

Effects of Five Antitranspirants on White Spruce and White Pine Seedlings Subjected to Greenhouse Drought

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Five film-forming antitranspirants (Cloud Cover, X2-1337, Plantco, Vapor Gard, and Wilt Pruf) were applied to containerized white spruce (*Picea glauca* (Moench.) Voss) and white pine (*Pinus strobus* L.) seedlings transplanted into pots in the greenhouse. After 28 days without water the survival, level of foliar damage, height growth, and biomass were recorded for each seedling. Although many of the differences were not statistically significant, seedlings treated with Wilt Pruf had the most favorable seedling characteristics: high survival rate, low levels of foliar damage (needle browning or tip death), and high biomass in combination with moderate height growth. Seedlings treated with Vapor Gard had a high survival rate but showed variation in accumulated biomass and height growth with high levels of foliar damage. Treatment with X2-1337 and Plantco resulted in greater height growth but low biomass (suggesting a poorer root/shoot ratio) and variable effects on survival and foliage. Treatment of white spruce or white pine seedlings treated with Cloud Cover was not effective, and the seedlings responded in a similar fashion to those not treated. Tree Planters' Notes 41(1):34-38* 199f)

Poor survival of conifer seedlings because of drought is a widespread impediment to successful regeneration efforts on certain forest sites in many areas. Antitranspirants might be useful in improving regeneration success through two mechanisms: the reduction of transpiration losses during the stressful period after outplanting and the extension of the spring planting season by pretreatment of seedlings to resist drought stress (6, 9). Ideally, treatment with an antitranspirant would increase the survival rate, prevent water loss by trees, and increase or allow seedling growth, although not necessarily in height.

Antitranspirants can be classified into those that either cause stomatal closure, form thin films, form thick films, or reflect light (7). The results of tests on the use of antitranspirants of these types have been inconsistent. Although research has shown positive results in some cases, certain antitranspirants have had toxic effects on different plant species under varying conditions (3). For these reasons, Simpson (9) suggested a screening process for antitranspirants to use on coniferous outplanting stock.

With respect to antitranspirants examined in this study, Simpson (9) did not recommend

treatment of certain coniferous seedlings with Wilt Pruf and Vapor Gard, and concentrations of 1:10 and 1:20, respectively. These treatments increased seedling ability to withstand moisture stress but also had negative impacts on root growth capacity, storability, and field survival/growth of containerized white spruce (*Picea glauca* (Moench) Voss), Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), and western hemlock (*Tsuga heterophylla* (Raf.) Sarg.). An exception was noted with lodgepole pine (*Pinus contorta* Dougl. ex Loud.) seedlings which, when treated with Wilt Pruf, showed reduced moisture stress development without significantly reducing root growth capacity or storability. Similarly, Davies and Koziowski (2) found that Wilt Pruf had favorable effects on transpiration and photosynthesis in white ash (*Fraxinus americana* L.) and red pine (*Pinus resinosa* Ait.) seedlings.

Odlum and Colombo (1,4-6) conducted a number of experiments on the use of antitranspirants on containerized black spruce (*Picea mariana* (Mill.) B.S.P.) seedlings. They found that X2-1337 was most effective in reducing water loss although Wilt Pruf, Vapor Gard, Plantco, and Cloud Cover were

Table 1—Product formulation and supplier

Antitranspirant	Type of compound	Supplier
Cloud Cover	Not available*	Adkar Inc., 1006 South Tenth Street McAllen, TX 78501
X2-1337	Polydimethyl-siloxane emulsion	Dow-Corning Canada, Inc. 6747 Campobella Road Mississauga, ON L5N 2M1
Plantco	Acrylic emulsion	Plant Products Co. Ltd. 314 Orenda Road Bramalea, ON L6T 1G1
Vapor Gard	Pinolene	Miller Chemical and Fertilizer Corp. Hammer, PA 17331
Wilt Pruf	Pinolene	Nursery Specialty Products Greenwich, CT 06830

*Supplier defunct or relocated.

also effective to a lesser extent. However, Wilt Pruf and X2-1337 were also associated with increased mortality (6) and Vapor Gard resulted in high incidence of needle browning. They suggested that X2-1337 might be useful for preventing desiccation over winter and that Plantco and Cloud Cover may be more suitable for reducing postplanting water loss.

