HORTGRO TECHNICAL SYMPOSIUM

2018

the big thirst

summary report

HORTGRO

Growing Fruit IQ

hortgro.co.za
hortgro-science.co.za

+27 21 870 2900
Welgevallen Experimental Farm, Stellenbosch, South Africa
PO Box 12789, Die Boord, 7613

CONTENT

Writers: Anna Mouton, Dane McDonald, Munyaradzi Makoni, and Esté Beerwinkel
Editors: Wiehann Steyn and Esté Beerwinkel
Layout: Esté Beerwinkel

Ed's note: Please note that unless stated otherwise all research data images belongs to the speaker of that topic.

TECHNOLOGIES for minimising physiological disorders in apples

talk by Prof Randolph Beaudry
summary by Anna Mouton

Professor Randolph Beaudry from Michigan State University in the USA discussed factors that impact postharvest apple quality. He presented research results that suggest ways to avoid losses due to physiological disorders.

BEAUDRY began by reminding the audience that, although apples are stored, they are not storage organs. At harvest, apples lose all access to water and nutrients. "We reduce the temperature, we put them in the dark, and we remove the oxygen. What's not stressful about that?" asked Beaudry.

According to Beaudry, fruit development is a continuous process and maturity represents more than one aspect of development. Degree of maturity plays a role in several disorders: softening, water core, superficial scald, soft scald, soggy breakdown, carbon dioxide injury, and senescent browning and lenticel breakdown. Therefore, consider maturity when making decisions about storage.

"There's a harvest window for every apple variety during which the quality peaks," said Beaudry. Climate change shifts this window by affecting the growing degree days. A rapid increase in the rate of growing-degree-day accumulation at the time of harvest can result in poor storability. Different apple maturity indices are not synchronous, complicating harvest decisions.

"Apples always require ethylene to continue ripening," said Beaudry. Treatment with SmartFresh^{SM}– 1-methylcyclopropene (1-MCP)–is most effective when applied early, but there is still a significant improvement in firmness when fruit are treated late compared to no treatment. Whereas SmartFresh^{SM} blocks the action of ethylene, ReTain (aminoethoxyvinylglycine) stops the fruit from producing ethylene. Applying ReTain three to four weeks before harvest delays maturation, creating a longer harvest window.

Pre-harvest application of ReTain combined with postharvest treatment with SmartFresh^{SM} significantly improves firmness retention over use of either treatment in isolation. This was true even when fruit were harvested late.

There are many factors that affect storage decisions. "Every variety has its own optimal temperature," explained Beaudry. "Some cultivars are chilling-sensitive. Temperatures below 3°C–or even 5°C–are damaging." These varieties are susceptible to soggy breakdown and soft scald. Other than careful timing of the harvest, preconditioning is the main tool for controlling disorders caused by chilling. Preconditioning, also known as cooling delay or delayed storage, involves maintaining fruit at a higher temperature than the final storage temperature between harvest and cold storage. Preconditioning and storage at 3°C rather than 0°C can reduce soggy breakdown and soft scald, but may induce more bitter pit.

Soggy breakdown is highly variety-dependent and increases with maturation. Preconditioning (five to seven days at 10°C to 20°C) and elevated storage temperatures suppress soggy breakdown. Diphenylamine (DPA) reduces soggy breakdown slightly. Controlled atmosphere storage and treatment with SmartFresh^{SM} has no effect.

Soggy breakdown and soft scald may occur together. Soft scald is affected by the same factors as soggy breakdown, but can in some cases be reduced by treatment with SmartFresh^{SM}. Moisture

"Storage environments are stressful—fruit are biologically 'designed' to be consumed, not stored."

loss is another problem of certain apple varieties. The relative humidity in a storage room decreases with an increase in the difference between room and coil temperature. The lower the relative humidity, the greater the moisture loss in the fruit.

Storage technologies that affect fruit quality include controlled atmosphere–standard, ultra-low oxygen, initial low oxygen stress and dynamic–and treatment with SmartFresh^{SM}. Beaudry presented data on the effect of 1-MCP treatment on firmness in apples stored at 20°C. "Untreated fruit soften. If you treat them once, you get about 40 days before the fruit begin to soften." More frequent treatment extends this period. However, there is a reduction in titratable acidity with long storage periods.

Beaudry stressed that both oxygen and carbon dioxide affect storage disorders. Elevated carbon dioxide and low oxygen suppress ethylene action, thereby slowing softening, respiration and loss of sugars and titratable acids. Standard controlled atmosphere (oxygen levels of 1.5 to 3.0 percent and carbon dioxide levels of 2.0 to 3.0 percent) don't allow for longer-term storage. Ultra-low oxygen storage (oxygen levels of 0.5 percent) maintains apple quality better than standard conditions.

"Ultra-low oxygen storage basically requires all the same equipment but tighter rooms," said Beaudry. "It works well with 1-MCP and can provide year-round storage." Beaudry recommends ultra-low oxygen for most storage operations. Initial low-oxygen stress is a modification in which apples are exposed to oxygen levels below 0.5 percent for a limited time. Initial low-oxygen stress protects against the development of superficial scald.

"Dynamically controlled atmospheres use the idea that you don't just set it and forget it," explained Beaudry. "You manipulate the oxygen and carbon dioxide concentrations during storage." Oxygen levels are kept just above the level at which the apples show stress. Stress manifests as a measurable increase in chlorophyll fluorescence. Other stress indicators, used to detect fermentation, are ethanol levels and the respiratory quotient (estimated from oxygen and carbon dioxide levels).

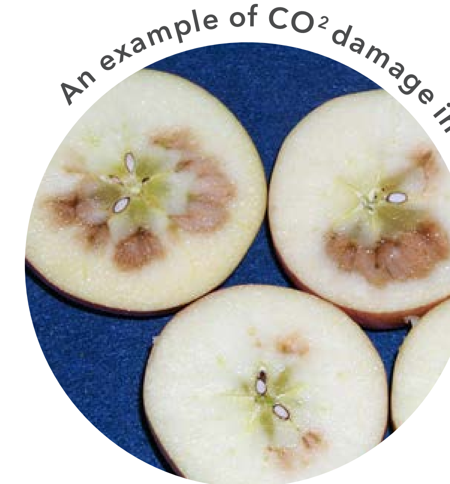
Advanced systems for atmospheric control don't provide better firmness retention than regular controlled atmosphere combined with application of SmartFresh^{SM}. However, internal browning may be reduced. Apples stored without SmartFresh treatment may also qualify for organic status.

