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Effects of cultural treatments, seedling type and morphological characteristics on survival and growth of wild cherry seedlings in Turkey

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Wild cherry (*Prunus avium* L.) is receiving increasing attention from foresters in Europe and Turkey for its fast growth, highly-valued wood and benefits for wildlife and biodiversity. Little documentation may be found concerning the selection of appropriate cultural treatments and the quality and types of seedlings used for wild cherry plantations. This study reports the effects of various combinations of intensive cultural treatments (including weed control, soil tillage, and fertilization) and seedling types on early growth, survival, and nutrition of one-year-old wild cherry seedlings out-planted on four different sites in the western Black Sea Region of Turkey. After two years, early seedling survival and growth were clearly enhanced for potted seedlings. For bare-root seedlings, initial seedling root-collar diameter and height successfully correlated with survival two years after planting. Seedlings with a root-collar diameter of 6-8 mm and height of 60-70 cm demonstrated the best survival rates in the field. The wild cherry seedlings were shown to be highly sensitive to herbaceous weed competition early in their establishment, warranting effective weed control. When used in addition to weed control, neither intensive fertilization nor soil tillage treatments significantly increased seedling survival and growth two years after planting. Therefore, intensive site preparation, as well as fertilization, are not recommended at this stage for planting sites without severe nutrient deficiencies.

Keywords: Fertilization, Seedling Quality, Tillage, Weed Competition

Introduction

Reaching up to 1.20 m in diameter and 35 m in height, wild cherry (*Prunus avium* L.) is a fast-growing, broadleaved tree species with a wide natural distribution in both Europe and Turkey. Due to its significant environmental (*e.g.*, biodiversity) and economic (*e.g.*, high-quality wood) importance, wild cherry is considered a valuable broadleaved tree species in Europe. The demand for its high-quality wood often exceeds the supply, resulting in higher prices in the market. Therefore, there is an increasing incentive to grow wild cherry in both Europe (Russell 2003, Hemery et al. 2008, Savill et al. 2009) and Turkey (Tosun & Özpay 1988, Yaman 2003, Esen et al. 2005).

Wild cherry is found scattered in mixed deciduous and coniferous-deciduous forests in Europe and Turkey, growing as single individuals or in small groups. It prefers deep, moist but well-drained, fertile, and slightly acidic sandy loam to loamy soils (Tosun & Özpay 1988, Savill 1991, Russell 2003, Yaman 2003, Esen et al. 2005, Stojecova & Kupka 2009). In northern Turkey, cherry is mostly found on the mesic north- and east-facing aspects of the mixed deciduous forests of the Black Sea Region (BSR). The coastal belt of the BSR, where it occurs most frequently, is characterized by heterogeneous topography, oceanic climate, and high soil productivity. The average annual temperature of the belt is 14-15°C, and the average annual rainfall is about 1000 mm (Atalay 2002).

Similar tree species are associated with wild cherry in natural forests in Europe (especially Germany - Thies et al. 2009) and Turkey. In the western BSR, it grows in the *Castanetum* phytoclimatic zone at low elevations (Tosun & Özpay 1988, Atalay 2002, Yaman 2003). Wild cherry is found heavily mixed with sweet chestnut (*Castanea sativa* Mill.), maples (*Acer* spp.), European hornbeam (*Carpinus betulus* L.), eastern beech (*Fagus orientalis* Lipsky), and ashes (*Fraxinus* spp.). Scattered occurrences of wild cherry are frequent in the pure eastern beech stands of the *Fagetum* zones in the region. It is occasionally found with oaks (*Quercus* spp.) on drier sites (Tosun & Özpay 1988, Atalay 2002, Yaman 2003). Wild cherry is a shade-intolerant species, making it very sensitive to competition from the surrounding trees. Therefore, shade-tolerant eastern beech frequently outcompetes and displaces wild cherry in natural settings, a situation very similar to that of the wild cherry and European beech (*F. sylvatica* L.) in Europe (Stojecova & Kupka 2009).

