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RESPONSE OF HONEYLOCUST CULTIVARS TO AIR POLLUTION STRESS IN AN URBAN ENVIRONMENT[1]

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Abstract. Five honeylocust cultivars were evaluated for tolerance to O_3 pollution over a 3-year period. Symptom development was monitored on a monthly basis during the growing season and changes in diameter growth measured once each year. Measurements of diffusive resistance and transpiration were used to determine if cultivar differences in O_3-tolerance were associated with differences in gas exchange rates through the stomates. 'Imperial' was the most O_3 sensitive and 'Majestic' the most O_3 resistant cultivar based on foliar response. The average yearly increase in diameter was greatest in the cultivars more resistant to O_3. Ozone sensitivity was negatively correlated with leaf diffusive resistance and positively correlated with transpiration rate. When making cultivar selections for urban tree plantings on the basis of O_3-tolerance 'Majestic' should be considered first, followed by 'Sunburst,' 'Skyline,' and 'Shademaster.' 'Imperial' should not be used in polluted environments.

Air pollution damage to urban trees is a problem of increasing importance to the urban tree manager (6, 9). The air pollutant of primary concern with respect to its phytotoxic potential in this area is ozone (O_3). Several researchers have published O_3 tolerance rankings for a number of tree species (3, 4). For the most part, these tolerance lists have been based on chamber fumigations of tree seedlings grown under artificial conditions. The results are frequently inconsistent with observations made on mature trees in the field (8, 12). Another problem with such tolerance rankings is that they are generally limited to comparisons made between species. There is little information on intra-specific variability in tree response to O_3 (10, 14).

In this study, five cultivars of honeylocust *(Gleditsia triacanthos inermis)* were evaluted for air pollution tolerance (primarily O_3) during the 1981, '82, and '83 growing seasons. Preliminary field observations indicated significant differences in foliar sensitivity to O_3 among the five cultivars. The reasons for these differences are not known. In other species or cultivars, genetic differences in O_3-sensitivity have been associated with differences in stomatal frequency or stomatal response (1, 15, 16). Stomates are directly involved in the movement of O_3 into plant leaves and, theoretically, any genetic or environmental factor that limits gas exchange through the stomates will reduce O_3 uptake and protect plants from injury.

The major objectives of this study were (i) to identify those cultivars with resistance to O_3-induced foliar injury, (ii) to determine if resistance is dependent on a reduction in gas exchange through the stomates, and (iii) to assess the impact of O_3 on the growth of honeylocust over a 3-year period.

Materials and Methods

Plant material. The five honeylocust cultivars used in this study included 'Shademaster,' 'Skyline,' 'Majestic,' 'Imperial,' and 'Sunburst.' The test trees (4 per cultivar) were part of a field

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planting of approximately 100 trees established in 1978 in New Brunswick, New Jersey in cooperation with Dr. David F. Karnosky of the New York Botanical Garden Cary Arboretum. The design and complete species composition of the plot have been described elsewhere (7).

Visual injury. In 1981, '82, and '83, each tree was scored monthly from June to September for foliar air pollution injury. A leaf injury index was calculated by multiplying the percentage of injured area by the intensity of injury, both rated on a scale of 0 to 5 (0 = no injury, 1 = 1-20%, 2 = 20-40%, 3 = 40-60%, 4 = 60-80%, and 5 = 80-100%). A mean score was then determined for each cultivar.

Stomatal response. In 1982 and '83 stomatal resistances and transpiration rates were obtained 5 times during the growing season, at the same time of day on each sampling date. All measurements were made using a LICOR LI-1600 Steady State porometer equipped with a narrow leaf aperture (1.0 cm^2). Measurements were taken on the lower leaf surfaces of mid-aged leaves at similar positions in the tree crown. Two readings were obtained per leaflet on two leaves per tree for a total of 16 readings per cultivar mean.

Diameter growth. Stem diameters were measured once each year, in the fall, at 6 inches above ground level using a Manostat caliper, type 6911. The diameter increase from 1 year to the next was determined for each tree and an overall mean calculated for each cultivar. The three-year mean diameter growth increment was used to compare the relative growth rates of the 5 cultivars.