Beaudry considered carbon dioxide injury to be more common than low oxygen injury. Apple varieties differ in their susceptibility to carbon dioxide injury. Injury risk decreases with maturation. It is controlled by DPA and minimised by conditioning. Low oxygen levels and application of 1-MCP can exacerbate carbon dioxide injury. Damage usually occurs early in storage.

"You want to assess stored fruit on a regular basis," Beaudry reminded the audience. The timing of monitoring depends on an assessment of fruit storability. When carbon dioxide injury is a concern, sample fruit at two to three weeks. For chilling injury, do the first evaluation at one to two months; after a warm season, evaluate at two months. During long-term storage, check the fruit at four, six and nine months. Sample untreated fruit a month later than fruit treated with ReTain or Harvista™ (1-MCP). •


Soggy breakdown in a Honeycrisp apple.


Soft scald in a Suncrisp apple.


An example of CO^{2} damage in Fuji apples.

THE PHYSICS OF WATER: Understanding the basics of humidity

talk by Dr Marius Huysamer
summary by Anna Mouton

Dr Marius Huysamer is a postharvest physiologist. His talk focused on the interaction between humidity and moisture loss in fruit.

HUMIDITY is a measure of the amount of water vapour in the atmosphere. "If we want to talk about humidity, we first need to understand what happens in air," said Huysamer. Dry air contains 78 percent nitrogen, 21 percent oxygen and less than one percent each of carbon dioxide and the noble gases. Moisture in air accounts for one to four percent of total air volume.

"At sea level and 20°C there are about 25 septillion molecules in a cubic meter of air," observed Huysamer. "That's 25 times ten to the power of 24." The total mass of molecules per volume of air represents the density of that air. Density increases when temperatures fall and pressures rise. "If you take the same volume of air, but at different temperatures, the warm air will contain fewer molecules than the cold air," explained Huysamer.

At temperatures above absolute zero (minus 273°C) water molecules have energy and vibrate. The more energy, the faster the vibration and the higher the temperature of the water. "Changes in phase, from solid ice to liquid water to a gas [water vapour], are a function of energy," noted Huysamer.

"Cold-room humidity is an important determinant of moisture loss during storage".

Specific humidity—absolute humidity or mixing ratio—is the mass of water vapour present per unit mass or volume of air. As specific humidity increases, the air becomes more saturated until rates of evaporation and condensation are equal: the air cannot hold any added water vapour. This point is temperature dependent. "Cold-room air at 0°C cannot contain more than five grams of water per cubic meter," stressed Huysamer. "And that's dry!"

Relative humidity represents degree of saturation expressed as a percentage. Because the amount of water in saturated air is temperature-dependent, specific humidity cannot be inferred from relative humidity unless temperature is known.

Huysamer demonstrated the use of the psychrometric chart (a graphic representation of the relationship between specific humidity, relative humidity and temperature). He also pointed the audience to an **online resource for humidity calculations**. Users can enter temperature, relative humidity and pressure (Huysamer used 1010 hectopascal which is equivalent to atmospheric pressure at sea level) and the calculator will return variables such as specific humidity, dew point and water vapour pressure.

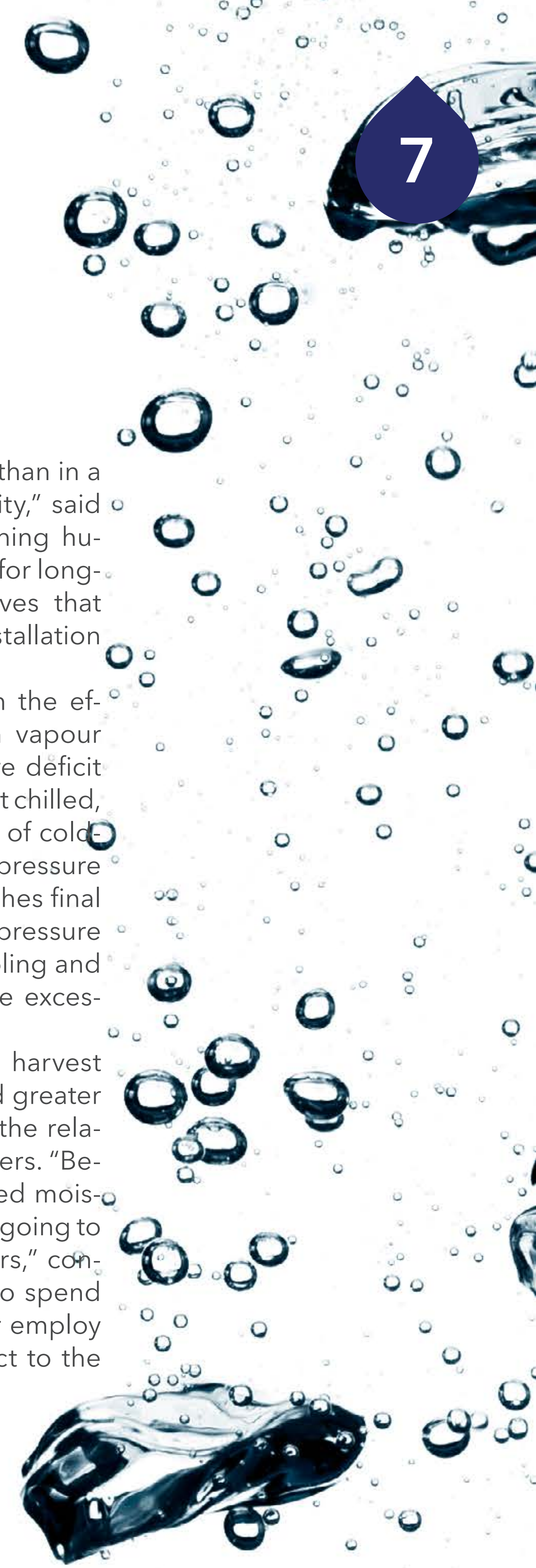
Water vapour pressure is important in understanding moisture loss from fruit. The intercellular air space inside the fruit is saturated with water vapour. Because relative humidity outside the fruit is less than 100 percent, the vapour pressure deficit between fruit and atmosphere drives moisture loss through diffusion of water vapour from a region of high pressure (inside the fruit) to a region of lower pressure (outside the fruit). "As relative humidity increases, there is a reduction in water vapour pressure deficit," said Huysamer. "At any given relative humidity, the vapour pressure deficit – and subsequent rate of moisture loss – is much lower at 0°C than at higher temperatures."

