020).

To secure the future and minimize the risks of forest establishment and afforestation efforts, which involve extended durations and high costs, it is imperative to employ superior genetic qualities of seeds and seedlings (Çalışkan and Boydak, 2017; Gregorio et al., 2017). Additionally, the success of afforestation initiatives, from both economic and biological standpoints, is contingent upon environmental conditions, appropriate planting techniques, land preparation, timing, and the

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use of high-quality seedlings (Gezer and Yücedağ, 2006). Seedlings of high quality are characterized as those that achieve the expected levels of growth and survival after being planted (Johnson and Cline, 1991; Mattsson, 1997).

The advancements observed in afforestation efforts have also accelerated studies in tree breeding. The percentage of quality in the seedlings to be grown in nurseries primarily depends on the quality of the seeds used. The primary challenge in this regard is determining the origin in terms of region, altitude, and trees from which high-quality seeds can be sourced. Therefore, identifying populations with superior trees and progressively improving them through their breeding could lead to achieving superior attributes. Rational utilization of existing forest areas in terms of both quality and quantity should be enhanced (Turna and Güney, 2009). It is emphasized that morphological characteristics of seedlings such as diameter, length, stem-root ratio, and dry weight significantly influence the quality attributes of seedlings established in afforestation areas (Şevik et al., 2003). The utilization of high-quality seedlings in afforestation endeavors could contribute to increased planting success, reduced completion efforts, and the production of higher quality and quantity of timber in a shorter time frame per unit area (Bilgin, 2019).

Morphological features are the most often assessed qualities in seedling quality classifications because they are inexpensive and simple to measure (Mexal and Landis, 1990; Yahyaoğlu and Genç, 2007). Assessing morphological aspects doesn't require specialized tools or much training, in contrast to physiological qualities. Measuring root-collar diameter and seedling length are the easiest morphological parameters to measure. (Haase, 2008). Morphological characteristics have been used in several studies to assess the quality of seedlings in a variety of species (Donahue and Upton, 1996; Apholo and Rikala,

2003; South et al., 2005; Aksu and Tilki, 2015; Ivetić et al., 2016; Ayan et al., 2020a; Atar, 2021; Güney et al., 2023). However, there is a limited number of studies in the literature regarding the classification of seedling quality for the Oriental spruce, which is one of our tree species with significant distribution areas in Turkey.

Picea orientalis (L.) Link, recognized as a paleo-endemic tree species (Yahyaoğlu et al., 1991), holds significant importance within the forest ecosystems of Turkey's Eastern Black Sea region. This species exhibits widespread presence in the northeastern sector of the Black Sea region and in adjacent areas within the Caucasus. The expanses of pure and mixed oriental spruce forests initiate just west of the Melet River in Ordu, Turkey, and continue along the southern stretches of the Caucasus Mountains into Georgia. Its natural distribution commences at the coastal regions and ascends to elevations as high as 2400 meters above sea level (Kayacık, 1980).

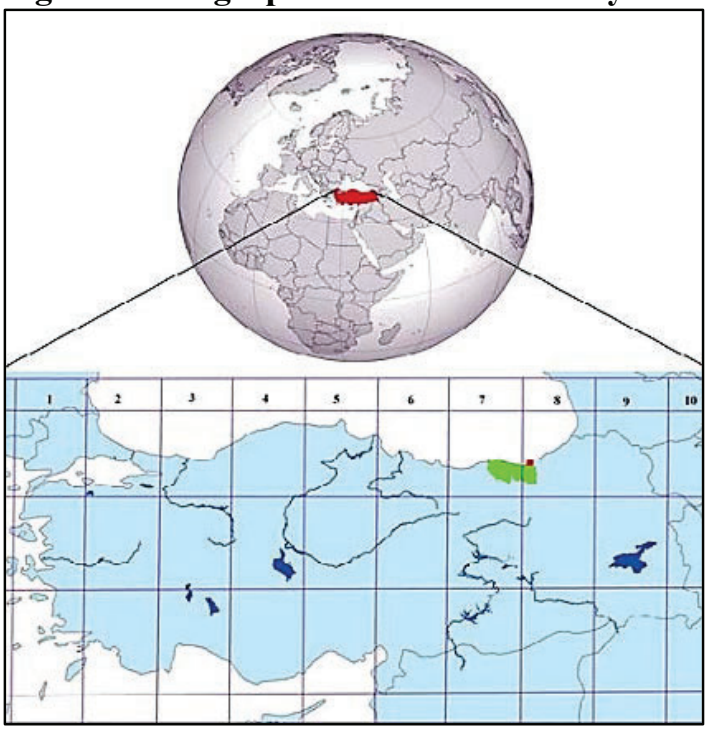
In this study, (I) the determination of certain morphological characteristics of Oriental spruce seedlings at different ages and (II) the identification of quality classes of seedlings based on Turkish Standards Institution (TSE) seedling standards and sturdiness quotient were aimed at.

