Attachment C

Christmas Tree Promotion Board

Final Research Report

CTPB Project Number: 17-04-OSU

Project Title: Developing Strategies for Leader Length Control

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Institutions: OSU/MSU

Final Report (Technical)

Introduction

Controlling and managing leaders on true fir species is a task all Christmas tree growers find necessary, and time consuming. Until recently, the only way to control the length of leaders was using cultural controls via trimming. Over time, growers have developed a number of techniques relating to timing, how to cut and where to cut to shorten leaders to develop quality trees.

Plant Growth Regulators (PGR's) are a possible new option for length control on some species. These have been used in Europe to control Nordmann fir leader lengths for some time. This study will look at the use of PGR's in Michigan (Fraser and Korean firs) an in Oregon (noble and Turkish fir).

The PGR trial, evaluated a new growth regulator product, ProTone (Valent BioScience). This is a new ABA product similar to that used in Europe. Evaluations looked into rate responses on 4 species. These are only the initial evaluations and trials. The product is not currently registered for use on conifer trees.

The cultural controls (trimming) used in this trial evaluated cutting leaders on noble and Turkish fir at budbreak and 30 days following.

The CTPB funding and effort for this project was split 50/50 with Michigan State University and Oregon state University. This report will discuss project results for both locations.

Methods

Trial designs are as follows -

1. PGR trial-

a. In Michigan, Fraser fir and Korean fir trees were treated in 6 replications of 5-tree row plots (n=30 for each rate) except for the highest S-ABA rate (300 ml L^{-1}), which was applied to 3 replication of 5-tree row plots (n=15)
b. In Oregon, individual noble fir and Turkish fir trees were randomly selected based on consistent tree height, leader length and condition. For Turkish fir, 25 replications were included at the 200 and 300 ml L^{-1} rates at three sites. At the 400 ml L^{-1} rates two sites had 11 replications and one 25 replications. For noble fir, three sites had 25 replications for rates between 300-400 ml L^{-1}. At the 600 ml L^{-1} rate two sites had 7 trees, one site had 11 trees.
c. Treatment timing ranges from late May for Turkish fir through the end of June for noble depending on the site.
d. Application of ProTone was made using the EasyRoller device with one upwards roll per tree.
e. Measurements include- tree height, leader length at treatment and in September following full leader extension, damages and straightness.

2. Cultural Techniques-
    a. 25 nobles and 25 Turkish/Nordmann firs at 3 sites in Oregon had leaders cut at 2 different times (during bud swell and when buds are 2-4 inches in expansion). The original study plan included an August time as well, but this did not fit with the commercial operations at these sites.
    b. Measurements include- bud size (lammas, large, medium or small), isolation (were buds within 2 inches removed) tree heights new leader length in September, leader straightness, multiple leaders and leader condition (lammas, natural leader, or branch).
    c. Cultural techniques trials were not initiated at Michigan sites.

Results

PGR Trials- Illustrated below (Fig.1-3) are leader lengths and damage estimations at the conclusion of growth for 2018 at test sites in Oregon and Michigan. It is important to note that these lengths depict growth beyond the targeted leader heights of 10 to 12 inches. For example, at the Hupp site (Figure 1), the untreated check (UTC) grew 5.6 inches (30 cm) longer than our target or ideal height of 10-12 inches. Following along with the same site, when treated with 200 gm/l of ProTone the leader only grew 1.7 inches (5.7 cm.) above our target length. While there are site growth differences, the overall trend was consistent, higher rates produce shorter leaders.

Leader damage was assessed in two ways. First, average damage values for each treatment were calculated. Secondly, mean percentages of trees with unacceptable damage were calculated. For mean percentages, we considered damage ratings up to and including level 2 to be acceptable.

