Travel Report:
Visit to USA

May 2025

HORTGRO
Growing Fruit IQ

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1. Executive summary

A South African delegation visited Washington State and Oregon in May 2025 to strengthen research collaboration, gain insights into international best practices in entomology and postharvest management, and attend the XIV International Controlled Atmosphere (CA) and Modified Atmosphere Conference in Wenatchee, WA. The programme included entomology-focused visits, participation in a major international research conference, and technical tours of leading US packhouses, orchards, and research facilities.

1. Entomology & Phytosanitary Outcomes

Renate Smit visited USDA-ARS facilities in Wapato and Oregon State University to benchmark insect-rearing systems and explore collaboration opportunities.

Key insights:

- USDA shared protocols and diets for codling moth, brown marmorated stink bug, and other pests.
- New rearing-room design concepts—cleaner, safer, more efficient—will inform upgrades at PHYLA.
- OSU's SWD work showed challenges with large cage systems, confirming the strengths of PHYLA's smaller, contained rearing systems.
- Industry interest in ozone for decay and pest management is increasing, especially for organic packers.
- USDA expressed interest in collaborating on fumigation research, particularly due to staffing gaps after retirement of their phytosanitary specialist.

2. XIV International CA & MA Research Conference

- The South African team presented multiple Hortgro Science–funded research projects and attended cutting-edge sessions.

Major themes:

- Complex cultivar-specific responses to CA, DCA, and 1-MCP require tailored storage strategies.
- Advances in energy-efficient storage include EC fans and the potential to combine DCA with 1-MCP at higher temperatures.
- Preharvest conditions, tree vigour, crop load, and growing region strongly influence storage disorders such as internal browning and CO_2 injury.
- X-ray CT and new modelling tools are improving prediction of storage potential and injury risk.
- Highlight: MSc student Daniela Ramos won the ISHS Young Minds Award for Best Oral Presentation.

3. Insights from Washington State Packhouses and Orchards

- Visits to McDougall & Sons, Stemilt, Borton & Sons, and Gilbert Orchards demonstrated highly automated operations supported by low-cost hydroelectric power and large-scale, integrated supply chains.

Postharvest practices:

- Stemilt uses 0% O_2 storage for organic Granny Smith to manage bitterpit, rapid cooling protocols for Honeycrisp, and cultivar-specific CA regimes.
- Large-scale CA facilities (up to 2000 bins/room) use extensive monitoring, powerful fan systems, and dedicated research CA rooms.
- Strella sensors (Agrofresh) are increasingly used to guide room-opening decisions in 1-MCP-treated fruit.

Production practices:

- Orchards (200–500 ha) are fully mechanised, with picking platforms, automated spraying tractors, and night harvesting during high-temperature periods.
- Desert climate supports organic production but creates challenges with sunburn, wind, and chilling of early-spring orchards.
- Wind screens, V-trellises, overhead cooling irrigation, and strict weed control are integral to orchard management.
- Labour costs are high ($17–25/h), but reliance on guest workers is strong (≈95%).

4. Collaboration Opportunities for South Africa

- Joint research with USDA-ARS on superficial scald markers, fumigation, and CA-related fruit responses.
- Adoption of the Wenatchee research model: small-scale trials followed by semi-commercial testing in industry CA rooms.
- Application of insights from US packhouse design, CA monitoring, and orchard mechanisation to strengthen South African industry competitiveness.

2. Objectives of the visit:

- To **visit entomology rearing and research facilities in Washinton state and Oregon** (Renate Smit only)
- **To build relationships** with researchers, technical experts, and industry members in various government and academic institutes involved in entomological and phytosanitary research in Washington state and Oregon. (Renate Smit only)
- To **attend the XIV International Controlled Atmosphere and Modified Atmosphere Research Conference in Wenatchee, WA** to stay abreast of the newest developments in the field of controlled atmosphere storage and modified atmosphere packaging.
- To **visit postharvest facilities in the Wenatchee region** to familiarise ourselves with their research and postharvest practices on pome fruit.
- **To build relationships** with researchers, technical experts, and industry members in Wenatchee.

3. Touring party members:

- Mariana Jooste (Hortgro)
- Renate Smit (Hortgro)
- Elke Crouch (Department of Horticultural Science, Stellenbosch University)
- Daniela Ramos (Department of Horticultural Science, Stellenbosch University)
- Anél Botes (ARC)
- Adriaan Theron (CFG)
- Braam Mouton (Dutoit Agri)
- Jaco Moelich (Fruitways)
- Kenias Chigwaya (Fruitways)

4. Entomological and phytosanitary focused visit

(Renate Smit)

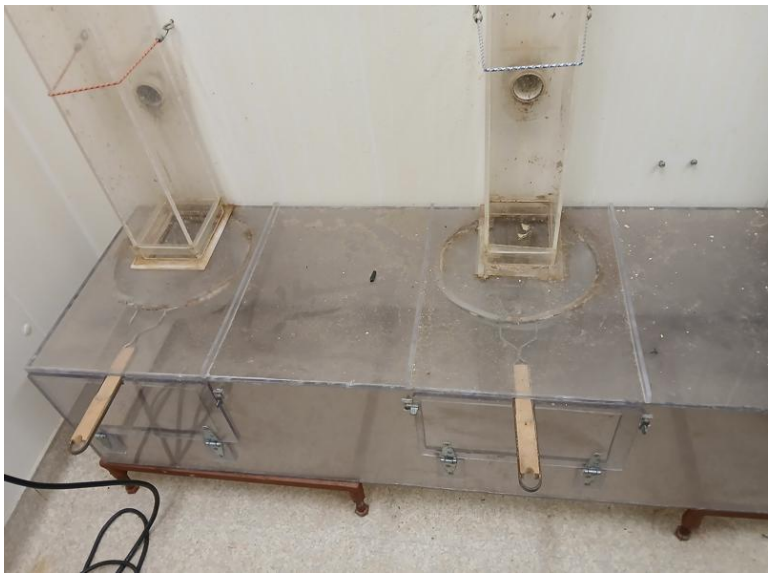
9 – 17 May 2025

Main objectives for visits to USDA and Corvalis:

- Examine rearing facilities at both facilities and examine how/if they differ from PHYLA?
- If their systems are improvements on what we are currently using at PHYLA what do these systems entail? (Based on infrastructure, rearing diets and methods).
- Rearing practices of specifically codling moth and marmorated stink bug
- Research focus of the USDA facility (currently) and what could potentially be ideas for future projects at PHYLA.
- Problem insects that stakeholders in Washington state are currently struggling with.
- Engage and network with Industry partners (pome fruit and cherries) in Yakima on postharvest research such as fumigation and ozone currently being examined at PHYLA.

The ARS Facility in Wapato currently has various projects on codling moth, but on a molecular level with CRISPR work being the main focus at the moment. Due to a shift in research focus/funding the mass rearing of codling moth was scaled back from previous visits. The previous system (which is currently not operational) definitely provided insight into a new design we could use for mass rearing when rebuilding rooms at PHYLA 2. The design ideas would enable us to have a cleaner working environment for the staff and insects.

The images below are examples of the system that was used for codling moth rearing, whereby insects would fly into these chambers directly for easy collection and cleaning.



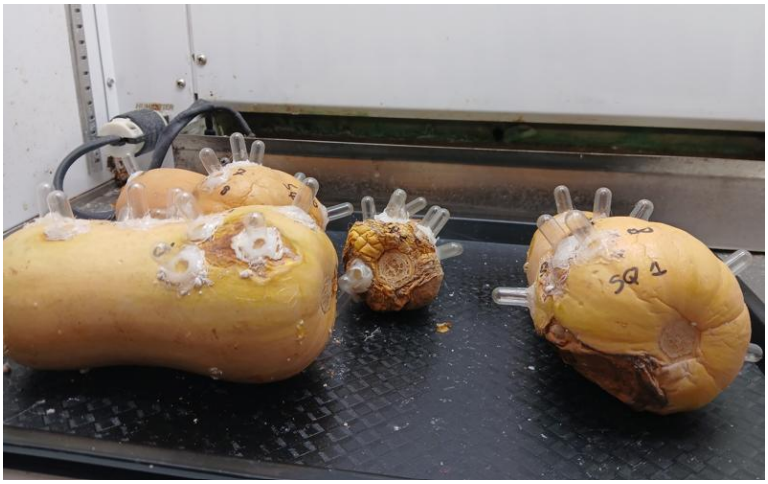
The diet they use for mass rearing has also been modified to exclude the use of formaldehyde which we have also been trying to reduce, due to health and safety concerns. Their process of "cooking" the diet also provided an alternative method (using an autoclave), which we could potentially implement rather than "cooking" the diet using LP gas

As Washington state produces a lot of cherries, little cherry fruit disease is one of the big focus areas for researchers currently. It is a viral disease that is primarily spread by insect vectors and currently infected trees are removed to prevent the spread. Insects such as leafhoppers are transmitting the disease through their feeding process.

