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Survival and Growth of Three Hardwood Species (*Fraxinus angustifolia, Ulmus laevis* and *U. minor*) on a Bottomland Site with Heavy Clay Soil

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Abstract: Seedlings of *Fraxinus angustifolia* Vahl., *Ulmus laevis* Pall. and *U. minor* Mill. were grown in nursery for this study. The one-year old bareroot planting stocks so produced were out-planted on the bottomland site with heavy clay soils and 360 seedlings per species was assessed two years after planting for diameter, height and survival. Significant differences were found among species in survival, diameter and height. *Fraxinus angustifolia* and *U. laevis* had excellent survival (100%) and survival was lower in *U. minor* (92%). *Ulmus laevis* had the greatest height increment (128.3 cm) and total height (187.5 cm) followed by *U. minor*. *Fraxinus angustifolia* had the lowest height increment (76.4 cm) and total height (147.2 cm). Diameter increment was also different among species and *U. laevis* had the greatest diameter increment (15.1 mm) and there were not significant differences among *U. minor* and *F. angustifolia*. It might be concluded that the overall survival and growth of the species were high enough on this bottomland site with heavy clay soils although there were significant differences among the species in survival and growth.

Key words: Ash, elm, field performance, plantation, seedling growth

INTRODUCTION

Fraxinus angustifolia Vahl. is the most common and useful native ash species due to its fast growing ability and valuable wood and dominates the bottomlands forest of northern region of Turkey. It also grows in riparian areas and founds as scattered trees or in small groups in mixed hardwood stands up to 700-800 m altitudes (Davis, 1997; Mayer and Aksoy, 1998). In Turkey, almost all ash forest areas are occupied by *F. angustifolia* rather than other ash species (*F. excelsior* and *F. ornus*).

Like most hardwood trees, *F. angustifolia* grows best on fertile, moist and well drained soils. Although its natural stands are confined to bottomlands which are considered marginal for plant growth (FRAXIGEN, 2005), it has a high growth rate on these sites (Kapucu *et al*., 1998). Ash species (*F. excelsior* and *F. angustifolia*) is 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 (Eriksson, 2001; FRAXIGEN, 2005). Despite its relative importance little is known about plantation success of *F. angustifolia*.

In Turkey, to regenerate *F. angustifolia* stands with *Ulmus* species that are located on bottomland areas, the preferred method is clearcuting and planting *F. angustifolia*. Survival and early growth are often poor in these plantings because of their small sizes and low grade seedlings, low planting density, neglected post planting treatments (maintenances) and excessive herbaceous plant competition (Çiçek and Yilmaz, 2002; Çiçek *et al*., 2006a, 2007). In these sites, during the early years of planting, an excessive weed competition problem is observed because of the site conditions. The weedy vegetation can grow up to 1.5-2 m in a few months once it comes out.

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Even if elms are widespread in Turkey and Europe, they have been neglected and scarcely studied and relatively little is known population dynamics, seed biology, seedling production and field performance of these species. Elms are valuable for their hard, tough wood and they have been used for environmental purposes and amenity plantings.

Ulmus laevis Pall. and *Ulmus minor* Mill. are mostly grown on bottomland sites in Turkey (Davis, 1982; Mayer and Aksoy, 1998). Habitat destruction and the bark beetles (*Scolytus* sp.), which are the vectors of the Dutch Elm Disease fungal agent (*Ophiostoma novo-ulmi*), have caused enormous damage to elm populations and continues to pose a major threat to the genetic diversity of the species in Turkey and in Europe (Anşin and Özkan, 1993; Collin, 2002). Dramatic changes in the landscape are occurring on bottomland areas in Turkey, especially where land can be drained and reclaimed for agriculture or poplar cultivation (Efe and Alptekin, 1989; Çiçek, 2004; Çiçek and Yilmaz, 2006). Since natural regeneration is poor or the number of seed trees is insufficient in these bottomland sites due to small and fragmented populations, planting of *Ulmus* species on these sites is too important. Unfortunately, only *F. angustifolia* was planted on the bottomland sites but elm and other scatter species were not planted on bottomland sites until now. Thus, this study was carried out to determine the early field performance of three hardwood species (*Fraxinus angustifolia*, *Ulmus laevis* and *U. minor*) after 2 years planted on a bottomland site with heavy clay soils in Adapazari, Turkey.

MATERIALS AND METHODS

Study Site

The field experiment was established at an artificial regeneration area in Akyazi, Adapazari, Turkey (lat. 40°48' N, long. 30°33' E, alt. 25 m). The site formerly supported a stand of *F. angustifolia* and there were also elm (*Ulmus laevis*, *U. minor*), oak (*Quercus robur*, *Q. hartwissiana*) and maple (*Acer campestre*) as scatter trees. The soil on the study site has more than 70% clay and pH 7.5-7.9 (Çiçek *et al*., 2006b). The standing water (ground water) level on the site may rise above the ground level through January-May, however summers may include drought periods (Çiçek, 2002). The study area experiences a warm, humid climate, with a mean annual temperature of 14.2°C, mean annual precipitation of 800 mm and the mean growing season precipitation of 560 mm. The normal growing season averages 230-240 days. Late summer to early fall is customarily the driest period of the year (Anonymous, 2006). Older stands on the sites were clear felled and then the stumps were uprooted in fall 2003. After the stumps and slashes were disposed, the soil was first ripped and then disk.