2. MATERIAL AND METHOD

In this study, 1 and 3-year-old Oriental spruce (*Picea orientalis* L.) seedlings, raised from seeds collected from Giresun-Bicik origin, were used as the material. The seedlings utilized as material were cultivated in the Trabzon-Of Forest Nursery. Geographically, the nursery is located at 40° 58' 39" to 40° 59' 19" north latitude and 40° 19' 34" to 40° 20' 19" east longitude (Figure 1). Its average elevation from sea level is 5 meters. The nursery spans a total area of 242,000 square meters.

The region experiences cool and highly rainy summers, coupled with cold winters. Situated at the base of the valley, the nursery encounters cooler nights while days exhibit typical Eastern Black Sea climatic conditions. The soil composition consists of a sandy-loamy structure, primarily comprising a mix of sand and silt. Being an old riverbed, the nursery area is generally flat (Anonymous, 2007–2011).

Figure 1. Geographical location of study area



At Trabzon-Of Forest Nursery, Oriental spruce seedlings are cultivated in ENSO-type containers. Peat and perlite are used as the filling materials. Planting of Oriental spruce seeds is initially done in 84-cell ENSO-type containers. One-year-old seedlings spend their first growth phase in the 84-cell containers and are subsequently transferred to 24-cell ENSO-type containers at the end of this initial growth period. The 1-year-old seedlings used in the study were grown in 84-cell ENSO-type containers, while the 3-year-old seedlings were cultivated in 24-cell ENSO-type containers. All nursery operations (irrigation, shading, weed

control, maintenance, etc.) were routinely and systematically conducted.

Measurements related to morphological characteristics were conducted on a random and three-repeated sample of 50 seedlings from containerized seedling production beds. Root-collar diameter and seedling length values were measured for 1 and 3-year-old seedlings. Additionally, the calculated values of morphological traits and the sturdiness quotient were determined.

The seedling length (SdL) was measured with an accuracy of ±0.1 cm using a meter, while the root collar diameter (RCD) was measured with a digital caliper with an accuracy of ±0.01 mm. Sturdiness quotient (SQ) was determined by the ratio of seedling length (mm) to root collar diameter (mm). The sturdiness quotient signifies the vitality and robustness of the seedling (Thompson 1985; Aldhous 1994; Jaenicke 1999).

The seedlings were classified based on the SQ values into quality seedlings (SQ < 50), medium-quality seedlings (50 < SQ < 60), and low-quality seedlings (SQ > 60) (Yahyaoğlu and Genç, 2007). Additionally, to determine the quality classes of Oriental spruce seedlings, compliance with TS 2265/February 1988 TSE standards was assessed using the quality classes of coniferous species (Table 1).

Table 1. Quality classes of Oriental spruce seedlings according to TS 2265/February 1988 standards

Seedling Age	Seedling Class	SdL (cm)	RCD (mm)
1	I	≥ 4.0	≥ 2.0
	II	3.0 – 3.9	
	Non-standard	< 3.0	< 2.0
3	I	≥ 13	≥ 2.0
	II	10.0 – 12.9	
	Non-standard	< 10.0	< 2.0

(Anonymous, 1988)

The basic statistics (mean, standard deviation, standard error, minimum and maximum values, ranges) for the seedling

length, root-collar diameter measurements, and calculated sturdiness quotient values were computed using the SPSS 26.0 statistical software.