"The bottom line is, at any relative humidity, cooler is better," said Huysamer, "and the temperature effect becomes larger the lower the relative humidity." During harvest, fruit experiences extreme conditions with relative humidity as low as 25 percent and temperatures of 30°C or higher. "Water vapour pressure deficit can be thirtyfold greater than under cooling," warned Huysamer. "It shows how critical it is to get your fruit into a cold-room as soon as possible."

Cold-room humidity is an important determinant of moisture loss during storage. "Let's look at a poor cold-room –80 percent humidity. The vapour pressure deficit is four times greater than in a cold-room at 95 percent humidity," said Huysamer. "This is why maintaining humidity at 95 percent is so critical for long-term storage." Huysamer believes that saving money on cold-room installation is a false economy.

Huysamer presented data on the effect of post-harvest cooling on vapour pressure deficit. Vapour pressure deficit is highest when warm fruit are first chilled, due to the low moisture content of cold-room air and the high vapour pressure in warm fruit. Once the fruit reaches final storage temperature, vapour pressure deficit is low. Both a delay in cooling and a slow rate of cooling can cause excessive moisture loss.

Reducing the time between harvest and cold-storage is likely to yield greater benefits than trying to increase the relative humidity in shipping containers. "Before the industry hasn't addressed moisture loss at the farm level, it's not going to help to try and modify containers," concluded Huysamer. "If you want to spend money, buy more bin-trailers, or employ more staff, and get your product to the cold-store faster." •



THE OPPORTUNITIES and challenges of pre-sorting

talk by Jaco Moelich
summary by Anna Mouton

Jaco Moelich, product technical manager at the Fruitways Group, provided insights on the technical aspects of pre-sorting in apples. Fruitways are industry leaders in the packing and marketing of apples and pears.

"I'M not here to convince you that pre-sorting is either better or worse than commit–to–pack," said Moelich in his opening remarks. "I'm merely sharing our experience."

"Pre-sorting is to sort fruit into size, grade and colour groups, and then to put it back in some bulk format before you pack or process it," explained Moelich. "Pre-sorting can be done before or after long-term storage." In contrast, commit-to-pack involves sorting fruit into size, grade and colour groups at the same time as packing in the final format.

Moelich discussed the advantages of pre-sorting in the context of harvesting, storage, packing and marketing. During harvesting, pre-sorting reduces the need for culling at farm-level in the orchard. Referring to a photo of workers bent double over a harvesting bin, Moelich said, "That is not a very comfortable position to be in. It's difficult to be accurate and not damage other fruit in the bin. Pre-sorting provides the opportunity to improve that process significantly. But it's not cheaper."

When it comes to storage, pre-sorting helps identify those fruit for which long-term storage is not financially justified. South African apples tend to be variable. "We've got some varieties that have relatively low Class 1 pack out. On those varieties the advantages of pre-sorting before storage are much greater. You can avoid high storage costs on the lower grade fruit," advised Moelich. Reserve expensive cold storage and treatments like 1-MCP (1-methylcyclopropene) for high-value fruit.

Pre-sorting also offers benefits during packing. "When you have your fruit pre-sorted in groups—all uniform—your packing is much more efficient. You can set up your production teams to be very cost-effective," said Moelich. "However, your capital layout is greater than in commit–to–pack."

Regarding marketing, Moelich believes the biggest opportunity offered by pre-sorting is the ability to market different groups of fruit at the ideal time. Pre-sorting enables a rapid response to changing market conditions and client requirements. "If your client has a desperate need and the money's right, you can pack a certain specification of fruit in a very short time. Your reaction time is much quicker."

But there are challenges associated with pre-sorting. "I can assure you: these challenges that I'll be talking about are just a few," Moelich warns the audience. "I could probably have made the list five times longer."

The additional handling of fruit in a pre-sorting system elevates the risk of cold chain breaks and damage. Rebinning fruit with injuries or bruising can cause significant problems. "You need top-class equipment which is usually very expensive," stresses Moelich. "If you're not careful, you can very quickly have negative effects on fruit quality."

Pre-sorting promotes storage complexity. "In commit-to-pack, your complexity lies in your carton management and it's the marketer's problem. He must sell that fruit. With pre-sorting, we've moved the complexity to the bin area." Moelich calculated that a pre-sorting operation deals with ten times as many product variables as a commit-to-pack business.

"You need to be on top of your bin stock management," emphasised Moelich. Marketing of fruit needs to take differing quality retention during storage into account. Postharvest defects are yet another potential cause of losses. Moelich highlighted the importance of good water sanitation in preventing the development of defects during storage. "When you put fruit through water and afterwards into long-term storage, you really increase your risks for rots and other problems."

Pre-sorting systems also present challenges during marketing. The marketing team has to have accurate marketing intelligence to predict demand. The production and marketing teams need to work closely together to ensure a quick response to requests from clients. A flexible packing operation is essential to reap the benefits of pre-sorting. "More often than not, we plan a week ahead," said Moelich, "just for the order to change a day before packing."

"Pre-sorting has some significant technical challenges that should be well-understood," concluded Moelich, "so if you are considering pre-sorting, understand exactly how it fits in with your business philosophy." •

"When you have your fruit pre-sorted in groups your packing is much more efficient."

LENTICEL disorders on apples: The impact of cooling on lenticel damage

talk by Dr Ian Crouch
summary and illustrations by Anna Mouton

Dr Ian Crouch, research and development director at ExperiCo, explained the different types of lenticel disorders on apples and summarised the best practices for avoiding these.