Table 1. Damage assessment codes and descriptions

Shoot Damage Code	**Description**
0	None
1	1-10% red needles along shoot, buds normal
2	10-50% red needles along shoot, all buds alive and normal size
3	50-100% red needles along shoot, terminal buds present but viability unknown
4	Terminal buds dead, leader shriveled

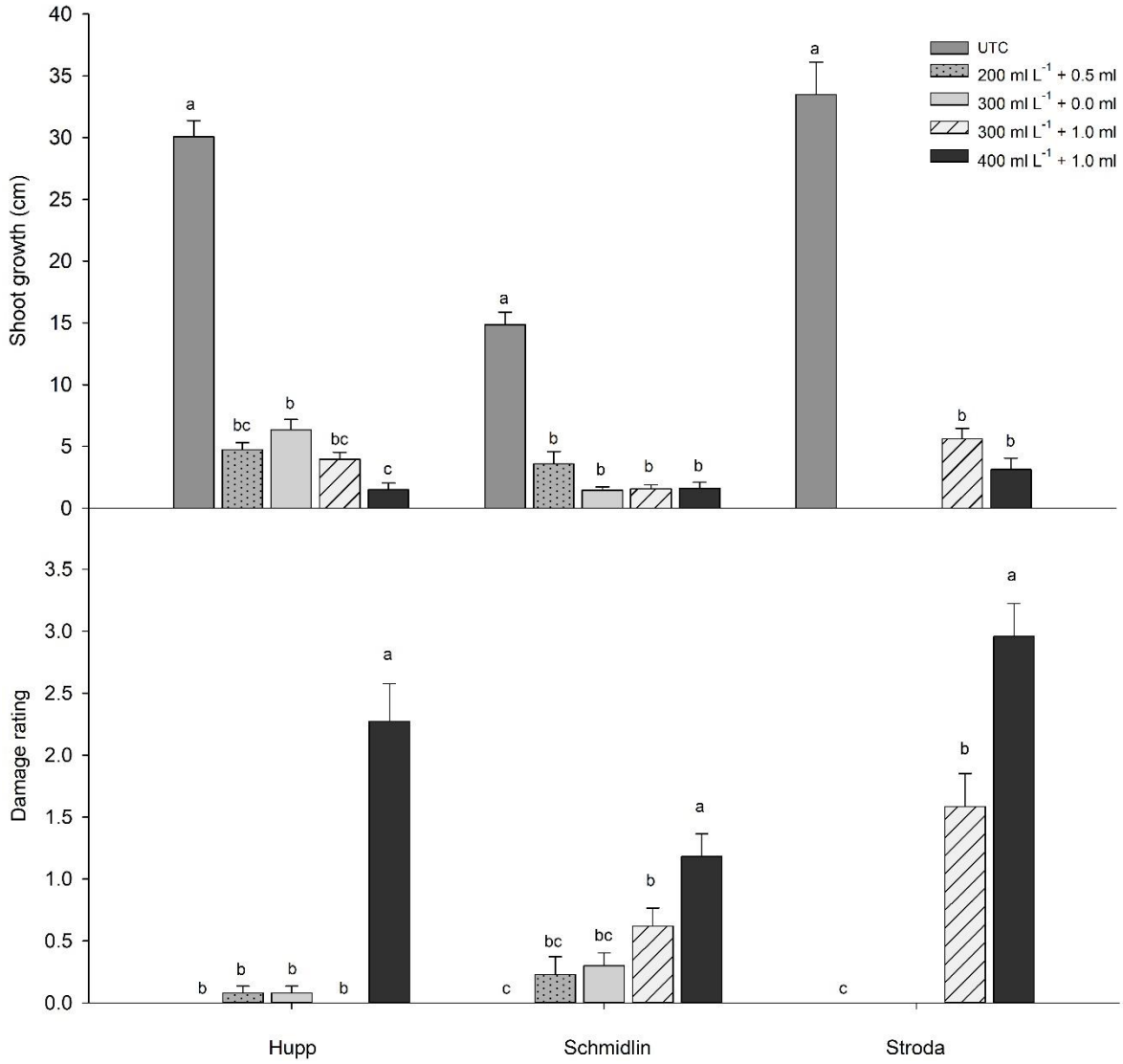

Figure 1. Turkish fir leader lengths above target and damage ratings (Oregon)

Figures 1 and 2 summarize Turkish fir and noble fir results at 3 grower test sites (Hupp, Schmidlin and Stroda). These sites range across the major production areas in Oregon. ProTone rates are depicted along with the rates of Silwet LI 700 surfactant (if used).