In addition to high-quality wood production, intensive plantations may help to conserve native forest resources (Donoso et al. 2009). The key characteristics of a successful plantation include appropriate site selection and establishment techniques. Intensive silvicultural treatments accelerate stand development, channel the limited site resources to targeted species and individuals, and reduce rotation periods (Newton et al. 2002). Growing wild cherry in intensively managed plantations can also help reduce Turkey's shortage of quality timber. Although the seed ecology and early seedling growth performances of different seed sources of wild cherry have been studied to a certain extent, no research has been conducted in Turkey so far on the possible survival and growth responses of young wild cherry seedlings to intensive silvicultural treatments (Esen et al. 2005, 2006a, 2009, 2011).

Poor seedling stock can dramatically reduce survival and field performance. Unlike with conifers, there has been little research on the key morphological characteristics associated with the performance of broadleaved tree species following out-planting (Jacobs et al. 2004). Various morphological characteristics, including root-collar diameter, shoot height, and sturdiness ratio (height-to-diameter ratio), are commonly used to evaluate the ability of hardwood seedlings to tolerate environmental and transplanting stresses (Jacobs et al. 2004). Identifying key morphological characteristics improving the survival of young wild cherry seedlings in the first period of establishment will cer-

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Tab. 1 - Locations and geographic data of the study sites in the jurisdiction areas of Bolu and Zonguldak regional forestry directorates in the western Black Sea region of Turkey, where one-year-old *Prunus avium* seedlings were planted.

Site	Forest Unit	Series	Aspect	Elevation (m)	Mean Slope (%)	Latitudes/ Longitudes
Eregli	Merkez, Kdz. Ereglisi, Zonguldak	53	W-NW	248	19	41° 18.346’ N 31° 25.454’ E
Bendere	Bendere, Kdz. Ereglisi, Zonguldak	75	N	1100	20	41° 03.667’ N 31° 36.800’ E
Akçakoca	Deredibi, Akçakoca (Düzce), Bolu	34b	NW	790	2	40° 59.704’ N 31° 07.504’ E
Cumayeri	Melen (Düzce), Bolu	223	-	145	1	40° 51.802’ N 30° 56.881’ E

tainly help ensure a successful plantation.

This study assessed the early effects of various combinations of intensive cultural treatments (including weed control, soil tillage, and fertilization) and seedling types on the survival, growth, and nutrition of one-year-old wild cherry seedlings planted on four different sites in the western Black Sea Region. The study also focused on the relationships between early seedling survival and various morphological characteristics, including initial diameter, height, and sturdiness ratio.

Materials and methods

Site description

The study was carried out on four different sites in the western Black Sea Region (BSR) of Turkey (Tab. 1). Three sites, the Karadeniz Ereglisi (Eregli), Bendere, and Akçakoca (Deredibi) sites, are in recently clear-cut, natural, pure or mixed eastern beech stands located in the vicinity of the Black Sea coast (Anonymous 2008a, 2008b, Yildiz et al. 2009, 2010). The overstorey is primarily a closed beech canopy. Sweet chestnut, maples, and wild cherry make up < 10% of the forest canopy (Anonymous 2008a, 2008b, Yildiz et al. 2009, 2010). The understorey is overgrown with purple-flowered rhododendron (*Rhododendron ponticum* L.). The average yearly temperature and precipitation are 13°C and 1100 mm, respectively (Anonymous 2008a, 2008b, Yildiz et al. 2009, 2010). The fourth location, Cumayeri, is inland and was formerly a degraded oak (*Quercus* spp.) site. Its average yearly temperature and precipitation are 13°C and 840 mm, respectively (Anonymous 2008c).

The soils of the three coastal sites are comparatively fertile and well-drained, and vary from sandy loam to clay, whereas the inland site has heavy, clayey soil with low drainage (Anonymous 2008a, 2008b, 2008c, Yildiz et al. 2009, 2010). The standard treatments employed by the General Directorate of Forestry prior to plantings were applied to all the sites in preparation for this study. In the fall of 2007, the sites were first raked in a broadcast manner to remove the existing woody vegetation (rhododendrons and oaks). Then, using a bulldozer carrying a brush rake or soil ripper, the sites were ripped down to the first one-meter soil depth in order to promote root growth.

