HortScience 42(3):712–714. 2007.

'Fiorente' and 'Arno' Elm Trees

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Additional index words. tree breeding, *Ulmus*, Dutch elm disease, resistance, elm cultivars

***Abstract*. Dutch elm disease (DED) has spread through Europe since the beginning of the 20th century. Several independent genetic improvement programs for breeding DED-resistant elms have been established in Europe. The Italian elm breeding program began in the late 1970s with the goal of hybridizing susceptible European elms with resistant Asian species to select DED-resistant clones suited to the Mediterranean climate. *Ulmus* 'Fiorente' and 'Arno' are two new releases selected for DED resistance, superior growth rate, attractive foliage, and upright habit.**

During the 20th century, two destructive pandemics of Dutch elm disease (DED), incited by the introduction of two very different fungal pathogens [*Ophiostoma ulmi* (Buisman) and *O. novo-ulmi* (Brasier)], devastated elm species native to Europe and North America. The severity and extent of the damage incited by the disease aroused the concern of scientists and public alike, and the search for a solution to the problem was considered imperative. The idea of screening elms for resistance to DED and enhancing resistance through breeding first arose in the Netherlands after the end of World War I.

A second elm breeding program in Europe was initiated in Florence by the Institute of Plant Protection (IPP), part of the Italian National Research Council (C.N.R.), in the late 1970s when the second more destructive DED pandemic incited by *O. novo-ulmi* reached Italy. The goal of the Italian elm breeding program was the selection of elm cultivars resistant to DED but suited to the Mediterranean climate, unlike the Dutch selections intended for northern Europe. European elm species and selections with desirable morphological and physiological characteristics were hybridized with DED-resistant Asian species (Smalley and Guries, 1993) that had thrived in the Mediterranean climate, broadening genetic resources (Simmonds, 1993). 'Fiorente' and 'Arno', following 'San Zanobi' and 'Plinio' (Santini et al., 2002), are the two latest results of this research.

Origins

'Fiorente' (patent RM 2006 NV000005) was selected from seedlings obtained by controlled pollination of *U. pumila* S.10 with *U. minor* C.02. 'Arno' (patent RM 2006 NV000004) was obtained by controlled pollination of Heybroek's 'Plantyn' (or Plantijn) elm (Heybroek, 1983) [(*Ulmus glabra* "Exoniensis" × *Ulmus wallichiana* p39) × (*U. minor* 1 × *U. minor* 28)] with *U. pumila* S.2.

Pollen from cultivars C.02 and S.2 was collected in a warm room from flowering twigs, filtered, and dried to 10% relative humidity (Mittempergher and La Porta, 1991). In January, the female flowers of 'Plantyn' and S.10 were covered with terylene bags for protection and the prevention of random pollination. The controlled pollination was effected by forced air injection of pollen into the bags, which were retained in situ until fruit maturity.

Cultivation

The seedlings and rooted cuttings were obtained at IPP's Monna Giovannella experimental nursery at Antella (43°43′N, 11°22′E, 170-m elevation), near Florence, Italy, where the artificial inoculations were also performed. The trees were planted out in 1993 in a fully randomized design with eight replicates per clone at two sites of differing topography in the Province of Ravenna, Northern Apennines (Presiola: 44°08′N, 11°36′E, 599-m elevation; Purocelo: 44°10′N, 11°40′E, 312-m elevation). The Presiola site is characterized by a poor clay soil on a steep northeast-facing slope, whereas Purocelo is flat with a marly (calcareous) clay soil of poor permeability.

Analysis

Biometric data were measured in 2005 and analyzed using one-way analysis of variance. Mean values were compared using Duncan's test. Statistical analysis was performed used Statistica 6.0 (StatSoft Italia srl 1984–2001, Italy) software, and color determinations were made using the Royal Horticultural Society color chart (Royal Horticultural Society, 1966).