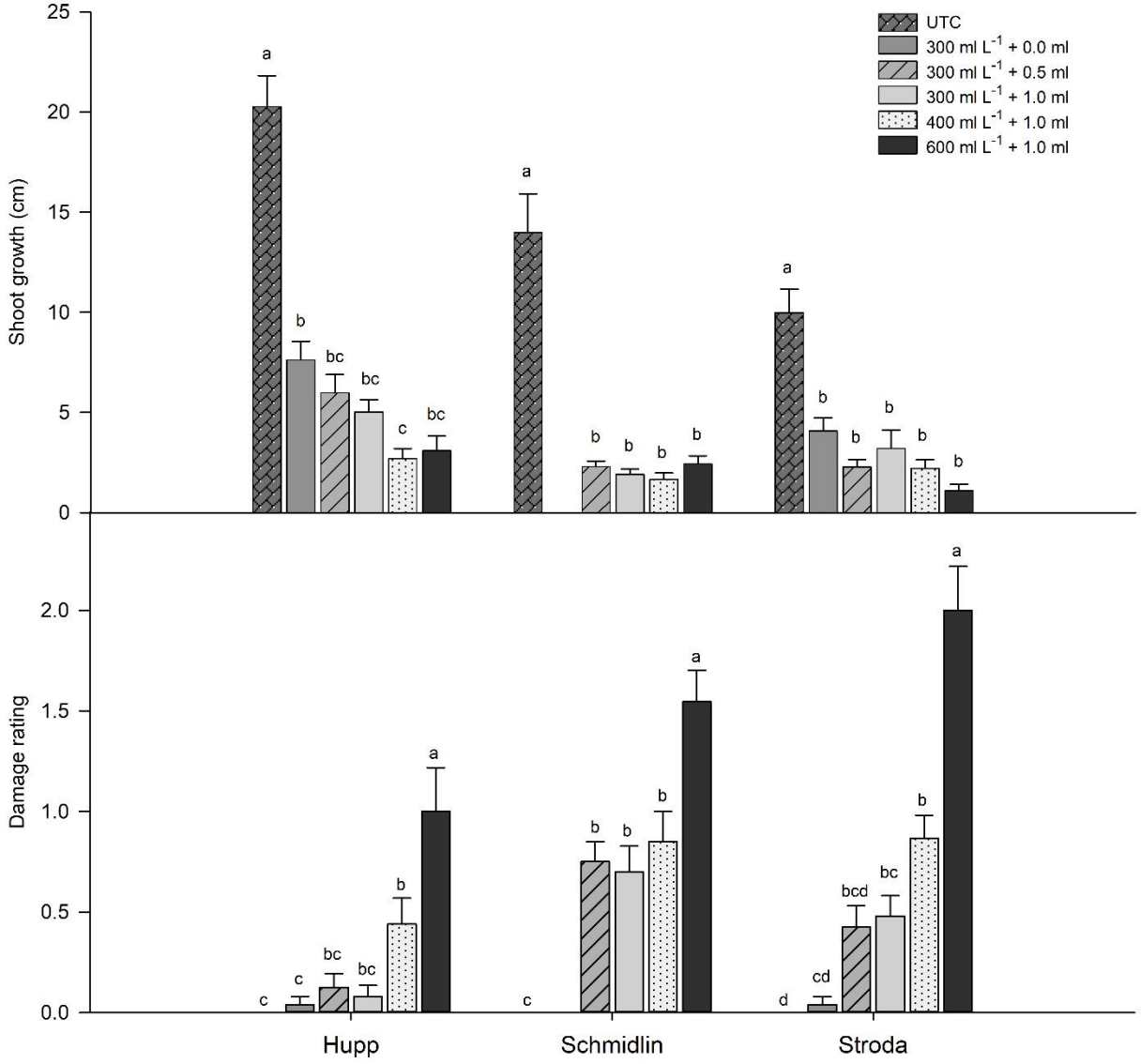

Figure 2. noble fir leader lengths above target length and damage ratings (Oregon)

Noble fir (fig. 2) tended to produce longer leaders than Turkish fir in this trial and also required higher ProTone rates to produce similar reductions in growth. At the 600 ml/L^{-1} ProTone rate with 1 ml of surfactant, damage proved unacceptable.

Damages to the leaders were also monitored (fig. 1-2). There was little damage to Turkish fir up to the 200 gm/l rate. The appropriate rate for Turkish fir appears to be 100 gm/l. Noble fir showed little damage at the highest rate.

