GENETIC IMPROVEMENT OF ELMS AND OTHER TREE GENERA[1]

by A.M. Townsend

Abstract. An extensive selection and breeding program for disease resistant, stress tolerant elm clones is being carried out. Efforts have involved making controlled hybridizations for improvement of not only resistance to aggressive and non-aggressive forms of *Ceratocystis ulmi* but also variable growth rate, leaf size, and form. The many new selections include several American elms as well as horticulturally desirable hybrid clones from European and Asiatic crosses. These selections are currently being evaluated in nurseries and cities across the U.S. Research with red maples has demonstrated opportunity to select from among seed source progenies for superior growth rate, winter hardiness, stem straightness, and tolerance to Verticillium wilt, ozone, and drought. Seed source studies are also being conducted with the Chinese elm (*Ulmus parvifolia* Jacq.), blue spruce (*Picea pungens* Engelm.), and European black alder (*Alnus glutinosa* (L.) Gaertn).

You are all familiar with the challenge of keeping trees healthy in urban areas. Diseases, insects, deicing salts, air pollution, soil compaction, and drought interact to create a stressful environment. Unfortunately, most trees have evolved over thousands of years to adapt and grow well under forest, not urban, conditions.

In order to find better urban and highway trees, "genetic engineering" using scientific methods of selection and breeding is needed. Our objective in genetics research at the USDA Nursery Crops Research Laboratory is to develop better tree material and more useful information on survival characteristics important for planting in urban areas. Currently our genetic studies are concentrated on elms, red maple, blue spruce, and European black alder.

Elm Breeding and Selection

Despite the susceptibility of a few elm species, particularly *Ulmus americana* L., to Dutch elm disease and phloem necrosis, the elms constitute one of the best groups of trees for harsh urban sites. They are tough, they transplant readily, and they have the inherent vigor necessary to survive stressful city sites. By breeding and selecting for disease resistance, we have created a reservoir of many disease-resistant progenies and clones which diminish the importance of diseases on elms, and which therefore allow us to capitalize on the superb adaptability of this genus.

The objective of our elm improvement effort is the eventual release of disease-resistant, aesthetically-pleasing clones that will survive environmental stresses. The first phase of reaching this goal has been an extensive program of controlled-hybridization among many species and clones, resulting in a wide array of progenies representing more than 60 different parental combinations (Townsend, 1975). Parents used have been resistant selections of *U. pumila* L., *U. parvifolia* Jacq., *U. glabra* Huds., *U. wilsoniana* Schneid., *U. carpinifolia* Gleditsch, *U. rubra* Muhl., as well as several resistant clones from the Netherlands. Our breeding studies have shown that by choosing the right combination of male and female parents, we can "tailor" an offspring's growth rate, branch form, leaf size, and degree of disease resistance. We have found that disease resistance is controlled by many genes contributing horizontal resistance to both aggressive and non-aggressive strains of the fungus (*Ceratocystis ulmi* (Buism.) C. Moreau) which causes Dutch elm disease (Townsend and Schreiber, 1976; Schreiber and Townsend, 1976). Crosses resulting from certain parents yield progenies which differ in disease-resistance depending on whether each parent is used as a female or as a male (Townsend, 1979). For example, an *U. pumila* clone has functioned more effectively as a female than as a male parent in transmitting disease-resistance. Such a phenomenon suggests maternal or cytoplasmic inheritance as one possible explanation.

All selected clones are rigorously tested for resistance to Dutch elm disease. After an initial inoculation in a field plot, clones are propagated by

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rooted cuttings and then after 3 years these propagules are inoculated at different times throughout the growing season with a mixture of aggressive and non-aggressive isolates of *Ceratocystis ulmi.* Propagules of clones passing this test are sent out to nurserymen and arborists for further evaluation before final release is made.