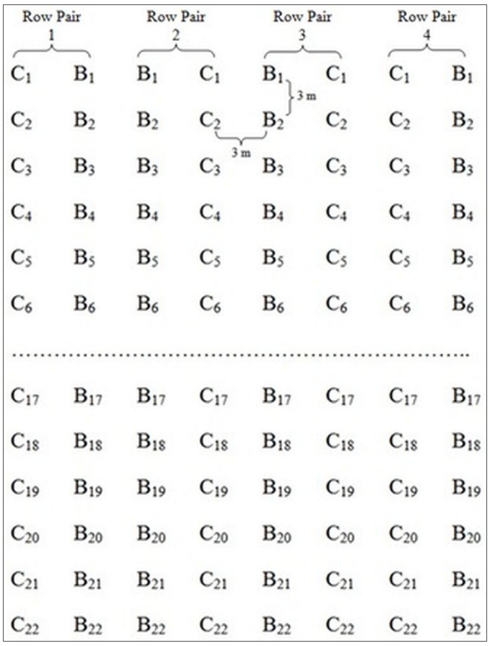

Fig. 1 - An illustration of the experimental layout of bare-root (B) and potted (C) one-year-old seedlings of wild cherry out-planted on four different sites in the western Black Sea Region of Turkey.

Plant material

In the late summer of 2006, the Eregli Forest Management Directorate collected seeds from naturally open-grown mature (40 to 50 years-old) wild cherry trees. These trees were scattered throughout Halli and Gümeli (41°05’09”N; 31°28’00”E) between 400-800 m a.s.l. in the sub-province of Karadeniz Ereglisi, Zonguldak. Seedlings were grown from seeds under standard nursery practices at the Zonguldak Devrek Forest Nursery (41°13’30”N; 31°57’35”E) during 2007. Seedbeds were irrigated as needed and fertilized monthly between May and August with 18-46-0 diammonium phosphate at the rate of 45 kg N and 115 kg P ha^{-1}. Herbaceous weeds growing in the nursery beds were removed by hand monthly during the growing season.

At the end of the growing season, a group of the cherry seedlings were lifted, root-pruned, and then transplanted into 4-L plastic pots. The seedlings were irrigated on an as-needed basis. A month later, a second group of bare-root seedlings were lifted and root-pruned similar to the first group. The roots of these were covered with burlap and kept moist until they were planted. By the end of 2007, all of the potted and bare-root seedlings had been carefully transferred to the experimental sites and planted.

Cultural treatments

Four treatments, including different combinations of weed control (WC), tillage (T) and fertilization (F), and finally the control (no treatment), were used for the study. For the weed-control treatment (WC), in the early spring of two consecutive years (2008 and 2009), herbaceous vegetation growing within a 50-cm radius of a given seedling stem was completely removed to the bare ground using a hand sickle. The treatment was repeated within the same growing season on an as-needed basis to control weed regrowth.

For the second treatment (WC + T), the soil within a 50-cm radius of seedlings was hoed by hand in the early spring for two growing seasons. This treatment basically removed the competing vegetation and tilled the soil around the seedlings in one step. As in the WC treatment, weeds that regrew within the same growing season were manually controlled when deemed necessary.

For the last and most intensive treatment (WC + T + F), seedlings received the same

WC + T treatment; in addition, subsequent to hoeing, 15-15-15 NPK and triple super phosphate (TSP) fertilizers were applied once by hand to the tilled soil around the seedlings at 275 kg ha^{-1} and 138 kg ha^{-1} rates, respectively. Successive weed competition that occurred within the same growing season was eliminated manually.

Tab. 2 - Effects of various cultural treatments in increasing intensity on mean survival, height, diameter, and relative growth rates of one-year-old *Prunus avium* seedlings planted in the western BSR of Turkey one and two years after treatments (YAT) with standard errors. (1): treatment x seedling-type interaction effect was not significant ($p > 0.05$); (2): due to total seedling mortality, the control treatment was excluded from the analysis; (3): means within the same column within the same year with different letters are significantly different ($p \leq 0.05$).

