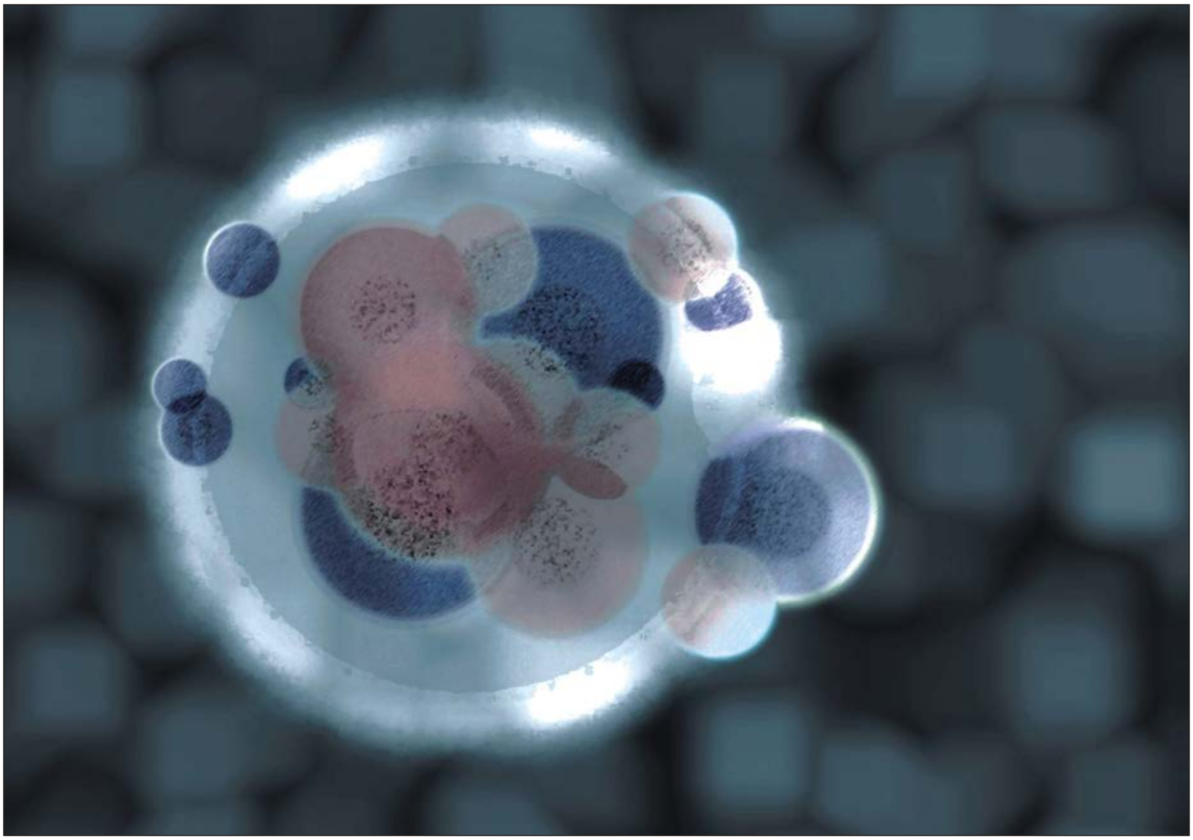

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Field Performance of Narrow-leaved Ash (*Fraxinus angustifolia* Vahl.) Rooted Cuttings and Seedlings

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Abstract: Outplanting performance of 1-year-old narrow leaved ash stocks (rooted cuttings and seedlings) grouped into three height categories (large, medium and small) were examined in a bottomland site with heavy clay soils. Stock type and stock size factors were not a significant predictor of survival of seedlings and rooted cuttings at the end of the first year in the field. The overall first-year outplanting survival of the 1+0 seedlings and rooted cuttings was 100% for all treatments. Stock type significantly affected first year diameter and height growth rate after planting and both diameter and height growth were higher in rooted cuttings (4.5 mm and 51.6 cm, respectively) than seedlings (2.8 mm and 27.0 cm, respectively) average for three stock sizes. Stock sizes had no significant affect on seedling diameter and shoot growth in both stock types. Large size rooted cutting-propagated narrow-leaved ash can provide significant advantages on seedlings and small size rooted cuttings on bottomland sites.

