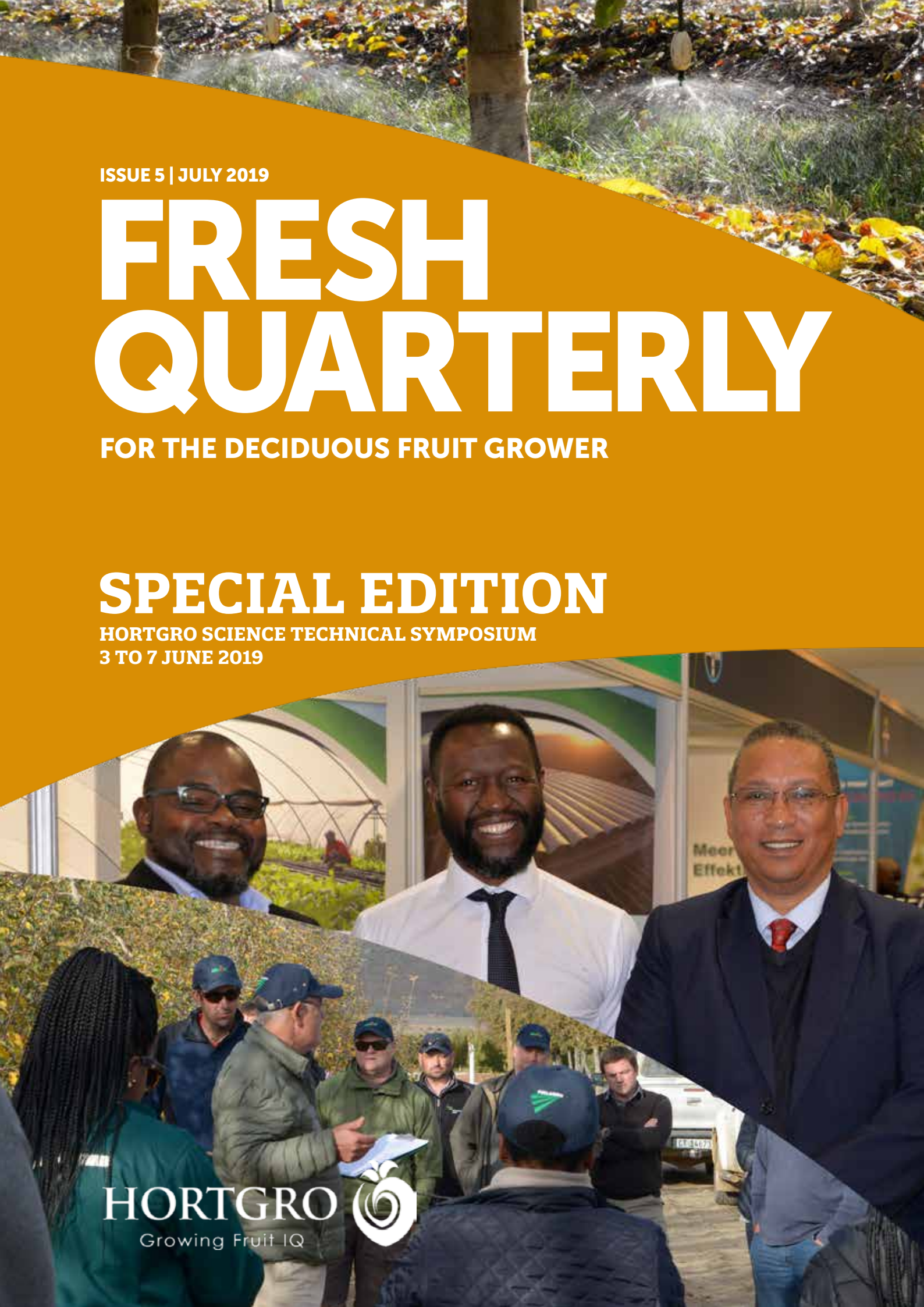




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FRESH QUARTERLY

FOR THE DECIDUOUS FRUIT GROWER

SPECIAL EDITION

HORTGRO SCIENCE TECHNICAL SYMPOSIUM
3 TO 7 JUNE 2019



HORTGRO
Growing Fruit IQ

FRESH QUARTERLY

ISSUE 5
JULY 2019

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The 2019 Hortgro Symposium Special Edition

3 to 7 June 2019

This issue of Fresh Quarterly brings you some of the highlights of the 2019 Hortgro Symposium. The event opened with an address by Dr Ivan Meyer, the Western Cape Minister of Agriculture.

Meyer emphasised the contribution of agriculture to the economy and quoted research showing that a 5% increase in agricultural exports will lead to 23 000 new jobs in the Western Cape. He stressed the importance of water and energy to agriculture, and also referred to the ongoing uncertainty around land reform — all issues on the symposium programme.

Water security remains front of mind for fruit producers and we were fortunate to hear from a leading hydrologist about lessons learnt in Israel. Israel has a vibrant agricultural sector in one of the driest regions of the world. Prof. Eilon Adar, former director of the Zuckerberg Institute for Water Research at Ben-Gurion University of the Negev, gave two talks, both of which are summarised in this issue of Fresh Quarterly.

Adar was one of four international speakers. The others were Prof. James Carey, University of California, Davis, on the challenges of fruit-fly control; Dr Alberto Dorigoni, Edmund Mach Foundation, Italy, on advances in tree training; and Frank van de Geijn, Wageningen University and Research, The Netherlands, on optimal storage

conditions for fruit.

"From an organisational point of view we are very pleased with the turnout of over 700 delegates that attended the symposium," says Hugh Campbell, general manager of Hortgro Science. "We are indebted to our speakers and particularly our keynotes for setting such a high standard. For those that didn't attend, we trust that this Fresh Quarterly provides some insights into what was presented and discussed at the event."

The symposium kicked off on Monday with a pome fruit field day in Ceres and concluded with Fruit Farming 101 on Friday. A total of 41 speakers contributed their expertise over the course of five days. We have included summaries of 22 of the talks in the following pages. We have also provided an overview of the land reform panel discussion. A quick scan of the contents reveals something for everyone — whether you're interested in crop production, crop protection, post-harvest technology or big-picture questions about politics and Eskom.

The last word must go to the Western Cape Minister of Agriculture. "Keep doing what you do best," Meyer told the audience, "producing for the export market." We hope the 2019 Hortgro Symposium and Fresh Quarterly will help you in that goal

Anna Mouton

Editor

Reform Holds the Key to Economic Growth

Individuals should control communal land

By Engela Duvenage

Prof. William Gumede, an economist and political scientist at the School of Governance at the University of the Witwatersrand, briefed the audience about South Africa's political landscape after the May 2019 elections. He said that leftist populism should be taken out of the South African land debate.

"There's an important lesson in China's history," noted Gumede. "In China, the change really came when land was taken away from the state and given to individual households."

According to Gumede, communal land is one of the reasons behind a lack of development and growth in the South African economy.

"Communal land must be moved into the hands of individuals. That's where five to ten million black farmers are sitting," he explained. "Because they do not have control over the land that they farm, they cannot go to the bank to secure loans or collateral for equipment, fertiliser and so on."

"One of the reasons why Africa has been left behind and may still be left behind as we enter the new world epoch, is that more than ninety percent of land across the continent is communal, controlled by chiefs and not households. People and households cannot use it as productive assets."

He said that people farming on communal land do not have real power over decisions made on their behalf. "If they vote for the wrong political party or criticise the chief, they might not get further grazing rights, for instance."

According to Gumede, no political pressure is placed on chiefs at all to release land. This is because of the way in which they have obtained the right to lead. "Political parties allow chiefs to be in power, and in return they must secure votes."

"Communal land must be moved into the hands of individuals."

To strengthen the South African economy President Cyril Ramaphosa will need the political courage to release land from state-owned entities, cities and especially chiefs, and to place it in the hands of individuals and households. This is the strategy followed by most developing countries that over the past century have successfully moved from poverty to a low- to middle-income economy. It's also the strategy that kick-started China's economic growth after the Cultural Revolution of 1966–1976.

A FUTURE OF ABSOLUTE UNCERTAINTY

If President Cyril Ramaphosa has the political courage to do something about communal land, he will become more popular among millions of rural black South Africans," Gumede noted. "However, it is politically very difficult for him to deal with."

Ramaphosa would also have to make difficult decisions about the vast tracts of land that sit in the hands of state entities and cities that are unwilling to let go of it.

"The last pillar of land reform is getting housing right. People want housing and jobs. We need to solve it," added Gumede.

He underlined that there are various practical solutions to the land debate. However, these are resisted by the populists within the ANC and the EFF because they know that Ramaphosa is against land expropriation.

Gumede warned that South Africans should not expect major changes in the first year of Ramaphosa's current term. "There's going to be a period of twelve months of absolute uncertainty as Ramaphosa tries to push through reform."

"President Ramaphosa has three years at most to take hard decisions, in an effort to steer the South African economy in the right direction," said Gumede, who believes that the local economy is worse off than it was in 1994 during a period of recession.

"We are in a moment of uncertainty in the world and in South Africa. It demands leadership in every space of our society. The last ten years have depleted our fiscus, as well as the capacity of the state itself," asserted Gumede. "It becomes important for the state to partner with the private sector."

Gumede believes that South Africa has extraordinary surpluses of savings and human capital in the private sector. "The obvious thing is that the state will have to partner with the talent and the money in the private sector. But politically the struggle for Ramaphosa is that the populists inside and outside the ANC are hostile towards the ideas and capacity in the private sector."

Using the private sector to deliver will be crucial to resolving the current crisis, concluded Gumede. "Every sector will have to take its own leadership now. You cannot wait on the state. You have to ask what your future is in the next five years, and then do it." **FQ**

"It becomes important for the state to partner with the private sector."



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To the Last Drop

Reclaiming deserts for farming

By Engela Duvenage

Sewage or effluent is not waste. It is a treasure. If managed correctly, it can be sustainably used by the agricultural sector. If Israel can do it, South Africa can do it too. That was the challenge put to the local deciduous fruit sector by Israeli water expert Prof. Eilon Adar from the Zuckerberg Institute for Water Research at the Ben-Gurion University of the Negev.

“In 2016 two-thirds of the water consumed by the agricultural sector in Israel was from reclaimed effluent.”

Adar explained how sewage and effluent water from most major Israeli towns and cities is cleaned, fed into dedicated water grids and then used by farmers for drip irrigation.

“In 2016 two-thirds of the water consumed by the agricultural sector in Israel was from reclaimed effluent and we reclaim up to 89% of sewage water,” he

noted. “Sewage is produced almost at a constant level all year around. It is nature. Knowing how to treat it makes it a sustainable source of water supply to the farming sector.”

The statement elicited uncomfortable giggles from participants at the Hortgro Science Technical Symposium.

“Don’t tell me you are afraid of your market’s reaction,” he pre-empted many participants’ sceptical responses. “Israel exports to central and western European markets and North America. We meet all the constraints of the European and US environmental protection agencies.”

ALTERNATIVE WATER SOURCES

Sewage water was not the only alternative water option that Adar presented to show how Israel manages to be the only country in the

Middle East not to suffer from desertification.

“We produce more water than what God provides us with, because our demand is higher than what nature delivers,” noted Adar, who added that water management in Israel is a balancing act between how much water is available and which sources can be further accessed.

LEFT Careful water management enables intensive agriculture in the deserts of Israel.

