Response of Common Milkweed to Oxidant Air Pollution in the Shenandoah National Park in Virginia

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ABSTRACT

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The effects of ambient doses of ozone on *Asclepias syriaca*, common milkweed, were determined in twelve 10-ft-diameter plots in the Big Meadows area of the Shenandoah National Park in Virginia. Chlorosis and purple stippling on the adaxial leaf surface were observed on milkweeds grown in ambient air chambers and open plots; those grown in charcoal-filtered air were asymptomatic and taller than those in other treatments. In the laboratory, ozone at 0.05, 0.10, and 0.15 ppm for 6 hr/day for 7 days induced symptoms identical to those observed in the field.

Common milkweed (*Asclepias syriaca*) is a native perennial herb located throughout the eastern half of the United States, with the exception of some areas along the Gulf Coast. It propagates naturally by seed and from long-spreading rhizomes. In recent years, purple stippling and chlorosis on the adaxial surface of milkweed leaves have been observed in all parts of the Blue Ridge Mountains of Virginia. Symptoms were more severe on older leaves and appeared similar to the grape disorder that Shaulis et al (5) found to be induced by ozone (O_3).

The long-distance transport of oxidant precursors and ozone into remote forested areas has been well documented (1,2,4,7). Data collected since 1975 have indicated that phytotoxic concentrations of oxidant air pollution occur throughout the Blue Ridge and southern Appalachian mountains of Virginia (2,7). Specific major episodes occurred in 1975, 1976, 1977, and 1979, and substantial episodes occurred in 1980. Each episode from 1975 through 1977 was significantly stronger than prior episodes; the 1978 air quality was relatively good. Episodes during 1979 were weaker than those of prior years, but average O_3 concentrations were higher for extended periods of time. When such episodes occurred early (May and June) in the oxidant season (May–September), direct injury to eastern white pine became obvious 2–10 days later (6).

The purpose of this study was to determine whether ambient doses of ozone are responsible for the milkweed disorder that is often observed throughout the mountainous areas of Virginia.

MATERIALS AND METHODS

Field experiment. In May 1979, we established twelve 10-ft-diameter plots at random in the Big Meadows area of Shenandoah National Park. Four plots received charcoal-filtered air and four received unfiltered air via blowers attached to open-top chambers (3); four additional plots received ambient air as open plots. Populations of common milkweed became established within each plot as part of the natural flora.

We observed symptoms throughout the growing season and measured the height of all milkweeds within the plots on 6 October 1979. Ozone was monitored at the study site with a Bendix model 8002 chemiluminescent ozone analyzer (Bendix Corporation, Lewisburg, WV); SO_2 was monitored with a Teco SO_2 analyzer model 43 (Thermo Electron Corporation, Hopkinton, MA).

Fumigation experiments. In October 1979, we collected seeds from two adjacent milkweed plants in the Big Meadows

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area. The seeds were stratified in a moist sand medium in a cold storage room at 2 C for 7 wk, then planted in soil in the greenhouse. After germination, groups of four seedlings were transplanted separately into 1-L plastic pots containing equal parts by volume of soil, Weblite, and vermiculite.

In experiment 1, three sets of 33 plants at 11 wk of age and of similar size were selected and randomly assigned to one of three treatments: exposure to 0.00, 0.05, or 0.15 ppm O_3 for 6 hr/day (0800–1400) for 7 days. The temperature and relative humidity within laboratory fumigation chambers ranged from 20–27 C and 70–80%, respectively. Light intensity ranged from 28–31 klux.

In experiment 2, four sets of 16 plants at 26 wk of age were selected from the original nonfumigated greenhouse population and randomly assigned to one of the following treatments: exposure to 0.00, 0.05, 0.10, or 0.15 ppm O_3. Exposure periods, temperature, relative humidity, and light intensity were maintained as in experiment 1.

RESULTS AND DISCUSSION

Field experiment. By mid-June, chlorosis and purple stippling on adaxial leaf surfaces were observed on all milkweeds growing in unfiltered air in open-top chambers and in open plots (Fig. 1A). Symptoms were more severe on older leaves, which frequently defoliated prematurely. Milkweeds growing in the charcoal-filtered air were asymptomatic or had very slight stippling on upper leaf surfaces. Average heights of milkweeds in the filtered, unfiltered, and open plots were 41, 31, and 31 cm, respectively. During the 5-mo study period, the highest monthly average and peak hourly ozone concentrations were 0.051 and 0.095 ppm, respectively (Table 1). Sulphur dioxide was not detected at the study site.

Fumigation experiments. Symptoms identical to those observed in the field developed on the upper leaf surfaces of milkweeds in experiments 1 and 2 (Fig. 1B). Symptoms were more severe on older leaves; younger leaves exhibited stippling on the leaf margins and tips only. In both experiments, symptoms developed 2 and 5 days after plants were fumigated with 0.15 ppm and 0.05 ppm O_3, respectively. The percentage of leaf area exhibiting purple stipples increased with increasing exposure to O_3 (Table 2). In experiment 2, three consecutive daily exposures to 0.10 ppm O_3 were required to produce symptoms. The average number of leaves per plant that prematurely senesced 4 days after fumigation ended was 0, 0, 1, and 5 for the control, 0.05 ppm, 0.10 ppm, and 0.15 ppm O_3 exposures, respectively.

