GENETIC POTENTIAL OF RED MAPLE

FOR URBAN USE

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ABSTRACT--- Red maple has been shown to be highly variable genetically in many traits associated with adaptability and marketability. Current research efforts are being made to determine the inheritance of these traits, and to identify clones which represent a superior combination of economically valuable attributes. Through the "Species Trial Project" METRIA can participate in propagating and testing this valuable germplasm for future use by both the private and public sectors.

Red maple (Acer rubrum L.) is considered to be the most widespread forest tree in eastern United States. Its native habitat extends from Newfoundland, Canada, westward through southern Ontario and Quebec to Northern Minnesota south to Oklahoma, Texas, and southern Florida (Little 1971). Red maple reaches its best development on moderately well-drained moist sites, but is common where the soil moisture conditions are extremely wet or dry, in swampy areas or on dry ridges and south and west exposures of mountainous terrain. Typical mature forest trees are about 60 to 90 feet in height and about 2 feet in diameter. In landscape sites or along streets, however, 35 to 50 feet in height and 12 to 18 inches diameter is about average.

This species is unique in having not only good adaptability to many urban sites but also attractive form and color. Younger twigs become increasingly tinged with red color in late winter, and this is followed by red or yellow flowers, red winged samaras, red newly formed leaves, pink petioles, and later, scarlet autumn leaf color. Red maple has become very popular among nurserymen and arborists and is considered a first-rate choice for planting in lawn and landscape sites or along suburban streets and highways (Kozel and Jansen 1976;, Parrish and Wiedenmann 1978). However, it does not grow well on extremely stressful sites and in high pH soil areas often shows chlorosis as a result of manganese deficiency. Diseases and insects are not serious problems, although Verticillium wilt, anthracnose, and leafhopper injury can occur.

After nursery-grown trees are transplanted, usually best done in late winter or early spring, red maple requires regular watering during establishment. Trunks of young trees need to be wrapped in the first winter to prevent sunscald. Red maple is generally less prone to ice and wind damage than is silver maple (Acer saccharinum L.).

GENETICS AND BREEDING

Taxonomy and Cytology

Red maple has been placed by several taxonomic investigators into the section Rubra (Murray 1970; Santamour 1982). Taxonomists have divided the species into several subspecies (Ellis 1963; Murray 1970). Acer rubrum var. rubrum Pax is the most predominant type, occurring in a wide range of habitats and elevations from near sea level to more than 6000 feet throughout eastern United States and Canada. Acer rubrum var. tridens Wood or var. trilobum Koch is character= by having only three major leaf veins and lobes. It occurs most frequently along streams and swamps in the coastal plain from New Jersey southward but is also infrequently distributed in the unglaciated portion of eastern United States, usually at elevations below 3000 feet (Ellis 1963). Acer rubrum var. Drummondii (Hook and Am.) Sarg. inhabits wet sites along the lower Mississippi River Valley as far north as southern Indiana. This variety has longer and wider samaras and longer seeds than the other types (Townsend 1972).

Foster (1933) and Duffield (1943) carried out cytological studies and found the chromosome number of red maple to be either hexaploid (2n = 78) or octoploid (2n = 104). Santamour (1965) later found that in addition to these numbers, the species can exist as a septaploid (2n = 91) or aneuploid such as 2n = 97, 98. Ellis (1963) found Acer rubrum var. Drummondii to have fewer chromosomes, 2n = 65, than the other types which had chromosome numbers of 2n = 78. He found no octoploid types, but examined only 15 trees.

Sexual Reproduction

The flowers of red maple are perfect structurally but not functionally (de Jong, 1976). In most cases, trees in various north central U. S. locations produce almost exclusively either male or female flowers (Townsend and others 1982). In those few cases where both male and female flowers do occur on the same tree, each sex usually is represented on different branches; only in a few of these trees are both sexes found to occur on the same branch. Flowers are produced in clusters which develop singularly at the end of slender, reddish pedicels, with a short S-lobed calyx, five small petals, five to eight stamens, and one pistil (Taylor 1920). Flowers usually

appear in December or January in the South, and from March to May in the North. Certain precocious seed sources progenies grown in Ohio began flowering when trees were only three years old (Townsend and others 1982).

