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PERFORMANCE TESTING TREE CULTIVARS IN METROPOLITAN ENVIRONMENTS[1]

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Abstract.
A performance testing system is proposed for evaluating the health and growth of landscape trees planted in metropolitan regions. Test results would assist arborists in choosing species and cultivars that are best adapted to tolerate various kinds of unnatural stresses. Municipal arborists and commercial nurserymen would collaborate in the test program, contributing modest amounts of time. They would use ordinary procedures by which trees are grown, purchased, planted, and maintained, with only minor modifications. Data collected periodically by arborists would be analyzed by a test coordinator. Results pertaining to particular cities, and compilations for each species at all test sites, would become available to cooperators four years after the program started, and annually afterwards. Procedures of the test program are described, and the feasibility of putting it into operation is discussed.

Introduction

Information that can be used to select trees for planting in metropolitan environments is grossly inadequate, as shown by recent surveys (Gerhold *et al.* 1975, Gerhold and Steiner 1976). About 300,000 trees worth $12,000,000 are planted annually along the streets and highways of thirteen northeastern states. There they encounter stresses caused by restricted growing space, air pollutants, road salts, and other unnatural conditions. Additional large numbers of trees planted around homes and commercial buildings experience problems that are similar, though perhaps less severe.

Debilitating environments to which many valuable trees are exposed, and the increasingly widespread use of clones, suggest an urgent need for testing to find which trees can best tolerate various conditions (Flemer 1972, Lighty 1975, Reisch 1971, Santamour 1967, 1971, Seibert 1969, Spicer 1971, Townsend and Schreiber 1972). The genera *Acer, Quercus, Gleditsia, Tilia,* and *Fraxinus* account for 67 percent of the trees planted by municipalities and highway departments (Long *et al.* 1973). Many of these are cultivars produced by budding, grafting, or rooting of clones. Because all members of a clone are genetically identical, they are much less variable than trees grown from seed. Clonal uniformity can be both a blessing and a curse (Santamour, 1976). Reliable superiority in appearance or other desired qualities is a reason why clones are so popular. But in each new clone there may also be hidden risks of susceptibility to harmful stresses or pathogens. Such risks can best be reduced by thorough testing early in the development of the clone, before it is marketed in large numbers.

Performance tests of cultivars that are already in wide use also would be worthwhile. In most cases this would not be a matter of trying to eliminate poorly adapted cultivars, but of defining the range of urban conditions they can tolerate. The results would guide arborists in putting the right tree in the right place.

Several kinds of testing, formal and informal, have been underway for some time. The pur-

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poses of this report are (1) to consider how current methods of testing are meeting the needs of municipal and highway arborists, and (2) to describe an extensive, cooperative testing system that is capable of providing much better knowledge about tree performance than is currently available.

Current Methods of Testing

A great amount of testing has been done by several large, commercial nurseries and their cooperators. Typical procedures and criteria have been described by Collins (1976). For many potentially fine trees, the process which begins in a nursery may also end there if they fail to meet any of the requirements for ease of propagation, superior appearance, and the various traits that affect marketability. Improved cultivars that pass all of these nursery tests possess desirable combinations of traits, and so are far superior to wild populations. It is not practical to evaluate some characteristics in nursery conditions however, particularly those that become evident only after many years or in different environments. Therefore, although testing in nurseries is important and must continue, it is insufficient by itself for producing trees adapted to metropolitan conditions.

Arborists have tested trees, too. They have had to rely mainly on their own observations to recognize merits and defects of different species and cultivars (Gerhold and Steiner 1976). This means of testing, though informal in design and analysis, has detected some of the larger differences and those that occur repeatedly.