Air quality. Air quality (O_3) information was obtained from a monitoring station of the New Jersey Department of Environmental Protection, located within 2 miles of the tree plot. The concentration of O_3 in ambient air was monitored continuously by chemiluminescence, and hourly averages were computed for ease of presentation in this report. The monitoring station also provided continuous measurements of other potentially phytotoxic air pollutants such as SO_2 and NO_2. Those data are not presented here because the ambient concentrations of both SO_2 and NO_2, at the test site, were well within the national standards set by the Environmental Protection Agency to protect plant health.

Results and Discussion

Air quality and symptom development. A summary of the air monitoring data for the summer months of 1981-83 (Table 1) revealed that ambient O_3 concentrations were sporadically high at the test site and in excess of the Federal Air Quality Standard. Such concentrations are known to injure herbaceous plants, and results from the current experiment indicate that certain tree cultivars are also sensitive. The O_3-injury data for the 5 honeylocust cultivars are presented in Table 2. 'Imperial' was by far the most O_3-sensitive cultivar, receiving high injury scores each year of the 3-year study. 'Shademaster' also showed a consistent, sensitive response to O_3, although it was not as sensitive to the pollutant as 'Imperial.' Injury scores for 'Skyline,' 'Majestic,' and 'Sunburst' varied from one year to the next. 'Majestic' was the most O_3-resistant cultivar remaining entirely free of any toxicity symptoms for two of

Table 1. The number of hours that the ozone concentration in New Brunswick exceeded 0.12 ppm and the highest 1-hour ozone levels recorded during the growing season, 1981-1983.

	1981		*1982*		*1983*	
Month	*No. hours 0.12 ppm*	*Highest conc. (ppm)*	*No. hours 0.12 ppm*	*Highest conc. (ppm)*	*No. hours 0.12 ppm*	*Highest conc. (ppm)*
June	4	.138	5	.168	29	.177
July	1	.131	18	.160	12	.151
August	1	.122	2	.143	30	.197

the three study years.

Ozone toxicity symptoms in the tree plot included upper leaf surface stipple, chlorosis, and premature leaf drop. Cultivar differences in the nature, degree, and timing of injury were apparent. 'Imperial' (O_3-sensitive) typically developed stipple symptoms by mid-June, chlorosis by mid-July, and by mid-August over half of the foliage had dropped prematurely. Cultivars showing an intermediate response to O_3 did not develop visible symptoms until August and injury was normally confined to premature senescence of less than 20 percent of the tree foliage. In contrast, the foliage of 'Majestic' (O_3-resistant) generally remained green and the tree crown remained full through mid-September. The extreme differences in O_3 tolerance ('Imperial' vs. 'Majestic') are illustrated in Figure 1. None of the 5 honeylocust cultivars displayed specific symptoms characteristic of SO_2 or NO_2 injury. This does not discount the possibility that low levels of SO_2 or NO_2, in combinations with high ambient O_3 concentrations, may have contributed, in some way, to symptom development in the tree plot.

Stomatal response. The relationship between O_3 tolerance and gas exchange rates is illustrated in Figure 2. Because all of the data collected in 1982 and '83 could not be conveniently presented, two representative sampling dates were selected, one in early summer and one towards the end of the growing season (1983). At both dates, the leaf diffusive resistance was negatively correlated with O_3 sensitivity (P>10%) when the 5 honeylocust cultivars were compared.

