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Effects of Air Quality on Growth, Yield, and Quality of Watermelon

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Abstract. **Watermelon, *Citrullus lanatus* (Thunb.) Matsum & Nakai cv. Sugar Baby, were grown in the field as a fall crop in open-top chambers (OTC) in southwestern Indiana with either charcoal-filtered (CF) or nonfiltered (NF) air. Ozone and sulfur dioxide were continuously monitored in OTC and ambient air. There was a significant decrease in marketable yield by weight (19.9%, *P* = 0.05), percentage of marketable fruit by number (20.8%, *P* = 0.10), and total yield by weight (21.5%, *P* = 0.05) from plants grown in the NF air treatment compared with those grown in CF air. Ozone-induced foliar injury was significantly greater on plants grown under NF conditions. Ambient concentrations of 0_3 in southwestern Indiana caused foliar injury (*P* = 0.10) and significant yield loss to a fall crop of watermelons.**

Ambient concentrations of O_3 have caused substantial foliar injury to watermelon in southern Indiana, which has resulted in a breakdown of the canopy during fruit maturation (Decoteau et al., 1986). Ozone injury to watermelons grown under field conditions, previously known only as "yellow crown dieback", appears initially as premature chlorosis and chlorotic mottle; advanced stages exhibit bleaching and stippling of leaves, followed by tissue breakdown and loss of canopy biomass. The smaller-fruited cultivars, such as 'Petite Sweet', 'Blue Belle', and 'Sugar Baby', appear to be more sensitive than medium- to large-fruited cultivars such as 'Crimson Sweet', 'Jubilee', or 'Charleston Grey' (Decoteau et al., 1986; Simini et al., 1987).

Although O_3 injury has led to substantial deterioration of the foliar canopy, the degree to which O_3 stress could affect watermelon growth and yield was unknown. In a study to determine the growth and yield effects of O_3 on muskmelon, plants of 'Superstar' muskmelon *(Cucumis melo* L. var. *reticulatus)* grown in nonfiltered (NF) open-top chambers (OTC) showed significant increases in the severity of visible foliar injury, 21% less marketable fruit weight, and 21% fewer marketable fruit than those from carbon-filtered (CF) OTCs (Snyder et al., 1988). Because watermelon foliage appears to be more sensitive to O_3 injury than that of muskmelon (Simini et al., 1987, 1989), and the yield of muskmelon was significantly depressed by O_3, we hypothesized that ambient concentrations of O_3 in southwestern Indiana would also depress the yield of watermelons. Because watermelon are an important horticultural crop in southwestern Indiana, grown commercially on ≈ 1100 ha in a five-county area (Daviess, Gibson, Knox, Sullivan, and Vigo counties), and 1300 ha statewide in Indiana (Bureau of the Census, 1984), the objectives of this study were to quantify effects of air quality on growth, yield, and quality of watermelon.

This study was carried out on a commercial farm in Decker, Ind., during Summer and Fall 1986. The site was selected because severe O_3-induced foliar injury on watermelons was previously observed at this location (Decoteau et al., 1986; Simon et al., 1986). Treatments consisted of two levels of ambient O_3. This was accomplished with the use of OTCs (Heagle et al., 1979; Snyder et al., 1988) into which either CF or NF air was introduced continuously through the watermelon canopy of all chambers. This experiment was conducted in the latter part of the growing season and followed a similar experiment with muskmelon (Snyder et al., 1988). Although watermelons are not often grown so late into the fall, our previous monitoring studies (unpublished data) indicated that while O_3 concentrations are higher in the spring, O_3 is present in sufficient concentrations during the fall to induce injury on sensitive crops. The experimental design was a randomized complete block, with six plants per treatment chamber and six replications of each of the two treatments. The study was tested by analysis of variance using SAS (SAS, 1985).