A few special experimental or demonstration plantings have been made for purposeful comparisons among street tree species and cultivars. Each planting is represented by several trees per cultivar growing at one location under similar conditions. Kozel (1974) in Ohio and Ticknor (1971) in Oregon have published extensive findings from such experiments. Peter Van der Bom in Holland (personal communication) periodically sends out sets of plants from his nursery for testing by cooperators in cities and at arboreta in several countries. Demonstration plantings of street trees can be seen at the Morton Arboretum, Lisle, Illinois; the Holmdel Arboretum, Holmdel, New Jersey; and near the Woodster, Ohio, hospital. Conclusions drawn from such experiments or demonstrations can be extended with reasonable accuracy to other spacious situations with similar soils and climates. However, important exceptions are to be expected when the same cultivars are exposed to radically different conditions, especially urban stresses along streets and highways.

Planned comparisons of trees actually growing along streets and highways have been reported by Mower (1973) in New York and Reisch *et al.* (1971) in Ohio. The growth and health of such trees unquestionably is representative of their performance under metropolitan conditions, especially when they are at multiple locations. Uncertainty is introduced, however, by the fact that two or more cultivars seldom occur at a single location, or even under very similar conditions. Genetic differences between them, therefore, may be partially confounded with environmental effects associated with different planting sites. Geographic distribution of the sites evaluated also has been rather limited.

Still another category of testing should not be overlooked. Research specialists sometimes use chambers with controlled environments or special techniques such as inoculation with pathogens for refined studies of tree reactions. This kind of test usually is conducted for a highly specialized purpose, which may provide practical information to arborists, but cannot substitute for testing in "the real world."

Figure 1. Severe chlorosis in pin oak resulted from planting a good tree on the wrong site; information from performance tests can assist arborists in making the proper choice, and thus to avoid such problems.

Improvement of Performance Testing

Although current methods of testing are far from perfect, we can learn much from them. They can help point the way to improved testing procedures, which retain the best features of methods that have proven useful, and which overcome disadvantages. What ideals should be sought in designing a better system for testing the performance of trees in metropolitan environments? The more important features should include:

1. Testing of a large number of cultivars that are now or are likely to be among the most popular, and whose genetic properties can be reproduced reliably by methods such as vegetative propagation or repeated seed collections from the same trees. The choice of trees to be tested should be guided by arborists according to their requirements for information, and by the nurserymen who produce them. The plants to be tested should be grown in commercial nurseries using normal cultural methods.
2. A large number of test sites that sample the geographic region extensively and represent the range of conditions in which each species is planted, particularly along streets and highways.
3. Planting designs that are statistically sound and efficient, yet practical for cooperators (Steiner & Gerhold 1976).
4. Periodic measurements of the most important characteristics, made by arborists and other tree experts using standardized procedures.
5. Results analyzed and reported in ways that are meaningful to arborists, nurserymen, landscape architects, and other cooperators.

Proposed Performance Test System

With these considerations in mind, a cooperative testing system has been devised that would utilize the talents and facilities of many arborists and nurserymen. Cooperators would not be required to grow or plant additional trees, or to disrupt their standard operational methods, or to greatly increase their work load. The operation of the proposed performance testing system is described in the following section, to promote consideration of whether it would be useful, practical, and feasible. Numbers that are employed are intended to be realistic estimates, but subject to revision.

Let's assume that the collaborators include 5 to 30 nurserymen, 40 to 200 arborists, and 1 or 2 coordinator-analysts, most of them located in the 19 states north and east of St. Louis. Occasionally 10 to 40 specialists in pathology, entomology, genetics, physiology, soils and other sciences might also participate in various ways. During a twelve year period, sufficient test plantings could be made to evaluate 50 to 100 cultivars thoroughly. Results would become available initially 4 years after planting started, and would become more extensive and precise every year in which observations are recorded.

