

# DUTCH ELM DISEASE RESISTANCE IN PROGENY FROM INTERSPECIFIC CROSSES WITH CHINESE ELM (Ulmus parvifolia)

EUGENE B. SMALLEY and RAYMOND P. GURIES  
Departments of Plant Pathology and Forestry  
College of Agricultural & Life Sciences  
University of Wisconsin-Madison  
Madison, WI 53706

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**ABSTRACT** - - In 1984 we initiated breeding studies to determine the usefulness of Chinese elm (Ulmus parvifolia) as an improved source of genes for pest resistance in elms. Although the Chinese elm has generally been recognized to be resistant to diseases such as Dutch elm disease (DED) and black leaf spot (Stegonhora ulmea) as well as various insects (especially elm leaf beetle, Xanthosaleruca luteola), its usefulness in elm breeding has been limited due to its fall flowering habit, small leaf size, and especially its lack of hardiness in the North Central Region. Among the 1986 progeny were 8 to 10 apparently authentic hybrids with American elm. These crosses when repeated in 1987 yielded 684 seedlings of which 149 (21.8%) possessed hybrid vigor and had large leaf characteristics typical of U. americana. Progeny from these studies have exhibited striking variability in leaf size and general growth habit (e.g. architecture) and high levels of resistance to the DED pathogens.

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## INTRODUCTION

Research at the University of Wisconsin to develop pest-resistant elms has relied heavily on Siberian elm (Ulmus pumila L.) as a major source of genes for resistance to Dutch elm disease (DED) (Smalley & Guries, 1993). With the exception of the cultivar "Independence" (an American elm), all of our DED-resistant cultivar releases to date contain genes from U. pumila (e.g. "Sapporo Autumn Gold" (50%), "Regal" (25%), "New Horizon" (50%) and "Cathedral" (50%)). Beginning about 10 years ago in the North Central Region, periodic infestations of the elm leaf beetle (Xanthosaleruca luteola) in urban plantings of "Regal" elm resulted in severe defoliation. Although our other elm cultivars showed less injury, they are clearly not immune. In 1984 we initiated breeding studies to determine the usefulness of Chinese elm (U. parvifolia) as an improved source of genes for pest resistance in elms. Although the Chinese elm has generally been recognized to be resistant to diseases such as DED and black leaf spot (Stegophora ulmea) and various insects (especially elm leaf beetle), its usefulness in elm breeding has been limited due to its fall flowering habit, small leaf size, and especially its lack of hardiness in the North Central region. The feasibility of producing interspecific hybrids with Chinese elm with

resistance to DED had been demonstrated earlier by Santamour (1972, 1973, 1974, 1989).

We report here the results of controlled environment inoculations using various strains of the DED pathogen on selected progeny of interspecific crosses with Chinese elm. Progeny from these studies have exhibited striking variability in leaf size and general growth habit (e.g. architecture) of an intensity not previously observed in our elm breeding program. Ramets for use in greenhouse inoculation trials were produced by vegetative propagation from selected field-grown trees which were representative of the various families.

#### ORIGIN OF PARENTS AND SPECIFIC CROSSES

The initial breeding study in 1984 used a single selection of U. parvifolia (W114-1) originally from seed sent to us from South Korea, as female, and pollen from 9 spring-flowering elm species and a few hybrids. About 200 authentic hybrid progeny were produced. More crosses were made in the fall of 1986 using additional parents to yield 1600 hybrid seedlings from 20 families (including 10 elm species and 10 hybrids or controls. Among the 1986 progeny were 8 to 10 apparently authentic hybrids with American elm (Smalley et al, 1993). The best of these hybrids had very large leaves, grew 50% faster than the controls, and morphologically appeared identical to American elm. Crossing in the fall of 1987 and 1989 emphasized the creation of new hybrids between U. americana and U. parvifolia. In 1987, a total of 97 families were created, including five sources of U. parvifolia as female, and 15 U. americana selections and 12 other species or hybrids as males. Additional Chinese elm parents included two trees located at the U.W. Arboretum and two specimen trees located at the Morton Arboretum, Lisle.

Crosses in 1989 utilized a single female (W114-1). Of the 22 families in this series, 19 used different U. americana males previously selected for high disease resistance. Over 50 obvious U. parvifolia x U. americana hybrids were produced, with 7 of 19 males contributing the majority of the hybrids. A resistant (F-1) U. americana hybrid (Campus#3 x W185-10) from the "American Liberty" series proved to be the most fertile male and produced 13 vigorous hybrids. Nine of the U. americana males utilized produced no hybrids, while 6 others produced only 1 or 2.

Fall pollinations in 1990 sought additional resistant U. americana males compatible with U. parvifolia. Crosses again utilized a single U. parvifolia female (W114-1). Of the 21 families in this series, 5 used different U. americana resistant selections as males, 7 used U. americana F-1 resistant selections as males, while 4 used susceptible or untested U. americana selections as males. To assess the level of female fertility at pollination a known highly fertile cross (W114-1 x W368) (e.g. U. parvifolia x U. carpinifolia) was used and served as one of the controls.

