14E CONFÉRENCE SCIENTIFIQUE INTERNATIONALE SUR LES ARBRES DE NOËL

14TH INTERNATIONAL CHRISTMAS TREE RESEARCH & EXTENSION CONFERENCE

ORAL AND POSTER PRESENTATIONS

RÉSUMÉS DE RECHERCHE ET AFFICHES

14TH INTERNATIONAL CHRISTMAS TREE RESEARCH & EXTENSION CONFERENCE

August 26–30, 2019 Quebec, Canada

IQDHO

IUFRO
Interconnecting Forests, Science and People

Québec

Proceedings of the 14th International Christmas Tree Research and Extension Conference 2019

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Dear Christmas tree friends

The 14th International Christmas Tree Research and Extension Conference was hosted by the Quebec Institute for the Development of Ornamental Horticulture (IQDHO), at the Hotel Château Laurier in Quebec City, from August 26 to August 30, 2019. In total, about 50 participants from USA, Australia, Denmark, Germany, Norway and, of course, Canada attended the congress.
Gary A. Chastagner, Coordinator of the IUFRO UNIT 2.02.09 Christmas Tree Working Group, opened the conference. Marc André Laplante, General Manager of IQDHO, then presented a welcoming speech to the participants from the local organizing committee. He mentioned that the local organizing committee is grateful to the Ministry of Agriculture, Fisheries and Food of Quebec (MAPAQ) for their financial support. Mr Laplante also mentioned that the 14th Conference was financed by the Innov'Action Agrifood Program based on the Agreement Canada-Quebec for the Canadian Agricultural Partnership.
It was a great honor for the local organizing committee to host this International Christmas Tree Conference. The committee hopes that the congress met the expectations of the participants by creating fruitful knowledge exchanges. The organizing committee wishes that this congress gave innovative ideas to the participants and that the conference will be useful for their future work.
During the conference, the following topics were covered:

- Status report in the province of Quebec and Canada
- Breeding & Molecular Biology / Propagation & Biotechnology
- Pest Management
- Plantation Management / Production Technology / Others
- Breeding & Molecular Biology / Post-Harvested Technologies
- Tree Physiology / Others

The program included six presentation sessions, two poster sessions and two full day of field tours. Abstracts of oral presentations appear in the order they were programmed. Poster abstracts follow after the oral presentation abstracts and are not organized by topics.
Many collaborators of the Quebec Christmas Tree Industry have invested time and human resources in the organization of the congress. It was a tremendous team effort. We sincerely thank all of them for the time and ressources invested in the conference.
Additionaly, we are very grateful to the welcoming hosts during the field tours (Productions Résinex inc., St-Modeste Nursery, Downey Tree Farm & Nursery).
This annual conference is an unique opportunity to increase your knowledge, while enjoying invaluable networking opportunities with colleagues and friends who work in the same sector of research.

Marylaine de Chantal, agr., M.Sc. (Coordinator of activities and Special Projects, IQDHO) - Coordinator Local Organizing Committee

signature

The Conference Organizing Committee:
Dominique Choquette (Christmas Tree Advisor in Estrie region, MAPAQ)
Chloé Gendre (Horticultural Advisor, Club agroenvironnemental de l'Estrie)
Gérald Couture (Owner and Grower, Productions Résinex inc.)
Larry Downey (Owner and Grower, Downey Tree Farm & Nursery)
Julie Bilodeau (Administrative Manager, IQDHO)
Julien F. Guertin (R&D Manager, IQDHO)

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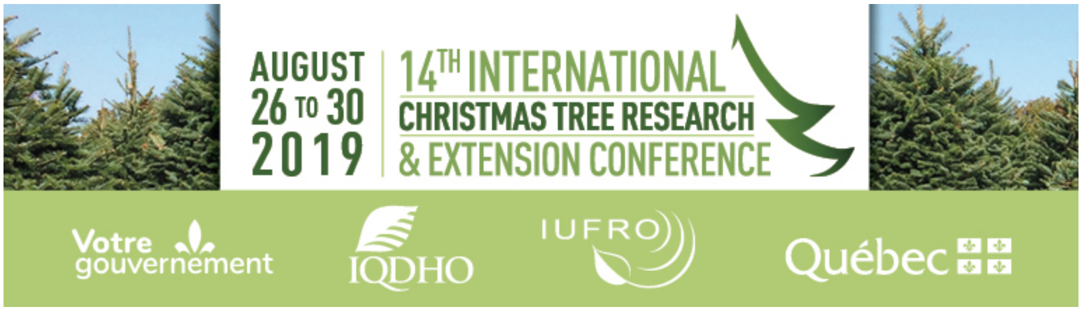


Program

Monday August 26, 2019

8:30 Breakfast (Abraham-Martin room)

8:30 Registration and poster setup

9:30 OPENING SESSION –De la Colline room

9:30 Opening of the congress

Gary Chastagner, *Coordinator of IUFRO Christmas tree working group*

9:45 Welcome from the Quebec Ministry of Agriculture, Fisheries and Food (MAPAQ) and The Quebec Institute for the Development of Ornamental Horticulture (IQDHO)

Marc André Laplante, *General Manager, IQDHO, Quebec, Canada*

SESSION 1 Status report in the province of Quebec and Canada

10:00 Christmas Trees Production in Quebec, Canada

Larry Downey*, Downey Tree Farm & Nursery inc. and President of the Canadian Christmas Trees Growers Association, Canada*

10:30 Break

11:00 IPM & Technical services to Christmas tree producers in Quebec

Chloé Gendre, Club agroenvironnemental de l'Estrie (CAE), Quebec, Canada

11:30 Partnership and innovation in Quebec

Dominique Choquette, Christmas tree advisor, *Estrie, Ministry of Agriculture, Fisheries and Food (MAPAQ)*

Innovation in Quebec Christmas Tree Industry

Julien F. Guertin*, R&D Manager, IQDHO, Quebec, Canada*

12:00 Lunch

SESSION 2 Breeding & Molecular Biology, Propagation & Biotechnology

13:00 Realised gain trials in nordmann fir – breeding works!

Ulrik Bräuner Nielsen

13:30 Clonal production of Douglas-fir via somatic embryogenesis

Pramod K Gupta

14:00 Bioreactors for production of conifer somatic embryos

Ulrika Egertsdotter, Nazmul Mamun and Cyrus Aidun

14:30 Highlights from Nordmann fir tissue culture experiments

Ulrik Bräuner Nielsen, Jing Xu and Ole Kim Hansen

15:00 Break

POSTER SESSION –Abraham-Martin room

15:30 Exchanges at the display site

BANQUET, EVENING RECEPTION AND VISIT OF THE PARLIAMENT OF QUEBEC

17h30 MEETING POINT: Lobby of Château Laurier

Everybody must be at the security gate at the same time

BANQUET Le Parlementaire
In the parliament of Quebec (3 min. of walking)
(Address : 1045, rue des Parlementaires. Door 2)

18:00 Cocktail

18:15 Visit

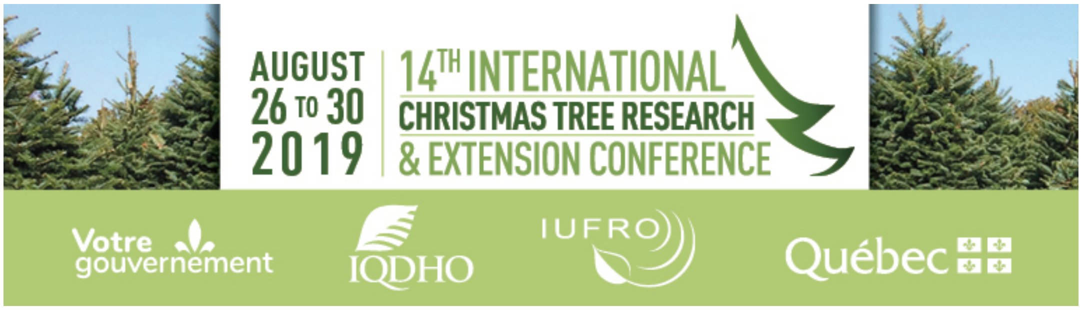
19:00 Banquet and evening

Tuesday August 27, 2019

FIELD TOUR IN THE BAS ST-LAURENT AREA

Tour program

8:00	Bus departure from Château Laurier
9:00	Visit of Productions Résinex inc.
10:15	Departure of Productions Résinex inc.
12:00	Arrival at Saint-Modeste Nursery
12:00	Lunch at Saint-Modeste Nursery
13:00	Visit of Saint-Modeste Nursery
16:00	Departure of Saint-Modeste Nursery
18h30	Arrival at Château Laurier



Program

Wednesday August 28, 2019

7:00 Breakfast (Abraham-Martin room)

SESSION 3 Pest Management –De la Colline room

8:00 New projects to address two regulatory issues affecting the exportation of PNW-grown Christmas trees and importation on conifer seed
Thomas Whitney, Gary Chastagner and Chal Landgren

8:30 Detection of Delphinella shoot blight in balsam fir plantations in Quebec, Canada
Carole Beaulieu, ***Julien F. Guertin***, Mina Zitouni, Philippe Tanguay and Richard Hogue