Treatment $^{(1)}$	Survival (%)	Height (cm)	Diameter (mm)	Height Growth (%)	Diameter Growth (%)
One YAT					
Control $^{(2)}$	0	0	0	0	0
WC	$77 \pm 4^{a\,(3)}$	82 ± 6^{a}	10.2 ± 0.9^{a}	122 ± 23^{a}	96 ± 19^{a}
WC+T	86 ± 4^{a}	92 ± 6^{a}	10.8 ± 0.9^{a}	145 ± 23^{a}	94 ± 20^{a}
WC+T+F	82 ± 3^{a}	87 ± 4^{a}	11.2 ± 0.7^{a}	142 ± 18^{a}	102 ± 15^{a}
Two YAT					
Control	0	0	0	0	0
WC	78 ± 4^{a}	102 ± 9^{a}	13.9 ± 1.2^{a}	214 ± 37^{a}	160 ± 23^{a}
WC+T	83 ± 3^{a}	111 ± 9^{a}	14.6 ± 1.3^{a}	189 ± 38^{a}	155 ± 24^{a}
WC+T+F	78 ± 3^{a}	107 ± 7^{a}	14.8 ± 0.9^{a}	216 ± 29^{a}	171 ± 18^{a}

Experimental design and statistical analysis

A factorial design within a randomized complete block design (RCBD) with four blocks (sites) was used for the experiment. The first experimental factor was the seedling type, occurring at two levels (potted and bare-root), whereas the cultural treatment was the second factor, occurring at four levels initially. However, all seedlings in the control treatment were killed off one year after planting due to severe herbaceous competition. To prevent this fact from swamping any treatment differences between the non-control treatments, the data were analyzed without the control treatment, except for the leaf nutrient analysis.

The potted and bare-root wild cherry seedlings were separately planted within two adjacent rows, constituting a row pair (Fig. 1). There were four pairs of seedling rows on each experimental site. The order of the seedling type (bare-root or potted) was randomly determined for each row pair prior to planting. Each row constituted an experimental unit for this study, containing 22-24 potted or bare- root seedlings planted with 3 x 3 m spacing. In total, 368 potted and 372 bare- root seedlings were planted for the study.

The four experimental treatments were randomly assigned to the four seedling row pairs for each experimental site (Fig. 1). The effects of the seedling type and cultural treatments on seedling survival, growth, and nutrition were analyzed with the two-way analysis of variance (ANOVA). P values < 0.05 were considered significant. Data were analyzed using the SAS package (SAS Institute Inc 1996).

Measurements

For each treatment, the seedlings were measured for initial height and root-collar diameter (hereafter termed diameter) at the beginning of the experiment, and re-measured at the end of each growing season for two years. The percent of seedling survival was also determined for each treatment for each growing season. The relative growth rate of the seedlings in each treatment was measured using a formula for the first and second growing seasons (Radosevich et al. 2007 - eqn. 1):

$$RGR(\%)=\frac{V_2-V_1}{V_1}\cdot 100$$

where *RGR* is the relative growth rate of a seedling from time 1 to time 2; V_1 is the seedling diameter (mm) or height (cm) at the beginning of the experiment; V_2 is the seedling diameter (mm) or height (cm) at the end of the first or second growing season.