The study reported on here expands on the work of Odum and Colombo (4-6) and Colombo and Odum (1) testing many of the same antitranspirants on white pine and white spruce seedlings in pots. We tested the effects of 5 film-forming antitranspirants (table 1) on the growth and survival of containerized white spruce and

white pine (*Pinus strobus* L.) seedlings subjected to drought in the greenhouse.

Methods and Materials

Flats of white spruce seedlings and white pine tubelings were grown for 14 weeks under standard conditions in greenhouses at the Orono Forest Tree Nursery, Ontario Ministry of Natural Resources, and then placed in cold storage at -3 °C. After 4 months, the seedlings were removed from cold storage and transported to a greenhouse at the University of Guelph. Groups of 5 white pine or 4 white spruce seedlings were transplanted into pots containing equal portions of peat, vermiculite, and sand, and then watered generously.

Three replications of six antitranspirant treatments were applied in a randomized complete block experimental design for each tree species, with each pot being treated as an experimental unit. The treatments were applied by dipping the seedlings into a control (tap water) or 5% solutions of Vapor Gard, X2-1337, Plantco, Cloud Cover, or Wilt Pruf and tap water. The total heights and root collar diameters of the seedlings were recorded.

The white spruce seedlings were destructively sampled after 28 days, during which time they were not watered. The total height and root collar diameter of the seedlings were measured, the root systems were cleaned of soil, and wet and dry weights of the seedlings were recorded. Seedling survival and the presence of browned foliage, or tip death, on surviving seedlings was also recorded. The white pine seedlings were destructively sampled at 35 days and measurements similar to those made on white spruce were taken.

Analysis of variance was conducted using PCSAS (8) general linear models procedure. Height growth and biomass were used as dependent variables in the ANOVA and tree species, antitranspirant, and the tree species-antitranspirant interaction terms were used as independent variables. Duncan's multiple range test was used to

detect differences among treatment means. A similar analysis was conducted for seedling survival and burned (desiccated) foliage using experimental unit means for ANOVA and individual seedling data for multiple range testing. Square root or arcsine transformations to the survival or foliar damage (needle browning or tip death) data did not result in any improvement in the analysis. A significance level of 0.10 was used in means separation ($p > 0.10$) because two of the treatment differences were significant at that level in the ANOVA. Rankings of variables were also used to illustrate trends in the results. Additional ANOVA were conducted using initial seedling height and percent height increase as dependent variables, but the information is redundant and not reported in this note.

Results and Discussion

Ideally, characteristics of antitranspirant-treated seedlings subjected to drought would include a high survival rate with minimal desiccation of foliage, combined with reasonable height and biomass growth, indicating more vigorous root growth.

ANOVA (table 2) and Duncan's multiple range test (table 3) resulted in significant differences among white spruce seedlings due to treatment effects in

Table 2—The probability of significant differences from ANOVA in characteristics of white spruce and white pine seedlings due to anti-transpirant treatment

Variable	White spruce ($p > f$)	White pine ($p > f$)
Height growth	0.6680	0.0685
Biomass	0.0850	0.3688
Survival	0.4562	1.0000
Browned foliage	0.0483	0.6254

Table 3—Treatment means for white spruce and white pine seedlings treated with five antitranspirants

Treatment	Height growth (cm)	Biomass (g)	Survival (%)	Browned foliage (%)
White spruce				
Control	1.6	0.40 a	66.7	54.5 bc
Cloud Cover	1.8	0.27 b	60.0	50.0 bc
X2-1337	1.6	0.21 b	86.7	76.9 a
Plantco	1.6	0.21 b	73.3	57.1 bc
Vapor Gard	1.2	0.20 b	93.3	60.0 ab
Wilt Pruf	1.2	0.23 b	100.0	40.0 c
White pine				
Control	1.6 a	1.40	100.0	50.0
Cloud Cover	1.7 a	1.39	100.0	58.3
X2-1337	2.9 b	1.14	100.0	25.0
Plantco	1.8 a	1.10	100.0	16.7
Vapor Gard	3.0 b	1.22	100.0	50.0
Wilt Pruf	2.1 ab	1.35	100.0	25.0