Here are the steps in the program:

1. The coordinator initiates plans each year with the advice and consent of cooperating nurserymen and an ad-an advisory committee. He sees to it that the test program is advertised in trade journals and nursery catalogs, indicating cultivars to be emphasized that year. Instructions and data forms are prepared for cooperating arborists.
2. A participating arborist obtains advisory information from the coordinator, and then outlines a simple or complex test program designed for the unique needs of the area for which he is responsible. The cultivars to be compared are identified and tentatively scheduled for planting over a period of years, as part of his regular planting program. He is free to revise the test plan in any year, as the availability of cultivars or his planting needs may change.
3. A cooperating nurseryman inserts information about the test program in his catalog. He may make all of his materials available for testing, or designate certain existing or new cultivars for the program.
4. Each participating arborist purchases trees for testing as part of his regular order, and may obtain them from one or

more participating nurseries. At least two cultivars, and preferably more, should be obtained per year, each with some minimum number of plants such as 20. Copies of the orders are sent to the coordinator, who then provides alternative planting designs, instructions for measurements, and data forms. Test plants in a shipment are marked at the nursery, and their identities are double-checked.

5. The test trees become part of the regular plantings of a municipality or other agency. Ordinary methods of planting and care are used, but with some restrictions on assignment of test trees to planting locations (plots) and minimum numbers to be planted. For example, an arborist who wanted to test 'Greenspire' and 'June Bride' lindens might be asked to choose among three options (Table 1): A) 4 plots each with 6 trees, i.e., 3 per cultivar, or a total of 24; B) 4 plots for each of the 2 cultivars with 5 trees planted in each, for a total of 40; C) 6 plots per cultivar, each with 3 trees for a total of 36. At any of the plots more trees could be added to fill up the spaces to be planted on a given street. Most arborists probably would not be able to put in test plantings of more than four to six cultivars or species per year, because they could not accommodate the large numbers of trees required. But this is not a serious limitation, as the work can be spread out over a period of years. If some larger cities, state highway departments, or arboreta could plant 10 to 20 cultivars per year, this would greatly extend the utility of the results.

6. Arborists would measure height, spread, and diameter of test trees when they are planted. These traits would be measured again 4, 8, 12, and 16 years after planting (Table 2). In addition, the healthiness of foliage, branches, and trunks would be rated according to a simple scale, and causes of injuries identified. Similarly, maintenance problems would be noted and rated. Pathologists, entomologists, and other experts would be asked to assist in diagnosing injuries, as needed. The extra time required for planning and measurements of four cultivars is estimated to be 7 hours the first year and 9 hours in years 4, 8, 12, and 16. A series of test plantings covering 12 years and comparing 48 cultivars would vary from 7 hours in years 1 through 4, to 27 hours per year in years 13-20 (Table 3).

7. The coordinator receives data forms from arborists and maintains all records. Starting in the fourth year he analyzes data, interprets the findings, and reports results to arborists, nurserymen, and other members of the test program. For each municipality there would be comparisons of the cultivars tested, giving survival, growth rate, healthiness, injurious agents, and maintenance ratings. For every cultivar in the program the same information would be summarized for all test localities. Growth and health zone maps could be prepared for cultivars with extensive test plantings. As

Table 1. Three options for test plantings in which two cultivars are compared.

	A	B	C
No. plots (locations in city)	4	4 x 2[a]	6 x 2[a]
No. cultivars in each plot	2	1	1
No. trees in each plot	2 x 3[b]	5	3
No. trees per cultivar	12	20	18
Total number of trees	24	40	36

[a] If there are two kinds of planting sites, such as residential and business districts, cultivars should be equally divided between them, and randomly assigned to plots.

[b] Planting in pairs, one tree from each cultivar, is preferable.

Table 2. An arborist's work in testing four cultivars in a single series of plantings.

Year	Work	Hours
1	Map and measure 80 trees (4 cultivars x 4 plots x 5 trees each)	7
4	Measure 76 trees (4 died)	9
8	Measure 74 trees	9
12	Measure 72 trees	9
16	Measure 70 trees	9

Table 3. An arborist's plan for testing 48 cultivars, 4 planted annually for 12 years.

Year	Number of trees planted per year	Hours of work per year
1- 4	80	7
5- 8	80	16
9-12	80	25
13-16	0	27
17-20	0	27

data accumulate in successive years, results would be updated periodically and trends would be analyzed. If serious disease or insect outbreaks or maintenance problems were detected, special alerts and recommendations might be issued by specialists in these fields.

