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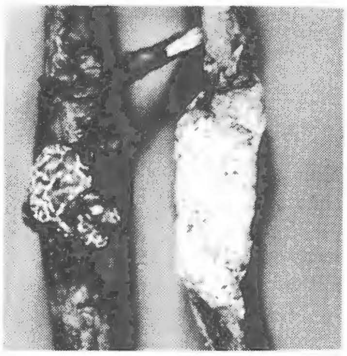

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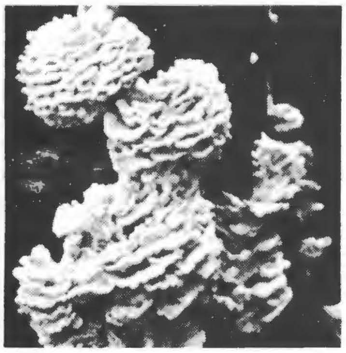

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The Use of Fertilizer to Alleviate Air Pollution Damage to White Pine (Pinus strobus) Christmas Trees

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Eastern white pine (Pinus strobus) is an important Christmas tree planting stock throughout the Northeast and is well suited to Virginia Conditions. This species is relatively free from major diseases, but occasionally an individual tree will develop chlorosis and produce short needles and little terminal growth. This disease has been termed white pine needle blight (8), emergence tipburn (3), semi-mature tissue needle blight (SNB) (5), and "Chlorotic dwarf" disease (11). Various levels and types of air pollutants are reported to be responsible for this disease condition (4,9).

Several attempts have been made to cure or prevent air pollution damage to pines with the application of fertilizers (1, 6, 7). Soluble carbohydrates have been reported as possible factors influencing tipburn sensitivity in eastern white pine (3). They reported that more tipburn injury was noticed on trees whose needles remain low in soluble carbohydrates. As a part of a study to determine the causal agent of chlorotic dwarf, Dochinger (7) treated both healthy and dwarfed white pines with organic chelates, fertilizer, lime, and fertilizer-lime combinations. Trees fertilized with 0.5 lb of 10-6-4 fertilizer responded with increased growth. No treatment reduced foliar symptoms or premature needle abscission. Cotrufo and Berry (6) found that soluble NPK fertilizer increased the tolerance of susceptible white pines to SO_2 injury as related to needle tipburn. The 23-9-9 fertilizer reduced needle tipburn on several pollution-sensitive clones of white pine. Once again chlorotic banding and mottling were not ameliorated. Their study was conducted with potted trees in both the greenhouse and field studies.

The presence of oxidant injury to white pine in the immediate area of this study has been previously reported on large trees (10). In addition, phytotoxic levels of oxidant have been monitored in the mountains of North Carolina far removed from any single point sources (2).

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This study was initiated to determine whether the symptoms of air pollution injury could be eliminated on plantation-grown white pines established for Christmas tree production.

MATERIALS AND METHODS

Thirty eastern white pine Christmas trees that displayed symptoms of air pollution injury were selected at the Hockman Christmas Tree plantation near Mt. Sidney, Virginia in November 1971 for the 1971 trial. During the first week of December 1972, 20 white pine Christmas trees were selected at the Tamuin Christmas tree plantation in Deerfield, Virginia, and an additional 31 trees were selected at the Hockman location for further study. All trees ranged from 7 to 9 years of age. Trees were marked with plastic flagging and numbered aluminum plant tags. Unfertilized trees in the immediate vicinity that also exhibited air pollution injury served as checks.

For the 1971 trial, the parameters measured and recorded were total height (1 ft classes), foliage coloration, and percent tipburn. Coloration was sight-rated by using the color categories of yellow, light yellow, pale green, light green, and dark green. Percent tipburn was rated on the scale of 1) 0-10% tipburn; 2) 10-50% tipburn; 3) 50-90% tipburn; and 4) 90-100% tipburn. In the 1972 trial, total height, terminal shoot length, and percent tipburn were recorded. Total height was a direct measurement and terminal shoot length was measured with a tape from the previous year's whorl to the tip of the terminal shoot. The percent tipburn was rated on the same scale as the previous trial.