Facts about water in Israel

- The average annual rainfall ranges from less than 50 mm in the south to 1 250 mm in the north.
- The Sea of Galilee is the only inland natural freshwater reservoir in the Middle East.
- All groundwater sources in aquifers are mapped and developed
- The annual renewable water in Israel amounts to about 1 400 cubic metres of water per person per year. This is less than 20% of the basic per capita requirement recommended by the World Bank.
- Only 24% of the water used for agriculture in Israel today is from fresh and desalinated sources. Another 8% is brackish water. The rest — 68% — comes from treated effluent.

The world’s first drip irrigation system was developed in Israel in the early 1960s. Adar described the development of focused, efficient irrigation systems as an absolute necessity, given that the evaporation rate in the arid Middle East is about 12 to 14 millimetres of water per day. This equates to 12 to 14 litres of water loss per square metre.

“We simply cannot afford it,” stated Adar. “Drip irrigation has been a game changer and allows farmers to reach between 88% and 95% water-use efficiency.”

Five seawater desalination megaplants in the country have been operational since the mid-2000s, and in 2018 produced 655 million cubic metres of potable water. Brackish groundwater is also desalinated at various smaller inland plants.

Thanks to vast stretches of greenhouses, the country is able to produce food in desert areas with minimum water. Producers microharvest mist and rainwater, and plant crops modified to withstand brackish water. Fertiliser-rich water is recycled and reused.

Subsurface irrigation, more energy-efficient effluent treatment methods and responsive irrigation systems have been developed. The latter ensures that plants are only given the water that they need at any given time. Water requirements are calculated using advanced technology such as real-time photosynthesis meters and soil moisture sensors.

PREPARING FOR WORST-CASE SCENARIOS

Israel’s focus on alternative water sources stretches back to its establishment in the late 1940s. The national water grid system has been developed since 1956. Israel’s national water carrier was inaugurated in 1964 and is nationalised. It allows water from different sources to be mixed and transferred across the country. Each source of water also carries a different cost which in turn drives water optimisation.

The substantial volume of water contained in the water grid is a valuable backup in case of trying times in the Middle East.

“Being in an arid, desert area, it became a kind of obsession to ensure that water scarcity is never a limiting factor to our economy. We have done everything we could, and still do, not to just survive but to flourish,” Adar emphasised.

Adar also noted that Israel already responded when the first red flags about climate change were raised, and has subsequently implemented pre-emptive measures.

“We work according to worst-case scenarios. We simply cannot afford a water shortage. We know the toll it will have on our economy,” he explained.

“It can be done if you have a vision, and are willing to invest and drive it,” Adar believes. “Our motto is that water will not hinder the local economy. We are motivated by the need to produce food for the world’s growing population.” **FQ**



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Be Savvy About Salt

Brak management in crop production

By Grethe Bestbier

In South Africa, the term 'brackish' refers to any salt-related issues. While salts are a natural part of any farmer's soil, it is important to manage it correctly to reduce risks of crop damage. Mico Stander and Karen van der Westhuizen, soil scientists from Agrimotion Consulting, explained the key concepts regarding brak — salinity — management and its importance in crop production.

Calcium, magnesium and sodium — according to Stander, these are the elements you need to consider when thinking about brackish soils. These primary cations are found in soil and water, and are usually accompanied by chlorine, sulphate and bicarbonate anions.

Salinity refers to the concentration of all salts. If the salt concentration becomes high enough it will affect plant function and crop production. Sodicty, on the other hand, refers to the composition of the salts — the ratio of sodium to calcium and magnesium — in the soil. "It's important to note that you can have a medium that is saline without being sodic and vice versa," said Stander.

Salinity is usually caused by one or more of the following: inherent soil mineralogy, poor water quality, poor drainage, shortage of water for leaching, and over-fertilisation.

According to Stander, we can distinguish between direct and indirect impacts of brackish conditions on crop production. The first direct impact is reduced water potential in the soil, making it harder for a plant in saline soil to take up water. The second involves the toxicity of prevalent elements,

like sodium or chlorine, which the plant struggles to eliminate. The final direct impact is deficiency of certain elements due to competing root uptake.

Indirect effects include the degradation of soil structure. This can lead to poor water infiltration causing run-off and erosion, poor gaseous exchange, and poor root development.



MICO STANDER | AGRIMOTION

MANAGING BRACKISH SOILS

The easiest way to deal with brak conditions is to do a soil survey, to analyse your soil and your water sources, so you can avoid moving to these areas in the first place," said Van der Westhuizen. For situations where salinization cannot be escaped, she discussed a number of mitigation strategies.

- **Ridging** – In brackish conditions, ridging is a very useful tool to improve surface drainage and to move the effective rooting depth higher, out of potentially waterlogged and salt-affected sub-soils.
- **Rootstock choice** – For stone fruit in brackish conditions, Van der Westhuizen recommends choosing either a GF677 or a Viking rootstock, while for pome fruit a more vigorous rootstock should be considered.
- **Irrigation system** – An irrigation method with a low delivery rate will promote a better infiltration depth and less runoff. This is where drip irrigation should be considered.
- **Effective drainage** – When leaching, you're putting water into the soil to dissolve, dilute and transport excess salts, but you now need to remove the saline water. It is important to consider drain spacing, depths, maintenance and safe disposal of water.

- **Gypsum application** – When adding gypsum, you're adding calcium to displace the sodium and magnesium from the soil. This will increase the soil electrical conductivity. If the soil is saline and sodic and has a high pH, then gypsum should not be added. Rather use sulphur-based products.

- **Fertilisation** – Avoid fertilisers that contain chlorine. Rather use fertilisers that are sulphur- and sulphate-based.

- **Mulching** – Organic matter in the form of mulch decreases surface evaporation thereby reducing salt movement to the surface. Mulch also helps decrease run-off and improves soil structure and water infiltration.

- **Leaching and flushing** – Salt accumulation at the edge of the root zone is a natural part of fertigation and drip-irrigation. A longer irrigation flushes this accumulation of salts away from the root zone. Leaching

removes salts from the profile so it can be carried away by drains.

- **Consistent monitoring** – Hand-held meters can be used to monitor soil electrical conductivity every ten days. Laboratory analyses of your soil should be done at least every two years to determine the percentages of different cations. Also analyse your water sources two to four times a year. Lastly, soil moisture probes should be used to monitor soil moisture, as well as leaching depths.

- **Running at a higher easily-available water percentage** – Salts in the soil solution reduce the potential for water uptake by roots. Maintaining a slightly wetter profile, but not saturated, will improve water uptake.

- **Applying irrigation after rainfall** – Apply irrigation either during or just after rainfall, to avoid salts being pushed back into the root zone by the rain. **FQ**



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LEFT Leaf scorch is one of the signs of brackish soils.

Below the Surface

Exploring groundwater as a significant sustainable water source

By Grethe Bestbier

"One thing I can tell you," said Prof. Eilon Adar, leading groundwater hydrologist and former director of the Zuckerberg Institute for Water Research at Ben-Gurion University of the Negev, "groundwater is a reliable and non-trivial source of water." While most of South Africa relies on surface water, difficult climatic conditions and limited rainfall is forcing us to consider properly using other water sources. According to Adar, groundwater is the best way to bridge this water shortage.

The Western Cape has much to learn about using groundwater.

SURFACE WATER'S LIMITATIONS AND ISRAEL'S RESPONSE

Although surface water sources are easily developed and relatively inexpensive to use, they depend on rainfall fluctuations and climate change. Groundwater is not influenced to the same extent. Compared to surface reservoirs, groundwater reservoirs are huge and can tolerate climatic variations much better.

"In Israel, until 2004 when massive seawater

desalination began, the entire development of the modern water supply system was based on groundwater," said Adar.

Israel secured sufficient and adequate water supplies, even in desert areas, by developing their groundwater resources.

"Without enough streams, we were looking for groundwater in Israel. Excluding the Jordan River, the only source of agricultural development throughout the history of Israel were aquifers," said Adar.

Aquifers discharge groundwater through natural springs and seepage into the oceans. To add to its water supply, Israel constructed the National Water Carrier, completed in 1964. The system combines groundwater from the natural Yarkon springs and production wells with surface water from the Jordan River, and diverts it via pipelines to the Negev Desert.

Initially, they drilled relatively shallow wells into the coastal aquifer. When that was not enough, they dug deeper — sometimes more than a kilometre — into artesian aquifers.

"We knew that we had deep groundwater, because we had 3D-mapped the subsurface hydrological structure, in order to identify potential pockets of fresh and brackish water," stated Adar.

Expensive? Yes. Worth the investment? According to Adar, a definite yes. "It provided most of the water needs for Israel until 2004 when additional desalinated water was introduced into the water supply system."



Water collecting after rains in the Arava Desert, Israel.

A FRAGILE SOURCE OF WATER

"Whenever we interfere with Mother Nature, there can be problems. Our job is to mitigate this and ensure that we act in an environmental and appropriate way," said Adar.

He emphasised that unless you have studied the hydrogeological structures, there is no way to know what is going on in these underground water stores. A lack of knowledge can lead to catastrophic mistakes.

Groundwater is stored within the saturated zone — where the space between mineral grains is saturated with water — and within an unsaturated zone — which also contains air. The natural recharge of the reservoir is from rainwater percolating through the unsaturated zone, which sieves away unwanted substances. Sometimes, to increase the natural recharge, water is directly injected into the saturated zone, bypassing this filtering system, with disastrous consequences.

Many other examples of the fragility of the groundwater system exist. Not knowing a spring's storage capacity and the process of recharge, one might mistakenly think that you have an inexhaustible amount of groundwater, when that is not the case. Inadequate groundwater abstraction might completely destroy the aquifer's storage and water quality within months. But, as Adar rightfully asks, "Without adequate hydrogeological information, how can you know that?"

According to Adar, the Western Cape has much to learn about using groundwater, starting with its lack of hydrogeological data.

"In the Western Cape, I have seen that farmers

hire a contractor, start to drill and have no idea what the target layer is," said Adar.

There are no drilling records, no collection of soil and rock information, and no one knows what the subsurface three-dimensional hydrological structure is. Adar stressed the need to make observation boreholes in strategic locations for future groundwater abstraction, as a back-up system to surface water supply.

"I'm almost sure that in the future, because of climate variations, the surface water resources will not be sufficient to sustain increasing demands," said Adar. "Groundwater is a reliable water source and sustainable water store. However, it is very fragile and unless studied in the most vigorous way, it can be a disaster. On the other hand, it can be a treasure as the best water savings account." **FQ**



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Train Your Trees for the Future

Tree architecture and training systems of yesterday, today and tomorrow

By Grethe Bestbier

If the orchard is seen as a jigsaw puzzle, then tree architecture is the most important piece. According to Dr Alberto Dorigoni, pomologist at the Edmund Mach Foundation in Italy, changing the tree architecture can affect all the other pieces of the puzzle. Various systems of tree training are seen all over the world. The question is, which of these systems is most suitable for the future?

Tall spindle and solaxe training is the traditional way of doing things. The typical spindle or solaxe training system is based on a single vertical or central leader and some secondary structural branches that are not cut back — this is called long pruning. Structural and permanent wood is often unproductive, serving only to redirect energy from the rootstock and tree outwards. The result is a three-dimensionally shaped tree, with strong peripheral and lateral structure.

Spindle and solaxe training gives good yields and quality, but has a few drawbacks. Pruning spindles is labour-intensive and demands high-level skills. It also requires spacing of four metres or more between rows, and time-consuming bending and spur pruning.



