Influence of Ozone on Growth of Two Poplar Cultivars

J. MOOI, Research Institute for Plant Protection, Wageningen, The Netherlands

ABSTRACT

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Populus x euramericana cultivars Dorskamp and Zeeland were exposed to 81 μg O_3/m^3 (0.041 ppm) for 12 hr/day from 5 May to 13 October 1977 in controlled, plastic fumigation chambers in a greenhouse. The fumigation induced severe premature defoliation (about 60%), slight reduction in stem dry matter production (4–12%), and no reduction in stem elongation, compared with unexposed control plants. Foliar symptoms began to appear about 10 days after the fumigation began.

Poplars in The Netherlands often show premature defoliation for no apparent reason. Previous unpublished research at our laboratory in 1973-1976 indicated that the early leaf drop may be due in part to low concentrations of ambient ozone. Jensen and Dochinger (4), Karnosky (5), Kohut et al (6), and Wood and Coppolino (7) reported that various clones of poplars in the U.S.A. are very susceptible to ozone; most of these reports were based on short-term acute exposures at high concentrations of ozone, making it difficult to relate the results to the field situation.

Because poplars are very susceptible to ozone, a study was initiated to determine if very low concentrations of ozone influence leaf drop and dry matter production of *Populus x euramericana* 'Dorskamp' and 'Zeeland,' two cultivars commonly planted in The Netherlands.

MATERIALS AND METHODS

On 28 February 1977, 100 cuttings of each cultivar were placed, two per vessel, in 27-L vessels containing a mixture of 17:3 peat and sand (v/v). The vessels were equipped with an automatic, porous ceramic candle watering system, and plants were fertilized once a month with 1 g of 12-10-18 (N-P-K) fertilizer per liter of soil. Fifty plants of each cultivar were exposed daily to ozone, 81 $\pm$ 22 $\mu g/m^3$, or to charcoal-filtered air from 8 a.m. to 8 p.m., beginning 5 May 1977 and ending 13 October 1977. Exposures were conducted in two similar chambers (each 30 m^3) in the same greenhouse. The air exchange rate was 80 m^3/min. The temperature was 18.4 C (s = 3.1) in the day and 14.1 C (s = 3.7) at night, with relative humidity at 67% (s = 9) and 59% (s = 9), respectively.

Light intensity was 120 W/m^2 (s = 96.8) in the day and 10.0 W/m^2 (s = 31.8) at night. Each value was calculated from about 1,500 hourly averages. Ozone was generated by passing oxygen through a Fisher ozone generator (model 502) and measured with a chemoluminescent analyzer (Mc. Millan 1100-3B). The analyzer was calibrated using a buffered solution of KI. Air entering each chamber was cooled, moistened, and passed through an activated charcoal filter. The air was then mixed with the incoming ozone or remained ozone-free. Because of slight differences in climatic conditions between the fumigation and filtered air chamber, plants were exchanged between chambers every 3 wk. Simultaneously, the chamber that previously received ozone then received charcoal-filtered air, and vice versa.

RESULTS

After 10 days of exposure to ozone, a very slight chlorosis was noted on the adaxial leaf surfaces of both cultivars. With time, the symptom occasionally developed into slight necrosis. The first leaf drop was observed after about 6 wk of fumigation and continued until harvest on 13 October 1977. By the end of the exposure period, 55 and 64% of the stems of Dorskamp and Zeeland, respectively, were without leaves. Control plants exposed to charcoal-filtered air exhibited only 2–5% leaf drop.

The dry matter production of the stems was reduced 12 and 4%, compared with the controls. The total dry matter production of the plant parts above soil was slightly or not reduced (6 and 0%). Zeeland had lower total dry matter production than did Dorskamp; but dry matter production of the stems (8%) and the leaves (4%) differed only slightly compared with the unexposed control plants (Table 1). Stem elongation of Dorskamp was slightly increased by the ozone treatment, but that of Zeeland was unaffected.

Table 1. Influence of a daily 12-hr exposure to ozone (81 $\mu g/m^3$) from 5 May 1977 to 13 October 1977 on growth of two *Populus x euramericana* cultivars[a]

	Dorskamp			Zeeland		
	Control	Fumigated	% of control	Control	Fumigated	% of control
Stem length (cm)	96.9	110.7 +[b]		62.3	61.0	
Without leaves (cm)	1.7	69.1 +		3.5	34.1 +	
With leaves (cm)	95.2	41.6 +		58.9	26.9 +	
No leaves per stem	42.6	19.3 +		34.4	12.5 +	
Dry weight (g) of:						
Stem	996	847	87.7	626	599	95.7
Dropped leaves	54	720	1333.3	98	678	691.8
Leaves on stem	1167	479	41.0	883	330	37.4
Total dry weight (g)	2187	2046	93.6	1607	1607	100.0

[a] Each number is the average of 50 trees.
[b] + = significant at the 95% level.

DISCUSSION

The symptoms produced in short-term fumigations differ from those produced in long-term fumigations with low levels of ozone. Kohut et al (6) reported that short-term fumigations (4 hr at 353 $\mu g/m^3$) produced a dark brown to black bifacial foliar necrosis. In contrast, long-term low level fumigations (12 hr/day, 81 $\mu g/m^3$) initially produced very slight chlorosis on the adaxial leaf surface; with time the symptoms occasionally developed into slight yellow necrosis, followed by leaf drop. Recognition of ozone-induced symptoms in the field is very difficult, because similar symptoms may be produced also by nutrient deficiencies, herbicides, etc.

Wherever possible, symptoms on plants exposed to ambient ozone should be compared with plants exposed to known levels of ozone in chambers and to unexposed control plants.

At time of harvest on 13 October, the differences in dry matter productions of the stems of exposed vs. unexposed plants were rather small. This could be explained as follows:

When plants were placed close together, only the leaves at the top of the plants received enough light for production. Because of light deficiency at the end of the vegetation period, poplars stopped their growth. The leaves of the exposed plants dropped, so the differences in dry matter production of stems of exposed vs. unexposed plants become bigger. In other unpublished fumigation experiments to the end of the vegetation period, maximum reduction of the dry matter production of the stems was 38% in the poplar cultivar Spijk exposed to 93 ± 34 $\mu g/m^3$ of O_3 for 4 mo.

In unpolluted areas of The Netherlands, a natural background of 80–130 $\mu g/m^3$ O_3 may occur, with higher concentrations measured only during short periods (3). However, concentrations of 500 $\mu g/m^3$ O_3 have been measured (2,3) in rural areas in The Netherlands. Ozone concentrations used in the fumigation experiment (81 $\mu g/m^3$) do occur in The Netherlands.

The National Monitoring Network for Air Pollution in The Netherlands has shown significant differences in ozone injury on tobacco Bel W_3 at various places (1). Our results indicate that leaf drop on poplars in the field probably could be caused by low levels of ambient ozone.

LITERATURE CITED

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