In this study, common milkweed was very sensitive to the concentrations of ozone found naturally in the Blue Ridge Mountains. Plant age and ozone dose were important interacting variables in milkweed injury. Younger plants (11 wk) expressed more symptoms than older plants (26 wk) when fumigated with 0.05 ppm ozone; older plants expressed more symptoms when fumigated with 0.15 ppm ozone. Individual milkweeds also

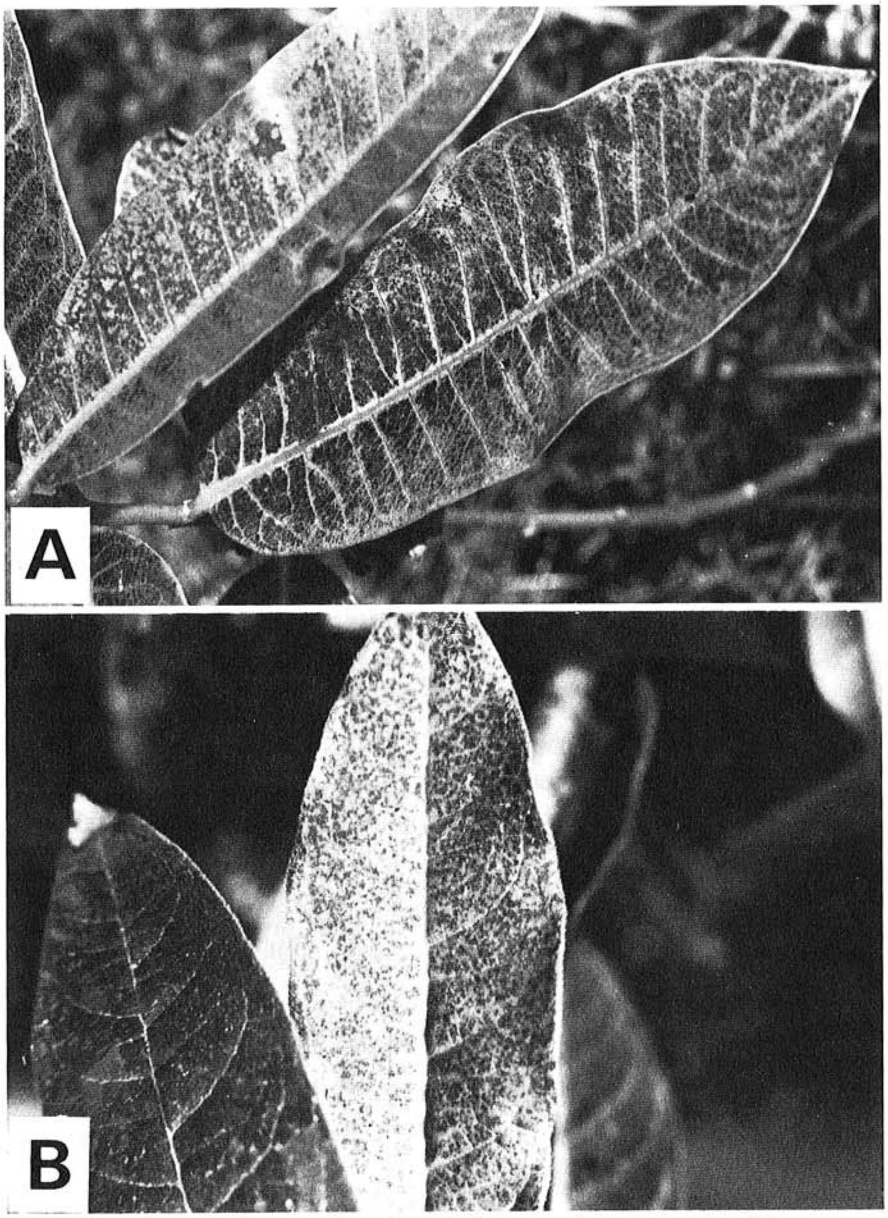

Fig. 1. Ozone-induced injury to milkweed. **(A)** Plant grown in unfiltered air within open-top chamber at Big Meadows area of Shenandoah National Park, Virginia; **(B)** plant fumigated with 0.15 ppm O_3 for 6 hr/day for 7 days.

Table 1. Ozone concentrations monitored in 1979 at Big Meadows area of Shenandoah National Park, Virginia

	Ozone concentration (ppm)	
Month	Monthly mean	Peak hourly mean
May	0.048	0.082
June	0.051	0.082
July	0.044	0.094
August	0.050	0.072
September	0.044	0.095

Table 2. Symptom expression of *Asclepias syriaca* after fumigation with ozone for 6 hr/day for 7 consecutive days

Ozone concentration	Plants with purple stippling (%)[a]	Leaf area with purple stipples (%)[b]
	Experiment 1	
Control	0	0
0.05 ppm	62	10 (3–17)
0.15 ppm	100	25 (19–35)
	Experiment 2	
Control	0	0
0.05 ppm	6	5
0.10 ppm	81	18 (5–40)
0.15 ppm	100	50 (24–70)

[a] Of 33 plants in experiment 1 and 16 plants in experiment 2.

[b] Average for all leaves treated; ranges given in parentheses.

responded variably to ozone fumigation. Some plants had substantial stippling whereas others showed slight stippling when exposed to the same ozone doses (Table 2).

The long-term effects of ozone on milkweed growth and development are not known. Some adverse effects may result from continual exposure. The abundance of milkweeds and their sensitivity to ozone would make them good indicator plants for detection of ozone air pollution.

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