warm or hot marketing periods, and chilling injury to tomatoes marketed in winter. We identified chilling injury principally by the failure of mature tomatoes to ripen properly. Some chilled fruits infected by *Alternaria* were placed in the disease category. *Alternaria* rot commonly occurs on chilled tomatoes (6).

About 25% of all tomatoes in consumer samples of Florida and California fruits required trimming. In the Florida samples, 15% and 18% of all prepackaged and loose fruits, respectively, were diseased; and the corresponding values for California fruits were 18% and 14%. On most mechanically injured fruits, trimming losses seldom exceeded 10g per fruit. The soft rots, especially rhizopus and bacterial, were generally more extensive and occasionally involved whole fruits. *Alternaria* rot occurred more frequently but was usually localized and shallow.

By extrapolating our loss data obtained on tomatoes from all sources of supply, annual LRL in Greater New York would range from 4,100 to 4,500 metric tons and the annual LCL would range from 4,300 to 5,000 metric tons. Thus the combined LRL and LCL would range from 8,400 to 9,500 metric tons depending upon the volumes delivered to the Greater New York market in any 1 year (10).

Our data reveal that disease is the greatest contributor to losses of fresh tomatoes on the market. The identification of these diseases and their magnitude indicate that current field disease control measures are generally effective against diseases that formerly caused considerable losses on the market (6). Much of the loss in our study was caused by pathogens that are innocuous in the field. These pathogens inhabit packinghouses, transit vehicles, ripening rooms and wholesale and retail storages. Tomatoes must be physically injured to be invaded by many of these organisms. The decays and the physical damage found in our study indicate that fresh tomatoes are frequently mishandled in marketing channels. To minimize physical injuries and the related losses that ensue, we, like previous researchers (1, 4, 5, 6), emphasize the need for careful handling of tomato fruits at all stages of marketing.

Literature Cited


Yield Response of Four Fresh Market Tomato Cultivars after Acute Ozone Exposure in the Seedling Stage

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Additional index words. *Lycopersicon esculentum*, air pollution

Abstract. Seedlings of ‘Fantastic’, ‘Homestead 24’, ‘Walter’ and ‘Heinz 1439’ tomato (*Lycopersicon esculentum* Mill.) were exposed to ozone 6 times between the 2nd and 5th week after emergence. Early total, marketable, and U.S. No. 1 yield were reduced when plants were exposed to 40 pphm ozone for 2 hours for all cultivars, except for ‘Walter’ in one trial. Early marketable yield of the most sensitive cultivar, ‘Fantastic’, was reduced an average of 14.7 metric tons/ha per year at 40 pphm ozone for 2 hours. Effect on early yield of 10 pphm ozone for 8 hours and 40 pphm ozone for 1 hour was influenced by cultivar and year. Early yield was affected more by ozone concentration than by dose. Season marketable yield was unaffected by early acute ozone fumigation except for ‘Homestead 24’ at 40 pphm ozone for 2 hours in 1976. Fruit quality and fruit weight were not appreciably influenced by acute ozone exposure.


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Sensitivity to ozone (O3) has been studied in tomato and within *Lycopersicon* species (1-8). Of 1200 entries from *Lycopersicon esculentum*, *Lycopersicon pimpinellifolium* (Just.) Mill., *Lycopersicon hirsutum* Humb., & Bonpl. and *Lycopersicon peruvianum* (L.) Mill., 2 cultivars and 4 plant introductions, all from *L. esculentum* were identified by Clayberg (1, 2) as tolerant. Gentile et al (3) found *L. esculentum* was the most tolerant *Lycopersicon* species of 5 tested and *L. pimpinellifolium* was the most sensitive. Most research concerning cultivar sensitivity has involved an evaluation of foliar injury at the 6th leaf stage and older (3).

In a California study involving 11 locations tomato yields decreased as the ambient O3 dosage increased (6, 7). Tomato yields were also reduced at one location in New York where
daily ambient O₃ varied from 1.7 — 7.2 pphm (4). Greenhouse studies with O₃ concentrations of 8-10 pphm, 5 days per week, 7 hr per day reduced tomato yields (5).