"AS a postharvest physiologist, I get many calls about lenticel breakdown," said Crouch. "It's important to recognise the different types of lenticel disorders on apples." Crouch described six disorders that could be confused: bitter pit; blister pit; Jonathan spot; chemical burn; lenticel spot or breakdown; and lenticel blotch or blotch pit.

Bitter pit

- Spots on surface are initially highly coloured but then become grey, brown or black
- Spots sink in a round or slightly angular pattern
- Flesh under spots is corky (dry, brown and spongy)
- Physiological disorder that begins on the tree but manifests during storage
- Worse in light crops from young trees; larger apples; apples picked when immature
- Increased by irregular watering; heavy application of nitrogen; heavy pruning and thinning; magnesium nitrate
- Reduced by calcium nitrate

Blister pit

- Small raised blisters on the surface appear as brown spots
- Caused by a bacterial infection (*Pseudomonas syringae*)
- Not common in South Africa

Jonathan spot

- Spots on surface originate at lenticels which become dark brown or black
- Spots may be slightly sunken with a surrounding halo
- Flesh under spot may be corky (dry, brown and spongy)
- Worse after a dry season; on larger apples; in late-harvested fruit; when fruit are cooled slowly
- Cause is unknown

Chemical burn

- Chemical damage can be confused with lenticel disorders
- Caused by both pre- and postharvest chemicals
- Chlorine drench blemishes skin but damage is not restricted to lenticels
- Calcium application affects lenticels and manifests as clusters of small, black or brown spots

Lenticel spot or breakdown

- Spots on surface are round; sunken; centered on a lenticel; and sharply defined
- Spots become deeper and larger over time and may coalesce
- Flesh under spot is not affected – differs from bitter pit and Jonathan spot
- Appears on less exposed side or colour margins of fruit
- Physiological disorder affected by pre- and postharvest factors and manifests after storage

Lenticel blotch or blotch pit

- Spots on surface have an irregular outline – differs from round spots in lenticel spot
- Spots are centered on a lenticel and become sunken
- Flesh under spot is brown – similar to bitter pit and Jonathan spot
- Appears on calyx or more exposed side of fruit – differs from lenticel spot
- Physiological disorder that begins on the tree but manifests during storage

Crouch presented results of a cooling trial conducted with Golden Delicious apples. Fruit packed directly in boxes, without bags, cooled fastest. The speed at which fruit in bags cooled depended on whether the bags were perforated and the size of the perforations. Non-perforated bags slowed down cooling and larger perforations promoted more rapid cooling. Fruit packed in non-perforated bags had less lenticel spot but more bitter pit than other treatments.

According to Crouch, the increased bitter pit can be explained by the higher levels of ethylene trapped in the bags. This research indicated that additional cooling stress after packing may increase expression of lenticel disorders and that care should be taken in the rate of cooling of lenticel sensitive cultivars.

Researchers and industry have put together a best-practice guide for lenticel-damage mitigation. "Evidence shows that lenticel damage can be related to moisture loss," said Crouch. "All practices that prevent moisture loss will have a beneficial effect." Crouch shared the best practices with the audience.

At harvest

- Harvest each cultivar at optimum maturity
- Deliver bins within 12 hours (preferably six hours)
- Limit exposure to high temperatures after picking
- Fruit at risk of developing lenticel disorders should only be stored short-term in controlled atmosphere, followed by 10 days at regular atmosphere, and sorted before packing.

Prior to storage

- Move fruit from loading areas to cold stores as soon as possible
- Do not apply calcium postharvest to sensitive cultivars (Braeburn, Fuji and Kanzi).

Step-down cooling

- Use a seven-day gradual step-down cooling period
- Do not cool below the recommended temperature for the cultivar.

Storage

- Market fruit from warmer orchards (north-facing, sandy soils or warm area) earlier in the season
- Fruit at risk of developing lenticel disorders should only be stored in regular atmosphere or short-term controlled atmosphere to allow development before sorting
- Wait ten days before packing fruit from controlled atmosphere storage, to allow development of lenticel disorders before sorting.

Packaging

- Use micro-perforated bags.

Crouch pointed out that the recommendation on packaging may be revised following recent research results. "What's important," concluded Crouch, "is to not stress the fruit." •

PREVENTION IS BETTER THAN CURE: Food safety and the consumer

talk by Dr Corné Lamprecht
summary by Anna Mouton

"Are we ready to face new microbiological challenges?" was the question posed by Dr Corné Lamprecht from the Department of Food Science, University of Stellenbosch.

"IN order to stop foodborne illness, we have to stay vigilant, evaluate current strategies and adapt when necessary," stated Lamprecht. She shared figures from an article published in The Lancet in 2016. The authors summarised data on major causes of death worldwide between 1980 and 2015. Conditions linked to food and water safety, particularly diarrhoeal diseases, result in significant loss of life, especially in developing countries. Diarrhoea strikes approximately 1,000 million young children every year, killing about 525,000 of them.

Lamprecht also highlighted the importance of food security. "The world faces a potential crisis. By 2050, the world's population is predicted to reach 9 billion, which may increase the demand for food by 70 percent and double the demand for water. Food spoilage and wastage as well as an increase in food safety risk will become very important issues. We will need to produce more food – more safe food – with fewer resources."

Food safety problems are challenging and complex, according to Lamprecht. "It is not a commercial option to fail. Linking a product to consumer illness can be catastrophic for the processor." Losses due to foodborne disease include the economic impact of product recalls and reputational damage.

"There's an increase in emerging pathogens and we've also seen greater antimicrobial resistance," cautioned Lamprecht. "In order to counter these












pathogens that are continuously adapting to our strategies, the process of food safety has to be dynamic." As demand for convenience foods grows, consumers become more reliant on producers and processors for safe food. Ready-to-eat foods are high-risk because they do not undergo further processing at home.

Lamprecht showed data on the occurrence of food-related illness in the United States of America. Four groups of bacteria stand out: Campylobacter, Salmonella, Listeria and Escherichia coli. Listeria infection is rare, but more likely to result in death than infection by the other three. "South Africa holds the record for the biggest Listeria outbreak," said Lamprecht, "but it is a problem worldwide."