For nutrient analysis in the first growing season, 15 seedlings on each seedling row (*i.e.*, experimental unit) were randomly chosen in July 2008 to determine the treatment effects on seedling nutrition. However, only five to eight seedlings could be used for leaf sampling of the control treatment group due to low seedling survival at the time of the sampling. Eight to ten leaves from different crown positions (upper, middle and lower) were collected from each sample seedling. The leaf samples were air-dried, later ground with a coffee grinder. After grinding, leaf samples were dried at 80ºC and weighed in 100-200-mg aliquots for total C analysis, and 500-mg aliquots for analysis of N (Jones & Case 1990, Yildiz et al. 2010). Leaf C and N concentrations were determined using a dry combustion method in a LECO CNS 2000 Carbon Analyzer (LECO Corp., St. Joseph, MI - Nelson & Sommers 1996, Yildiz et al. 2010). For nutrient analysis, plant tissue samples were digested with a mixture of nitric and perchloric acids (Jones & Case 1990, Yildiz et al. 2010). Phosphorus concentrations were determined with a Spectronic Colorimeter. K and Ca were determined with a Jenway Flame Photometer (Sparks et al. 1996, Yildiz et al. 2010).

Results

Seedling survival and growth

One and two years after treatment (YAT), no significant interactions were detected between the cultural treatment and seedling type. Seedling survival, diameter, height, and relative growth rate 1 and 2 YAT did not significantly differ among the cultural treatments (Tab. 2). However, seedling type significantly affected the mean survival rate of the seedlings 1 and 2 YAT (Tab. 3), with the potted seedlings showing almost a 12% greater survival rate than the bare-root seedlings 1 and 2 YAT. The two seedling types did not dramatically differ in growth variables 1 and 2 YAT, except for second-year diameter. The potted seedlings were almost 35% greater in diameter than the bare-root seedlings 2 YAT (Tab. 3).

Tab. 3 - Effects of seedling type (potted and bare-root) on mean survival, height, diameter, and relative growth rates of one-year-old *Prunus avium* seedlings planted in the western BSR of Turkey one and two years after treatment (YAT) with standard errors. (1): treatment x seedling-type interaction effect was not significant ($p > 0.05$); (2) means within the same column within the same year with different letters are significantly different ($p \leq 0.05$).

Seedling Type $^{(1)}$	Survival %	Height (cm)	Diameter (mm)	Height Growth (%)	Diameter Growth (%)
One YAT					
Potted	$86 \pm 3^{a\,(2)}$	88 ± 4^{a}	11.4 ± 0.6^{a}	147 ± 17^{a}	87 ± 14^{a}
Bare-rooted	77 ± 3^{b}	86 ± 4^{a}	10.1 ± 0.6^{a}	125 ± 17^{a}	107 ± 14^{a}
Two YAT					
Potted	84 ± 3^{a}	112 ± 6^{a}	16.6 ± 0.9^{a}	147 ± 17^{a}	181 ± 17^{a}
Bare-rooted	76 ± 3^{b}	102 ± 6^{a}	12.3 ± 0.9^{b}	126 ± 17^{a}	142 ± 17^{a}

Tab. 4 - Effects of the different cultural treatments in increasing intensity on leaf nutrient concentrations (%) and C:N ratios of one-year-old *Prunus avium* seedlings planted in the western BSR of Turkey one year after treatment. (1): treatment x seedling-type interaction effect was not significant ($p > 0.05$); (2): means within the same column with different letters are significantly different ($p \leq 0.05$).

Treatment(1)	C	N	C:N	P	K	Ca
Control	48.2 a (2)	2.14 b	26 a	0.33 a	1.08 a	1.07 a
WC	47.9 a	2.11 b	24 a	0.29 a	1.10 a	1.02 a
WC+T	48.0 a	2.43 ab	20 ab	0.32 a	1.08 a	0.91 a
WC+T+F	48.0 a	2.73 a	18 b	0.34 a	1.08 a	1.02 a

