TESTING THE AIR POLLUTION TOLERANCES OF SHADE TREE CULTIVARS[1]

by David Karnosky

Abstract. *A program in progress to test the relative air pollution tolerances of some commonly planted shade tree cultivars is described. The relative sulfur dioxide and ozone tolerances of several cultivars of Acer, Fagus, Fraxinus, Ginkgo, Gleditsia, Platanus, and Quercus species are being determined by examination of foliar response to short-term, high-concentration fumigations. In a follow-up study, the extent of foliar injury, growth reduction, and mortality caused by air pollution will be examined for the same cultivars grown in test plantings in and around New York City. The correlation of the relative sulfur dioxide and ozone tolerances, as determined by the controlled-fumigation tests, with urban survival and growth will be useful in determining the adequacy of acute exposure fumigations in testing the air pollution tolerances of the tree species under study.*

Air pollution damage to shade trees is widespread and increasing in economic and biological importance (Townsend and Dochinger, 1974). At a time when the significance of planting urban shade trees is becoming recognized, increasing quantities of industrial and motor vehicle emissions have created major constraints upon vegetation introduced into urban areas (Flemer, 1972).

Ozone (O_3) and sulfur dioxide (SO_2) are the most commonly reported air pollutants in large metropolitan areas. These two pollutants probably cause more damage to urban trees than any other pollutants. Ozone is a secondary pollutant that is generated in the atmosphere from reactions of auto exhaust products (nitrogen oxides and hydrocarbons) and oxygen in the presence of sunlight. Because of our country's dependence on the automobile, the ozone pollutant problem is sure to be with us for many years to come.

Sulfur dioxide is a primary pollutant given off in the combustion of fossil fuels. High SO_2 concentrations in urban areas are generally attributable to industrial or power plants. Sharp reductions in SO_2 emissions in urban areas were made in the 1950's and 1960's as the result of air pollution control laws. These laws forced the usage of oil and natural gas instead of coal because less SO_2 is emitted when oil and gas are burned than when coal is. However, the recent oil and natural gas shortages have caused the relaxation of standards in such states as New York and New Jersey to allow companies to convert back to the burning of coal (Anon., 1974). If the United States goal of energy self-sufficiency is actively pursued, massive increases in the amounts of coal consumed will be necessary (Abelson, 1975; Smil, 1975). These increases will probably mean that EPA SO_2 emission standards will not be met for the next 20 years (Smil, 1975).

Tree breeders have been encouraged to select and breed trees resistant to air pollutants (Gerhold and Palpant, 1968; Knabe, 1970; Pollanschutz, 1969; Santamour, 1971). However, for the most part, genetic studies of air pollution effects on trees have dealt with describing the variation rather than with the utilization of the variation in resistance-breeding programs. As a result, municipal authorities are still planting untested and unimproved seedling or clonal material in their cities. This point was highlighted in a recent survey by Gerhold and Steiner (1976). Arborists rated information on air pollution resistance over increased information on survival, tolerance to deicing salts, maintenance problems, and several other tree problems, as their greatest need.

This paper describes an ongoing research project with a dual purpose. First, it is designed to test a combination of chamber fumigations and field exposures for determining the air pollution tolerances of commonly planted shade tree cultivars. Second, it is designed to give in-

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formation on the relative air pollution tolerances of a total of 29 cultivars of ash, European beech, ginkgo, honeylocust, maple, oak, and planetree.

Plant materials

The shade tree cultivars used in this study were selected on the basis of their being: 1) commonly used in urban plantings in the Northeast and 2) available from nurserymen in a usable size. An attempt was also made to select cultivars with a range of suspected air pollution tolerances. Thirty to 40 individuals of the cultivars were purchased from the nurseries indicated in Table 1. *Those listed as being from Cary were grafted at* the Cary Arboretum. Whenever possible, an attempt was made to use the largest plant material that would fit in the air pollution chamber. In this way, the plants were more nearly the size and age at which they are outplanted than occurs for many air pollution studies on trees.

Chamber tests

The chamber tests consisted of 7½ hr exposures to either 0.5 ppm O_3, 1.0 ppm SO_2, or 0.5 ppm O_3 plus 1.0 ppm SO_3. Two replicates of 3 plants per cultivar were given an exposure to one of the pollutant regimes. The first replicate was run at approximately 4 weeks from budbreak, and the second was run at about 8 weeks *from budbreak.* Thus, a total of 6 plants per cultivar were exposed to O_3, an additional 6 exposed to SO_2, and 6 more exposed to O_3 + SO_2. The plants ranged in size from 3 to 8 ft tall at the time of fumigation, and had all been grafted at least 1 year prior to the fumigations.

The fumigations were done inside the greenhouse in a chamber similar to but larger than that described by Heagle *et al.* (1974). The chamber is cylindrical with a 15 ft diameter and is 8 ft tall. The sides are 5 mil polyethylene (Krene), and the top is 2 mil Teflon film. Air entering and exhausting the chamber was passed through activated charcoal filters to remove air pollutants. In order to maximize air circulation in the chamber, no more than 30 trees were fumigated at one *time. The trees were maintained in the* greenhouse prior to and after the fumigations.