9:00 DAD-Path: Dead and Alive Detection of Pathogens; a case study of the Phytophthora root rot-conifer pathosystem in Michigan
Monique L. Sakalidis, Carmen M. Medina-Mora and Keumchul Shin

9:30 An update on weed control research in NC
Joseph Neal and ***Jeffrey Owen***

10:00 Break

SESSION 3 Pest Management (continuing)

10:30 Webinar – Determining Impact of Elongate Hemlock Scale on Potential Host Species
Jill Sidebottom and Adam Dale

11:00 Established and emerging insect pests of Christmas tree plantations in Québec: relative abundance and bases for efficient control based on IPM principles
Conrad Cloutier, Jean-François Doherty and Jean-Frédéric Guay

11:30 Status of integrated pest management (IPM) in Nowegian Christmas trees
Venche Talgø, Guro Brodal, Martin Pettersson, Katherine A. G. Nielsen and Inger Sundheim Fløistad

12:00 Lunch

SESSION 4 Plantation Management, Production Technology, Others

13:00 Controlling coning in Fraser fir with plant growth regulators
Bert Cregg, Dana Ellison and Jill O'Donnell

13:30 Strategies to increase noble fir seedling survival in Christmas tree plantations in Oregon
Judy Kowalski and Chal Landgren

14:00 Leader length control in Christmas trees using plant growth regulators
Chal Landgren

14:30 Online Courses and Webinars for Convenient, Low-cost Trainings
Jill O'Donnell, Heidi Lindberg and Bert Cregg

15:00 Break

SESSION 5 Breeding & Molecular Biology, Post-Harvest Technologies

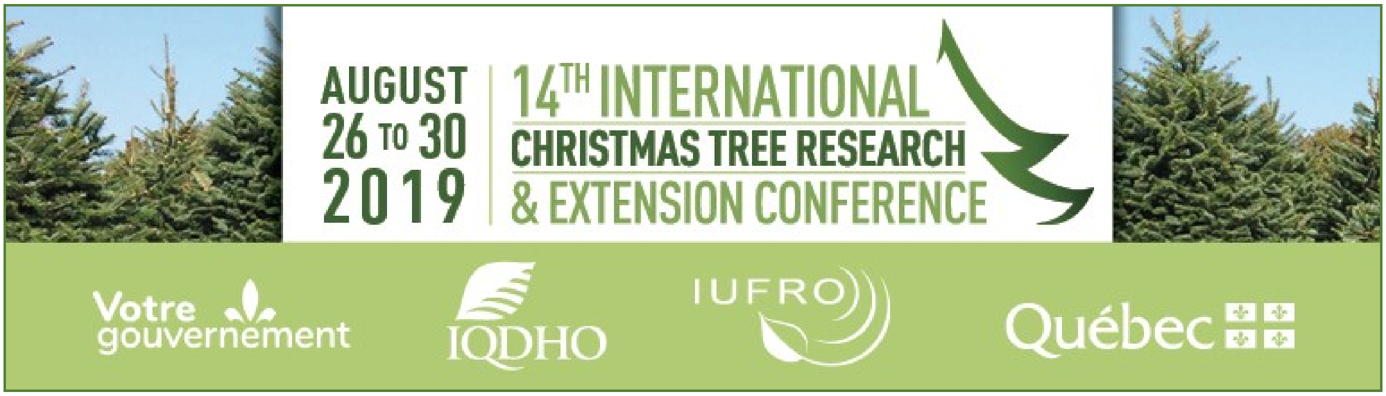
15:30 Webinar – Transcriptome analysis of North American Firs provides insights into the molecular basis of postharvest needle abscission
Lilian Matallana, Alexander Trouern-Trend, Alyssa Ferreira, Olivia Maher, Jill Wegrzyn, Gary Chastagner, Kathryn Coats, John Frampton and Ross Whetten

16:00 Elevation, harvest date, and cold storage – Effect on the postharvest quality of noble fir
Gary Chastagner and Marianne Elliott

POSTER SESSION – Room Abraham-Martin

16:30 Exchanges at the display site

Dinner and evening : on your own, free time

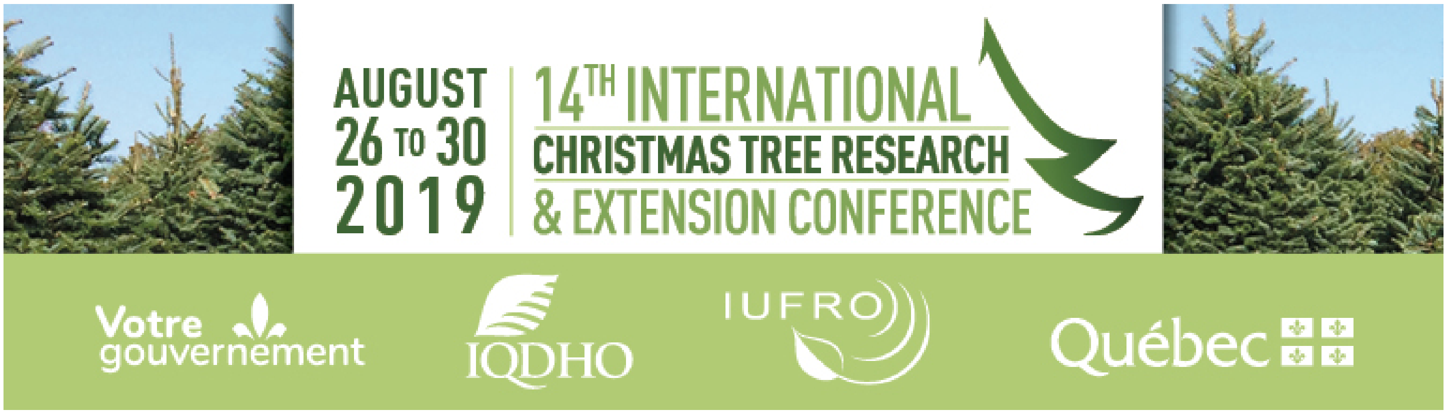


Thursday August 29, 2019

FIELD TOUR in the ESTRIE AREA

Tour program

8:00	Bus departure from Château Laurier
11:15	Arrival at Hatley
11:20	Historic of Downey Nursery
11:30	Lunch at Downey Nursery (lunch boxes)
12:30	Visit of Downey Nursery
16:30	Refreshments
17:00	Dinner at Downey Nursery (buffet)
18:00	Departure of Hatley
21:15	Arrival at the Château Laurier



Program
Friday August 30, 2019

7:30	Breakfast (Abraham-Martin room)
SESSION 6	**Tree Physiology, Breeding & Molecular Biology, Others**
8:30	Variation in post-harvest needle retention of Norway spruce (Picea abies) for Christmas trees in Norway - a pilot study from 2018 *Martin Pettersson*, Venche Talgø, Jan-Ole Skage and Inger Sundheim Fløistad
9:00	Collecting Noordmann fir seed in the Republic of Georgia *Chal Landgren*
9:30	Identification of superior sources of Turkish and Trojan firs for the production of Christmas trees in the U.S. Pacific Northwest *Gary Chastagner* and David McLoughlin
10:00	**Break**
10:30	Business Meeting
12:00	**Lunch**
13:00	End of the congress and departure

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WE ARE THANKFUL FOR THE SUPPORT

Productions Résinex inc.
CULTURES ABRITÉES DE SEMIS EN RÉCIPIENTS

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tree farm & nursery

PARTENARIAT CANADIEN pour l'AGRICULTURE
Canada Québec

IQDHO

Abstracts–Oral presentations

SESSION 1: STATUS REPORT IN THE PROVINCE OF QUEBEC AND CANADA

Abstract of the four oral presentations

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Four talks were held on Monday morning August 25th by Quebec and Canadian Christmas Trees Industry stakeholders. These presentations aimed to present the Christmas Trees Production Industry and to explain the organization of innovation in Quebec, Canada.

The Christmas Tree Industry in Canada represents cash receipts close to 80 million dollars (Canadian dollars) and half of those receipts goes to the Quebec producers. The Province of Quebec is the most important province regarding the production and the exportation of Christmas trees in Canada. This crop is spread almost everywhere in Quebec but particularly concentrated in the south of the province (Estrie region). The Province of Quebec holds 280 businesses growing Christmas trees on approximately 8000 hectares (ha). Each year, approximately 1.5 million Christmas trees are harvested in Quebec and most of them are exported. In 2017, 95% of the Quebec Christmas trees were shipped to United States and other southern American countries. The exportations of trees generate income close to 44 million dollars for all the country and 27.4 million dollars for the Province of Quebec (Canadian dollars).

Varieties grown in Quebec and in Canada are: balsam fir, Fraser fir, Fraser and balsam hybrids, bracted balsam fir, Canaan fir and Korean fir. The main species grown in Quebec are Balsam fir and Fraser fir. A 7 to 8 foot tree (2.1 to 2.4 m) is grown in 14 years including the time cultivated in a nursery. The harvest starts in late October and ends in December. The cup over is done on a period of 3 years: 8 years = 10 to 20%; 9 years = 30 to 60%; 10 years = 20 to 30%. The three quality grades used in Canada are the following: Premium, 1st grade and 2nd grade.

