XV International Symposium on Plant Bioregulators in Fruit Production

June 23-26, 2025

ISHS
International Society for Horticultural Science

WELCOME TO THE SYMPOSIUM

A Letter from the Convener

Welcome to Chicago and the XV International symposium on plant bioregulators in fruit production!

We are grateful for your arrival, presence, and scientific contributions. We look forward to the continued impassioned exchange of this thriving and longstanding ISHS group and we acknowledge our colleagues around the world who have hosted the preceding plant bioregulator congresses:

- Riva del Garda, Trento, Italy (Virtual), 2022
- Chiba, Japan, 2017
- Orlando, FL, USA, 2013
- Bologna, Italy, 2009
- Saltillo, Mexico, 2005
- Seoul, South Korea, 2001
- Valencia, Spain, 1997
- Kyoto, Japan, 1994 (XXIV IHC)
- Penticton, Canada, 1988
- Bologna-Rimini, Italy, 1985
- Hamburg, Germany, 1982 (XXI IHC)
- Ithaca, NY, USA, 1981
- Skierniewice, Poland, 1977
- St. Paul, Minnesota, USA & Long Ashton, Bristol, UK, 1972

We are delighted to continue the tradition of creating a stimulating academic agenda accentuated by rich cultural, culinary and historical offerings of downtown Chicago. With representation from six of the seven continents, we stand to gain invaluable insights that will enrich our human connections and promote unity, as we strive to make positive and enduring contributions toward the production of sustainable food.

We would like to thank our sponsors for their generous financial support and the efforts of Michigan State University's Betsy Braid and her staff for help planning and executing our vision for this congress. We hope that the shared experiences over the ensuing week enhance your professional and personal growth. If there is anything we can do to improve your experience, please ask.

Sincerely,

Todd Einhorn, Convener; on behalf of co-Conveners, Randy Beaudry, Steve McArtney, and Pete Petracek

SYMPOSIUM AGENDA

Unless otherwise noted, events take place in the Avenue Ballroom

Sunday, June 22

7:30 p.m.— 8:30 p.m.	Registration Opens Sponsor Display Setup Poster Setup	Avenue Ballroom Lobby

Monday, June 23

7:00 a.m.	Registration Opens	Avenue Ballroom Lobby
8:00 a.m.	**Welcome**	
8:30 a.m.	**Keynote: Martin John Bukovac: Career and Concepts** *Petracek, P.*	
9:10 a.m.	**Studies on Octylphenoxy Surfactants: XII. Effect of Surfactant Concentration on Foliar Penetration of NAA Into Cowpea Leaves** *Shafer, W.*	
9:30 a.m.	**Ethylene Evolution From Plant Bioregulators Is Differentially Affected by Ambient CO2** *Larson, J.*	
9:50 a.m.	Break	
10:10 a.m.	**Keynote: Perspectives on Apple Crop Load Management** *Kon, T.*	
10:40 a.m.	**Review of Crop load Management in Apples with PGR's under American Northeast and Spain Conditions-Part 1, Flowering** *Gonzalez Nieto, L.*	
11:00 a.m.	**Review of Crop Load Management in Apples with PGR's under American Northeast and Spain Conditions-Part 2, Fruitlets** *Gonzalez Nieto, L.*	
11:20 a.m.	**The Need to Selective, Individual Apple Tree Adapted Fruit Thinning and Return Bloom Spraying Program** *Stopar, M.*	
11:40 a.m.	**A Sustainable, Non-Chemical Thinning Method for US Midwestern Apple Producers: Novel Use of Anti-Hail, Insect-Exclusion Netting** *Elsysy, M.*	
12:00 p.m.	Break for Lunch *(Lunch on your own)*	
1:30 p.m.	**Developing Agronomic Strategies That Reduce Biennial Bearing in Apple** *Campbell, T.*	
1:50 p.m.	**Using Ethephon, ACC, and NAA to Improve Return Bloom of 'Honeycrisp' Apples in Western New York** *Lawrence, B.*	
2:10 p.m.	**Induction of a Carbohydrate Deficit to Improve Efficacy of a Post-Bloom Thinner Application** *Larson, J.*	
2:30 p.m.	**Monitoring Abscission and Thinning Efficacy With a Fruit Set Prediction Model From Distributions of Apple Fruitlet Mass** *Hillmann, L.*	

SYMPOSIUM AGENDA

Unless otherwise noted, events take place in the Avenue Ballroom

Monday, June 23 (cont.)	
2:50 p.m.	**Linking Carbohydrate Status of Apple Fruitlets to Their Sink Strength: Implications for Fruit Set Prediction and Thinning Models** *Hillmann, L.*
3:10 p.m.	**A Comprehensive Overview of Thinning of Peaches With ACC** *Evans, M.*
3:30 p.m.	Break
3:50 p.m.	**Differences in Temperature-Dependency of the Conversion of 1-Aminocyclopropane-1-Carboxylic Acid (ACC) or Ethephon to Ethylene in Peach and Apple Leaves** *Sopcak, B.*
4:10 p.m.	**Thinning Efficacy of 1-Aminocyclopropane-1-Carboxylic Acid (ACC) in Sweet Cherry** *Beyá, V.*
4:30 p.m.	**Reduction of Labor in Thinning 'PS 10711' Peach Using Different Chemical Thinners** *Fagundes, E.*
4:50 p.m.	**Uptake of 1-Aminocyclopropane-1-Carboxylic Acid (ACC) When Used as a Peach and Apple Chemical Thinner** *Racsko, J.*
5:10 p.m.	**1-Aminocyclopropane-1-Carboxylic Acid (ACC) Is an Effective Late Thinning Agent in Apple Trees Without Compromising Future Plant Development** *Lopes Ferraz, A.*
5:30 p.m.	**The Influence of 1-Aminocyclopropane-1-Carboxylic Acid (ACC) on Thinning of Apples and Stone Fruits in the Intermountain West Region of the USA** *Fallahi, E.*
5:50 p.m.	**Day 1 Closing Comments**
7:00 p.m. - 9:00 p.m.	**Welcome Reception** *featuring MSU Professors of Jazz*

THE PROFESSORS OF JAZZ

The Professors of Jazz from Michigan State University, one of the most elite performing and educating jazz faculty groups in the United States. These nationally and internationally acclaimed musicians bring a level of collaboration and innovation that promises an unforgettable evening of world-class jazz.

Unless otherwise noted, events take place in the Avenue Ballroom

Tuesday, June 24

8:00 a.m.	**Welcome**
8:05 a.m.	**Keynote: Balancing Growth and Defense Phytohormones for Optimal Productivity of Citrus** *Vashisth, T.*
8:35 a.m.	**Rehabilitation of Huanglongbing-Affected Sweet Oranges With Use of Methyl Salicylate and Gibberellic Acid** *Kaur, G.*
8:55 a.m.	**Early Gibberellic Acid Applications to Improve Canopy Health and Fruit Production in HLB-Affected 'Valencia' Sweet Oranges** *Postillos Flores, M.*
9:15 a.m.	**Ethephon and Gibberellin-Based Growth Regulators as Alternatives to Manual Deblossoming in Blueberries** *Jayasinghege, C.*
9:35 a.m.	**Suppression of Flower Bud Development in Newly Established Blueberry Plants** *Qiang Yang, W.*
9:55 a.m.	**Sequential Applications of Plant Growth Regulators, Ring Barking, and Ring Incision in the Early Development of Apple Trees in Southern Brazil** *Soldatelli Paim, L.*
10:15 a.m.	Break
10:35 a.m.	**Keynote: Programmable Plants: Engineering Living Sensors and Inducible Traits** *Cutler, S.*
11:05 a.m.	**Integrating Developmental Genetics Into the PGR Pipeline** *Hollender, C.*
11:25 a.m.	**Effect of Salicylic Acid Applications in Summer Stress Tolerance in Sweet Cherries** *Maldonado, F.*
11:45 p.m.	**Using Acibenzolar-S-Methyl to Reduce Flood Stress in Apple Trees** *Muñoz, M.*
12:05 p.m.	Break for Lunch *(Lunch on your own)*
1:35 p.m.	**Keynote: Molecular Mechanisms Underlying the Regulation of Dormancy by Phytohormones in Fruit Trees** *Teng, Y.*
2:05 p.m.	**Carbohydrate Dynamics and Dormancy Regulation in Peach: A Whole-Tree Perspective** *Jahed, K.*
2:25 p.m.	**Biochemical Changes and Lethal Temperature Limits of Apple Floral Buds Throughout Dormancy** *Sapkota, S.*
2:45 p.m.	**Horticultural Oil and Dormex® Affect Bloom Time and Yield in Pistachios by Changing Metabolite Levels** *Brar, G.*
3:05 p.m.	**Chemical Induction of Budbreak in Apple Trees With Combinations of Compound Classes, Timing, and Application Frequencies** *Soldatelli Paim, L.*

Tuesday, June 24 (cont.)	
3:25 p.m.	**Control of Apple Trees' Vegetative Growth in Mild Winter Climate Regions** *Fagundes, E.*
3:45 p.m.	Break
4:05 p.m.	**Poster Session *(Five-minute, lightning round poster presentations)*** • Calcium in Fruit Trees: Using X-Ray Fluorescence Scanning as a Rapid and Quantitative Analysis of Leaf Calcium, *Beaudry, R.* • A Sustainable Strategy Using Limited N Doses and a Biostimulant That Improve the Valorization of Purple Cauliflower By-Products, *Collado-González, G.* • The Effects of Exogenous Melatonin on Pepper Plants Submitted to Heat Shock and Different Irrigation Strategies, *Otálora Alcón, G.* • Evaluation of Metamitron as a Post-bloom Thinner for Apple and Pear, *Elsysy, M.* • Fruit Thinning of Date Palms Using Plant Bioregulators, *Wright, G.*
4:35 p.m.	**Closing Remarks**
6:00 p.m. - 8:30 p.m.	**Gala Dinner**

VALENT BIOSCIENCES

Valent BioSciences is a global leader in the development and commercialization of biorational products, specializing in sustainable solutions for agriculture, public health, and forest health. Headquartered in Libertyville, Illinois, the company operates the Melnik and Shafer Biorational Research Center, a state-of-the-art facility that opened in 2018. This center houses over 90,000 square feet of laboratory and greenhouse space, fostering innovation in plant science, microbiology, and formulation technology . In 2024, Valent expanded its research capabilities with the addition of the Venburg Wing, named in honor of Dr. Greg Venburg, Senior Director of Global Research, to accommodate growing business needs and enhance collaborative efforts.

SYMPOSIUM AGENDA

Wednesday, June 25	
7:15 a.m.	**Load Buses**
7:30 a.m.	**Depart**
9:00 a.m.	**Arrive to Valent BioSciences**
11:30 a.m.	**Board Buses** **Lunch on the Bus**
12:30 p.m.	**Arrive to Chicago Botanic Garden**
3:30 p.m.	**Depart for River Tour**
4:30 p.m.	**Arrive to River Boat Tour**
5:00 p.m.	**Architecture River Tour**
6:30 p.m.	**Tour Concludes**
6:45 p.m.	**Participants Return to Intercontinental Hotel** *Participants will walk approximately 0.5 miles from the boat back to the hotel*
7:00 p.m. – 8:30 p.m.	**Keynote Speaker Dinner**

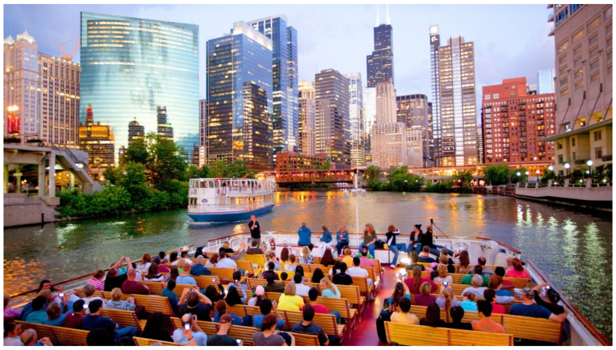
WEDNESDAY TOUR HIGHLIGHTS

CHICAGO BOTANIC GARDEN

The Chicago Botanic Garden, located in Glencoe, Illinois, is a 385-acre living museum featuring 27 display gardens, four natural areas, and over 2.5 million plants. Opened in 1972, it spans nine islands connected by bridges and is a hub for conservation research through its Plant Science Center. The Garden offers year-round events like the Orchid Show and Lightscape, attracting over a million visitors annually.

RIVER ARCHITECTURE TOUR

The Chicago River Architecture Tour is a 75-minute boat cruise that showcases over 40 of the city's most iconic buildings, including the Tribune Tower and Marina City. Guided by expert narrators, the tour offers stunning views and fascinating insights into Chicago's architectural history and skyline.