In 1992 the search for resistant U. americana males compatible with U. parvifolia continued. Crosses utilized several U. parvifolia females including W114-1 and W948 (from southern Japan). Of the 36 families in this series, 3 used different U. americana resistant selections as males, and 6 used U. americana F-1 resistant selections as males. Precocious flowering U. parvifolia hybrids from earlier crosses were also used as females in several crosses with the U. americana males. These included W2216-5 (U. parvifolia x [U. laciniata x U. pumila]), and W2224-1 & W2224-2 (U. parvifolia x U. pumila). The latter 2 females flowered on rooted cuttings grown for about 8 months in the greenhouse. To assess the level of female fertility at pollination known highly fertile diploid males served as controls. Fall pollinations in 1993 continued the search for compatible resistant U. americana males. Crosses utilized two U. parvifolia females (W114-1 & W114-1 x self) as well as the precocious flowering U. parvifolia x U. pumila hybrids (W2224-2) (which continued to flower for a second year) and 29 selected "resistant" U. americana selections and F-1 & F-2 hybrids.

#### **INTERSPECIFIC CROSSABILITY**

The crosses made in the fall of 1986 were very successful and yielded a total of 4126 seedlings and provided useful information on interspecific crossability in U. parvifolia. Especially interesting were the hybrids with American elm. Of a total of 684 seedlings produced in the U. americana crosses, 149 (21.8%) possessed hybrid vigor and had large leaf characteristics typical of U. americana. The crosses with diploid males yielded even higher percentages of hybrids. Crosses with males of U. carpinifolia, U. slabra, U. japonica, and U. pumila yielded respectively, 90.3%, 79.5%, 78%, and 67.4% hybrids. However, crosses with the other North American species, U. rubra, yielded only 33.3% hybrids.

#### **PRECOCIOUS FLOWERING**

To assess the precocious greenhouse-flowering capability of known field-flowering U. parvifolia selections and hybrids, 50 ramets each of several such individuals including, 2 U. parvifolia, 5 U. parvifolia x U. pumila, 1 U. parvifolia x [U. laciniata x U. pumila], and 1 W2220], were rooted and grown in the greenhouse without artificial illumination until leaf-fall. Except for the held-over year-old precocious-flowering W2224-2 individuals, none of the ramets produced flowers in 1993 (with a single dwarfish exception). The reasons for failure to flower among these numerous ramets is not clear! The 1992 flowering event may have been related to the unusually cold, short growing season in 1992, or possibly because most of the flowering individuals in 1992 had been a part of the Ophiostoma ulmi or O. novo-ulmi inoculation series.

## RESULTS OF RESISTANCE TRIALS

Greenhouse inoculations in 1991 contrasted the resistance of various new U. parvifolia x U. americana hybrids from the 1989 field planting with other elms with known levels of resistance. Selections included 20 individuals from 9 families; one family (W114-1 x [Campus-4 x Cornell-18]) has clearly produced the preponderance of superior trees. Most of the U. parvifolia x U. americana hybrid selection remained symptomless although internal discoloration in certain clones was severe. The American elm controls developed severe foliar symptoms and most individuals had died by the end of the study. It is clear the resistance genes from U. parvifolia were transferred to hybrid progeny with American elm. These progeny also resembled their American elm parent morphologically (e.g large leaves, highly vigorous, etc.) (Smalley & Guries. 1993; Smalley et al, 1993).

Greenhouse inoculations in 1992 contrasted the resistance of selected diploid progeny from U. parvifolia hybrids created in 1987-88. Emphasis in this trial was given to 70 vigorous hybrids selected from the field from progeny of crosses with various elm species and hybrids as male parent (But excluding the U. americana hybrids tested in 1991.) Resistance of these clones was contrasted with other elms with known levels of resistance in early spring greenhouse inoculation trials. Most of the clones showed high resistance to inoculation with O. ulmi or O. novo-ulmi as contrasted to susceptible controls. Candidate selections for possible cultivar release will be made in 1994 based on crown architecture and various ornamental features. All of the Chinese elm hybrids remained symptomless following inoculation. Their resistance as measured by the length of xylem discoloration also proved to be very high, was only slightly less than the U. pumila control. Half sib open pollinated progeny of the W114-1 U. parvifolia clone (e.g. the mother tree) also remained symptomless, but surprisingly, similar half sib progeny from a specimen U. parvifolia tree in the U. W. Arboretum proved to be extremely susceptible. Their susceptibility, in fact, did not differ significantly from our highly susceptible U. americana seedling controls from Louisiana.

## LITERATURE CITED

- Santamour, F. S., Jr. 1972. Interspecific hybridization with fall-and spring flowering elms. *For. Sci.* 18:283-89.
- Santamour, F. S., Jr. 1973. Resistance to Dutch elm disease in Chinese elm hybrids. *Plant Dis. Rep.* 57:997-99.
- Santamour, F. S., Jr. 1974. Resistance of new elm hybrids to Dutch elm disease. *Plant Dis. Rep.* 58:727-30.
- Santamour, F. S., Jr. 1989. Flowering and fertility of hybrids between spring and fall-flowering elms. *HortScience* 24:139-40.
- Smalley, E. B., and R. P. Guries. 1993. Breeding elms for resistance to Dutch elm disease. *Annu. Rev. Phytopathol.* 31:325-52.
- Smalley, E. B., Guries, R. P., and D. T. Lester. 1993. American Liberty elms and beyond: Going from the impossible to the difficult. pp 26-45 in: Sticklin, M. B. and J. Sberald, eds. *Dutch elm disease: Cellular and Molecular Approaches.* Springer-Verlag, New York. 335 pp.