Recently, the Canadian Industry has faced many challenges. The market is challenged by oversupply of trees, price modulation, workforce shortage, transportation availability, currency variation and artificial trees. The production challenges for the third generation of tree growers includes the soil compaction, root diseases, needle diseases and climate change. Adoption of new environmental regulations is also a big challenge to consider for Christmas tree growers in Canada.

While, the Canadian Christmas Tree Growers Association (CCTGA) is a key player in the Canadian industry, the Association des producteurs d'arbres de Noël du Québec (APANQ) plays the same role in the province of Quebec. Both associations represent the sector with the public and private organizations and act as a knowledge disseminator for the growers. Researchers are involved in the Christmas trees Industry and are working on different aspects. In Quebec, Conrad Cloutier (entomologist, Université Laval), Carole Beaulieu (phytopathologist, Université de Sherbrooke), Steeve Pepin (Université Laval), Philippe Tanguay (phytopathologist, Laurentian Forestry Centre) are one of those researchers. In Quebec, independant non-profit organizations specialized in consulting offer many services to Christmas tree growers. The Club agroenvironnemental de l'Estrie (CAE), Fertior and the Quebec Institute for the Development of Ornamental Horticulture (IQDHO) are important key players in the fields. They offer IPM and Technical services to growers such as insects and diseases scouting, fertilization plans, pesticides recommendations, drainage and irrigation advices, management help and so on. These consulting firms are also accompanying growers with their R&D projects. Some independent individual consultants and specialized suppliers (ex: pesticides and fertilizers distributors) are also advising growers. Governmental subsidies offer funds for independent technical, agroenvironmental and scouting services.

The Ministry of Agriculture, Fisheries and Food of Quebec (MAPAQ) has regional technical advisors who give support to start-up clients, technical support to agroenvironmental clubs (ex: CAE, IQDHO) and help to develop the sector. Also, the ministry finances fundamental and applied research in universities and research centers. The MAPAQ also plays a great part in the dissemination of the knowledge to the Industry.

SESSION 2 : BREEDING & MOLECULAR BIOLOGY, PROPAGATION & BIOTECHNOLOGY

Realised gain trials in Nordmann fir – breeding works !

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In Denmark, breeding of Nordmann fir (*Abies nordmanniana*) was initiated in 1992. The breeding objective was securing seed supply and simultaneously improve the genetic material available for Christmas tree production. Classic phenotypic mass selection was applied in Danish stands of mostly known origin using two strategies. 1) Old material (> 35 y), where little plus-tree effect was expected, but flowering allowed immediate progeny testing, 2) Christmas tree stands (no previous commercial harvest of superior trees) selecting the final product, but due to Nordmann firs late flowering – at least 15 years before progeny testing could be initiated. The Danish Nature Agency established a number of first generation seed orchards based on the selected material and University of Copenhagen was responsible for progeny testing and development of research and breeding methods. In 2009 all the first generation seed orchards had a substantial seed crop, and seed were collected. In 2013 a RCBD design at four sites was used to test eight first generation seed orchards in comparison with imported seed sources and the provenances initially used for plus-tree selection. First results after 6 years showed that the standard material Ambrolauri had 47% superior saleable Christmas trees whereas the best seed orchard had close to 60% saleable trees. The importance of proper choice of base material for breeding were highlighted. Further breeding and improvement will be discussed.

Clonal production of Douglas-fir via somatic embryogenesis

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Douglas-fir is a beautiful Christmas tree with soft, shiny green needles. In 2016, the White House chose a Douglas-fir to festoon the Obamas' final Christmas in the Executive Mansion, and for good reason: Douglas firs are gorgeous, equipped with soft needles that radiate out from the branches in all directions, and emit a sweeter scent if you crush them. The Douglas fir is native to western North America, occurring from British Columbia to Washington, Oregon, and California, parts of the Rockies and as far south as Yosemite. It's been one of the most common Christmas trees of the Pacific Northwest since the '20s and also exports to Hawaii, Guam, and other territories. Despite its name, it isn't a member of the genus Abies, and isn't a true fir at all. It's still a beautiful and a favorite across the country tree.

Douglas-fir propagates naturally from seed. Genetic improvement and propagation using seeds are slowed by its long-life cycle. Asexual methods of propagation of proven superior genotypes have not been very successful due to poor rooting and plagiotropic growth of cuttings. Success has also been achieved with somatic embryogenesis in Douglas-fir (Gupta et al. 1994, Gupta et al. 1995).

Clonal propagation via somatic embryogenesis is currently applied to many horticultural and forestry species and many papers has been published and patents have been granted on somatic embryo development, maturation and germination. However, plantlet production via somatic embryogenesis is still not commercialized for any conifer species. Large-scale clonal production via somatic embryogenesis of Douglas -fir has been done at KF-Bioplants India. Several hundred thousand plantlets have been shipped to Weyerhaeuser company for clonal field trials. Large-scale clonal production of Douglas-fir will be discussed in this presentation.

References

1. Plantlet Regeneration via Somatic Embryogenesis in Douglas-fir. P.K. Gupta et al. (1994) TAPPI Proceedings Biological Sciences Symposium (1994) p. 35.
2. Somatic Embryogenesis in Douglas-fir. P.K. Gupta et al. (1995) In Somatic Embryogenesis in Woody Plants. Jain et al. (Eds) Kluwer Academic Publs. Netherlands. p. 303.

Bioreactors for production of conifer somatic embryos

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Somatic embryogenesis is a key method for clonal propagation of many conifer species where cuttings propagation is limited due to aging of donor plants, poor rooting and plagiotropism. A key rate limiting steps of the somatic embryogenesis process in conifers is conversion from the multiplication-stage of early stage somatic embryos (proembryogenic masses; PEMs) to the maturation stage. During the multiplication-phase, PEMs occur at different developmental stages where the earlier stages are unable to respond to the maturation treatment thus limiting yields of mature embryos. By dispersing interconnected tissue of PEMs, early stage embryos are singulated and maturation is more synchronized. A temporary immersion bioreactor designed for conifers together with a specific system for dispersion was used to dissociate connected tissue of PEMs and release smaller aggregates of early stage somatic embryos to a more uniform spatial distribution. An automated set up for dispersion was successfully tested and could be used for scale up production. Development of mature embryos was significantly stimulated by dispersion compared to controls in both liquid and on solid media. A study using the model conifer species Norway spruce (*Picea abies*) showed that in three out of four cell lines the yield of mature embryos from dispersed PEMs is three to five times higher than from non-dispersed controls. Past and present studies with Nordman fir (*Abies nordmanniana*), Fraser fir (*A. fraseri*) and Trojan fir (*A. nordmanniana* ssp. *equi-trojani*) show similar results.

Highlights from Nordmann fir tissue culture experiments

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Tissue culture or somatic embryogenesis (SE) of Nordmann fir have been undertaken at the University of Copenhagen for more than 30 years. Initiated by Jens Viktor Nørgaard in the late 1980's and for more than 20 years continued by late Jens Ivar Find, and for the past nearly three years headed by the author. During the past three years a number of trials have been carried out to document and fine-tune procedures, i.e. temperature requirements during germination, light demand during embling development in sterile airyated boxes as well as plug-production. Furthermore, experiments documenting how severe mature embryo-quality impact the following steps of embling production. Breeding values from the Danish breeding program have been applied to select superior families as basis for cloning. First results from field testing of clones from SE cultures are now available and results will be discussed.

SESSION 3: PEST MANAGEMENT

New projects to address two regulatory issues affecting the exportation of PNW-grown Christmas trees and importation on conifer seed

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Twig weevil (*Cylindrocopturus furnissi*) and *Megastigmus* larvae are insect pests of regulatory concern. Although twig weevil has historically caused sporatic problems on PNW-grown Douglas-fir Christmas trees, and particularly on dry sites, this insect affects virtually all species of Christmas trees grown in the PNW today. During the past few years, this pest has emerged as a significant export problem and is affecting the quality of tree for the domestic market. It is also affecting the marketability of noble fir boughs in low elevation production stands. Twig weevil is the number one insect pest causing load rejections into Mexico. To address this issue, the U.S. Christmas Tree Promotion Board (CTPB) has funded a project to: 1) Determine the diversity of twig weevil populations on different Christmas tree species, 2) Develop a degree day model for critical twig weevil life stages, and 3) Develop a twig weevil scouting and management guide for growers.

The presence of *Megastigmus* larvae in imported Turkish and Nordmann fir seeds threatens the future supply of seedlings of these species. A significant amount of seed has been destroyed because of the detection of larvae at APHIS PPQ plant introduction stations. PPQ has records of 15 species/subspecies of *Megastigmus* that are considered to be quarantine pests and there are currently no APHIS approved treatments for *Megastigmus*-infested conifer seeds. Previous research on *Megastigmus strobilovius* infested Douglas-fir seed has shown that exposing infested seed to 45C for 27 to 33 hours was effective in killing larvae. This heat treatment also had no adverse effect on seed germination and subsequent growth of seedlings. The goal of this project, which is being supported by the CTPB and USDA APHIS, is to evaluate the potential post-entry use of heat treatment to eradicated *Megastigmus* larvae in infested Turkish and/or Nordmann fir seeds.