PHOTOS: ALBERTO DORIGONI | AZIENDA S. GIUSTO OF DORIGONI BROTHERS

"Another major problem is that you need to thin very aggressively," Dorigoni added. "This is difficult when trees are pruned long. Even harvest is complex. The complex secondary structures make almost any form of mechanisation impossible."

GOING 2D: THE VERTICAL MULTIPLE-LEADER TRAINING SYSTEM

There are different ways of obtaining a two-dimensional tree structure. The most natural is a multi-leader trained structure that exploits the tendency of the tree to grow vertically. This structure consists of two or more permanent vertical leaders and short branches. Mechanisation and lack of skilled labour are favouring these narrower canopy systems.

Dorigoni pointed out that having two leaders divides the volume of the tree and creates new exposed surface. "The ratio of surface to volume is increased," he said. Greater surface area improves light distribution and reduces shading. In terms of vigour, increasing the number of leaders creates an effect similar to that of a dwarfing rootstock — every added leader causes a reduction in trunk cross-sectional area.

"The number of leaders is an additional variable when we want to choose the right spacing and planting for a given area," said Dorigoni, "besides the cultivar and the rootstock."



FAR LEFT The Guyot system in action: Pink Lady photographed 15 days after mechanical leaf removal.

LEFT Mechanical pruning maintains a narrow canopy in trees trained on the Guyot system.

- High-efficiency precision horticulture: With a Guyot system, the flat-canopy multiple-leader trees make it possible to calculate exact tonnage. This cannot be done with three-dimensionally shaped trees.
- Harvesting efficiency: The Guyot system offers an impressive harvest speed, easily reaching 300 kilograms per hour per person without expensive machinery.
- Crop protection: "Guyot revolutionises crop protection altogether," said Dorigoni. "You need less water, pressure and ventilation."

Tree rejuvenation: With Guyot systems, replacement of strong vertical branches is possible for the entire life of the orchard.

Optimal canopy structure: Even though V-shaped Tatura structures are highly productive, they impede mechanisation. According to Dorigoni, vertical Guyot systems can be planted in double rows, which is better from a mechanical and management point of view. **FQ**

Up to eight leaders can be used on vigorous rootstocks and still form a narrow canopy. Narrow canopies don't block the passage between rows in the same way as the secondary structures on spindle and solaxe systems.

THE FUTURE: GUYOT SYSTEMS AND ULTRA-NARROW TRAINING

According to Dorigoni, the last step in the evolution of the multi-leader is the Guyot system. The main differences between Guyot and vertical leader training are that, in the Guyot system, the vertical leaders become horizontal, the horizontal branches become vertical and semi-permanent, and there is no further important structure.

There are several benefits to Guyot systems. Removing long and lateral secondary structures allows:

- Better light distribution: Trees remain very flat throughout their lives. Since the crop is uniformly distributed, the fruit experience a better and more even light exposure.
- Mechanisation: Guyot systems facilitate mechanisation and allow transition towards SLIM — Small Light Manageable Intelligent — mechanisation.
- Easy visualisation of fruit: The fruit can easily be seen and removed from the tree. According to Dorigoni, about 95% of fruit are easily spotted without putting a hand on the tree or lifting branches.



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From Blossom to Apple

Understanding why some flowers set and others drop

By Grethe Bestbier

Many questions regarding fruit production were raised during the past season. With heat waves, warmer autumn temperatures and drought conditions, growers were uncertain what to expect, especially in terms of fruit set. According to Prof. Karen Theron, Chair in Applied Preharvest Deciduous Fruit Research at Stellenbosch University, countless factors — plant and environmental — affect fruit set.

In the most basic sense, when there is a rapid increase in cell division in fertilised flowers, it is said that the fruitlet or flower has set. An unfertilised flower will not show that rapid increase in cell division, and will drop before forming a fruit.

According to Theron, to understand all the factors that control fruit set, we first have to know why certain flowers drop.

For most trees, there is a rapid first drop of flowers and even small fruitlets until about four weeks after full bloom, and a less severe second drop in November. Flowers lost during the first drop are either entirely unfertilised due to pollination problems, incompletely fertilised or out-competed by other flowers or shoots.

The second drop varies in intensity and is usually due to competition. By this stage, there are fruit of different sizes on the tree. The fruitlets that

drop will generally be dull in colour and smaller than others, with yellow stems. The stage of seed development inside the fruitlet also plays a role, explained Theron. "There is internal competition. If you end up with fruit with fewer seeds, they will tend to drop."

FACTORS DETERMINING FRUIT SET

Fruit set is determined by pollination, fertilisation and competition. A flower needs to be pollinated to set — it requires overlapping flowering of a cross-pollinator and bee activity to transfer pollen. Both of these aspects are influenced by climate. An overlap in bloom is heavily dependent on winter and early spring climate, while bees become inactive in cold, windy or cloudy conditions.

Once pollinated, a flower must be fertilised. Successful fertilisation depends on good flower quality, a long effective pollination period and a receptive stigma. In turn, all of these are influenced by various factors.

Firstly, fertilisation is influenced by flower quality, with high quality flowers being more prone to fertilisation due to a longer ovule lifespan. Quality depends on bearing position and the process of flower differentiation. In terms of bearing position, in apples the king or central flower outranks the lateral flowers. Differentiation, on the other hand, is influenced by stress factors such as excessive cropping, high autumn temperatures and drought, which all lead to a weaker flower.

Secondly, a longer effective pollination period

LEFT Flower quality is one factor affecting fruit set.

is very important for successful fertilisation. The effective pollination period is the difference between the lifespan of the ovule and the time that the pollen tube needs to grow down to the ovule. Therefore, a longer-lived ovule or a more rapid pollen-tube growth rate, will result in a longer effective pollination period, and increased chances of fertilisation.

An ovule's lifespan is dependent on flower quality, spring temperature — high temperature is a red flag — and cultivar. For pollen-tube growth, temperature also plays a significant role — the higher the temperature, the faster the tube grows.

"Now, you have a problem. Your ovule degenerates quickly at high temperatures, but your pollen tube grows faster. However, faster growth of pollen is not enough to cancel the negative effect the high temperature has on the ovule lifespan. In total, it means that high spring temperatures have a negative effect," explained Theron.

Successful fertilisation depends on good flower quality, a long effective pollination period and a receptive stigma.

Research from Europe has found that spring temperatures above 17 degrees Celsius are detrimental.

The receptivity of the stigma also plays a role in the effective pollination period. When spring temperatures are very high, especially if combined with low relative humidity, the stigma dries out faster, which can become a limiting factor.

The final consideration in fruit set is competition. Fruit-fruit competition takes place in the cluster, where the king flower dominates the laterals and is more likely to set. "The degree of dominance of a flower is determined by when it sets — so the earlier it opens, the better its chances are of becoming a dominant fruit and staying in the cluster — and by seed number — more seeds, higher chance of set," said Theron.

Theron concluded by reminding the audience that fruit-shoot competition tends to be overlooked. It is increased by high night temperatures, heat waves during the day and low light levels, resulting in a reduced set. **FQ**



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Late Bloomers

The effect of extended bloom period on fruit quality

By Grethe Bestbier

“I don’t have to explain to this audience the challenges of trying to farm apples with mixed maturity,” said Dr Esmé Louw from the Department of Horticultural Science at Stellenbosch University. Mixed maturity at harvest due to an extended bloom period is often seen in the Western Cape, where unsynchronised flower development results in flowers of different developmental stages on the same branch. This issue prompted Louw to investigate how extended bloom period affects fruit quality.

MAKING CHRISTMAS TREES OUT OF ORCHARDS

Louw identified six Golden Delicious orchards from two trial sites — Ceres and Grabouw. When October arrived, her team tagged newly developed flowers every second day using different colours.

“By the end of the extended flowering period, our apple trees looked like Christmas trees. We now had brightly decorated branches, clearly identifying when the flowers emerged,” explained Louw.

By harvest time the flowers had turned into fruit, still clearly marked by colourful tags. The apples were harvested and moved to the laboratory where they were split in two subsets.

One set immediately went for destructive maturity indexing to determine starch breakdown and flesh firmness. The other was stored for three months in a regular atmosphere, followed by a seven-day shelf-life period, after which it also underwent maturity analysis.

The process generated a robust dataset and she could attempt to link extended bloom period with the quality parameters determined in the laboratory.

To compare the orchards from the two areas, the researchers overlapped the phenology by aligning all the full-bloom dates of the orchards. In this way, they could distinguish between fruit from early, full-bloom, and late flowers.



For Ceres, about a third of the fruit harvested came from flowers blooming during each of these periods. For Grabouw, almost half the fruit came from full-bloom flowers, 28% from early flowers and 24% from late flowers.

Therefore, while both of the areas show an extended bloom period, Grabouw seemed to have more of its fruit develop from full-bloom flowers while Ceres showed a wider distribution.

In terms of starch breakdown at harvest, Louw found different results for Ceres and Grabouw. Grabouw showed a higher starch breakdown, signifying greater maturity, for fruit from early-flower fruit compared to late-flower fruit. Ceres, on the other hand, showed no difference in starch breakdown between these groups.

Moving on to firmness at harvest, the apples from the two areas behaved the same. Fruit from early flowers were softer than fruit from late flowers.

FLOWER QUALITY AFFECTS FIRMNESS AFTER STORAGE

According to Louw, Grabouw’s trends are typical of what they expected for both starch breakdown and firmness when suffering from an extended bloom period. The surprising result lies in firmness after storage.

“If we look at Grabouw, we can see what we would expect. Fruit from early flowers had higher starch breakdown values and lower firmness at harvest compared to the late flowers, and this pattern holds after storage. For Ceres, however, this was different. In terms of firmness after storage, there was no difference between the early- and the late-flower fruit.”

Louw said that they also succeeded in finding some valuable correlations in Grabouw’s data. They concluded that, firstly, one could use starch breakdown as an indication of the firmness at harvest, and, secondly, that firmness at harvest serves as an indication of firmness after storage. However, these correlations were much stronger in the full-bloom and late-bloom fruit compared to the early-bloom fruit.

The question remains: what made Ceres’ early-flower fruit behave so unexpectedly after storage, and how do we tie the flower to fruit behaviour?

According to Louw, a wider flower receptacle is a good indication of a high-quality flower. A flower with a wide receptacle has more cells. Some researchers have suggested that, in fruit of the same size, this can increase osmotic potential, leading to firmer fruit with a higher quality and extended storability, as well as improved acids and sugar levels.

From flowers harvested during the extended bloom period, Louw found that Grabouw’s flowers all had equally-sized receptacles. This explained why all the fruit lost their firmness in a similar fashion after storage, resulting in softer early-flower fruit and firmer late-flower fruit. However, she saw that the early flowers from Ceres had wider receptacles compared to the later flowers, explaining why the fruit from early flowers had higher firmness values post-storage. She concluded that better quality flowers lead to better fruit storability. **FQ**



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Less is Not More

The pros and cons of low- and high-density tree planting

By Grethe Bestbier

When Anton Müller, technical manager of Kromco, visited Italy ten years ago, he came back with quite a few things to rethink. While explaining why, in South Africa, we believe it is so important to plant 4x1.5m, he was challenged by an Italian farmer. "You know what," the farmer said, "You grow your area full, but I plant my area full." This prompted Müller to re-examine why we plant at such low density, and whether it really is the best for crop production.

“Get the best tree quality, even if the cost is shocking”

ASKING THE QUESTIONS THAT MATTER

There are many questions regarding South African farmers growing their areas full, instead of planting more trees. Most importantly, why do we do this? Müller believes that the cost of nursery trees is the main reason for our choice of low-density planting.

