Alternative Leader Growth Control for Fraser Fir and Korean Fir Christmas Trees

Pascal Nzokou, Bert M. Cregg, and Jill O'Donnell

ABSTRACT

Excessive leader growth is a challenge for Christmas tree growers who are seeking about 30–35 cm (12–14 in.) shoot elongation for good balance between height and lateral growth. Current cultivation practices include manually pruning leaders to 30–35 cm. In this study we investigated the use of a growth regulator Ethyl-naphthaleneacetate acid (NAA) and a girdling process using a five-bladed plier (Top-Stop Nipper, Monterey Lawn and Gardens Products, Inc., Fresno, CA) as alternative methods to slow leader growth in Fraser fir (*Abies fraseri* [Pursh] Poir.), and Korean fir (*Abies koreana* Wils). NAA applications at rates of 40–160 ml/L reduced the height growth in both Fraser fir and Korean fir. However, in Fraser fir, other morphological parameters such as the leader straightness and bud density were generally adversely affected. The highest rates of 250 and 500 ml/l caused unacceptable reduction in growth and in many cases leader death. NAA applications on Korean fir resulted in significant reduction of leader growth and significantly increased the bud density without negative impact on leader straightness. Partial girdling of stems was not effective at reducing the leader height in both Fraser fir and Korean fir.

Keywords: *Abies fraseri*, *Abies koreana*, leader girdling, leader growth, naphthalene acetic acid

Excessive leader growth on Christmas tree species is problematic because it increases the tree height too quickly; not allowing enough time for the lateral growth that produces the desired density required for high-quality Christmas trees. To address the problem, growers manually prune leaders down to 30–35 cm (12–14 in.) after budset to improve the tree density. However, pruning removes terminal buds, disturbs the natural apical control, and interrupts the natural branching, resulting in lateral branches growing larger and bending upward to become dominant. This physiological process increases the need for further manipulation of the shape of the tree through future shearings. In addition, pruning the leader in certain species such as Korean fir (*Abies koreana*) tends to result in complete loss of the apical dominance, producing horizontal growth without any dominant leader elongation. For these reasons, tree growers in North America are looking for alternative methods to control leader growth.

Several studies using plant growth regulators (PGR) to manipulate apical dominance and other morphological characteristics have been conducted (Wilson 2000, Duck et al. 2004). Examples include using synthetic auxins such as naphthalene acetic acid (NAA), on woody plants (House et al. 1998, Wilson 2000), applying 1-NAA to naturally remove suckers in grapevine and other fruits (Dolci et al. 2004), using PGRs in conifer species to reduce transplanting stress (Moore 1984), or control shoot elongation on tabletop Christmas trees (Duck et al. 2004). PGRs also have be used to control the second flushing in Douglas fir shoots (Cline et al. 2006), promote bud development in Balsam fir trees (Cha 1984), and improve shoot growth and budset (Hinesley et al. 1998). This article reports on field experiments conducted in Michigan to evaluate a chemical control method (NAA PGR) and a nonchemical method (stem girdling) for the control of leader growth in Fraser fir (*Abies fraseri*) and Korean fir.

Materials and Methods

Test Locations

The tests were conducted at two Christmas tree farms, the Korson's Tree Farm (Sidney, Michigan), and Mathisen Tree Farm (Greenville, Michigan). Both farms are located within the same geographic region and have similar elevations (about 270 m [880 ft] above sea level), annual precipitation rates (about 1,000 mm [40 in.]), and mean growing season temperatures (20.5°C [68.9°F]).

