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Impact of Ozone on Growth of Peach, Apricot, and Almond

Patrick M. McCool and Robert C. Musselman[1]
Statewide Air Pollution Research Center, University of California, Riverside, Riverside, CA 92521

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Abstract. **Almond *(Prunus amygdalus* Batsch cv. Nonpareil), apricot *(Prunus armeniaca* L. cv. Royal Blenheim), and peach *[Prunus persica* (L.) Batsch cv. Halford] grafted nursery stock seedlings were exposed once per week for 4 hours to a maximum O_3 concentration of 0.25 $\mu l \cdot liter^{-1}$ in field exposure chambers. Exposures were repeated for a total of 4 months in 1986 (year 1) and 1987 (year 2). Trunk caliper, number of shoots, and net growth (total seasonal weight increase) were measured at the end of each year. Almonds appeared to be the most sensitive to O_3. Almond seedlings exhibited extensive foliar injury from O_3, while apricot and peach seedlings were relatively insensitive. Total net growth of O_3-exposed almond was reduced during both years relative to the controls and an impact on caliper was evident after year 2. Apricot seedlings exposed to O_3 developed a thinner trunk but more shoots than the controls in both years. Peach tree seedlings exposed to O_3 had fewer shoots than the controls at the conclusion of year 2 but thicker trunks after both years. No significant difference in variance or shape of distribution of net growth within the treatment populations between O_3-exposed seedlings and controls was detected for any of the three fruit crops. The impact of O_3 on young, nonbearing perennial fruit crops may be most evident in specific growth characteristics, such as net growth or trunk caliper.**

The impact of O_3 on a wide range of agricultural crops, ornamental, and forest species has been studied extensively over the past 20 years. However, information on perennial fruit and nut crops is scarce because of the logistics of exposing mature trees and vines. Grape has shown distinct injury and yield decreases at O_3 levels that are representative of ambient conditions (Brewer and Ashcroft, 1983; Musselman et al., 1978). Previous studies have demonstrated that oxidants are detrimental to growth and yield of navel orange and lemon (Thompson and Taylor, 1969; Thompson et al., 1972). Perennial fruit and nut crops, prevalent in the Central Valley of California, have received little attention in the past because of the relatively low levels of ambient O_3 in these areas. However, increased population and activities in areas adjacent to primary fruit crops place these crops at risk from increasing O_3 concentrations. This study focuses on the effects of O_3 on vegetative growth of commercially important cultivars of three perennial fruit tree species elicited by repeated multiseason exposures.

Dormant 2-year-old trees of peach (‘Halford’ on Nemaguard), apricot (‘Royal Blenheim’ on Marianna) and almond (‘Nonpareil’ on Nemaguard) were obtained from a commercial nursery in California in 1986 (year 1). All tree trunks were 9.5 mm in diameter (caliper), 30 cm above soil line, and were initially pruned to similar size and total fresh weights before planting. Trees were planted in 56-liter plastic pots containing a uniform soil mix of 2 sand : 1 peat : 1 redwood shavings (by volume). There was a total of 100 trees per species, divided into O_3-exposed and control treatments (two replications per treatment, 25 plants per replication). All trees were grown in an evaporatively cooled, carbon-filtered greenhouse during the

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[1]Current address: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, 240 West Prospect, Fort Collins, CO 80526.

Table 1. Impact of 4 months of once-weekly exposure in 1986 and in 1987 to 0.25 μl O_3/liter on growth characteristics of peach, apricot, and almond.

Measurement and year	Peach		Apricot		Almond	
	Control	O_3	Control	O_3	Control	O_3
Net growth (g)						
1986	477	451	410	372	325	235***
1987	274	273	385	385	304	195***
Caliper (mm)						
1986	17.0	18.4***	20.7	20.0*	17.1	17.4
1987	19.1	20.2**	25.0	24.1*	20.6	19.8*
Shoots (no.)						
1986	12.8	12.7	15.1	17.0**	15.0	14.8
1987	22.6	19.7*	19.7	22.7*	28.4	30.5

*,**,***Denotes significance of two-tailed *t* test at $P = 0.05$, 0.01, and 0.001, respectively.

normal growth seasons. Trees were watered three times weekly and fertilized once weekly with 20N–8.7P–16.6K (Peters 20-20-20) at a recommended greenhouse rate of 26.4 g·liter^{-1}. During dormancy, i.e., at the conclusion of the season, the soil was removed from the roots and the fresh weights of entire trees were again recorded to determine total seasonal net growth. Caliper 30 cm above soil line and number of shoots per tree were determined. The trees were then stored at 5C for 55 days. Procedures used in 1986 for tree preparation, potting, measurements, exposures, and harvest were duplicated on the same trees in 1987.