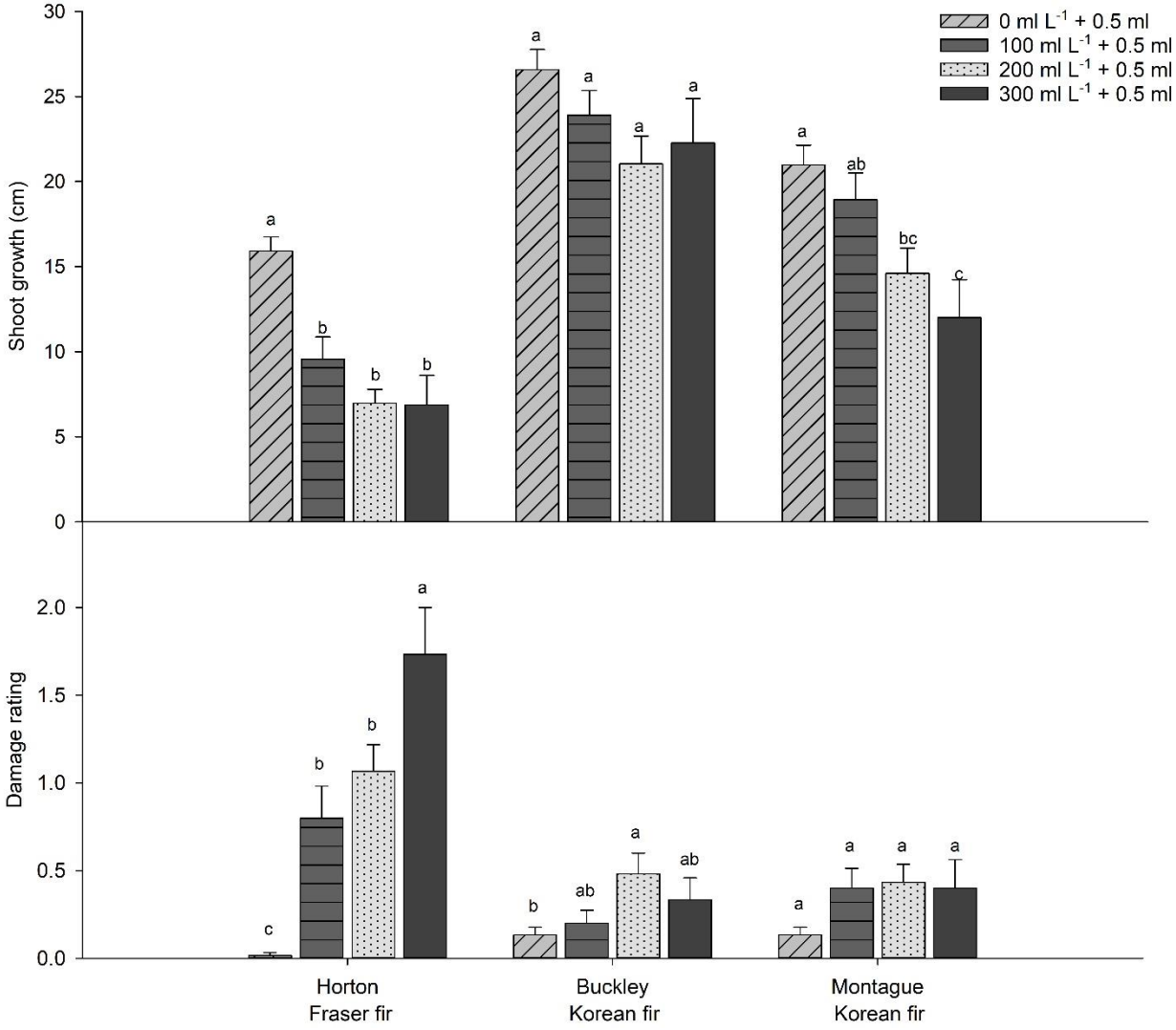

Figure 3. Fraser and Korean fir above targe lengths and damage ratings (Michigan)

Fraser fir was evaluated at the Horton site and Korean fir at Buckley and Montague sites in Michigan (fig. 3). Fraser fir appears easily damaged from PGR applications above 200 ml/L and rages above 100 ml/L provided only modest growth regulation. Korean fir in contrast, showed little damage at rates as high as 300 ml/L and little growth control until rates reached 300 ml/L.

Cultural Techniques- Knowing the best time of the year to trim tops is helpful in order to maximize tree height and quality. With noble fir, the typical time for top work coincides with shearing (August). For Turkish and Nordmann fir, shearing typically precedes noble. Top work at this time often results in misshapen tops. Consequently, this trial investigates top cutting when buds are swelling (May) and after budbreak (late May- June).

Table 1 illustrates results on 3 noble fir sites. The excellent rating could be described as a single, straight leader developing by the end of the growing season (August). An average rating would be given if double leaders developed or the leader was less than straight (10-20 degrees off center). A poor rating would be given if a leader was >20 degrees off vertical and more than 2 competing leaders developed during the season. In this trial, cutting the leader at bud swell was superior to waiting 30 days by a significant margin.