8. Results of the performance tests could be applied in various ways. An arborist, after studying his test results and comparing them to others in his state, might decide to plant more of some cultivars, less of others in adverse sites, and thereby lower his costs of replacing dead trees, nursing the sick ones, and trimming the wild ones. Another arborist might decide to diversify his plantings, or to tailor his insecticide spray program more precisely to problem species. Nurserymen may be able to use summaries of results to anticipate changes in market demands and to adjust their production accordingly. If this can help to stabilize fluctuation in demand, it should be beneficial to profit margins and prices paid by customers. Stimulation of interest in tree planting could be a desirable side effect, even if it is not the primary purpose.

Feasibility of Proposed Test Program

If your enthusiasm for the proposed test program has been kindled, it may be time to temper it with the realization that there are some questions about its feasibility. Would enough arborists and nurserymen participate to provide sufficient test sites and test trees? Are suitable experimental and analytical methods available? Can adequate financial support be obtained?

The utility of test results will depend partly on widespread participation. Expressions of willingness to collaborate in a performance testing system were received from about 30 nurserymen and 100 arborists in response to our survey questionnaires. Additional potential participants have been identified through a newly formed organization, METRIA, the Metropolitan Tree Improvement Alliance (details available from the senior author). The potential seems to be there, but of course it has not yet been mobilized. This can best be done by asking arborists and nurserymen to try out a practical program, so they may decide if the effort required is warranted by the results.

We are currently developing the methodology that is required. Thirteen arborists in seven states took part in a pilot project, in which the practicality of data collection methods were tested on 20 street tree cultivars. The methods worked very well, and provided estimates of variability which are being used to design statistically efficient planting designs and analytical methods. These will be adequate for starting, and can be adjusted as additional experience is obtained.

Because affirmative answers can be given with reasonable assurance to the questions about participants and methods, the matter of feasibility can be reduced to the usual question: can adequate financial support be obtained? "Adequate" for purposes of discussion might be defined as $20,000 to $40,000 per year, to be used for salaries of one or two coordinator-analysts, secretarial help, and operational costs. Time contributed by participating arborists and nurserymen would amount to a similar value. Together they represent about 5 percent of the value of street trees planted annually in northeastern U.S. Could savings of this magnitude be realized through lower mortality, reduced costs of tree trimming and spraying, and other benefits? If so, the performance test program could be a wise investment.

Finally, who might be persuaded to make such an investment? The proposed program consists of a technical service to municipal, county, and state agencies that are responsible for landscape

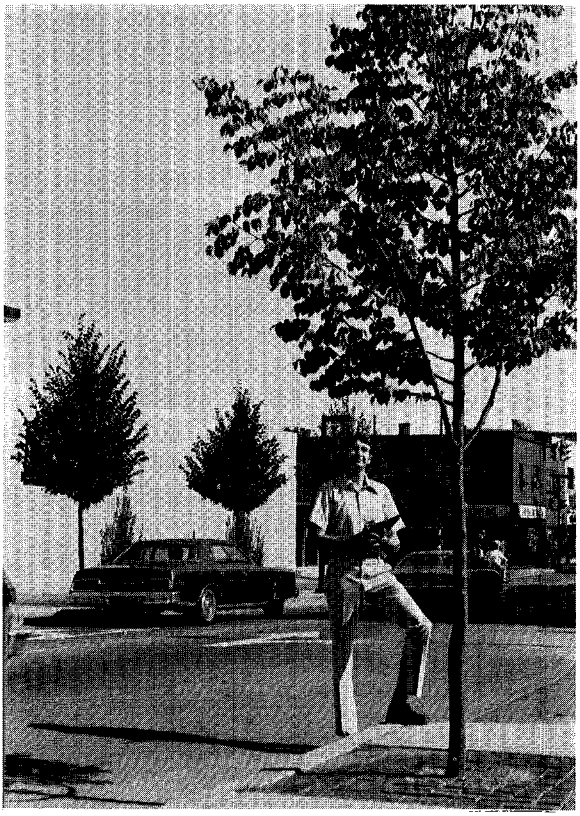

Figure 2. Certain cultivars, such as these Greenspire lindens, can provide amenities even under adverse urban conditions. Objective performance data would help in selecting the best cultivars for particular planting locations.