Information gained from USDA visit:

- Protocols for rearing and diet recipes for various insects such as codling moth and marmorated stink bug were shared.
- Protocols or operating procedures for rearing of specifically codling moth and brown marmorated stink bug would be useful in future.
- Dr Cooper expressed an interest in collaborating with fumigation research we are conducting as their Post harvest researcher (Dr Neven) has recently retired and alternatives for methyl bromide are essential. Due to hiring freeze he does not know when they will be able to refill her position at the facility.
- Visiting Corvalis enabled me to see the facilities and systems they use to rear spotted wing drosophila. They use a large cage system which differs from the system currently being used at PHYLA. They struggle with insects escaping and infecting other colonies in the same laboratory, one of the experiments they had running with another insect species failed as SWD contaminated the cage resulting in the collapse of the colony in that cage.

The image below is of mealybugs reared on butternut, very similar to our methods except for the addition of the centrifuge tubes to inoculate butternuts with.



Information gained from Corvalis visit:

- System/protocols we use at PHYLA are more efficient in reducing the risk of insects escaping.
- Rearing in smaller more contained manner enables us to ensure/control the age of the flies and larvae more effectively than the mass cage system they use.

Currently pre-harvest research is the main focus for monitoring and control of SWD.

Discussions with industry members involved in packing organic apples regarding ozone are ongoing. With the loss of chemicals for commercial packhouses and the limitations of what organic packers can use has raised the question again of the potential of ozone (as fumigant or in water) to control or reduce decay.

5. XIV International Controlled Atmosphere and Modified Atmosphere Research Conference

18 – 22 May 2025

Event	XIV International Controlled Atmosphere and Modified Atmosphere Research Conference
Convenor	Dr Carolina Torres, Washington State University
Local Organising committee	Dr David Rudell (USDA-ARS), Dr Rene Mogollon (Washington State University), Dr Ines Hanrahan (Washington Tree Fruit Research Commission)
RSA participants	Mariana Jooste, Renate Smit, Elke Crouch, Danieal Ramos, Adriaan Theron, Braam Mouton, Jaco Moelich, and Kenias Chigwaya.
Programme	The symposium spanned 4 and a half days and featured 50 presentations including 5 keynote sessions. On Tuesday, 20 May, we had a technical tour to McDougall & Sons packhouse and CA stores and Stemilt in Wenatchee, WA.
Presentations on Hortgro Science-funded projects by RSA participants	• Mariana Jooste:' *Oxidative metabolism associated with superficial scald development in 'Granny Smith' apples*' • Elke Crouch: '*Superficial scald inhibition treatments and their ethylene-dependence in symptom expression on 'Granny Smith' apples*' • Anél Botes: '*The effect of delayed cooling and delayed CA establishment on internal browning and fruit quality of 'Fuji' apples*' • Daniela Ramos: '*Dynamic controlled atmosphere – chlorophyll fluorescence (DCA-CF) and controlled atmosphere (CA) in long-term storage of 'Cripps' Pink' apples with special reference to internal browning*' • Kenias Chigwaya: '*Long-term storage of 'Fuji' apples and characterization of different internal browning types using X-ray computed tomography*'
Poster on Hortgro Science-	• Anél Botes: 'The Effect of Stepdown Cooling on Internal Browning and Fruit Quality of 'Fuji' Apples'

funded projects by RSA participants	
Noteworthy and interesting presentations	**Keynotes** • Holding their breath: how innovative controlled atmosphere storage technologies keep pome fruit pristine (or not) – Bart Nikolai o Research shows that pore formation in fruit begins when cell division transitions to cell enlargement, triggered by hypoxic conditions from high respiration and low oxygen diffusivity. o Apples form pores through enzymatic cell breakdown (lysigenous), while pears form them by physical cell tearing (schlerenchymatous), with both involving cell wall degradation and changes in programmed cell death. o Questions remain about whether CO_2 cavities result from pore formation malfunctioning, and whether porosity can predict storage potential. X-ray CT can measure porosity, and current evidence suggests pears from warmer areas are less prone to CO_2 damage, though regional and seasonal effects are still unclear. • Dynamic Controlled Atmosphere Storage – A USA Perspective on Challenges and Opportunities – Chris Watkins o DCA and CA storage combined with 1-MCP generally improve fruit quality, but some newer apple cultivars require a small amount of ethylene, making suppressants sometimes detrimental. o ReTain showed strong benefits, with lower browning at specific oxygen levels and temperatures, and PGRs plus 1-MCP proved effective when applied correctly. o Responses to DCA and 1-MCP vary widely among new cultivars, influenced by harvest maturity and growing conditions, meaning each cultivar behaves almost like a new fruit type. • Target atmospheres for the storage of blueberry fruit: what should we expect in terms of decay control and physiological impacts – Randolp Beaudry o To ensure the best blueberry quality and shelf-life, cooling must begin within two hours after harvest, with fruit cooled to 0 °C, and relative humidity kept above 95% to limit decay and moisture loss.

	○ Stem scars, bloom preservation, plastic packaging, and polymer choice all play key roles in reducing water loss and preventing condensation issues, while pallet wraps with added CO_2 can further limit fungal growth. ○ Elevated CO_2 levels (>6%) reduce decay but also lower firmness and internal quality, making careful monitoring essential, while SO_2 fumigation and low-dose X-ray treatments effectively suppress fungal decay and certain pests. ○ Ultimately, strict temperature control, proper RH management, and selective use of fumigation or controlled atmospheres are critical for maintaining fruit quality. • Reduction of energy use during pome fruit storage – Bart Nicolai ○ Global warming will increase the energy demand for refrigeration, and since fans are the largest heat source in cold stores, studies focus on improving fan efficiency. Installing Electronically Commutated (EC) fans achieved 30–50% energy savings, while raising evaporator and room temperatures improved system efficiency but also increased respiration heat, negatively affecting fruit quality unless mitigated by 1-MCP or DCA. These treatments reduced respiration, improved firmness and colour, and decreased scrubbing needs, though they may raise risks like browning and cavity formation. Computational fluid dynamics highlighted the importance of preventing short air circulation with proper room filling, flaps, and spoilers at the fans for uniform air distribution, and rapid postharvest cooling was recommended to reduce energy costs from prolonged removal respiration heat. **Presentations** • Dynamic Controlled Atmosphere (DCA) storage of Conference pear retains background color better than normal CA storage ○ RQ ≤ 1.3 is optimal for Conference pears, but an RQ ≥ 1.3 is not recommended for the cultivar. • Metals in the CA room can degrade 1-MCP – Randolph Beaudry ○ Aluminum is the preferred material for CA rooms using 1-MCP, as copper tubing accelerates depletion, otherwise requiring longer or higher-dose applications. • From recorded Controlled Atmosphere chain conditions to model predictions for remaining storage life - Leo Lukasse ○ Work was done on 150 containers of avocados. Cultivars were mixed in a container.