The concentration of O_3 within each OTC was monitored continuously, throughout the growing season, with a chemiluminescent O_3 analyzer (Bendix Corp., Model 8002, Ronceverte, W.Va.) as described by Heagle et al. (1979). Hourly means of O_3 concentrations were calculated for both treatments over the period of time from transplanting to final harvest.

In addition, ambient O_3 and SO_2 were monitored at the farm site, in cooperation with the Indiana Dept. of Environmental Management (DEM) as part of their statewide network of air pollution monitoring (Simon et al., 1986). Ozone concentrations were monitored continuously with a UV photometer (Dasibi, Model 1003AH). Ambient O_3 concentrations were calculated for 10 categories over the range of 0.000 to 0.100 ppm (Table 1). Ambient SO_2 was measured

Table 1. Percentage of hourly ambient O_3 concentrations (ppm) in each of 10 ranges at Decker, Ind., during watermelon growing season, 1986.

O_3 concentrations (ppm) > ≤	Month: July	August	September
0.000–0.010	8.2	12.7	13.0
0.010–0.020	15.8	17.0	27.1
0.020–0.030	19.2	19.3	23.2
0.030–0.040	14.1	17.0	16.1
0.040–0.050	15.7	14.2	11.9
0.050–0.060	13.7	10.2	5.3
0.060–0.070	8.4	6.1	2.4
0.070–0.080	2.5	2.0	1.0
0.080–0.090	1.8	1.2	0.1
0.090–0.100	0.6	0.3	0.0

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Table 2. Influence of air quality on growth, yield, and quality of watermelon from Decker, Ind., 1986[z].

	Yield						
			Marketable				
	Total		Actual		Relative (%)[x]		Foliar injury[w]
Treatment[y]	kg	No.	kg	No.	Wt	No.	(%)
CF	29.3	10.3	28.1	9.00	96.0	87.2	0.8
NF	23.0	10.3	22.5	7.17	97.2	69.1	5.3
P	0.034	1.000	0.039	0.090	0.480	0.004	0.062

[z]Based upon six plants per plot and six replications; yield is per plot.
[y]CF = charcoal-filtered and NF = nonfiltered open-top chambers.
[x]Data arcsin-transformed; actual means presented.
[w]Entire foliar canopy in each chamber visually rated for O_3 injury: 0 = no injury; 100 = entire leaf surface injured.

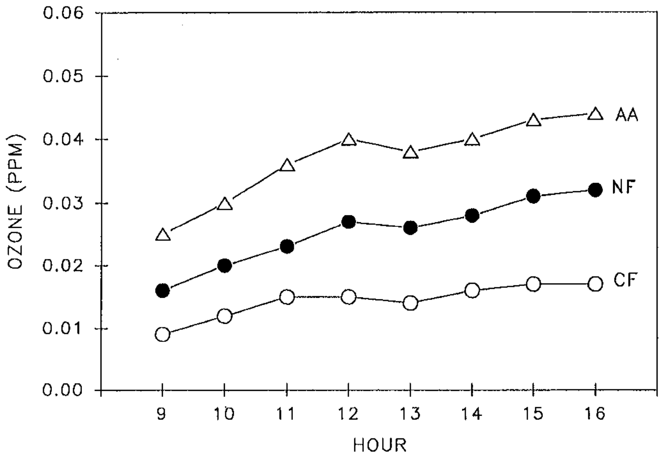

Fig. 1. Mean hourly O_3 concentrations from 0900 to 1600 HR in charcoal-filtered (CF) and nonfiltered (NF) open-top chambers and ambient air (AA) from 31 July through 21 Oct. 1986, Decker, Ind.

continuously with a UV-stimulated fluorescence analyzer (Monitor Labs, Model 8850, San Diego, Calif.) and a pulsed fluorescence monitor (Thermo Electron Corp., Model 43A, Hopkinton, Mass.). Hourly ambient SO_2 concentrations >0.025 ppm were tabulated for each month.