Detection of Delphinella shoot blight in balsam fir plantations in Quebec, Canada

C. Beaulieu[1], J.F. Guertin[1], M. Zitouni[1], P. Tanguay[2] & R. Hogue[3]
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Christmas trees produced in Quebec (Canada) mostly include balsam fir (*Abies balsamea*), which is a species susceptible to *Delphinella* shoot blight disease. Over the past decade, the Quebec Christmas tree industry has encountered an increase of *Delphinella* shoot blight, and only few studies have aimed to comprehend and quantify the damages caused by this disease. Shoot blight of firs is caused by two fungal species, *Delphinella abietis* and *Delphinella balsameae*. Diseased needles were collected in Quebec plantations from May to August during two consecutive years. The presence of pseudothecia on these needles were recorded. Mature fruiting bodies were detected around mid-May and the dissemination of ascospores ended between mid- and end of June. Cylindric-clavate bitunicate asci with a typical size of about 100 µm were observed. They contained 16 multiple ellipsoidal, uniseptate and hyaline ascospores of about 37 × 10 µm. Fruiting bodies observed on the diseased needles contained asci and ascospores characteristic of *D. balsameae*. The size of ascopores in this pathogen allowed it to be distinguished from D. abietis. Nevertheless, *D. balsameae* was rarely isolated from the diseased needles while its phylogenetically closely related pathogen *Sydowia polyspora* was frequently isolated. Species-specific PCR protocols to detect both *D. balsameae* and *S. polyspora were* thus developed and the occurrence of these species in infected and symptomless needles was evaluated. While *D. balsameae* was detected only in diseased needles, *S. polyspora* was frequently found in asymptomatic needles as well as in needles displaying shoot blight. Experiments brought evidence that *D. balsameae* is the main causal agent of fir tree shoot blight in Quebec, whereas *S. polyspora* rather harbors an endophytic lifestyle.

DAD-Path: Dead and alive detection of pathogens; a case study of the Phytophthora root rot-conifer pathosystem in Michigan

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Phytophthora root rot can cause widespread mortality in numerous species of plants. In a survey of conifer growers in Michigan, Phytophthora root rot was among the top disease issues concerning these growers. Culture-based methods of Phytophthora detection may take several weeks for a positive or negative confirmation. The day of lab work required for direct amplification of pathogen DNA from plant or soil samples negates the need for lengthy culture and microscopy work. Enhancing our ability to detect pathogens is the ability to determine if the pathogen is dead or alive. Conventional PCR and quantitative PCR (qPCR) assays used to detect and quantify pathogen presence may overestimate the number of active pathogens due to the lack of discrimination between viable and non-viable propagules of the pathogens. Detection of a pathogen and determination of live or dead status is critical to evaluate the efficacy and success of pathogen mitigation treatments. A quantitative PCR (qPCR) assay using pre-treatment of propidium monoazide (PMA), a DNA-binding dye penetrating broken membrane of dead cells and inhibiting PCR amplification, was evaluated to test the viability of *Phytophthora* spp. in artificially inoculated and field samples. The PMA-qPCR (atp9-nad9 region) protocol developed in this study, was specific and multiplexed with genus and species-specific for the detection of *Phytophthora* spp. in the samples tested. Detection limits for the genus and species-specific assays were 10 and 100 fg/µl of genomic DNA extracted from pure culture, respectively. Artificially inoculated soil samples treated with 40 µM of PMA showed a signal reduction (3.03 cycles) in qPCR between live and heat-killed zoospores of *Phytophthora* spp. We demonstrate this approach using lab, greenhouse and field soil and root samples.

An update on weed control research in NC

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Weed resistance to low rates of glyphosate (Roundup) herbicide has reduced Christmas tree grower reliance on ground cover suppression practices that protect steep mountain soils in North Carolina. Growers are using higher rates and more frequent applications of herbicides to control escaping weeds. NC growers have problems primarily with three annual weeds: horseweed or marestail, *Conyza canadensis* L., common ragweed, *Ambrosia artemisiifolia* L., and lambsquarters, *Chenopodium album* L. The purpose of current alternative herbicide research is to identify safe and effective postemergent herbicides with different modes of action that can be rotated year-to-year without killing dwarf white clover ground covers. Herbicides tested in 2018 & 2019 include Firstrate (cloransulam-methyl), Harmony (Thifensulfuron-methyl), 2-4D amine, Frequency (topramazone), and Detail (saflufenacil). Firstrate and Harmony continue to provide promising levels of selective weed control but are at risk of their own weed resistance issues. 2-4D amine and Detail provide alternative modes of action that can be safely used prior to Christmas tree budbreak. Special labels contingent on product rotation will be sought through the IR4 Program which was set up to register pesticides for minor crops.

Webinar – Determining impact of elongate hemlock scale on potential host species

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A host study was conducted to determine if elongate hemlock scale (*Fiorinia externa*; EHS), an exotic pest present in the eastern US for over 100 years, could become a problem in native and ornamental conifers in Florida. Though the primary host of EHS is hemlock which is not found in Florida, eight other genera of conifers have also been reported as hosts. In 2012, the Florida Department of Agriculture first reported EHS entering the state on cut Fraser fir and active crawlers were observed. A host study was initiated in October 2017 to evaluate 13 conifers either native to Florida or grown by Florida Christmas tree choose and cut growers as compared to known hosts of hemlock, Fraser fir and blue spruce. Each plant was challenged with heavily infested Fraser fir branches on two dates representing natural crawler production and shipment of Christmas trees to Florida. After 50-weeks representing three generations of scale, plants were evaluated for growth and the total number of infested needles were counted. A sample of up to 20-infested needles was removed and evaluated under the microscope to determine scale life stage and percent mortality. The EHS successfully reproduced on eastern hemlock, Fraser fir, blue spruce and Deodar cedar over time. There was minimal reproduction on Virginia pine. However, EHS is not found on either Deodar cedar or Virginia pine in EHS-infested areas in North Carolina. The EHS settled and developed on several species that did not support continued reproduction. The Florida torreya, an endangered species, did support initial feeding but there was little to no reproduction. Loblolly pine, southern red cedar, spruce pine, sand pine, slash pine, arborvitae, Atlantic white cedar, Arizona cypress, Florida yew (also endangered) and Leyland cypress were not hosts under study conditions.

Established and emerging insect pests of Christmas tree plantations in Quebec: relative abundance and bases for efficient control based on IPM principles

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We briefly review work conducted in our group in the main region of Christmas tree production in Quebec to improve knowledge of common insect and mite pests, mainly on balsam fir planted as Christmas trees. Experimental and observational data on the balsam twig aphid (*Mindarus abietinus*) allowed to better understand its multi-generation, early season life cycle and predict short-them impact of climate change. New temperature-dependent models of overwintering egg development were parametrized for *M. abietinus* and for both the spruce spider mite (*Oligonychus ununguis*) and the pine needle scale (*Chiosnaspis pinifoliae*), a scale which needs to be monitored for the export market despite causing no apparent damage to Christmas trees. Studying overwintering conditions of the gall midge (*Paradiplosis tumifex*), which is second in importance as a Christmas pest, in relation to those of the associated gall midge inquiline (*Dasineura balsamicola)* indicated different overwintering ecological strategies, which should help to develop better grower practices for efficient control of the episodic gall midge.

Status of integrated pest management (IPM) in Norwegian Christmas trees

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As of June 2015, all professional plant growers in Norway who use pesticides are obliged to follow Intergrated Pest Management (IPM) strategies, regardless of crop. This includes Christmas trees. The Norwegian regulations for IPM follow the EU directive where eight principals are outlined; 1) prevention and suppression, 2) monitoring, 3) decision-making, 4) non-chemical methods, 5) pesticide selection, 6) reduced pesticide use, 7) anti-resistance strategies, 8) evaluation (Barzeman 2015). The intention of these principles is to use as little pesticides as possible, making the production more environmental friendly. An IPM-guidelines document has recently been published in Norwegian for Christmas tree growers (https://www.nibio.no/ipv-veileder), but according to the extension service, the IPM practices are not yet well implemented in Christmas tree fields. Many growers, however, are concerned about available, high quality nursery stock since healthy transplants are crucial for avoiding introduction of diseases. Our main focus, since our previous presentation of disease management practices in Norwegian Christmas trees at the CTREC in Norway, has therefore been on seed and nursery hygiene. The most used seed lots have been tested and surveys of nursery stock and production conditions have been carried out. Resulting data was used to generate a number of fact sheets aimed at benefitting nurseries (www.nibio.no/skogplanter).

References

Barzman M, Bàrberi P, Nicholas AEB, Boonekamp P, Dachbrodt-Saaydeh, Graf B, Hommel B, Jensen JE, Kiss J, Kudsk P, et al. 2015. Eight principles of integrated pest management. Agron. Sustain. Dev. DOI 10.1007/s13593-015-0327-9.