The "type" of bud used to form the new leader was also important, with the smaller buds producing more consistent tops. Also removing potentially competing buds within 2 inches of the remaining bud contributed to fewer competing tops.

Table 1. noble fir leader ratings.

Noble fir leader condition after cutting		
Site/Rating	**Bud swell**	**+30 days**
Stroda		
excellent	28%	7%
average	52%	40%
poor	20%	53%
Schmidlin		
excellent	53%	21%
average	7%	29%
poor	40%	50%
Hupp		
excellent	43%	n/a
average	36%	n/a
poor	21%	n/a

For Nordmann/Turkish fir (Table 2) there appeared to be more site response differences. At the Stroda site, delaying top work to 30 days following bud break produced better tops.

The Schmidlin site produced opposite results. On the Hupp site, timing at bud swell was slightly better, but not by a large margin.

There was a marked difference in how Nordmann/Turkish fir responded to top cutting relative to noble. Nordmann/Turkish fir consistently formed straight tops without regard to the "type" of bud selected. Removal of competing buds within 2 inches made little difference for top straightness or in the number of competing tops that formed. Single leaders formed on only 39% of the trees while 2 leaders formed on 44%. For most growers, having multiple straight tops to select from is a much better option than a single off-center leader. In general, 85% of the leaders were vertical in the Nordmann/Turkish trial while only 52% of the nobles were straight.

Table 2. Nordmann and Turkish leader ratings.