Key words: Outplanting performance, rooted cuttings, seedling morphology, vegetative propagation

INTRODUCTION

Ecosystems of bottomland hardwoods support a wide diversity of tree species, each of which is unique in terms of its biological requirements, silvical characteristics and pattern of growth over time. Successful management of these diverse ecosystems is necessarily complex. Narrow-leaved ash (*Fraxinus angustifolia* Vahl.) is the most common and useful native ash in Turkey. It is a fast-growing tree in moist bottom land of north-western swampy woodlands of Turkey (Çiçek and Yilmaz, 2002). Its wood is also desirable because of its strength, hardness and high shock resistance, and this species is also an ornamental tree (Pliura, 1999; Anonymous, 2005; Çiçek, 2005). It grows most commonly in riparian areas and also is a common associate in other forest cover types to about 700-800 m in Turkey (Davis, 1987; Mayer and Aksoy, 1998).

Like most trees, narrow leaved ash grows best on fertile, moist and well drained soils. Although natural stands of narrow leaved ash are confined to bottomlands in which soil fertility is low and soil water table is high, artificial stands of narrow leaved ash have a high growth rate and volume growth can reach to can yield 23 m^3 ha^{-1} per year (Kapucu *et al*., 1999). Thus, the species can grow well and have more yields when planted on fertile, well drained soils and used suitable silvicultural techniques in the artificial stands.

Ash species (*Fraxinus excelsior* and *F. angustifolia*) are getting more important in European forestry due to their fast growth ability, and valuable woods, and researches concentrate on their silviculture, breeding, genetics and gene conservation (Pliura, 1999; Eriksson, 2001; Çiçek, 2004; Anonymous, 2005).

In Turkey small sized narrow-leaved ash seedlings were usually planted for artificial regeneration and planting small seedlings can not tolerate competitions from weeds. Various levels of cultural treatments should be applied but this increases the cost. Planting high quality seedlings with more height can increase the planting success and reduce cost. But there is no study on the effect of seedling height on the plantation success.

Although there are some studies on micro- (Perezparron *et al*., 1994; Tonon *et al*., 2001) and macro-vegetative propagation (Kızmaz, 1996; Çetin, 2003; Çiçek, 2005) of this species, there are no or few studies on outplanting success of rooting cuttings. Thus, to assist in developing successful artificial regeneration techniques for narrow-leaved ash, there is a need for Turkish forestry to propagate this species by rooted cuttings and investigate the outplanting performance of the rooted cuttings in riparian areas. The objective of this study was to assess the out-planting performance of different stock types (rooted cuttings and seedlings) and stock sizes of 1+0 narrow-leaved ash in the field.

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MATERIALS AND METHODS

The field study was established on a bottomland site (artificial regeneration area) dominated by *F. angustifolia* located in Hendek-Adapazarı, Turkey (40°8' N, 30°32' E, altitude 25 m asl). The site has heavy clay soil with a soil pH of 7.5-7.9. The standing water level on the site may rise above the ground level through January-May, but soils on the site during summer are much dry (Çiçek, 2002). Annual precipitation averages approximately 800 mm and the temperature averages 14.2°C. The growing season is between 220-240 days (Anonymous, 2004). Older stand in the regeneration area was clearcut in fall, 2004 and then the stumps were uprooted. After the stumps and slashes were disposed, the soil was first ripped and then disked.

Seedlings were produced from seeds which were collected from natural narrow-leaved ash stands in Hendek, Turkey (40°52' N, 30°36' E, altitude 25 m). Collected seeds were sown in early spring of 2004 to produce 1+0 bareroot seedlings in Hendek forest nursery (altitude 60 m asl). Seedbeds were standard 1.2 m wide with five rows and the seeds were hand sown at 80 seed m^{-2} density. During the vegetation period, following the sowing date, the only treatment given was irrigation and weed control-hoeing.

Rooted cuttings were propagated from stem cuttings of 1+0 and 2+0 seedlings of narrow-leaved ash which were produced from seed collected from natural narrow-leaved ash stands in Hendek. Rooted cuttings were produced at the density of 33 rooted cuttings m^{-2} in Hendek forest nursery.

Two stock types (seedlings and rooted cuttings) were lifted by hand and graded in late February, 2005. After grading, two stock types were root-pruned to 25 cm and 30 seedlings and 30 rooted cuttings per plot were measured for their numbers of fine (diameter <2 mm) and coarse roots (diameters >2 mm) (Table 1).

