Invest Agrar: Sist Recur For (2004) 13 (1), 179-184

Elm breeding for DED resistance, the Italian clones and their wood properties

A. Santini[1]*, A. Fagnani[1], F. Ferrini[1], L. Mittempergher[1], M. Brunetti[2], A. Crivellaro[2] and N. Macchioni[2]

[1] *Istituto per la Protezione delle Piante. CNR. Via Madonna del Piano. 50019 Sesto f.no (FI). Italy*
[2] *Istituto per la Valorizzazione del Legno e delle Specie Arboree. CNR. Via Madonna del Piano. 50019 Sesto f.no (FI). Italy*

Abstract

In Italy, an elm breeding program to develop Dutch elm disease-resistant trees has been established by cross-breeding Asian elms with indigenous species, in order to produce individuals that combine resistance of the first with growth characteristics and higher degree of environmental adaptability of the second. Thus, the favourable adaptation of *Ulmus pumila* in Italy has been explored: «San Zanobi» and «Plinio» are two recent results of this research and many others promising clones as «FL090», «FL146», «FL441», «FL568», «FL634», are in the final stage of field testing. The resistance levels of all these clones were significantly higher level of resistance than «Lobel» and «Urban» in several assessments during different years. First technological tests indicate that the wood characteristics of «San Zanobi» and «FL090» clones are comparable to those of elm wood traditionally present on the market, thus highlighting that those clones is likely to satisfy the elm wood demand. The present characterisation needs to be confirmed by further evaluations of mature trees having bigger diameters and allowing industrial trials, still not available so far.

Key words: physical-mechanical characteristics of wood, *Ulmus*, wood quality.

Resumen

Mejora del olmo para resistencia a DED: clones italianos y características de su madera

En Italia, el programa de mejora genética del olmo para la obtención de árboles resistentes a la grafiosis se ha desarrollado a partir del cruzamiento de olmos asiáticos con especies nativas, y tiene por objetivo producir individuos que combinen la resistencia de los primeros con las características vegetativas y el alto grado de adaptación al ambiente de los segundos. Por esta razón, se ha aprovechado la favorable adaptación de *Ulmus pumila* en Italia: «San Zenobi» y «Plinio» son dos resultados recientes de estas investigaciones, y otros muchos clones prometedores como «FL090», «FL146», «FL441», «FL568» y «FL634» están en las fases finales de las pruebas de campo. Los niveles de resistencia de todos estos clones fueron significativamente mayores, en diferentes ensayos, que los niveles de resistencia de «Lobel» y «Urban». Los primeros ensayos tecnológicos han mostrado que las características de la madera de los clones «San Zenobi» y «FL090» son comparables a los de las maderas de olmo tradicionalmente presentes en el mercado, indicando que esos clones pueden probablemente satisfacer las demandas de madera. La actual caracterización debe ser confirmada con nuevas evaluaciones en árboles maduros de mayores diámetros y mediante ensayos industriales aún no disponibles.

Palabras clave: características mecánicas y físicas de la madera, *Ulmus*, calidad de la madera.

Introduction

Elms have been utilised by human beings for fodder, timber, ornamental, and even for food purposes ever since prehistoric times. During the past century, however, this tree suffered major losses, with the almost total disappearance of adult trees in some areas of the world. This was the result of two pandemics of Dutch elm disease (DED), caused by two ascomycetes: *Ophiostoma ulmi* (Buisman) Nannf. and *Ophiostoma novo-ulmi* Brasier. The European elm species *Ulmus glabra* Huds., *U. laevis* Pall. and *U. minor* Mill. *sensu latissimo*, are generally susceptible, although some individuals of the latter species —and its hybrid *U.* X *hollandica* Mill.— have shown

* Corresponding author: a.santini@ipp.cnr.it
Received: 29-09-03; Accepted: 09-12-03.

enough resistance to form the starting point of a breeding program (Heybroek, 1993). *U. pumila* L., an Asian species introduced as an ornamental tree in areas of the Mediterranean, has proved to be moderately to highly resistant.