	○ www.shelflifecalculator.nl • Refrigeration system effects on apple fruit conservation, mass loss and in-situ metabolism activity during CA storage– Daniel Neuwald ○ Research showed that using R744 as a coolant resulted in lower temperatures, more stable humidity, and reduced mass loss compared to R290, with the highest mass loss occurring in the middle row of the cold room. • Progress towards understanding the link between preharvest factors and controlled atmosphere related storage disorders for apple fruit- Jason Johnston ○ Cooler growing conditions, rapid postharvest ripening slowdown, and high CO_2 increase IB incidence, while higher crop loads reduce it, likely by altering fruit membrane lipid composition. • Cuticular wax content and fatty acid composition of 'Fräulein' apples under different storage methods – Daniel Neuwald ○ ULO and 1-MCP inhibit lipid production and membrane remodeling (with 1-MCP possibly disrupting hormone-driven ester synthesis), while DCA storage supports refined membrane remodeling and preservation. • Effects of low oxygen on storage disorders in 'Honeycrisp' apples– Jennifer DeEll ○ 'Honey Crisp' apples are prone to chilling injury, CO_2 damage, bitterpit, lenticel breakdown, and other storage disorders, with 1-MCP worsening CO_2 injury and DPA helping to control it. Conditioning at 10 °C for 1 week and low O_2 storage (3% O_2, 1.5-3% CO_2) at 3 °C can reduce some defects, but they also introduce other problems, making this cultivar very challenging to store. • Synergy of dynamic controlled atmosphere and 1-MCP application in preserving apple fruit quality at elevated storage temperatures in response to rising energy costs – Daniel Neuwald ○ Their research found that storing fruit at 1 °C doubles storage life compared to 5 °C, but requires 1.5 times more energy for refrigeration, while higher temperatures accelerate ripening yet reduce evaporator icing and defrosting energy use. ○ They also showed that DCA combined with 1-MCP can slow metabolism and may allow storage at 5 °C without compromising fruit quality, depending on the cultivar.

	• Recovery of ester production following simulated DCA storage with and without 1-MCP treatment– Randolph Beaudry o Low-oxygen storage is mainly used to manage ethylene, but while high CO_2 has little impact on fruit aroma, low O_2 strongly affects it during long-term storage, especially with DCA+1-MCP. • Controlled atmospheres improve postharvest quality of Regina cherries depending on maturity stages – Victor Escalona o Lapins, Santina, and Regina are Chile's main cherry cultivars, and studies showed that CA storage (5% O2/12% CO2 or 7% O2/15% CO2) was more effective than perforated bags, with Regina cherries stored at 0 °C for 35 days plus 3 days at 10 °C showing the lowest incidence of IB. o However, cherries should not be stored longer than 45 days, as this leads to very high IB incidence, while storage for 42 days at 0 °C plus 3 days at 10 °C resulted in low decay. • Evaluating Cold Chain Scenarios, Including Controlled Atmosphere Storage, to Optimize Sweet Cherry Quality – Gabriela Bolanos o In Washington State, cherries are commercially pre-cooled to below 4 °C and stored at -1 to 0 °C with high humidity, often using CA storage or MAP bags to regulate gas concentrations and reduce respiration. o In their trials fruit were hydrocooled to 0 °C and stored under different regimes, with the low CA treatment (1% O_2, 1% CO_2) showing the best pedicle condition and lowest weight loss after 30 days. o Although compression values increased over time and pitting was more pronounced in H2 fruit, harvest maturity had little effect after 45 days, and overall, the low CA regime proved most effective. • From pollination to postharvest conditions: towards understanding the development of CA-related disorders in CH201/FRED® pears – Séverine Gabioud Rebeaud o Postharvest CO_2 cavities in pears under CA are linked to factors such as high vegetative growth, low crop load, young trees, excessive pruning or thinning, vigorous rootstocks, excess nitrogen, and conditions of high CO_2, low O_2, short CA delay, or use of 1-MCP. The disorder is also associated with fruit traits like a higher

K:Ca ratio, TSS, greater weight, increased density, and seed number, with seeds influencing Ca uptake through auxin-related pathways (Bangerth, 2000).

- Controlled atmosphere, temperature management, and harvest timing to mitigate 'Gem' pear internal breakdown development – Rachel Leisso
  - Rapid cooling after harvest and an 8–12-day RA delay before applying low-O_2, very low-CO_2 CA storage (1-2.2%O_2; <0.1% CO_2) minimizes internal breakdown.

Panel discussions

- New Apple Cultivars: What Do We Need to Know to Optimize Storage? – Rob Blakey, Stemilt Growers; Carolina Torres, Washington State University; Dave Rudell, USDA-ARS Wenatchee; and Chris Watkins, Cornell University
  - Fruit maturity should be assessed using multiple indices, since starch breakdown alone is not always reliable, and storage potential depends on whether the cultivar is climacteric or suppressed climacteric.
  - To manage the high CO_2 production often seen after 1-MCP application, the panel recommended delaying treatment until fruit are cooled gradually from 10 °C to 4 °C, avoiding overfilling cold rooms, and using lime when fans are off.
  - They noted no fruit damage under high stress for 24 hours and suggested alternatives such as DPA or ventilation for new cultivars shipped in containers.
- Pear Disorders and Storage Challenges – Séverine Gabioud Rebeaud, Agroscope ; Dirk Köpcke, Lower Saxony Fruit Research Station
  - Switzerland enforces strict fungicide rules on pears, allowing no postharvest use and requiring the last application three weeks before harvest, while Washington State's main challenges are decay and moisture loss.
  - In Northern Germany and the Netherlands, 1-MCP is applied selectively—only to firm or late cultivars, and within 24 hours of harvest—alongside measures such as good insulation, misting, and plastic covers to limit moisture loss.
  - Swiss growers generally avoid 1-MCP except when extended storage is needed, emphasizing rapid cooling after harvest to reduce respiration and moisture loss.

Daniela Ramos, an MSc(Agric) student at the Department of Horticultural Science, Stellenbosch University, received the ISHS Young Minds Award for Best Oral Presentation. Competing against international PhD students, this award recognises both the importance of her research field and the high quality of her work on a global scale.

6. Mid- and post-conference visits in Washington State:

18– 28 May 2025

Washington Tree Fruit Research Commission, Wenatchee, WA, USA

- Dr. Ines Hanrahan, executive director of WTFRC, explained that the organization plays a similar role to Hortgro Science, funding research through levies collected per ton of fruit delivered to packhouses.
- Their annual research budget is $4.1 million, of which $2 million goes to Washington State University, and while they do not fund postgraduate bursaries, they employ about two interns per year and also place them on farms.
- Research proposals are submitted by institutions and evaluated by producers and technical experts, with a current portfolio of around 70 projects.
- Key research areas include Little Cherry disease eradication, codling moth management (especially for organic programs), orchard renewal, and technology such as robotic fruit picking, although political shifts recently cut funding for the robotics project.
- Collaboration between competitors is strong, but challenges remain around labour shortages, reliance on older workers with few immigrants, and water supply that comes from Canada.

USDA-ARS, Wenatchee, WA, USA

From left to right: Adriaan Theron (CFG), Renate Smit (Phyla), Daniela Ramos (SU), Anél Botes (ARC), Mariana Jooste (Hortgro), Elke Crouch (SU), David Rudell (USDA-ARS)

- Dr David Rudell, the research lead and principal investigator specialising in developing cold chain management strategies and tools for apples, pears, and sweet cherries to reduce food waste, invited the SA delegation to visit the USDA-ARS during the conference.
- Their mission is to expand knowledge of deciduous tree fruit production systems, focusing on plant diseases and fruit quality.
- Dr Rudell showed us their well-equipped laboratories.
- He expressed great interest in the Monja Gerber's research on superficial scald and indicated his willingness to collaborate with Dr Elke Crouch on her related research projects. He also shared with Dr Crouch a method involving a component that may be valuable to measure as a potential early marker of superficial scald.
- Both Washington State University and the ARS (USDA in Wenatchee) use small-scale systems to test different atmospheric compositions and temperatures on various apple and pear cultivars. The images below are examples of a gas tight/insulated chambers used in which the temperature, CO_2, and O_2 levels are controlled. This is similar to a system at PHYLA for insects (without temperature control). The system for CA control that is used in these containers is the same operating software used for the CATTS machine.