Ozone was generated by three helical U.V. lamps placed in the inlet duct between the filter and the chamber. The O_3 concentration was regulated by varying the voltage to the lamps. Ozone was monitored inside the chamber with a Columbia Scientific Industries' MEC 1100 Ozone Meter which was calibrated biweekly with an MEC 1000 *Ozone Generator.*

Sulfur dioxide was leaked into the chamber as described by Karnosky (1976) and monitored in

Table 1. Cultivars of shade tree species being tested in the Cary Arboretum's air pollution tolerance study. The sources of plants are Cole Nursery (C), Hess' Nurseries (H), A. McGill and Son Nursery (M), Sherman Nursery (S), *and John Vermeulen and Son* (V). Plants grafted at Cary are listed as (G-Cary). The scions were from Cole Nursery, Princeton Nursery, and the Saratoga Horticultural Foundation. The heights listed are those of the trees at the time chamber fumigations were run in the spring of 1977.

Species	*Cultivar*	*Source*	*Height (in.)*
European ash	Hessei	C	50 to 90
European beech	Rotundifolia	H	20 to 25
ginkgo	Autumn Gold	G-Cary	15 to 25
ginkgo	Fairmont	G-Cary	10 to 20
ginkgo	Fastigiate	H	20 to 25
ginkgo	Sentry	G-Cary	10 to 15
green ash	Marshall's Seedless	C	70 to 90
green ash	Summit	S	50 to 90
honeylocust	Emerald Lace	M	25 to 35
honeylocust	Imperial	C	20 to 30
honeylocust	Majestic	C	35 to 45
honeylocust	Shademaster	M	20 to 50
honeylocust	Skyline	C	25 to 35
honeylocust	Sunburst	C	20 to 30
London planetree	Bloodgood	C	40 to 80
Norway maple	Cleveland	M	25 to 35
Norway maple	Crimson King	V	15 to 30
Norway maple	Crimson Sentry	M	30 to 40
Norway maple	Columnar	M	40 to 55
Norway maple	Emerald Queen	M	45 to 55
Norway maple	Jade Glen	M	35 to 45
Norway maple	Schwedler	C, M	35 to 40
red maple	Autumn Flame	M	45 to 55
red maple	Bowhall	G-Cary	15 to 25
red maple	Red Sunset	M	40 to 50
red maple	Tilford	G-Cary	15 to 30
red oak	Fastigiate	H	20 to 25
sugar maple	Goldspire	G-Cary	20 to 30
sugar maple	Temple's Upright	G-Cary	20 to 25
white ash	Autumn Purple	C	60 to 90