Fruit production occurs 4 to 6 weeks after flowering. The fruit, a samara, is often tinged with pink or red color in its early development maturing to brown. Seed generally will germinate quickly after they fall, or they can be stored in cold (4°C) for up to a year for future use. There is some evidence to suggest that trees which flower late in the season have a better chance of reproducing viable fruit (Townsend and others 1982).

Asexual Reproduction

Until recently, commercial cultivars of red maple have been propagated by budding or grafting onto red maple seedlings (Kozel and Jansen 1976). However, this technique often leads to graft failure, either immediately or it can be delayed and occur in 2-2-l/2 in. caliper trees in the nursery, landscape, or street tree planting.

To overcome this incompatibility between stock and scion, the nursery industry is gradually doing more and more propagation by rooted cuttings. Orton (1978) has successfully rooted 'October Glory' and 'Red Sunset' from single node cuttings taken in July or August. Intermittent mist was used in a propagation bench containing a sand; peat (4:l v:v) or a peat:sand:soil (2:7:1 v:v) mix.

Welsh and others (1979) have attempted tissue culture propagation of red maple using various media and several phenolic inhibitors. They found that actively growing shoots were a prerequisite for high percentage rooting of proliferated shoots which arose from axillary buds on shoot-tip explants.

Cultivars Selected

Many cultivars of red maple have been selected based usually on fall color or form. The ones most commonly used are 'Armstrong', 'Autumn Flame', 'Bowhall', 'Columnare', 'October Glory', and 'Red Sunset' (Kozel and Jansen 1976). Many other cultivars have been selected and listed in Santamour and McArdle's (1982) first article on the cultivated maples.

Genetic Variation in Important Traits

The first major genetic and physiological studies of red maple were carried out by Dr. Thomas 0. Perry, now a Professor at North Carolina State University. He and Wang (1960) found that seedlings from northern seed sources could not break dormancy in the spring without adequate chilling, whereas seedlings from southern Florida

seed sources could; that is the Florida trees had no chilling requirement. In a subsequent study of genetic variation in temperature and light requirements, Perry (1962) found that northern red maples became dormant when the night temperature was about 23°C or when the light intensity was 1000ft-c or less. Florida trees, in contrast, continued to grow at high night temperatures and low light intensities. In a later biochemical study, Perry (1971) observed higher concentrations of fats, phenols, proteins, and pigments in New York red maple seedlings as compared to others from Florida. He noted that some of these differences in protein and pigment content disappeared by the end of the winter season and suggested that they may be related to observed differences in cold resistance and chilling requirement of the two seed sources.

The U. S. Department of Agriculture initiated an intensive study of red maple in 1971. Seed was collected from 128 single parent trees located in 51 natural stands scattered throughout the species' natural range. Several greenhouse and laboratory studies of this material subsequently have shown sufficient genetic variation among progenies to select and breed for tolerance to Verticillium wilt (Townsend and Hock 1973), drought (Townsend and Roberts 1973), ozone (Townsend and Dochinger 1974), and deicing salts (Dochinger and Townsend 1979).

Concomitant with the laboratory studies, a replicated nursery bed test of all progenies was established at Delaware, Ohio. Variance component analyses showed highly significant differences among stands of seed origin and among half-sib families within stands for height and diameter growth, autumn color, winter injury, earliness of flushing and cessation of growth (Townsend 1977). Northern progenies in the nursery beds generally showed the slowest growth and most intensely red autumn color.

Nursery-grown seedlings were lifted and then used to establish progeny tests in Ohio, Michigan, Indiana, Wisconsin, and Minnesota. When seedlings were five years old, significant variation was found in height among seedlings from different stands and from offspring of different trees within the same stand in all plantations (Townsend and others 1979).