Screening tomatoes for sensitivity to O₃ has generally involved O₃ concentrations exceeding 25 pphm. This study was designed to determine whether intermittent exposure of fresh market tomato seedlings to O₃ before field transplanting would delay early yield and/or reduce season yield.

Materials and Methods

Four tomato cultivars were selected based on their differences in sensitivity to O₃: ‘Fantastic’, most sensitive; ‘Homestead 24’, moderately sensitive; and ‘Walter’ and ‘Heinz 1439’ (‘H 1439’) least sensitive (Reinert and Henderson unpublished data). In the first year (1975) of a 2-year study, seeds of all 4 cultivars were planted in the greenhouse on March 27 with seedlings subsequently transplanted to peat pots containing a peat-perlite-soil-sand medium. All cultivars were exposed 6 times (April 11, 14, 18, 22, 25 and 29) to three O₃ treatments: control, 40 pphm for 1 hr (40-1), or 40 pphm for 2 hr (40-2) and transplanted to field plots on April 30. The exposure chambers were of a continuous stirred tank reactor (CSTR) design (W. W. Heck, R. B. Philbeck, and J. A. Dunning, unpublished). Ten plants from each O₃ treatment by cultivar combination were spaced 76 cm apart within rows and 152 cm between rows. There were twelve O₃ treatment x cultivar combinations per block, replicated 4 times in a randomized complete block design. Fruit were first harvested on June 26 (57 days after transplanting) and harvesting continued for 13 harvests (two per week) until August 11 (103 days after transplanting). Data were collected by harvest beginning with harvest 3 (sum of harvests 1-3) since harvests 1 and 2 were too small to present individually.

The second year’s study included 3 cultivars (‘Fantastic’, ‘Homestead 24’ and ‘Walter’). Seeds were planted in the greenhouse on April 5 and seedlings were transplanted to peat pots. The cultivars were exposed 6 times (April 19, 23, 26, 30, May 3 and 7) to four O₃ treatments: control, 10 pphm for 8 hr (10-8), 40-1, or 40-2 and were transplanted to the field on May 11. A randomized complete block design with 10 plants per row and 12 O₃ treatment x cultivar combinations was established similar to the first study. Harvesting began on July 8 (58 days after transplanting) and continued for 11 harvests (2 per week) until August 12 (93 days after transplanting). The harvest data were handled the same as that for the first year.

In both years fruits were harvested at the pink storage of maturity. They were graded according to USDA fresh market standards and were recorded as: grade No. 1; marketable (grades No. 1, 2 and 3); and total yield (marketable plus culls). Season yield was divided into an early season (harvests 1 to 7) and a late season (harvests 8 to 13) between the O₃ treatments and the control (Fig. 2). Eight plants from each cultivar in all O₃ treatments were sacrificed for height and dry weight measurement at the time of field transplanting. This provided a base-line evaluation of growth of the plants set in the field.

Results

Marketable yield. Early marketable yield (7 harvests) of ‘Fantastic’ in 1975 was reduced by 7.1 metric tons (MT) per ha (24%) with treatment 40-1 and by 19.2 MT/ha (65%) with 40-2 as compared with the control plants (Fig. 1). Marketable yield of ‘Fantastic’ was reduced by treatment 40-1 through harvest 8 and by treatment 40-2 through harvest 12 (Fig. 2). Marketable yield of ‘Homestead 24’ and ‘H1439’ treated with O₃ at 40-1 was not different from the control at any harvest. Treatment 40-2 lowered early marketable yield of ‘Homestead 24’ by 4.9 MT/ha (52%) and ‘H1439’ by 10.8 MT/ha (76%). Exposure at 40-2 ozone reduced marketable yield of ‘Homestead 24’ through harvest 9 and of ‘H1439’ through harvest 11.

