Relative Sensitivity of Red, Jack, and White Pine Seedlings to Ozone and Sulfur Dioxide

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ABSTRACT

Groups of red pine (*Pinus resinosa*), jack pine (*P. banksiana*), and white pine (*P. strobus*) seedlings at ages 3, 5, and 7 weeks were exposed to individual dosages of ozone and sulfur dioxide. Exposures to each gas were 2 hours at 25.0 or 50.0 parts per hundred million (pphm). Jack pine was the most sensitive to ozone. None of the species was sensitive to sulfur dioxide at the 25.0 pphm level. Red pine, however, was more tolerant to sulfur dioxide at the 50.0 pphm level. Ozone was more injurious to all three species than was sulfur dioxide. Phytopathology 61:231-232.

Additional key words: artificial exposures, phytotoxicants, primary needles, cotyledons, ozone, fumigation.

The sensitivity to air pollutants of tree seedlings less than 1 year old has only recently been investigated. (3). Such work is important because information is needed on the survival of new reproduction in polluted areas. Eventually it will be necessary to relate air pollution sensitivity to the occurrence of other seedling characteristics, such as growth rate, form, and resistance to pathogenic diseases. We also need to relate sensitivity of young seedlings to that of mature trees. The latter information is particularly desirable before seedlings can be used extensively in determining the effect of air pollution on tree physiology. Needless to say, the use of seedlings 1 to several months old instead of young trees would, if feasible, be more desirable because seed can be germinated and seedlings produced in a few weeks, whereas grafted ramets or even young trees may require years from the time stock is obtained until plants are ready for experimentation.

The objectives of this work were (i) to determine relative sensitivity of eastern white pine (*Pinus strobus* L.), jack pine (*P. banksiana* Lamb.), and red pine (*P. resinosa* Ait.) seedlings when exposed to individual dosages of ozone and sulfur dioxide. These three species were selected because of their adaptability to this kind of research and because of their economic importance to the forest industry; (ii) to select both tolerant and sensitive populations of these species so that these can be reexamined later to determine whether the relative susceptibility changes between a few weeks and 1 year or more of age. Costonis (2) and Dochinger (4) already have reported that there is little or no change in sensitivity of white pine to ozone or the chlorotic dwarf disease between ages 1 year and several years.

MATERIALS AND METHODS.—Seedlings for this study were obtained by germinating seed purchased on the open market. Seedlings were grown in a planting medium composed of six parts forest soil, two parts sand, and one part peat moss and potted in 10-cm × 10-cm × 10-cm plastic pots. The planting medium was not sterilized, and no fertilizer was added. Twenty seedlings were grown in each pot for the first series of fumigations, and 10 were grown in each pot for the second and third series. Plantings were made 2 weeks apart so that seedlings of three age groups, approximately 3, 5, and 7 weeks, could be treated simultaneously.

Seedlings were grown in a greenhouse until ready for exposure and returned to the greenhouse after exposure to await symptom development. Data were taken about 1 week after exposure. Greenhouse temp ranged from 19 to 32 C. Humidity in the greenhouse could not be controlled, and it often fell to 30% or lower. Plants were carefully watered, however, to prevent the occurrence of undue soil moisture stress. The greenhouse was not supplied with filtered air, although filtration would have been desirable. Slight injury was produced by phytotoxicants in ambient air but was negligible in evaluating results.

All fumigations were conducted in the chamber described by Berry (1). The exposure interval for the tests was 2 hr at 27 C and approx 70% relative humidity. The three series of fumigations were conducted as follows: (i) 2, 3, 4, and 5 December 1968; (ii) 14, 15, 16, and 17 January 1969; and (iii) 11, 12, 13, and 14 March 1969.

Sensitive populations were selected by marking with artists' oil paint individual seedlings injured by either sulfur dioxide or ozone at 25 pphm. Tolerant populations were selected from seedlings uninjured or only slightly injured by either gas at 50 pphm.

Each seedling was examined critically and rated sensitive if one or more needle lesions could be found, or tolerant if no lesions were found. Exceptions were made for jack pine seedlings exposed to 50 pphm ozone; because all seedlings were injured, tolerant plants were selected from those least injured. No attempt was made to distinguish injury on cotyledons from that on primary needles.