3. RESULTS

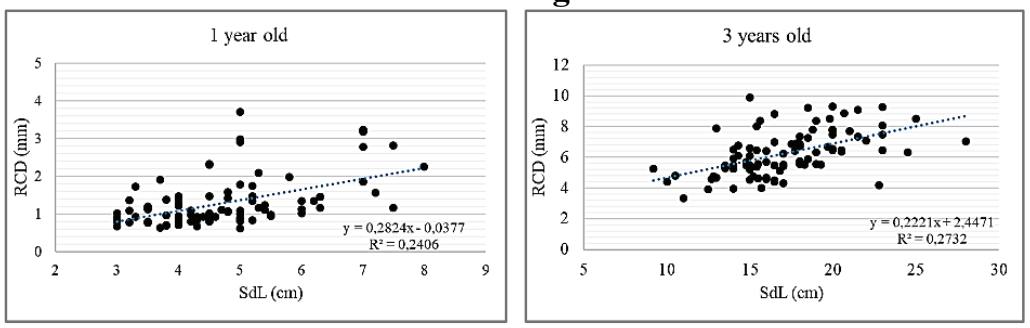
The basic statistics for seedling length, root-collar diameter, and sturdiness quotient values obtained from seedlings are presented in Table 2. The lengths of 1-year-old seedlings vary between 3.00 cm and 8.00 cm, with an average seedling length of 4.76 cm. For 3-year-old seedlings, lengths range from 6.00 cm to 28.00 cm, with an average seedling length of 17.22 cm. Observing the minimum and maximum values for seedling length, a considerable range of variability is evident. RCD for 1-year-old seedlings ranges between 0.62 mm and 4.25 mm, with an average of 1.33 mm. In 3-year-old seedlings, RCD ranges from 3.32 mm to 9.90 mm, with an average of 6.27 mm. Similar to seedling length, there is a notable variability between the maximum and minimum RCD values. Looking at the results for the SQ, the average SQ value for 1-year-old seedlings is 40.58, while for 3-year-old seedlings, the SQ value is determined to be 28.25.

The relationship between root-collar diameter and seedling length in Oriental spruce seedlings was separately evaluated for one- and three-year-old seedlings. Accordingly, the correlation coefficient between root-collar diameter and seedling length was determined as $R2 = 0.24$ for one-year-old seedlings and $R2 = 0.27$ for three-year-old seedlings (Figure 2).

Table 2. Statistical data on the seedlings' morphological characteristics

		Seedling age	
		1-year old	3-year old
SdL(cm)	Mean	4.76	17.22
	Standard deviation	1.13	3.45
	Standard error	0.12	0.36
	Minimum	3.00	6.00
	Maximum	8.00	28.00
RCD (mm)	Mean	1.33	6.27
	Standard deviation	0.73	1.46
	Standard error	0.08	0.15
	Minimum	0.62	3.32
	Maximum	4.25	9.90
SQ	Mean	40.58	28.25
	Standard deviation	13.73	6.01
	Standard error	1.45	0.63
	Minimum	5.88	15.15
	Maximum	80.85	54.29

Figure 2. The relationship between RCD-SdL in Oriental spruce seedlings



The compliance of seedlings with TSE standards was evaluated based on criteria related to seedling length and root-collar diameter. It was determined that 12.2% of one-year-old seedlings met the criteria for the first-quality class, while 87.8% were considered discarded seedlings. There were no seedlings classified in the second-quality class. Concerning the sturdiness quotient, it was observed that 76.7% of one-year-old seedlings were of quality, while only 6.5% were categorized as low-quality. Notably, there exists a significant inconsistency between the TSE quality standards and the sturdiness quotient for one-year-old

seedlings. As per TSE standards, 92.2% of three-year-old seedlings were classified in the first-quality class, 6.7% in the second-quality class, and 1.1% were considered discarded seedlings. Based on the sturdiness quotient, 98.9% of three-year-old seedlings were of quality, 1.1% were of medium quality, and no seedlings were categorized as low quality. It was observed that the results between TSE standards and the sturdiness quotient for three-year-old seedlings generally aligned and demonstrated coherence (Table 3).