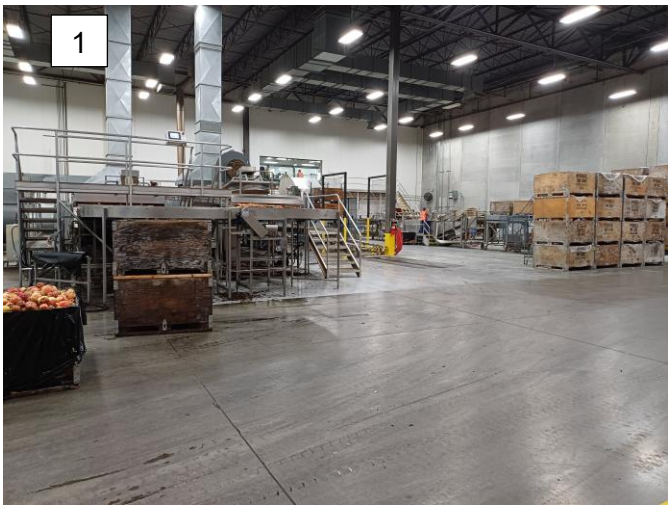
- Larger chambers shown below could be used in a cold room to examine different permeations/compositions of different gas concentrations and combinations (in the individual environment) in conjunction with temperature. These units would be perfect for central composite design experiments to determine the optimum concentration, duration and temperature required for a specific insect, and will also have great benefit for fruit research.

- The CA research model used by the research institutions in Wenatchee is as follows:
  - The small-scale systems, such as those used by Dave Rudell, are employed for applied laboratory tests. Results from these small-scale trials are reported, after which semi-commercial trials are conducted with a commercial industry partner to test the most promising treatments. In the Wenatchee scenario, Stemilt serves as the commercial partner, providing CA rooms that can store up to 30 bins of fruit for

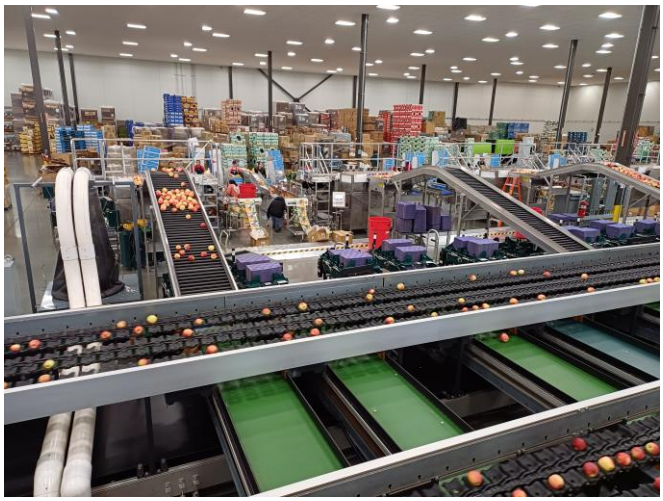
semi-commercial testing. The research institution enters into a contract with Stemilt for these trials. To make a semi-commercial trial worthwhile for Stemilt, a minimum of 10 bins of fruit is required. The research team provides the evaluation schedule, target temperature, and CA regime, while Stemilt provides a fork lift, fork lift driver, and manages the CA rooms. Stemilt applies the CA treatments in their small-scale commercial rooms, and the researchers evaluate the fruit. Because up to 30 bins can be stored, new treatments can be tested effectively. Leftover fruit from successful treatments are packed and sold by Stemilt, which helps offset the research costs. This model could be a useful approach for the South African pome industry to consider when testing new cooling, storage and CA regimes.

Technical tour to McDougall & Sons packhouse and CA stores, Wenatchee, WA, USA

- The grower-packer operates two cherry packlines and one apple packline, 24 CA cold stores, and 15 loading docks for loading of fruit into trucks.
- Fruit enters a 'wet' room, where it is cleaned before entering the packhouse (see pictures below of McDougalls 'wet' room). A wall separates the 'wet' room from the packhouse ('dry' room). In the 'wet' room, bins are washed in chlorinated water with brushes after the fruit is tipped. They use exclusively wooden bins.



- They apple packline is highly automated, and the cherry packline is almost fully automated.
- Organic apples are treated with carnauba wax to cover skin cracks and enhance shine, and are stored under CA conditions.
- Cherries are fumigated with methyl bromide at 6 °C.
- Electricity is supplied by hydroelectric dams on the Colorado River, resulting in very low electricity costs.

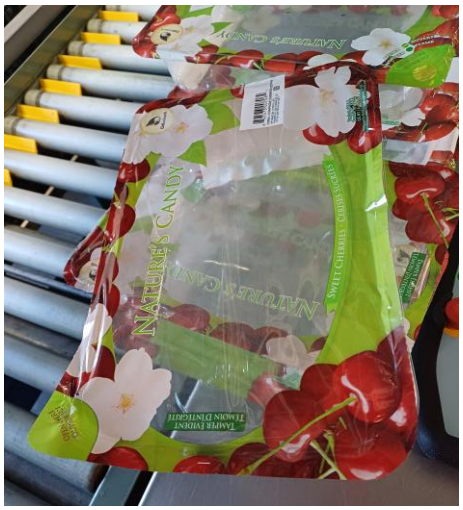


The apple packline at McDougall and Sons.

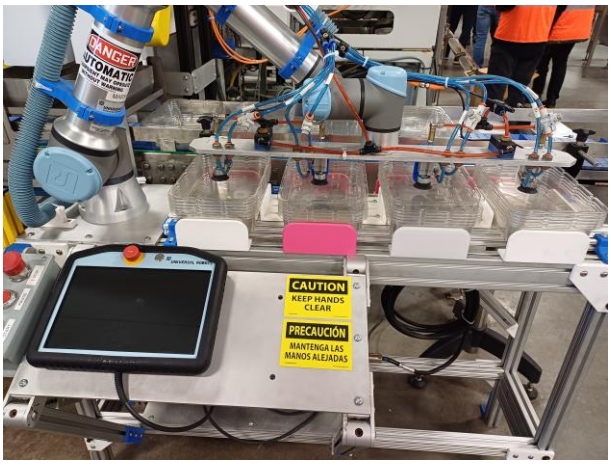
The robotic arm used for palletizing.

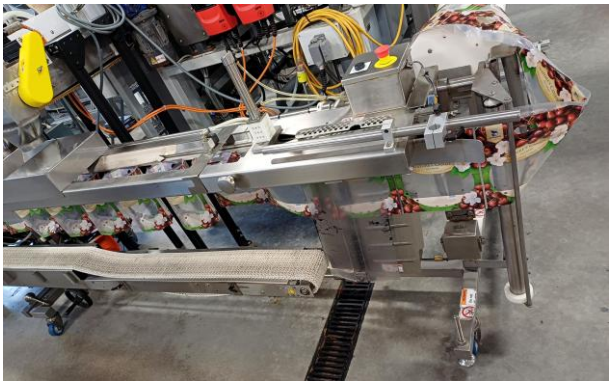


Irregular octagonic bulk cardboard bins, instead of wooden or plastic bins, used for transporting Class II fruit.



MAP punnets used at McDougalls and Sons for packing for cherries.



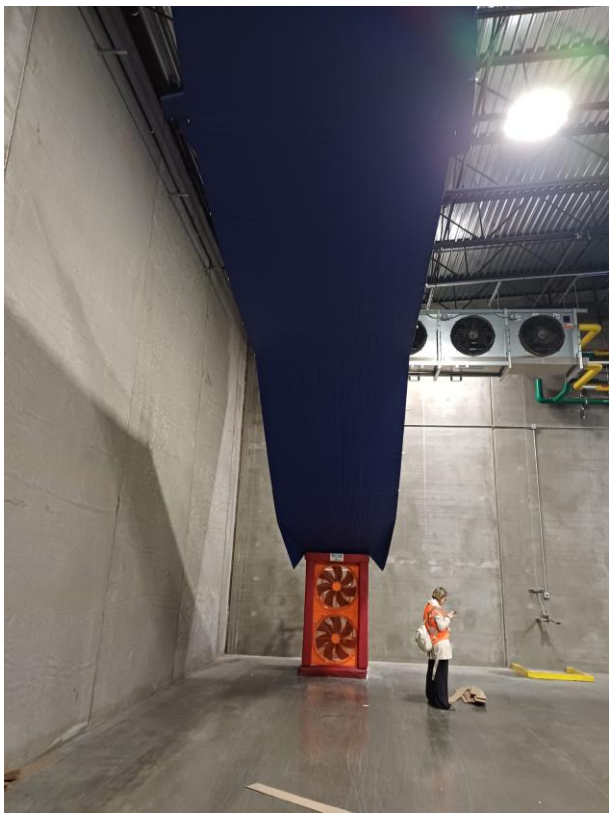


Packing equipment used at McDougalls and Sons on their cherry packline. Unfortunately, we were visiting outside the cherry season, and the packline was not operational.