Plant Material and Treatments

The Fraser fir study was conducted at Korson's Tree Farm, and the Korean fir study was established at Mathisen Tree Farm. Both trials, established as separate experiments, were conducted on trees planted in 2003 as plug + 2. The average heights were 156 cm (62.7 in.) for Fraser fir and 89.7 cm (35.9 in.) for Korean fir. The experimental designs for the two tests were randomized designs with seven NAA concentrations applied to single tree plots, replicated 50 times for a total of 350 treated trees. The NAA used Ethyl 1-naphthaleneacetate, was a commercial formulation called Sucker-Stopper (Monterey Lawn and Gardens Products, Inc., Fresno, CA). The seven NAA concentrations (0, 40, 80, 120, 160, 250, and 500 ml/l) were prepared by mixing the appropriate volume of concentrate with water. About 5 ml of WA 100 surfactant (BASF Chemical, Inc., Florham, NJ) was added to the mixture to lower the surface tension of the solution. Each concentration was applied to the leader using a double-sided roller applicator. The treatments were applied to healthy uncut leaders with 7.5–15 cm (3–6 in.) of current-year leader growth.

The girdling treatment had three levels (0, 1, 2, and 3 nips) also randomly applied to 50 trees per treatment. The treatment was applied by nipping the stem 5–7.5 cm (2–3 in.) below the current-year leader growth. When applying multiple nips, the nipper was

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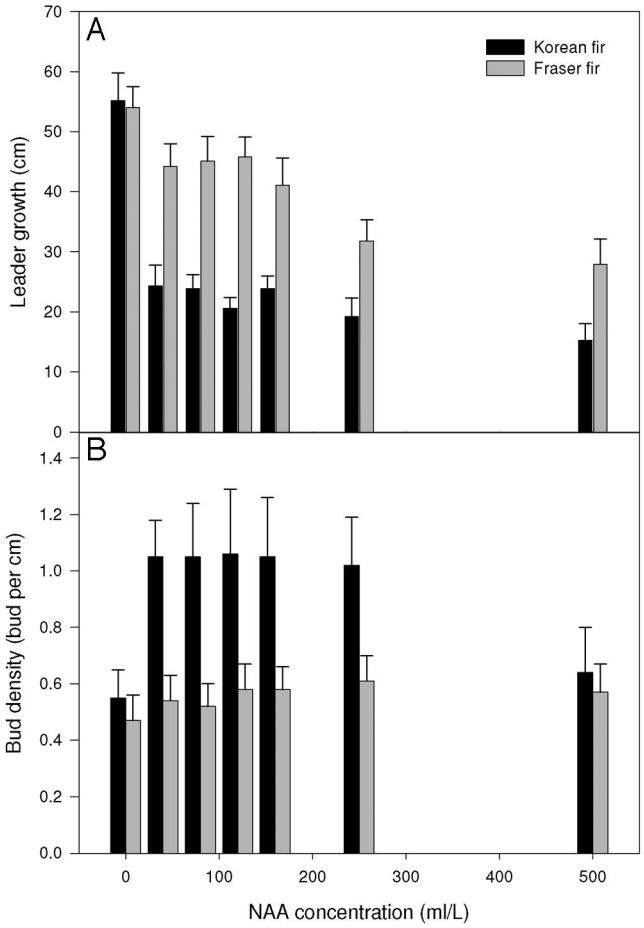

Figure 1. (A) Leader growth and (B) bud density of Fraser fir and Korean fir treated with NAA PGR. (A) For leader growth, all treatment concentrations were statistically different compared with control treatments using the *t*-test (LSD) at $P = 0.05$ for both species. (B) For bud density, all treatments (except 500 ml/l for Korean fir and 80 ml/l for Fraser fir) were statistically different compared with control treatments using the *t*-test (LSD) at $P = 0.05$ for both species.

moved radially around the stem to allow an even distribution of applied cuts.

Measurements

Data collected included leader height growth, bud count, and a visual evaluation of damage to the current-year leader (multiple tops and leader waviness). The bud density was calculated as the ratio of the bud count and leader height. The statistical comparison between the treatments was done using a one-way analysis of variance test at $P = 0.05$ level of confidence. Means were separated using the *t*-test Least Significant Difference (LSD) Procedure with SAS version 8 (SAS Institute, Inc., Cary, NC).