Table 3. Classification of quality based on sturdiness quotient and TSI standards

Seedling age	Quality classes of TSI (%)			SQ (%)		
	I	II	Non-standard	Quality	Medium Quality	Low Quality
1-year old	12.2	0.0	87.8	76.7	16.7	6.6
3-year old	92.2	6.7	1.1	98.9	1.1	0.0

4. DISCUSSION AND CONCLUSIONS

The primary criterion used in the early research on seedling quality categorization was seedling length (Yahyaoğlu and Genç, 2007). While some researches suggested a negative link between seedling length and survival rate (Larsen et al., 1986; Dirik, 1991), Semerci (2002) demonstrated a positive correlation between these two measures. Furthermore, compared to seedling length, it has been proposed that root-collar diameter is a more important factor in seedling quality assessment (Şimşek, 1987; Yahyaoğlu and Genç, 2007). In this study, the average lengths of one-year-old and three-year-old seedlings were determined to be 4.76 cm and 17.22 cm, respectively. The mean RCD values for the seedlings were obtained at 1.33 mm for one-year-old seedlings and 6.27 mm for three-year-old seedlings. Observation of the minimum and maximum values for seedling length and root-collar diameter reveals a substantial range of variability. Indeed, Ayan et al. (2020b) highlighted a considerable

range of variation in seedling lengths and indicated high heterogeneity in seedling production across different ages of stone pine seedlings. Genç (1992) emphasized the significance of Oriental spruce seedlings used in afforestation projects having a minimum length of 20 cm and a minimum root-collar diameter of 8 mm.

The four-year growth performance of common hornbeam seedlings was investigated in a research by Atar et al. (2018), and the results showed that there were notable variations in seedling length and root-collar diameter between various populations. Similar to this, research on the Oriental beech species showed that different populations varied significantly in terms of root-collar diameter and seedling length (Gülseven et al., 2019). Likewise, variations in populations have been illustrated in species such as Oriental spruce (Atasoy, 1996; Güney et al., 2019), Kazdağı fir (Velioğlu, 1999), Oriental beech (Güney et al., 2016), Turkish red pine (Işık, 1994; Işık and Kara, 1997), Taurus cedar (Yahyaoğlu et al., 2012), Anatolian black pine (Şimşek et al., 1985), common hornbeam (Güney et al., 2015; Atar et al., 2017; Atar, 2021), and Oriental hornbeam (Güney et al., 2013; Atar et al., 2014; Atar and Güney, 2021) common using various morphological traits to depict variations among populations.

In seedling quality classification, another criterion of preference is the sturdiness quotient, where a smaller sturdiness quotient value is desired concerning seedling quality, indicating higher success rates in planting for seedlings with lower sturdiness quotient values (Genç, 1992). Atar et al. (2023) observed that as the age of oriental hornbeam seedlings increased, the percentage of high-quality seedlings based on the sturdiness quotient was found to be 24%, 32%, 34%, and 18%, respectively. Kestek (2012) reported the highest SQ value at 39.6% for conventionally grown control seedlings among one-year-old stemless oak seedlings, while the lowest SQ value at 28.7% was

observed for tube-grown seedlings. In a study involving various populations of Oriental beech seedlings, all populations were classified as high-quality due to their SQ values being less than 50 (Gülseven et al., 2019). According to Atar (2021), based on the sturdiness quotient, 11.5% of common hornbeam seedlings and 27.2% of oriental hornbeam seedlings were categorized as high and medium quality, whereas 88.6% of common hornbeam seedlings and 72.8% of oriental hornbeam seedlings were classified as low-quality and unsuitable for use. Another study indicated variation in SQ values for *Quercus brantii* based on planting density, ranging from 43 to 53 (Çanakçı, 2011). It was stated that 100% of *Acer pseudoplatanus*, 93.3% of *Fagus orientalis*, and 97.8% of *Carpinus betulus* were classed as low-quality seedlings based on SQ values in a research examining the morphological traits of certain broad-leaved forest tree seedlings (Ayan et al., 2020a).

When examining the results between TSE quality standards and the sturdiness quotient, significant inconsistencies were noted in the classifications of one-year-old seedlings, whereas classifications of three-year-old seedlings were found to be coherent. Based on the data collected, these findings imply that the TSE seedling quality standards and the sturdiness quotient criteria alone are not adequate to assess the quality of oriental spruce seedlings that are one-year-old.

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