Other gene sources for resistance to DED has been found in several species growing in central-eastern Asia, which is the most important centre of genetic diversity of *Ulmus* (Smalley and Guries, 1993), as *U. wallichiana* Planch, largely used in the Dutch breeding program (Heybroek, 1993). Unfortunately, the Asian species do not always meet ornamental and production requirements; nor do they adapt easily to different environmental conditions. The main breeding programs set up in Europe and in North America to develop resistant trees involve a cross-breeding of Asian species with other indigenous ones, in order to produce resistant individuals still possessing desirable features of European elms.

The Italian breeding program was set up in the late 1970s in Florence by the Institute for Forest Tree Pathology (now the Institute of Plant Protection) of the Italian National Research Council (CNR), when the second DED pandemic wave was destroying the elms all around Europe. The project was leaded by Prof. Lorenzo Mittempergher until his retirement in 1999. The idea underlying this project was the conviction that the Mediterranean environment would need its own selections because of the unsuitability of the Dutch selections to the hot, dry areas of Italy. For this reason, the favourable adaptation of *U. pumila* in Italy has been exploited. The plant material used in the crossings derived mainly from the exchange with other European research institution, and in particular from De Dorschkamp in Holland. Other materials came from native species and from extant plantations of Siberian elm, widely planted since the 1930s in response to the first pandemic (Goidanich and Azzaroli, 1941), as well as through exchanges with North American research institutes. The inoculation and crossing techniques used in Florence were also derived from the Dutch experience, with the introduction of a few improvements, such as for example the realisation of pollination without having to lift the isolation sack, by blowing the pollen into the sack (Mittempergher and La Porta, 1991). More than 50,000 hybrid seedlings have been raised and tested, of which 80 individuals totalled a very high score. «San Zanobi» and «Plinio» are two recent results of this research and many others are in the final stages of field testing.

Origin, growth, and propagation

«San Zanobi» (Patent RM 97 NV 0006) was selected among seedlings obtained from controlled pollination of Heybroek's «Plantyn» elm (Heybroek, 1976) [(*Ulmus glabra* «Exoniensis» x *Ulmus wallichiana* p39) x (*U. minor* 1 x *U. minor* 28)] with *U. pumila* S15. «Plinio» (Patent RM 97 NV 0005) was obtained from controlled pollination of «Plantyn» with *U. pumila* S02.

«San Zanobi» (FL094) is monocormic, and shows exceptionally rapid growth in fertile soils and in temperate climates up to 1.20 m/year in height and 1.75 cm/year in average (Santini et al., 2002). Its shape is fastigiate with pronounced apical dominance (Fig. 1). This results in limited lateral branching on the developing shoots of the current season's growth. The name «San Zanobi» comes from the reportedly prodigious flushing of a dead elm, an acknowledgement of the passage of the relics of the bishop, St. Zenobius, who came to the Florence (Italy) Cathedral from outside town in the year 429 AD. The event was commemorated by a marble stele that flanks the Baptistry.

Figure 1. «San Zanobi» elm tree in Tuscany (Italy), spring 2003.

«Plinio» (FL089) grows rapidly, although somewhat slower than «San Zanobi»: in average 1 meter per year in height and 1.4 cm in diameter (Santini *et al.*,2002), and adapts readily to the Mediterranean mountainous climates of Northern Italy (unpublished data). «Plinio» could be used as an ornamental shade tree (Fig. 2). The name «Plinio» derives from the Roman naturalist and historian, Pliny the Elder, of the first century AD, who wrote about elm trees in his *Naturalis Historia*.

«San Zanobi» and «Plinio» are easily propagated from hardwood cuttings taken in January and February, quickly dipped in EtOH 30% solution containing IBA 3,000 ppm, and placed in warm beds at 18°C in a mixture of 1 peat :1 perlite :1 sand by volume. Rooting generally occurs within 4 weeks.