"As you know, everything costs money, so in the words of William Shakespeare, 'To buy trees, or not to buy – that is the question'," joked Müller.

After his return from Italy, Müller looked into

studies that link tree numbers with crop production. He found that in various cases, more trees lead to a much higher crop accumulation.

Müller realised that a fundamental question was what exactly the prerequisite is for a successful orchard. He wanted to discover how this links to tree numbers and planting density. Maybe then he could find out whether growing our areas full, like we do in South Africa, really is the best choice.

Müller learned that the number one prerequisite is reaching optimal light interception as quickly as possible. For perennial crops, it is also important to maintain the maximum light distribution as time passes. This requires keeping a high ratio of surface area to volume. Thinner and more rectangular trees have better light distribution than wider and more spherical trees.

THE EVOLUTION OF TREE PLANTING

According to Müller, the good old days were characterised by very wide planting. Growers relied on heading cuts, with trees tending to develop strong structural branches over time.

The final tree often formed a half-sphere, known for a weak ratio of surface area to volume, and poor light distribution.

"Over the long term, their complex light distribution management required Solomon's wisdom and Job's patience," said Müller.

The current standard is to plant 4x1.5m. For these trees, growers often choose a management approach similar to wide systems.

"You start off with roughly a 1.5m to 1.8m tree, and in most cases, people pat themselves on the back

when they reach 80% of row width," said Müller, referring to tree height. "You also end with a tree with a lot of permanent structures, but the tree is more rectangular."

Not only do the thinly-shaped trees experience better light distribution, but production is increased.

"Way back, everyone referred to the maximum crop of about 60 tonnes per hectare," said Müller. "Everyone is now in the 100-tonnes club."

Although income increased, it has reached a plateau. Looking at industry comparisons, the past ten years are characterised by an income of about R200 000 to R250 000 per hectare. However, inflation doesn't stand still, and breaking this ceiling is an important objective.

PLANTING FOR THE FUTURE

"The future will be innovative," said Müller. "Standard trees will be planted closer together." He envisages row spacing of 3.5 to 3.0 metres.

According to Müller, we will see more double leader, Guyot, double spindle, and V-structured systems, and early cropping with much higher pack-out of South African standards. The adoption of simpler systems will also simply instructions to employees.

"I also believe there will be an increased income per hectare, efficiency and profitability," Müller added.

Müller modelled the sensitivity of net present value to tree price and crop quality for orchards planted at different densities. According to his calculations, the impact of tree price on net present value in high-tonnage orchards is less than 2.5%. "Get the best tree quality, even if the cost is shocking," he stressed.

When considering quality, Müller pointed out that it's not surprising that growers with orchards that have low establishment costs only focus on tonnes per hectare. "It's possible, from an economic point of view, to have a successful orchard with low-quality but high tonnages."

In conclusion, Müller emphasised that saving money on trees is a false economy. "Do not save money on the early management of that orchard – spend time on your orchard design if you are serious on increasing fruit quality," he said, "because whether you buy more trees or not, you are going to pay for them." **FQ**

“Plant your area full. Don't grow your area full.”



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Fruit Fly Expert Calls for New Policies

Detection data should inform regulation

By Engela Duvenage

An ominous anniversary of sorts was celebrated on 5 June 2019 when Prof. James Carey from the Department of Entomology and Nematology at the University of California, Davis gave an overview of the Californian fruit fly problem at the Hortgro Technical Symposium.

Carey told the audience how, on the same date 39 years earlier, California's fruit fly eradication programme started in earnest. It followed the first ever major Mediterranean fruit fly outbreak over thousands of hectares in northern and southern California. Even though more than US\$ 280 million has since been spent, Carey believes there is no light at the end of the tunnel.

Carey is worried that current policies do not adequately consider risks and probabilities in light of future climate change scenarios. He finds current policies archaic, since most were developed more than fifty years ago, and have not kept up with recent research findings.

REINTRODUCED OR ESTABLISHED?

Fruit flies have only been detected in three American states: Florida, Texas and California. More species — 17 — have been detected in California than in the other states combined.

In a recent paper, Carey and colleagues challenged the long-held notion that new fruit fly populations are continually being introduced to California, for instance through ports and airports. They called this explanation inconceivable when the historical detection data are applied to the theory.

"If repeated outbreaks are due to reintroductions, then such events should also occur in other parts of California and fly-friendly regions of the US. It doesn't happen. Fruit flies are nearly always captured in the same regions, year after year," he explained. "This raises questions, yet the position

"You cannot legislate a fly out of existence."

of the United States Department of Agriculture and the California Department of Food and Agriculture is that insects are reintroduced every year."

He said that such a stance might have the short-term benefit of being able to pronounce an area free of fruit flies when they have been absent for a few generations. However, in the long term, it does not address the very real possibility that populations are firmly established in California, or that micropopulations go undetected for generations until again causing outbreaks.

LEFT The Mediterranean fruit fly (*Ceratitis capitata*) first invaded California in the 1970s.

"You cannot legislate a fly out of existence. We need to adapt eradication programmes accordingly," stated Carey, who for nearly a decade served on America's fruit fly scientific advisory panel.

He believes urgent policy changes should take cognisance of available data showing when and where fruit flies have been trapped over the years, as well as evidence that populations have become established. "Current policies are uninformed by detection data. They are ad hoc and static. They do not really consider the challenges of growers who are simply expected to adhere to regulatory protocols."

USING DATA TO DRIVE DECISIONS

Carey finds it astounding that so little is done with data meticulously gathered between 1950 and 2018 about when and where fruit flies have been trapped in the US.

"No one uses the data. It is unbelievable to me," said Carey, who estimates that the government-sponsored surveillance programme has over the years cost more than a billion dollars. According to Carey, there are 10 000 fruit fly records in the database but it is not available to scientists.

Carey believes databases should be used to assign outbreak risk that is useful to growers, and to inform government surveillance strategies. The data could also help reveal shortcomings in eradication protocols, including for how long an outbreak region should be subject to regulations such as treatment and monitoring.

Carey stated that the single most important reason for examining the fruit fly detection data is to base decisions on evidence. "The results of data analysis help move decision-making by stakeholders and policy makers from the realm of intuition and uncertainty to the domain of risk management."

Carey questioned the definitions used by the US authorities and the International Phytosanitary Commission to decide whether fruit fly populations are eradicated or not. He also challenged the binary approach of classifying the suitability of produce for the export market only according to whether flies are fully eradicated in an area or not.

"Such determinations are virtually impossible to make based on the results of short-term monitoring," Carey concluded. Instead, he advocates for policies in which risk is graded and reflects the history and frequency of local outbreaks. **FQ**

Carey's advice to the South African deciduous fruit industry

- Policies should be evidence-based according to data and adapted as and when new information becomes available.
- Basic science should inform policy and be integrated into it. Make use of the invasion biologists of stature working at Stellenbosch University and at other South African institutions.
- Policy forums need to not only update current policies but thoroughly reconceive many of them.
- Do more research about the ability of micro-populations to go undetected for decades and then to cause outbreaks.



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Biological Control of Fruit Flies

Researchers turn to nature for help

By Engela Duvenage

Does nature provide its own little helpers to support the South African agricultural sector in controlling its fruit fly problem? Indeed, said Dr Pia Addison, upon reflecting on four years of biological control research by the Integrated Pest Management section of the Department of Conservation Ecology and Entomology at Stellenbosch University.

Biological control measures fight nature with nature, using insects, microscopic worms, fungi or other pathogens found naturally in an environment to reduce the effects of specific pests.

Most of the work done by Addison's team was conducted in the southwestern Cape to search for natural enemies of Cape fruit flies and Mediterranean fruit flies. Studies were conducted on parasitoid wasps, and entomopathogenic nematodes and fungi. It was funded by Hortgro Science, the South African Table Grape Industry and the National Research Foundation.

"We're starting to tick the boxes and to get good results," Addison reported. "So far we have found one option, but it needs more intense research before we can potentially mass produce and release it as a biocontrol agent."

She cancelled out the possibility of using parasitoid wasps to control fruit flies in the Western Cape, because their natural numbers within the region are simply too low. The use of entomopathogenic nematodes and fungi that are normally found in healthy soils are however showing promise. Entomopathogenic organisms cause disease in insects.

"Entomopathogenic nematodes are valuable tools to have in our pest management toolbox, because they generally attack the soil stages of

insects," Addison explained.

THE WORM TURNS ON FRUIT FLIES

The initial work at Stellenbosch University on entomopathogenic nematodes that attack fruit flies started in 2016. It began with MSc student Monique James screening soil samples collected in 20 orchards for potential candidates. Her work was supervised by Prof. Antoinette Malan.

In due course, two entomopathogenic nematode species were found to be the most effective. The first, *Heterorhabditis noenieputensis*, was first discovered near the settlement Noenieput between the border of South Africa and Namibia. It targets fruit fly pupae at a high rate. The second, *Steinernema yirgalemense*, attacks adult flies.

As part of her studies, James also noted the presence of entomopathogenic fungi in local soils. One fungal isolate in particular – MJO6 – was found on Mediterranean fruit flies. Further tests showed that most flies infected with the fungus died.

"MJO6 is part of the *Metarhizium robertsii* complex which is known to be virulent and quite effective against insects," noted Addison.

In closing, Addison mentioned that she'd like to investigate the use of tent-like structures called augmentoria. These have an opening and tops that are covered with fine mesh. According to Addison, augmentoria are used in many other African countries to ensure better sanitation within home gardens and smaller orchards, and to control localised fruit fly populations.

She explained that fruit flies emerging from infested fruit are trapped within the augmentorium and die. Adult parasitoid wasps on the other hand can escape through the fine mesh.

In a preliminary study conducted by one of her collaborators, Dr Julien Haran, 800 fruit flies emerged from 1 kilogram of infested fruits, along with 300 wasps. **FQ**



ABOVE Entomopathogenic nematodes destroy a pupating fruit fly. Entomopathogenic nematodes are microscopic worms found naturally in healthy soil. They only attack insects and are very target specific. When a worm finds a larvae or pupae of an insect in the soil, it enters it through natural openings. Once inside, the worm transmits a specific bacteria that eventually kills the host insect. When the host insect dies, there are no resources for the worm to feed on. It goes back into the soil to search for a new host.

BELOW Entomopathogenic fungi attack a fruit fly. These fungi have a similar life cycle to that of nematodes. They are present in the soil as spores. These attach to insects' cuticle or covering, and then penetrate it. The fungi's growth stage occurs within the insect. It then reproduces and eventually kills the host insect. Spores can stay in the soil for extended periods, until a new host is located and the cycle repeats.



MONIQUE JAMES | STELLENBOSCH UNIVERSITY

What are the benefits of using biocontrol measures on fruit flies?:

- These are highly specific and do not harm beneficial organisms like bees and parasitoids.
- Biocontrol is easy to use with other control practices, such as sterile insect techniques and softer pesticides applications such as bait sprays.
- Biocontrol can be used just before harvest when the pest populations are starting to increase because there are no insecticide residues, as would be the case with conventional chemical control programmes.
- No resistance builds up against the biocontrol agents.
- Agents target eggs and pupae. These stages of a fruit fly's life cycle are very difficult to control using other methods, such as chemical control.
- Prolongs the use of chemicals in an integrated pest management system. It does not discriminate, and removes resistant individuals from the population too.