Two granular fertilizers were used in the initial study. These were Evergreen 10-10-10 turfgrass fertilizer and 25-9-9, a special mixture by Southern States Cooperative. In the 1972 study, only the 25-9-9 fertilizer was used on the basis of results from the 1971 study. The fertilizers were applied to the trees by direct application and were portioned out by means of a measuring cup (8 oz) and were spread evenly over the crowns of the trees. The trees were then shaken to remove the fertilizer from the foliage to avoid burning the needles.

For the 1971 trial, the two fertilizers were applied at the rates of 0.25, 0.50, 1.0, 2.0, and 3.0 cups. Three trees were fertilized with each rate. The rates used for the 1972 trial were 1.0, 2.0, 3.0, and 4.0 cups. The rates were selected by taking into account the height and degree (class) of needle tipburn of each tree, that is, smaller trees received less fertilizer than larger trees, and trees with less tipburn received less fertilizer.

Coloration, height growth, and percent tipburn were recorded during August or September of the year following fertilization.

RESULTS

The various parameters measured in the 1971 and 1972 studies are summarized in Tables 1 and 2, respectively. Results of the two plots used in the 1972 study are summarized in Table 3.

As indicated in Tables 1, 2, and 3, because of the poor response of the trees to 10-10-10 fertilizer application during the 1971 study, this lower nitrogen fertilizer was eliminated from the 1972 trials. In general, the 25-9-9 fertilizer alleviated the symptoms due to air pollution with few exceptions (Figs. 1, 2, 3). A few trees that were extremely burned (Class 4) and dwarfed because of a past history of damage succumbed following fertilization (Table 2) (Fig. 2). No check trees died, but none exhibited recovery from injury during the 1972 or 1973 growing seasons (Table 2).

Table 1. Results of 1971 fertilizer trial using 25-9-9 and 10-10-10 fertilizers applied in November 1971 to white pine Christmas trees. Data recorded August 1972.

	10-10-10 Fertilizer			25-9-9 Fertilizer		
Rate (cups)[a]	No. Trees	Needle color	Scale of tipburn[b]	No. Trees	Needle color	Scale of tipburn[b]
.25	3	yellow green	2.3	3	light green	3.0
.50	3	light green	2.0	3	light green	1.3
1	3	yellow green	2.0	3	green	1.0
2	3	---------	---	3	dark green	1.3
3	3	light green	2.0	3	dark green	1.0

[a]One cup: 8 oz. [b]Rating Scale tipburn: 1 = 0-10% tipburn; 2 = 10-50% tipburn; 3 = 50-90% tipburn; 4 = 90-100% tipburn.

FIGURE 1. (Left) Nonfertilized check white pine Christmas tree. Note sparse foliage, short needles, and poor growth rate.

FIGURE 2. (Right) Fertilized (3 cups 25-9-9) white pine exhibiting recovery from tipburn symptoms. Tree was comparable to that in Figure 1 before being fertilized.

FIGURE 3. Unfertilized (left) and 25-9-9 fertilized white pine (right).

Table 2. Results of 1972 fertilizer trial for white pine Christmas trees showing rate of tipburn and number of trees improving as a result of fertilization. Data recorded August 1973.

Rate (cups)	No. Trees	Avg Ht (inches)	Rate of tipburn[a] Before	Rate of tipburn[a] After	No. Trees improving 1 class	No. Trees improving 2 class	No. Trees improving 3 class	Improvement	No. Dead
Tamuin									
1	7	48	1.7	1.0	2	0	0	4	1
2	7	55	2.1	1.0	4	1	0	1	1
3	6	85	3.1	1.6	3	2	0	0	1
Avg	--	63	2.3	1.1	-	-	-	-	-
Total	20	--	---	---	9	3	0	5	2
Hockman									
1	8	39	3.6	1.5	2	3	3	0	0
2	8	66	2.5	1.1	6	0	1	1	0
3	9	59	3.9	2.2	0	3	2	2	2[b]
4	8	89	4.0	2.0	0	2	2	2	2[b]
Avg	--	53	3.4	1.6	-	-	-	-	-
Total	31	--	---	---	8	8	8	5	2
Check	5	70	4.0	4.0	0	0	0	0	0

[a]Rate of tipburn 1 = 0-10%; 2 = 10-50%; 3 = 50-90%; 4 = 90-100%.
[b]One tree was missing from each of these rates.