SYMPOSIUM AGENDA

Unless otherwise noted, events take place in the Avenue Ballroom

Thursday, June 26

8:00 a.m.	**Welcome**
8:05 a.m.	**Keynote: Current Status of Jasmonates in Fruit Production, Enhancing Fruit Quality and Storage Life: Preharvest and Postharvest Applications** *Singh, Z.*
8:35 a.m.	**Role of Endogenously Produced Ethylene in Highbush Blueberry (Vaccinium corymbosum) Fruit Ripening** *Ponce, C.*
8:55 a.m.	**A Meta-Analysis and Systematic Review of Plant Growth Regulator Use in Blueberry Production** *Vander Weide, J.*
9:15 a.m.	**ISHS Business Meeting**
10:15 a.m.	Break
10:35 a.m.	**NAA and ABA Consistently Reduce Bitter Pit Severity in 'Honeycrisp' Apple Fruit** *Griffith, C.*
10:55 a.m.	**Effects and Interactions of Aminoethoxyvinylglycine and Acibenzolar-S-Methyl on Stem-End Splitting and Glomerella Leaf Spot on Apple** *Clavet, C.*
11:15 a.m.	**Effect of Different Spray Strategies of 1-Aminoethoxyvinylglycine on Pre-harvest Fruit Drop and Fruit Quality of Apples** *Carra, B.*
11:35 a.m.	**Optimizing Fruit Size, Quality, and Profitability of Pears With Preharvest Application of Avg** *Beyá, V.*
11:55 a.m.	**Preharvest Plant Growth Regulator Effects on Flesh Firmness of Stored Apple Fruit** *Watkins, C.*
12:15 p.m.	Break for Lunch *(Lunch on your own)*
1:45 p.m.	**Keynote: Enhancing Fruit Shelf Life and Quality: From Ripening Fundamentals to Postharvest Fruit Excellence** *El-Sharkawy, I.*
2:15 p.m.	**ReTain and Harvista Effects on Maturity and Interactions With Postharvest 1-MCP on Storage Quality of 'Honeycrisp' Apples** *Watkins, C.*
2:35 p.m.	**Early Application of Ethephon, ACC, Dichlorprop-P and Trichlopyr Acid to Enhance the Red Coloration of 'Brookfield Gala' Apples** *Torres Lezcano, E.*
2:55 p.m.	**ACC for Red Colour Improvement of Bi-Colour Apples** *Truter, W.*
3:15 p.m.	**The Effect of 1-Aminocyclopropane-1-Carboxylic Acid (ACC) on Color Development in Apple Fruit** *Racsko, J.*
3:35 p.m.	Break
3:55 p.m.	**Effect of Near-Infrared Light Irradiation on Maintaining Freshness of Post-harvest Fruits and Vegetables After Refrigeration and Transportation** *Hada, A.*

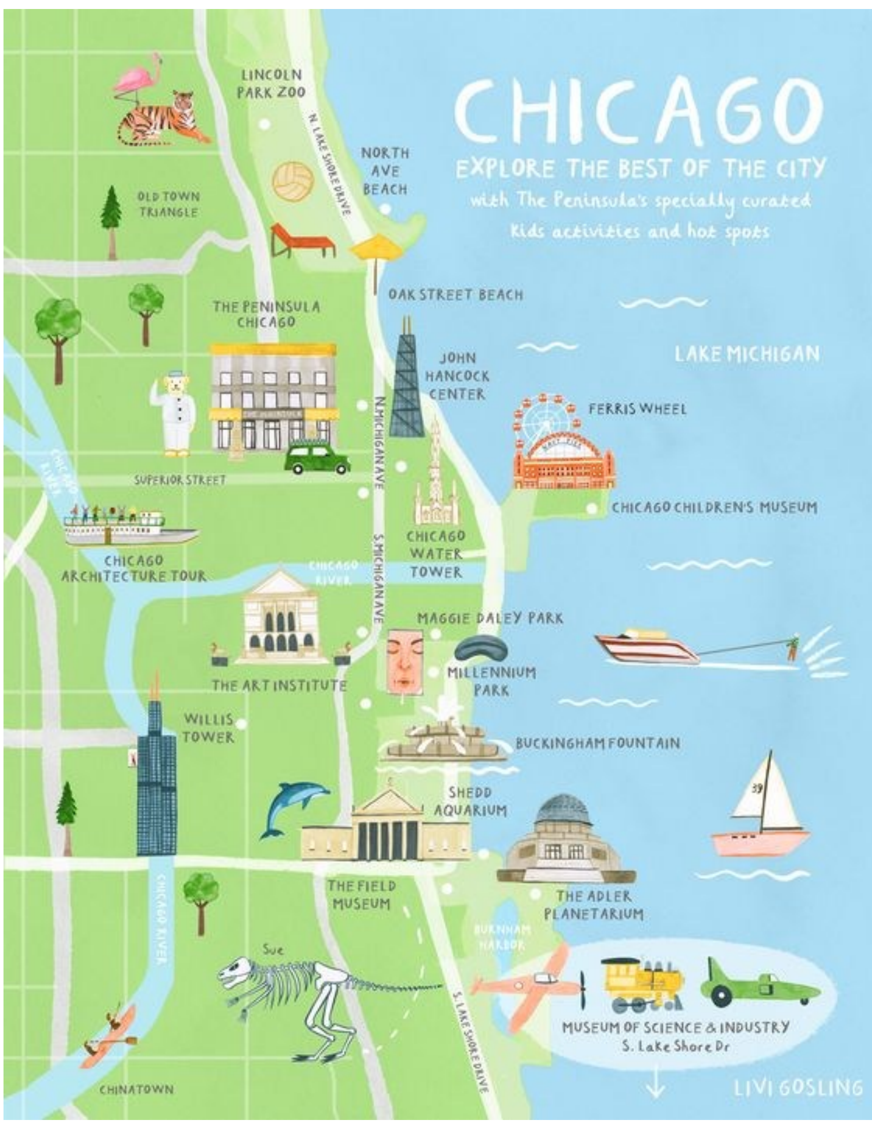
SYMPOSIUM AGENDA

Unless otherwise noted, events take place in the Avenue Ballroom

Thursday, June 26 (cont.)

4:15 p.m.	**Preharvest and Postharvest Applications of Hexanal: A Promising Approach to Enhance Fruit Quality and Extend Shelf Life** *Oz, A.*
4:35 p.m.	**1-MCP Dose-Response in Apples: Effective Doses Can Be Applied in Minutes or at Concentrations Below the Limits of Detectability** *Sugimoto, N.*
4:55 p.m.	**Factors Affecting the Release and Delivery of 1-MCP** *Beaudry, R.*
5:15 p.m.	**Closing Remarks**

CHICAGO HIGHLIGHTS & TRANSIT



Scan the QR Code Below to Access the Chicago Visitors Guide!

The **2025 Chicago Visitors Guide** is a comprehensive and vibrant resource showcasing the many attractions, cultural highlights, and logistical essentials for exploring the city. It highlights Chicago's world-class architecture, renowned theatre scene, and diverse neighborhoods, each rich in history and unique experiences—from Uptown's jazz heritage to Pilsen's colorful murals and Puerto Rican pride in Humboldt Park.

In terms of **transportation**, the guide outlines how to get around the city with ease, especially from page 62, detailing CTA trains and buses, bike and scooter rentals, rideshares, and water taxis. Notably, it mentions the **Route 66 origin marker** at Michigan Avenue and Adams Street—celebrating the start of the historic highway—and references the architectural significance of nearby landmarks like the **Tribune Tower**.

8:30 a.m.

KEYNOTE: Martin John Bukovac: Career and Concepts

Peter Petracek

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Dr. Martin John Bukovac, University Distinguished Professor Emeritus in the Horticulture Department at Michigan State University (MSU), died Sunday January 5 2025 in East Lansing, Michigan. John was born in the rough coal-mining town of Johnson City in southern Illinois on November 12, 1929. His family moved to a fruit and vegetable farm near Paw Paw, Michigan when he was 10 years old. John went on to earn his BS, MS, and PhD in Horticulture from MSU. During the Cold War, John served as a US Army tank unit commander along the West/East German border. John noted that his military training was essential to the development of his approach to research and communication: organized, focused, and direct.

John joined the Horticulture Department faculty at MSU in 1957. Over the next 40 years, John was the advisor to 18 M.S. and 17 Ph.D. students and mentored 41 postdoctoral students and visiting scientists. John's career was dedicated to development of plant growth regulators for fruit tree growers to improve the quality of their crop and the profitability of their farm. His approach was to focus on fundamental aspects of horticulture and translate those findings to meaningful applications within the fruit industry. His laboratory pioneered research on apple and cherry fruit physiology, commercial uses of plant growth regulators, the fundamentals of cuticular penetration, and spray application technology. His research and guidance eventually led to the commercialization of ethephon for cherry abscission, gibberellic acid for pasture grass production, abscisic acid for grape coloration, an improved benzyladenine formulation, and aminocyclopropane carboxylyic acid for apple and stone fruit thinning. John's pioneering work continues to impact the fruit industries.

John's contributions to science in general and to the agriculture industry in particular earned him numerous scientific awards including membership in the National Academy of Sciences. As a scientist, John dedicated his career to the advancement of the Michigan apple and cherry fruit industries. In 2016, he generously endowed the Martin and Judith Bukovac Professorship in Tree Fruit Physiology in the College of Agriculture and Natural Resources at MSU to support a faculty position focused on the study of applied tree fruit research and outreach to the industry. John actively mentored students and faculty in the Horticulture Department even after his retirement in 1996, continuing to influence future leaders in horticultural science as recently as 2024.

At the June 2025 ISHS meeting in Chicago, John's career will be presented along with select concepts on research.

9:10 a.m.

Studies on Octylphenoxy Surfactants: XII. Effect of Surfactant Concentration on Foliar Penetration of NAA Into Cowpea Leaves

Warren Shafer[1], Martin John Bukovac[2]

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The effect of a polyethoxy (EO) derivative of octylphenol (OP) condensed with 40 ethyleneoxy groups (OP+40EO) on foliar penetration of 2-(1-naphthyl)acetic acid (NAA) into cowpea (Vigna unguiculata (L.) Walp. subsp. unguiculata 'Queen Anne') leaves was studied. Buffered (pH 6.3) treatment solutions were prepared and droplets (1 or 5uL) applied to the adaxial leaf surface of the primary leaves from 10-day-old seedlings. NAA-induced ethylene evolution, as well as radiochemical techniques, were used to quantify penetration. Low concentrations (0.01, 0.05, 0.1%) of OP+40EO tended to improve NAA penetration. Droplet deposits from these treatments appeared as small discontinuous deposits within the outline of the droplet area. As the concentration of OP+40EO exceeded its critical micelle concentration (CMC; 0.17% w/v), NAA penetration began to decline. At OP+40EO concentrations above the CMC (0.5, 1.0, 5.0, 10.0%), NAA penetration was inversely related to OP+40EO concentration. Deposits from the 0.5 and 1.0% droplets appeared as an almost continuous film and at 5.0 and 10.0% as a thick, uniform deposit covering the entire droplet area. The reduction of NAA penetration was not due to changes in surface tension or droplet:leaf interface area. It is suggested that organized OP+40EO surfactant structures at concentrations in excess of the CMC are capable of trapping NAA on the leaf surface, thereby reducing penetration into leaf tissues. The relationship between this research work and the development of ReTain® Plant Growth Regulator (Valent BioSciences LLC) also will be briefly described.

9:30 a.m.

Ethylene Evolution From Plant Bioregulators Is Differentially Affected by Ambient CO2

James Larson[1], Thomas Kon[2]

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2: 455 Research Drive, Mills River NC USA | tom_kon@ncsu.edu | cdclavet@ncsu.edu

As a gaseous hormone, ethylene can be readily quantified by gas chromatography. This methodology frequently involves incubating plant tissue in a sealed container, then sampling the headspace of the container to quantify ethylene. Previous research has shown that the precursor to ethylene, 1-Aminocyclopropane-1-carboxylic acid (ACC), is converted to ethylene at a greater rate with increasing carbon dioxide (CO2) concentration, up to ~1%. To determine the effect of CO2 on ethylene evolution, apple leaf and fruit tissue was incubated with and without a CO2 capturing reagent (soda lime) in two experiments. Both experiments were split plot designs with the main plot being plant bioregulator treatment and sublot being soda lime incubation. Experiment 1 captured the effect of incubation time on ethylene evolution. There, whole trees were treated with either 0 or 200 mg·L-1 ACC when fruitlet diameter was ~ 6 mm. 24 h after treatment whole spurs were collected and fruit and spur leaf tissue separated into jars. Within each tissue and ACC treatment, there were 11 total jars for each soda lime treatment, 1 of the 11 were sampled every half hour from 2 to 7 h after collection. Incubation time did not have a significant effect on ethylene evolution for leaf ($P = 0.096$) or fruit ($P = 0.100$) tissue. For leaf tissue there was a significant interaction between ACC and soda lime treatment ($P < 0.05$) with a 43% reduction in ethylene evolution by including Soda lime within ACC treatment. In experiment 2, the effect of soda lime was determined after treatment of 200 µL·L-1 6-benzyladenine, 200 mg·L-1 ACC, 20 µL·L-1 1-naphthaleneacetic acid (NAA), 286 µL·L-1 ethephon, or an untreated control. There, soda lime reduced ethylene evolution only in ACC ($P < 0.001$) and NAA ($P < 0.05$) treated leaf tissue. These results indicated that CO2 can confound findings when comparing ethylene evolution between plant bioregulators.

10:10 a.m.

KEYNOTE: Perspectives on Apple Crop Load Management

Thomas Kon[1], Christopher Clavet[1], James Larson[2]

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Despite more than 100 years of apple chemical thinning research, we are still improving practices to reduce crop load to a level that balances yield, fruit quality, and return bloom. There are currently more registered plant bioregulators (PBRs) for apple chemical thinning than at any point in US history. Modern chemical thinning programs are often multi-step, with applications occurring from bloom until fruit are 25 mm. Thinner chemistry varies throughout this period, and multiple predictive models have been developed to inform management decisions at each step. With these new tools, improving our understanding of the mechanisms of action, environmental effects, and interactions between chemistries is critical for successful integration into crop load management programs.

Incorporating the use of computer vision systems for apple crop load management remains a research priority. While some of these new technologies show promise, many require additional development prior to widespread commercial adoption. Efforts to automate of flower and/or fruit thinning are underway, but significant progress is required before practical application of this technology is possible. PBRs remain critical in modern crop load management programs and the economic sustainability of the US apple industry.

10:40 a.m.

Review of Crop Load Management in Apples With PGR's Under American Northeast and Spain Conditions-Part 1, Flowering

Luis Gonzalez Nieto[1], Luis Asin[2], Gloria Avila[1], Joan Bonany[1], Joaquim Carbo[1], Carlota Gonzalez Noguer[1], Terence Robinson[3], Estanis Torres[2]

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3: Cornell AgriTech Campus, Cornell University, Geneva NY, USA | tlr1@cornell.edu

In apple, crop load management is one of the most difficult tasks that strongly determines annual profitability. The management of fruit load in orchards with Plant Growth Regulators (PGRs) begins with treatments during flowering, followed by treatments after fruit set. Depending on the variety and objectives, treatments usually vary based on the physiology of the variety. For example, in varieties like 'Sweetango' or 'Evercrisp', there is an increase in ethylene between flowering and 10 mm fruit size, which causes excessive flower or fruit drop. The strategy for these varieties focuses on increasing fruit set, and chemical thinning of fruits is not performed. However, most varieties require an intensive thinning program for flowers and fruits to achieve the minimum quality for commercial purposes. The commercial PGRs currently registered to increase fruit set are aminoethoxyvinylglycine (AVG) (USA) and 1-naphthaleneacetic acid (NAA) (USA and Spain). During 2022 and 2023, trials were conducted in Geneva (NY) to evaluate the best strategy with AVG applications at different times, aiming to increase fruit set in 'Sweetango'. Our results concluded that double applications of AVG during full bloom and petal fall increased fruit set in 'Sweetango'. The two applications achieved the goal of reducing ethylene, thereby increasing fruit set. However, for most varieties, a program of treatments is carried out during flowering to reduce the load through chemical thinning of flowers. While most products used during flowering are caustic and burn the flowers, good results have been observed with the application of 1-Aminocyclopropane-1-carboxylic acid (ACC) during the petal fall period. To evaluate ACC along with other products during petal fall, trials were conducted with 'Gala' in Geneva (NY) in 2023 and with 'Fuji' in Mas Badia (Spain) in 2024. Our results suggest that the use of ACC alone did not achieve good thinning efficacy. However, the combination of ACC and 6-benzyladenine (6-BA) produced a significant load reduction in both locations. Therefore, an increase in ethylene during petal fall, along with an increase in cytokinin's, provided superior efficacy compared to other reference products.