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Land Reform Success Stories

Landbouweekblad panel discussion

By Engela Duvenage

Four panelists shared their experiences of South Africa's land reform programmes at the Hortgro Science Technical Symposium. The session was sponsored by the agricultural magazine Landbouweekblad, and was ably chaired by editor Chris Burgess.

Gerrit van Vuuren, a director at Joubert Van Vuuren Attorneys in Ceres, is involved in the Partnership in Agri Land Solutions (PALS). It was initiated by leading farmers in 2014, now involves 33 projects countrywide and recently branched out to Mpumalanga, the Overberg, Robertson and the Eastern Cape.

Van Vuuren said PALS is about good corporate governance and about implementing as many initiatives as possible "to enlarge the joint impact and negotiating power of the farming sector."

"Farmers wanted to be part of the solution, not the problem," Van Vuuren explained. "They realised that the private sector must lead the process, using sound legal and business principles."

"There's good stories in our communities," he said, noting that the local economy of Ceres had grown with 8% since the inception of PALS.

André Cloete has farmed with apples, pears, barley, cattle and sheep for the past decade on Klein Ezeljacht near Greyton. He serves in organised agriculture and won the Toyota New Harvest of the Year award in 2016.

Cloete explained how being a beneficiary of government's Proactive Land Acquisition Strategy has drawbacks, in that the state owns the land.

"Although I have increased the value of my land by adding new orchards, I do not have a title deed in hand. I have no collateral to go to banks for loans," Cloete explained. "It is very difficult. I've been fighting this since I started."

He said that his success would not have been possible if it was not for the help and support of his neighbours, his family, the Western Cape Department of Agriculture, The Jobs Fund, initial bridging finance from Capespan, and loans from the Two-a-Day Group.

Rita Andreas started off as a farm worker at Bosman Family Vineyards outside Wellington and was chair of the farm's Adama Workers Trust. She is currently the mayoral committee member for rural development in the Drakenstein municipal council.

"If I'd been stuck in the past and only saw myself as a vulnerable farm worker, I would not have been where I am today," she noted.

Williams had advice for the audience on how to start with land reform. "The people you already work with are the best people to take forward with you. If you believe in your people, you can change their lives for the better. If you believe in transformation, do it."

She praised farmers who invest in uplifting their workers by providing better housing and training opportunities. "Nowadays most people coming

out of towns to farms are jealous of what the farm workers have on the farms."

Kosie van Zyl was a fourth-generation farm manager in the Overberg. He became a commercial grain and stock farmer in Napier in his own right after a neighbour offered to lend him money to buy his land. In 2006 he paid it forward, and set up the successful Agri Dwala BEE project to allow people from the local community to farm too.

"After ten years of being a commercial farmer, I had the desire to help others," he explained. "It's about people. Land is only our tool to survive. Ownership is important, but good relationships will be our goal until the end." **FQ**

BELOW FROM LEFT TO RIGHT

Chris Burgess, Gerrit van Vuuren, Rita Andreas, André Cloete. Absent: Kosie van Zyl.

More from the panel

- Transformation is a growth process based on mutual respect.
- The process needs honest, direct conversations between role players to manage expectations, right from the start.
- Beneficiaries should receive extensive training to better understand the long-term benefits of different options, such as receiving dividends.
- Plans should include the option of taking shares, rather than only actively work the land.
- Government should be on time with payments and loans allocated to beneficiaries of land reform projects.
- Financial institutions such as banks should develop more flexible ideas to help beneficiaries who do not own the land they farm.
- Farms should always be run according to good business models.
- Government must learn from past mistakes and successes.
- Models should include an exit strategy for when participants are taken ill, pass away, resign or have disputes.
- Contracts should be clearly worded.



Some Like It Hot

Winners and losers of climate change

By Engela Duvenage

There is increasing concern about how insect pests will respond to global warming. Will populations increase, or spread to other regions in South Africa? Will some species die out because of higher temperatures? "The verdict is still out on who will be the winners and the losers when it comes to climate change," said Dr Minette Karsten of the Department of Conservation Ecology and Entomology at Stellenbosch University.

Karsten informed the audience that no real predictions have yet been made about the future distribution patterns or abundance of most insect species currently attacking South African deciduous fruit. That's because so little is known about the thermal traits that are important to their growth, reproduction and activity.

She said that even less information is available on insect pests' ability to adapt to specific environmental conditions, such as seasonal changes.

The research group of which Karsten is part is increasingly focusing on insects' ability to adapt to changing climates. Karsten and her colleagues are trying to understand which factors affect climatic stress resistance and the potential implications thereof.

"No basic physiological measurements or data needed to calculate thermal responses are available for many of our most important pest species," she said. "There's of course a very practical reason why so little information is known about the thermal traits of local pest species. Their small size makes them very difficult to measure."

The most comprehensive information for insects pests of deciduous fruit is available for the Mediterranean fruit fly, the Oriental fruit fly, false codling moth and codling moth, followed by the obscure mealy bug, Cape fruit fly, green peach aphid, circular purple scale, grapevine mealy bug and Western flower thrip.

INSECTS IN A WARMER WORLD

Karsten said it remains uncertain how rising temperatures will influence the distribution and population sizes of most agricultural pests, or how changes in abundance may alter herbivory or attack rates on deciduous crops. There is also uncertainty whether rising temperatures will allow pests to increase their range to areas which are currently unsuitable for them or to shift their distributions.

She explained that changing weather patterns could have a direct influence on insects' behaviour and physiology. It could also influence them indirectly, for instance by changes in the life cycles of their host plants affecting timing of food availability.

Metrics based on thermal data compiled from the literature show that all the pest insects in the South African deciduous fruit industry for which we have reasonable data will be under increasing threat of overheating under future climate conditions if they do not compensate behaviourally or physiologically.

"Our results are similar to what was shown in a previous study by our group that investigated a number of global insect pests and also considered different life stages," Karsten said.

She extracted mean annual temperatures from the WorldClim database, which contains global climate data for current conditions and future predictions. Using these data, it showed that up



More research is needed on how insects will respond to changing temperatures.

to at least 2050, most species will be able to withstand the temperature increases predicted for the Stellenbosch region.

"These pests are relatively safe when it comes to the impacts of increased future environmental temperature when we use mean annual temperatures, but this may not be the case if we use the mean for the warmest quarter," she explained.

According to Karsten, much more research is needed into the thermal tolerance of specific insect species. Better microclimate data is also needed so that researchers are not only reliant on macroclimate data for their predictions. We currently know little about pest insect's use of microclimate sites — such as under leaves in the shade — where they would be able to buffer themselves against environmental temperature. **FQ**

Us versus them

People are **endotherms**, and capable of generating their own body heat. Insects, on the other hand, are **ectotherms**, and their body temperatures are therefore influenced by weather conditions and climate over the longer term. Abiotic factors such as moisture, temperature and solar radiation can help insects to thrive, to increase their range or disappear from specific regions.



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Save Money With Scientific Dosing

The MABO Dosing Model

By Engela Duvenage

Using more effective application methodologies to apply pesticide sprays, such as faster driving speeds, reduced air assistance and lower spray volumes, could potentially save apple producers up to 40% in working costs. Such vast savings are possible when using the MABO dosing model, according to Philip Rebel, a MSc student at Stellenbosch University.

Rebel conducted a series of trials using the MABO — Marktgemeinschaft Bodenseeobst — extended tree-row-volume dosing model. It was shown to be a more cost-effective and easier-to-use alternative to the conventional Unrath tree-row-volume model, when used in local high-density apple orchards at spray volumes of 750 litres or more per hectare and tractor speeds of 4.5 kilometres per hour.

MABO was developed in Germany and Austria in tall spindle-shaped canopied, high-density orchards with between 1 500 and 4 500 trees per hectare.

“Current models work when applying pesticide sprays, but we can be more efficient. We need to consider new models,” Rebel asserted. Pest and disease control can tally up to a third of a successful apple farm’s preharvest overheads.

Rebel explained that the Unrath tree-row-volume model currently used in high-density South African orchards originated in the 1980s. Current application volumes range on average between 650 and 2 000 litres of spray volume per hectare, and tractor driving speeds between 3.5 and 4.5 kilometres per hour.

The Unrath model was developed four decades ago on much larger, open, vase-shaped tree canopies that are not seen in orchards today. Rebel noted that over the years tree architecture and orchard structure in South Africa have been changing to higher density plantings of more trees per hectare, with tall spindle-shaped apple trees and smaller tree canopy volumes.



“The MABO model could be a good alternative for South Africa.”

“In South Africa, MABO would be suitable for orchards with a row width of four metres or less,” Rebel said.

MABO IN PRACTICE

Rebel explained that the MABO model uses the orchard with the largest filter area as a reference orchard. This determines a constant spray-machine calibration and tank concentration for the whole farm. All other orchards on the farm are then treated as a fraction of the reference orchard. Spray volumes for these orchards are manipulated by tractor speed and air assistance. For example, if an orchard has a smaller filter area than the reference orchard, spray volume and air assistance for that orchard will be adjusted by increasing the forward speed or reducing power-take-off speed.

The revolutions per minute of the power take-off change the air assistance produced. As a start, Rebel suggested that gear selection to the nearest speed indicated by the MABO model might be a better option to manipulate the air column, since changes to revolutions per minute can be

detrimental if not done correctly or with the correct sprayer.

Rebel’s experiments showed no significant differences in the spray deposition parameters of pesticides in trials conducted in orchards with a row width of four metres, when comparing conventional tree-row-volume and MABO models. There was however a significant drop in costs with the MABO model in terms of the work rate per hectare, and savings in water, fuel and time in the orchard.

“There is definitely a place for low-volume concentrate sprays and lower volumetric airflow rates in high-density South African orchards. The MABO model could be a good and easy alternative for the way in which we spray in South Africa,” Rebel concluded.

His research was supervised by Prof. Adèle McLeod of the Department of Plant Pathology at Stellenbosch University, and Bekker Wessels and Dr Gideon van Zyl from the agricultural consultancy firm ProCrop. The project was funded by Hortgro Pome. **FQ**

BELOW Producers can make significant savings by optimising spray applications.



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Maintain Your Net Benefits

Managing spray application in the presence of drape nets

By Engela Duvenage

ABOVE Maintaining good spray coverage under drape nets can be challenging.

“Drape netting reduces tree canopy penetration. It influences where and how thoroughly sprays are deposited onto leaves, and the amount of chemicals ultimately deposited on the outside and inside of tree canopies,” said Dr Gideon van Zyl, technical consultant with ProCrop, an agricultural advisory service.

Drape netting helps to protect fruit from being damaged by the sun, hail, birds, bats and the wind. However, the physics governing the movement of air carrying droplets through netting throws a spanner in the works of producers’ hopes to effectively spray covered orchards with pesticides and fungicides, or to apply supportive sprays.

According to Van Zyl, nets form a physical barrier around the trees. In the process, it increases the effective density of the canopy. “Nets are like perforated barriers that spray droplets have to penetrate,” he explained.

The material complicates air flow and diffusion. It influences the direction in which air moves — this could cause slight turbulence, increasing air resistance in the space between the net and the tree.

Van Zyl said that all this influences where droplets land and ultimate penetration into the canopy. More leaf disturbance can occur and some leaves

can be pressed to the insides of the net. This disturbs deposition. A cushion wave also forms on the outside of the net and disturbs airflow as it moves from the sprayer to the tree. This influences the column of moving air and makes it more difficult for air to penetrate into the enclosed orchard.

PEST AND DISEASE CONTROL UNDER NETTING

Van Zyl conducted trials in apple orchards of the Du Toit Group. He learnt that although nets seem to help capture spray drift, one does not get the same level of deposition on leaves and fruit when spraying through netting as in open orchards.