Lamprecht outlined the main characteristics of listeriosis. In healthy adults, Listeria infection is usually limited to the gut and the person may show little sign of illness. Susceptible people – pregnant women, babies, the elderly, those with weakened immune systems – can develop the invasive form of Listeria infection where the bacteria enter the bloodstream and spread around the body. There are many species of Listeria, but Lamprecht explained that only Listeria monocytogenes and L. ivanovii cause disease.

"Listeria is a down-to-earth pathogen," said Lamprecht, "it occurs everywhere and grows on anything dead." Most bacteria that cause foodborne disease cannot multiply in cold conditions, but Listeria proliferates even under refrigeration. Freezing will halt growth but not kill Listeria. Listeria can colonise factory environments and resist removal and disinfection. Listeria is especially common in factory drains, from where it can spread to contaminate food products.

Lamprecht pointed out that the globalisation of the food trade compounds food safety risks. Hazards can enter the food chain at any point and the centralisation of food production then facilitates widespread outbreaks of illness. An example is the 2011 E. coli outbreak in Germany that was linked to fenugreek seeds imported from Egypt. The same contaminated seeds also caused E. coli-related illness in France.

The main practices that lead to foodborne disease in South Africa are improper temperatures for cooking, refrigeration and freezing; poor personal hygiene; cross contamination between foods; and contaminated irrigation water. "Safe preparation of food at home is the last line of defence for preventing foodborne illness," Lamprecht stated, "but that's not an option when working with ready–to–eat foods."

For food processors, safe practices come down to proper cleaning; preventing cross-contamination; correct cooking and chilling temperatures; and using good-quality ingredients. Factories need to monitor pathogens such as Listeria and, when present, address them in their HACCP (Hazard Analysis Critical Control Point) programs.

Lamprecht concluded on a positive note, "If there's one good thing that has come from the Listeria crisis, it's increased communication between industry and academia. We shouldn't stop here: we should keep communicating to make sure that academic research is of practical relevance to industry." •

Illustrations by Kendyll Hillegas, www.behance.net/kendyll

APPLICATION of machine learning in surveying production

talk by Prof Adriaan van Niekerk
summary by Anna Mouton

Adriaan van Niekerk, director of the Centre for Geographical Analysis at Stellenbosch University, gave an introduction to machine learning. He used an example of yield predictions in the wine industry to show how machine learning and remote sensing could be applied to pome fruit production.

VAN NIEKERK started by contrasting machine learning with traditional statistics. Machine learning is a branch of computer science that uses algorithms to discover the relationships between variables. The goal is to build systems that learn from data. This differs from statistical modelling which tries to find mathematical equations that fit the data.

"My talk is about supervised learning, which is a subfield of machine learning," said Van Niekerk. Supervised learning starts with humans creating a database of labelled samples. The labelled samples make up a training set—literally data that trains the machine-learning algorithm. The algorithm generates a model from the training set which it then applies to unlabelled samples. Initially the algorithm will not label all the samples correctly, but adjusting or adding labelled samples improves performance. The algorithm thereby learns from its mistakes and becomes more accurate with every iteration.

Van Niekerk demonstrated how this would work for an algorithm that labelled fruit type according to shape and colour. If the only red, round fruit in the training set is an apple, the machine-learning algorithm will label all red, round fruit – including a tomato – as an apple. When the algorithm makes such a mistake, more training samples will help to refine classification accuracy. "Generally, the more data you feed into the machine-learning algorithm, the better the classification gets," said Van Niekerk. "You want at least one sample per class per predictor variable."

"Remote sensing," explained Van Niekerk, "is collecting information from a distance." Earth observation uses the observation and analysis of spectral characteristics to derive information about the surface of the Earth. Data sources range from satellites to drones. "We can use this type of information to monitor fruit crops," added Van Niekerk.

"We now have a huge amount of remotely-sensed data," said Van Niekerk, "and the nice thing about this data is that it's becoming cheaper – or free – every year. But the problem is that it's just too much data. We need something to help us make sense of all this data. And that's where machine learning comes in."

Examples of potential uses of machine learning applied to remote sensing data include: irrigation scheduling; harvest scheduling; crop condition monitoring; pest management; and crop yield estimation. Van Niekerk presented an example of crop yield estimation research conducted in the wine industry.

"Essentially we tried to model yield and phenology using FruitLook data as a series of covariants," explained Van Niekerk. "We applied

“We need to start collecting and sharing data in a systematic way to reap the rewards.”

ILLUSTRATION: SIMONE ALTAMURA

machine-learning algorithms to many blocks for which we had actual yield data, so we could assess the accuracy.”

The first part of the analysis used statistical methods to model a mathematical relationship between the different variables. Cumulative leaf area index (from aggregated FruitLook data) had the best correlation with yield of all the variables tested. Similar results were obtained using the normalised difference vegetation index.

Unfortunately, the correlation between predictor variables and yield was strong in only a few cases. “There’s too much variation here,” said Van Niekerk. “Regression is inefficient for such comparisons.” Machine learning performs much more reliably. Using monthly aggregated data, the algorithm attained 89 to 93 percent accuracy in forecasting yield. With weekly data, accuracy was between 83 and 95 percent.

“We are encouraged by these strong models that we built with only a very few samples,” affirmed Van Niekerk. “However, there were some inconsistencies.” Why is this? Whereas the training set should include 1,000 to 2,000 samples per cultivar per region, Van Niekerk’s team had only 20 to 300. Future research will focus on improving the quality and quantity of data. Automated data collection and greater incorporation of remote sensing technology is planned.