trees in the public domain. It should also be useful to landscape architects who serve all kinds of clients. Extensive benefits would accrue over a wide geographic area, and a long period of time, and to millions of people. The benefits, however, are largely intangible and would not be realized during the first four years of the program, so they provide very little incentive for private investment. Support from a federal agency seems to be the main hope, at least for starting the testing program. Federal financing is especially logical in a context of federal-state partnership, because of the matching value of time contributed by municipal and state employees and members of the nursery industry.

In a recent and most encouraging development, the Northeastern Forest Experiment Station's Pinchot Institute and The Pennsylvania State University have made plans to study the feasibility of a cooperative performance testing program. The U.S. Forest Service will provide funds for the study and participate in it. Detailed plans for implementing a testing program and a related information service for tree specialists of various kinds will be developed. We shall discuss with a sampling of nurserymen, arborists, and planners the possibilities they see of participating. The roles and resources of potential participants and supporting agencies will also be explored. The study will assemble factual information pertinent to the question of whether or not to undertake such an extensive, long-term venture.

Conclusion

The proposed system for performance testing trees in metropolitan environments is in a formative stage. Each person who is interested in seeing it become a reality is asked to evaluate it critically and realistically. Comments on perceived strengths or weaknesses will be welcomed, as will suggestions for securing financial support.

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MISTLETOE IS ANCIENT HOLIDAY DECORATION

by Ray Rothenberger

Among the plants used for holiday decoration, mistletoe dates back farther than most others in common use. It was important in religious ceremonies long before the origin of Christianity. Mistletoe was the sacred plant of the Druids of Britain and was believed to have all types of miraculous qualities: the power of healing diseases, making poisons harmless, giving fertility to humans and animals, protecting from witchcraft, banning evil spirits, and bringing good luck and great blessings.

Mistletoe was considered so sacred that if enemies would happen to meet beneath a tree bearing it in the forest, they would lay down their arms, exchange a friendly greeting, and keep a truce until the following day. It is believed that from this practice grew the custom of suspending mistletoe over a doorway or in a room as a token of good will and peace to all comers.

The most sacred mistletoe of the Druids was that which was growing on an oak tree. When this was found, it was solemnly consecrated by the sacrifice of white oxen, and cut from its parent stem by the Arch Druid with a golden knife, with extreme care not to let it touch the ground.

The introduction of mistletoe into the Christian celebration is not entirely clear. In early days of Christianity it was not allowed in Christian churches because it was the main symbol of pagan religion. However, there are records that before the reformation at the Cathedral of York in England, a large bundle of mistletoe was brought into the sanctuary each year at Christmas and solemnly placed on the altar by a priest. It was considered symbolic of Christ, the Divine healer of nations, the idea being derived from the Druids who called the plant "All-heal." It appears that from this beginning, it was soon adapted into Christmas decoration in homes, and the basic Druid origins were soon forgotten.

The custom of kissing under the mistletoe seems to have had English origin, but no reliable explanation of its beginning seems available. It appears to have risen from the custom of calling a truce when enemies met beneath the mistletoe in the forest. An early belief states that the maid who was not kissed under the mistletoe at Christmas would not be married in that year. To be effective, a berry had to be plucked off the branch with each kiss. This berry was then to be presented to the lady for good luck. When the berries were all plucked, the branch lost its magical properties and could not be replaced by another branch for the remainder of the season. Therefore, any branch selected was always heavily laden with berries.

Mistletoe is a very unique evergreen plant that is parasitic. It exists only by growing from the living branches or exposed roots of certain trees. It is more common in the southern United States, but may be found occasionally growing on trees in southeastern Missouri. Sycamore is a common host, but it has also been found on American elm, tupelo, and river birch.

The white berries which mature in fall and winter are eaten and distributed by birds. The berries are considered poisonous to humans. Therefore, sprigs should be hung well out of the reach of children.

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