Dr. L.R. Schreiber, Research Plant Pathologist and Research Leader at our station, has released one disease-resistant cultivar, the 'Urban' elm. Many other disease-resistant selections are currently being tested but no release has been made pending further trials. Included among these clones under test are No. 470, a complex hybrid (*U. pumila*) × [(*U. hollandica* 'Vegeta × *U. carpinifolia*) × (*U. pumila* × *U. carpinifolia*)] which is dense, dark green and fast-growing (Fig. 1).

Figure 1. Selection 470. A fast-growing hybrid with resistance to Dutch elm disease. Currently being evaluated by several nurserymen and arborists.

Another selection, No. 205, a hybrid between *U. glabra* and *U. carpinifolia*, has large dark green leaves, a dense oval shape, rapid growth, and should make a fine shade tree. Clone 970 (*U. glabra*) × (*U. wallichiana* × *U. carpinifolia*) is probably our most promising selection, because it is beginning to show a vase-shaped, symmetrical crown with rapid growth rate. Another vase-shaped selection we are testing is a red fall-colored Chinese elm (*U. parvifolia*).

We also continue to search for American elms (*U. americana* L.) that are disease-resistant. Unfortunately, the average level of resistance in American elm is so low that thousands of trees must be screened in order to find a few that may have some level of resistance. We are propagating several of the more promising trees for further testing. An American elm from near Findlay, Ohio has survived repeated attacks of the fungus and appears especially promising (Fig. 2). Dr. L.R. Schreiber is testing additional American and non-American elm selections besides the ones mentioned.

In 1980, we carried out an advanced-generation breeding program, crossing the best of our selections following a special breeding design. Seedlings resulting from these crosses were outplanted at Delaware this spring (1981) and will serve as a reservoir of trees from which superior selections can be made in the future. Another aspect of our elm program is the cooperative evaluation with Dr. E.B. Smalley, University of Wisconsin, of 6 Japanese seed source progenies of *U. parvifolia* outplanted in Ohio and Wisconsin in 1980.

Red Maple

Although maples comprise the most frequently planted group of urban trees, they are often not well adapted to urban stresses. We have carried out an extensive study with red maple (*Acer rubrum* L.) to test the hypothesis that sufficient genetic variation within maple species exists to select and breed for not only tolerance to maple decline but also other desirable attributes.

With the help of cooperators, seed was collected from 1 to 5 parent trees in each of 51 geographic areas throughout the species' natural range. Seed was planted and seedlings grown in nursery beds at Delaware, Ohio. Two-year-old seedlings were outplanted to sites in Delaware County, Ohio (Fig. 3); Kalamazoo Co., Michigan; DuBois Co., Indiana; Columbia Co., Wisconsin; and Carver Co., Minnesota.

Results from nursery bed (Townsend, 1977) and plantation (Townsend *et al.*, 1979) studies have shown highly significant differences in many traits among geographic areas and among parent trees from within these areas. Wide variation has been shown in height, autumn color, stem straightness, cold hardiness, time of seasonal growth initiation and cessation, and many other charateristics.

Results have been collected from north central states only, and therefore should not be extrapolated to other areas. Fast-growing progenies generally performed well in all outplanting sites. The tallest 5-year-old seedlings were from north central and east central seed sources such as southern Michigan, southeastern New Hampshire, northern Pennsylvania, northern Delaware, Kentucky, Tennessee, and Virginia. Most trees from the northern areas (northern New England, northern Minnesota and Michigan and Canada) have grown slowly. Trees from extreme southern areas have suffered winter dieback, resulting in slow growth on these trees, also.

Trees from the northernmost locations had the most reddish color and tended to color well in all plantations. Those from north central and west central seedlots were above average in fall color, but were less likely to color uniformly in all planting locations. Progenies from east central and southern sources generally showed poor fall color.

Northern sources generally showed the straightest stems, earliest flushing, budset, and defoliation, and least winter injury. Nurserymen who lift seedlings in mid- to late summer may want to grow seedlings of northerly origin because these enter dormancy earliest.