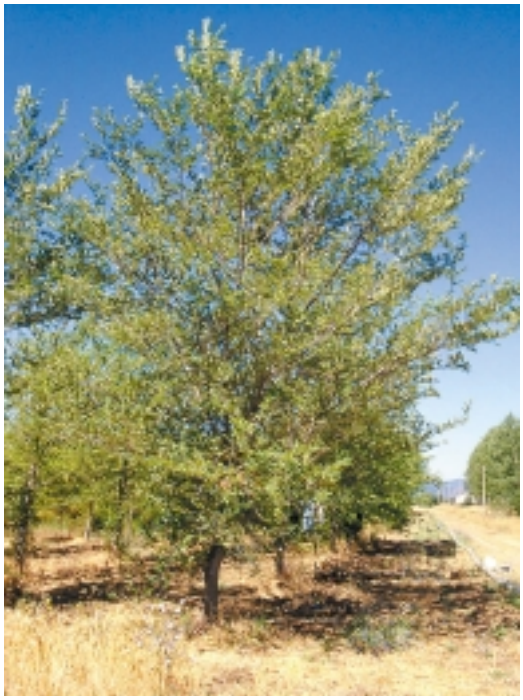

Figure 2. «Plinio» elm tree in Tuscany (Italy), summer 2000.

Resistance evaluation

Resistance was assessed by two series of artificial inoculations performed on the F1 progeny in 1990 and 1991. Seedlings presenting less than 10% dieback were vegetatively propagated and planted out the following year in a completely randomised 3 block design. Twelve rooted cuttings per clone were inoculated. Symptoms of disease (percent of defoliation and of dieback) were observed after 4 weeks, and at 3 (not reported) and 8 months by three independent assessors (table 1). The

Table 1. Descriptive statistics of defoliation (assessed 4 weeks after inoculation) and dieback (assessed 8 months after inoculation) of a) «Plinio», «Lobel» (of intermediate resistance), and CNR 118 (rated as strongly susceptible in previous tests) (inoculation year: 1990); and b) «S. Zanobi», «Lobel», «Urban» (resistant) and CNR118 (inoculation year: 1991), respectively, grown and inoculated in the same year and at the same location. Angles were used as a normalising transformation for statistical analysis

Year	Symptoms	Clone	N	Mean	STD	CV%	
A							
1990	Defoliation	«Plinio»	12	7.8	5.65	72.4	a
	Defoliation	«Lobel»	12	26.0	8.76	33.6	b
	Defoliation	CNR 118	12	95.0	2.36	2.5	c
1990	Dieback	«Plinio»	12	3.9	2.2	56.4	a
	Dieback	«Lobel»	12	11.5	7.5	65.2	b
	Dieback	CNR 118	12	100.0	0.0	0.0	c
B							
1991	Defoliation	«S. Zanobi»	12	19.5	5.5	28.2	a
	Defoliation	«Lobel»	12	50.0	9.1	18.2	b
	Defoliation	«Urban»	12	49.5	8.3	16.7	b
	Defoliation	CNR 118	12	90.0	4.7	5.2	c
1991	Dieback	«S. Zanobi»	12	8.5	2.4	28.2	a
	Dieback	«Lobel»	12	35.5	11.6	32.7	b
	Dieback	«Urban»	12	36.5	10.0	27.4	b
	Dieback	CNR 118	12	89.0	5.7	6.4	c

A: Defoliation: $F = 551.1$; $P \leq 0.001$; dieback: $F = 1095.1$; $P \leq 0.001$. B: Defoliation $F = 180.3$; $P \leq 0.001$; dieback $F = 201.8$; $P \leq 0.001$.

symptoms, were compared with clones having known DED responses («Lobel»: moderately resistant; «Urban»: resistant; CNR 118: highly susceptible). The resistance levels of the clones described here were significantly higher than the resistance levels of «Lobel» and «Urban» (Table 1 and Santini *et al.*, 2002).

Characterisation of the wood

Several clones showed rapid growth, straight monocormic trunk, and thin ramification, which could make them useful for agroforestry field and for wood production for aesthetic purposes. Among the available clones, the most suitable for this use purpose seem to be «San Zanobi» and «FL090». The genealogy of clone «FL090» is very similar of «San Zanobi» and also its growth (Figs. 1 and 3).

The material utilised for the wood characterization was sampled from several trees grown in central and northern Italy, as reported in Table 2. For comparisons purposes, a trunk of an *U. minor* tree of central Italy was also sampled. The sampling was necessarily limited because of scarce availability of individuals with suitable dimensions.