Technical tour to Stemilt, Wenatchee, WA, USA

- Stemilt packs one million bins of apples and pears annually.
- 28% of the product packed is organic.
- The desert climate allows for the production of organic apples.
- Research results from WU, along with Stemilt's own studies, are used to optimise packing and storage protocols.
- Harvest Watch is used to monitor **CA** storage.
- Organic 'Granny Smith' apples are stored at 0% O_2 for 2 weeks to induce anaerobic respiration, which helps manage bitterpit.
- 'Honeycrisp' apples are temperature-sensitive and kept at 10-15.6 °C (50-60 °F) for 7 days before lowering the temperature and establishing rapid CA at 2.5% O_2. CO_2 must be carefully scrubbed from the rooms to prevent accumulation.

- ‘Gala’ apples are initially stored at 0.2% O_2 after harvest, after which the O_2 is increased to 0.6% for 8 months.
- CA rooms can accommodate 650-2000 bins per room, with 289 rooms across three counties.
- Each CA room in inspected every 24 h.
- 19 CA rooms are dedicated to research, each holding 30 bins. Protocols from small-scale trials at the university are scaled up to 30 bins to develop commercia protocols.



Inside one of the small-scale CA rooms.

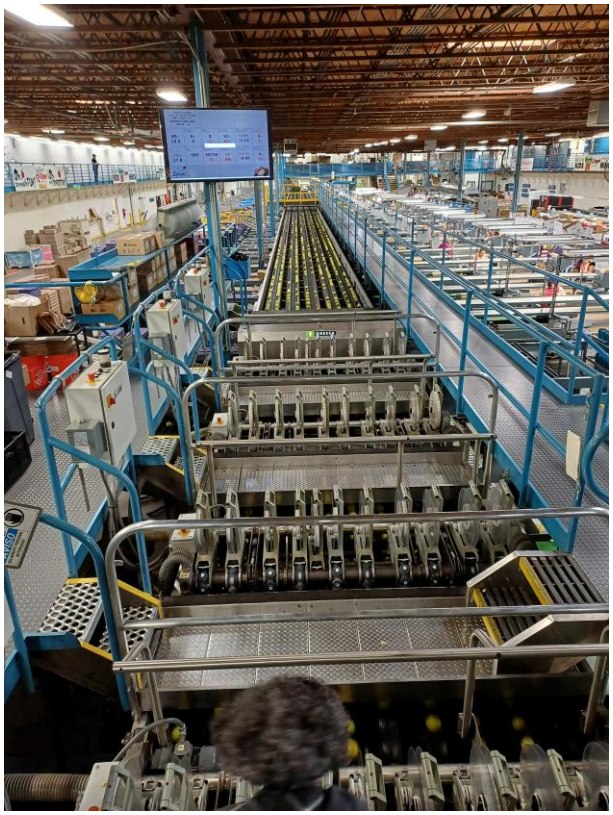
- Very large fans and 6 temperature probes per room ensure even temperature distribution (see picture below).

The large fans used in the Stemilt cold stores.

- Apples are packed at a rate of 75 bins per hour, and all cultivars are waxed with carnauba.
- Flume water is replaced weekly, and dump tank water every 24h.
- Stemilt packs 100 000 bins of **pears** annually, using a robotic dumper and a shallow, one-layer flume for gentle handling.
- Fruit is waxed, dried, and rotated 180 ° once on the packline to ensure gentle handling. Internal sorting is not performed, but optical sorting occurs twice.
- Multiple packing options are available, and the line operates August to March.
- Winter pears are conditioned with 100 ppm ethylene at 18 °C for 24 h before cooling within 18 h (following the avocado protocol). They do not treat their pears with 1-MCP, and conditioning is done according to orders, with fruit stored at low temperatures until conditioning is done.
- Stemilt packs 20% of the USA's **cherries** on 4 cherry packlines, allowing 18 h between harvest and packing.

- Cherry flume water is maintained at 2-3°C, and cherries are stored at 0-1 °C for a maximum of 3 days if packing cannot occur within 18 h. These fruit are sold quickly, as pitting typically appears 7 days after harvest.
- 70% of cherries are exported to Canada and Mexico via airfreight.

Accumulation and palletization of fruit

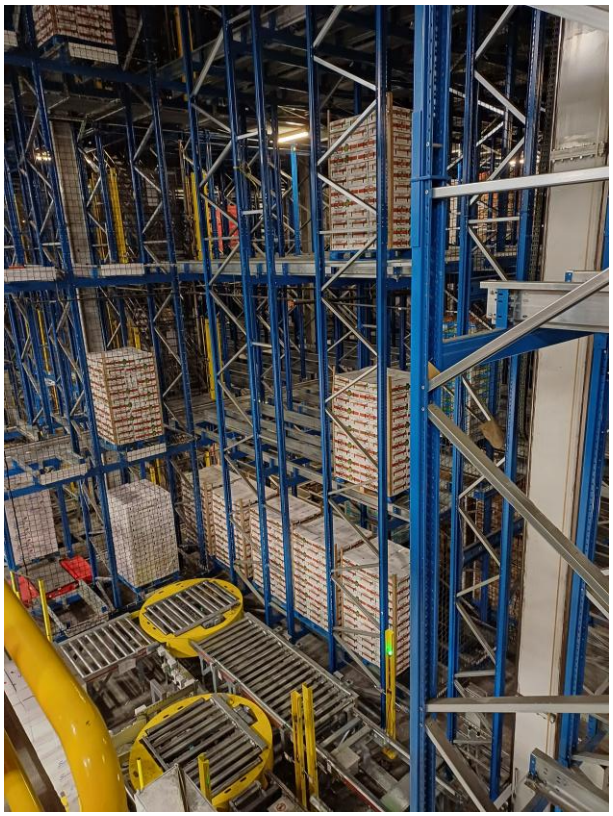


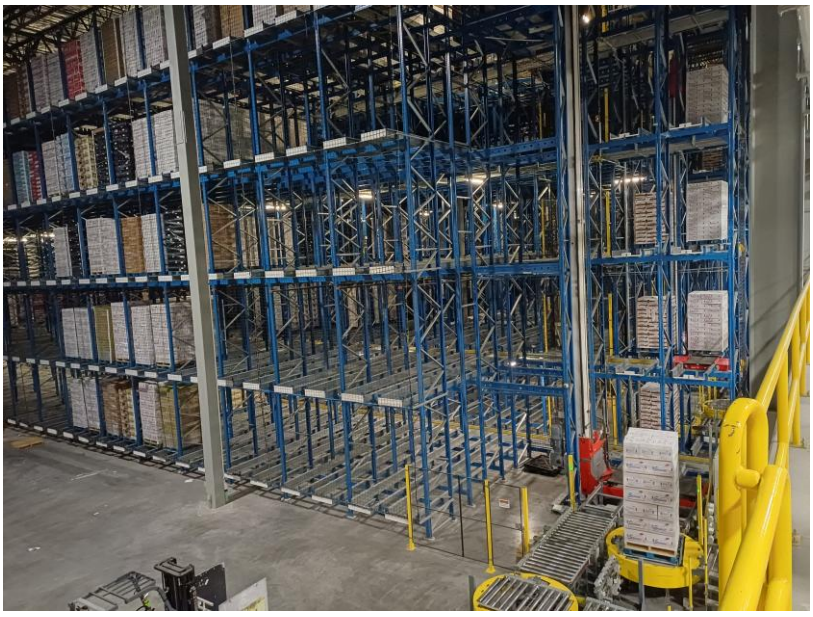
Inside the Stemilt packhouse.

- Stimult operates 75 lines that accumulates in their fully automated distribution center.