Disease-resistance Testing

Two-year-old seedlings from the two controlled crosses raised in the nursery were planted in the field in 1983 and 1984. During their second year in the field, the trees were inoculated in the upper third of the main stem. Inoculation was performed in the third week of May, when elms are at their highest susceptibility in Italy, by a single wound through the bark to the younger wood using a knife bearing two drops (0.2 mL) of a $1 \times 10^6/mL^{-1}$ fungal spore mixed suspension of yeast phase cells, so that the inoculum would be absorbed by the tree's rising sap. The spore suspension consisting of two tester isolates of *O. novo-ulmi* subsp. *novo-ulmi* and subsp. *americana* (Brasier and Kirk, 2001), both found to be very aggressive in previous assays. The isolates were prepared by inoculating 10 mL modified Tchernoff's liquid medium (Brasier, 1981) in 50 mL Erlenmeyer flasks and incubating for 2 d on a shaker at room temperature. Spore concentration was then adjusted with sterile water to $1 \times 10^6/mL^{-1}$.

Searches for symptoms of disease (defoliation and dieback) were undertaken at 4 weeks, 3 months (not reported), and 8 months by three independent assessors. Seedlings presenting less than 10% dieback were vegetatively propagated and planted out the following year in a completely randomized block design. Twelve rooted cuttings per clone, divided into three blocks, were used. Ramets of both the new clones were inoculated in 1990, together with 53 more clones from the best performing seedlings and four control clones. Inoculations, disease evaluations, and analyses were performed as before, and the symptoms compared with hybrids of known DED responses. The resistance levels were comparable with those of 'Lobel' and 'Plantyn', and were significantly higher than 'Commelin' (Table 1) during the inoculation year. During the next 10 years (i.e., until 2000), ramets were regularly checked for symptoms of DED, but not one showed wilting or dieback. At the time of writing (2007), none of the clones have displayed any symptoms of either DED or elm yellows infections (Mittempergher, 2000), and their

Table 1. Descriptive statistics of defoliation (symptoms assessed 4 weeks after inoculation) and dieback (symptoms assessed 8 months after inoculation) of 'Plinio', 'LUTÈCE', 'Lobel', 'Plantyn', 'Fiorente', 'Arno', and 'Commelin' grown and inoculated at Antella (Florence) in 1990.

Clone	Mean defoliation (%)[z]	Mean dieback (%)[y]
Plinio	15.53 a[x]	10.05 a[x]
LUTÈCE	19.75 a	11.70 a
Lobel	27.87 b	21.55 b
Plantyn	27.97 b	20.47 b
Fiorente	32.34 bc	19.89 b
Arno	35.40 c	21.04 b
Commelin	83.54 d	88.16 c

[z]$F = 118.74$, $P = 0.0000$.
[y]$F = 140.97$, $P = 0.0000$.
[x]Means not sharing the same letters are significantly different according to Duncan's test. Angles were used as a normalizing transformation for statistical analysis.

Received for publication 21 Dec. 2006. Accepted for publication 26 Feb. 2007.
We gratefully acknowledge the field work of Mr. Abdellah Dahmani.
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susceptibility to elm leaf beetle remains comparable with that of *U. minor*.

It should also be noted that strong winds have not injured any of these selections.

Descriptions of the Cultivars

'Fiorente' is monocormic and shows exceptionally rapid growth, significantly greater than the other cultivars cultivated at the same site, suggesting that it could also be used for timber production (Table 2). Its habit is conical with pronounced apical dominance, a result of the limited lateral branching on the developing shoots of the current season's growth (Fig. 1). The crown is therefore slender and columnar. The trunk is straight, long, and the bark is gray–green (RHS66 198B/198C) with cracks of grayish orange (RHS66 177C).

Twigs are rather slender, devoid of corky wings, scarcely pubescent, and gray–green (RHS66 197A, 199A). Vegetative buds are small (<2 mm Ø), ovoid, covered by only three or four hairy perulae, gray–yellow (RHS66 177A), and rounded at the base of the shoot. The apical bud of the shorter shoots is larger than the subdominant buds, is typically oblique, and is inward folded.

Leaves are alternate and deciduous, remaining green into fall and shedding late. Leaf margins are often undulate, and green yellowish in color (RHS66 147A). The second leaf on the shorter shoots is ovate or lanceolate, 3 to 8 cm long by 3 to 5 cm broad, acute at the apex, with a convex central vein. The base is significantly more asymmetric on the leaves of the shorter shoots. The upper surface is rough; the underside, pubescent. The petiole is also pubescent, 7 mm long on short shoots and 11 mm on longer ones. Flowering starts comparatively late for a hybrid, from the fourth or fifth year of age on self-rooted trees. Fruits are ovate-roundish sessile samarae measuring 1.4 × 1.7 cm. Flushing is earlier than in *Ulmus minor* Mill.