Sulfur dioxide concn were monitored and controlled by a Davis sulfur dioxide analyzer. Ozone exposures were monitored and controlled by a Mast ozone analyzer. Phytotoxicant concn could usually be maintained at about ± 5% of the desired level.

RESULTS AND DISCUSSION.—No difference in sensitivity was detected among the different age groups. For this reason, data for all ages were combined. The rela-

TABLE 1. Relative sensitivities of jack, red, and white pine seedlings to 2-hr exposures of ozone and sulfur dioxide at 25 and 50 parts per hundred million (pphm)

Fumigant and exposure level	Jack pine		Red pine		White pine	
	Exposed	Injured	Exposed	Injured	Exposed	Injured
	no.	*%*	*no.*	*%*	*no.*	*%*
Ozone 25 pphm						
1st Experiment	282	14	309	1	347	4
2nd Experiment	149	59	120	4	129	8
3rd Experiment	110	62	119	16	119	18
Total and avg	541	45	548	7	595	10
Ozone 50 pphm						
1st Experiment	206	100	232	90	341	54
2nd Experiment	120	93	119	73	120	85
3rd Experiment	106	98	117	99	116	99
Total and avg	432	97	468	87	577	79
SO_2 25 pphm						
1st Experiment	208	5	302	0	340	7
2nd Experiment[a]						
3rd Experiment	114	4	116	1	117	6
Total and avg	322	4.5	418	0.5	457	6.5
SO_2 50 pphm						
1st Experiment	234	21	311	1	336	6
2nd Experiment	120	2	120	3	120	17
3rd Experiment	106	11	114	1	120	13
Total and avg	460	11	545	2	576	12

[a] Equipment failure, no data available.

tive degrees of injury to the three pine species by two levels of ozone and two levels of sulfur dioxide are shown in Table 1. Data from each of the three experiments are presented separately because the planting dates were different and, therefore, growing conditions were probably different. Ozone at 25 pphm was more injurious in the second and third experiments than in the first. Why this occurred is not understood, but it may be due to stresses associated with the higher density of seedlings growing in each pot (20 in the first experiment as compared with only 10 in the second and third experiments).

Ozone injury could not be distinguished from that caused by sulfur dioxide. Both gases produced symptoms ranging from flecking and banding to needle tipburn.

An important conclusion borne out by these data is that, at the ages tested, ozone is more injurious to all three species than is sulfur dioxide. In the exposures to the two gases at 50 pphm for 2 hr, at least 6 times as many seedlings of each species were injured by ozone as by sulfur dioxide (Table 1).

Another conclusion is that jack pine seedlings are more sensitive to ozone than are either red or white pine seedlings. In the exposure to ozone at 25 pphm, 4.5 times more jack pine were injured than white pine, and 6 times more jack pine were injured than red pine (Table 1). Red pine was intermittently, but not consistently, more tolerant to ozone than was white pine. For example, at 50 pphm red pine was slightly less tolerant than white pine, but at 25 pphm it was slightly more tolerant. This point will have to be clarified in subsequent investigations.

Davis (3), testing the relative sensitivities of 2- to 5-year-old seedlings of 18 species, also found red pine to be the most tolerant and jack pine the most sensitive to ozone. Therefore, while we do not yet have an instance of the same plant being tested repeatedly at different ages, it appears that older populations of red, jack, and white pine have the same relative sensitivities to ozone as do young populations.

There was also a strong indication that red pine is more tolerant to sulfur dioxide than are the other two species (Table 1). Davis did not test sensitivities to sulfur dioxide.

In this work, emphasis was on the establishment of relative sensitivities of three pine species. No attempt was made to determine the precise degree of injury produced by precise levels of phytotoxicants. It is the author's opinion that a great deal of standardization of techniques should be agreed upon by different researchers before meaningful thresholds of injury can be established. It should also be pointed out that this was not a provenance study, and conclusions may have to be altered somewhat at a later time when specific seed sources are tested.

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