Basal trunks (about 1.5 m in length) were sampled from the felled trees. In conformity with UNI ISO 3252, clear defects samples of small dimensions were obtained to study the following physical-mechanical properties: basic density (UNI ISO 3131); total shrinkage (UNI ISO 4858; UNI ISO 4469); static bending strength (UNI ISO 3133) and modulus of elasticity through a dynamic methodology. The mechanical tests were carried out on conditioned specimens in a climatic cell (T = 20 ± 2°C and RH = 65 ± 5%), up to a

Figure 3. FL090 elm tree in Tuscany (Italy), spring 2003.

Table 2. Data on the stations of origin of the samples

Clone	FL 090	«San Zanobi»	«San Zanobi»	*Ulmus minor*
Nb. Ramets	3	3	3	1
Age of ramets	9	9	9	18
Plot location	Roselle Terme (GR)		Montecchio Precalcino (VI)	Antella (FI)
Altitude (m a.s.l.)	5		74	170
Coordinates	42°48'N 11°05'E		45°39'N 11°32'E	43°43'N 11°22'E
Cllimate	Mediterranean, with strong thermal excursions in winter,		Mediterranean with strong thermal excursions, without arid prolonged and arid summer season	Mediterranean with strong thermal excursion in winter periods
Mean annual rainfall (mm)	650		1,050	750
Geological stratum	Reclaimed alluvial soil, clayey, rich in silt, prominent summer fissuring and on an average calcareous		Scree of Astico	Clayey soil, with prominent summer fissuring and on an average calcareous

Table 3. Physical-mechanical characteristics of the elm wood

		«San Zanobi» Roselle				«San Zanobi» Montecchio				FL090 Roselle				*Ulmus minor* Antella			
		N*	M	STD	CV%	N	M	STD	CV%	N	M	STD	CV%	N	M	STD	CV%
Diameter of trunks	cm	3	15.20	—	—	3	17.8	—	—	3	19.2	—	—	1	26.0	—	—
Average ring width	mm	3	8.00	—	—	3	9.8	—	—	3	8.7	—	—	1	5.9	—	—
Heartwood	%	3	56.6	—	—	3	61.3	—	—	3	58.6	—	—	1	47.3	—	—
Basic density	g/cm^3	261	0.56	0.034	6.0	282	0.568	0.028	4.96	251	0.497	0.034	6.8	90	0.567	0.013	2.35
Radial shrinkage	%	261	3.99	0.67	16.7	—	—	—	—	251	4.05	0.92	22.8	—	—		—
Tangential shrinkage	%	261	9.87	1.40	14.1	—	—	—	—	251	9.25	1.30	14.1	—	—	—	—
Volumetric shrinkage	%	261	13.99	1.38	9.9	—	—	—	—	251	13.51	1.42	10.5	—	—	—	—
T/R ratio	—	261	2.55	0.58	22.6	—	—	—	—	251	2.40	0.6	25.0	—	—	—	—
MOE	MPa	36	12,193	1,941	15.9	22	10,971	1,548	14.1	27	11,082	989	8.9	15	9,211	517	5.6
Bending strength	MPa	36	106	14.7	13.9	22	111	13.3	12.0	27	91.5	11.6	12.7	15	103	4.2	4.1

* N° of samples (N). M: mean values. STD: standard deviation. CV: percent coefficient of variation.

constant weight. The resistance values obtained were reported at the conventional moisture content of 12%, as indicated in the reference standards.

A disk was also sampled from each stump, 50 cm from the base, for the determination of the mean ring width and of the heartwood amount measured by means of image analysis.

The results of the wood characterisation of the elm clones are reported in Table 3.

Conclusion

More resistant clones of different vegetative trait and genetic origin are in the final stages of field testing, and a number of them will soon be patented. The parentage of these elms includes *U. japonica* and *U. wilsoniana*, in addition to species forming part of «San Zanobi» and «Plinio», which enlarges the genetic background of our selections.

Some promising clones are the already mentioned «FL090» («Plantyn» x *U. pumila* S02), which has a good shape of the crown and an abundant foliage (Fig. 3) even if it resulted a little less resistant than «San Zanobi»; «FL146» [«Sapporo Autumn Gold» (Smalley and Lester, 1973), open pollinated] which presents a nice shape of the crown, close to that of the field elm; FL337 (*U. wilsoniana* 3-14 x *U. pumila* S17) a very fast grower and strongly resistant; «FL441» [«Sapporo Autumn Gold» x «Jacan» (Ronald, 1979)] which presents an abundant foliage; FL 109 (*U. pumila* S10 x *U. minor* c2) monocormic, with a plenty conical shape of the crown; FL568 [164p x «Columella» (Heybroek, 1990)]; FL634 («S. Zanobi» open pollinated).

