the amount of reduction of top growth in comparison with the unsprayed trees.

At two weeks

Two weeks after application no visual symptoms were observed in any treatment; however, 50 days after treatment, growth differences were noticeable. At that time trees treated with all concentrations showed some degree of leaf tip shrivel in the area of new growth that was sprayed. As the NIA-10637 concentrations increased, a greater percentage of the larger leaves of the 9 to 12 inches of new growth that was treated, shriveled, and stopped growing.

Height measurements are given in table 2. The amount of growth inhibition was directly related to the concentration of the treatment. Growth reduction, in comparison with the check, was significant (see photo) for the 1,250 and 2,500 ppm treatments in this experiment.

Earlier trials

In earlier trials, MH sprays did not affect yield or fruit quality significantly, but some thickening of the rind was noted on some fruit near the sprayed area. Rind measurements made of random fruit samples from the NIA-10637-sprayed trees showed no appreciable rind difference due to sprays.

Eight months after the spraying of young regrowth of topped lemons with 250, 500, and 1,000 ppm of KMH, there was a significant inhibition of growth. There was still a growth reduction due to treatment after 12 months, but it was not statistically significant. Similar sprays of Alar at 2,500 and 5,000 ppm caused a slight reduction in top growth of some trees after eight months but there were no significant differences either eight or 12 months after treatment. A third new growth inhibitor, NIA-10637 at 625, 1,250 and 2,500 ppm inhibited some top growth two months after spraying. Five months later, these growth differences were significant at all concentrations.

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Effects of

PHOTOCHEMICAL ON AND NAVEL

C. R. THOMPSON O. C. TAYLOR

Los Angeles Basin smog, caused principally by automobiles, consists of ozone, oxides of nitrogen, carbon monoxide and peroxyacyl nitrates plus some fluorides and sulfur oxides. It causes much leaf injury to leafy vegetables, grapes and ornamentals in this basin and elsewhere; citrus is very resistant to this kind of damage. Because little overt injury was seen on citrus but yields were continuing to decline, a unique, broadly based cooperative effort was begun in 1960 to find out if and, if so, how much actual injury was being caused by air pollutants.

Research program

The Agricultural Air Research Program of the Statewide Air Pollution Research Center was organized to do the job and was supported by agriculture, industry, local and national government and private organizations with a total expenditure of $1.5 million over a period of eight years. Studies were begun on two lemon groves near Upland, California because of their rapid growth and the existence of both automobile smog and some fluorides in the area. Navel oranges were added later.

TABLE 1. EFFECT OF AIR POLLUTANTS ON LEMON LEAF DROP UCR, 1962

Air Pollutant	Per cent leaves dropped, Lemon 1	
	12 mo.	18 mo.
Filtered air	8.4	32.0
Filtered air + HF	6.9	23.1
Low ozone air	12.3	40.2
Low fluoride air	37.3	93.7
Low ozone, low fluoride air	14.8	58.5
Ambient air	19.2	70.1
Check	12.8	56.9

The experimental procedure was to enclose young, vigorous bearing trees in plastic covered greenhouses (see photo) and supply fractions of the atmospheric pollutant complex to find out which components were having the greatest effect. Removal of the most toxic materials was done with activated carbon and limestone filters. Carbon removed ozone, peroxyacyl nitrates and nitrogen dioxide, while limestone removed fluorides. Six treaments of four trees each were used in the three locations to find out whether ozone, peroxyacyl nitrates or fluoride was causing injury. The ambient levels of total oxidants (mostly ozone) and fluoride were measured continuously with checks on oxides of nitrogen and peroxyacetyl nitrate during certain periods. The amount of carbon dioxide absorbed by lemon trees was recorded for several monthts.

Water use

Shortly after the experimental study was actually begun in 1962, differences appeared in the amounts of irrigation water needed to maintain soil moisture levels. Irrigation was on a bimonthly schedule. The trees which received carbon-filtered air required significantly more water than others, indicating that removal of ozone, peroxyacyl nitrates and nitrogen dioxide from the air allowed the trees to transpire water faster.