Rooted cuttings and seedlings produced at the same time and in the same nursery from the same origin were grouped into three height categories: large (~110 cm), medium (~80 cm) and small (~50 cm).

The factorial experimental design was a randomized complete block with four replications. Each block contained six rows and, each row consisted of seedlings from a stock type with three shoot height categories (50, 80 and 110 cm). Each row was an experimental unit and contained 20 plants. Stock type and stock size combinations were randomly distributed in each block. A total of 480 plants (240 seedlings and 240 rooted cuttings) were hand-planted at 2×2 m spacing in March 2005.

Field measurements of initial seedling height and diameter were made immediately after planting (Table 1). Seedling diameter was measured 2.5 cm above the soil surface due to the muddy (mesic) site condition. The study plots received one hand-hoeing of the soil around the seedlings within a 70 cm radius circles and discking among rows in July 2005. Seedling survival, seedling height and seedling root collar diameter were measured at the end of first year in February 2006 when all late season flushing had ceased.

Analysis of variance (ANOVA) was used to evaluate the stock type and stock/plant size effects. The variables analyzed were the mean sub-subplot value of the various seedling characteristics. Survival data were analyzed on transformed arcsin square root of survival percentage. Significant differences among variable means were determined by Duncan's New Multiple Range Test. Statistical analyses were performed with the help of the computer software package SPSS.

RESULTS AND DISCUSSION

Stock size did not significantly affect 1-year-old seedling diameter and height increment in both rooted cuttings and seedlings (Table 2 and 3). Stock type × stock size interaction was also not significant. But shoot height and diameter were significantly affected by stock types (rooted cuttings and seedlings). Stock type and stock size factors were not a significant predictor of survival of seedlings and rooted cuttings at the end of the first year in the field. The overall first-year outplanting survival of the 1-year-old seedling and rooted cutting was 100% for all treatments. Karlsson ve Russel (1990) found that stock type did not significantly affect survival percentage of *Chamaecyparis nootkatensis* as found for narrow-leaved ash in the present study.

Stock type significantly affected first-year stem diameter and shoot height increment after planting, and both stem diameter and shoot height increment were higher in rooted cuttings than in seedlings average for three stock sizes although fine root numbers were higher in seedlings than rooted cuttings (Table 1, 3 and 4). Rooted cuttings had almost 50% more height growth and 60% more diameter growth compared to seedlings at the end of first-year (Table 3 and 4). As seen in Table 3 stock sizes had no significant affect on stem diameter and height growth in both stock types.

First-year mean seedling heights showed average height gains for 1+0 seedlings in the range of 25 to 55% of initial heights depending on initial stock size. First-year mean rooted cutting heights showed average height gains for 1+0 rooted cuttings in the range of 45 to 100% of initial heights depending on initial stock size (Table 1 and 3). First-year mean seedling diameters showed average diameter gains for 1+0 seedlings in the range of 22 to 46% of initial diameters depending on initial stock size. First year mean rooted cutting diameters showed average

Table 1: Morphological properties of seedling- and rooted cutting-propagated narrow-leaved ash

Stock type	Plant size	Diameter (mm)	Height (cm)	Fine root No.	Coarse root No.
Seedling	Large	12.1a	108.3a	28a	7a
	Medium	9.8c	80.0b	24b	5b
	Small	6.8e	50.3c	21c	4b
Rooted cutting	Large	11.8b	112.6a	9d	8a
	Medium	9.3d	78.0b	7e	7a
	Small	6.7e	51.4c	5f	5b

Means not followed by the same letter in each column are significantly different (p<0.05)

Table 2: Analyses of variance for the effects of stock type and stock size on variables

Variable	Source	df	MS	F
	Block	3	0.184	0.183 ns
	Stock type	1	13.602	13.494***
Diameter increment	Stock size	2	0.214	0.213 ns
	Stock type × stock size	2	0.059	0.059 ns
	Error	10	1.008	
	Block	3	0.204	0.192
	Stock type	1	10.046	9.439*
Diameter	Stock size	2	37.258	35.007***
	Stock type × stock size	2	0.049	0.046 ns
	Error	10	1.064	
	Block	3	0.536	0.025 ns
	Stock type	1	2735.534	126.173***
Height increment	Stock size	2	3.711	0.171 ns
	Stock type × stock size	2	7.321	0.338 ns
	Error	10	21.681	
	Block	3	2.765	0.080
	Stock type	1	4544.222	131.636***
Height	Stock size	2	5115.687	148.191***
	Stock type × stock size	2	1.562	0.045 ns
	Error	10	34.521	

