BREEDING BETTER URBAN TREES--
PROBLEMS, PRACTICES, AND POTENTIAL

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Abstract.-- Importation of species or cultivars native to foreign countries has been, and will continue to be, an integral part of landscape-tree improvement in the United States. What is needed, in most exotic species, is a broader base of genetic variation from which superior selections and progenies can be developed. Seed source or provenance has been largely neglected in the past, but its importance is becoming recognized and appreciated. Still, the marketing practices of large commercial nurseries demand that only the most widely adaptable provenances will likely be recognized and propagated. Seed orchards are distinct possibilities for the continual production of superior trees in species where the need or desire for absolute uniformity is not great. The development of clones and cultivars based on single-tree selections will likely continue for the foreseeable future. Adequate testing of these cultivars will assure, that, in addition to the visual uniformity required in some landscape schemes, the cultivars will also be uniformly superior in survival traits. For cultivars propagated by budding or grafting, some attention must be paid to the provenance and adaptability characteristics of the rootstocks. Vegetative propagation is the norm in landscape-tree production and any improvement in rooting techniques or cell culture of difficult species could result in an abundance of new cultivars. Interspecific hybridization will continue to be important in developing new cultivars resistant to major disease and insect pests.

INTRODUCTION

Shortly after the research project on "Cytogenetics, Breeding, and Selection of Shade Trees" was established at the U.S. National Arboretum in 1967, I presented a comparative appraisal of the goals and procedures of tree improvement in horticulture and forestry to the Central States Forest Tree Improvement Conference (Santamour 1968). In subsequent papers and reports, I have attempted to amplify or clarify certain aspects of tree improvement for urban areas (Santamour 1969, 1971, 1972, 1976a). Today's presentation should be considered as merely another attempt to put urban tree improvement into an understandable perspective for scientists already trained in genetics and forestry.

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In that early paper, I wrote (somewhat hopefully) of an upsurge of interest in urban trees. The past decade has, indeed, seen an increased awareness of the plight of metropolitan flora and a modest increase in the number of scientists devoted to improving man's living and working environment through the production of superior woody plants.

The first International Symposium on the possibilities of genetic improvement of trees for metropolitan areas was held in 1975 (Santamour, Gerhold, and Little 1976). This Symposium was highlighted by the excellent spirit of cooperation among nurseryman, foresters, horticulturists, landscape architects, arborists, and representatives of associated scientific and practical disciplines. METRIA (the Metropolitan Tree Improvement Alliance) was both the parent and the child of the Symposium, and held its first conference in 1976.

There is no doubt that more and more persons are becoming interested in trees in urban areas. More often than not, positions of major responsibility are being filled by individuals with a forestry background. Therefore, in presenting this subject matter for the first time to the Southern Forest Tree Improvement Conference, I have followed the outline used by Dorman (1976) in chapter 20 of "The Genetics and Breeding of Southern Pines".

BUT FIRST, A FEW WORDS ....

As I talk with foresters around the country, I still meet some who are not totally aware of recent changes in the semantics and terminology of urban horticulture. There are many terms with various shades of meanings that could be discussed, but today I would like to focus on only a few.

The first of these is "ornamental". Does this word suggest useless, affluent, wasteful, superfluous, or other thesauric variations on the theme of non-utility? I think it does. It is a word that those of us engaged in the production, planting, and care of trees in urban environments cannot countenance. It is a word that is out of place in these times of ecological and environmental awareness. It is a word that should never have been used to describe so intricate an object as a living, green plant. So, let us erase "ornamental" from our lexicon, and concentrate on the ecological imperatives of plants for people.

What can we substitute for "ornamental"? The British have been doing quite well with "amenity" for a long period of time. The more ecologically aware have suggested "environmental". My own favorite, at least with regard to woody plants destined for outdoor use in city and suburb is "landscape". A landscape tree, a landscape shrub, a landscape planting: all phrases at least alluding to the interrelationship of plants and man. There may be other, and better substitutes for "ornamental". Whatever they are, let's use them.

The second term is "cultivar". Even though the International Code of Nomenclature for Cultivated Plants was published in 1969 (Gilmour and others 1969), it has not made much of an impact on forestry or foresters. However, as foresters move out of the woods and into the streets, they would do well to become aware of the Code and its ramifications. Basically, "cultivar" was coined from "cultivated variety" and was intended to replace the improper use of "variety" in designating vegetatively propa- ated plants selected from or intended for cultivation and which had no counterpart in natural plant communities. Those "fancy" names you see in nursery catalogs are all cultivar names, used to distinguish a particular selection from all other selections within a species or genus and especially from run-of-the-seedlot seedlings.