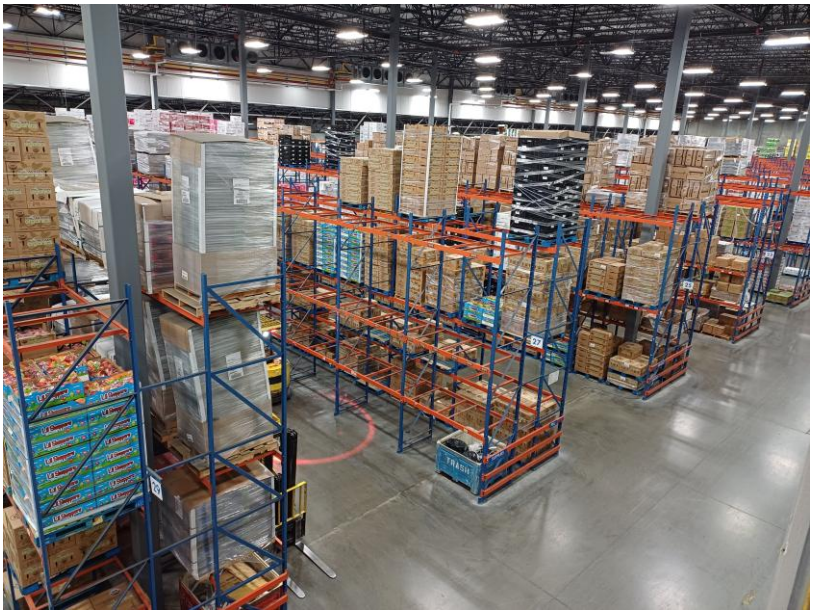

Some of the lines that accumulate in the distribution center, bringing packed cartons of fruit from the various packing lines. Each carton's barcode is read, and a robotic system build the pallets which is then send for stacking in the holding room.

- Trucks can be loaded, including pallet retrieval, within 20 minutes.





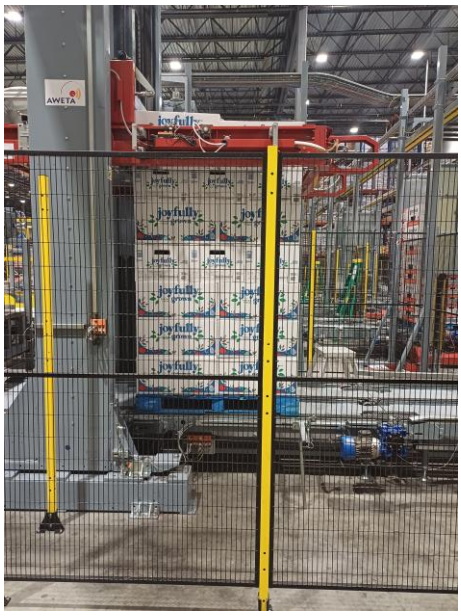
The robotic system for stacking packed pallets into a holding cold room before distribution.



Inside the Stemilt distribution center.

Borton and Sons, Yakima, WA, USA

- The packhouse was built in 2017 and has the longest packline in the world.
- Mat Borton is the MD and represents the 4th generation of Bortons leading the business.
- Apple maturity is determined based on starch breakdown, with a starch index of 2-3 or less.
- Starch testing begins in the orchards.
- Fruit with similar starch levels is stored in the same room. Orchard factors are also used to determine appropriate storage conditions.
- The packhouse has QC teams at three receiving areas. MI of the fruit is based on TSS, TA, firmness and starch.
- They have 150 CA rooms, of which 20 are used for Gala, and 50 for cherries.
- 60% of their fruit is stored under normal CA conditions, and the rest is stored under DCA.
- Each cultivar has its own cooling and storage regime. Most cultivars are step-cooled. 1-MCP is applied to specific cultivars, and DPA is also used.
- No fruit samples are tested during CA storage; instead, they solely rely on Strella technology.
- Fruit is stored up to12 months.
- Labour rates are high, but they have access to affordable electricity and sufficient water rights, which have increased as the business has grown.
- Fruit is stored in a racking system at 0.6 °C (33 °F).
- Most of the operation is automated.

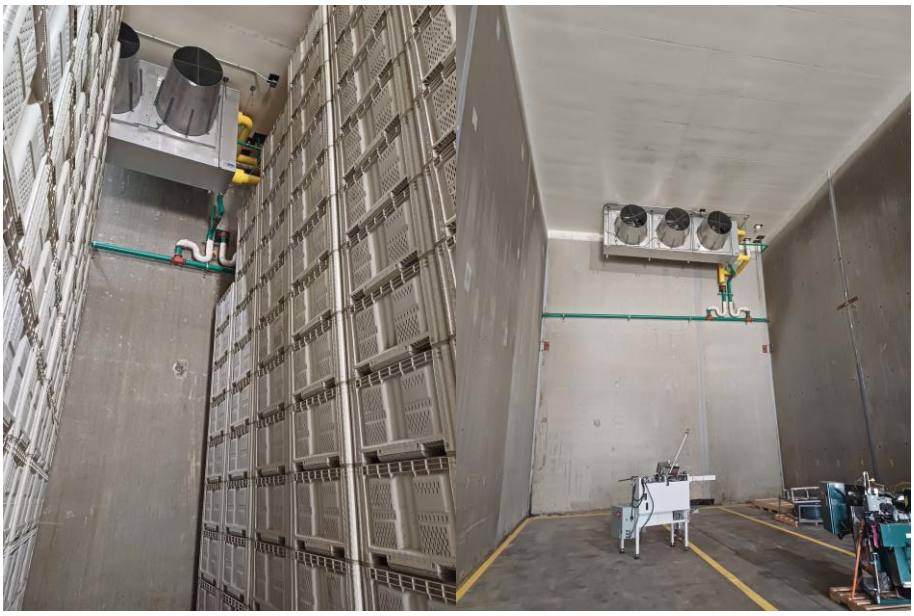


The robotic palletizer used by Bolton.

Pallets are strapped with plastic straps – this was a practice observed in all the packhouses we visited.

Irregular octagonic bulk cardboard bins, instead of wooden or plastic bins, used for transporting Class II fruit.

Bins stacked in a cold room. Bolton is systematically changing over to plastic bins.



The fans used within the cold rooms for better air distribution.

Gilbert orchards, Yakima, WA, USA

- 25% of the apples produced and packed are organic.
- Supermarkets require organic apples year-round (52 weeks a year).
- Gala apples are harvested at a starch level of 1.5 and can be stored for extended periods.
- Since workers dislike the smell of chlorine, a combination of chorine and acetic acid is used in the flumes. The pH is reduced to 4.5 when acetic acid is added to the water and can drop as low as 2.5,although no lenticel breakdown has been observed.
- They have 150 CA rooms.
- The fruits' natural wax is removed with alcohol and soap, then dried, treated with a surface sterilant (PBA), and is finally treated with carnauba wax.
- The fruit passes over brushes to apply the carnauba wax, then through a long drying oven at 43-49 °C (110-120 °F), after which it is packed.

Post-conference visit to Stemilt orchards in Mattawa, Quincy, and Stemilt Hill with Rob Blakey, Wenatchee, WA, USA

General

- Apples are massively oversupplied, therefore, poorly coloured fruit have little market value. They earn $20/ bin for juice compared to R1800/ ton in South Africa.
- Most large farms integrate production, packing, cooling, transport, and marketing of their fruit. Some even have their own nurseries.
- Stemilt uses Willow Drive and Gold Crown nurseries to supply their trees.
- USA laborers receive $17/h, while guest workers (seasonal) workers receive $20/h, with additional benefits (housing, transport, and visas) that can increase labour costs to $25/h. Overtime is paid when workers work exceed 40 h per week. The workforce relies mainly on guest workers (95%).
- Worker housing is audited by the US Department of Labour

General information about Stemilt orchards

- Orchard sizes range from 200-500 ha.
- Woven white material is used beneath the trees on the orchard floor to improve colour development for red varieties.
- Some orchards produce fruit specifically for slicing. Individual apples are sliced into containers and sold at $1 each. These sliced apples are very popular in the USA.
- Because their orchard floors are very even, the use of platforms for picking and pruning is standard. Stemilt has 80 platforms, each equipped with strong lights for night picking).