Table 3. Combined data for 1972 study using 25-9-9 fertilizer at Tamuin and Hockman Christmas tree plantations in Virginia. Data recorded August 1973.

Rate (cups)	No. Trees	Avg Ht (inches)	Rate of tipburn[a] Before	Rate of tipburn[a] After	No. Trees improving 1 class	No. Trees improving 2 class	No. Trees improving 3 class	No. Same	No. Dead
1	15	43	2.7	1.4	4	3	3	4	1
2	15	61	2.2	1.2	10	1	1	2	1
3	14	72	3.6	2.2	3	5	2	2	2[b]
4	7	89	4.0	2.0	0	2	2	2	1[b]
Total	51	--	---	---	17	11	8	10	5
Avg	--	66	2.9	1.5	--	--	-	--	-
Check	5	70	4.0	4.0	0	0	0	0	0

[a]Rate of tipburn: 1 = 0-10%; 2 = 10-50%; 3 = 50-90%; 4 = 90-100%.
[b]One tree was missing from each of these rates.

Fertilized trees (25-9-9) responded by increased growth rates of terminal shoots and needle length (Figs. 2, 3). Adverse coloration of the foliage and needle tipburn was alleviated in most cases with an improvement of 1, 2, or 3 tipburn rating classes resulting in one season of growth following fertilization.

The trees fertilized with 25-9-9 in the 1971 study continued to show improvement or remained the same in 1973, as the improved rating indicated in 1972. The 1971 trees fertilized with 10-10-10 did not show any evidence of improvement in 1973.

The relationship was apparent between the amount of fertilizer applied, the height of the tree and its burn class prior to fertilization. Several larger trees that were fertilized with low rates of 25-9-9 (1-2 cup) did not respond as well as those fertilized at higher rates.

DISCUSSION

The alleviation of air pollution-induced symptoms exhibited by eastern white pine Christmas tree stock appears to be feasible under field conditions. The previous work of several researchers indicated that this may indeed be so, but extensive field testing was not done in these earlier studies (6, 7).

The continued expression of symptoms by the unfertilized trees utilized in the study and of affected trees in the surrounding plantations indicated that sufficiently high levels of pollutants were in the area each year to cause damage to the newly developing needles. The symptoms expressed on these trees, as well as those expressed on trees prior to their fertilization with high nitrogen fertilizer, were identical.

The transformation of trees severely affected by air pollution injury into salable trees within one growing season is of significance to the Christmas tree industry. Pollution levels in these areas are predicted to increase during the next decades even with control and abatement programs coming into existence (12). Through the use of a low-cost fertilization program, a significant financial gain may be realized after a 7-year investment has produced a dwarfed, thin, and chlorotic tree as a result of continued exposure to air pollutants.

In general, fertilization helped to alleviate air pollution injury at all rates on most trees; however, for efficiency of treatment in relation to response of the damaged white pines the following rates are recommended:

Tree height	Fertilizer (25-9-9)
1-3 ft	1 cup
3-6 ft	2 cup
> 6 ft	3-4 cups

Not all of the trees responded favorably to the high nitrogen fertilizer and trees severely affected by air pollution, that is, short, brown, and sparse-needled trees, may be too heavily damaged to respond. In some instances, these types of trees died after fertilization at high rates. Because these trees were not of economic importance prior to fertilization, the risks are low when one considers the excellent chance of recovery in most cases.

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