11:00 a.m.

Review of Crop Load Management in Apples With PGR's Under American Northeast and Spain Conditions-Part 2, Fruitlets

Luis Gonzalez Nieto[1], Luis Asin[2], Gloria Avila[1], Joan Bonany[1], Joaquim Carbo[1], Carlota Gonzalez Noguer[1], Terence Robinson[3], Estanis Torres[2]

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Managing crop load in apple orchards is a challenging task that significantly impacts annual profitability. The process involves using Plant Growth Regulators (PGRs) starting with treatments during the flowering stage and continuing after fruit set. The specific treatments applied can vary depending on the apple variety and objectives, as they are based to the physiological characteristics of each variety. Thinning after fruit set can be performed using 1-aminocyclopropane-1-carboxylic acid (ACC - not registered in Europe), metamitron, 6-BA, NAA, or carbaryl. The timing for spray chemical thinning after fruit set is between 6 and 22 mm, depending on the product. NAA was the first hormone thinner adopted for commercial use. NAA works by reducing auxin transport from lateral fruits within the cluster, effectively promoting thinning. Its efficacy is highest when applied at a fruit size of 6 to 8 mm and remains effective up to 15 mm. 6-BA is a cytokinin that enhances cell division and modifies auxin transport dynamics. Its highest efficacy is with diameters of 8 to 12 mm, though it shows activity between 6 and 16 mm. Metamitron is a relatively new thinning agent in Europe and US. Metamitron is a photosynthetic inhibitor, and its highest thinning effect is between 10 and 16 mm, though it is effective in the 6 to 22 mm range. ACC was registered in the US in 2022, and its approval in Europe is forthcoming. It shows better efficacy on larger fruit sizes, between 18 and 22 mm, although the application window ranges from 6 to 22 mm. On the other hand, the combination of all these products showed better results than programs of thinning that used only one of them.

11:20 a.m.

The Need to Selective, Individual Apple Tree Adapted Fruit Thinning and Return Bloom Spraying Program

Matej Stopar[1], Nika Hillmayr[1], Marko Hocevar[2]

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Alternate bearing of apple trees in orchard rows is still common trait in commercial apple production. In order to express the necessity of spraying adapted to the individual tree, two experiments were carried out with the ´Golden Delicious/M.9´ apple. The trees were divided into three flowering groups: low flowering trees (L), medium flowering trees (M) and high flowering trees (H). Firstly, the trees were sprayed with 1-naphthaleneacetic acid (NAA; 12 mg L-1; experiment 1) or 6-benzyladenine (BA, 100 mg L-1; experiment 2) to thin the fruitlets in the apple crowns. Secondly, one month after full bloom in both experiments, five consecutive weekly applications of NAA 5 mg L-1 or ethephon 100 mg L-1 were sprayed on the same trees to promote return bloom. Thinning with NAA on L trees has proven to be detrimental; it reduced the amount of commercial fruit on L trees. Spraying with BA also resulted in thinning of L trees, but not significantly. Thinning with NAA or BA alone did not result in a satisfactory return bloom of H trees. The five consecutive applications of NAA 5 mg L-1 or ethephon 100 mg L-1 strongly increased the return bloom of the H trees. Thinned L and M trees achieved satisfactory return bloom and do not necessarily need to be sprayed for flowering promotion program. A selective approach to fruit thinning and return bloom promotion management is needed to selectively avoid thinning of the L trees and, furthermore to apply flowering promotion program only to the H trees. The prototype of a selective sprayer was developed based on the analyses of HSL images (hue, saturation, luminance) to detect flowering abundance of individual trees in a high density planted apple orchard.

11:40 a.m.

A Sustainable, Non-Chemical Thinning Method for US Midwestern Apple Producers: Novel Use of Anti-Hail, Insect-Exclusion Netting

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Netting systems offer an environmentally sustainable alternative to chemical inputs, reducing surface water contamination risks and supporting native pollinators. This study evaluates over-the-row anti-hail, insect-exclusion netting as a non-chemical method to regulate fruit set, reduce pesticide use, and mitigate environmental stress in Midwestern apple production. Conducted in 2024, the experiment included ‘Liberty,’ Honeycrisp,’ and ‘Gala’ across two commercial orchards and MSU’s Clarksville Research Center. Netting was applied at 30% and 60% King Bloom and compared to a chemically thinned control (lime sulfur plus oil or NAA).

Fruit set and yield in netted trees were generally comparable to chemically thinned controls. ‘Liberty’ and ‘Honeycrisp’ had lower fruit set under netting, with ‘Honeycrisp’ also showing reduced yield. Netting significantly reduced hail damage in ‘Gala’ and ‘Liberty’ compared to non-netted trees. Fruit quality and vegetative growth remained similar across treatments, except for slightly reduced red color in ‘Liberty’ and increased leaf area in netted trees. Netting effectively excluded codling moth males but did not eliminate fruit infestation. San Jose scale captures were lower under nets, and no scale injury was observed. However, netting increased woolly apple aphid and flower thrip populations, likely due to predator exclusion. Plum curculio and apple maggot pressure remained low under nets.

While netting requires a significant initial investment, its multifunctional benefits—crop protection, microclimate regulation, and reduced chemical reliance—support its adoption. These findings provide data-driven recommendations for Midwestern apple growers, particularly organic producers, seeking sustainable alternatives to conventional thinning and pest management.

1:30 p.m.

Developing Agronomic Strategies That Reduce Biennial Bearing in Apple

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Biennial bearing in tree fruit can cause losses in yields and affect fruit quality. These patterns are not unique to tree fruit and occur in natural species. Despite extensive research, biennial bearing still affects commercial apple production. Biennial bearing cycles are costly and result in inconsistent yields and fruit quality. Crop load management is one commonly used management strategy to control biennial bearing. However, trees can continue a biennial cycle the year following adequate crop thinning. We evaluated six different agronomic strategies to combat biennial bearing in apple trees: two for years when the crop load was low and four for years when the crop load was excessively high. In 2023, 'Honeycrisp' trees on B.9, G.41, G.890, and M.9-T337 rootstocks in their high-cropping year were root pruned, girdled, sprayed with ethephon, or fertilized with nitrogen (ammonium nitrate) in the fall, along with untreated control. Low-cropping trees in 2023 were defoliated, sprayed with gibberellic acid (GA3), and untreated control. Due to the limited availability of low-cropping trees in 2023, only 'Honeycrisp' trees on B.9 and M.9-T337 rootstocks were used. In 2024, treatments were applied to 'Honeycrisp' trees on M.9 T337 rootstock. All treatments were applied two to three weeks after full bloom except for nitrogen fertilization, which was applied in late August. Crop load, vegetative growth, and fruit quality were measured for treated trees and controls. Carryover effects of treatments were calculated to quantify the reduction/amelioration of biennial bearing incidence. In low-cropped trees, GA3 had significantly higher return bloom from controls and defoliated trees. In high-cropped trees, ethephon significantly increased return bloom compared to the control. GA3 also increased vegetative growth. Ethephon and defoliation are potentially effective agronomic strategies to use in the "on" and "off" years, respectively, to combat biennial bearing.

1:50 p.m.

Using Ethephon, ACC, and NAA to Improve Return Bloom of 'Honeycrisp' Apples in Western New York

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The 'Honeycrisp' apple remains highly demanded by US consumers, but the strong biennial tendency of the cultivar makes it challenging for growers to consistently produce from the same orchard. The cultivar begins floral initiation prior to other popular cultivars and targeting an early window with plant growth regulators may encourage return bloom and be a potential strategy to mitigate biennial bearing. Several experiments were done in Western New York to test whether an early timing (beginning at 16 mm fruit size + 10, 20, and 30 days) or traditional timing (June 21st + 10, 20, and 30 days) applications of ethephon (150ppm at 16mm, then 300 ppm after); ACC (200ppm at 16mm, then 400 ppm after); or NAA (10ppm at each spray) would increase the number of return blossom clusters the following season. The three chemicals were applied at both the early and traditional timings to an orchard of 4-year-old and 5-year-old 'Honeycrisp' trained as Tall Spindles, as well as a 13-year-old 'Honeycrisp' trained as Bi-Axis. Results showed that on the Tall Spindle trees, ethephon and ACC sprayed at the early timing were able to increase return bloom compared to an untreated control but not when applied at the traditional timing. On the Bi-Axis trees, NAA and ethephon both increased return bloom when applied at the early timing compared to an untreated control, but not at the traditional timing. The early timing of ethephon, ACC, and NAA all appear to induce floral induction and subsequent return bloom.

2:10 p.m.

Induction of a Carbohydrate Deficit to Improve Efficacy of a Post-bloom Thinner Application

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Apple post-bloom chemical thinning applications made when trees are producing more carbohydrates than consuming (surplus) are generally ineffective. To induce a carbohydrate deficit a photosynthetic inhibitor, metamitron, was applied prior to a chemical thinning application. This concept of "priming" trees first to improve post-bloom thinning activity was tested in two locations: Utah, a semi-arid climate where there are frequently carbohydrate surpluses, and North Carolina (NC), a humid subtropic climate in which carbohydrate deficits are more commonly observed. In both locations a hard-to-thin cultivar was used for the study: 'Fuji' (NC) and 'Golden Delicious' (Utah). In 2024, study was 3 x 3 full factorial between priming application (0, 235.6, and 471.1 µL·L-1 metamitron) applied 3 d before a traditional post-bloom application (0, 75, 150 µL·L-1 6-benzyladenine). There was a negative relationship between chlorophyll fluorescence and metamitron rate 4 days after application (1 day after post-bloom thinner) in both Utah (r2= 0.709, P < 0.0001) and NC (r2=0.681, P < 0.0001). By 8 days after metamitron application, chlorophyll fluorescence had mostly recovered in Utah (r2= 0.373, P < 0.05) but was still depressed in NC with increasing metamitron rate (r2= 0.539, P < 0.0001). Ultimately, there was thinning activity observed in NC, but not Utah. In NC there was a significant interaction between metamitron and 6-benzyladenine application (r2= 0.823, P < 0.01) for final crop density. In Utah there was no effect on crop density by either metamitron (P = 0.65) or 6-benzyladenine (P = 0.88). Carbohydrate status likely was a clear differentiator between these two sites as there was an estimated surplus trend in Utah while a deficit in NC in the week after application. These results indicate that a greater disruption of photosynthetic capacity than observed in this study is needed for thinner efficacy during a carbohydrate surplus.

2:30 p.m.

Monitoring Abscission and Thinning Efficacy With a Fruit Set Prediction Model From Distributions of Apple Fruitlet Mass

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Crop load management of apple is largely achieved by thinning using plant growth regulators. Thinning is an important practice to ensure consistent yields and high-quality fruit. Though the effective thinning window typically ranges from petal fall to 20mm, environmental conditions, primarily temperature and solar radiation, can affect the daily and cumulative tree carbohydrate status and response to thinners resulting in highly variable thinner responses. The fruit growth rate (FGR) model was developed to produce timely estimates of thinner efficacy and facilitate additional thinner applications, if necessary; the FGR model, however, is timely to implement given the need for repeated measurements of fruitlet diameter. The objective of the current research was to develop a user-friendly alternative to the FGR model by generating fruit set predictions from measures of fruitlet mass using a digital balance that exports data to a macro-enabled Excel spreadsheet. This approach was termed the fruitlet size distribution (FSD) model and we tested this alongside the FGR model on 'Gala' and 'Honeycrisp' in four unique apple growing regions of the United States: Michigan, New York, North Carolina, and Washington. Post-bloom chemical thinning applications were made over a range of developmental timings according to fruitlet diameter and weather conditions at each location. Over the course of 12 separate experiments, the FSD model had an 83% rate of accuracy, which was higher than the FGR model (67% accuracy). Accuracy was determined if the prediction was within 10% of the actual fruit set measured in the orchard ~40 days from full bloom, after June drop. When both models returned accurate estimates of final fruit set, the FGR model predicted set 2.8 days earlier than the FSD model; this was likely attributed to the higher sensitivity of relative fruit growth rate analysis compared to sample population distributions of mass. To improve sample preparation time, an analysis of the pedicel contribution to the variation in fruit mass proved inconsequential and thus, pedicels can be retained during measurements. The FSD approach can inform nascent, automated imaging system technologies that remotely quantify fruitlet diameter or volume, i.e. georeferencing of individual fruitlets to facilitate repeat measures may be unnecessary to produce accurate predictions of fruit set. Overall, the FSD model returned consistent results under disparate regions, cultivars, and years compared to the FGR model but required a few additional days to generate a prediction. While these improvements can increase labor-use-efficiency and precision crop load management programs, they require early implementation of the model, generally before 8 mm fruitlet diameter.

2:50 p.m.

Linking Carbohydrate Status of Apple Fruitlets to Their Sink Strength: Implications for Fruit Set Prediction and Thinning Models

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Chemical thinner applications can reduce crop load in apple (Malus x domestica Borkh.) but are often variable and unpredictable. The highest sensitivity of fruitlets to thinner applications is typically between 6mm and 15mm fruitlet diameter. During this period environmental factors and developmental status highly affect fruitlet growth and sink strength thereby influencing abscission rates in the orchard. In this study, we analyzed the carbohydrate concentrations of individual fruitlets of Honeycrisp and Gala over two years following chemical thinner applications and compared to non-treated controls. Fruitlets were sampled according to their weight, position in the cluster (king or lateral), and predicted probability to set according to the fruitlet size distribution (FSD) model. Sampling occurred at ~6 to 8 mm fruitlet diameter and comprised three distinct size classes (90th, 50th, and 10th percentile of the population), collected every two to three days. Nonstructural carbohydrate concentrations (glucose, fructose, sucrose, sorbitol, and starch) were analyzed using enzymatic assays. Fruitlets in the lowest percentile size class also had the lowest concentration of soluble sugars and starch throughout the sampling period. In contrast fruitlets in the 50th percentile size class did not significantly differ from those in the 90th percentile on many sample dates, particularly in the non-treated control, where this similarity was most pronounced for starch concentrations. Following a chemical thinner application, sorbitol concentrations were significantly reduced in fruitlets of all size classes, with the fruitlets in the lowest size class showing the slowest recovery rate. A similar drop in sorbitol concentration was not observed for fruitlets in the non-treated control. Differences in carbohydrate concentrations were more strongly associated with fruit size class than with their position within the cluster. However, shifts in carbohydrate concentration closely aligned with changes in abscission rates across positions, both observed in the orchard and predicted by the FSD model. In 2022, king fruit set occurred in 56% Gala and 77% of Honeycrisp clusters, compared to lower rates of lateral fruit set. These findings highlight that differences in carbohydrate concentrations and recovery rates contribute to fruitlet sink strength and influence subsequent abscission fate. Changes in fruitlet carbohydrate status reflect real-time sink strength responses to chemical thinners, which can be anticipated using fruit set prediction models.