A "clone" may be a cultivar, but not necessarily. A cultivar need not be a clone. For a more provocative discussion of this latter point, see Santamour (1976c). But do get hold of a copy of the Code and see how it pertains to forestry and forest-tree improvement and read Dudley's (1976) paper in the aforementioned Symposium.

I could also speak of "arboriculture", which is the art and science of cultivating trees for the improvement of man's environment. The International Shade Tree Conference, the world's largest organization of arboriculturists, changed their name to the International Society of Arboriculture in 1975, in recognition of the provenciality of "shade tree" as compared to the more international "arboriculture".

What, then, is an "urban tree"; the subject of my talk today. Perhaps it would have been better to use "landscape tree" in the title, but with the current vogue of "urban forestry", the "urban tree" should have some status. I must confess that up until now I have not been pressed for a definition -- and it might be prudent to duck the question. An "interim" definition might state that an urban tree is one presently growing in, or destined for, environments characterized by a lack of natural tree vegetation and an abundance of people and people's things.

METHODS OF URBAN TREE BREEDING

IMPORTATION

Importation of species from foreign countries has been an important aspect of the nursery and landscape scene since the late 1700's. The European horsechestnut (*Aesculus hippocastanum* L.) was imported as seed in 1741, and it became the "spreading chestnut tree" under which Longfellow's "village smithy" stood. The Lombardy poplar (Populus *nigra* L. 'Italica' and *Ginkgo biloba* L. were introduced into this country in 1784, and the weeping willow (*Salix babylonica* L.) also came in the latter part of that century (Li 1963). Norway maple (*Acer platanoides* L.) made its first appearance in 1870 and Ale "London" plane (*Platanus* x *acerfolia* (Ait.) Willd.) in about 1900. More recent introductions include the Oriental cherries, Siberian elm (*Minus pumila* L.), Callery pear (*Pyrus calleryana* Dcne., and the Dawn redwood (*Metasequoia glyptostroboides* Hu & Cheng).

How many species native to foreign lands now are growing in the United States would be difficult to estimate. Indeed, one is tempted to think that practically all foreign tree or shrub species capable of survival in the more temperate zones have already been tried at least once. The "once" in the last sentence is a critical point.

The fact is, that even with the thousands of exotic species presently growing in this country, there may be little genetic diversity <u>within</u> species available for landscape-tree improvement research. Early, and sometimes the only, introductions of certain species were made from plants already under cultivation in their native lands. Furthermore, in some genera like <u>Magnolia,</u> it is possible that the wild progenitors of some cultivated species no longer exist in the native state.

We might already have the hardiest, most adaptable, most pest-resistant, and most floriferous specimens of a given species available to us. Or we might have only the "culls". Few studies have been made to determine the extent of available genetic diversity in non-forest trees of foreign origin. Feret and Bryant (1974) found that American sources of <u>Ailanthus altissima</u> (Mill.) Swingle (Chinese tree-of-heaven) possessed a considerable amount of variability as compared to native Chinese sources. Similar studies are desperately needed in more important exotic species.

Past plant exploration for hardy exotic trees was conducted largely along opportunistic rather than systematic lines, and with few exceptions, this method has persisted to the present day. It is likely that no single organization has the land, labor, money, interest, or tenacity to adequately develop a broad genetic base for the exotic species of even a single large genus, like the maples. The enormity of the task of assembling germplasm collections for the thousands of horticulturally important exotic species is sufficient to dissuade most arboreta, experiment stations, or nurseries from even making a start.

At the U.S. National Arboretum we have only recently begun efforts to develop domestic seed sources for some of the important Asiatic birch <u>(Betula)</u> species. Our interest in this project was prompted by the discovery that many Asiatic birches in the collections of American arboreta were not even true to species. We have made a good beginning with Japanese white birch (B. <u>platyphylla</u> Suk, var. <u>japonica</u> (Miq.) Hara and are also attempting a collection of monarch birch (B. <u>maximowicziana</u> Reg.) sources. Other exotic white-barked birches deserving of attention are B. <u>costata</u> Trautv. and B. <u>jacquemontiana</u> Spach. In addition, we are working to preserve the entire gene pool of the recently rediscovered native American B. uber Ashe (Ogle and Mazzeo 1976).