The yield results (table 2) were grouped into two categories—those trees receiving carbon-filtered air and those without treatment. The addition of ambient levels of hydrogen fluoride to the carbon-filtered air (filtered air plus HF) showed no statistical difference. It was

SMOG LEMONS ORANGES

B. L. RICHARDS

Plastic-covered shelters over trees allowed control of air pollutants in studies of smog effects on citrus in Southern California.

TABLE 2 AVERAGE ANNUAL YIELD OF CITRUS FRUIT (KILOGRAMS PER TREE) IN AIR POLLUTION TESTS 1962

Trial	Years	Filtered air	Filtered air + HF	Low ozone air	Low fluoride air	Low ozone, low fluoride air	Ambient air	Outside check
Lemon 1	1962–67	84.2	93.0	56.1	57.1	65.1	63.4	78.6
Lemon 2	1963–68	69.0	62.5	30.2	26.7	34.2	30.6	71.1
Navel orange	1964–67	66.7	62.0	21.6	32.4	41.8	23.9	11.7

thought that the removal of ozone by adding nitric oxide to the incoming air streams ("low-ozone air" and "low-ozone, low-fluoride air") would improve the performance of the trees, but apparently the nitrogen dioxide formed from reacting nitric oxide with ozone was about as injurious as the ozone. "Outside check" tree data are shown but are not strictly comparable, because trees inside the greenhouses were exposed to higher temperatures, higher relative humidity and were more vegetative than the outside checks. The overall results show that in lemon test 1, the yield in the two filtered-air treatments was about one-third more than the remaining unfiltered trees. In test 2, and in the navel orange study, yields doubled.

Ten branches were selected on each tree in lemon test 1 to analyze leaf drop response. The percentage of leaves dropping, as recorded at 12 and 18 months, indicated that the trees receiving filtered air retained leaves much longer than the others (table 1).

Fruit drop in lemons was of minor consequence, averaging from 2 to 11 per cent of the harvested fruit, but it represents a major problem in navel oranges. These results showed that during summer the trees in "ambient air" lost 61.8 per cent and the "outside checks" lost 76 per cent of the total fruit set. This loss is over twice that lost by trees in "filtered air" or "filtered air plus fluoride." The fall and winter fruit drop was about the same in all treatments. Thus, the fruit drop in navel oranges account for the major differences in yield which show up later.

Photosynthesis

Another sensitive index of plant health is the rate of photosynthesis. This measurement was made on a series of individual trees during 1961 before the treatments outlined in table 2 were begun, to provide a "base line," and subsequently in 1962 after the treatments were started in January. The results showed that the trees in ambient air were reduced in photosynthesis to 66 per cent of the filtered-air treatments. All other treatments were reduced except the filtered-air-plus-HF which increased slightly.

Fluoride accumulation in leaves was measured quarterly. Ambient air samples accumulated more fluoride than outside check trees probably because dew and rain leached fluoride from the leaves before or after absorption. None of the accumulations were high enough to cause leaf symptoms and the responses in other trees would indicate that fluoride while present in the atmosphere was of minor importance to the health and performance of the trees.

Both tree growth, as measured by increase in girth, and weights of air dried prunings were measured but no consistent differences were observed.

The higher rate of apparent photosynthesis and water use of trees receiving filtered air as compared with ambient could be caused by early senescence of leaves in photochemical smog or other metabolic effects including previous observations by other UC researchers that ozone fumigation reduced starch and sugars in lemons. The reduction in yield of lemons in ambient air seemed to be the result of lack of set either by lack of blooming or a very early abortion of fruit. In navel oranges, the set of fruit seemed normal in all trees but the June drop (when the fruit is about 1.5 cm diameter) was so excessive in "ambient air" that a very poor crop was left for maturity.

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