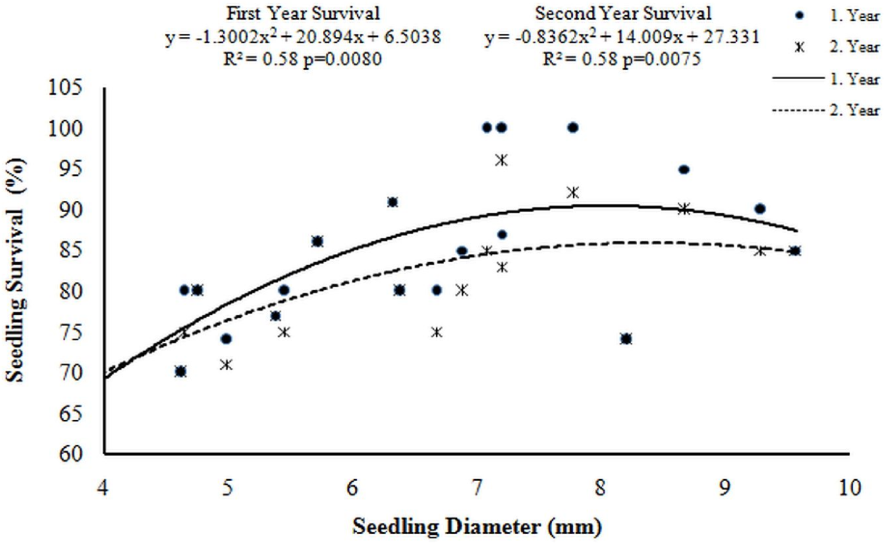

Fig. 2 - Relationship between mean seedling survival rate (%) and initial seedling diameter (mm) for one-year-old wild cherry seedlings planted on four sites in the western Black Sea Region of Turkey one and two years after planting with regression equation, Pearson correlation coefficient, and significance level.

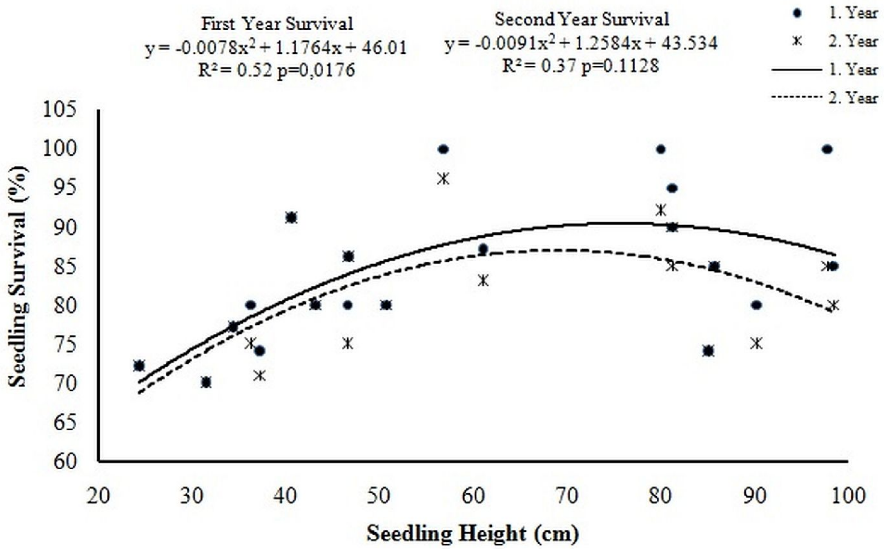

Fig. 3 - Relationship between mean seedling survival rate (%) and mean initial seedling height (cm) for one-year-old wild cherry seedlings planted on four sites in the western Black Sea Region of Turkey one and two years after planting with regression equation, Pearson correlation coefficient, and significance level.

Leaf nutrient analysis

Similar to the findings of the survival and growth data, no significant interactions between the cultural treatment and seedling type were found for leaf nutrient analysis (Tab. 4). The seedling type had no significant effect on the concentrations of the leaf nutrients analyzed. Also, the effects of various cultural treatments, including the control, on leaf C, P, K, and Ca concentrations were not significantly different. However, the seedlings with the most intensive cultural treatment (WC+T+F) had a significantly greater (28%) leaf N concentration compared to the seedlings of the WC and control group (Tab. 4). The seedlings with the WC+T+F treatment had the lowest C:N ratio among those of all treatments. The mean leaf C:N ratios of the control and WC seedlings were significantly greater (33% and 44%, respectively) than those of the WC+T and WC+T+F seedlings (Tab. 4).