There is no doubt, however, that past introductions of non-native trees have served the nursery industry and the American public well over the last few decades. By prudent selection among well-adapted trees in street and landscape plantings or nursery plots, American nurseryman have produced vegetatively propagated cultivars of great utility and esthetic qualities, notably in Norway maple and flowering crabapples. Direct importation of cultivars developed by European and Asiatic nurserymen or arboreta has brought some fine plants to our shores and the products of foreign research projects, like the disease-resistant elms from the Netherlands, may well play a major role in the future.

We should continue to exploit the variation encountered within existing American populations of exotic trees and strive to make further introductions of important foreign species more meaningful for future tree-improvement research. The key to the successful utilization of these foreign introductions, whether from 1777 or 1977, is, of course, testing,

RACIAL AND STAND SELECTION

Many nurserymen have, over the years, relied on certain trees or stands as parents for the production of seed-propagated species. Often the choice has been dictated merely by convenience, but the economics of production practices would argue that some selection for uniformity of seed germination, growth characteristics, and adaptability to nursery culture must have taken place. The selected trees or stands may or may not have been native to the region where they were growing but the fact that they were selected would indicate that they were at least well-adapted to that particular area. This type of seed source selection and use demonstrates, with few exceptions, the limited attention most nurseries have paid to geographic seed origin.

When the "selling range" of the nursery was restricted to a local area or within a given climatic zone, the seed-propagated progenies could be expected to perform reasonably well. When these progenies were sold and planted outside their zone of origin, the results were erratic and often disastrous. Still, there was a certain measure of protection against total failures by the built-in genetic variability of the seedlings.

As clonal and cultivar selections became more widely used in the nursery trade, the genetic variation was reduced, and thus the geographic origin was even more important. For many of the more widely used cultivars, the original seed source is unknown or relatively imprecise. One of the most popular red maple (Acer rubrum L.) cultivars was selected in Oregon from trees grown from seed collected "in Pennsylvania". Some cultivars of sweetgum (Liquidambar styraciflua L.), now being sold throughout the country for their attributes of fall color, were selected for this esthetic trait in California, after being grown there from seed of largely unknown origin.

The fact is that we know very little about the geographic origin of most of our cultivars of native trees and, perhaps, even less about the exact origin of exotic species. This lack of knowledge concerning origin has not deterred the widespread sale and use of many cultivars and few catastroph have been reported that could be traced to improper provenance. Perhaps, if more exact information were available concerning the geographic origin of certain cultivars, the full impact of poor provenance choice could be determined.

What are nurserymen doing about provenance selection? What are the arboreta and agricultural experiment stations doing about provenance selection? What are the handful of landscape-tree geneticists doing about provenance? The answer is "very little".

Forest geneticists in forestry-oriented institutions are virtually the only scientists actively exploring the genetic variation in broad-leaved deciduous trees, and this testing is largely with native American species. Many of our important oak and poplar species are being studied, as well as sweetgum and tuliptree, white and green ash, American sycamore, sugar and red maples, yellow and paper birches, etc. These tests may vary in their breadth and purpose, but most of them are designed for limited utility and the test areas cover only a small portion of the "selling range" of our major nurseries -- the 48 contiguous States.

What kind of impact will the results of such provenance studies have on the commercial nursery trade? The more progressive nurserymen will be interested, of course, since they have a personal commitment to grow the best plants possible. But can they afford to custom-grow plants for the diverse geographic or climatic zones of adaptation? I doubt it. If one or a few provenances can be singled out as having a rather broad range of adaptability, these would be the sources of greatest interest to nurserymen. Then, provenance research in "forest" species will have a positive influence on the landscape-tree business.

It should be mentioned here that for budded or grafted cultivars, the provenance of the rootstock may be as important (or more so) as that of the scion. Flemer (1976) has pointed out the necessity of cold-hardy rootstocks for trees destined for growing in containers in northern areas. The use of rootstocks of more northern origins may well extend the usable range of some trees that have a restricted geographic use on their own roots or on roots of seedlings from more southerly origins. The importance of rootstock provenance and the rootstock influence on the adaptability and performance of the scion cultivar are neglected areas of research.