Results and Discussions

NAA Treatment

For Fraser fir treatments, increasing NAA concentrations reduced the average leader growth from 54 ± 11 cm (21.6 ± 4.4 in.) for the control treatment to 28 ± 13.2 cm (11.2 ± 5.3 in.) for the highest concentration of 500 ml/l (Figure 1a). Concentrations between 40 and 160 ml/l produced very similar leader growth responses (Figure 1a) varying between 45.7 ± 10.5 cm (18.3 ± 4.2 in.) and 41.0 ± 14.2 cm (16.4 ± 5.7 in.). Higher concentrations of

Table 1. Percentage of trees with multiple and wavy leaders after treatment with the Top-Stop Nipper.

Concentration	Fraser fir		Korean fir
	Multiple leaders	Wavy leaders	Wavy leaders
	(%)		
Control	64[a]	14[a]	6[a]
40 ml/l	72[a]	46[b]	12[a]
80 ml/l	70[a]	38[b]	6[a]
120 ml/l	56[a]	56[b]	12[a]
160 ml/l	68[a]	28[b]	4[a]
250 ml/l	86[a]	62[b]	8[a]
500 ml/l	84[a]	70[b]	18[b]

Note: Letters indicate significance compared with control treatments using the *t*-test (LSD) at 0.05. Same letter as control means not statistically different computed to control. Different letters mean statistically different.

250 and 500 ml/l reduced the leader growth to 31.7 ± 11 cm (12.7 ± 4.4 in.) and 28.0 ± 13.2 cm (11.2 ± 5.3 in.), levels that can be considered as optimal for Christmas tree production. The statistical analysis comparing each treatment with the untreated specimens showed a significant reduction in leader height only with the highest NAA concentration ($P \geq 0.05$). However, the tree quality was negatively impacted with trees treated at 250 and 500 ml/l developing high percentages of multiple leaders (86 and 84%) and wavy leaders (62 and 56%; Table 1). The two highest concentrations also resulted in high incidence of death of the treated leader and subsequent takeover of the apical dominance by lateral buds. The concentrations ranging from 40 to 160 ml/l also produced large amounts of wavy leaders (28–56%) making the leader straightness a key factor for the unacceptability of NAA treatment for Fraser fir.

All NAA treatments significantly ($P \geq 0.05$) reduced leader height in Korean fir with the average height growth decreasing from 55.2 ± 14.5 cm (22.1 ± 5.8 in.) to below 25 cm (10 in.) for all treatments. The overall straightness of the leaders also was much better with only 4–18% of the treated trees developing wavy leaders (Table 1).

The bud density data (Figure 1b) indicate a higher response for Korean fir that more than doubled the number of buds produced per centimeter for treatments ranging from 40 to 250 ml/l. The combination of a shorter leader and higher bud density on current-year leaders in Korean fir is an indication that more branches and lateral growth will develop, ultimately producing a fuller and denser tree. For Fraser fir, there was no apparent bud density response for all NAA treatments (Figure 1b). The reasons for the differential species response to NAA treatment are not known but presumably arise from the selective advantages of different modes of shoot growth in their native environments.

Nipper Treatment

The morphological responses to nipper treatments for Fraser fir and Korean fir indicated no significant response ($P \geq 0.05$) to any of the nipping treatments in terms of leader height, total bud count, or bud density for either of the two species. This result indicates a tree's ability to heal from wounds created by the nipping process and its ability to carry on its normal growth process.

Conclusion

PGR treatment with NAA concentrations ranging from 40 to 500 ml/l significantly reduced the leader height growth of Fraser fir

and Korean fir. However, for Fraser fir other morphological characteristics such as the leader straightness, bud density, and leader mortality were adversely affected, making it not recommendable, especially at the high rates of 250 and 500 ml/l. Korean fir was more responsive with a significant increase in bud density and limited change in leader straightness. This indicates a good potential for field applications of NAA treatments to control leader growth in this species. Girdling treatments were not effective at reducing leader height growth in either Fraser fir or Korean fir.

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