Trees were exposed to O_3 in large (2.5-m diameter, 2.1-m height) octagonal chambers (Musselman et al., 1986a). Two chambers were used for each of the two treatments (O_3 and control). Trees were subjected to filtered air or 0.25 μl O_3/liter for 4 hr once weekly. The exposure season spanned 4 months in 1986 and 1987, from June through September. Plants remained in the carbon-filtered greenhouse between exposures. Ozone was monitored by a Dasibi 1003 AH ozone monitor (Dasibi Environmental Corp., Glendale, Calif.) and maintained within ±5% of desired concentration.

Growth responses in 1986 to O_3 exposure depended on tree species. Peach did not exhibit any visible injury. Net growth and production of shoots were unaffected by O_3. Caliper increased in the O_3 treatment relative to control (Table 1). Slight leaf chlorosis was observed on apricot trees exposed to O_3. No significant change in net growth of apricot compared to control trees was observed. Number of shoots was increased by exposures to O_3, but caliper was decreased, suggesting a shift from trunk to lateral shoot growth. Severe chlorosis developed on almond after only two exposures to O_3. Defoliation was evident after ≈5 weeks, followed by a flush of new leaves. Once the new leaves matured, chlorosis, defoliation, and regrowth-again occurred within the fumigation season. Net growth was reduced 28% in O_3 treatments (Table 1). Caliper and shoot number were not significantly changed by O_3 exposure during year 1.

The second year of O_3 treatments (1987) did not reduce net growth of peach. As in 1986, caliper was increased by O_3 but number of shoots decreased 13% (Table 1). No visible injury symptoms were noted. Apricot net growth was not affected by O_3. Number of shoots was increased by O_3 and caliper was decreased, as in 1986. Slight chlorosis was observed in O_3-treated trees. The impact of O_3 exposures on net growth of almond was as severe as in 1986. Net growth was reduced 36% after seasonal O_3 exposures. Caliper was also significantly reduced (Table 1). Ozone treatments did not influence shoot number. Patterns of severe chlorosis followed by defoliation, regrowth, and defoliation were again present for O_3-treated seedlings.

To determine if resistant or sensitive subpopulations of trees existed, specific tests examined variance and response distribution. An F-ratio test was used to determine if exposure to O_3 resulted in significant changes in the variance of tree growth within treatment. The presence of sensitive and resistant subpopulations would increase the variability of the response variable, e.g., net growth. Therefore, these subgroups would have differential response to O_3. Specific genetic subgroups were not expected because grafted nursery stock was obtained. For this test, the larger variance was divided by the smaller variance and the resulting statistic was tested against the appropriate value from F tables. No significant differences in variance between O_3-treated and control trees were found for any species when testing the net growth response variable (data not shown).

To test for differences in distribution, the Kolmogorov-Smirnov (K-S) test was used between control and O_3-treated trees within each species. The nonparametric K–S test has been shown to be useful in detecting any shape or distributional differences in response to O_3 (Musselman et al., 1986b). No significant differences in distribution between treatments were observed. Ozone, therefore, does not appear to significantly increase the variance of the net growth response variable of these tree species, and no other changes in response distribution were noted. These data were useful in assessing O_3 impact on tree crops because no other underlying within-population responses that could confound interpretation of the results were identified.

In the trials reported here, peach and apricot did not exhibit more than mild chronic response to O_3 exposure in terms of some of the characteristics measured. For some characteristics, e.g., caliper, increases were observed for O_3 treatments, but this may possibly be a compensatory response to stress and may result from carbon reallocation. When foliar stimulation is observed, the root systems may suffer and overall vigor can be reduced (Oshima et al., 1978). Although graded nursery stock was used, root stocks may vary with grafted cultivars. Because potential impacts of O_3 stress maybe exhibited in roots, rootstock may vary in ability to cope with reduced carbon allocations. Therefore, differential responses in growth and, potentially, yield of like culivars might be expected on differing rootstock.

Root and shoot weights were not measured separately in this experiment. Almond, however, demonstrated acute symptoms after O_3 exposure, including severe chlorosis, defoliation, and significant decreases in net biomass accumulation after each of the exposure seasons. The impact of O_3 on mature, bearing fruit trees cannot be determined from our data. The extent of O_3 impact on mature trees may be somewhat different than on seedlings, but the potential exists for growth and yield reductions after repeated pollutant stress. The sensitivity of almond seedlings to O_3 suggests that further examination of O_3 effects on mature almonds is warranted.

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