“Clearly machine learning holds much potential for yield modelling,” concluded Van Niekerk, “but there are many other applications we could also be looking at. We need a lot of in situ data and we need to start collecting, collating and sharing such data in a systematic way so we can reap the rewards of machine learning.” •

THE LAY OF the land: GIS, machine learning and fruit fly distribution

talk by Gulu Bekker
summary by Anna Mouton

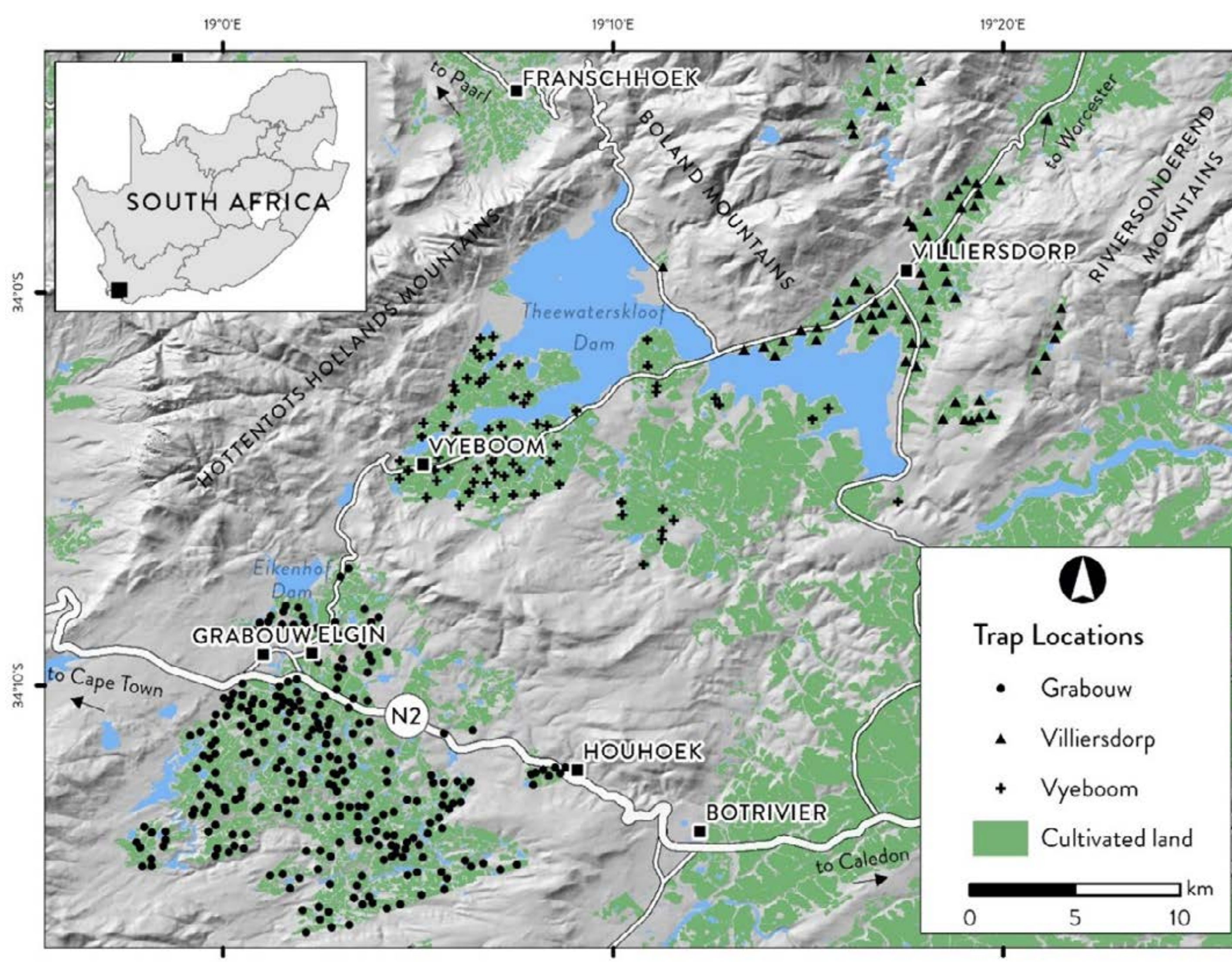
Gulu Bekker from Stellenbosch University described the use of geographical information systems (GIS) and machine learning to study Mediterranean fruit fly distribution. His research took place in the Elgin, Grabouw, Vyeboom, and Villiersdorp (EGVV) area.

"INSECTS—including fruit flies—respond to changing environments," said Bekker, "and this determines where they find themselves within the system." Bekker highlighted the complexity of the agricultural environment. Spatial characteristics range from microclimates and soil types to large-scale features such as topography and water bodies.

Bekker's research focussed on the Mediterranean fruit fly or Medfly (Ceratitis capitata). Medflies cause significant economic losses in stone and pome fruit production. Female flies lay eggs in fruit and the developing larvae feed within the fruit. Pupation takes place in the soil. Adult flies emerge from the ground and fly off to find mates and continue the cycle. "No fence or wall will stop them from moving around," remarked Bekker.

"Most control is aimed at the adult stage," said Bekker. "However, it's a moving target." Area-wide integrated pest management (AW-IPM), which proposes to manage the entire fruit-fly population, has been successful, but it poses challenges. AW-IPM has to be applied over a large area and requires substantial logistical and financial inputs.

More efficient AW-IPM requires a better understanding of the spa-



tiotemporal distribution of the flies. “We need to know when and where the pests are within the landscape,” explained Bekker, “but we also need to know why the pest is there. The answers to these questions can contribute to improved decision-making.

“Some of the main factors influencing Medfly seasonal dynamics and spatial distribution are weather conditions and on-farm management actions, both of which can be highly variable within and between seasons, making it very difficult to gauge the impact of these factors on an area-wide scale.”

Therefore, Bekker examined the influence of stable geographical characteristics on Medfly trap catches in the EGVV area. The aim was to identify geographical characteristics that may be predictive of the spatial distribution of the Medfly population.

Weekly trap-catch data was obtained from 399 traps for four consecutive fruiting seasons. The data was captured and analysed using a GIS. GIS enables the visualisation of data in order to find spatial relationships and patterns. “It helps us in our attempts to represent the real world on a piece of paper,” summarised Bekker.

The problem is that the high variability of trap-catch data makes pattern recognition difficult. To counter this, Bekker performed a hot-spot analysis. A hot spot is a statistically significant cluster of high values (whereas a cold spot is a cluster of low values). Hot-spot analysis can differentiate a random spatial distribution from one that is related to an underlying cause.

The monthly and seasonal hot-spot maps for Medfly trap data in the EGVV area showed variation in the location of the hot spots. “But if you look closely, there was a north-west and a south-east split between hot spots and cold spots,” Bekker pointed out. “Surprisingly, we saw the same split in long-term mean temperature and annual rainfall.”