“It’s better to manage and spray for pests and diseases before draping an orchard. A reduction in spray deposition parameters after draping complicates and ultimately reduces pest and disease control,” Van Zyl explained. “Optimal deposition is a necessity for disease control. When you want to prevent or control apple scab and powdery mildew, for instance, you’d ideally want even, comprehensive coverage throughout a tree. This cannot be guaranteed when spraying through a net.”

On the plus side, nets keep certain insects out. However, the material can also trap other insects inside, such as woolly apple aphids and mealy bugs. It complicates the control of these pests.

“If you want to use drape netting, I’d first control the primary fungal infections and pests in an orchard before closing it down. Do so early and

“Use a higher air volume setting when spraying draped orchards.”

effectively. I’d also think twice before closing up an orchard later in the season that has a history of pests and diseases, or where control was suboptimal,” he advised.

OPTIMISING SPRAY DEPOSITION

Van Zyl did trials spraying horticultural products such as calcium through netting, and noted a reduction in how much landed on the trees.

“Doing so will ultimately influence the amount of calcium being taken up by the trees. If you want to spray through nets, you will have to consider spraying more often. This might have cost implications,” he underlined.

According to Van Zyl drape netting can influence the breakdown of pesticides. “In theory it is possible because of less light penetration through the material. Another possible issue is the build-up of pesticides on inner and outer netting throughout the season. These factors will be investigated in future studies,” he noted.

Better spray deposition was obtained when higher air volume applicators were used on inner and outer canopy leaves, because of improved canopy penetration. Producers using more progressive application methodologies, such as sprayers producing low air volume and speed, should rather use a higher air volume setting when spraying draped orchards.

Van Zyl’s trials showed that sprayer setup, the type of nozzle used, the actual nozzle setup, and calibration all significantly influence how well sprays are deposited onto leaves and fruit throughout the tree canopy.

Another finding was that spray deposition is not improved when one simply increases the spray volume.

“In fact, it makes it worse,” he concluded. The more water is used, the easier a film of water forms on the outside of the net, from which water simply runs off. **FQ**



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Data-drive Farming

Real-time information and forecasting of pest and disease development

By Engela Duvenage

Information gathered daily on farms can be fed into effective modelling programmes to take precision farming to a next level. Modelling can help producers time disease and pest control programmes better, and determine the best times for fruit thinning. So said Dr Gideon van Zyl of the agricultural consultancy firm ProCrop. He was presenting on behalf of his colleague, Bekker Wessels.

Van Zyl was referring to the cloud-based interactive decision support system RIMpro. RIMpro is used by fruit producers worldwide. It is based on simulation models developed and tested globally. It uses localised weather forecasts to simulate how specific diseases or pests might spread within a matter of hours or days.

RIMpro uses data gathered from a virtual weather station based on a predetermined location, and not real data from the weather stations on a specific farm. ProCrop has found that the virtual weather data correlates very well with real-time weather data.

ProCrop has been evaluating RIMpro's performance on the farms of 27 clients for the past three years. Van Zyl described their results in the context of codling moth, apple scab and fruit thinning.

CODLING MOTH

RIMpro's codling moth model was validated by Bekker Wessels of ProCrop by comparing real-time events with RIMpro forecasts. RIMpro's

model forecasts when the first female flights are expected, when eggs will be laid and when larvae will start moving.

RIMpro's codling moth model takes into account how much heat insects accumulate over a 24-hour period, as well as fluctuations in day length. These environmental variables stimulate pupation of overwintering larvae and the onset of the first moth flight of the season. Once this so-called biofix is set, the model forecasts mating, egg-laying, egg

RIMpro could help producers better plan their apple scab spray programmes.

hatch and subsequent instar development.

This information is critical in timing first-generation sprays, planning spray intervals and deciding when it is safe to stop applications under low infestation pressure.

"By knowing what's going on at a specific time in an insect's life cycle, we know when to react, and how to react. This saves money and increases the efficacy of spray programs," Van Zyl explained.

APPLE SCAB

Older models for modelling scab epidemiology base disease forecast only on climatological parameters and ontogenic resistance of fruit to scab infection. For primary scab infections, the RIMpro model incorporates the maturation of ascospores — overwintering spores — as well as the quantity of spores to be released during an infection event.

This allows for a much more accurate measure of the severity of infection events and better guidance on the aggression of fungicide intervention needed to prevent lesion development.

Van Zyl believes that RIMpro could help producers better plan their apple scab spray programmes.

Validation of the apple scab module is being done by ProCrop in conjunction with Prof. Adèle McLeod of the Department of Plant Pathology at Stellenbosch University. The project is funded by Hortgro Pome.

FRUIT THINNING

RIMpro's fruit thinning model uses temperature and radiation data to simulate the carbohydrate metabolism of trees.

According to Van Zyl, the limited contribution of photosynthesis to carbo-

hydrate accumulation during and shortly after flowering can easily result in trees with a negative carbohydrate balance during cloudy weather at relatively high temperatures, because respiration exceeds photosynthesis. The indiscriminate use of chemical thinning products during such periods could result in overthinning and therefore crop loss.

The RIMpro fruit thinning model indicates the occurrence of such periods and helps growers time thinning events and choose products according to prevailing climatic conditions.

Van Zyl singled out the RIMpro codling moth, apple scab, apple powdery mildew and thinning models as especially relevant to South African apple producers. He believes that many other RIMpro models show promise for local use. **FQ**



Apple scab is one of several RIMpro models of potential interest to South African producers.



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Rewriting the Rules

The changing landscape of international trade

By Anna Mouton

Stephanie van der Walt of Agbiz Fruit is an attorney and expert in international trade. She described the position of South Africa in a complex and shifting global marketplace and explained how events such as Brexit can impact local industries.

WHY DOES FREE TRADE MATTER?

A free flow of goods and services aids consumers by lowering prices and increasing their options. Businesses profit too through access to larger markets. Free trade encourages competition and allows companies to exploit comparative advantage and economies of scale. "If you can't produce everything, you're able to supplement with imports and fully mobilise your exports for the benefit of your economy," explained Van der Walt.

Global exports are currently around a third of global gross domestic product. Ninety-eight percent of this trade is conducted under World Trade Organisation (WTO) rules. The WTO was established in 1995 to promote free trade by creating a framework for trade negotiations and providing a mechanism for dispute resolution. WTO members may not discriminate against other members by singling out some trading partners for higher tariffs or stricter standards on their goods.

The WTO is credited for creating a more stable trading environment and overall lower tariffs, but there has been a proliferation of non-tariff barriers. According to Van der Walt, sanitary and

phytosanitary measures have been used repeatedly to prevent market access for South African products.

She also pointed out that WTO rules maintain the imbalance between large and small economies. "It's like you taking away the ladder that you yourself used to climb up. Before the inception of the WTO, countries used tariffs to protect their own markets and to build their own economies until they were strong enough to compete. Currently developing countries face more challenges in using WTO rules to improve their position in the global market."

THE RISE OF REGIONALISM

WTTO members are allowed to enter into bilateral and regional trade agreements and these have multiplied rapidly over the past thirty years. "The downside is an increase in complexity," said Van der Walt. When a country is a member of multiple trade agreements it becomes difficult for it to draft consistent rules that meet the requirements of all its partners.

"This creates problems with uncertainty and implementation," related Van der Walt, "It's something that we are struggling with in Africa and that has been a huge obstacle in harmonising trade and in promoting trade on the continent." This is why the African Continental Free Trade Agreement has come into force but not yet opened markets — the details of implementation still have to be negotiated.

Van der Walt described how South Africa suffered losses in the past when it signed on to the WTO as a developed country. South Africa opened its

“You could see your ships setting sail not knowing if your products will be able to enter the market.”

markets hoping to stimulate trade with other developed nations but saw little reciprocity. That experience has made the Department of Trade and Industry cautious about entering into additional trade agreements. The Southern African Customs Union is the only active free trade agreement to which South Africa is party.

BREXIT AND THE CUMULATION CHALLENGE

Van der Walt highlighted the issue of cumulation in the context of bilateral agreements as it is one of the obstacles to concluding a trade agreement between South Africa and the United Kingdom. Cumulation allows a country to treat imported goods as though they originated locally when trading with another country. The details are subject to negotiation but there is frequently a minimum threshold for the value a country needs to add before it can claim a good as its own and therefore entitled to preferential treatment.

The UK is seeking cumulation for all products from the EU going through the UK to South Africa. Concession by South Africa would amount to preferential treatment of EU countries in contravention of WTO rules.

Van der Walt cautioned that cumulation rules may become a barrier to trade for South Africa after Brexit. "We have an agreement with the EU, we hope to have an agreement with the UK, but what happens if they don't have an agreement with each other?"

Another area of concern is the recognition of certificates of origin and product and phytosanitary standards. "If those things are not addressed, you

could see your ships being turned away or setting sail not knowing if your products will be able to enter the market," warned Van der Walt.

The outcome of Brexit is expected by the end of October, but as Van der Walt's talk made clear, change and uncertainty in global trade will remain long past that date. **FQ**



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The State of Energy in South Africa

Will we survive Eskom?

By Anna Mouton

"I'm here to explain where Eskom has brought us and where it's going to take us," opened Paul Nel, energy expert at infrastructure engineering and advisory company Aurecon. Nel has three decades of experience in the energy industry of which 18 years were spent at Eskom.

Nel began by outlining the external challenges faced by Eskom. Load-shedding started in 2008 — the same year as the global financial crisis — and energy sales by Eskom have stagnated ever since. Growth in annual gross domestic product has likewise been poor. The mining sector has performed disappointingly from around 2005 and manufacturing has shown only modest growth. "The only sector with a different story is agriculture," said Nel, referring to the steady increase in the size of this sector. "The last thing we as a country need is for agriculture to also start suffering due to a failing utility."

POOR PLANT PERFORMANCE AND THE NEW BUILD

According to Nel, Eskom has four main internal problems. Two of these relate directly to their generating plants. "The power stations are simply not performing," he stated. "In March this year when we went through load-shedding, Eskom had 28 000 megawatts available but a total installed capacity of about 48 000 megawatts."

Lack of maintenance has contributed to the decline in plant performance over the past decade. This is exacerbated by the age of Eskom's power

stations. "Sixty-five percent of the megawatts that Eskom has to drive this economy is thirty-plus years old," said Nel. "If you don't invest in ageing plants you're looking for trouble."

The second major issue lies with Eskom's new power stations — Medupi and Kusile — expected to be completed from 2021. "The unwritten expectation is that these power stations will eventually cost the country R400 billion before the contractors walk off site fifteen years after they started — seven years late." The original budget for construction was R150 billion. On top of that the plants are struggling to deliver the capacity for which they were designed.

FINANCIAL WOES AND PEOPLE PROBLEMS

"Eskom's current debt is R450 billion — 15% of South Africa's total sovereign debt. "That gives you a sense of why the rating agencies are so fixated on what's happening at Eskom," said Nel. "The expectation is that the debt will rise to R600 billion before we get anywhere close to a turnaround."

The new builds are not the only reason Eskom has money troubles. Over the past ten years Eskom has burnt more than R47 billion of diesel to supplement their generation capacity. Eskom has also seen a

One certainty is that electricity prices will rise.

ABOVE Solar power is one way to address South Africa's energy needs.

tripling of their manpower budget and a near four hundred percent increase in coal spend. "And keep in mind that in this period they didn't sell a single additional gigawatt-hour," stressed Nel.