On 17 July 1986, seeds of 'Sugar Baby' were planted into flats in a greenhouse at the Southwest Purdue Agricultural Center in Vincennes. Soil samples were taken from each plot in the field. Dolomitic limestone and fertilizer were applied to plots to raise soil pH to 6.5 and to supply nutrients as indicated by soil tests and based upon standard recommendations for the commercial production of watermelons in Indiana (Latin et al., 1986). Fertilizer, dolomitic limestone, and the insecticide carbofuran were rototilled into the soil of each plot that then was covered with black plastic. Six seedlings were manually transplanted through the plastic on 31 July, at which time the third pair of true leaves had appeared. Sprays of fungicides (chlorothalonil, triadimefon), insecticides (carbaryl, methoxychlor), and miticides (dicofol) were applied as needed according to standard production recommendations (Latin et al., 1986). Soil moisture was monitored by irrometers and, when reading registered ≥ 50 centibars, water was supplied as needed via a PVC irrigation system with mist nozzles.

Mature fruit were harvested three times per week during October, with ripeness determined by color of subtending tendril, ground spot color, thumping, and fruit size. Each fruit was weighed at harvest. Soluble solids (Brix) content (SSC) from one mature fruit per treatment chamber (two samples per fruit) was determined with a hand-held refractometer (Atago, Model no. ATC-1) on the last harvest date. Ozone damage to plant foliage was rated visually on 8 Sept., estimating the percentage of leaf area injured per plot, where 0 = no injury and 100 = entire leaf surfaces injured. At the end of the growing season, 21 Oct., all shoots from each plot were cut at the soil surface, bulked, and fresh and dry weights of foliage per plot obtained.

The CF hourly O_3 means ranged from 0.009 to 0.017 ppm, and NF O_3 means were 0.016 to 0.032 ppm from 0900 to 1600 HR (Fig. 1). Hourly mean concentrations of ambient O_3 were 0.025 to 0.044 ppm during these hours. The NF O_3 was 31.7% and CF O_3 was 61.5% less than ambient values, while CF was 43.5% less than NF, averaged over the entire growing period from 0900 to 1600 HR. Higher O_3 concentrations have been reported earlier in the same growing season (Snyder et al., 1988) as well as during previous seasons at Decker (Simon et al., 1986). Ozone concentrations are highly dependent on atmospheric and meterological conditions, and the average mean O_3 concentrations from August through October were lower than earlier in the season. Average hourly SO_2 concentrations exceeded 0.025 ppm for 37, 38, and 37 h, respectively, with means of 0.06, 0.05, and 0.06 ppm in July, August, and September.

There was a significant decrease in marketable yield by weight (19.9%), percentage of marketable fruit by number (20.8%), and total yield by weight (21.5%) from plants grown in the NF air compared to those from CF air (Table 2). Marketable fruit count was also depressed (20.3% less) in NF treatments. There were, however, no differences between air quality treatments in the total number of fruit, mean fruit weight (≈ 3.1 kg), SSC (≈ 8.5%) foliage fresh (≈ 4.5 kg/plot) and dry weights (≈ 1 kg/plot) and dry matter of foliage (≈ 24.5%). Foliar injury tended to be about six times greater under NF than CF conditions, although this difference was only significant at $P = 0.062$.

These results are consistent with O_3-induced yield loss reported for spring crops of muskmelon during 1986 and 1987 at Decker (Snyder et al., 1988). Yet, the condensed harvesting period of only 1 month during this study may have masked greater differences that could have been observed over a longer harvesting period. Watermelon grown earlier in the season and subjected to higher ambient O_3 concentrations than reported in the fall could also incur even greater yield losses. Further studies with watermelons grown in OTCs during the spring and summer would quantify the potential for yield losses during periods when O_3 concentrations are higher and plant development more rapid. This study demonstrates that ambient concentrations of O_3 induced foliar injury and significant yield loss to a fall crop of field-grown watermelons.

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