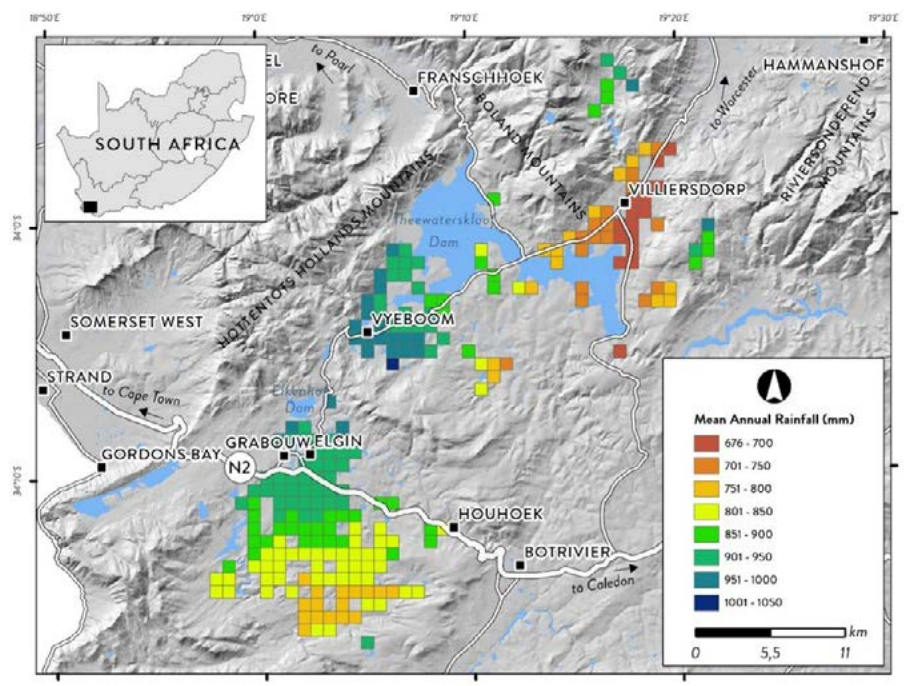
Machine learning was used to determine whether this pattern could be explained by stable geographical variables. “We used the data from the hot-spot maps as known outputs in the random -forest algorithm,” said Bekker, “and the geographical variables as inputs. The algorithm gave an overall model accuracy but also a variable importance list—which is a measure of the role played by each variable in constructing the model.”

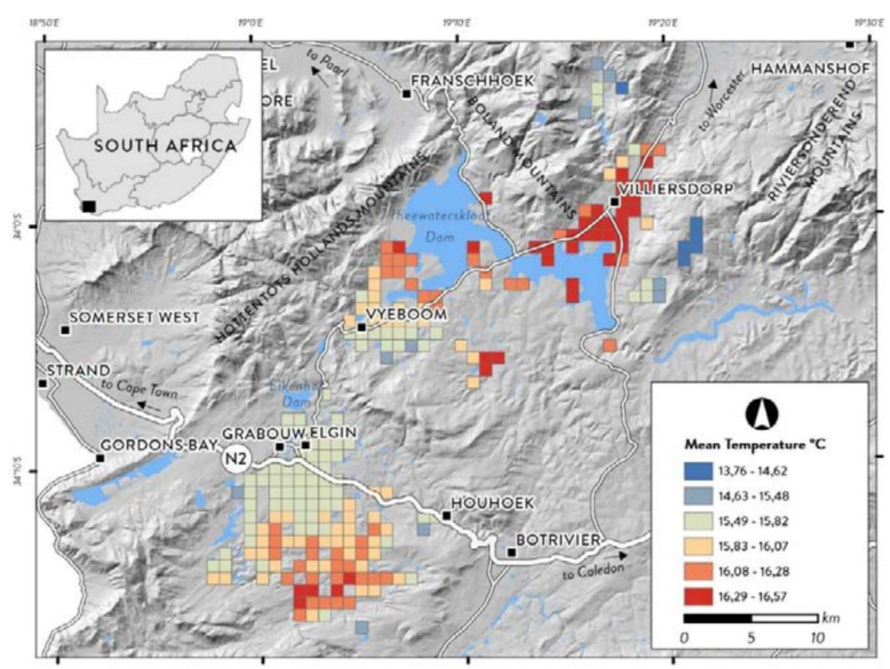
The results showed that long-term rainfall is a prominent driver of Medfly trap-catch hot spots and cold spots in the EGVV area. Maximum temperature is also important. “It’s not just one variable that explains these hot spots and cold spots,” said Bekker, “but it’s a combination of a multitude of variables.”

“Within a complex agricultural system we could identify a relationship between the spatial distribution of long-term Medfly trap catches and the geographical characteristics of each zone,” concluded Bekker. “GIS and machine learning proved to be valuable tools in determining and explaining these patterns.

“Hopefully this research will help AW-IPM managers to conduct more precise spatial planning—which could lead to better program performance and reduced costs.” •

Click **here** to watch Bekker’s summary on our YouTube channel.





NEW technology in monitoring and spraying

talk by Gideon van Zyl
summary by Anna Mouton

Gideon van Zyl, technical consultant with ProCrop, discussed the impact of remote control, remote sensing and automation on application technology in modern fruit production systems.

"I THINK this is the way that farming of the future is going," announced Van Zyl, gesturing to an image showing sweeping farmlands centrally controlled through remote sensing and automation.

Although unmanned aerial vehicles (UAVs or drones) are already used for chemical applications in some crops, there are limitations. The deposition of aerial sprays is restricted by tree canopies, particularly with stone and pome fruit. When spraying from above, the application is complicated by the number and density of leaves and fruit that intercept the droplets.

Van Zyl gets many enquiries about the use of drones. "We need deposition data," is his response, "specifically for different parts of the canopy." Without this, there can be no assurance of effective disease control. Current drones also have small payloads (30 to 60 liters of spray product). This excludes their use for most application situations.

Whereas data is lacking on the use of drones, more information is available for remote sensing technology. "This is where research in spray application has been moving," said

Van Zyl. The focus is on crop-adapted application, in which concentration and spraying are adjusted for the size and geometry of the canopy.

Tree-row-volume (TRV) is considered when planning chemical applications, but it is calculated on an orchard basis. "Imagine if you can do it for every tree, in real time, as the unit is spraying," said Van Zyl. "If we can do that, we can determine the volume, canopy density and leaf area. We can stop dosing per hectare and start dosing per square centimeter of leaf area that we need to cover."