'Arno' is monocormic, with erect habit, ascending branches, and an upright oval crown (Fig. 2). Adaptation field trials indicate that 'Arno', although slower than 'Fiorente', is among the fastest growers ever tested (Table 2). Trials of this clone have now been made at many sites of differing topography and geology. The trunk is straight, branching at a height of ≈3 m. The wood characteristics of this clone (previously encoded as FL 090) are not different from those known for field elm (Santini et al., 2004). The bark is gray–green (RHS66 198B/198C) with cracks of gray–orange (RHS66 177C). Twigs are slender, glabrous, and gray–green (RHS66 197A), and devoid of corky wings. Vegetative buds are small (<2 mm Ø), ovoid, covered by only three or four hairy perulae, and are brown (RHS66 200B/177A) and rounded at the base of the shoot. Apical buds of the short shoots are larger than the subdominant buds, typically oblique, and inward folded. Leaves are alternate and deciduous, remaining green into the fall and shedding late. The leaf margins are often undulate, and green–yellow (RHS66 147A). The second leaf of the shorter shoots is ovate or lanceolate, 5 to 9 cm long × 3 to 5 cm broad, the base uneven, and the apex acute to acuminate; the central vein is convex. The base is more asymmetric on the leaves of the shorter shoots. The petiole is glabrous, 7 mm and 8 mm long on short and long shoots respectively.

Flowering starts relatively late, at 5 years of age on self-rooted trees. Fruits are ovate to round sessile samarae, measuring 1.4 ×

Table 2. Mean growth in diameter and height of the selections compared with the Dutch releases 'Lobel' and 'Plantyn', the French release 'LUTÈCE', and the Italian release 'Plinio'.

Clone	Field	Mean diameter (cm)[z]	Mean ht (m)[y]
Plinio	1	5.89 a[x]	5.93 a[x]
Plantyn	1	7.68 ab	6.50 a
Arno	1	8.55 abc	8.38 b
Lobel	1	8.91 bcd	6.88 a
LUTÈCE	1	10.78 cd	8.63 b
Fiorente	1	11.50 d	8.63 b
Plinio	2	9.23 a	9.17 a
Plantyn	2	12.25 ab	9.63 a
Arno	2	15.23 b	9.50 a
Lobel	2	12.45 ab	9.75 a
LUTÈCE	2	11.74 a	9.38 a
Fiorente	2	18.46 c	12.75 b

[z]1) F = 10.41; *P* = 0.0008, 2) F = 9.01; *P* = 0.0003.
[y]1) F = 4.99; *P* = 0.0048, 2) F = 17.26; *P* = 0.0000.
[x]Means not sharing the same letters are significantly different according to Duncan's test.
Data refer to plants obtained from self-rooted cuttings. Values were obtained from the mean of measurements made in 2005 after 12 years of growth in two experimental fields in the Northern Apennine (Presiola and Purocelo, Fields 1 and 2, respectively, RA, Italy).

Fig. 1. 'Fiorente' elm, 15 years old, grown in Tuscany.

Fig. 2. 'Arno' elm, 12 years old, grown in Tuscany.

1.7 cm. Flushing is simultaneous with *Ulmus minor* Mill.

Propagation

'Fiorente' and 'Arno' are easily propagated from hardwood cuttings taken in January and February, quickly dipped in Ethanol (EtOH) 30% solution containing Indole 3-butiric acid (IBA, Merck, Germany) 3000 ppm, and placed in a rooting mix of (by volume) 1 peat : 1 perlite : 1 sand heated to 18 °C. Rooting should occur within 4 weeks.

Etymology

The name 'Fiorente' means ''flourishing'' and was chosen because of the tree's fast and lush growth, and also because it recalls the ancient name of the city of Florence (*Florentia, Fiorenza, Firenze*). 'Arno' is named for the river that passes through Florence.

Availability

Licenses for the commercial cultivation of 'Fiorente' and 'Arno' are available. Inquiries should be addressed to the Istituto per la Protezione delle Piante–C.N.R., Via Madonna del Piano, 10–50019 Sesto fiorentino, Italy.

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