The fourth challenge facing Eskom is people. Eskom has lost many skilled personnel. "I need to mention that there are still really good people in Eskom," said Nel. "Eskom needs to figure out how to retain the skills they have." Eskom also has to consider its labour force of more than 40 000 when attempting significant organisational change that may affect employment levels.

WHAT LIES AHEAD?

"This is where the news gets a little better," said Nel. "There's intent from both government and the current management at Eskom that something is wrong and we need to fix it." The appointment of a credible board and an industry task team was the first step. Subsequently the task team's recommendations around restructuring Eskom have been accepted by government.

Nel warned that turning around the maintenance backlog and addressing technical issues at the new plants would be difficult. Managing Eskom's debt is a further predicament. One certainty is that electricity prices will rise. "In the last ten years tariffs already increased by five hundred percent," said Nel, "but we still pay relatively little for our energy."

Nel believes that growth in energy production must come from renewable sources. "It's the cheapest energy available at the moment — and it's quick. In the time that Eskom struggled to get one unit at Medupi on line, private industry built 4 500 megawatts of wind, solar and hydro projects.

It's the only energy that's currently being considered for funding by large institutions."

Nel concluded on a positive note. "We're at a low point, but I don't think we're going to go much lower. We will survive and we'll hopefully come back here next year and have a better story to tell." **FQ**



Paul Nel
Energy consultant
Aurecon

Parting Ways With Plastic

Exploring collaborative solutions across value chains

By Anna Mouton

"Why is plastic packaging so ubiquitous?" asked Lorren de Kock from the World Wide Fund for Nature (WWF). WWF is the largest conservation organisation in the world and is active in more than a hundred countries.

According to De Kock, plastic is so popular because it's inexpensive and versatile. Plastic packaging also extends the shelf life of fruit. "But there's a dark side to this," said De Kock. "Plastic packaging has become the number one environmental issue. At a global scale we release nine million tonnes of plastic into the environment each year."

The production of plastic has skyrocketed over recent decades and is expected to increase a further forty percent in the next ten years. De Kock highlighted that three-quarters of all the plastic that has ever been produced is now waste. "The current waste management infrastructure cannot keep up with this increase in plastic."

Most plastic is used for packaging and most of that is single-use — it's used once and then discarded. Packaging is designed to be attractive and light-weight as opposed to reusable or recyclable. "Eighty percent of the environmental impact of plastic can be addressed in the design stage," stressed De Kock.

The European Commission recently approved the single-use plastics directive and are taking measures to reduce the consumption of plastic packaging.

The private sector is being equally proactive with several retailers — including Tesco and Waitrose — assessing plastic-free aisles in their stores.

South Africa has seen a significant increase in waste recycling mainly due to the informal waste sector. "Waste pickers have led to collection rates increasing over the last ten to fifteen years," said De Kock. Informal waste collection represents eighty to ninety percent of the recovery of post-consumer recyclables.

Legislation has also expanded over the past decade. Last year the plastics industry had to submit targets to government which included collection rates for recycling and increased levies on different plastic materials. This is likely to lead to price hikes for plastic packaging. Proposals are in the pipeline to phase out six common single-use items.

The private sector in South Africa is aware of the changing landscape and are following the example of their European counterparts. Woolworths has announced that they will transition to fully reusable or recyclable packaging by 2022. — continued on p42.

“Three-quarters of all the plastic that has ever been produced is now waste.”

A quick guide to better packaging choices

BOX LINERS

Use clear bags rather than red or green
Use bags made of a single material such as LDPE
Avoid multilayers or composites
Choose bags made of recycled content

STRAPPING

Avoid black strapping
Choose blue, green, white or transparent instead
Choose strapping made of recycled content

FLOW WRAP

Not recycled in South Africa
Not recycled in some export markets
Consider phasing out

FRUIT TRAYS

Consider paper pulp or cardboard trays
Recycle black polystyrene trays locally
Black polystyrene trays to be phased out by EU retailers at the end of 2019

STICKERS

PLU labels and similar are not recycled
Consider phasing out

FRUIT BAGS

Minimise printing
Consider using a wrap-around label or sleeve
Use bags made of a single material such as LDPE
Avoid multilayers or composites
Choose bags made of recycled content

MOVING TO A CIRCULAR ECONOMY

The current flow of plastics — and many other materials — is based on a linear economy. New plastics are manufactured to replace that which is lost. "The majority of plastic ends up either being landfilled or leaks into the environment. Very little goes back into a closed loop," said De Kock.

Shifting from a linear to a circular economy would keep plastic out of the environment and retain the value within the material stream. This requires a new emphasis on design for reuse and recyclability in addition to visual appeal. "WWF is committed to support the adoption of a circular plastics economy in South Africa," stated De Kock. "One of our interventions at industry level is the South African Plastics Pact."

Examples of the targets set by the Plastics Pact are that all plastic packaging should be reusable, recyclable or compostable by 2025, and that problematic plastics should be addressed by 2021. Organisations that want more information on sustainable packaging design can consult the Design for Recycling guidelines available online from PackagingSA.

"Organisations that are signatories to the various Plastic Pacts internationally are sending their fruit exporters and suppliers guidelines on the materials to be used for their packaging," said De Kock. Materials are classified as red, amber or green. Red materials — including polystyrene, oxo-degradable and black plastics — will be phased out this year. Amber materials are those where use is discouraged and include flow wrap. Green materials are preferred. Plastics in the green category include high- and low-density polyethylene.

De Kock presented some general principles to consider when making choices around packaging. "Look at your material combinations and separability. Multilayers are not recycled currently so try to move away from them if possible." Labels, printing inks and adhesives used on packaging can also affect recyclability. Packaging with food residues that are difficult to remove may be impossible to recycle.

De Kock believes that the challenges of plastic pollution can be met. "We need to keep in mind the trade-offs between extending shelf life, what the consumer wants, versatility and affordability, and the waste that is generated. Let's design smartly and not take the easy route — which will just generate more waste. The packaging landscape is changing and the sooner you get on board the better for your product." **FQ**



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Minimising Moisture Loss in Pears During Storage

What is in the producer's toolbox?

By Anna Mouton

Frank van de Geijn is a senior consultant and post-harvest researcher at Wageningen University and Research. He is with the Agrotechnology and Food Sciences Group which focusses on all questions relating to post-harvest: processing, packing, energy, and fruit quality.

Consumers demand pears year-round but long-term storage leads to moisture loss and associated quality issues like shrivelled necks and sensitivity to damage. Humidity control during storage aims to limit moisture loss. "We set a goal of 1.5%–1.8% weight loss for Conference pears over the storage period which can be for nine months or more," said Van de Geijn.

The atmosphere of the storage room has a relative humidity of 90%–95% compared to almost 100% for the fruit. This leads to a vapour pressure deficit that drives moisture from the pear to the air. Moisture in the air of the storage room is removed as part of the cooling process.

Van de Geijn outlined the variables affecting moisture levels in storage room air. "The concrete floor can take up 0.1%–0.3% moisture. I hear that

some people in South Africa wet the floor — at least that will prevent this uptake."

Wooden bins also absorb water but Van de Geijn has found them to have no impact on the total moisture balance compared to plastic bins. Most of the moisture added to the storage room atmosphere is contributed by the fruit. This effect is greatest during the initial cooling of the product.

The moisture balance in the storage room is not the only driver of water loss. "There's a huge product factor," said Van de Geijn. "Moisture loss drops as pears increase in size. And the same size fruit from different orchards can have different levels of moisture loss."

Van de Geijn's studies suggest that shrivelled necks are correlated with moisture loss of above 0.5%. He pointed out that some pears are more resistant to shrivel than others. Recent research suggests that dry matter content may explain some of this variation.

TOOLS TO MANAGE MOISTURE LOSS

There are four ways in which producers can manage moisture loss: protective packaging, humidification, optimisation of cooling equipment and putting ice on the bins. Van de Geijn doesn't



PHOTOS: WAGENINGEN UNIVERSITY AND RESEARCH | THE NETHERLANDS

“Covering the top of closed bins can reduce moisture loss by 30%–40%.”

recommend this last option. "It's effective but it's an enormous amount of work. It's not practical."

Van de Geijn has found packaging to be excellent for moisture loss control. Covering the top of closed bins can reduce moisture loss by 30%–40%. "That's enormous — you will never reach it with another technology," stated Van de Geijn. The Zeelandse method which uses foam on the bottom and sides of the bin combined with a top cover will reduce losses even further — by as much as 50%. Covering only the tops of bins will not work if they have open sides — like the standard South African plastic bins — through which moisture can escape.

There are several systems for humidification of storage rooms but Van de Geijn warned that all suffer from poor stability in operation. Humidification systems need to be checked regularly and installed to ensure that the moisture is evenly distributed throughout the room. "One of

the challenges of a humidification system is how do I balance moisture levels? It seems simple to measure but it's quite difficult because the volumes we add are low."

Van de Geijn believes that a solution to many humidification challenges can be found in installing ample cooling capacity. The aim is to have as little cooling time during storage as possible to minimise condensation and water loss. "I define my evaporator capacity at minus 8 degrees Celsius," said Van de Geijn, "which is 8 degrees difference to the entrance temperature of the air in the coil."

Van de Geijn remarked on the difference in cooling strategies between the Netherlands and South Africa. In the Netherlands cooling occurs through short cooling actions characterised by large temperature drops. This minimises the impact on humidity. In South Africa, cooling is more moderate but creates an ongoing vapour pressure deficit that increases water loss.

Minimising moisture loss carries risk as well as rewards. A new pathogen of apples and pears called *Fibulorhizoctonia psychrophila* has recently been identified in storage facilities in the Netherlands. It is associated with lenticel spot and can lead to



FAR LEFT Covering fruit is the most effective way to combat moisture loss during storage

LEFT Humidifications systems should be checked regularly to ensure that they are functioning correctly.

Best practices to combat moisture loss

- Invest in cooling equipment with high-capacity evaporators.
- Box-in-box cooling: cool the building as well as the storage rooms.
- Fast initial temperature pull-down: reach product temperatures of minus 0.5 degrees Celsius in less than 48 hours.
- Achieve maximum temperature stability over time and throughout room.
- Optimise air circulation and run fans only when needed.
- Measure defrost water: aim for moisture loss of 1.5–1.8 litres per tonne per month.
- Apply humidification to correct but not to solve problems.
- Use protective packaging in older or less efficient facilities.

total loss of the fruit in affected storage rooms. *Fibulorhizoctonia* is a threat at high humidity levels and therefore bagging fruit for long-term storage is no longer advised. High humidity also increases the risk of internal browning and cavities.

Managing humidity during long-term storage is just one of the challenges facing pear producers. Fortunately, as Van de Geijn's presentation showed, improved technology has opened many more avenues to success. **FQ**



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Edible Coatings

A potential multifunctional post-harvest treatment for stone fruit

By Anna Mouton

Dr Olaniyi Fawole is a senior researcher in post-harvest technology at Stellenbosch University. He has previously worked on pomegranates and apples and is currently helping to find solutions to the problem of shrivel in stone fruit.

"This year we had a lot of shrivel-related problems," said Fawole. One exporter suffered financial losses of as much as 48% due to claims. Shrivel also impacts the confidence of the export market in South African produce.

Shrivel affects stone fruit once moisture losses reach 5%. Moisture loss is influenced by the properties of the fruit cuticle and the underlying epidermal cells. Fawole pointed out that more research is needed to fully understand what causes shrivel. "We need to keep researching but it could take forever and we can't keep losing money. So we have to find a possible solution."