SESSION 4: PLANTATION MANAGEMENT, PRODUCTION TECHNOLOGY, OTHERS

Controlling coning in Fraser fir with plant growth regulators

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Early cone production of Fraser fir trees is a major concern for Christmas trees growers. Individual Fraser fir trees can produce hundreds of cones and growers have reported over 1,000 cones on large trees. Fir cones disintegrate in the fall leaving unsightly stalks that reduce the salability of trees. Presently, growers remove cones using picking crews, which is a major labor expense. In spring 2016, we installed field trials at four cooperating farms in Michigan (Allegan, Horton, Manton, and Sidney). Trees in each plantation were 1.0-1.7 m tall at the time of initial treatment application and therefore approaching the age when Fraser fir trees in Michigan typically begin to produce cones. At each farm, we applied treatments to six replicate 10-tree row plots (60 trees per treatment at each location). The treatments included three rates of soil-applied paclobutrazol, foliar applied paclobutrazol, and an untreated control. At the Allegan farm, which had the highest rate of coning, application of paclobutrazol reduced coning by up to 40% in 2018 and by 22% in 2019. At the remaining farms, paclobutrazol application reduced coning by an average of 60% in 2018 and 2019. In addition to reducing coning, paclobutrazol reduced shoot extension by 21% in 2017 and by 16% in 2018. Foliar nitrogen increased from 1.7% on the untreated control trees to 2.0% for trees treated with the high rate of paclobutrazol.

Strategies to increase noble fir seedling survival in Christmas tree plantations in Oregon

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With increasingly dry and hot summers in recent years, Oregon Christmas tree producers have experienced much higher mortality of newly planted noble fir seedlings at their plantations. Past data from trials indicates typical mortality to range between 10-15%, yet many growers have experienced much higher percentages and even complete crop losses. Irrigation is an expensive option for most growers, so other strategies are being investigated. In May of 2018, a trial was set up at a local plantation in the Willamette Valley to evaluate options to improve seedling survival. Three treatments were evaluated: Rootex dip, a root growth stimulator, MoistureLoc anti-transpirant sprays and the use of physical tree shades. At the conclusion of the trial in early October, the only effective treatment was the shading with an average mortality of 13%. The other treatments, including the untreated controls, had mortalities ranging from 28-32%.

A new trial was initiated spring 2019 at two Willamette Valley sites. Pre-plant treatments included: B-1 root dip, Solid Rain-a potassium polyacrylate product placed into the planting hole, Dynahume SW-a 10% humic acid/ 1% soluble potash crop enhancement product as a root dip, and Stomaboost Supreme 7-17-4 foliar fertilizer sprays and supplemental water applications. Post-plant treatments include: Shade and mulch treatments. Stomaboost Supreme sprays are scheduled to be applied at approximately 30 days after planting (early June) and the supplemental water treatments will be included later in the growing season. Soil moisture, air temperature and seedling health will be monitored throughout the growing season. Final mortality evaluations will be conducted in October after the first seasonal rains arrive.

Leader length control in Christmas trees using plant growth regulators

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Over the years, a number of plant growth regulator compounds have been tested and utilized with varying levels of success (and many failures) in controlling the length of true fir leaders in Christmas trees. Recently, a new plant growth regulator compound, S-Abscic acid, has been tested first in Denmark and recently in Germany/Austria on Nordmann fir. The compound tested was a 10% a.i. liquid typically sold under the name- ConShape
In 2018, tests with S-Abscic acid were initiated In Oregon utilizing a 20% a.i. granular formulation of a Valent product called ProTone. A species and rate trial,partially funded by Valent, tested rates from 25-200 gm/l on noble fir (*Abies procera*), Nordmann fir (*A. nordmanniana*) and Turkish fir (*A. bornmuelleriana*). Results were promising and showed a definite dose/response relationship and little damage, even at the high rates.

In 2019, a leader contrai trial will be initiated utilizing the 10 % a.i. liquid formulation sold in the US under a variety of product names. This trial,with funds from Valent, will again evaluate rates and include a time and motion component to evaluate per unit area costs.

Results of the 2018 trial will be summarized and preliminary observations from 2019 discussed.

Online courses and webinars for convenient, low-cost trainings

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Online courses and webinars provide easy-to-access, convenient, and cost-effective training options for growers. MSU Extension educators have hosted four Christmas tree winter webinar series and three non-credit online floriculture courses since 2015. For the webinar series, 694 people participated in webinars covering nutrient, disease, insect, and weed management topics. The participants were from 32 U.S. states (64 counties of Michigan) and 5 Canadian providences and represented at least 138,386 acres of Christmas tree and nursery production. The three courses in the Floriculture College of Knowledge Online Course Series provides basic training to commercial greenhouse growers. During a 3-month period, participants could access 4 hours of pre-recorded video, handouts, pre-test and final exam. To date, a total 589 participants from 37 states and 30 countries have taken the online courses. Participants in the webinar series and those who have taken the online courses reported significant improvements in knowledge on critical topics according to their self-assessment quizzes or short-term impact surveys. One year after the webinar series or course, participants received a long-term impact survey where they could report the changes in practices and the number of acres affected by the management change. For the webinar series from 2016 to 2018, 93% of survey respondents reported that they made changes to at least 8,314 acres of production (n=74). The online content has been successful in distributing information to wide audience of Christmas tree producers and is an important avenue for Extension in the 21st century.

SESSION 5: BREEDING & MOLECULAR BIOLOGY, POST-HARVEST TECHNOLOGIES

Webinar – Transcriptome analysis of North American firs provides insights into the molecular basis of postharvest needle abscission

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Postharvest needle abscission (PNA) is the separation of needles from the main body of the tree after harvest and one of the main challenges that real Christmas tree growers are facing to compete effectively in the market with artificial ones. Fraser fir (*Abies fraseri*), balsam fir (*Abies balsamea*), and Canaan fir (*Abies balsamea* var. *phanerolepis*) represent three of the main fir species used as Christmas trees in North America. While there is remarkable intra- and inter-specific variation in needle retention (NR) across cultivated firs, phenotypic data collected over several years allowed the identification of clones with consistent year-to-year NR phenotypes, suggesting a strong genetic component of the variation. We performed deep transcriptome sequencing of needle abscission zones (NAZs) from individuals representing extreme NR phenotypes. Our hypothesis was to test if molecular differences were detectable between good and poor NR phenotypes before PNA occurred, and if those differences were correlated to the process of abscission. Using a combination of phylogenetic and trait-based information, we uncovered several polymorphisms that could have predictive power for the identification of superior NR phenotypes. We built an abscission candidate gene database including regulatory genes experimentally validated in other plant species based on co-expression analyses and comparison to putative orthologs from Arabidopsis and non-model plants. Additionally, we developed a simple histological method that revealed the presence of a non-permeable suberized layer in the NAZ that is present before any sign of abscission occurred. Our results suggest novel hypotheses about candidate genes that regulate the molecular and cellular onset and progression of needle abscission and PNA in firs, and will guide further physiological and histological investigations, as well as breeding applications.

Elevation, harvest date, and cold storage – Effect on the postharvest quality of noble fir

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The Mt. St. Helens area of the Cascade Mountains of Washington State represents the geographic center of noble fir (*Abies procera*) bough production in the U.S. Pacific Northwest (PNW). Noble fir occurs naturally at high elevation sites and the major bough production region consists of public and private lands that were replanted with noble fir after the eruption of Mt. St. Helens in 1980. Because of the limited harvesting and replanting of noble fir in this region, the number of suitable high elevation stands of noble fir has been decreasing. During the past 10 years, there has been an increased conversion of former low elevation Christmas tree sites to bough production. In 2014, an estimated 45% of the noble fir boughs came from these sites. Although noble fir Christmas trees and boughs are known for their excellent keepabilty, some in the bough industry have been reluctant to harvest noble fir boughs from lower elevation former Christmas tree sites because of the perceived inferior quality and keepability of greenery products made from these boughs. Postharvest trials were conducted in November and December 2017 to examined the keepability of wreaths made from noble fir boughs that were collected from two high and two low elevation sites. Wreaths were made from boughs from five trees per site. Boughs were harvested early (October 5-10) and late (November 9-14) from the same trees at each site. We looked at the rate of moisture loss and quality of wreaths displayed at 20C and also held an event for "consumers" to rate their preferences in wreath color, needle orientation, and overall quality. The results suggest that for noble fir foliage, the elevation, harvest time, and time in cold storage do not affect wreath quality, and that consumers prefer wreaths with a darker blue-green color than lighter green.