Seedling morphological characteristics

Among the three non-control cultural treatments, there were no statistically significant variations for seedling survival and growth 1 and 2 YAT. The relationships between the morphological characteristics and the survival of the bare-root seedlings were assessed using additional correlation and regression analysis. Relationships of the first- and second-year survival of the bare-root seedlings to the initial diameter, height, and height-to-diameter ratios were determined using simple regression and correlation analysis. Second-order regressions described the curvilinear relations of the initial diameter, height, and sturdiness ratio of the bare-root wild cherry seedlings with seedling survival 1 and 2 YAP (Fig. 2, Fig. 3).

The seedling diameters demonstrated a significant positive relationship with survival 1 and 2 YAP, with relatively high correlation coefficients (Fig. 2). First- and second-year seedling survival rates increased almost linearly with increasing seedling diameter up to diameters of 7-8 mm, yet tended to decline above this diameter range (Fig. 2).

Similarly to the first-year results for diameter, seedling height demonstrated a significant relationship with seedling survival 1 YAP (Fig. 3). Seedling survival increased with increasing height up to 60-70 cm, after which the relationship gradually turned negative. However, these two variables had no significant relationship 2 YAP (Fig. 3). Finally, the relationships between the sturdiness ratio and survival for both one- and two-year-old seedlings were not significant.

Discussion and conclusions

Wild cherry has a high demand for light, soil water, and nutrients; therefore, the species is highly sensitive to herbaceous weed competition in the first three years of establishment (Savill 1991, Joyce et al. 1998, Kupka 2002, Esen et al. 2006b). Unwanted vegetation substantially reduces the growth and survival of young cherry seedlings during establishment (Kupka 2002, Löf et al. 2004, Esen et al. 2006b). This was clearly confirmed by the present study, which had total seedling mortality in the control treatment group (Tab. 2). Elimination of competing vegetation is therefore an important requisite to producing wild cherry individuals with diameters of 50-60 cm in a 50- to 60-year rotation (Joyce et al. 1998, Nicolescu & Nicolescu 2002). However, the present study has shown that neither fertilization nor soil cultivation, nor a combination of the two performed as well as weed control in terms of additional survival and growth in the first two years (Tab. 2); therefore, they are not recommended. Similar results were obtained in Latvia (Daugaviete 2000) and in the Czech Republic (Dostalek et al. 2007), where various intensive cultural treatments, including mechanical and chemical weed control and tillage, did not produce significant growth differences for young wild cherry seedlings in the first three and five years following planting.

There are contradictory results in the previous studies of the effects of fertilization on the seedlings of broadleaved tree species (Jacobs et al. 2005). One group of these studies states that fertilization increases the seedling growth of broadleaved tree species (Chang 2003, Jacobs et al. 2004, 2005, Scowcroft & Silva 2005). However, another group reported that fertilization during the early establishment period does not have a major sustainable effect on tree seedling growth (Duryea & Dougerthy 1991, Löf & Welander 2004, Jacobs et al. 2005, Donoso et al. 2009) and is actually detrimental in some cases (Jacobs et al. 2005). The results of the present study were consistent with the findings of the second group.

The foliar nutrient levels of the cherry seedlings in the present study are similar to those of young eastern beech seedlings reported in previous studies that were carried out in the mesic, coastal part of the western BSR (Yildiz et al. 2009, 2010). Based on foliar analysis of the present study, as well as the survival and growth data, we found no substantial evidence that added nutrients had a significant effect on the cherry seedlings, except for N (Tab. 2, Tab. 4), and this was not substantiated by the survival and growth data. The lack of effects of fertilization on cherry survival, growth, and nutrition suggests that the productivity of the experimental site was adequate. The mesic and coastal sites of the western BSR, where three-fourths of this experiment were carried out, are well known for their relatively high productivity (Atalay 2002, Yildiz et al. 2010). The present case demonstrates that costly site operations, including fertilization, should be thoroughly justified before being applied to cherry planting sites. However, one should remember that these are early assessments and may change with future long-term data.