Seedling Production and Planting

Fraxinus angustifolia seeds for this study were collected from the natural stand found on the bottomland area of Hendek-Suleymaniye, Turkey (40°52' N, 30°36' E, 25 m) in late October 2002. *Ulmus* seeds were also collected from the same area mid-May 2003. One month warm-stratified followed by one month cold-stratified (±4°C) *F. angustifolia* seeds and untreated *Ulmus* seeds were sown in spring of 2003 at Hendek forest nursery (40°48' N, 30°43' E, 60 m asl) to produce one-year old bareroot seedlings (70 seedlings m^{-2}). After lifting the one-year old seedlings by hand in mid-December 2003, all seedlings were graded for uniformity of height (65-75 cm), roots were pruned and to ensure that shoots and root systems were well developed and structurally sound.

Randomized complete block design with four replications were established at the planting area. Each experimental unit (plot) contained three rows and each row contained 30 plants. One- year old bareroot seedlings (360 seedlings per pecies) were hand planted at a spacing of 2.5×2.0 m in late December 2003. The study plots received both hand-hoeing of the soil around the seedlings and disking between rows in June 2004 and 2005.

Measurements

Initial seedlings diameters (2.5 cm above the root collar) and height were determined at plantations in the row in the middle of the plots contained 30 measurement trees immediately after planting in late December 2003. Above ground diameter was measured instead of root collar diameter owing to the muddy site condition. After two growing seasons, survival counts and diameter and height measurements were taken in December 2005.

Statistical Analyses

Analyses of variance (ANOVA) were used to evaluate seedling growth and survival. Arc-sin transformation was performed on seedling survival. Significant differences between variables were determined by Duncan's New Multiple Range Test ($p<0.05$). Statistical analyses were performed with the help of the computer software package SPSS.

RESULTS

Two years after planting, survival showed significant differences among species. *F. angustifolia* and *U. laevis* had excellent survival (100%) and survival was lower in *U. minor* (92%) (Table 1).

Species also differed significantly in 2-year growth increment. Seedling diameter increment was the highest in *U. laevis* (15.1 mm) and was statistically greater than *F. angustifolia* and *U. minor*. Diameter increment was not statistically different between *F. angustifolia* and *U. minor* (8.8 and 9.3 mm, respectively) (Table 1).

Table 1: Survival counts and growth measurements of three hardwood species after two growing seasons

Species	Survival (%)	Diameter increment (mm)	Height increment (mm)	Total diameter (mm)	Total height (cm)
F. angustifolia	100a[1]	8.8b	76.4c	18.6b	147.2c
U. laevis	100a	15.1a	128.3a	22.9a	187.5a
U. minor	92b	9.3b	90.5b	17.8c	165.4b

[1]Means within each column followed by the same letter are not significantly different ($p<0.05$)

Seedling height increment was the highest in *U. laevis* (128.3 cm) and the lowest in *F. angustifolia* (76.4 cm). *Ulmus laevis* seedlings were also the tallest at 187.5 cm, significantly taller than all and total diameter was also the highest at 22.9 mm.

DISCUSSION

Survival through the 2nd growing season after outplanting in three species was high (>90%) and planting tall seedlings (65-75 cm) have been shown to benefit survival.

In Turkey, to regenerate bottomland *F. angustifolia* stands in which *U. laevis* is found, the preferred method is clear cutting and planting *F. angustifolia*. In these sites, during the early years of planting, because of the site condition, an excessive weed competition problem is common. The weedy vegetation (*Potentilla* spp., *Vicia* spp., *Plantago major*, *Calamintha grandiflora*, *Scutellaria glericulata*, *Lactuca serriola*) can grow more than 1 m in a few months once it comes out. However, small (20-40 cm) and low quality seedlings were planted traditionally on these bottomland areas so far (Çiçek *et al*., 2007). This caused low seedling survival and increased the planting cost. Since seedlings have to compete with other excessive weedy vegetation after planting in artificial regeneration areas on bottomland sites, tall seedlings can protect themselves from browsing and excessive weed competition. And the present study showed that tall seedlings greatly influenced the field performance of the species.

Although this study showed that these three species could tolerate high clay content, *Ulmus* species grew better than *F. angustifolia* 2 years after planting. Ash species as in most deciduous species grow well in deep and fertile soil with pH 7-8 and high moisture content (Savill, 1992; Kerr and Cahalan, 2004; FRAXIGEN, 2005). The soil on the study site has more than 70% clay. Thus, this shows that *F. angustifolia* can tolerate high clay soils. But the site was not well-drained and had summer drought period which decreases growth rate of ash (Savill, 1992). Growth of *F. angustifolia* could be higher in a well-drained and fertilized site.

Collin (2003) stated that *Ulmus* are found in humid environment as well as semi-humid environment with deep soils and also step forests. Thus, the planting site might be more suitable for *Ulmus* growth and the results supported this idea since *Ulmus* species grew better than *F. angustifolia*.

Fraxinus angustifolia is light demanding unlike *Ulmus* species in its stands and it is not possible to create stands with different strata (Çiçek, 2002; FRAXIGEN, 2005; Çiçek, 2006). Since mixed stands have higher productivity than monoculture (Kelty 1992; Smith *et al*., 1996), *Ulmus* species can be planted under *F. angustifolia* to increase productivity and protect *Ulmus* species in bottomland area.

In conclusion, the present study shows that site on the bottomland areas which are not suitable for agriculture and poplar plantation can be planted by *F. angustifolia* and also *Ulmus* spp. and planting tall seedlings can be recommended to promote early establishment of the seedlings.

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