Picking platforms being used at Stemilt.

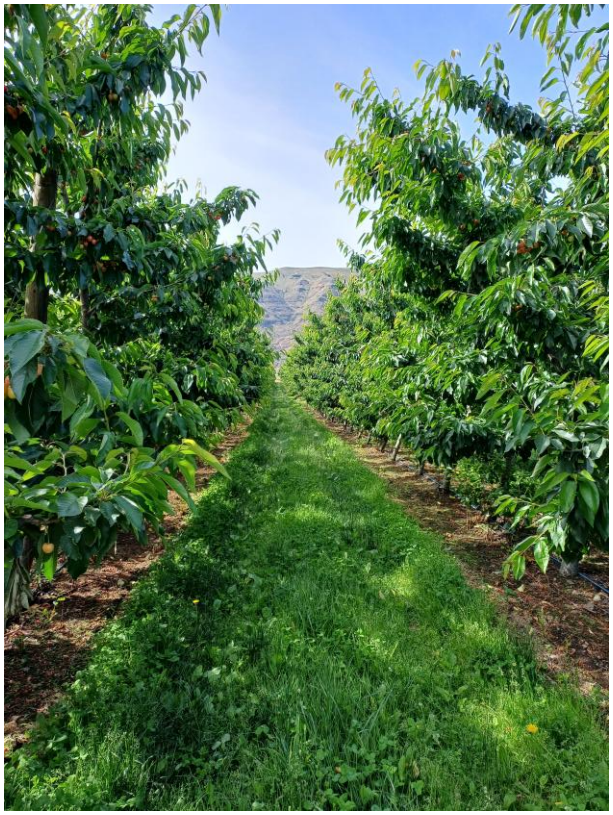
- The majority of their orchards are within 2-3.5 h drive from the packhouse, therefore, the fruit is transported without cooling.
- Overhead irrigation is used in the orchards to cool the fruit, as temperatures can get very high due to desert conditions, and water supply is not a limitation. For evaporative cooling, they have switched from micro sprinklers to fogging systems.
- Their Mattawa orchards are early and warm, and the fruit from these orchards is used for short-term storage. Their Quincy orchards are later and cooler, and the fruit from these orchards is used for long-term storage, as it gives better storage results.
- Regarding water rights: if allocated water is not used, it is taken away. Water can be 'move' (similar to putting electricity on the grid) or stored in a dam, but farms are not allowed to extract more water than allocated.
- Electricity costs are 1.5 cents/ kWh
- They have deep, sandy soils.
- They are transitioning from vertical to V-trellises in their orchards to increase production per ha.

V-trellises in a cherry orchard to increase production per ha.

- The orchards experience strong winds, therefore, they use V-trellises combined with wind screens (nets). The wind screens are more effective than trees as wind breaks. Due to the windy conditions, the screens require regular maintenance, and they are usually lifted during the off-season.

Wind screens that are used. In the off-season the wind screens are pulled up to protect it from wind damage.

- Their springs are very cold, which affects bee activity.
- In summer, temperatures in Mattawa reach ≥40 °C.
- Harvesting stops at 10:00-11:00 am when temperatures reach 27 °C and resumes at night when temperatures are lower. Picking platforms are equipped with lights to assist night-time harvesters.
- In spring, they struggle with both wind and fire blight in Mattawa, therefore, pears are not produced there..
- Apples are planted in their Quincy orchards, mainly on spindle systems.
- They are moving away from Geneva 41 rootstocks. For rootstock trials, they plant a row per rootstock.
- Their most important fruit defects are sunburn, senescent browning, and mechanical issues such as punctures and bruising.
- Clover and grass are used as cover crops. Grass is preferred, as clover becomes too slippery for tractors when wet.



Cover crops in a cherry orchard.

- All broadleaf weeds are removed, as they can harbor little cherry disease.
- To scare birds away, gunshot sounds, cat mewing, and distressed bird calls are played over speaker systems in the orchards. Falconers are also hired during cherry season to keep birds away.
- Robotic tractors are used for spraying. They refill at nursing stations, and only one operator is needed to manage 5 tractors.

Cherries

- Cherries are hydrocooled in the orchard using mobile hydrocoolers with water temperature at 5 °C, then transported under refrigeration (5 °C) to the packhouse. Flume water in the cherry packlines is maintained between 1-2 °C.
- Cherries are exported in MAP bags or plastic liners (the latter only for airfreighted fruit). They ship their cherries at plus 0.5 °C.
- Bing cherries are being replaced with Sancia due to their superior eating quality. Sancia is planted on a trellis to protect it from wind, as it has a shallow root system and is easily blown over. Black Pearl is used as its cross-pollinator.
- They also grow Rainier cherries; Black Pearl is Rob's favorite cultivar.
- Two Gibbs sprays are applied from straw colour at either 5+5 ppm or 7+3 ppm.
- Retain is sprayed at flowering if bee activity is a concern, although its effectiveness is uncertain.
- Cherries are strip-picked and harvested into totes, which are then placed in half bins.
- Target yields are 10-14 ton/ha.

Decay management

- Before CA storage, cold-fogged Candida oleophila strain O (Nexy) is applied, though it is considered not very effective. After CA storage, fruit is treated with 4 ppm chlorine (4 ppm) followed by a fresh water rinse.
- They alternate between pyrimethanil and fludioxonil.
- Very low rainfall reduces decay issues, making organic production relatively easy.

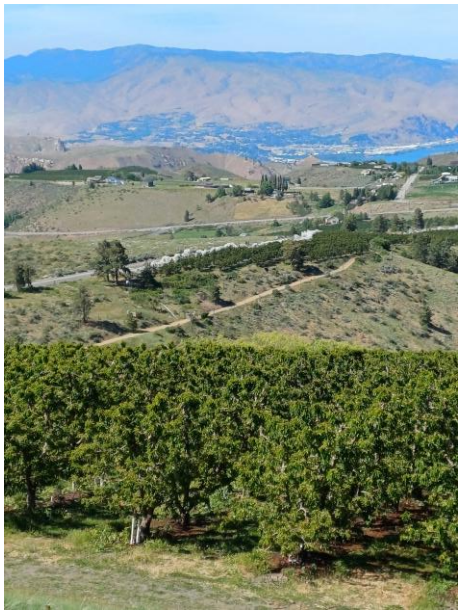
Rosy Glow apples

- This cultivar tends to, mostly due to rain.
- CaCl is sprayed before rain, and helicopters are used after rain to dry the fruit.

- CaCl can cause dull spots on the fruit.

Postharvest treatments

- Bins are drenched with fungicide and DPA.



View from Stemilt Hill towards the Colorado River.

Post-conference visit to Strella Head Office, Seattle, WA, USA

- Strella is a subsidiary of Agrofresh, and its head office is located in Seattle.
- The Strella device measures CO_2, O_2, RH, temperature and ethylene. It is primarily used in CA storage rooms that contain fruit treated with 1-MCP. The system monitors these variables to help CA managers decide when room conditions should be adjusted or when a room should be opened.
- The values of the five measured variables are converted into individual scores, which are then combined into a maturity score to help store managers determine when a room should be opened. The CO_2 and O_2 scores also assist in making timely adjustments to gas concentrations when necessary.
- Two devices are placed on the floor in the front corner near the door of the CA room, and they transmit their measurements via a router to Strella in Seattle. The device batteries last for more than a year.

- Ethylene concentrations are measured every 30 min, while the other four variables are measured every 10 min.
- Permanganate is used as the ethylene adsorbent in the sensor.
- They are currently experimenting with adding ethanol measurement. They are also improving RH measurement accuracy - especially under high humidity - by heating the sensors after each measurement to dry condensation.
- Currently, Strella devices are used to monitor approx. 1000 CA rooms worldwide.
- Brazil and South Africa have shown the highest growth in Strella device adoption. New Zealand is also growing, while very few clients in Wenatchee use the system, as apple overproduction has limited their ability to invest in the technology.
- Apples are the main product monitored with Strella devices, followed by pears.

The plaque on the building that houses the Strella head office in Seattle.

The Strella device on the inside with the different components that measure CO_2, O_2, RH, temperature and ethylene.

The South African delegation with Strella employees at the Strella head office in Seattle.