Other red maple studies have shown a wide range of response among progenies in tolerance to *Verticillium* wilt, drought, ozone, and to a combination of ozone and deicing salts. This variation is adequate to improve upon these traits through scientific selection and breeding. The wide degree of genetic variation in red maple is an example of what probably can be found in many other urban tree species. If such variation is present, each species offers tremendous opportunity for genetic improvement in traits important for beauty and survival.

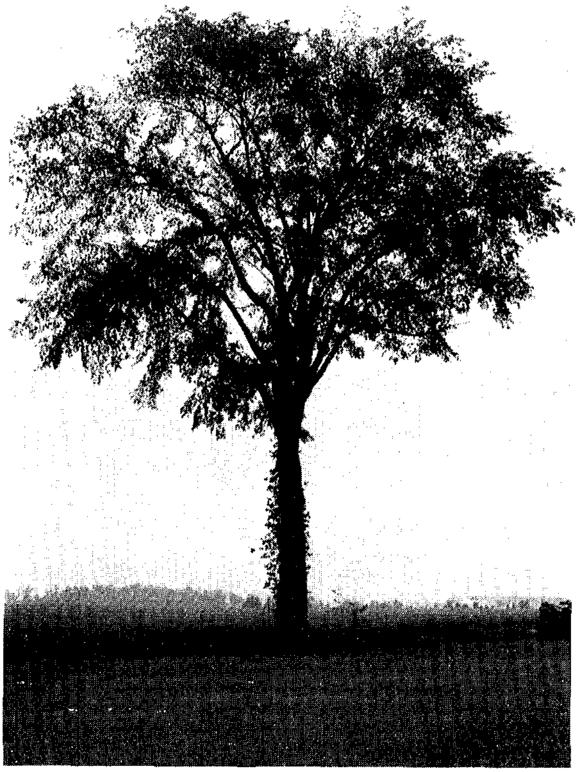

Figure 2. An American elm near Findlay, Ohio that has shown promising levels of disease-resistance. Being propagated and subjected to further testing.

Colorado Blue Spruce

Because of its symmetry, beauty, and hardiness, Colorado blue spruce (*Picea pungens* Engelm.) is a popular and highly valued tree species for landscape, highway, and shelterbelt plantings. In cooperation with Dr. James W. Hanover of Michigan State University, we established a 32-seed source planting of this species in 1975 at our laboratory (Fig. 4). Results to date indicate wide genetic variation in growth rate and foliage color among the progenies. Seedlings from specific locations in New Mexico, Arizona, and Colorado have shown the best color development. The tallest seedlings have been grown from seed collected from certain stands in Colorado, Utah, and New Mexico. One can not generalize about the best states from which to collect seed, because wide variation in color and height growth has been shown among progenies from different areas within the same state. Future genetic improvement of this species should yield payoffs to both nurserymen and arborists by increasing growth rate, foliage color and frost resistance while retaining inherent superior qualities of pyramidal form, long needle retention time, and resistance to damage from cold, salt spray, and drought.

European Black Alder

Interest in European black alder (*Alnus glutinosa*) as an urban tree has recently increased because of its fine performance in several American cities. It is fast-growing and vigorous, with dense dark green foliage and an ability to fix its own nitrogen. With a natural range that extends over most of Europe into Asia Minor, this species shows much potential for future genetic improvement. In April, 1981, at our laboratory, we outplanted seedlings grown from seed collected from 12 seed sources. Seed was contributed by Dr. Richard Hall, Iowa State University, and Dr. Kim Steiner, The Pennsylvania State University. Seed sources included specific locations in Iran, Bulgaria, Italy, Yugoslavia, Spain, France, Ireland, Scotland, Denmark, West Germany, Poland, and USSR. Also included in our outplanting for com-

Figure 3. The 8-acre red maple plantation near Delaware, Ohio. This planting contains trees grown from seed collected from 51 different geographic locations.