3:10 p.m.

A Comprehensive Overview of Peach Thinning with ACC

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1-Aminocyclopropane-1-carboxylic acid (ACC) is a recently registered plant growth regulator for blossom thinning in stone fruit. Despite its potential, key questions remain regarding application practices and environmental factors that affect ACC's thinning efficacy. This study summarizes findings from four independent trials in peach, evaluating the importance of spray water volume efficacy, application timing, post-application rewetting, and ethylene expression in treated flowers on ACC thinning performance.

In the spray volume efficacy trial, four treatments were applied at a constant rate of 15 oz of Accede per acre, using increasing spray volumes of 50, 100, 150, and 200 gallons per acre. This resulted in ACC concentrations of 225, 300, 450, and 900 ppm, respectively. Final fruit set, measured as the number of fruits per 100 blossom clusters, was significantly lower in the 200-gallon treatment compared to the 50- and 100-gallon treatments ($P < 0.0020$), with approximately 45% fewer fruit. Overall, higher spray volumes were associated with increased thinning, suggesting that greater carrier volume may enhance ACC efficacy.

The application timing trial assessed ACC applied at three phenological stages within the labeled application time: pink, 70% full bloom, and 70% petal fall. No significant difference in initial or final fruit set was seen between the three application timings.

In the rewetting trial, water-only sprays were applied one, two, or four days after ACC treatment, with a non-rewetted treatment serving as the control. The 1-day rewetting treatment significantly differed from the control in the initial fruit set, having a 48% lower initial fruit set, but no significant differences were observed in final fruit set across any treatments.

Building on prior research into varietal differences in ACC efficacy, flowers from multiple peach cultivars were sampled two days after ACC application and analyzed for ethylene production. Preliminary results indicate that ACC stimulates ethylene production in peach floral tissues, with the magnitude of this response varying among cultivars and appearing proportional to their thinning sensitivity. These findings suggest a potential link between ethylene biosynthesis and thinning response, supporting the need for cultivar-specific ACC application guidelines.

Together, these studies provide new insights into the use of ACC for blossom thinning in peach, emphasizing the importance of spray volume and highlighting potential varietal differences in physiological response. Further research is warranted to optimize application strategies and to elucidate the ethylene-mediated mechanisms underlying ACC-induced thinning.

3:50 p.m.

Differences in Temperature-Dependency of the Conversion of 1-Aminocyclopropane-1-Carboxylic Acid (ACC) or Ethephon to Ethylene in Peach and Apple Leaves

Brian Sopcak, Derek Woolard, Poliana Francescatto, Steven McArtney, Marci Surpin

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Valent BioSciences recently introduced ACCEDE® as a solution for chemical of thinning stone fruits and apples. The active ingredient in ACCEDE® is 1-aminocyclopropane-1-carboxylic acid (ACC), a naturally occurring non-protein amino acid and the immediate metabolic precursor to ethylene in plants. The objective of this research was to determine the effect of temperature on ACC-induced ethylene production in leaves from peach and apple trees. We included another commercial ethylene generator, ethephon, as a comparison in our experiments. Ethephon (2-chloroethylphosphonic acid) is hydrolyzed in a pH-dependent reaction after uptake into plant tissues, releasing ethylene, while ACC is converted into ethylene by the enzyme ACC-oxidase. Flavorich peach trees and Geneva 41 apple rootstocks were grown in a temperature-controlled greenhouse. When the trees and rootstocks developed sufficient numbers of leaves, they were sprayed to drip with 300 ppm ACC, 300 ppm ethephon, or 429 ppm ethephon (equimolar to 300 ppm ACC) and returned to the greenhouse overnight. The following day leaves were excised from the trees, weighed, sealed in jars, and incubated in the dark at temperatures between 5 and 40 0C. Headspace ethylene was analyzed via gas chromatography. Ethylene emission was temperature dependent for both the ACC and ethephon treatments. Similar results were obtained from peach and apple leaves. ACC-induced ethylene emission increased linearly between 5 and 20 0C and was consistently higher than ethephon-induced ethylene emission in this temperate range. ACC-induced ethylene emission plateaued between 30 0C and 40 0C, while ethephon-induced ethylene emission continued to increase up to 40 0C. Our results support previous research demonstrating different kinetics for ethylene emission for these two plant bioregulators. Our results suggest ACC has less potential than ethephon to produce damaging levels of ethylene in response to high temperatures shortly after application.

4:10 p.m.

Thinning Efficacy of 1-Aminocyclopropane-1-Carboxylic Acid (ACC) in Sweet Cherry

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The precursor of ethylene, 1-Aminocyclopropane-1-carboxylic acid (ACC), has been developed as a flower or fruitlet thinner in different fruit crops, and no studies have been reported on sweet cherries (Prunus avium). The aim of this study was to evaluate the efficacy of ACC as a chemical thinner when sprayed, at different concentrations and stages, on 'Santina' and 'Lapins', grafted on 'Colt'. The trials were conducted over two seasons. In the first season, ACC at concentrations of 504, 672, and 840 mg/L was applied at the balloon, 10% bloom, and full bloom stages. ACC proved to be an effective flower thinner across all timings and concentrations, but sensitivity varied by cultivar. 'Lapins' was most sensitive at full bloom, while 'Santina' was most sensitive at the balloon and 10% bloom stages. The 840 mg/L concentration demonstrated a significantly greater and more consistent thinning effect across both cultivars, regardless of the timing. In the second season, 504 and 840 mg/L concentrations were tested at full bloom, 10% shuck split, and shuck split stages. 'Lapins' showed greater sensitivity at the shuck split stage than at full bloom, while 'Santina' was more sensitive at full bloom than at shuck split. Although all concentrations exhibited a thinning effect, the 840 mg/L concentration had a significantly greater and more consistent effect, irrespective of timing, on both cultivars. In 'Lapins', the higher concentration applied during the early stages negatively impacted fruit growth. No consistent positive effect on fruit size was observed from early thinning, likely due to the fruit set and tree vigor. However, fruit maturity, including color, firmness, and soluble solid content, was enhanced in some trials

4:30 p.m.

Reduction of Labor in Thinning 'PS 10711' Peach Using Different Chemical Thinners

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In peach trees (Prunus persica), the most labor-intensive management is thinning, which can account for 50% of the total annual cost. One of the greatest difficulties in carrying out chemical thinning in peach crops is the lack of products with proven efficacy; their response varies greatly depending on the climate and variety. Ethephon (ET) and 1-aminocyclopropane-1-carboxylic acid (ACC) are already used in apple trees. On the other hand, there are still few studies on recommended doses for chemical thinning in peach trees. Therefore, the objective of this study was to evaluate the application of different doses of ET, ACC and vegetable oils for thinning 'PS 10711' peach, under mild winter climate conditions. The experiment was carried out in Videira- SC, in the 2022/23 and 2023/24 harvests. Different dosages of ACC, ET and vegetable oils and their combinations were used. Well-lignified and poorly lignified branches were marked on the plants and the variables thinning percentage and thinning time (minutes/plant), yield (kg/plant), pulp firmness and soluble solids were evaluated. For both ET and ACC, as the dose increases, fruit drop increases and thinning time decreases. The dose of 190 ml 100L resulted in low yield and is not recommended for chemical thinning of this cultivar. The 150ml/100L dose showed lower yield but reduced about 57% the thinning time compared to the control, in the first year of study. This dosage would be the recommended for Chemical thinning in PS10711 peach trees. There was no difference in this cycle regarding lignified or non-lignified branches. The vegetable oils tested, in percentages of up to 5%, do not cause fruit thinning. More years of study are needed to propose an ideal dosage and thinner combinations for peach tree thinning.

4:50 p.m.

Uptake of 1-Aminocyclopropane-1-Carboxylic Acid (ACC) When Used as a Peach and Apple Chemical Thinner

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1-aminocyclopropane-1-carboxylic acid (ACC) is a naturally occurring precursor to ethylene. Accede SG containing ACC as active ingredient has been registered as a chemical thinner in the US and elsewhere for stone fruit and apple. When applied as a chemical thinner in peach and apple, it causes abscission of flowers and fruitlets, respectively. The objective of the studies reported here was to investigate the site of uptake of ACC when used as a chemical thinner in these crops to aim commercial application strategies for optimum field efficacy. In a series of experiments in the US (Oregon, California) and Brazil (Rio Grande do Sul) we determined that ACC is a compound with limited mobility within the plant. When the ACC spray solution was applied via paintbrush to various parts of peach flowers, it became evident that for sufficient flower thinning activity, the presence/ uptake of ACC is needed through the pedicel and/or Abscission Zone tissues of the pedicel. Application of ACC to the petals only, resulted in petal drop only but did not correlate with flower abscission. In apple fruitlet, uptake appeared to be mainly through the leaves and, in part, through fruitlets evidenced by ethylene evolution and fruitlet abscission after localized application of ACC to various parts of the fruit clusters. From these studies, we concluded that uptake of ACC for thinning activity can be different in different crops, particularly if the timing of application and/or phenological stage of the flower and fruitlet is different. These findings emphasize the importance of application technology, spray coverage of the sites of uptake for optimum thinning efficacy.

5:10 p.m.

1-Aminocyclopropane-1-Carboxylic Acid (ACC) Is an Effective Late Thinning Agent in Apple Trees Without Compromising Future Plant Development

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Apple trees often exhibit a high load of flowers and fruits, making thinning essential to ensure fruit quality and to reduce labor costs. Although chemical thinning is recommended at the beginning of flowering and fruit set, climatic and operational factors may delay this practice, requiring effective alternatives for late thinning (fruits > 15 mm). This study evaluated 1-aminocyclopropane-1-carboxylic acid (ACC) as a late chemical thinning agent, analyzing its long-term effects on vegetative and reproductive development. Two doses of ACC (300 or 400 ppm) were tested at BBCH 72 (50% of central fruits at 20 mm), metamitron (300 ppm) at BBCH 72 (50% of fruits at 14 mm), and a control, using the same trees over two consecutive years (2021 and 2022). Manual thinning was performed in all treatments, adjusting the final fruit load to approximately 150 fruits per tree after June drop. Thinning efficiency was assessed by the number of fruits manually removed per tree, as well as agronomic variables related to fruit quality and vegetative growth. In both years, ACC at both doses significantly reduced the need for manual thinning compared to the control, by at least 46% in 2021 (metamitron – 38%) and 39% in 2022 (metamitron – 31%). Due to hand thinning, the final fruit number/tree was equivalent at harvest; however, ACC at 300 or 400 ppm resulted in higher fruit weight in 2021 and 2022 with the highest rate providing better fruit sizing effects than metamitron. None of the treatments affected return bloom in the following years, and did not affect the number and length of new shoots or caused any phytotoxicity. Our results indicate that ACC at 400 ppm is an excellent late fruit thinning tool on apples, without compromising tree development, fruit quality or return bloom in subsequent years.

5:30 p.m.

The Influence of 1-aminocyclopropane-1-carboxylic acid (ACC) on Thinning of Apples and Stone Fruits in the Intermountain West Region of the USA

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A few post-bloom thinners are available for apple (Malus domestica Borkh.) and stone fruit, and the prospect for additional thinners is limited. We studied the impacts of various rates of 1-aminocyclopropane-1-carboxylic acid (ACC) in three strains of 'Fuji' apple and different rates of ACC and one rate of Ethrel in 'Buckeye Gala' apple, when fruitlet diameter was about 20 mm, on fruit set, yield and fruit quality attributes at harvest, and return bloom in the Intermountain West region, USA. Application of Ethrel at 300 mg·L–1 did not affect fruit set or size 34 days after application, or fruit yield, weight, color, russet, and starch degradation pattern (SDP) at harvest, while application of ACC at 150 mg·L–1 or higher reduced fruit set in 'Buckeye Gala' apple. In this cultivar, application of ACC at 350 mg·L–1 increased fruit weight and size 34 days after application, and increased fruit weight, color, and SDP at harvest time. Application of ACC at all rates reduced total yield per tree in 'Buckeye Gala'. Application of ACC at 300 mg·L–1 significantly reduced fruit set but applications 150 mg·L–1 or 300 mg·L–1 ACC did not affect yield or quality attributes of 'Sun Fuji' apple. Application of ACC reduced fruit set and slightly increased fruit size in 'Top Export Fuji'. Application of ACC at 600 mg·L–1 reduced fruit set in 'Aztec Fuji' apple. In 2022, The influence of ACC on fruit set and in two strains of 'Gala', one strain of 'Delicious', and one strain of 'Fuji' apples, when fruitlet diameter was about 20 mm, on fruit set and fruit size at hand-thinning was studied. Applications of ACC reduced fruit set in 'Schlect Spur Delicious' in 7 and 30 days after application. ACC sprays reduced fruit set in 'Gala' and 'Fuji' apples 30 days after application. Fruit weight after 30 days of ACC application (hand thinning) in trees receiving ACC was higher than those in Untreated Control and the difference was significant only in 'Schlect Spur Delicious' apple. In 2023 and 2024, the influence of ACC on fruit thinning in several cultivars of peaches, nectarines, and apricots were studied. When ACC was applied at about 75% to full bloom, application of 450 ppm ACC on peaches and nectarine and 350 ppm ACC on apricots, applied at 935 to 1870 L.ha-1 effectively reduced fruit set and needs for hand thinning.

8:05 a.m.

KEYNOTE: Balancing Growth and Defense Phytohormones for Optimal Productivity of Citrus

Tripti Vashisth

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Currently, Huanglongbing (HLB) affects nearly all citrus-producing counties in Florida and Texas, and it is spreading to other citrus-growing regions in the U.S. Unfortunately, there is no cure for HLB, so the survival of the citrus industry in Florida and Texas relies on strategies that can be quickly implemented to sustain tree growth and productivity until long-term solutions, such as developing resistant germplasm, are found. Infection with Candidatus Liberibacter asiaticus (CLas), the bacteria responsible for HLB, leads to significant loss of feeder roots in affected trees. This impairment restricts nutrient and water uptake and disrupts carbohydrate transportation within the tree, ultimately resulting in increased preharvest fruit drop and reduced fruit productivity. Recent research has shown a negative correlation between canopy density and fruit drop in HLB-affected sweet oranges. Additionally, studies have revealed that the primary reason for poor growth in HLB-affected trees is a deficiency in growth-promoting hormones combined with an overaccumulation of defense-related hormones. This indicates that these trees experience a growth trade-off when their plant defense responses are heightened. The application of specific plant growth regulators (PGRs), such as gibberellic acid (GA), synthetic auxins, and cytokinins, has been shown to enhance the productivity of HLB-affected citrus. Multi-year field trials, along with molecular and biochemical studies, suggest that utilizing these PGRs can help increase yield by reducing preharvest fruit drop and improving the source-to-sink ratio in declining trees. This presentation will explore the latest advancements in plant hormone research related to HLB and the new application patterns of PGRs to mitigate the effects of this disease.