In the present study, the Cumayeri site was characterized by two extreme edaphic conditions. The soil was mostly waterlogged during the winter, whereas the water table fell quickly during the summer, leaving very dry and hard-to-penetrate soil. The lowest seedling survival and growth occurred on this site (data not shown), suggesting that soil moisture and aeration are essential and even more critical than soil nutrients for wild cherry survival and growth (Savill 1991, Higgs et al. 1995, Russell 2003). These findings present the opportunity to test the effect of plowing as an option for site preparation. Previous experiments have demonstrated that plowing may enhance soil drainage, weed control, and root growth of tree seedlings, enabling the establishment of broadleaved tree plantations in clay soil (Kätterer et al. 1995, Ponti et al. 2004).

Care should be taken with total plantations of wild cherry, since they are more susceptible to diseases than mixed plantations (Spiecker 1994). Mixing wild cherry with other broadleaved tree species, including ash (*F. excelsior* L.), is in fact recommended for enhanced productivity and disease control (Kerr 2004).

The superiority of potted seedlings over bare-root seedlings for tree seedling survival and growth is well documented (Wilson & Jacobs 2006, Haase 2007). The results of the present study were consistent with this finding (Tab. 4). The bare-root seedlings of broadleaved tree species commonly undergo a transplant shock, mostly due to drought and nutrient deficiency experienced following planting (Struve & Joly 1992). The soil column surrounding the root system of potted seedlings protects them from environmental stresses (*e.g.*, drought, freezing-thawing cycles, and transplant shock) and physical stresses (*e.g.*, abrasion, crushing, and root stripping). Additionally, in the spring, the constant contact of the root with the soil might physiologically activate potted seedlings earlier than the bare-root seedlings, improving survival and growth (Rietveld 1989, Jacobs et al. 2004, Jacobs et al. 2005, Haase 2007).

Using high-quality seedlings is an important prerequisite for successful plantation. The initial diameter has been reported to be the trait that was most significantly and positively related to early field survival and growth performance for many broadleaved tree species (Dey & Parker 1997, Jacobs et al. 2004). For example, in one Canadian study (Dey & Parker 1997), one-year-old red oak (*Quercus rubra* L.) seedlings with large initial diameters (> 8-10 mm) exhibited greater growth than those with smaller diameters. The present study corroborated this for wild cherry, yet with a size limit (Fig. 2). The diameter corresponds closely with above- and below-ground features, including root volume, area, and biomass, that are correlated with the success of seedlings after outplanting (Dey & Parker 1997, Jacobs et al. 2004). Also, greater diameters indicate greater carbon storage and energy for broadleaved seedlings, thus enhancing survival until seedlings begin harvesting resources from the soil following outplanting (Jacobs 2003). In the present study, the tendency of seedling survival to decline above a certain diameter range (7-8 mm) for wild cherry (Fig. 2) might suggest “the lack of balance in larger seedlings” (Thompson 1985).

Seedling height defines the photosynthetic and transpiration capability of seedlings and their competitiveness against weeds, and thus correlates well with seedling growth (Jacobs 2003, Haase 2007). Kupka (2001) stated that the initial height is a good estimate of wild cherry seedling survival during establishment. As they are sensitive to weed competition, young wild cherry seedlings that are taller can gain a substantial advantage over competing vegetation (Kupka 2001). Similar to findings of the present study (Fig. 3), the curvilinear relation of the initial height with survival has been reported for *Q. serrata* Murray and *Q. acutissima* Carruth. (Matsuda 1989, Hashizume & Han 1993, respectively). Hashizume & Han (1993) found that the survival of oak seedlings increased with initial height up to 100 cm, yet gradually declined for seedlings taller than 150 cm.

For successful wild cherry plantations, the quality and type of seedlings are important. Potted seedlings are to be preferred to bare-root seedlings for enhanced early survival and growth. Initial seedling diameter and height are effective indicators of early seedling survival. Selecting seedlings for planting of approximately 8 mm in diameter and 70 cm in height is therefore recommended for greater survival of bare-root seedlings of this broadleaved tree species.

Finally this study has been focused on the early development and on a short period of time; further work and long-term data are needed to confirm the results.

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