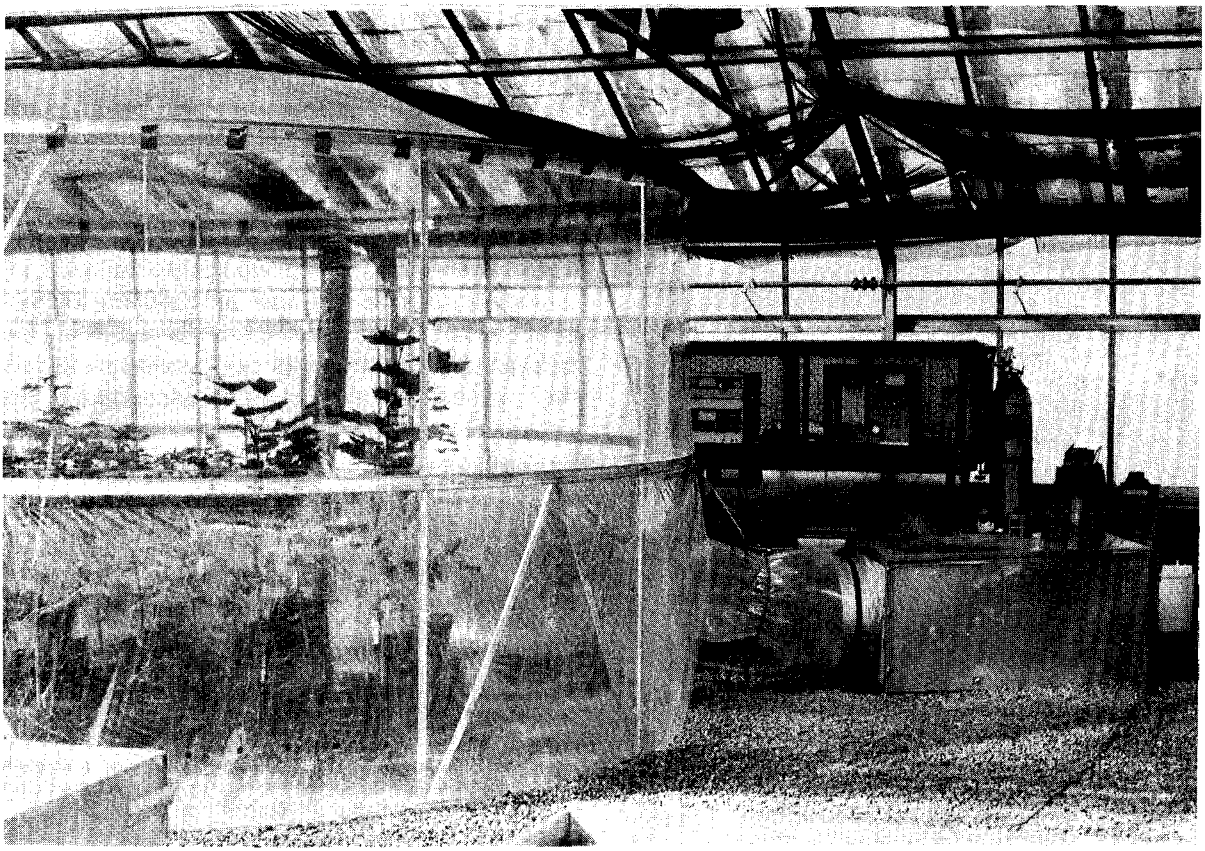

Figure 1. Air pollution chamber being used in a program to test ozone and sulfur dioxide tolerances of urban trees. The chamber is located in the Cary Arboretum's greenhouse.

the chamber with a Beckman Instruments' Model 906A SO_2 Analyzer. The analyzer was calibrated biweekly as described by Karnosky (1976).

The plants were examined for foliar injury for 1 month after the fumigation. At plus 1 week, they were scored for injury using the injury index system described by Davis and Coppolino (1976).

Field tests

Because nearly all air pollution tolerance testing has been done in chambers, the reliability of extrapolating the results to the field are not well documented. The second phase of this air pollution tolerance testing program involves the planting of trees of the same cultivars used in the chamber tests at various sites in and around New York City. The test sites include the New York City Parks Department Nursery on Rikers Island (in the East River between Queens and the Bronx), the New York Botanical Garden (in the Bronx), and the Cary Arboretum (about 75 miles north of New York City). The trees are planted in randomized complete block designs consisting of two replicates of 2 tree plots. Thus, a total of 4 trees per cultivar are planted at each location. The spacing is 9 x 9 ft.

Survival and height growth are taken annually at the three sites. The trees are scored monthly from May 1 to September 1 of each year for foliar air pollution and pest problems. The monthly scoring consists of estimates of the percentage of leaves showing air pollution injury and of the leaf area injured. Other observations include location of the injured leaves on the plant, injury type (necrosis, chlorosis, etc.), leaf surface affected, relative age of leaves affected, injury patterns (i.e., interveinal, marginal, stipple, etc.), and injury color. The pollutants suspected of causing the injury are noted, as well as insect, disease, or other stress factors that might be contributing to the injury. This field test will last a minimum of 3 years for each cultivar tested.

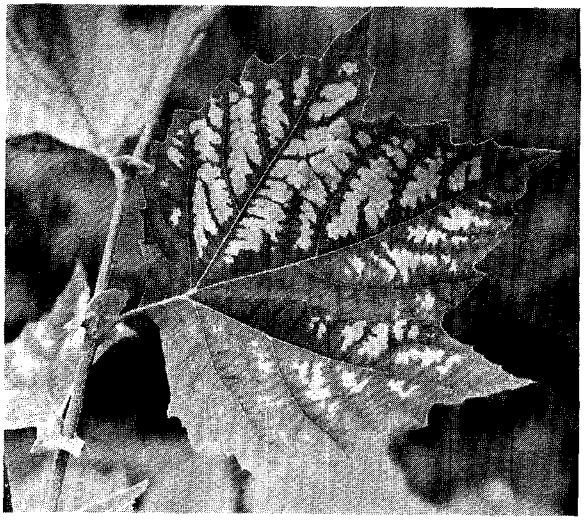

Figure 2. Sulfur dioxide injury in the form of interveinal necrosis on a 'Bloodgood' London planetree leaf. The injury occurred following an exposure to 1.00 ppm sulfur dioxide for 7½ hours.

A comparison will be made as to the relative pollutant sensitivities of the various cultivars as determined by the chamber and field tests. A strong correlation would indicate that the short-term, rapid chamber tests could be used to estimate pollutant sensitivities of urban trees. A poor correlation could indicate that the longer-term field tests are necessary to test air pollution sensitivities of urban trees.

Current status

Chamber fumigations of the 29 cultivars shown in Table 1 were completed in the spring of 1977. Test plantings consisting of 19 of these cultivars were made at the three field sites in May, 1977. Additional plant material was procured to complete the field test plantings (with the additional 10 cultivars) in the spring of 1978.

Chamber and field tests of additional cultivars of ash, European beech, honeylocust, ginkgo, maple, oak, and planetree, as well as other genera, will begin next year. Municipal arborists and nurserymen are encouraged to send suggestions as to cultivars that they would like to have tested in this program. The author also encourages nurserymen releasing new urban tree cultivars and those who would like to have information on their cultivars' air pollution tolerances to send along sufficient numbers of the cultivars (30 to 40 plants per cultivar) to test in the chamber and field plots as described in this paper.

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