Crop-adapted application based on real-time sensing leads to more efficient spraying – time is saved on measurements, calculations and refilling; and the process uses less diesel and chemicals. Less chemical use is better for the environment as it reduces run-off and pollution. In addition, chemical application is more accurate.

The main systems for characterising plants rely on various types of sensors linked to electronic data collectors. Digital cameras are low-cost, easy-to-use and provide acceptable accuracy for estimating variables such as plant height, volume and leaf area index. However, digital photogrammetry requires a large number of images and complex post-processing which precludes real-time use. Stereoscopic systems overcome some of these limitations, but lose effectiveness under certain conditions such as variable lighting.

"We use digital photography every day to measure deposition," said Van Zyl. "This is a service that Stellenbosch University provides to growers." The digital image analysis laboratory of the Department of Plant Pathology can measure deposition quantity, quality and uniformity. A smartphone and web tool called SnapCard is also available – from the App Store or Google Play – for assessing spray coverage.

Technologies that are currently under investigation are light detection and ranging (LIDAR) and ultrasonic sensors. The first variable delivery machine with adjustable liquid flow rate nozzles and airflow louvers has already been developed. Spray rates are matched to individual tree size and density using real-time data obtained from a LIDAR system. The machine only sprays where it detects leaf area.

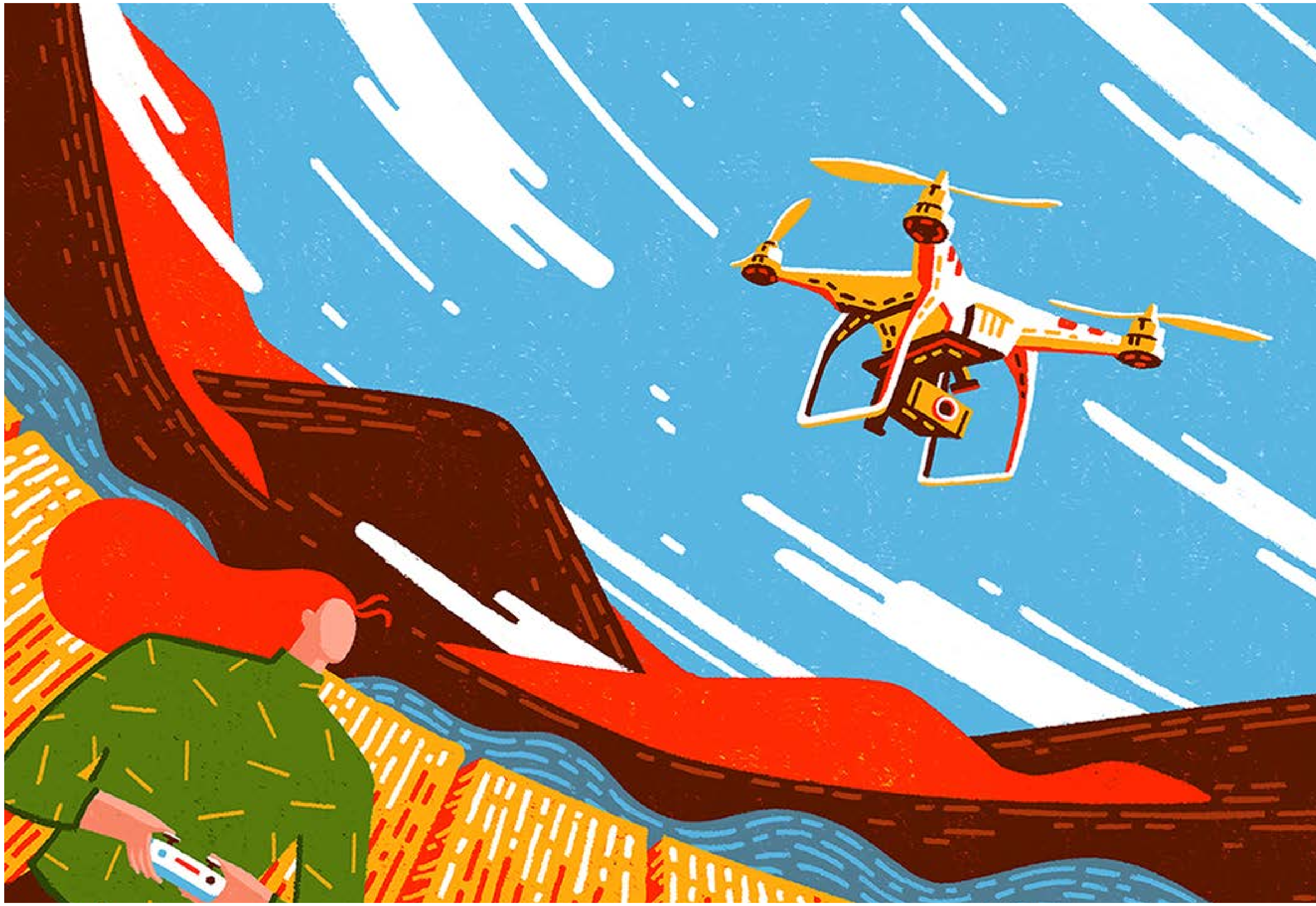
"With our canopies changing – as we move to high density orchards – is the TRV system still relevant?" Van Zyl asked the audience. "There are other calibration models that have been used successfully in other countries."

The MABO (Marktgemeinschaft Bodenseeobst) dosing model adjusts water volume based on canopy characteristics by manipulating forward speed and power take-off revolutions per minute. MABO reduces fuel, time and labour inputs and generates less spray drift than conventional systems. Calibration discs are another tool for calculating total flow and flow per nozzle without the need for a calculator. Electronic flow meters are available for measuring nozzle output.

Patternators are useful to quantify deposition patterns, but can be expensive. Van Zyl pointed the audience to an **online resource for free patternator building plans.**

"The future is here," concluded Van Zyl. "In the next few years we are definitely going to move into automated spraying. Until then – focus on improving your calibration!" •

Click **here** to watch Van Zyl's summary on our YouTube channel.



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Mailto: **este@hortgro.co.za** & **thea@hortgro.co.za**
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