8:35 a.m.

Rehabilitation of Huanglongbing-Affected Sweet Oranges With Use of Methyl Salicylate and Gibberellic Acid

Gurleen Kaur, Taylor Livingston, Shalini Pareek, Tripti Vashisth

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Huanglongbing (HLB), presumed to be caused by the bacterium Candidatus Liberibacter asiaticus, disrupts citrus tree growth and fruit development by inducing hormonal imbalances, with a growth tradeoff for enhanced plant defense speculated as a major contributing factor. With no resistant citrus germplasm available, effective management strategies are essential for sustaining production. This study evaluated the efficacy of methyl salicylate (MeSA), a systemic acquired resistance (SAR) inducer, and gibberellic acid (GA_3), a growth-promoting hormone, in improving tree health and mitigating HLB symptoms. The experiment was conducted using 15-year-old 'Valencia' sweet orange trees on Swingle rootstock. Four treatments—Control, GA_3 (33 ppm), MeSA (150 ppm), and GA_3+MeSA—were foliar applied every 45 days from July to November for two consecutive years. Overall, pre-harvest fruit drop was significantly lower in GA_3 (45.8%) and GA_3+MeSA (42.3%) treatments compared to the control. GA_3-treated trees produced significantly higher yield (23.7 kg/tree) compared to control (12.88 kg/tree), while no effect on total soluble solids and titratable acidity. Canopy volume increased in GA_3 (21.9 m^3) and MeSA (21.8 m^3) treatments than in control (15.4 m^3), while canopy density remained unchanged. GA_3+MeSA improved leaf water content (58.4%) over control. Leaves were collected for molecular analysis on Days 7, 14, 30, 45, and 60 after the first treatment. Gene expression analysis revealed downregulation of oxidative stress response genes Rboh (Respiratory burst oxidase homolog) and LOX2 (Lipoxygenase 2) on Days 7 and 14 in GA_3+MeSA treated trees, indicating reduced oxidative stress, and upregulation ofdefense related gene CDR1 (Constitutive disease resistance 1) on Days 30 and 45, suggesting SAR activation. These findings suggest that combining growth promoting, GA_3 and SAR inducing, MeSA can alleviate oxidative stress and induce enhanced plant defense response while improving tree productivity.

8:55 a.m.

Early Gibberellic Acid Applications to Improve Canopy Health and Fruit Production in Hlb-Affected 'Valencia' Sweet Oranges

Maricielo Postillos Flores[1], Taylor Livingston[2], Tripti Vashisth[2]

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Huanglongbing (HLB), also known as citrus greening, remains one of the most destructive diseases affecting citrus worldwide, significantly impacting the Florida citrus industry. Five monthly foliar applications of gibberellic acid (GA_3) from September to January have been shown to improve tree health, promote fruit growth, delay peel senescence, and inhibit abscission and senescence in HLB-affected sweet oranges. However, multiple applications of GA_3 (September – January) can delay fruit color development, hindering fresh market sales.

Therefore, this study aimed to evaluate the early application of foliar GA_3 on HLB-affected 'Valencia' sweet oranges under Florida conditions to improve canopy health and fruit production while minimizing the number of GA_3 sprays and color delay. In contrast to the current recommendation of spraying from September to January, the early GA_3 applications in this study were applied at 45-day intervals, beginning on July 1st and continuing through January 1st.

Results indicate that three to five early foliar applications of GA_3 can improve canopy density and yield. Trees receiving four or five applications showed higher fruit detachment force (FDF), lower fruit abscission, and improved peel integrity. Nonetheless, key quality traits such as total soluble solids and total acidity percentage were unaffected. We also observed a positive correlation between the number of GA_3 applications, peel greenness, and FDF. Overall, multiple GA_3 applications (at least 3) between July 1st and October 1st can improve the yield and minimize fruit drop with minimal impact on internal fruit quality. This research highlights the advantages of early GA_3 sprays for mitigating HLB's adverse effects in 'Valencia'sweet orange production.

9:15 a.m.

Ethephon and Gibberellin-Based Growth Regulators as Alternatives to Manual Deblossoming in Blueberries

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Highbush blueberry (Vaccinium corymbosum) plants are typically deblossomed during the first two years after planting to prevent fruit set. This practice reallocates resources to root and shoot development, accelerating plant establishment and enhancing yields in subsequent years. Currently, deblossoming is performed manually, a labor-intensive process for growers. This study evaluated two plant growth regulator strategies to eliminate fruiting in blueberry plants: (1) deblossoming through spring applications and (2) preventing flower bud development through late summer applications. Experiments were conducted on a seven-year-old 'Duke' blueberry planting arranged in a randomized complete block design with three blocks, each containing three plants per treatment. For deblossoming, the ethylene-releasing agent ethephon (500, 750, and 1000 ppm) was applied weekly for three weeks, either alone or in combination with S-abscisic acid (ABA; 250 ppm). Applications began in late April, targeting ~25% of buds at the tight bud stage. To prevent flower bud development, gibberellic acid (GA_3; 100, 200, and 400 ppm) was applied two or three times at three-week intervals, starting at flower bud initiation in late August. Ethephon applied alone at 1000 ppm, as well as all ethephon treatments combined with ABA, significantly reduced fruit counts, achieving an approximately 80% reduction compared to controls, except for the 500 ppm ethephon + ABA treatment, where the reduction was around 60%. GA_3 applications during flower bud initiation reduced fruit counts by ≥98% across all treatments. Closer examination revealed that delayed dormancy following GA_3 treatments led to flower bud death due to low temperatures, while leaf buds remained unaffected. These findings suggest that GA_3 application during bud development in late summer is an effective strategy for eliminating fruit production in blueberry plants, providing a promising alternative to manual deblossoming.

9:35 a.m.

Suppression of Flower Bud Development in Newly Established Blueberry Plants

Wei Qiang Yang

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This study evaluates the effects of GA4+7 application and flower bud removal on flower bud set and plant growth in five commercial blueberry cultivars (Duke, Draper, Liberty, Legacy, and Aurora) during plant establishment. The experimental design was a randomized complete block with five replications, where each treatment combination involved three plants per experimental unit. The treatments included GA4+7 application (400 ppm, applied twice with a one-week interval), manual flower bud/blossom removal, and an untreated control. Data collected included flower bud counts, shoot and basal cane growth, and canopy index measurements, the latter calculated as the product of two canopy widths, plant height, and a density rating. Results indicated that GA4+7 applications significantly reduced flower bud set in all five blueberry cultivars, with the reduction in Liberty exceeding 50%. The effect of GA4+7 on the number of vegetative buds varied among cultivars, with a decrease observed in Aurora and Legacy, and an increase in Duke and Liberty. A significantly lower percentage of flower buds compared to vegetative buds was observed on the same fruiting wood in all five cultivars. These findings suggest that GA4+7 application can be used to reduce flower bud formation in young blueberry plants, thereby promoting greater vegetative growth during field establishment.

9:55 a.m.

Sequential Applications of Plant Growth Regulators, Ring Barking, and Ring Incision in the Early Development of Apple Trees in Southern Brazil

Leonardo Soldatelli Paim[1], Everlan Fagundes[2], Poliana Francescatto[3], Eduarda Dorigatti Gargioni[4], José Luiz Petri[5], Ana Paula Fernandes de Lima Turmina[6]

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In apple cultivation, the occurrence of budbreak deficits along the main stem in young plants is common, delaying the achievement of the productive peak and economic returns. Under these conditions, inducing budbreak of para-dormant lateral buds and promoting branch formation is an intrinsic need in southern Brazil. Certain horticultural interventions can mitigate the issue of blind wood, such as the use of plant growth regulators (PGRs), ring barking, and ring incision. This study aimed to apply these strategies to promote budbreak and branching of the main stem. Experiments were conducted in commercial orchards in Vacaria/RS, Brazil, with young 'Gala' apple trees grafted onto G.202, G.210, G.814, and Marubakaido/M9 rootstocks. Treatments, applied to one-year-old wood, consisted of sequential applications of 6-benzyladenine (BA) combined with gibberellic acid 4+7 (Promalin® 25 mL L^{-1}) or 6-BA alone (MaxCel® 25 mL L^{-1}), as well as combining these PGRs with ring barking or ring incision, in addition to the control (no strategy applied). During the 2023/2024 and 2024/2025 seasons, three and six applications were performed, respectively, at three-week intervals, with the initial application near the onset of flowering. Variables analyzed included initial and final budbreak of lateral buds, the number of formed branches, and branch length along the main stem. The isolated use of PGRs did not enhance lateral budbreak; however, when combined with ring barking or ring incision, there was an increase in budbreak levels. The number of branches formed varied by experiment, while branch length tended to increase with 6-BA and gibberellic acid 4+7 applications. The combination of sequential PGR applications with ring barking or ring incision is effective for proper plant development and has the potential to advance and enhance the productive peak in apple cultivations in southern Brazil.

10:35 a.m.

KEYNOTE: Programmable Plants: Engineering Living Sensors and Inducible Traits

Sean Cutler

I will describe my lab's development of plant-based sense-and-response modules that enable crops to detect and react to specific environmental chemicals. Using the ABA sensor PYR1/HAB1 as our engineering scaffold, we introduced targeted mutations to uncouple the module from its native hormone and reprogram it to recognize new ligands. Two orthogonal sensors—one activated by the oomyceticide mandipropamid and the other by the insecticide azinphos-ethyl—exhibit nanomolar sensitivity and trigger visible or physiological outputs on demand. By designing and screening thousands of PYR1 variants, we've built a data-driven pipeline for rapid sensor discovery. When deployed in crops, these "living sensors" deliver real-time, in-field diagnostics and enable precise, agrochemical-controlled regulation of traits.

11:05 a.m.

Integrating Developmental Genetics into the PGR Pipeline

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Growth regulator development for tree fruit production has predominantly focused on spraying varying concentrations of different formulations of well-established phytohormones at different time points. While this approach has and will continue to benefit the industry, it is limiting in nature. A greater understanding of the molecular mechanisms and genetic factors associated with desirable phenotypes is needed to enhance plant growth regulator (PGR) and cultural practice development. Such data will generate new ideas and provide new targets for controlling growth and development. My research program is applying this approach to identify new strategies for manipulating fruit tree architecture, bloom time, and fruit maturity. The concept, however, could be applied to manipulate numerous traits in all crop plants. This presentation will be an "idea talk" to encourage discussion, as well as new research directions and non-traditional collaborations.

11:25 a.m.

Effect of Salicylic Acid Applications in Summer Stress Tolerance in Sweet Cherries

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The cultivation of cherry trees has become one of the main economic activities in terms of return for the national agricultural sector, which has generated an exponential increase in the area planted with this fruit tree during the last 5 years, expanding its distribution from Coquimbo to Aysén regions. However, the highest concentration of commercial orchards is in the central area of our country.

The northern and central regions of Chile have been strongly affected by climate change, with decreases in the annual rainfall regime between 20 and 40%, which has significantly increased drought events and stress conditions in the main areas of fruit production of our country. The decrease in water availability and the exposure of plants to abiotic stress conditions (high temperature, high radiation, and low relative humidity) are generating negative impacts on productivity, vegetative growth, and the final quality of the fruit. In addition, productivity the following growing season, due to the effect of summer stress (December to February), negatively affects the processes of floral induction and differentiation, generating significant losses in exportable fruit volume, due to the production of deformed and double fruits in seasons with stressful conditions. Given that water is a scarce resource, and the management of controlled deficit irrigation is not a common practice for cherry orchards, the present research proposes the exogenous use of phytohormones as an alternative for physiological activation in cherry plants, as a strategy of natural defense that would allow cherry trees to tolerate abiotic or environmental stress conditions in a better way and keeping a high metabolic activity. In that framework, the main goal of this proposal is to evaluate the effects of phytohormone salicylic acid on the tolerance of cherry trees to abiotic stress, managed under summer stress conditions of the central valley of Chile. During three seasons (19/20, 20/21, and 21/22) trials were carried out in Pencahue, Maule Region of Chile. Sweet cherry cvs. Lapins and Santina were treated with Salicylic acid (SA) during summertime to improve plant abiotic stress tolerance. Water potential, stomatic conductance, and photosynthesis status were improved with SA treatments. Expression of key genes related to abiotic stress tolerance was induced with SA applications. Phenylalanine ammonia-lyase (PAL) and Superoxide dismutase (SOD) increased their expression after SA applications. These data could be valuable to keep researching SA as a tool to manage the abiotic stress generated during summer conditions.

11:45 a.m.

Using Acibenzolar-S-Methyl to Reduce Flood Stress in Apple Trees

Melissa Muñoz, Christopher Clavet, Thomas Kon

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Flood stress is a common abiotic stress that can have devastating effects after prolonged or severe rain events, particularly in areas with poor drainage, resulting in anaerobic respiration of the roots. In apple trees, flood stress is associated with reduced productivity, stunted growth, chlorosis, decreased photosynthetic efficiency, damage to the root system, increased susceptibility to pests and diseases, and tree mortality. This study evaluated the potential effects of acibenzolar-s-methyl (ASM) treatments to enhance apple tree responses to flooding. Specifically, a greenhouse experiment was conducted on potted 2-year-old 'Aztec Fuji®'/ 'M-9 (T337)' trees using a randomized complete block design with a 3 x 2 factorial treatment structure. Effects and interactions of ASM application number (0x, 1x, 2x) and soil moisture (non-flooded and flooded) were evaluated. ASM treatments (75 mg·L-1) were applied preventively four or four + eleven days before flooding for the 1x and 2x treatments, respectively. Flooding was imposed for seven days using a pot-in-pot system. Measurements of stomatal conductance, quantum efficiency, electron transport rate, chlorophyll fluorescence, and soil moisture were taken every four days after ASM application, and following the drainage of the flooded trees, measurements continued weekly for four weeks. Before flooding, all trees displayed comparable leaf function parameters. However, a rapid decline in chlorophyll fluorescence was observed in the trees with 0x and 2x ASM treatments, which exhibited a 50% decrease after seven days of flooding. In contrast, the trees treated with 1x ASM only showed a 10% decrease during the same period. Similar patterns were observed for quantum efficiency and stomatal conductance. Ultimately, the flooded trees treated with 1x ASM had a 50% higher survival rate compared to untreated trees; while, in non-flooded trees ASM treatments showed a lower incidence of fire blight, suggesting the multiple potential uses of ASM on apple trees.