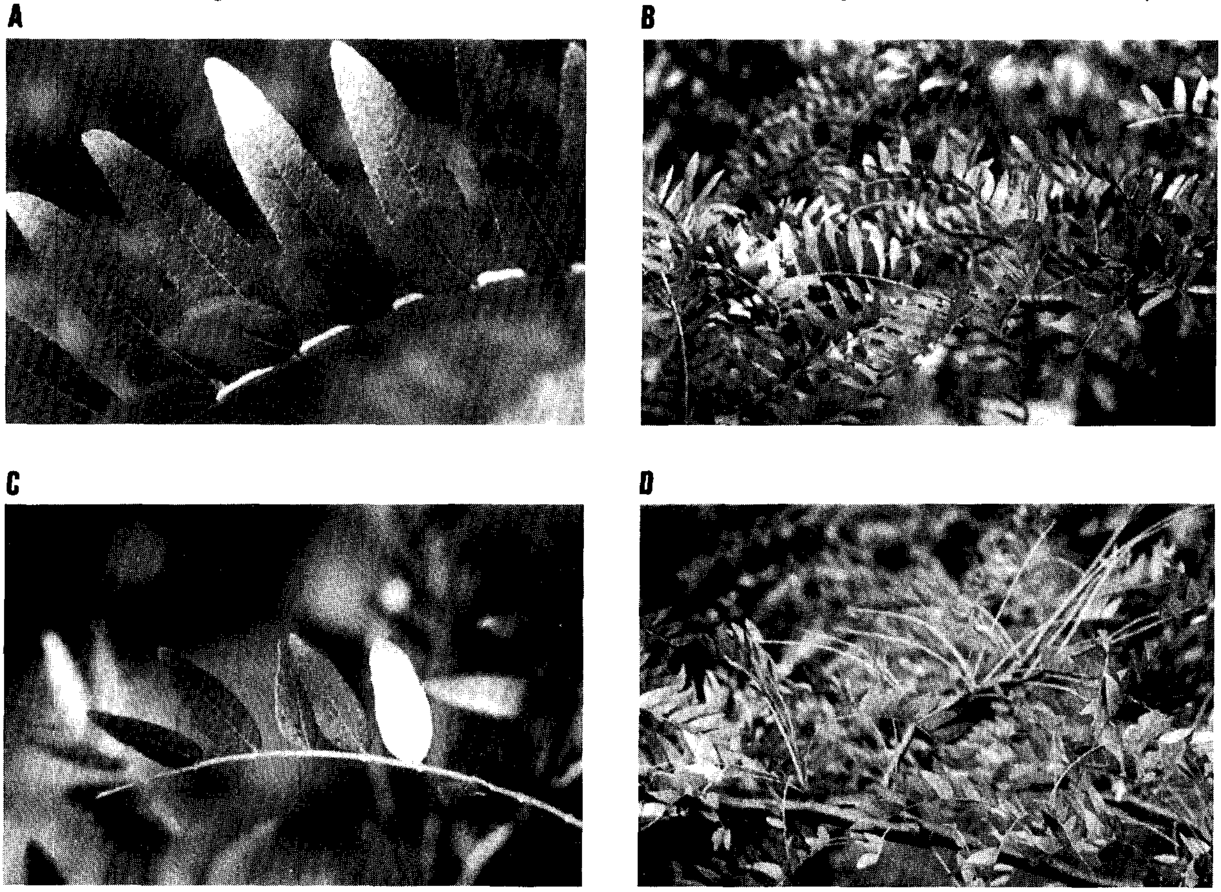

Figure 1. A. and B. Field shots of *Gleditsia triacanthos inermis* 'Majestic' (O_3 resistant). Compare with C. and D. Field shots of 'Imperial' (O_3 sensitive). Note upper leaf surface stipple and leaf drop on 'Imperial.' A. and C. were taken on August 17, 1983 and B. and D. on September 14, 1983.

This means that a cultivar which was sensitive to O_3 (high injury score, see Table 2) showed a low diffusive resistance and allowed a relatively large amount of the toxic gas to enter the leaf. Conversely, a cultivar which was tolerant to O_3 (low injury score) maintained a high leaf diffusive resistance. The relationship between cultivar O_3 sensitivity and transpiration rate was also significant in this experiment. Ozone sensitive cultivars had a high transpiration rate whereas O_3 resistant cultivars had a relatively low rate of transpiration. These results suggest that stomatal response plays a role in determining the resistance of honeylocust cultivars to O_3 pollution. Other researchers have obtained similar results with a number of different tree species (5, 13).