SESSION 6: TREE PHYSIOLOGY, BREEDING & MOLECULAR BIOLOGY, OTHERS

Variation in post-harvest needle retention of Norway spruce (*Picea abies*) for Christmas trees in Norway - a pilot study from 2018

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Postharvest needle retention is an important characteristic for Christmas trees and it is a limiting trait for Norway spruce (*Picea abies*). Compared to several fir (*Abies*) species, Norway spruce Christmas trees have poorer needle retention, and this trait prevents early harvest and long shipping distances. Postharvest needle retention studies conducted on fir species has proven that needle retention is under strong genetic control. By selecting superior families, needle retention has been improved for fir Christmas trees. However, few studies have been conducted for Norway spruce. We aim to investigate the variation in needle retention for Norway spruce as it is one of the most important Christmas trees in Norway. We hypothesize that there are significant differences in needle retention within the most widely used Norwegian spruce Christmas tree seedlots. In this pilot study, 26 seedlots where tested. Branches where collected 15 November and 6 December 2018 from a field trial in Vestfold county. Tung branches from the lateral branches from the third uppermost whorl were used for the study. The branches were displayed indoors under controlled conditions and allowed to dry. The accumulated needle loss was measured on day 4, 6, 8, 11, and 13 using the same needle loss rating scale as Nielsen et al. (2005). The Tukey pairwise comparisons test displayed the biggest differences between seedlots after 8 days displayed dry. Needle loss ratings ranged from 2.25 – 4.67 (where 2= 1- 5% and 5= 34- 66% needle loss). There was a significant difference between seedlots. Despite only one test location, this pilot study indicates that it should be possible to select for improved needle retention characteristics. In 2019, this baseline data will be complemented with new data from the same field, plus two new fields further north.

Collecting Nordmann fir seed in the Republic of Georgia

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A US nationwide project to collect Nordmann fir seed in the Republic of Georgia was recently funded by the Christmas Tree Promotion Board. Gary Chastagner, Rick Bates, Chal Landgren and a number of Georgian conifer seed companies will be identifying seed tree collection candidates in late August, 2019.
This presentation will be a an overview of the project and will solicit future participants in establishing progeny test sites.

Identification of superior sources of Turkish and Trojan firs for the production of Christmas trees in the U.S. Pacific Northwest

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As part of the U.S. and Danish CoFirGE project, a series of industry and University-supported replicated genetic plantings of Turkish and Trojan fir were established in Connecticut, Michigan, North Carolina, Oregon, Pennsylvania, and Washington in 2013 to identify regionally adapted sources of these species that produce superior Christmas trees. The test planting in Washington contains approximately 3,500 trees that includes progeny from 55 Turkish firs (3 provenances) and 34 Trojan firs (2 provenances) from Turkey. Seedlings from proven Christmas tree sources of balsam, Fraser, grand, Korean, noble, Nordmann (3 provenances and 2 Danish seed orchards) and white fir were also planted. Based on height growth, structure, bud break and postharvest needle loss data collected during the past five years from the trees in the plot in Washington the following trends are evident. Amongst the Turkish and Trojan fir sources, the Trojan 'Kaz' source appears very promising. While not as fast growing, the Trojan 'Çan' appears to have excellent needle retention characteristics. Although commonly grown, the Nordmann fir 'Amb' and 'Bor' sources were slower growing than the other three sources of Nordmann fir. In addition to identifying the top performing sources of trees, another goal of the CoFirGE project is to utilize growth and postharvest needle retention characteristics to identify individual top performing trees that can be used to establish grafted clonal Turkish and/or Trojan fir seed orchards. Of the sources of Turkish and Trojan firs included in the CoFirGE trial the Trojan fir, especially the 'Kas' source tended to produce a higher percentage of top performing trees. To date, the 'Aky' and 'Kar' sources of Turkish fir have produced a higher percentage of top performing trees than the 'Bolu' source.

Abstracts – Posters presentations

Hillbilly Marriages: Height as an indicator of inbreeding depression in Fraser fir seedlings

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Forest tree populations generally exhibit high genetic variability, but also possess recessive deleterious genes within heterozygous populations. While patterns of relatedness among neighborhood populations occur naturally, conifers exhibit inbreeding depression including growth reduction if crossing among relatives happens, especially to the extreme of self-pollination (selfing). Conifer species such as *Picea, Pinus* and *Pseudotsuga* show lowered seed set and germination, lower survival and loss of vigor. A study of selfing in Noble fir (Sorensen, et al 1976) showed no effect on seed weight, germination and 3-year survival but showed a lowered seed set and 24% decrease in 3-year height. The depression of height increased by age 10 (Sorensen and Miles, 1982). Due to long-term consequences in advanced generations of tree improvement programs of crossings among related selections, a small study was initiated with controlled pollinations (CP) in a Fraser fir clone bank in Macon County North Carolina. Executed in 2005 and 2011, eight selections were self-pollinated in addition to the cross-pollinations. Open-pollinated (OP) cones of the selection were also collected. The resulting material was grown in a greenhouse at the NCSU Horticulture Field Lab and measured at age four for survival and height growth.

Mean observations for seven parent trees showed slower height growth of selfed families as compared to all control- and open- pollinated families. However, for one exceptional parent, the height of the selfed family exceeded the mean height of both the CP and OP families from the same selection. Five of the eight selfed families showed the most variability in heights, counter to the norm of increased uniformity among selfed trees. Material evaluated in the greenhouse was established in two progeny field trials in the mountains of NC and will be assessed for quality and measured throughout the eight year Christmas tree rotation.

Pre-bud break harvesting and cold storage of noble fir for use as Christmas trees in the southern hemisphere

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In the northern hemisphere, the current season growth on Christmas trees typically emerges 6 to 8 months prior to harvest. In addition, trees have been exposed to increasing colder temperatures and shorter day lengths prior to harvest, increasing needle retention on displayed trees. In the southern hemisphere there is a relatively short period between bud break and when Christmas trees need to be harvested and displayed for the holidays. This can limit conifers that can be used to species, such as Monterey pine, that break bud very early. Alternatively, trees can be grown in containers as living trees to reduce problems with wilting of new growth on species that break bud during late spring. During spring 2018, an experiment was conducted to determine the postharvest quality of displayed noble fir Christmas trees harvested before bud break and stored until they were displayed at a time corresponding to the Christmas holidays in the southern hemisphere. High elevation, open-grown noble fir trees were harvested on May 24th and stored in a cold room maintained at 1C with >85 relative humidity until June 19th, when 5 trees were displayed dry or with their freshly cut bases in water at 20C. Changes in the moisture status and quality of the trees were assessed until early July. The trees displayed in water rehydrated and had an average moisture content of 141.7% after 13 days, while the trees displayed without water dried out rapidly. The quality of trees displayed in water ranged from good (3) to excellent (5) and averaged 4.2, while the quality of trees displayed dry was unacceptable (rating 1.2). Minimal needle loss occurred on any of the trees during this trial. These results indicate that noble fir can be used in the southern hemisphere if harvested before budbreak and displayed in water.

Gray mold on conifer nursery stock in the U.S. Pacific Northwest

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Conifer nurseries in the Pacific Northwest annually produce more than 100 million seedlings for forest restoration, the production of Christmas trees and landscaping plant material. Nurseries fall into two broad groups, those that produce bareroot seedlings and producers of container stock. Container production, especially of species that are often used in the Christmas tree or landscape industries, has been increasing over the past 10 to 15 years, accounting for about half of the total production. Botrytis cinerea is considered to be the primary cause of gray mold on conifer nursery stock. Gray mold is a chronic disease problem, particularly in container produced seedlings, that despite up to 10 applications of fungicide per season continues to elude reliable control, resulting in crop losses of 5 to 50%. To improve Botrytis disease management programs, we are examining the diversity of Botrytis species associated with gray mold in conifer nurseries and determining the level of fungicide resistance in nursery populations of the pathogen. Based on sequence data, all of the isolates have been identified as *B. cinerea*. Isolates were screened in vitro for resistance to 7 fungicides by growing isolates on potato dextrose agar (PDA) amended with three rates of each fungicide (0.1, 1.0 and 10 ppm ai) to determine the concentration required to inhibit the growth of each isolate on PDA alone by 50% (EC50). There was very little difference in the sensitivity of the isolates from the different nurseries. Overall, all of the isolates were very sensitive to fludioxonil, while isolates varied in their sensitivity to fenhexamid, iprodione, boscalid, pyraclostrobin, cyprodinil, and thiophanate-methyl. Current trials are screening new reduced-risk fungicides and biopesticides for their effectiveness in controlling gray mold.

Detection of elongate hemlock scale on Fraser fir shipped into the Pacific Northwest

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The elongate hemlock scale (EHS, *Fiorinia externa*) is a potentially serious pest that is able to attack a number of conifer species. The principal hosts are hemlock, true firs and spruce. Other conifers, such as Douglas-fir are not preferred hosts and infestations are typically limited to areas where they are growing in close proximity to infested hemlocks. This pest is thought to have been introduced into the U.S. in the early 1900's and its current distribution is mostly limited to areas in the eastern U.S.. Except for an isolated area in Utah, EHS is not known to occur in the western U.S. EHS can occur on Fraser fir Christmas trees and has been intercepted on Fraser fir that are imported annually into Florida as cut Christmas trees. In 2018, Fraser firs originally from North Carolina were shipped through Oregon to California and a number of other western states. The California Department of Food and Agriculture found EHS on some of the trees that had been shipped to California and the Oregon Department of Agriculture (ODA) subsequently collected samples from the Fraser firs that had been shipped back to Oregon and confirmed CDFA's findings. The EHS was also detected on trace forward samples collected by the Washington State Department of Agriculture (WSDA) from some of the Fraser firs that had been shipped to retail outlets in Washington. Each of the regulatory agencies issued a stop sale notification and ordered the Fraser firs to be returned or destroyed. While there are questions about the ability of the life stages of EHS that are on Christmas trees to spread to other hosts, ODA and WSDA are considering taking steps to reduce the potential importation of this pest on host material, such as pre-notification of Christmas tree imports, inspection of out-of-state Christmas trees, and/or phytosanitary certification from state of origin.