1:35 p.m.

KEYNOTE: Molecular Mechanisms Underlying the Regulation of Dormancy by Phytohormones in Fruit Trees

Yuanwen Teng[1], Qinsong Yang[2]

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Bud dormancy in deciduous fruit trees is a critical adaptive mechanism for surviving cold winters, yet its timely release is essential for spring budbreak and productivity. The antagonistic interplay between abscisic acid (ABA) and gibberellins (GA) plays a central role in regulating dormancy maintenance and release. Studies show that short-term exposure to low temperature induces bud dormancy in some fruit trees by increasing ABA levels. This process promotes the expression of CBFs and other genes that directly interact with DORMANCY-ASSOCIATED MADS-box (DAM) genes, key transcription factors that control bud dormancy. DAM inhibits the expression of the flowering integrator FT2, thereby suppressing bud break. Mechanistically, ABA promotes dormancy maintenance by activating the transcription factor ABF3, which directly and indirectly upregulates DAM, e.g. DAM3 in pear. ABF3 recruits the COMPASS-like complex to increase H3K4me3 levels at the DAM3 and GA2OX1 loci, thereby integrating ABA signaling with GA degradation to maintain dormancy. In contrast, prolonged chilling reduces ABA levels through upregulation of CYP707A3 and induces miR6390, which targets DAM3 for downregulation. Simultaneously, chilling accumulation increases H3K4me3 levels at cell division-related genes (e.g., CYCD), suggesting that epigenetic modification of growth-related genes may regulate chilling requirement thresholds to facilitate dormancy release. Exogenous GA application accelerates dormancy release by counteracting ABA signaling, whereas ABA treatment enhances dormancy via DAM3-mediated repression. These results highlight a dynamic ABA-GA balance that governs dormancy transition. Overall, the molecular framework of ABA-GA antagonism in pear bud dormancy involves transcriptional regulation, epigenetic modifications, and hormonal crosstalk, which may aid in the development of chemical interventions to mitigate dormancy disorders induced by climate change.

1:55 p.m.

Carbohydrate Dynamics and Dormancy Regulation in Peach: A Whole-Tree Perspective

Khalil Jahed, Sherif Sherif

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Dormancy is a pivotal adaptive mechanism in perennial plants, essential for winter survival and subsequent reproductive success. While previous investigations have predominantly focused on vegetative and floral buds during the dormancy-regrowth cycle, often overlooking the potential contributions of other plant compartments, this study adopts a comprehensive, whole-tree perspective. Utilizing four-year-old Prunus persica (cv. 'John Boy') trees, we investigated carbohydrate dynamics and their regulatory role during dormancy progression in roots, stems, branches, and floral buds relative to chilling unit (CU) accumulation and growing degree hour (GDH). Our results indicated that roots maintained the highest starch concentrations during endodormancy. However, soluble sugar accumulation in roots appeared largely independent of local starch hydrolysis, suggesting translocation from distal storage tissues. This hypothesis is supported by a concomitant decline in starch content and an increase in soluble sugars within branch and stem tissues. As dormancy progressed, soluble sugars were progressively redistributed, peaking in roots at the onset of ecodormancy and achieving a more uniform distribution across tissues during ecodormancy. Furthermore, a significant pre-budbreak surge in floral bud soluble sugars, without corresponding local starch depletion, indicates an enhanced carbohydrate import capacity in buds. Transcriptomic analysis of root tissues identified two key gene modules (ME) inversely correlated with carbohydrate levels. ME3, associated with starch accumulation, was enriched for genes regulating fatty acid metabolism pathways (e.g., SBE2, DBE1, FAD8, KAS1). Of these, FAD8 upregulation during ecodormancy suggests increased membrane fluidity, potentially facilitating carbohydrate transport. Conversely, ME10, linked to soluble sugar levels, showed enrichment in genes involved in hormone signaling and carbohydrate metabolism pathways (e.g., SUS3, BAM6, GH9A1). These findings highlight coordinated regulation between carbohydrate metabolism and membrane lipid composition during dormancy transitions and budbreak. Our data further suggest that starch catabolism in aerial woody tissues during chilling accumulation provides soluble sugars for roots, which may sustain metabolic activity and contribute to bud dormancy release. Future research employing this whole-tree system is warranted to elucidate the comprehensive roles of roots and other storage organs in the regulation of dormancy.

2:15 p.m.

Biochemical Changes and Lethal Temperature Limits of Apple Floral Buds Throughout Dormancy

Sangeeta Sapkota[1], Todd Einhorn[1], Sherif M. Sherif[2]

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Dormancy and cold hardiness are important adaptive traits of tree fruit species that enable survival during subfreezing temperatures in winter. Endo- and eco-dormancy release and subsequent budburst can only proceed after sufficient chilling and heat accumulation, respectively. Understanding the physiological and molecular processes that underpin these developmental transitions could result in lethal temperature time stamps and predictive empirical models that facilitate implementation of crop protective strategies to reduce the negative impacts of episodic freeze events. Numerous studies have implicated various metabolic mechanisms in the regulation of hormone concentration, carbohydrate metabolism, and reactive oxygen species that contribute to the onset, duration and release of dormancy and subsequent changes in cold hardiness. We measured a notable increase in reactive oxygen species, particularly superoxide (O_2^-) and hydrogen peroxide (H_2O_2) in floral buds of apple during the transition from endodormancy to eco-dormancy. Concurrently, we detected a decrease in starch levels and increase in total soluble sugars during eco-dormancy and an increase in cytokinin and decrease in abscisic acid commensurate with the transition from eco-dormancy to bud burst. Further, a transcriptomic and co-expression network analysis revealed the upregulation of 4,204 genes and downregulation of 7,817 genes when comparing endodormancy to eco-dormancy. During this developmental transition, the top 20 genes in the co-expression network analysis were primarily involved in jasmonic acid biosynthesis and signaling, lipid metabolism, redox processes, and transmembrane transport functions. Identifying biological markers to estimate developmental time of apple is of major importance since floral buds lose significant levels of cold hardiness as eco-dormancy has lifted but visible changes in bud phenology have yet to occur. During this period, significant differences in the lethal temperatures of florets were dependent on their position on the cymose inflorescence; developmentally advanced King florets were ~6°C less hardy than the subtending laterals. The onset and continued loss in hardiness of all flowers was highly associated with a concomitant increase in the relative water content (RWC) of floral buds. An RWC of ~ 60% signified the separation of bud scales (visible green stage), termed bud burst. Collectively, several potential molecular and physiological makers were identified to aid in the prediction of developmental transitions and lethal temperature limits and may inform future breeding strategies and/or precision agriculture technologies to mitigate crop loss of apples during freeze events.

2:45 p.m.

Horticultural Oil and Dormex® Affect Bloom Time and Yield in Pistachios by Changing Metabolite Levels

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Lack of dormant chilling is a major problem in producing pistachio trees in locations with warm periods during the winter time. In the past years, some locations in California have received insufficient winter chilling which has led to late bloom and crop reduction. Horticultural oil has been used as a rest-breaking agent to promote bud break and improve production. However, there is limited information regarding the merit of chill portion spray timing and the physiological mechanism behind bloom advancement by oil application. In the present study, three locations in California, North (Colusa County), Central (Madera County) and South-Western Fresno County (Cantua Creek) were selected for oil spray applications while Hydrogen cyanamide (Dormex®) was sprayed at Cantua Creek site. Tree of cv. Kerman (female) and Peters (male) on UCB-1 rootstock were sprayed with horticultural oil (IAP 440) @ 6% v/v or Dormex @4% at various chill portion (CP) accumulation milestones. Bloom period from bud swell to full bloom, tree yield, yield components, non-structural carbohydrates and macro and micro nutrients in buds and bark of pistachio shoots were analyzed. NMR-based metabolomics analysis was conducted to investigate the changes in metabolic profiles induced by exogenous oil or Dormex® application. Results showed that oil spraying in two southern locations advanced bud break but not in the northern site showing each location respond to oil spray differently. In Cantua site, Dormex® and oil spray at CP55 could significantly increase the yield while in Madera, oil spray at CP59 showed the highest yield. Results also showed that oil spray at different CPs and Dormex® could change the trend of soluble sugars and starch in bark and bud of pistachio trees. In Cantua, Dormex® significantly increased nitrogen (N), phosphorous (P), sulfur (S), boron (B), copper (Cu) and zinc (Zn) mobilization towards bud swell. Moreover, oil spray increased N, P, S in all CPs at all locations. A multivariate analysis conducted to compare the metabolite changes in control samples of bark and bud with these two rest-breaking agents led to the identification of nine metabolites that show a significant change in at least one of the comparisons (Creatine, Aspartate, Sucrose, Asparagine, Succinate, Fumarate, Leucine, Adenosine, and Uridine). It seems that oil and Dormex® applications can significantly increase the yield of pistachio trees by advancing bud break, improving bloom synchrony and also, by changes in carbohydrate, nutrients and metabolite changes in bark and bud of pistachio tree.

3:05 p.m.

Chemical Induction of Budbreak in Apple Trees With Combinations of Compound Classes, Timing, and Application Frequencies

Leonardo Soldatelli Paim[1], Natasha Cardoso[2], Everlan Fagundes[3], Eduarda Dorigatti Gargioni[4], José Luiz Petri[5], Thania Roberta Zonta[6]

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Using budbreak promoters is essential in apple cultivation when chilling requirements are unmet, as it can sustain the activity economically under such conditions. Historically, hydrogen cyanamide (HC) has been the most used molecule, applied annually with mineral oil (MO). However, biostimulants and hormonal compounds combined with MO or calcium nitrate (CaN) have proven effective both as substitutes and in sequential applications. The search for alternatives due to HC's high toxicity and the need to optimize chemical effects under specific conditions motivated this study. Experiments were conducted during the 2023/2024 and 2024/2025 seasons in commercial orchards of adult ‘Gala' and ‘Fuji' apple trees grafted onto Marubakaido/M9 rootstocks in Fraiburgo/SC and Vacaria/RS, Brazil, regions where budbreak promoters are widely used. At the silver tip stage, HC 0.5%, Citare® 1% or thidiazuron (TDZ) 250 mg L^{-1} were applied with MO 3.5%, and Citare® 2% with CaN 3%. Three days later, some treatments included a second application of 6-benzyladenine (BA) 10 mg L^{-1}; TDZ 250 mg L^{-1}; Erger® 3%; or Citare® 2% with CaN 3%. HC 0.5% with MO 3.5% at the green tip stage and a control (no application) were also evaluated. Phenological development, budbreak, fructification, yield, and fruit quality were analyzed. Overall, budbreak promoters advanced and increased lateral/apical budbreak. Treatments with HC 0.5% and MO 3.5%, 6-BA 10 mg L^{-1}, or TDZ 250 mg L^{-1} did not negatively affect fructification, yield, or fruit quality, outperforming the standard treatment. Sequential applications, especially with TDZ 250 mg L^{-1}, enhanced fructification in ‘Gala'. Citare® 2%, particularly following HC 0.5%, both with MO 3.5%, showed promising results. At the green tip stage, HC 0.5% with MO 3.5% caused no phytotoxicity but might compromise the practice's efficiency. Understanding the combined effects of compound types, timing, and application frequency is essential for optimizing chemical-induced budbreak in apple trees.

3:25 p.m.

Control of Apple Trees' Vegetative Growth in Mild Winter Climate Regions

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Apple cultivation in Brazil mainly focuses on Gala and Fuji cultivars and their clones. The chilling accumulation is not sufficient to induce budding and, under these conditions, vegetative growth, even on dwarf rootstocks, is superior to that observed in regions with traditional temperate climates. Thus, growth is prolonged after harvest, increasing pruning labor, promoting greater shading of the plant, and reducing fruitset. Prohexadione calcium (Viviful®) to restrict vegetative growth has become essential and was introduced in apple cultivation in Brazil in the 2000s. However, there was little information at first, with the initial recommendation of one to two applications per cycle, in high doses. With the development of research, several experiments were conducted aiming to improve the timing and concentration of application, not only aiming at controlling growth but also at increasing fruitset. Prohexadione calcium was effective not only in stopping vegetative growth but also in increasing fruitset and yield, with an increase in the red color of the fruits and a reduction in the incidence of Colletotrichum spp. in the Gala cultivar. The results showed greater efficiency with multiple applications at low doses compared to one or two applications at high doses. In both cultivars, there was a reduction in pruned materials that varied between 50 and 80%, depending on the time of application, concentration, and crop cycle. Low dosage application at full bloom increased fruitset and, consequently, yield. The most efficient concentration will be between 110 and 220 grams/ha of Proexadione calcium, varying from two to four applications during the cycle.Results indicate that three to five early foliar applications of GA_3 can improve canopy density and yield. Trees receiving four or five applications showed higher fruit detachment force (FDF), lower fruit abscission, and improved peel integrity. Nonetheless, key quality traits such as total soluble solids and total acidity percentage were unaffected. We also observed a positive correlation between the number of GA_3 applications, peel greenness, and FDF. Overall, multiple GA_3 applications (at least 3) between July 1st and October 1st can improve the yield and minimize fruit drop with minimal impact on internal fruit quality. This research highlights the advantages of early GA_3 sprays for mitigating HLB's adverse effects in 'Valencia'sweet orange production.

8:05 a.m.