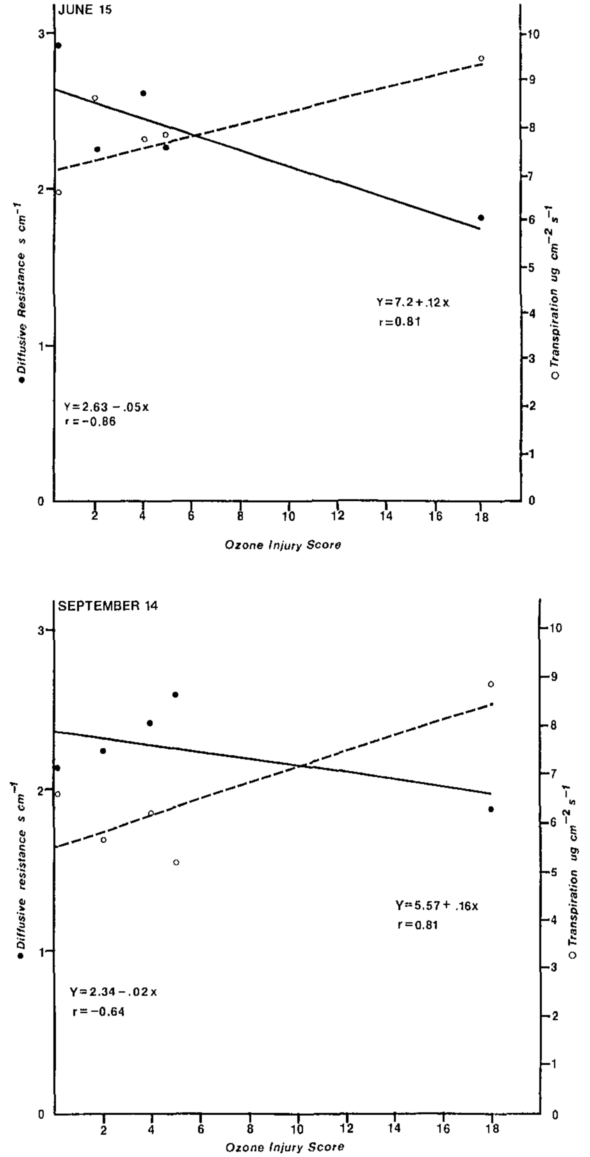

Figure 2. The relationship between ozone tolerance and gas exchange rates of 5 honeylocust *(Gleditsia triacanthos inermis)* cultivars on 2 representative sampling dates in 1983. Each point on the graph represents the mean of 16 readings per cultivar. The 5 cultivars used and the ozone injury score for each cultivar are as follows: 'Shademaster' = 5, 'Skyline' = 4, 'Majestic' = 0, 'Imperial' = 18, and 'Sunburst' = 2.

Diameter growth. The question remains whether or not the presence of O_3 toxicity symptoms on honeylocust affects tree growth over the long term. To begin to answer this question, changes in stem diameter were monitored over the 3-year study period. The average yearly increase in diameter growth for each cultivar is presented in Table 2. The cultivar most resistant to O_3-induced foliar injury ('Majestic') showed the largest increase in diameter and the most O_3 sensitive cultivar ('Imperial') showed the smallest diameter increase. This suggests a strong relationship between O_3 tolerance and plant growth. However, not enough is known about the relative growth rates of the cultivars used in this study to make a definitive statement in this regard.

Table 2. The ozone injury scores of 5 honeylocust cultivars determined in the field and the mean diameter growth increment for 1981-1983.

	Ozone injury score			*Diameter increase*
Cultivar	*1981*	*1982*	*1983*	*(cm)*
Shademaster	4	4	5	1.06
Skyline	0	2	4	1.14
Majestic	4	0	0	1.25
Imperial	12	20	18	0.90
Sunburst	0	2	2	1.01

Conclusion

Honeylocust has received mixed reviews in urban tree plantings in the Northeast. Chapman (1980) considers honeylocust an outstanding tree for the urban environment whereas Potts and Herrington (1982) reported that honeylocust exhibits premature senescence and early mortality on urban sites. Cultivar differences in air pollution tolerance may partially explain these conflicting reports. The results reported here indicate that at least one cultivar, 'Imperial,' is very susceptible to O_3 pollution; a characteristic that affects not only its ornamental value but also limits its potential for long term survival in polluted environments. Given a choice, 'Imperial' should be avoided when making cultivar selections for urban tree plantings. Of the four other cultivars considered in this study, 'Majestic' is by far the superior tree, followed by 'Sunburst,' Skyline,' and 'Shademaster.'

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ABSTRACT

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Teaching and research programs at the University of Illinois are helping to improve our use of urban forests for the benefit of Illinois citizens. The urban forestry class, for example, has designed a noise and dust barrier of trees for a foundry in Decatur. Researchers have studied the effect of heavy metal pollutants on tree growth and feedlot runoff on a forested watershed. The findings will be useful in establishing tolerance levels and systems for dealing with these pollutants. In other research, we have studied the selection, biology,and cultivation of bottomland tree species, including eastern cottonwood, sycamore, and alder. This work has provided a basis for improving production on wetlands such as urban floodplains and wastewater discharge areas. These and other research projects can help urban society use trees more effectively to improve the quality of human life.