Soil incorporation of sulfur reduced losses of Christmas tree transplants in a field infested with *Phytophthora* spp.

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High rainfall events, poorly-draining soil, and susceptible fir trees lead to heightened risk of losses from phytophthora root rot, caused by several species. A field trial planted in 2010 investigated the growth of exotic firs at a cooperating farm site where there had previously been losses consistent with the presence of phytophthora root rot. By October of 2013, all 60 Fraser firs planted at this site had died, whereas there were few losses among the 660 Turkish, Nordmann, or Trojan firs, suggesting that this field was unusually evenly infested with *Phytophthora* spp. inoculum. During May of 2014, the trees were removed, including main roots uprooted with the trunks, so that the field could be repurposed for additional experiments to study interactions between species planted (Canaan vs. Fraser fir), soil pH, and root dips at the time of planting for protecting bare-root transplants from disease. Sulfur was added to main plots at a rate of 3,000 kg/Ha and incorporated with a rototiller in June, 2014. The field was planted in mid-April, 2015, with 644 trees randomized in a split-split plot design. Reducing the soil pH markedly improved the color of both species of trees during the year of planting; in the year after planting those in the sulfur amended, low pH plots had terminal leader growth twice that of the higher pH plots. Use of insecticides to elicit the systemic acquired resistance pathways did not provide benefit, but the root dip with potassium phosphite did benefit the Fraser firs. Over the course of four years after planting trees, 64% of Fraser firs had died from root rot. Planting Canaan fir and lowering the soil pH from 6 to 4 reduced losses by 91%. Lowering soil pH significantly reduces losses due to phytophthora root rot.

Fungicide timing and products for efficient management of Swiss needlecast (*Phaeocryptopus gäumannii*) on Douglas-fir (*Pseudotsuga menziesii*)

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Douglas-firs are an important part of Northeast US Christmas tree production and are desired among conifers due to high resistance to deer herbivory. Unfortunately, needlecast diseases can devastate Douglas-fir plantings which lead many Northeastern US Christmas tree growers to treat with several times each spring with fungicide sprays. However, through new on-farm research we're finding that Douglas-firs can be grown with as few as one or two sprays a season and possibly with fungicides that have lower environmental impacts. We're finding that the timing of the sprays and thoroughness of coverage are key factors in the success of the reduced spray regime. With reduced frequency of sprays Douglas-firs can remain a viable option for producers and contribute to diversity among the evergreen plantings that are important for a robust industry.

Commercialization of somatic embryogenesis for the large scale production of superior Balsam fir clones

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Superior *Abies balsamea* trees were developed through a multi-year Christmas tree enhancement project initiated in Nova Scotia. Parental lines identified and selected for needle retention, fullness of shape, fragrance and growth habit had embryonic tissue clones prepared for mass multiplication by embryogenesis.

2017 saw Phytocultures initiate its commercialization methods to mass propagate the superior Balsam fir clones via a solid media culture system utilizing somatic embryogenesis (SE).

Commercialization challenges quickly became evident as scaling-up existing protocols resulted in highly variable embryo yields. Starting in 2018, techniques developed by Dr. Pramod Gupta were incorporated within Phytocultures' scale-up efforts. New media formulations at all stages were introduced according to Dr. Gupta's suggestions and in-house findings.

Embryo maturation, a critical step for the successful implementation of SE, is the process through which embryogenic cell masses become somatic embryos. The objective of this study was to test eight different maturation media formulations for their effect on *Abies balsamea* embryo yield. Formulations included different combinations and concentrations of carbohydrates, activated charcoal, osmotic stressors and abscisic acid (ABA) – components often used to trigger the maturation process.

Embryo yield means by media type varied from zero (media type A) to 48.87 embryos per plate (media type I). Overall, these tests demonstrated that altering the concentration and/or type of sugar, concentration of activated charcoal, concentration of osmotic stressors and concentration of ABA in maturation media had significant effects on embryo yields from Balsam fir embryogenic callus.

Starting with initiated embryogenic callus, through to maturated embryos and germinants, viable emblings are successfully being produced for soil acclimatization. As Phytocultures refines its tree propagation programs through somatic embryogenesis, ever increasing embling production numbers will serve to place the region in a leading position with superior Christmas tree products.

Evolution of intervention strategies against the balsam twig aphid (*Mindarus abietinus* Koch) following the withdrawal of diazinon

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The balsam twig aphid (*Mindarus abietinus* Koch) is the main insect pest of Quebec Christmas tree plantations. With the withdrawal of Diazinon, which was the main insecticide used, producers and consultants were concerned about the effectiveness of alternative insecticides. In 2016 and 2017, seven insecticides (imidacloprid, thiamethoxam, pymetrozine, dimethoate, potassium salt of fatty acid, acetamiprid and malathion) were evaluated, compared to Diazinon and a control, with the objective of promoting safer insecticides.

Two Christmas tree plantations were selected based on the percentage of infested shoots in two regions of Quebec. Insecticides were evaluated with a cannon airblast sprayer and a horizontal sprayer. Two evaluations were conducted, one before treatment and one post-treatment. In each of the plots, 10 trees were selected (at least 10% of the shoots with at least one aphid) and identified.

Unfortunately, as a result of this test, the lower risk insecticides on health and the environment were less effective than the two more damaging ones, dimethoate and malathion, with both sprayers. In addition, the performance of cannon-sprayed insecticides was lower for all insecticides in the trial due to poorer foliage coverage. However, when the population is slightly above the intervention threshold, the use of low-risk insecticides could be used. Indeed, they reduce the aphid population, but not enough to control large populations.

In 2018, we used water sensitive paper to visualize the coverage at different application rates (150, 300 and 600 L/ha), sprayer distances (1st, 4th, 8th, 13th, 17th tree) and location in the tree (top, middle and bottom). Spraying on the two sides of plantation block is now obligatory, which wasn't the case with Diazinon.

To offer more choices to Quebec producers, a new insecticide (flupyradifurone) is being tested in 2019 and 2020. The results look promising for this active ingredient.

Evaluation of Fraser fir cone production control methods

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The production of Fraser fir (*Abies fraseri*) is gaining momentum in Quebec (Canada). This species is more susceptible than the balsam fir (*A. balsamea*) to seed overproduction. The current practice of removing cones manually is considerably expensive. With the aim of finding a solution to this problem, a project was set up in 2016 to test two approaches to control cones chemically in Abies fraseri plantations in Quebec. The first approach consisted of attempting to inhibit the formation of female flowers (cones) and promote the development of vegetative buds by using growth regulator the first year of the cycle. Four growth regulators (Apogee, MaxCell, Fruitone and Bonzi) applied at the initiation or at the end of bud differentiation by foliar spraying or by trunk injection was tested. Compared to the control, none of the products, regardless of the timing or method of application, significantly reduced the number of cones on the trees in the two years following the treatment (2017-2018).

The second approach tested consisted of destroying the cones at the very beginning of their development in the spring of the second year of the cycle. Eight treatments (Water Control, Sulfur Lime, Ethrel, Ag-Surf, Finalsan Pro, LeafShield, citrus solvent, Fruitone) that were applied at the beginning of the development of the cones, before the bud burst, was tested. Finalsan Pro (ammonium soaps of fatty acids) has been the most effective product for rapidly stopping cone development, up to 100% on some trees. However, the results were variables depending of the coverage, the atrophic cones remained attached to the trees and the product caused phytotoxicity on the trees at one of the two test sites. For the moment, the results obtained in Quebec environmental settings do not allow to issue recommendations to Quebec Fraser fir growers as to inhibit the development of cones or to abort them without phytotoxicity. Further work is needed to develop the method, including the timing, the method, the volume and the rate of application.

Update: Fraser fir cone control research in NC

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After seven years of Fraser fir cone control research in NC, efforts have narrowed to using chemical pruning agents to kill tender emerged cones in the spring. Of more than twenty products tested, herbicidal soaps (fatty acid/alcohols) seemed to be the most effective at killing immature cones. Killed immature cones shrink as they dry to become small persistent brown cones. Additional rate and sprayer application work has been conducted with two organic herbicides, Axxe (ammoniated pelargonic salts) and Scythe (a fatty acid) over the last two years. Initial testing was conducted using manual backpack sprayers. Recent rate and timing studies have been conducted with high pressure hose sprayers. Both herbicides have the potential to injure new growth. Used at the right time – after all cones have broken bud, but before any foliage buds break, even the highest rates of Axxe were used safely. In NC, applications of Scythe have been prone to varying degrees of foliage injury particularly with the onset of foliage bud break. Evaluation of 2019 cone control studies should provide information needed to finalize treatment recommendations.