KEYNOTE: Current Status of Jasmonates in Fruit Production, Enhancing Fruit Quality and Storage Life: Preharvest and Postharvest Applications

Zora Singh

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Jasmonates including jasmonic acid, and its derivative methyl jasmonate (MeJA), are noticeable signalling compounds employed in fruit production and postharvest phases. MeJA has been extensively investigated over three decades in fruit crops for regulating ripening and mitigating storage disorders. Preharvest application of MeJA regulates ripening, colour development, and improves antioxidants in different fruit crops. Poor and erratic colour development poses a serious threat to several fruit crops grown in the Mediterranean regions around the globe including California, Australia and South Africa. My research group has conducted several studies over two decades and demonstrated that exogenous application of MeJA on different fruit crops such as apples, oranges, plums, persimmons, Rubus berries grown in the Mediterranean climate improved colour and fruit quality. Poor red blush on the fruit surface of 'Cripps Pink' apples causes economic losses to the industry. MeJA application greatly enhances red blush on fruit skin and increases export-grade fruit, and flavonoid accumulation in apple fruit skin without affecting quality grown in different geographical locations. In the M7 Navel orange, the MeJA application three weeks before harvest improved the fruit colour. Preharvest application of MeJA followed by cold storage significantly enhanced the peel and juice colour index in 'Tarocco Ippolito' blood oranges. MeJA also substantially improved fruit colour in 'Yoho' and 'Jiro' persimmons when applied four weeks before harvest. Postharvest MeJA treatments impact ethylene biosynthesis in plums and strawberries, mitigate chilling injury in stone fruits and cold-stored oranges, minimise red drupelet reversion in blackberries and delay raspberry softening in cold storage. In conclusion, MeJA has emerged as a novel plant growth regulator and its preharvest and postharvest applications are beneficial in fruit production, improving quality and extending storage life.

8:35 a.m.

Role of Endogenously Produced Ethylene in Highbush Blueberry (Vaccinium corymbosum) Fruit Ripening

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Blueberries are widely cultivated soft fruits with exponential production in the past two decades, with the United States being their primary market. Ensuring timely market arrival is vital for achieving optimal sales prices, which is often managed by applying plant growth regulators (PGRs). However, selecting the appropriate PGR and timing of application is only possible when the ripening characteristics are well understood. In blueberries, fruit ripening classification is still a debated topic, described variously as climacteric or non-climacteric. While ethylene's role has been mainly studied through exogenous ethephon treatment (an ethylene-releasing compound) at a post-commercial harvest stage, the function of endogenously produced ethylene during ripening remains untested using perception inhibitors such as ethylene antagonist 1-methylcyclopropane (1-MCP) in planta treatment. Therefore, the aim of this study was to investigate the role of endogenous ethylene in blueberry fruit ripening for production management. Gas chromatography analysis revealed that Vaccinium corymbosum interspecific hybrid 'O'Neal' exhibited low emissions levels of ethylene but increased during the fruit coloring and pink stages, paralleling the ripening process. Additionally, in planta 1-MCP treatment delayed fruit ripening by reducing anthocyanin accumulation and preventing acidity loss, without impacting ethylene emission when treated alone or in combination with an ethylene-agonist. Furthermore, transient overexpression assay in fruit of Arabidopsis etr1-1 mutant, a dominant negative allele that confers ethylene insensitivity even under heterologous expression, yielded similar outcomes to the in planta 1-MCP treatment, confirming the role of ethylene in blueberry fruit ripening without involving autocatalytic ethylene biosynthesis. These findings suggest that endogenous ethylene release during blueberry fruit development contributes to ripening but is not autocatalytically regulated as observed in climacteric fruits. This study provides valuable insights for future PGRs use in controlling blueberry fruit ripening.

8:55 a.m.

A Meta-Analysis and Systematic Review of Plant Growth Regulator Use in Blueberry Production

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Plant growth regulators (PGRs) include natural and synthetic plant phytohormones and other substances with the capacity to shape one or more aspects of plant growth and development at small concentrations. PGRs are commonly utilized in tree fruit and table grape production to reduce fruit set and increase fruit size, coloration, and quality. However, use of PGRs in the production of berry crops, such as blueberry, is less common despite the abundance of production issues and the breadth of PGRs generally registered for fruit crops. This meta-analysis and systematic review discuss the past and current literature surrounding PGR use in blueberry production. First, we highlight the lack of products registered and available to use in the production of blueberry relative to its increase in production value over the past decade. Next, we discuss the published literature on PGR use in various blueberry species by production topic, including fruit set, berry mass and plant yield, ripening rate and harvest fruit quality, post-harvest fruit quality, and winter hardiness. Meta-analysis of qualifying PGR and production topic combinations revealed that GA3 and CKs increase fruit set, CKs increase berry size, ABA and GA3 do not influence berry size, GA3 and CKs increase yield, and ABA does not enhance anthocyanin concentration. As global blueberry production continues to expand globally, PGR use will likely increase to address production issues and sustain production and fruit quality.

10:35 a.m.

NAA and ABA Consistently Reduce Bitter Pit Severity in 'Honeycrisp' Apple Fruit

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Apples develop calcium deficiency symptoms when the vascular transport networks within the fruit become dysfunctional. While phloem retains function as fruit mature, xylem does not. In the commercially important cultivar 'Honeycrisp', xylem integrity in the outer cortex is severely compromised by the time fruit reach maturity. This directly limits calcium delivery to the peel resulting in bitter pit (BP), a physiological disorder characterized by necrotic lesions subtending the fruit peel.

Xylem differentiation and maintenance is governed by the action of plant growth regulators. Auxin and abscisic acid (ABA) are particularly important as they are involved in the initial patterning, reinforcement, and maturation of xylem elements. Because of these functions, we hypothesized that whole-tree applications of the native auxin, indole-3-acetic acid (IAA), a synthetic auxin, naphthaleneacetic acid (NAA), and ABA would increase the initial distribution of vascular networks in fruit and/or maintain their function longer compared to untreated fruit or fruit treated with the auxin transport inhibitor, 2,3,5-triiodobenzoic acid (TIBA). Xylem longevity should result in higher peel calcium content at harvest and lower BP. TIBA, in contrast, would be expected to reduce xylem function and calcium concentration and increase BP.

In 2023 and 2024, IAA, NAA, ABA, and TIBA were applied separately to 'Honeycrisp' trees as whole-tree sprays at 30, 45, and 60 days after full bloom, the period in which xylem function begins to decline. Fruit were sampled weekly (bloom to harvest) in 2023 and at select time points in 2024 to quantify mass, xylem functionality, and peel calcium concentration. Fruit were assessed for BP before and after three months of storage in regular air (3^0C).

In 2023, a year where untreated fruit had low BP incidence, NAA and ABA generally improved vascular function relative to the control until 7 weeks after full bloom (WAFB), but this effect did not persist later in the season. NAA and ABA did not improve calcium or BP incidence, but they did reduce BP severity by roughly 50%. TIBA, on the other hand, reduced xylem function from 8-10 WAFB, peel calcium at harvest and, consequently, significantly increased BP. In 2024, a year with markedly higher BP, NAA and ABA significantly improved xylem function relative to the control, especially during the period of rapid xylem dysfunction, i.e., 8-10 WAFB. NAA improved peel calcium concentration throughout the season compared to control, but ABA did not; however, both compounds similarly reduced BP severity by approximately 50%. These data corroborate two previous years (2021 and 2022) of experimentation that demonstrated a marked, positive role of ABA and NAA in the mitigation of BP. They additionally suggest potentially different mechanism of action for ABA and NAA in BP mitigation.

10:55 a.m.

Effects and Interactions of Aminoethoxyvinylglycine and Acibenzolar-S-Methyl on Stem-End Splitting and Glomerella Leaf Spot on Apple

Christopher Clavet, Thomas Kon, Sara Villani, Aaron Weber

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Stem-end splitting of apples is a recurring physical defect that can fluctuate annually in incidence and severity. Interventions to prevent or reduce this defect have been inconsistent. Aminoethoxyvinylglycine (AVG) is an ethylene biosynthesis inhibitor primarily used as a harvest aid to delay maturity. Based on previous research, applying AVG pre-harvest can significantly reduce stem-end splitting of apples. An additional consideration in extending the harvest period in apple production areas with a humid, sub-tropical climate is management of glomerella leaf spot (GLS; Colletotrichum spp.). GLS is a serious and economically devastating fungal pathogen with the potential to cause premature defoliation and unmarketable fruit. Acibenzolar-S-methyl (ASM) is a host defense response inducer that can elicit systemic acquired resistance (SAR) in plants. Current research regarding ASM applications proximal to harvest on apple is limited. We evaluated the effects and interaction of AVG and ASM on fruit quality, stem-end splitting, and GLS severity in apple. Experiments were conducted at the Mountain Horticultural Crops Research and Extension Center in Mills River, NC, USA in 2024. A block of mature 'Banning Gala'/ 'M.9 RN-29' planted 0.9 x 4.0 m and trained to tall spindle was used for fruit quality and stem-end splitting evaluations while a mature block of 'Gala'/ 'G.41' planted 2.4 x 6.0 m trained to central leader was used for disease ratings and leaf area index. Treatments included AVG (66 mg·L-1) and ASM (75 mg·L-1) applied alone and in combination compared to an untreated control. A CO2 sprayer calibrated to apply 935 L per hectare was used to apply all treatments. The experiment had a completely randomized design and a 2 x 2 factorial treatment structure with five replications. AVG was determined to be the main factor for fruit quality and splitting; however, the combination significantly reduced GLS severity warranting continued research to determine if this effect is consistent.

11:15 a.m.

Effect of Different Spray Strategies of 1-Aminoethoxyvinylglycine on Pre-harvest Fruit Drop and Fruit Quality of Apples

Bruno Carra[1], Maximiliano Dini[1], Poliana Francescatto[2], Cecilia Martínez[1], Pablo Montaldo[1], Pablo Rodríguez[1]

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1-Aminoethoxyvinylglycine (AVG) is widely used by apple growers to prevent pre-harvest fruit drop and delay fruit maturity by decreasing ethylene production rate. Depending on the objective of the grower, fruit destination, or variety, AVG can be applied at different timings and rates: high, reduced or split rates. The development of new spray technologies has enabled farmers to target specific areas as needed, reduce costs and minimize environmental impact, while also improving efficiency and safety. Electrostatic low-volume sprayers for instance, are designed to help growers increase the efficiency of work (spraying a bigger area with a single load) and reduce the amount of commercial product used. However, when using plant growth regulators (PGRs) these technologies can be challenging as most of the PGRs are typically measured in parts per million (ppm), and recommended rates vary widely depending on the specific PGR, mode of action, translocation and plant species. Therefore, the aim of this study was to evaluate the performance of AVG on pre-harvest fruit drop and fruit quality attributes when I) targeting the different parts of the tree canopy; and II) using an electrostatic low-volume sprayer at different rates. The studies were performed in two apple orchards: I) ´Early Red One´ (Red Delicious type variety) and, II) ´Rosy Glow´ (Cripps Pink type variety). Treatments in the first study consisted of an untreated control, 125 mg L-1 of AVG sprayed to the upper part of the canopy or the same rate sprayed to the entire tree; 14 days before predicted harvest. In the second study, treatments consisted of untreated control; 125 mg L-1 of AVG (830 g ha-1 of the commercial product ReTain) sprayed with an standard airblast sprayer (1000 L ha-1); or different AVG rates sprayed with an electrostatic low volume sprayer (300 L ha-1) with 0 , 35 or 70% of commercial product reduction per hectare (417, 270 or 125 mg L-1 of AVG, respectively). All treatments in the second study were applied at 21 days before predicted harvest. Pre-harvest fruit drop and fruit quality parameters were assessed in all studies. When AVG was applied only to the upper canopy, the effect was greatest in this part, having little or to some extent an effect in the lower part of the tree. The advantage of this strategy is that AVG can delay harvest of the upper part and allow growers to spot pick the bottom of the tree at the normal harvest time and strip off the whole tree in the second pick, potentially reducing labor costs and bruising caused by the picking ladder. When testing different spraying technologies, all AVG treatments reduced fruit drop and improved fruit quality compared to the untreated control. However, the best results were achieved when AVG was sprayed either with the airblast sprayer at full rate of commercial product in 1000 L ha-1 or with the electrostatic low-volume sprayer at full rate of commercial product in 300 L ha-1.

11:35 a.m.

Optimizing Fruit Size, Quality, and Profitability of Pears With Preharvest Application of AVG

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As with many other fruit crops, fruit size is one of the most important quality parameters that determine market returns in pears. Increased fruit size is often related to lower crop loads, however reduced yield may lead to lower income if not managed adequately. Fruit size can also be optimized by delaying the ripening process of the fruit as the fruit has more time for cell expansion and growth, therefore leading to higher yields. During the final stage of fruit growth, pears can experience growth rates ranging from 2.5 to 10 g/day, depending on the variety. Thus, the aim of this study was to evaluate the optimum timing and effectiveness of field applications of the ethylene synthesis inhibitor AVG (ReTain®) on fruit size, fruit drop, and fruit maturation of the pear cultivar 'Abate Fetel'. A rate of 125 mg/L of AVG was applied at different maturity stages based on fruit firmness: 17, 15, or 13 lbs. AVG applied at 17 lb fruit firmness (~4 weeks before harvest) provided the best response in regard to all fruit parameters. There was no effect on fruit skin color, fruit drop was reduced to 3% compared to 10% in the control, and firmness loss was delayed by 5 to 6 days. Fruit weight was increased by 9%, which consequently resulted in 9% more yield. This treatment had no negative effects on postharvest quality (after 45 days) or shelf life (7 days at 20°C) in terms of delay of yellow coloration, starch content, or softening inhibition. Additionally, no AVG residues were detected on the fruit when harvested at 17 and 15 lbs, but residues were detected at 13 lbs. Considering the benefits of this treatment, the return on investment or profit (the difference between the crop value and AVG application cost) ranged from approximately $2,000 to $3,000 USD, suggesting that the use of AVG would be profitable under the conditions evaluated.

11:55 a.m.

Preharvest Plant Growth Regulator Effects on Flesh Firmness of Stored Apple Fruit

Christopher Watkins

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The preharvest plant growth regulators (PGRs), aminoethoxyvinylglycine (AVG; ReTain) an inhibitor of ACC synthases in the ethylene biosynthetic pathway, and 1-methylcyclopropene (1-MCP, Harvista) an inhibitor of ethylene perception, are widely used by North American apple industries. The initial focus of PGR use was primarily on delaying preharvest drop. However, their use has become critical for management of harvest, especially given overlap of optimal harvest periods of high value cultivars. In addition, PGRs can reduce the incidence of storage disorders such as flesh browning of Gala. Less appreciated are the effects of PGRs on flesh firmness of fruit during storage, in part because of the emphasis on postharvest 1-MCP. In this presentation, the effects of PGRs of flesh firmness will be presented from three perspectives: 1) an overview from the literature; 2) assessment of the timing of PGR application before harvest on firmness; and 3) the effects of PGRs on controlling cold induced ethylene production, and subsequently increased softening, of cultivars such as Gala.

1:45 p.m.