Marketable yield of ‘Walter’ was not adversely affected by O₃. In fact, after harvest 4, accumulated yield from 40-1 tended to be greater (not significant) the remainder of the season. There was no difference in season marketable yield (harvest 1-13) between the O₃ treatments and the control (Fig. 2). In 1976, O₃ treatment at 10-8 affected early marketable yield by: slightly increasing (not significant) ‘Fantastic’ by 3.7 MT/ha (16%), decreasing ‘Homestead 24’ by 5.2 MT/ha (37%), and slightly reducing (not significant) ‘Walter’ by 4.7 MT/ha (28%) (Fig. 1). Early marketable yield of ‘Homestead 24’ and ‘Walter’ was reduced by both 40 pphm O₃ treatments but ‘Fantastic’ was lowered only by 40-2. Loss in early marketable yield was: ‘Homestead 24’ (40-1) 7.4 MT/ha (52%), ‘Homestead 24’ (40-2) 10.8 MT/ha (77%), ‘Walter (40-1) 8.8 MT/ha (50%), ‘Walter (40-2) 9.5 MT/ha (57%) and ‘Fantastic’ (40-2) 10.2 MT/ha (45%) (Fig. 1).

The effect of O₃ on marketable yield was not limited to the early harvest (7 harvests) entirely, but was somewhat prolonged. Yields were reduced in ‘Homestead 24’ at 10-8 and at 40-1 for 8 harvests and at 40-2 for all harvests; and
Fig. 2. Marketable yield of harvest (cumulative) for 'Fantastic', 'Homestead 24', 'H1439' and 'Walter' each at zero ozone, 40 ppb ozone for 1 hr and 40 ppb ozone for 2 hr, 1975. The difference required for significance (5%) in MT/ha between ozone treatments and the control was: harvest 1-3 = 0.6; harvest 1-4 = 0.8; harvest 1-5 = 2.4; harvest 1-6 = 2.4; harvest 1-7 = 4.0; harvest 1-8 = 4.8; harvest 1-9 = 5.9; harvest 1-10 = 6.0; harvest 1-11 = 6.0; harvest 1-12 = 5.9; and harvest 1-13 = 6.5.

Fig. 3. Marketable yield by harvest (cumulative) for 'Fantastic', 'Homestead 24', and 'Walter' each at zero ozone, 10 ppb ozone for 8 hr, 40 ppb ozone for 1 hr and 40 ppb ozone for 2 hr, 1976. The difference required for significance (5%) in MT/ha between ozone treatments and the control was: harvest 1-3 = 1.1; harvest 1-4 = 1.3; harvest 1-5 = 2.0; harvest 1-6 = 3.2; harvest 1-7 = 4.9; harvest 1-8 = 8.6; harvest 1-9 = 11.1; harvest 1-10 = 12.9; and harvest 1-11 = 13.3.
'Walter' at 40-1 and at 40-2 for 8 harvests (Fig. 3). Season marketable yield was unaffected by O₃ treatment except for 'Homestead 24' at 40-2.

Plant height and dry weight determined at the field transplant stage were severely reduced by O₃ exposure (Table 1). However, plant height and dry weight were not satisfactory predictors of yield. For example, early marketable yield of 'Walter' at 40-1 in 1975 was 120% of the yield of the control, whereas dry weight measurements and plant height for 'Walter' at 40-1 ranged from 70-75% of the control. Likewise, early marketable yield of 'Fantastic' at 40-1 in 1976 was 95% of the yield of the control, but plant height and dry weight (top) were only 18% of the control.

Average weight per fruit. In 1975 the cultivar × O₃ treatment interaction for fruit weight was significant at harvests 8 and 9 only. Fruits of 'Walter' at 40-2 weighed 27 g and 26 g more than those of the control at harvests 8 and 9 respectively. There was no difference in fruit weight between the control and either ozone treatment 40-1 or 40-2 at any other harvest (Table 2). The cultivars differed among each other in average fruit weight except at early harvest with 'Homestead 24' and 'Walter' and except at late harvest with 'Walter' and 'Heinz 1439' (Table 2).

