GROWTH IMPACT OF O$_3$, NO$_2$ AND/OR SO$_2$ ON PINUS TAEDA

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Abstract. Seedlings of two full-sib families of loblolly pine expressing different degrees of sensitivity to O$_3$ were exposed to 0.05 ppm O$_3$, 0.10 ppm NO$_2$, and/or 0.14 ppm SO$_2$ for 6 hr/day for 28 consecutive days. The treatments were O$_3$, NO$_2$, SO$_2$ (each used alone), O$_3$ + SO$_2$, O$_3$ + NO$_2$, and O$_3$ + NO$_2$ + SO$_2$. Significant growth suppressions were noted with the relatively sensitive family in all but the NO$_2$ alone treatments. The O$_3$ + SO$_2$ treatment had a more significant effect than O$_3$ alone, but adding NO$_2$ had an inconsistent effect. Significant growth suppressions were noted for the relatively non-sensitive family only in the O$_3$ + SO$_2$ and O$_3$ + SO$_2$ + NO$_2$ combination treatments. Adding NO$_2$ to O$_3$ + SO$_2$ had a slightly stimulatory effect. The relatively sensitive pine family suffered a 30% height growth suppression versus a 14% height growth suppression for the relatively insensitive family when exposed to the 3 pollutant combination. Symptoms were noted on less than 4% of the foliage in the most severe treatments. The pollutant concentrations used in this study were below the National Ambient Air Quality Standards (NAAQS) for each pollutant.

1. Introduction

In the ambient atmosphere, air pollutants usually occur at low concentrations in combination with one another. The National Ambient Air Quality Standards (NAAQS) have been based primarily on reports of single pollutant effects. The previous lack of adequate technology for handling and working with certain pollutants in combination was a major stumbling block, but instrumentation has become available in the last decade that is usable in support of research determining the effects of pollutant combinations to vegetation.

Another major gap has resulted from failure to deal with the effects of long-term, low-concentration exposures. It is important to consider that the exposures often should be continuous and without weekend breaks. Under ambient conditions, plants are usually exposed 7 days per week.

When this study was undertaken, there were only two reports of forest trees exposed under controlled conditions to long-term (at 7 days per week frequency), and low-concentration fumigation. Barnes (1972, 1972a) exposed several pine species to low concentrations of ozone (O$_3$) continuously for up to 22 weeks and noted changes in photosynthesis, respiration, total soluble carbohydrates, reducing sugars, and ascorbic acid.

Prior to this report only two studies regarding the effects of 3 pollutants in combination have been presented. Fujiwara et al. (1973) reported on the effects to peas of short-term exposures to ozone (O$_3$), nitrogen dioxide (NO$_2$), and sulfur dioxide (SO$_2$) and found

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that ozone was the most phytotoxic in concentrations up to 0.20 ppm for 5 hr. A synergistic effect was noted with SO₂ in combination with O₃, but no synergistic effect was in evidence between NO₂ and O₃. When the SO₂ concentration was 0.20 ppm, a slight synergistic effect was noted with NO₂. All three pollutants in combination induced no greater injury than the O₃ + SO₂. Reinert and Gray (1977) exposed several field crops to O₃, NO₂ and/or SO₂ at concentrations of 0.10 to 0.60 ppm for 3 or 6 hr. All species were injured by the SO₂ + O₃ mixture at 0.30 ppm and by the O₃ + SO₂ + NO₂ mixture at 0.25 ppm for 6 hr. A synergistic effect was noted for the O₃ + NO₂ mixture.

The objectives of this study were to determine if ambient concentrations of O₃, NO₂, and SO₂ alone or in combination could cause significant growth suppressions and foliar symptoms on O₃ sensitive and non-sensitive families of loblolly pine.

2. Materials and Methods

2.1. PLANT MATERIAL

Ozone sensitive (4-5 x 523) and non-sensitive (14-5 x 517) families of loblolly pine were selected based on the screening study reported by Kress (1978). Approximately 1000 seeds each of the two families were obtained from the North Carolina State University – Industry Cooperative Tree Improvement Program. Seeds were sown in 2:2:1 by volume Webelite® (an expanded shale product of the Webster Brick Co., Roanoke, VA 24016, U.S.A.): vermiculite: sphagnum peat moss potting mix. Developing seedlings were planted four per pot in 0.45 L pots containing the same potting mix. Approximately 5 days following germination, each pot received one gramme of Osmocote® 14-14-14 slow release fertilizer spread uniformly over the potting medium surface. The trees were grown in a greenhouse supplied with charcoal-filtered air and were watered daily. Supplemental irradiance of 21 Klux at plant height was provided by high pressure sodium lamps from 0600 to 2200 hrs.

2.2. TREATMENTS

Seed was sown at intervals for each treatment set so as to have uniform aged trees for all treatments. Trees were exposed when approximately 2 weeks old. Due to limitations in the number of exposure chambers available (three), the fumigations were performed in three exposure series (ES) in 1976 and repeated in 1977 (Table I). There was a control treatment for each set of three pollution treatments. There were to be 16 trees/family in each treatment, but poor germination and loss of seedlings following transplanting resulted in unequal numbers of trees per treatment (Table I). Such high loss occurred for seedlings in the 1977 ES-3 that reseeding the less sensitive family was necessary. Thus the 14-5 x 517 trees were about 10 days younger than 4-5 x 523 trees for ES-3.

Pollutant concentrations for all the exposures were 0.05 ppm O₃, 0.10 ppm NO₂, and 0.14 ppm SO₂, whether used singly or in combination. The plants in each treatment were exposed for 6 hr (0800–1400) per day for 28 consecutive days. The remainder of each day, all plants were held in a greenhouse supplied with charcoal-filtered air. The ES-2 in 1976 was terminated three days early because of a breakdown in the NO₂ analyzer.