SINGLE-TREE SELECTION

Single-tree selection is the very backbone of landscape-tree development. Nurserymen have, since the beginning, selected and propagated those trees that differed significantly from the "average" tree of a particular species. Unfortunately, much of this selection was for only visual and visible traits. Thus we have an abundance of dwarf, prostrate, weeping, creeping, and crawling cultivars with red, yellow, and variegated leaves gracing our nurseries, arboreta, cemeteries, streets, parks and houselots. The most bizarre cultivars have been selected among coniferous species, In most broadleaved deciduous species, the selection criteria of growth habit, growth rate, leaf texture, flower color, etc. have resulted in more "normal" trees. Some of these cultivars may be fine plants, with a wide range of adaptability and resistant or tolerant on the major biotic and abiotic stresses of urban areas. If there are such cultivars, we are indeed fortunate.

Is clonal or cultivar uniformity more dangerous than species uniformity? We tend to think so. Of course, the American chestnut (*Castanea dentata* Borkh.) had all of its genetic diversity available to withstand the charge of the chestnut blight. It lost:

Single-tree selection and the vegetative propagation of selected individuals will continue in landscape-tree research and development. It just makes good sense. The key to the success of this method in the future is *testing:* for climatic adaptability, for tolerance to air pollution and salty or compacted soil, for resistance to major insect and disease pests, and for the ability to recover from injury. We hope that, with the rather recent entry of a few scientists into the field of landscape-tree improvement, that nurserymen will be made more aware than ever of the need for thorough and rigorous testing. And we hope that we, as scientists, can practice what we preach.

SEED ORCHARDS

The concept of the "seed orchard" is, I think, relatively new to horticulture. Going back to my comments on seed source, it is likely that some nurserymen, when asked, might consider their parent tree or stand as a "seed orchard". They may be right--partially--but again the key word is *testing:* The testing (and selection) that turns a bunch of trees into a bona fide seed orchard.

The products of a seed orchard are superior trees. In current forestry practice there is, as yet, no uniformity in the designation of these superior seedlings. The superior seed or seedlings may be certified or the source described in some "longhand" fashion.

In landscape-tree horticulture, we have the advantage, I think, of being able to use the "shorthand" of a "fancy" cultivar name to refer the superior trees produced by the seed orchard method. Remember that the Code does not restrict the designation of *cultivar* to vegetatively propagated plants.

At the moment, there are very few seedling cultivars of woody plants destined for landscape or non-forest use. One of the more famous, deserved so, is the 'Chinkota' Siberian elm developed in South Dakota for planting in windbreaks and sheiterbelts in the Plains States (Collins 1955). This cultivar is the result of intensive selection for cold hardiness and climatic adaptability and has been produced under controlled conditions for over 20 years.

The use of cultivar names to designate the products of seed orchards is not, and should not be, restricted to non-forest trees. Forest trees are cultivated plants and, as such, come under the broad aspects of the Code. It is time that forest-tree geneticists recognize their responsibility to the Code and adapt its tenets-- or at least devise a similar system whereby seed and seedlings from seed orchards can be named, numbered, and recognized.

At the present time, commercial nurserymen grow trees from seed for two reasons: (1) it may be cheaper, or (2) the species cannot be easily propagated by vegetative means. Whether it is less expensive to grow seedlings as compared to vegetatively propagated selections is a matter for some argument, but it is noteworthy that most new, marginal, or fly-by-night nurseries offer only seedlings.

Not all landscape-tree species are suited to production in seed orchards -- at least not with our present state of knowledge. The inheritance of resistance to disease, such as Dutch elm disease or sycamore anthracnose, is seldom so dominant that the seedlings could be "guaranteed" resistant. The current vogue of using only male plants of dioecious species (e.g. Ginkgo biloba, Fraxinus americana L.) also argues against the seed orchard concept. There are also variables such as flower color, tree form, and leaf coloration that might not be as uniform in a seedling cultivar as in a grafted or rooted cultivar.

However, when we learn more about the genetics of our landscape trees and also learn that we can live (perhaps better) without the high degree of uniformity that we have come to expect from vegetatively propagated cultivars, we will see a dramatic increase in the use of seed orchards as an improvement method for woody plants in horticulture. Seed orchards will not replace single-tree selection and propagation, but should provide an important alternative for many landscape species.

INTERSPECIFIC HYBRIDIZATION

Many of our most important present-day cultivars (e.g. "London" plane, crabapples) are interspecific hybrids that occurred in nature or accidentally, under cultivation. To some persons, genetics is hybridization; and to a large segment of the public, the word "hybrid" denotes some superior status.