The cultivar × O₃ interaction in 1976 was not significant at any harvest. Fruits from treatments 40-1 and 40-2 were heavier than controls during the early harvest period (Table 2). However, O₃ at 40 ppm also reduced early fruit set; the number of marketable fruits/ha were: zero O₃ = 15,936, 10-8 =
Fruit quality was obtained by comparing marketable yield with late harvest periods. Fruits of 'Fantastic' were heavier than the control, whereas cull weight was unaffected. How-

exceptions cited, treatment did not have a pronounced proportion of U.S. No. 1 fruits (Table 3). Other than the freedom from diseases, insects and other defects.

percent early marketable yield was greater in 1975 for both the 40-1 and the 40-2 treatments than at zero O₃ (Table 2). Fruit quality was improved most by 'Walter' and 'Homestead 24' at 40-2 in 1975 and increased by as much as 3.3 MT/ha in 1976 was likely the result of a reduced fruit load rather than a direct effect of O₃ exposure. Loss to the grower due to an O₃-induced reduction in early marketable yield could be considerable even if season marketable yield is unaffected. Using the 1975 and 1976 data as an example, the average O₃ induced reduction in early marketable yield (all treatments, both years) was 5.6 MT/ha. Early marketable yield was reduced by as much as 19.2 MT/ha for 'Fantastic' at 40-2 in 1975 and increased by as much as 3.3 MT/ha for 'Homestead 24' at 40-1 in 1975. Thus, the loss (or gain) in value due to O₃ exposure using $0.33/kg ($0.15/lb.) differential between early and late season price would be: a loss of $1852/ha ($749/acre) with a yield reduction of 5.7 MT/ha; a gain of $1091/ha ($441/acre) with an increase in yield of 3.3 MT/ha; and a loss of $6350/ha ($2570/acre) with a yield reduction of 19.2 MT/ha.

## Discussion

Ambient O₃ exposure caused yield losses in tomato at Los Angeles, California (3), Yonkers, New York (4) and with O₃ generated at low levels, 8-10 pphm, in tomato greenhouse tests at Waltham, Massachusetts (5). Acute O₃ exposure in the present study, given during the 2nd through 5th weeks of growth, reduced early marketable yield (40-2) but season marketable yield was unaffected (Fig. 1, 2, and 3). The effect of O₃ exposure on early yield was influenced by year (previous reports have been limited to a single season's data) being greater in 1976 than in 1975, by cultivar, and by O₃ concentration. These results showed for the first time cultivars could not recover through early harvest, following exposure to O₃ at 40 pphm for 2 hr during 6 different exposure times between the second and fifth week of age.

Oshima et al (6) found that season yield loss could be predicted based upon ambient total O₃ dose. By contrast, yield loss in our study was related more to O₃ concentration than to O₃ dose. The 2 treatments, 10 pphm O₃ for 8 hr (6 exposures) and 40 pphm O₃ for 2 hr (6 exposures), each yielded 480 pphm O₃ total dosage. However, the latter treatment consistently decreased early yield whereas the former produced either a slightly increased or slightly reduced early yield depending upon the cultivar.

Oshima et al (7) showed that fruit size was reduced as ambient O₃ dose increased. MacLean and Schneider (4) did not observe a significant change in fruit size when tomatoes were exposed to ambient concentrations < 7.9 pphm. In greenhouse exposures Manning and Feder (5) found that fruit size was significantly reduced in the presence of daily exposure to 8-10 pphm O₃. In the present case acute early O₃ exposure did not affect fruit size in 1975. Further, the apparent increase in fruit size at 40 pphm O₃ in 1976 was likely the result of a reduced fruit load rather than a direct effect of O₃ exposure. Loss to the grower due to an O₃-induced reduction in early marketable yield could be considerable even if season marketable yield is unaffected. Using the 1975 and 1976 data as an example, the average O₃ induced reduction in early marketable yield (all treatments, both years) was 5.6 MT/ha. Early marketable yield was reduced by as much as 19.2 MT/ha for 'Fantastic' at 40-2 in 1975 and increased by as much as 3.3 MT/ha for 'Homestead 24' at 40-1 in 1975. Thus, the loss (or gain) in value due to O₃ exposure using $0.33/kg ($0.15/lb.) differential between early and late season price would be: a loss of $1852/ha ($749/acre) with a yield reduction of 5.7 MT/ha; a gain of $1091/ha ($441/acre) with an increase in yield of 3.3 MT/ha; and a loss of $6350/ha ($2570/acre) with a yield reduction of 19.2 MT/ha.

### Table 3. U.S. No. 1 and total yield of 'Fantastic', 'Homestead 24', 'Walter' and 'Heinz 1439' each at zero ozone (O₃), 10 pphm O₃ for 8 hr, 40 pphm O₃ for 1 hr and 40 pphm O₃ for 2 hr. 1975 and 1976 (MT/ha).