Is wounding by removal of lower branches an entry point for *Neo-nectria neomacrospora* on fir Christmas trees?

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Part of the management in Christmas tree fields, is removal of lower branches to improve the air flow and thereby reduce the disease pressure. A "handle" on the trees also makes the harvesting easier. In scars left by such trimming, we have occasionally observed attack by the fungus *Neonectria neomacrospora*, a devastating pathogen on many fir (*Abies*) species. To study this problem, and potentially find the best time of the year to carry out this operation, an inoculation trial with N. neomacrospora was initiated on subalpine fir (*A. lasiocarpa* provenance Upper Fraser) planted in Norway in 2008. Monthly throughout the year of 2015, six lower branches were cut on eighteen trees (3 blocks x 6 trees/block), leaving branch stumps of approximately five cm. Hereof, three of the stumps per tree were inoculated with a *N. neomacrospora* mycelium plug and covered with parafilm, and three were kept as control. Few or none visible symptoms developed and the experiment was terminated in the winter 2018/1019. The section from each tree containing the six branch stumps were carefully examined in the laboratory by removing the bark with a knife. *Neonectria neomacrospora* was reisolated from infected tissue. No *N. neomacrospora* grew from the controls. Stem diameter, branch stump diameter and longitudinally and latitudinally lesion length under the bark (LLUB) were measured using a caliper. The average LLUB was 1.5 x 1.5 cm (including the branch stump) and 0.9 x 0.8 cm for the inoculated and the control branch stumps, respectively. A slow disease development was evident. This is not in line with other inoculation experiments which resulted in a rapid disease development and plant death of younger plants. Some subalpine fir seed sources are known to be relatively resistant against *N. neomacrospora*, which may be the case for Upper Fraser.

Fungal diseases on spruce seedlings in Norway

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In several projects during the last two decades, we have studied fungal pathogens on conifer seedlings. In addition to analysing plant and soil samples, we have screened forest nurseries for fungi by placing open agar plates (PDA) in the indoor production facilities (e.g. greenhouses) and by transferring fungi to PDA after swiping surfaces with sterile cotton-swabs. Here we present the most problematic fungal diseases on spruce seedlings: grey mould (*Botrytis* spp.), Brunchorstia dieback (*Gremmeniella abietina*), Phomopsis canker (*Phomopsis* spp.), Sirococcus blight (*Sirococcus conigenus*) and cherry/spruce rust (*Thekopsora areolata*). Grey mould is a serious disease on spruce seedlings, especially in dense cultivations and during cold storage. Recently, fungicide resistance has has also become a problem. Serious outbreaks of Brunchorstia dieback is rather unusual, the last big outbreak occurring in Norway in 2001. However, moderate damage from this fungus is found regularly in nurseries, especially those surrounded by older conifer trees. Sirococcus blight is often a seed-borne disease and results in death of germinating seeds or seedlings. High levels of damage caused by *S. conigenus* were observed recently in several Norwegian forest nurseries on seedlings produced from seed lots harvested in 2015. *Thekopsora areolata* causes malformation of new shoots of Norway spruce. This rust fungus may also destroy cones and therefore seed production. Removal of its alternate host, bird cherry (*Prunus padus*), is the best management strategy. It is worth noting that all these fungi causealso become a problem. Serious outbreaks of *Brunchorstia* dieback is rather unusual, the last big outbreak occurring in Norway in 2001. However, moderate damage from this fungus is found regularly in nurseries, especially those surrounded by older conifer trees. Sirococcus blight is often a seed-borne disease and results in death of germinating seeds or seedlings. High levels of damage caused by *S. conigenus* were observed recently in several Norwegian forest nurseries on seedlings produced from seed lots harvested in 2015. *Thekopsora areolata* causes malformation of new shoots of Norway spruce. This rust fungus may also destroy cones and therefore seed production. Removal of its alternate host, bird cherry (*Prunus padus*), is the best management strategy. It is worth noting that all these fungi cause shoot and stem diseases. Currently, no soil-borne pathogens, such as species in the genera *Phytophthora, Pythium, Cylindrocladium, Rhizoctonia* and *Fusarium,* are problematic in Norwegian forest nurseries. This is attributed to container production that is lifted above ground.

Effect of ConShape on growth of top leader of *Abies nordmanniana* Christmas trees

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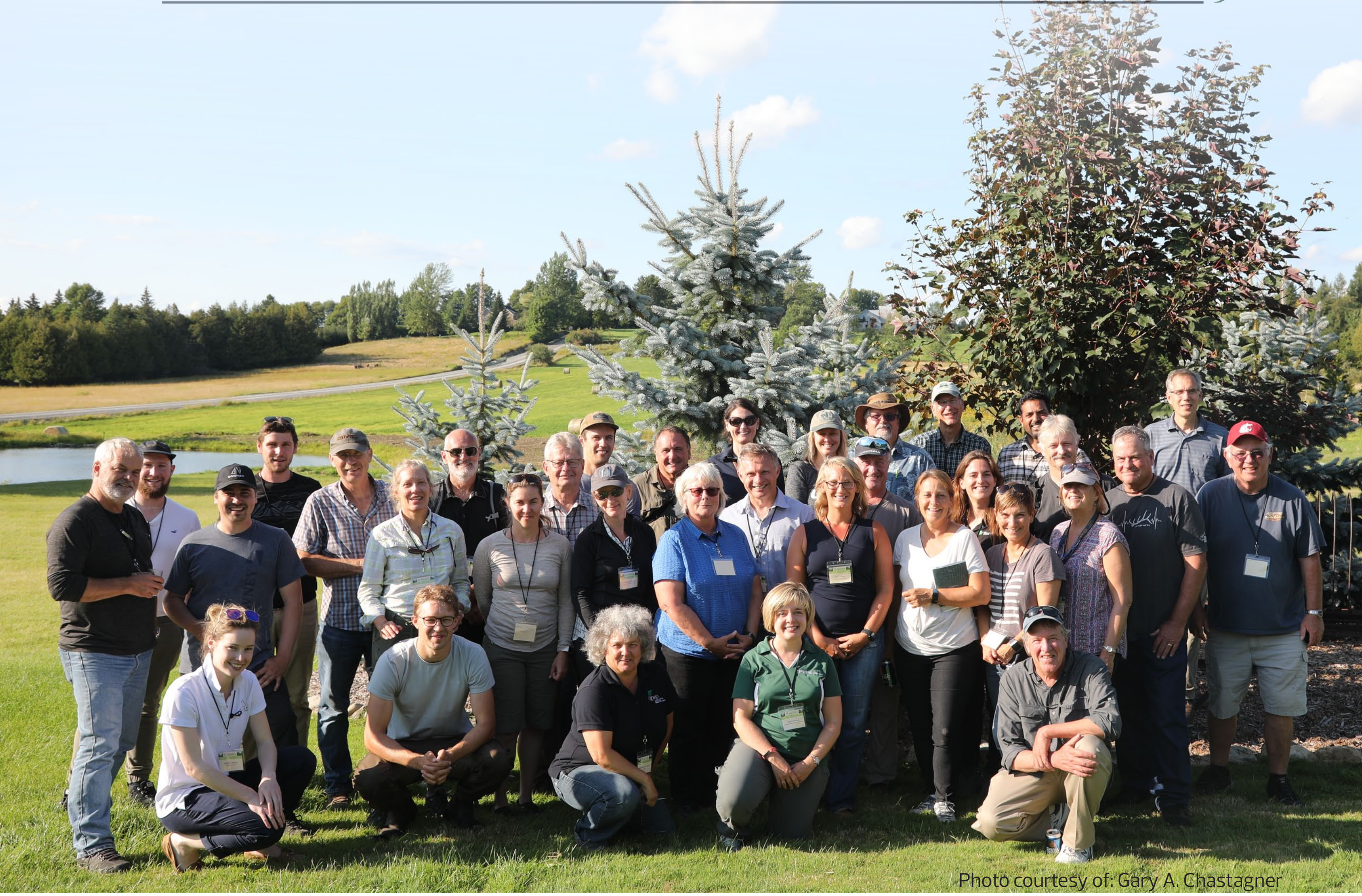
Regulation of growth of top leader of Nordmann fir (*Abies nordmanniana*) is necessary in Germany to harvest Christmas Trees of good quality. For this purpose, German growers currently have three growth regulators at their disposal or the use of Top-Stop pliers. In growing, warm and humid years, however, the effects of these methods are often inadequate. In some cases there may also be intolerance and symptoms of phytotoxicity on treated plants. For this reason German growers want a more effective and for plants more compatible means to control the growth of terminal shoots. ConShape (active ingredient: s-Abscisic acid, 100 g/l) is a possible new growth regulator to control the top leader for which Sumitomo Europe Agro Chemicals S.A.S is seeking registration also in Germany. GEP certified experimental station of Landwirtschaftskammer Schleswig-Holstein, Dept. Horticulture, has carried out over two years trials with ConShape, whereby here the result of one trial is reported, which is representative for the results of the other trials.

The results shown her indicate a clear dose-effect relationship between the application rate of ConShape and the length of the top leader. The number of plants in quality level A (very good) increased with the application rate of ConShape.



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