Elm genetic improvement for DED resistance initiated in Italy in the 1970s is now beginning to produce interesting results. The clones obtained, besides a high degree of DED resistance, at least in the Italian conditions, have valuable characteristics for use in the ornamental or forestry fields and the use of some of them, as windbreak plantations could be proposed. Up to now, suitability of these clones has been evaluated on the basis of the crown morphology and on type of ramification. With this study, it has found that their wood has similar properties to elm trees in the field, and therefore can be exploited by industry. Furthermore, in their first years of life, «San Zanobi» «Plinio» and «FL090» clones have shown considerable growth rates in diameter and height even in ecologically differentiated environments. These characteristics on the clones analysed make it possible to hypothesise relatively short cycles for the production of timber. In this sense, evaluations on the attitude of the elm clones to the culture treatments typical of the wood plantations, above all those of pruning and thinning have to be carried out.

In the trunks studied, a large percentage of heartwood was observed (Table 3) in spite of the early age

of the trees. As regards the physical-mechanical properties, the values obtained were no different from those reported by Giordano (1981) for elm wood. The wood analysed was found to be semi-heavy, resistant to flexion, with average shrinkage, and not very stable, according to Berti (1988). The differences among the different clones and the provenances need to be studied further and verified on the basis of a more exhaustive sampling. In the future, other studies need to be carried out in order to evaluate the presence and extent of the juvenile wood and its effect of on the wood properties.

Obtaining a wide range of DED resistant clones with different parentage should be a further safeguard against the possibility that their resistance be easily reduced by the appearance of new and even more aggressive strains of the pathogenic agent, as it occurred in the 1970s when the *O. novo-ulmi* appeared in Europe, or against unpredictable risks, such as «Elm Yellows» (Mittempergher, 2000).

References

BERTI S., 1988. Introduzione di nuove specie esotiche di legname da utilizzare sul mercato nazionale. In: I.S.E.A. Bologna Uzielli L. ed., pp. 223-224.

CAB International, 2000. Forestry Compendium Global Module CD. Wallingford. UK. CAB International.

GIORDANO G., 1981. Tecnologia del legno vol. 1. UTET Torino, pp. 938-939.

GOIDANICH G., AZZAROLI F., 1941. Relazione sulle esperienze di selezione di olmi resistenti alla grafiosi e di inoculazioni artificiali di *Graphium ulmi* eseguite nel 1939-1940. Bollettino Regia Stazione di Patologia Vegetale 21, 281-306.

HEYBROEK H.M., 1976. De iep «Plantyn». Nederland Bosbouw Tijdschrift 48, 117-123.

HEYBROEK H.M., 1990. De iep «Columella». Groen 46, 37-39.

HEYBROEK H.M., 1993. The Dutch elm breeding program. In: Dutch elm disease research. Cellular and molecular approaches. Sticklen. M.B. and Sherald J.L., eds. Springer Verlag, New York, U.S.A. pp. 16-25

MITTEMPERGHER L., 2000. Elm Yellows in Europe. In: The Elms: Breeding, Conservation, and Disease Management, Dunn C. P., ed. Kluwer Academic Publishers, Boston, pp. 103-119.

MITTEMPERGHER L., LA PORTA N., 1991. Hybridization studies in the Eurasian species of elm (*Ulmus* sp.). Silvae Genetica 40, 237-243.

RONALD W.G., 1979. «Jacan». Canadian Journal of Plant Science 59, 267-268.

SANTINI A., FAGNANI A., FERRINI F., MITTEMPERGHER L., 2002. «San Zanobi» and «Plinio» Elm Trees. HortScience 37, 1139–1141

SMALLEY E.B., LESTER D.T., 1973. «Sapporo Autumn Gold» elm. HortScience 86, 514-515.

SMALLEY E.B., GURIES, R.P., 1993. Breeding elms for resistance to Dutch Elm Disease. Annual Review of Phytopathology 31, 325-352.