Means within columns for each species followed by the same letter do not differ significantly ($P < 0.1$).

browned foliage ($p < .05$) and biomass ($p < .10$). The mean biomass of the control seedlings was significantly greater than for the treated seedlings (table 3). However, the untreated seedlings had one of the lowest survival rates (not significant) and a moderate level of foliage browning on surviving seedlings. White spruce seedlings treated

with Wilt Pruf had the best survival rate and the lowest level of foliage browning (tables 3 and 4). Seedlings treated with Cloud Cover responded in a similar fashion to the control seedlings. For white pine seedlings, ANOVA found significant differences due to treatment effects in height growth only (table 2). Multiple range testing showed

that the control seedlings and those treated with Cloud Cover and Plantco had significantly less height growth than seedlings treated with X2-1337 or Vapor Gard (table 3). There was 100% survival in white pine for all treatments and no significant differences due to treatment effects for the surviving seedlings with respect to foliage browning, although Plantco-treated seedlings showed the least browning (not significant).

Rankings (table 4) illustrate that seedlings from the control and Cloud Cover treatments were lowest in height growth and highest in biomass (suggesting a higher root biomass) but were also highest in number of seedlings with burned foliage. White pine seedlings treated with Wilt Pruf had moderate height growth and biomass combined with a lower level of foliage browning.

As indicated above, few significant differences attributable to treatment effects were found among tested seedlings in this study. Perhaps the most important differences were found in the low level of foliage browning among surviving white spruce seedlings treated with Wilt Pruf. This is significant, especially considering the 100% survival rate for the white spruce treated with this antitranspirant. Although differences among white pine seedlings for this variable were not significant, the ranking showed that seedlings treated with Wilt Pruf also had lower levels of foliage browning among surviving seedlings. Both species showed excellent survival when treated with this antitranspirant (table 4).

The control and Cloud Cover-treated seedlings of both species ranked similarly in all tested variables. This presents an inter-

pretative anomaly in some cases where it appears that the control seedlings actually performed better than would be expected. For example, control and Cloud Cover-treated white spruce seedlings had the highest height growth and biomass, a relatively low level of foliage browning, but the highest mortality rate. This can be explained by the death of less vigorous seedlings during the experiment, leaving thrifter seedlings with less foliar damage.

Overall, treatment of both white spruce and white pine seedlings with Wilt Pruf resulted in the most favorable seedling characteristics: high survival rate, low levels of foliar damage and higher biomass in combination with moderate height growth. Seedlings treated with Vapor Gard had a high survival rate but showed variation in biomass and height growth and high levels of foliage browning. Seedlings with X2-1337 and Plantco responded with greater height growth but low biomass (suggesting a poorer root/shoot ratio); inconsistent effects on survival and foliage were also noted. Treatment of white spruce or white pine seedlings treated with Cloud Cover was not effective.

Conclusions

The application of antitranspirants does show some benefit

Table 4—Rankings for treatment means for height growth, biomass, survival, and burned foliage of white pine and white spruce seedlings treated with five antitranspirants

Treatment	Height growth		Biomass		Survival		Browned foliage	
	Pine	Spruce	Pine	Spruce	Pine	Spruce	Pine	Spruce
Control	6	2	1	1	1	5	2	4
Cloud Cover	5	1	2	2	1	6	1	5
X2-1337	2	2	5	4	1	3	3	1
Plantco	4	2	6	4	1	4	4	3
Vapor Gard	1	3	4	5	1	2	2	2
Wilt Pruf	3	3	3	3	1	1	3	6

Rankings: 1 = highest, 6 = lowest.

to white spruce and white pine seedlings with improved survival and vigor during a period of drought following planting. In this study, seedlings treated with Wilt Pruf showed the best results. Seedlings treated with Vapor Gard also responded positively relative to untreated seedlings and treatment with X2-1337 and Plantco had moderate but indistinct effects on seedling characteristics. The results of this experiment suggest that some of these antitranspirants, particularly Wilt Pruf, have potential for use on a practical basis and should be considered for operational use subject to additional testing under greenhouse and field conditions.

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