Nordmann /Turkish leader condition after cutting		
Site/Rating	**Bud swell**	**+30 days**
Stroda		
excellent	13%	47%
average	67%	33%
poor	20%	20%
Schmidlin		
excellent	67%	31%
average	33%	23%
poor	0%	46%
Hupp		
excellent	36%	25%
average	29%	44%
poor	36%	31%

Discussion/Conclusions

In practice, growers currently are limited to using cultural methods for leader control. This investigation into the use of PGR solutions for leader control was a first important step. A number of additional trials will be needed to refine the use and rate responses for major Christmas tree species. Also, the PGR's used in this trial do not have an approved EPA label for use in Christmas trees as of this report date. The manufacture, Valent BioScience, was encouraged by these results and has funded additional years of trials in the major Christmas tree growing regions. Label application(s) has been submitted to appropriate agencies for approval in the 2021 growing season.

For noble fir, application rates between 300-400 ml/L, with or without surfactant, seem to effectively shorten leaders without excess damage. For Turkish fir, ProTone rates of 200-300 ml/L effectively shortened leaders.

Effective rates, if they can be determined, for Fraser and Korean fir leader control will require further evaluation.

Cultural leader length controls currently remain as the only option for length control, yet there is no single time or practice that provides 100% success. Rather, there are large site to site differences and even tree-to-tree response differences. So, growers are left trying to select practices that increase the odds of forming an acceptable top. Results from this study in Oregon on noble and Nordmann/Turkish can be summarized as follows:

- May, at the time the buds are ready to break, offers a good time for leader trimming on noble, Turkish and Nordmann fir. Try to finish the trimming before the new buds have extended greater than 3 inches.

- Two, or more, leaders frequently developed on Nordmann and Turkish fir, rarely on noble.

- The leaders that develop (by August) from trimming back the leader (in May) tend to be slightly shorter than the trimmed leader. For example, in our trial on Turkish fir, we trimmed the leaders to an average length of 11 inches; the developed leaders averaged 9" in August. On noble fir, the leaders were about the same length.

Top left photo was taken prior to leader pruning on May 22, 2018.

Top right photo was taken after leader pruning on May 22, 2018.

Bottom left photo was taken of the pruned leader on July 31, 2018.

Leader damage rating of 2 after PGR application.

Leader damage rating of 3 after PGR application.

Application of PGR with roller system.

Public Research Summary-
Developing Strategies for Leader Length Control

A promising new leader control option involves the use of Plant Growth Regulators (PGR's). This is a common practice in Europe with Nordmann and Turkish fir. Essentially the growth regulator slows or stops the extension of the leader and, in turn, increases the density of buds along the shortened leader. In this project, ProTone, an abscisic acid product was tested on four species. The product does not currently have a label for Christmas tree use. This trial showed promise. Applied at the correct rate and appropriate leader extension, leader length could be controlled within a few inches. In these trails, leader length control, with minimal damage, was effective on noble and Turkish firs at selective dosages. PGR applications on Fraser and Korean fir were less effective and will require further testing. Yet, even if the product is registered for use, cultural leader control techniques likely will remain the prevailing leader control method for the foreseeable future.

Nordmann/Turkish fir (the two species are lumped together as many growers have both and they are hard to distinguish) respond differently to leader trimming than noble. Typically, noble leaders are often cut at the same time as the trees are sheared (August).

This same strategy is often employed with Nordmann/Turkish with disappointing results. Alternative timing for trimming Nordmann/Turkish fir tested in this trial were, at budbreak and 30 days following budbreak. Results indicate that leader trimming at budbreak shows more consistent results than waiting 30 or so days to start trimming.

By trimming Nordmann/Turkish fir leaders at budbreak growers should produce a higher % of straight tops, often multiple tops, than at other trimming times. Unlike noble fir, selecting specific buds or isolating individual buds is not effective with Nordmann/Turkish fir.