KEYNOTE: Enhancing Fruit Shelf Life and Quality: From Ripening Fundamentals to Postharvest Fruit Excellence

Islam El-Sharkawy

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Understanding the fundamental mechanisms underlying climacteric, suppressed climacteric, and non-climacteric fruit ripening provides a strong foundation for innovative breeding strategies to enhance horticultural crops' shelf life and quality. Climacteric fruits experience a dramatic rise in respiration and ethylene production at the onset of ripening, processes governed by specific genes involved in ethylene biosynthesis and signaling. Targeted breeding and genetic engineering approaches, including the modulation or suppressing key ethylene-related genes, can delay ripening, extend fruit firmness, and reduce spoilage while preserving important sensory qualities such as flavor, color, and texture. Suppressed climacteric fruits, which produce less ethylene and exhibit slower softening, represent valuable breeding targets for intermediate shelf life improvement. Breeders can leverage fruit mutations and manipulate hormonal regulators to balance shelf life longevity and desirable eating qualities. Integrating multi-omics tools, such as genomics, transcriptomics, and metabolomics, accelerates the discovery of genetic determinants underlying ripening and shelf life, enabling precise marker-assisted selection and the creation of cultivars with improved postharvest performance while maintaining desirable sensory qualities. This comprehensive, knowledge-driven approach to breeding ultimately enhances fruit marketability and helps minimize postharvest losses.

2:15 p.m.

ReTain and Harvista Effects on Maturity and Interactions With Postharvest 1-MCP on Storage Quality of 'Honeycrisp' Apples

Christopher Watkins, Jaqueline Nock

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The 'Honeycrisp' apple is a major apple in the USA, being popular with consumers and highly profitable for growers. However, the cultivar is susceptible to a range of physiological disorders that can result in economic losses. The use of the preharvest plant growth regulators ReTain (aminoethoxyvinylglycine) and Harvista (1-methylcyclopropene; preharvest 1-MCP) is common, but there is concern about the effects of these treatments on fruit quality, especially on the incidences of physiological disorders. In a two-year experiment, an orchard block of 'Honeycrisp' apples in each of the Hudson Valley, western New York and Champlain regions of New York were untreated, or treated with ReTain or Harvista. Harvested fruit were either untreated or treated with postharvest 1- MCP and stored in air or controlled atmosphere (CA). ReTain and Harvista delayed fruit drop and color development. Ethylene production of the fruit was inhibited, as were starch indices and flesh firmness, although not consistently so. Little effect of preharvest treatment on firmness, soluble solids concentration (SSC) and acidity after storage was detected. CA stored fruit were superior to air stored fruit, but preharvest treatments sometimes increased risk of carbon dioxide injuries in CA storage. 1-MCP treated air stored fruit had higher titratable acidity, SSC, and lower greasiness than untreated fruit, and quality characteristics were similar to those of CA stored fruit.

2:35 p.m.

Early Application of Ethephon, ACC, Dichlorprop-P and Trichlopyr Acid to Enhance the Red Coloration of 'Brookfield Gala' Apples

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'Brookfield Gala' apples in warm summers often develop a poor color at commercial harvest, resulting in economic loss. To determine if fruit color could be improved without reducing storage ability, 'Brookfield Gala' apple trees were sprayed with two direct precursors of ethylene (ethephon and ACC) and two synthetic auxins (dichlorprop-P and triclopyr) at 60 days after bloom (DAB). All treatments increased the rate of endogenous ethylene production by the fruit. This was accompanied by a higher percentage of red blush at harvest, without causing the fruit drop that is usually associated with increased levels of ethylene. Additionally, all treatments accelerated fruit maturation and decreased fruit firmness at harvest. However, no negative effect on fruit firmness or other postharvest attributes were observed after 6 months of storage at 0 ºC and 5 or 10 days of shelf life. Therefore, the tested compounds sprayed at 60 DAB represent effective treatments to improve the color of 'Brookfield Gala' apple at commercial harvest, without adversely affecting fruit storage attributes.

2:55 p.m.

ACC for Red Colour Improvement of Bi-Colour Apples

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Fruit surface colour development, as well as colour intensity, determine the market value of bi-colour apples. This market value is especially important for the South African apple industry, as most apples are exported to international markets with strict quality requirements and customer preferences. As apples are grown in a Mediterranean-type climate in South Africa, colour development can be problematic. Several environmental factors viz., light distribution and intensity as well as temperature contributes to red colour development. Different management strategies, improving aforementioned factors, such as pruning, partial defoliation and installation of white reflective woven mulches and overhead evaporative cooling have been evaluated. Apart from environmental factors, fruit ripening is also associated with red colour development. We evaluated the effect of the ethylene precursor, 1-aminocyclopropane-1-carboxylic acid (ACC), on red colour development over two seasons on bi-colour apple cultivars in the Elgin region of South Africa. The cultivars used were 'Cripps' Pink' and 'Rosy Glow'. ACC improved red colour development of 'Cripps' Pink' apple when applied 14 days before estimated harvest at rates of 224, 336 and 448 µL·L-1 ACC. In addition, ACC applied 14 days before estimated harvest at 112, 224 and 448 µL·L-1 increased the proportion of fruit with adequate colour development in 'Rosy Glow' apple. In both trials fruit maturity was accelerated by ACC applications. However, this accelerated fruit maturity was counteracted with a postharvest application of 1-methylcyclopropene (1-MCP).

3:15 p.m.

The Effect of 1-Aminocyclopropane-1-Carboxylic Acid (ACC) on Color Development in Apple Fruit

Jozsef Racsko, Poliana Francescatto

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1-aminocyclopropane-1-carboxylic acid (ACC) is the immediate precursor of ethylene in plants. It has been established that ethylene plays a role in anthocyanin accumulation and thus color development in red and bicolor apple varieties. The objective of this study was to investigate the effect of preharvest foliar applications of ACC on fruit quality focusing on color development in apple. In a series of field experiments in Washington State, we evaluated the effects of rates and timings of ACC applications in 'Buckeye Gala', 'Honeycrisp', 'Cosmic Crisp' and 'Pink Lady' varieties. Results indicated greatest benefit of ACC application on color development in apple fruit two to three weeks before harvest. Optimum color development and fruit quality at harvest were achieved with 200-300 mg/L ACC concentrations. Varietal differences were also observed, 'Buckeye Gala', 'Cosmic Crisp' and 'Pink Lady' being responsive to ACC applications, while 'Honeycrisp' showed very limited color improvement after ACC application. Effects of ACC on other fruit quality parameters of above apple varieties will also be discussed.

3:55 p.m.

Effect of Near-Infrared Light Irradiation on Maintaining Freshness of Post-harvest Fruits and Vegetables After Refrigeration and Transportation

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The freshness of fruits and vegetables decreases after harvest, and the decrease in freshness is accelerated by low temperature damage caused by refrigeration and damage caused by sorting and transportation. On the other hand, iR FreshTM, a freshness preservation technology using near-infrared (NIR) light irradiation, has been shown to inhibit damage and mold on a variety of fruits and vegetables. As a result of investigating the effects of NIR light irradiation on damage caused by refrigeration and vibration during transport, it was observed that it inhibited fruit decay and maintained fruit firmness in Satsuma mandarins, tomatoes, and peaches.To investigate the mechanism of the freshness-preserving effect of NIR light irradiation, we performed RNA sequencing (RNA-Seq) analysis on the effects of refrigeration and vibration using 'Shimizu Hakuto' peaches, and compared genes that were increased by more than two-fold in the NIR light irradiation compared to the non-irradiated on the KEGG pathway. The results showed that the genes for pathways related to antioxidant, antibacterial, fungicidal, and plant defense were increased in NIR light irradiated peaches during cold storage, and genes for pathways related to plant defense, structural maintenance, and survival were increased during cold and vibration. Genes related to pathways that strengthen the cell wall were increased in normal temperature storage, and genes for pathways involved in metabolic pathways that protect cells from oxidative damage were increased in normal temperature and vibration. These results suggest that NIR light irradiation may inhibit oxidative damage, injury, and mold development in fruits and vegetables after harvest during refrigeration and transportation.

4:15 p.m.

Preharvest and Postharvest Applications of Hexanal: A Promising Approach to Enhance Fruit Quality and Extend Shelf Life

Ayse Oz

4:35 p.m.

1-MCP Dose-Response in Apples: Effective Doses Can Be Applied in Minutes or at Concentrations Below the Limits of Detectability

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1-Methylcyclopropene (1-MCP) has been used commercially in both pre- and post-harvest applications at various concentrations to preserve the quality attributes of produce by inhibiting ethylene action. In most applications, it is released as a gas from cyclodextrin powder formulations, which requires dissolution in water to free the encapsulated 1-MCP. Recently, several companies have begun developing and implementing alternative 1-MCP delivery systems, which include powder, effervescent tablets, sachets, water-sensitive sheets, and stickers. While some of these technologies promised to provide a slower or prolonged release of 1-MCP, the actual concentrations used in apple storages are not reported. Furthermore, data on continuous doses is rare and there is nothing in the literature with regards to storage treatment levels associated with these emerging technologies. In this study, we applied 1-MCP in two ways: as single, 'overnight' doses at concentrations of 0, 5, 50, 100, and 1000 ppb for 24 hours (ranging from the commercially recommended 1000 ppb down to our gas chromatograph detection limit of 5 ppb), and as continuous exposure at 0, 1, 5, 10, 20, 50, and 100 ppb for 14 days. We also tested very high concentrations of 1-MCP (10 and 100 ppm) for short durations 6 seconds to 24 hours. Surprisingly, we found that even very low levels of 1-MCP can effectively slow or delay apple ripening when applied continuously for an extended period. In contrast, very high levels of 1-MCP were found to be impactful in as little as 30 seconds exposure. Our findings suggest that plant physiological responses to prolonged low-level 1-MCP exposure are not yet fully understood and may open a new era for treating a wider range of commodities.

4:55 p.m.

Factors Affecting the Release and Delivery of 1-MCP

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The concentration of 1-MCP applied in the postharvest environment is a function of the release rate, the sorption by the target product and sorption by off target materials. In this report, the diverse release kinetics of various 1-MCP releasing products is described, the sorption by and competition between fruit for the 1-MCP molecule, and the types of materials found in treatment facilities that have the potential to sorb or destroy 1-MCP, including wood, cardboard, plastic and copper. Our evaluation of current or recently available 1-MCP releasing materials reveals that most deliver the promised amount of 1-MCP, although several do not. Some described as slow release are not slow release or are slow under some circumstances and rapid under others or have a release profile that has aspects of both rapid and slow release. The 1-MCP released has two destinies, either sorption by the product or sorption by (or loss to) other materials in the treatment environment. Competition between fruit for the existing pool of 1-MCP resulted in a minor loss in the headspace concentration. More important is the loss of 1-MCP to the environment (i.e., loss from the box in "in-box" treatments and sorption or destruction by non-target materials. Cellulose based materials (cardboard and weathered wood) rapidly absorbed 1-MCP. Copper, copper oxides, and other metals were also found to reduce the 1-MCP treatment concentration. Some 1-MCP breakdown products were tentatively identified. The potential impact of the various components of release, loss, and sorption are to be discussed.

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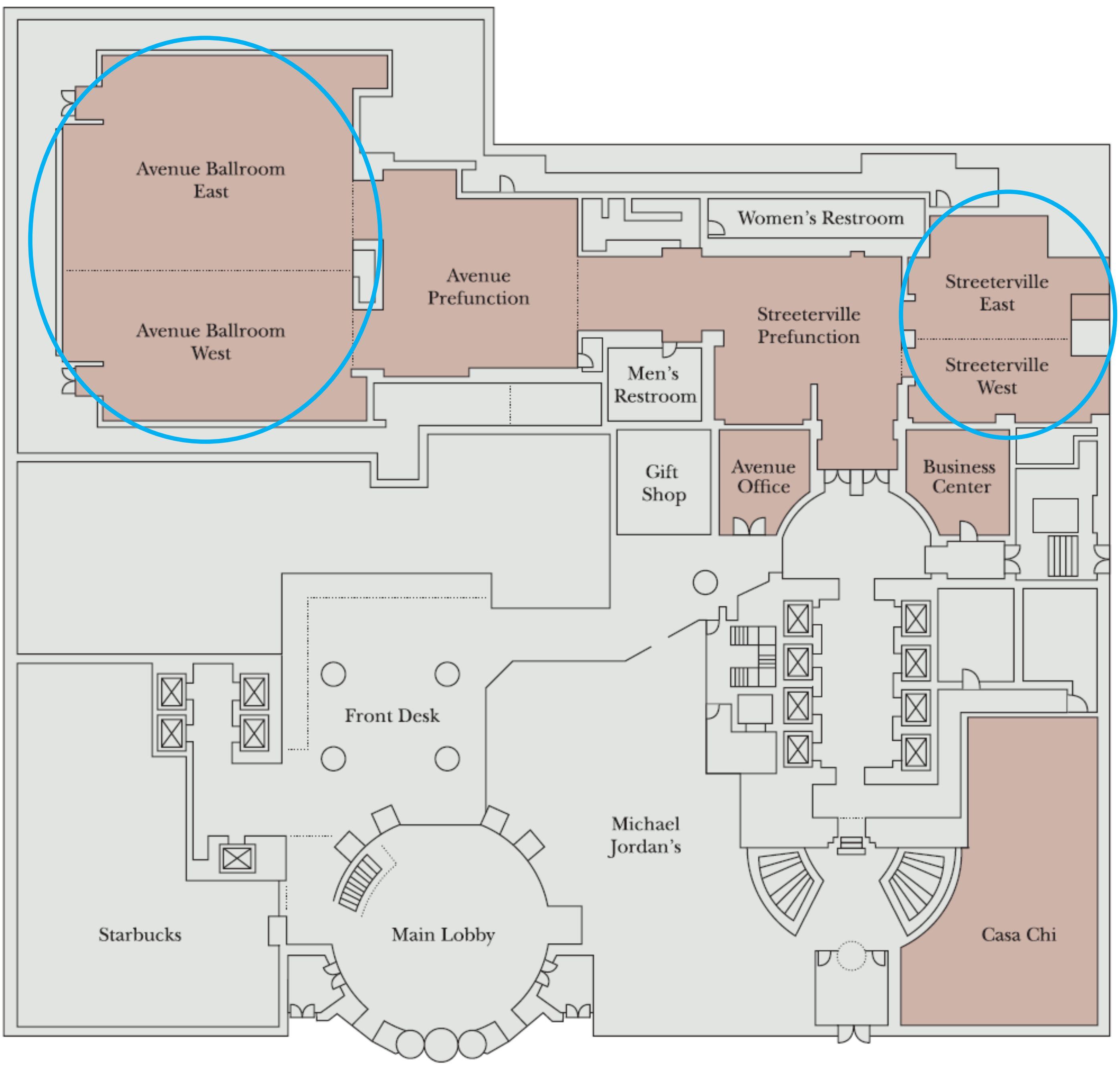
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