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Ozone exposure</th>
<th>U.S. No. 1 yield</th>
<th>Total yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Concn (pphm)</td>
<td>Time (hr)</td>
<td>1975 Early</td>
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<tr>
<td>Fantastic</td>
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<td>–</td>
<td>20.7</td>
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<tr>
<td></td>
<td>10</td>
<td>8</td>
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<tr>
<td></td>
<td>40</td>
<td>1</td>
<td>6.9**</td>
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<tr>
<td>Homestead 24</td>
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<td>40</td>
<td>2</td>
<td>2.9**</td>
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<td>Walter</td>
<td>0</td>
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<tr>
<td>Heinz 1439</td>
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<td>10.2</td>
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<tr>
<td></td>
<td>40</td>
<td>2</td>
<td>2.5**</td>
</tr>
</tbody>
</table>

*Significantly different from zero O₃ at 5% level (*) and 1% level (**).

Total = Marketable + culls.

Early harvest = harvest 1 through 7; late harvest = harvest 8 through 13 (1975), and harvest 8 through 11 (1976).
Reflective Film Mulches Influences Insect Control and Yield in Vegetables

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Abstract. In field tests, the most effective film mulch in deterring insects and reducing insect damage to fruits was aluminum. The insects affected were aphids, brown stink bugs, aphid parasites, and Diabrotica spp. Mosaic virus diseases were reduced among aluminum-mulched squash (Cucurbita pepo L.) and cucumber (Cucumis sativus L.) plants. Plant growth, flowering, and fruiting were delayed in tomatoes (Lycopersicon esculentum Mill.) and southernpea (Vigna unguiculata (L.) Walp.).

The need of vegetable growers and home gardeners in the U.S. to control plant pests might be met by using reflective mulches. In fact, such mulches are known to reduce the incidence of aphid-borne viruses and to deter the approach to some species of pest (1, 2, 4, 5, 6, 9). As a result, their application in some areas of large-scale agriculture has been gradually expanding. However, some insects are repelled, and others may be attracted to these reflective surfaces. For example, aluminum mulches do produce practical reduction of aphid-transmitted mosaic viruses of squash (2, 4, 9), and thrips (Frankliniella tritici: (Fitch)) and a leafminer (Liriomyza sp.) were repelled when mulched with a reflective mulch. Insect damage (10 heads/plot) and populations were measured according to commercial practice. The experimental design was a randomized complete block with 4 replicates. The mulches were applied at the appropriate time (shortly before planting) by machine and were applied to the ground. The controls were black plastic or no mulch (bare ground). Except for the mulches, normal commercial management practices were followed.

Experiment 1. Individual 6-m long plots were planted August 24 with either 'Poinsett' cucumber or 'Dixie' squash plants spaced 2 m apart. The design was a randomized complete block with 4 replicates. The melon used were aluminum, aluminized plastic, and black plastic. Observations were made to determine pickler worm damage (D. nitidalis), incidence of the mosaic viruses (squash and cucumber mosaic viruses) and infestations of aphid and Diabrotica spp. and aphid parasites (Braconidae).

Experiment 2. ‘Ferrys Round Dutch’ cabbage was transplanted April 3 into 7.6 m long plots (0.3 m apart; 25 hills/plot). Subsequently, Dipel, a bacterial insecticide (Bacillus thuringiensis Berliner), was applied at a rate of 2.3 kg/ha on May 11, 19, 25, and June 1. For every insecticide-treated plot, there was an untreated control. A randomized complete block design with 4 replicates was used. The mulches were aluminum, aluminized plastic, white plastic, and black plastic. Weight and head diameter of the cabbage (8 plants/plot) and insect damage (10 heads/plot), and populations were determined.

Experiment 3. ‘Walter’ tomato plants were transplanted March 23 (spaced 0.6 m apart) into 7.3 m long plots with 12 plants/plot. The plants were staked and tied for harvesting ease according to commercial practice. The experimental design was a randomized complete block with 4 replicates. The separate harvests of vine-ripened fruit coincided with commercial harvests. The weight and number of both marketable

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