There generally was little interaction between seedlot and place of planting; trees grown from seed from the north central and east central portions of the range were tallest at all sites. Some genotype-plantation interaction occurred for autumn color but seedlings from New York, Michigan, and Wisconsin northward generally showed the most reddish appearance, and above average stem straightness. Preliminary g-year-old height data analysis indicates that north central seed sources are continuing to be above average in height growth, and that some genotype-environment interaction is present.

Frequency of winter injury and earline.ss of growth initiation in the spring of eight-year-old red maple progenies showed a strong consistency between plantations, with northern progenies sustaining a lower frequency of winter injury and beginning growth first (Townsend and others 1982). This stability of response indicates genetic control sufficiently strong to make it possible to select and breed either for cold hardiness or for early or late budbreak.

Results from the USDA studies have important implications for nurserymen and arborists. Information is now available on where to collect seed for improved growth rate, autumn color, crown form, cold hardiness, and for those nurserymen who lift red maple early in the autumn, early growth cessation and early leaf defoliation.

Current Research Efforts

The USDA Nursery Crops Research Laboratory at Delaware, Ohio, is continuing research on this economically valuable crop species. In order to determine the inheritance of autumn color, various controlled crosses were made in the spring of 1982 among clones with varying degrees of red autumn color. Progenies resulting from these crosses were outplanted in April, 1983, and should yield information on the relative importance of specific vs. general combining ability in breeding for autumn color.

Nearly 100 clones in the Delaware, Ohio, plantation have been selected for uniqueness in growth rate, color, form or some other attribute. Propagation experiments with these clones are being carried out by Dr. Dan Struve of The Ohio State University. In the Delaware plantation, preliminary observations have been made on resistance to leafhopper damage, and we plan to identify families and clones with superiority in this trait. Because of the diverse nature of the seed sources material representing many geographic areas, the USDA red maple plantation effectively serves as a part of the National Plant Germplasm System (NPGS).

Need for Further Research and Role of METRIA

I see a need for much further effort if we are to continue to enhance the quality of red maples grown in urban situations. An advanced generational breeding program utilizing the USDA material is being planned. In order to carry out this crossing plan, further progeny data will need to be collected on growth, color, branching habit, and wounding response, and then combined with data from other traits to develop a selection index. Dr. Walter Harvey of The Ohio State University and I are trying to develop a statistically valid approach to create such an index that weighs information on each clone with regard to plantation, stand, family and plot of origin. Once

developed, this method could be used to identify those clones which should be used in breeding to make the most rapid economically valuable genetic advances in this species.

The METRIA membership of nurserymen and arborists that grow, plant and maintain red maples throughout the United States can serve this research effort as propagators and testers of new clones of red maples in the METRIA Species Trial Project. In this way, members of METRIA can help in genetically improving the survival ability, vigor, and stress and disease tolerance of this species.

An important first step would be to ship cuttings from USDA clones and from named red maple cultivars to one or two nurserymen. They in turn would propagate each clone, and then line out ramets and grow them on to street tree size.

A second step would be selection of test sites chosen to represent a wide variety of urban and suburban edaphic, atmospheric, and climatic planting sites. Clones would be sent from the cooperating nursery (nurseries) to METRIA city arborists for planting, using a statistically replicated design, while maintaining the identity of the clone itself, as well as the nursery that grew it if more than one nursery propagates the material.

Once established, METRIA could periodically record observations on all trees in all test sites. Such factors as height and diameter growth, mortality, summer and autumn leaf color, insect, disease, salt, cold, drought, and air pollution symptoms and injury would be recorded and analyzed. Reports on which of the tested clones and cultivars have proven superior would be made at biennial METRIA conferences. Testing of these clones and cultivars could also be included as part of the METRIA Cultivar Testing Project.

CONCLUSION

Red maple holds unparalleled opportunity for germplasm enhancement. The USDA's research program with this species can serve as a major source of information and superior germplasm. Clones derived from this program can be tested for adaptation to city, suburban, and landscape environments by the METRIA Species Trials Project.

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