At the National Arboretum, we have been very active in hybridization research because (1) it is a rapid means of producing diversity in an often inadequate gene pool, (2) it gives meaningful clues to species and generic relationships, and (3) it is frequently the only means of transferring certain desirable characteristics (such as disease resistance) to a widely used and adaptable species.

Forest-tree improvement in the United States has tended to rely, rightly, on well-adapted native species. Exotic species, whether as replacements for native species or as parents in hybrid combinations with natives have not proved to be very important. This should not be surprising, since the wide range of genetic diversity, (quite readily available) allows for critical selection procedures to solve most problems.

Perhaps it was the unavailability of intraspecific genetic diversity that has led most horticultural geneticists down the path of interspecific hybridization. If so, that is one very valid reason. Another reason might be that the rare "super" gene combinations developed by hybridization could be put to immediate use through vegetative propagation. Whatever the reason, I would predict that interspecific hybridization will continue to play an important role in landscape-tree improvement and also, as forestry becomes more intensive, that hybrids may solve some of the problems that will be encountered in such mass cultures.

It is interesting to note that, in the Netherlands, the new hybrid cultivars -- the only ones to show adequate resistance to the "aggressive" strains of the Dutch elm disease fungus -- have a "touch" of Himalayan elm (*Ulmus wallichiana* Planch.) in their background (Heybroek 1976). If this research project had relied exclusively on the European elm complex, which had produce four very fine cultivars, the appearance of the "agressive" strain might have not only wiped out the elms but also the research.

VEGETATIVE PROPAGATION

Vegetative propagation has been the cornerstone of plant improvement in horticulture for hundreds of years, and yet we still do not have all the answers. If, at this meeting, a paper were presented which outlined a "foolproof" technique for rooting stem cuttings of oaks, I am sure that, within 5 years there would be 50 new oak cultivars on the market. Would such a development be good or bad? Overall, I think it would be good. There are many apparently superior oak genotypes presently on our city streets and *we* cannot even test them, let alone mass-produce them, without an efficient means of vegetative propagation. The glut of new cultivars in any genus with landscape potential has always caused problems, but time and adequate evaluation should separate the "winners" from the "also rans".

It is perhaps true, however, that there is no species of woody plant that is *impossible* to root from cuttings. Not too long ago, the idea of establishing forests of clonally propagated pines and spruces seemed out of the question. The technology to produce such forests is now at hand.

We still need better rooting or cell-propagation techniques for difficult species. We need a greater understanding of the causes of graft incompatability. We need to know how and how much the rootstock influences the behavior of selected scion cultivars. The problems are solvable, if enough research effort is expended.

POLYPLOIDY AND MUTATION BREEDING

The use of colchicine to induce polyploidy and ionizing radiation and other agents to produce mutations has found little utility in forest-tree improvement. The same may be said of landscape-tree improvement. While such studies are of special experimental interest, the production of superior trees by these techniques may be difficult, and rather unlikely, in many genera.

However, in this context I would like to mention a rather effective new approach to woody plant improvement presently being explored at the National Arboretum. As mentioned previously (Santamour 1976b), the lack of fruit production can be a desirable attribute for many landscape trees and shrubs. Dr. Donald R. Egolf, at the Arboretum, has pioneered the use of colchicine-induced tetraploids in crossing to normal diploids to produce sterile (fruitless) triploid plants. The individual flowers of "created" triploids in Hibiscus syriacus Lo remain on the plant longer and the entire flowering period is lengthened. The lack of seed eliminates the potential problems that may occur when unwanted seedlings germinate in cultivated soil near the plants. It is also likely that the lack of fruit and seed production actually enhances the vigor and adaptability of the plant, although no studies have been made. Only one Hibiscus cultivar developed by this technique has been released so far (Egolf 1970), many other triploid selections of Hibiscus and *Lagerstroemia* are under evaluation.

Sterility and lack of fruit production are, of course, not the same thing. Parthenocarpy in such self-incompatible genera as Liquidambar and Liriodendron might eliminate any supposed advantages of triploidy in eliminating fruit production. Still, there are a number of genera like Albizia, Catalpa, Paulownia, and *Sophora* in which we have attempted the first step (induction of polyploidy by colchicine treatment) to test this technique.

It is also possible that triploids created by interspecific crosses in genera having polyploid series *(Carya, Fraxinus, Tilia)* may be fruitless.

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