*: p<0.05, ***: p<0.001, ns: non significant

Table 3: Effect of stock size and stock type on stem diameter and shoot height growth increment

Stock type	Stock size	Diameter increment (mm)	Height increment (cm)
Seedling	Large	2.7b	27.6b
	Medium	2.6b	25.3b
	Small	3.1b	28.1b
Rooted cutting	Large	4.6a	50.3a
	Medium	4.3a	52.3a
	Small	4.6a	52.4a

Means not followed by the same letter in a column are significantly different (p<0.05)

Table 4: Effect of stock type on diameter and height growth (average for three stock sizes)

Stock type	Diameter (mm)	Diameter increment (mm)	Height (cm)	Height increment (mm)
Seedling	12.3b	2.8b	106.5b	27.0b
Rooted cutting	13.8a	4.5a	132.3a	51.6a

Means followed by the same letter in each column are not significantly different (p<0.05)

diameter gains for 1+0 rooted cuttings in the range of 39 to 69% of initial diameters depending on initial stock size (Table 1 and 3).

Early growth and fusiform rust resistance of loblolly pine (*Pinus taeda* L.) rooted cuttings and seedlings from the same nine full-sib families established on two sites were compared by Frampton and Goldfarb (2000). They found that height, diameter and volume growth of the rooted cuttings and seedlings did not differ through the first six growing seasons in the field (with the exception of first year height growth at one site) although site effects on growth were large.

Tree size, survival and coppicing of micropropagated plantlets, macropropagated cuttings and seedlings of *Eucalyptus grandis* Hill ex Maiden were monitored through 57 months in a study in southern Florida to assess propagation options (Rockwood and Warrag, 1994). At 57 months, no differences in tree height, diameter, volume, or survival were detected between plantlet lines and between rooted cuttings and plantlets, but seedlings were inferior to plantlets and cuttings. Even though plantlets and cuttings may be more expensive to produce, they have numerous advantages over seedlings for *E. grandis* plantation establishment in Florida.

Three stock types (seedlings, rooted cuttings and plantlets) of douglas-fir were planted in the field and after five complete growing seasons, the plants were measured (Ritchie *et al*., 1994). It was found that nodal branch lengths, nodal branch diameters and total branches were the highest in the order seedlings and height growth was similar for the three stock types, but plantlet height increment was beginning to decrease during the fourth year.

Growth, gas exchange, root hydraulic conductivity and drought response of seedling and rooted cuttings of Lovell and Nemaguard peach and sour orange citrus rootstocks were compared to determine the influence of propagation method on these characteristics by Rieger (1992). Rooted peach cuttings had a higher proportion of root biomass in fibrous roots (less than or equal to in diameter) and lower root: shoot ratios than seedlings, although this did not occur in citrus. Net CO_2 assimilation was higher for peach seedlings than for cuttings, but similar for Redhaven scions on either seedling- or cutting-propagated rootstocks, suggesting that leaf-associated factors were responsible for differences.

In Turkey, to regenerate *F. angustifolia* that are located in bottomland sites, the preferred method is clearcutting and planting. In these sites, during the early years of planting, because of the site condition, it was observed that an excessive weed competition is problem. The weedy vegetation which includes species such as *Scutellaria glericulata*, *Vicia* sp., *Lactuca serriola*, *Potentilla* sp., *Plantago major*, *Sparganium erectum* and *Calamintha grandiflora* can grow up to 1.5-2 m in a few months once it comes out (Çiçek *et al*., 2006). However, traditionally *F. angustifolia* plantings entails using small (20-40 cm) and low quality seedlings, and replanting and post-planting maintenance raise the cost of aforestation. But the present study showed that rooted cuttings greatly influenced field performance. Although diameter and height growth rate of three stock sizes of rooted cuttings did not show significant differences after planting, large sized-rooted cuttings have an advantage on small or medium sizes because large size rooted cuttings can outgrow the excessive vigorous weed vegetation and the cost of cultural treatment in field would be less. Thus, planting large size rooted cutting-propagated narrow-leaved ash can provide significant advantages on seedling and small size rooted cutting on bottomland sites.

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