7. Appendix 1: Contacts

- **Dave Frampton**

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- **Craig Anderson (Gilbert Orchards, Inc)**

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- **John Poss (Washington tree fruit research commission)**

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- **Drew Bolton**

  Tel: 509 969 5220 Email: drew@strella.ai
- **Dr David Rudell (Researcher)**

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- **Dr Ines Hanrahan (Executive director)**

  Email: hanrahan@treefruitresearch.com

- **Maneola Mendoza (Research operations manager, Wanatchee)**

  Email: manoella@trefruitresearch.com

- **Rob Blakey (Director of Research and Development)**

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- **Scarlet Waller (Packing Director)**

  Email: scarlet@strellabiotech.com

8. Appendix 2: Itinerary

ITINERARY FOR TRIP TO USA

1) **9 May: ARS Temperate Tree Fruit and Vegetable Research Unit in Wapato (USDA) – Renate Smit**
    a. Shelly Watkins (Lab technician)
    b. Linda Ray (retired Lab technician – worked with codling moth)
    c. Anne Chapman (retired Lab technician)
2) **12-13 May: ARS Temperate Tree Fruit and Vegetable Research Unit in Wapato (USDA) – Renate Smit**
    i. Dr Rodney Cooper (Research Leader/Research Entomologist)
    ii. Dr Will Walker (Geneticist)
    iii. Dr Jacqueline Serrano (Research Entomologist)
    iv. Shelly Watkins (Lab technician)
    v. Linda Ray (retired Lab technician – worked with codling moth)
    vi. Faraday Rehfield (Lab technician)
    vii. Dr Lisa Neven (retired phytosanitary researcher USDA)
3) **14-15 May Corvalis University (Horticulture department) – Renate Smit**
    a. Dr Vaugh Walton
    b. Kyoo Rok Park
4) **16 May Gilbert Orchards – Renate Smit**
    a. Jesus Gaza (Gilbert Orchards)
    b. Craig Anderson (Gilbert Orchards)
    c. John Poss (Washington tree fruit research commission)
    d. Matt Miles (Allan brothers, Commissioner Washington Tree fruit research)
5) **16 May Systems West Construction (Construct large CA rooms) – Renate Smit**
    a. Dave Frampton
6) **Conference 18-22 May – South African delegation**
    i. Meetings/visits outside of conference arrangements:
        a. Washington tree fruit research council facility visit (19 May)

b. Dr Ines Hanrahan (Executive director)
c. Tory Schmidt (Horticulture Associate)
d. Maneola Mendoza (Research operations manager)

ii. ARS Tree Fruit Research Laboratory in Wenatchee (21 May)
a. Dr David Rudell (Researcher)

7) Visits 23 -29 May – South African delegation

i. Packhouse visit (Yakima) (23rd May)
a. Drew Bolton

ii. 23rd May Gilbert orchard visit and packhouse visit
a. Jesus Gaza (Gilbert Orchards)
b. Craig Anderson (Gilbert Orchards)

iii. 24 May Borton and Sons
a. Mat Borton

iv. 27 May Systems West Construction (Construct large CA rooms)
a. Dave Frampton

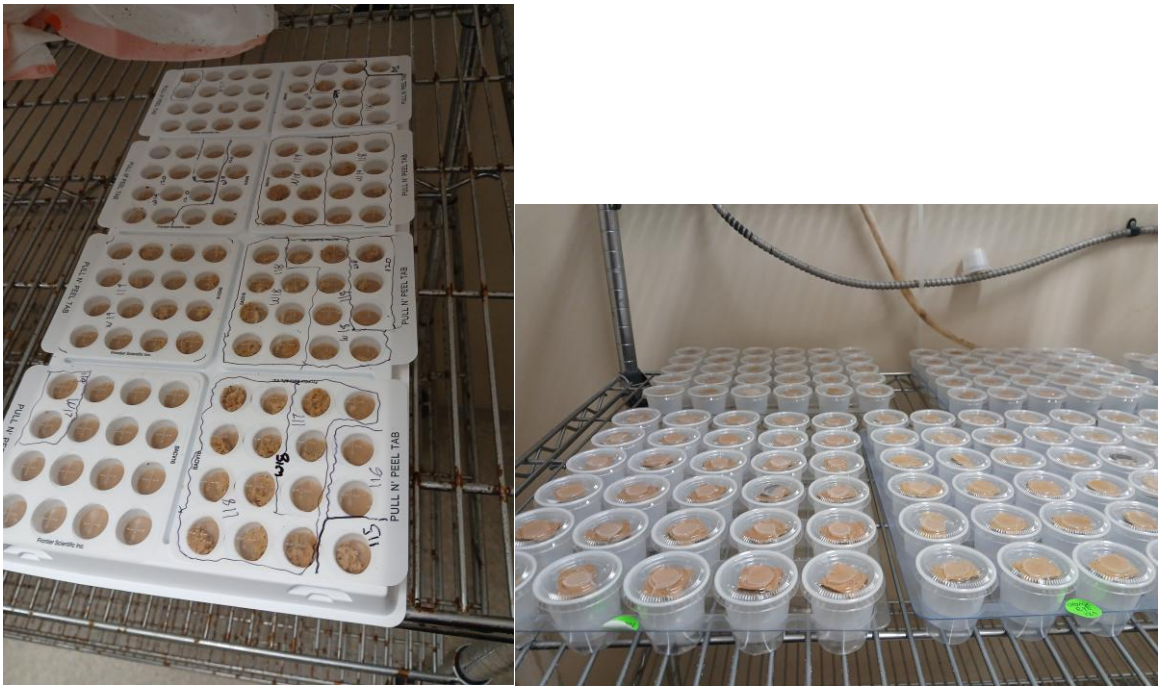
v. 27 May Stemilt Orchards
a. Rob Blakey

8) Travel to Seattle 28 May

i. Strella
a. Scarlet Waller

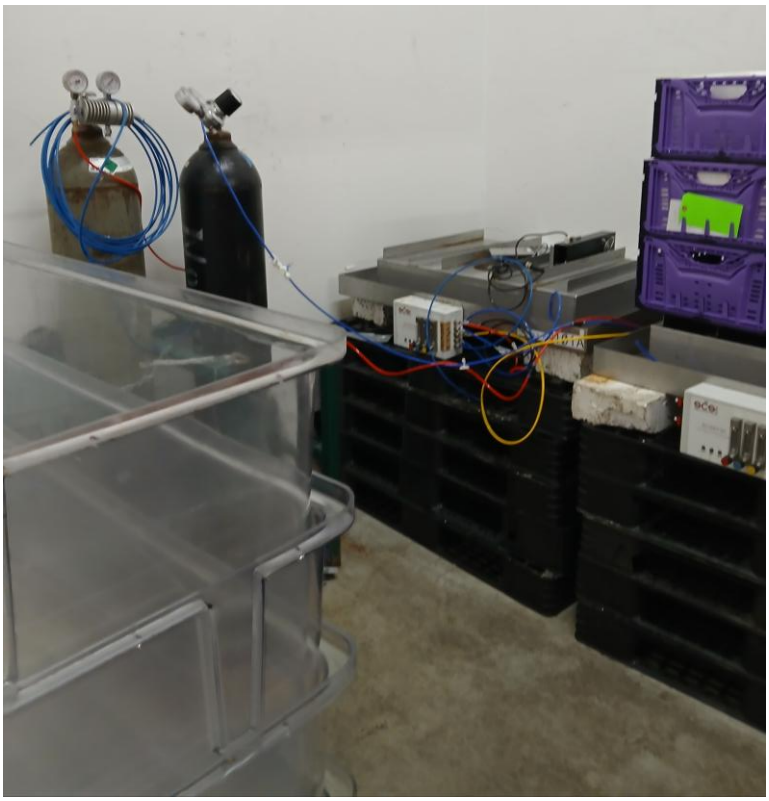
9) Fly back to South Africa 29 May

Images from Visits (Renate Smit):



Small scale trials on codling moth and gene silencing during egg stage.

Codling moths lying eggs on plastic bags for gene silencing trials.



Example of experimental system to examine different gas combinations (concentrations of CO_2 and O_2) in storage trials.