Current strategies to control shrivel rely on minimal post-harvest handling — to maintain cuticular integrity — and multilayer packaging. Existing multilayer packaging includes several plastic components. Fawole highlighted the global trend to eliminate single-use plastic. "We know what the market requires and if they don't want plastic we cannot ship plastic."

TRIALS WITH EDIBLE COATINGS

"When you coat fruit with a functional edible coating you create a barrier to water, to gas, to mechanical damage, and to light," said Fawole. "You can even reduce decay." Edible coatings present an alternative to both plastic packaging and fungicide treatment.

Fawole and his team started by screening six edible coatings: alginate, chitosan, gellan gum, gum arabic, an imported commercial coating, and a locally-available commercial coating. They compared the performance of these coatings to an untreated control in African Delight plums

stored for five weeks at minus 0.5 degrees Celsius followed by a shelf life of 20 days at 20 degrees Celsius.

The results showed that gellan gum, gum arabic and both commercial coatings reduced the occurrence of shrivel to a quarter or less of that of the control group.

PHOTOS: OLA FAWOLE | STELLENBOSCH UNIVERSITY

LEFT Typical signs of shrivel in a nectarine.

RIGHT Plums treated with different edible coatings compared to the uncoated control after 5 weeks cold storage followed by 20 days shelf life.

Chitosan increased the occurrence of shrivel while alginate had no effect. There was a strong correlation between shrivel and mass loss with the lowest mass loss in those plums that developed the least shrivel.

"We looked at the effect of edible coatings on respiration because we want to be sure that it doesn't lead to fermentation," said Fawole. The coatings didn't affect respiration rate. However alginate and chitosan delayed ripening and gum arabic extended shelf life by more than ten days. "This is interesting for the prospect of using these coatings to delay ripening," commented Fawole.

The research team also evaluated storage index and measured flesh firmness, fruit compression and skin toughness. The results were in line with their observations on ripening. There was no evidence of internal disorders associated with any of the coatings.

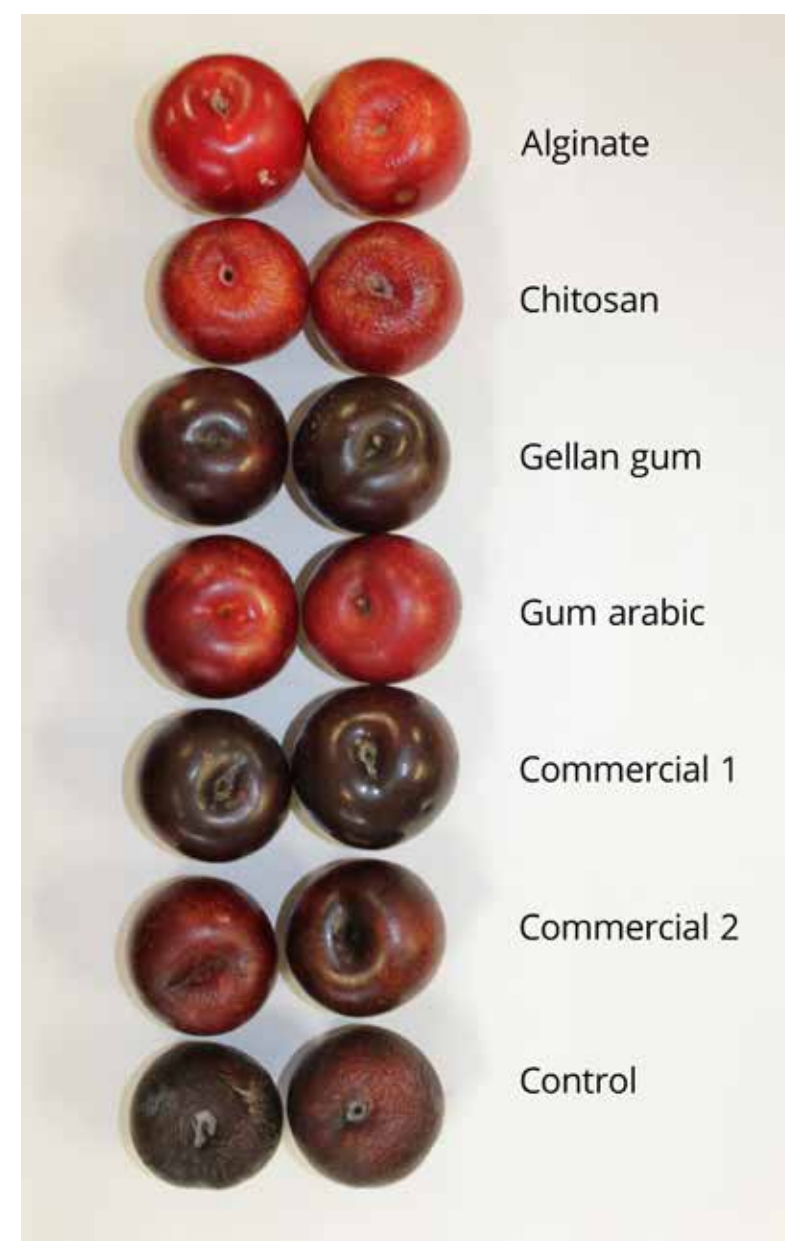
TAKING EDIBLE COATINGS TO THE PACKHOUSE

Based on the laboratory results, Fawole went on to conduct commercial trials with gum arabic. "We wanted to test how easy it is to use in the industry and what's the success in real life." His team ran experiments at a packhouse under normal production conditions. They compared the performance of the edible coating in fruit packed with and without shrivel sheets. Sensory analysis and testing for food safety were also performed.

The edible coating reduced the occurrence of shrivel by about half when used alone and to less than a fifth when combined with shrivel sheets. According to Fawole it was very easy to apply the coating on the normal pack line. "We didn't have to change anything. So it's very viable."

However it's unlikely that the edible coating will eliminate the need for shrivel sheets. Fawole also cautioned that interventions at the packhouse alone cannot solve shrivel. Fruit may suffer sufficient moisture loss to cause shrivel before reaching the packhouse. This moisture loss cannot be mitigated by changing packing procedures.

In conclusion, Fawole presented the audience with a novel suggestion. "We should start looking at how we can apply edible coatings just before harvest." In that way, fruit will be protected from the moment it's picked. Fawole is already working on this technology and — after the losses of the past season — producers will be impatient to learn the outcome. **FQ**



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Edible coating reduced the occurrence of shrivel.

Put the Brakes on Decay

Effective fungicide application on stone fruit

By Anna Mouton

Post-harvest decay of stone fruit can cause significant financial losses. Arrie de Kock, senior researcher at ExperiCo, explained how to prevent problems through an integrated approach that includes application of fludioxonil using atomisers.

"I don't think we can only talk about chemical control," said De Kock. Decay results from the perfect storm of interactions between the fruit, the fungal pathogen and the environment. De Kock outlined mitigation measures for each of these components.

Fungi that cause decay need a moist environment — avoid picking wet fruit or putting wet fruit over the pack line. Breaks in the cold chain will lead to condensation and increase the danger of decay. It's best not to store fruit under the dew point before packing. "And if a shrivel sheet will give good enough shrivel control, don't use a perforated bag, because the higher the humidity, the higher the decay potential," advised De Kock.

Decay pathogens are always present and it's important to reduce the number of spores that can infect fruit. Sanitation begins in the orchard with removal of mummies and damaged fruit and keeping the orchard floor clean. Packhouse sanitation is equally critical. Deprive spores of the chance to infect fruit by avoiding injuries. De Kock pointed out that control starts with harvesting fruit at optimal maturity — ripe fruit are at greater risk for damage and decay.

POST-HARVEST FUNGICIDE APPLICATION

"I'm going to talk specifically about atomiser systems," said De Kock. Coverage is key — atomisers must be calibrated to deliver 1.2 litres of fungicide mixture per tonne of fruit and this must be sprayed evenly across the pack line. The ideal droplet size is 200 microns.

Fludioxonil is currently the only fungicide registered for post-harvest use on stone fruit. It's supplied as a suspension concentrate and the fungicide mixture must be continuously stirred or mixed to keep the active ingredient from settling out.

Together with Ida Wilson, De Kock conducted a survey of post-harvest fungicide application practices at twenty packhouses across the fruit production area. The survey included an assessment of spray coverage by placing water-sensitive paper on the pack lines and measuring exposure time and fungicide residues. They identified a number of problems leading to poor fungicide deposition.

"There was uneven coverage in some cases," reported De Kock. Reasons included too few or incorrectly spaced nozzles, variation in delivery by different nozzles on the spray boom, and poor calibration. Spray drift occurred when the nozzles were not entirely covered by the cabinet.

The prescribed concentration of fungicide was not always used. "That could lead to low residues which are a waste of time because you will have poor decay control," warned De Kock. Overdosage can also be a problem as it can lead to rejections due to high residues.

Improper mixing was another source of incorrect



"The application of fludioxonil with atomisers can be highly effective to control decay."

LEFT Several fungal pathogens cause post-harvest decay in stone fruit.

concentrations, as were blocked nozzles. Blocked nozzles must be cleaned immediately — this should be easy and not require recalibration of the equipment.

De Kock recommends an application rate of 10 millilitres of fludioxonil per tonne of fruit. "It's also important to treat fruit as soon as possible after harvest," he stressed.

FACTORS AFFECTING FUNGICIDE EFFICACY

De Kock and Wilson conducted laboratory studies where fruit was inoculated with decay pathogens and then treated after three hours of incubation. Fludioxonil was effective at reducing decay in both nectarines and plums. Dip treatments worked better than the atomiser even though the final residues achieved with drip treatments were lower. De Kock stressed that higher residues don't amount to better decay control.

De Kock attributes the success of dip treatments to better coverage but believes atomisers are superior. The downside of dip treatments include wet fruit on the pack line and a dip mixture that becomes dirty and contains progressively less fungicide.

De Kock and Wilson investigated several variables that could affect residue levels. They found that exposure times of ten seconds resulted in the same residue levels as the recommended exposure time of thirty seconds. Extended exposure times of three and four minutes led to residues increasing by about thirty percent. "This means we must make sure the fruit doesn't stand under the atomiser when the pack line is switched off," said De Kock.

Harvest maturity and cultivar affects residue levels — Songold retains more fludioxonil than Laetitia — but adjustments to the fungicide dosage should not be necessary. The temperature of the fruit and the fungicide solution didn't affect residue levels in these experiments.

"If used correctly the application of fludioxonil with atomisers can be highly effective to control decay in stone fruit," concluded De Kock. **FQ**



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Exterminate Grain Chinch Bugs

Trials using ethyl formate yield promising results

By Anna Mouton

"Phytosanitary issues are among the many challenges we face in the international trade of fresh fruit," said Dr Shelley Johnson, research associate at Stellenbosch University. Johnson has been working on a solution to the problem of grain chinch bug.

South African fruit exporters increasingly face rejections due to the presence of grain chinch bug — *Macchiademus diplopterus* — in their produce. Fumigation with methyl bromide is effective but no longer an option. Finding an alternative that meets consumer demands for sustainably produced and residue-free food has been the driving force behind Johnson's research.

A REDISCOVERED FUMIGANT

Ethyl formate is the most likely replacement for methyl bromide. "They're calling it a rediscovered fumigant because it was used way back in the 1920s for dried fruit pests," recounted Johnson, "before methyl bromide fumigation came into use."

Ethyl formate occurs naturally in the environment as well as in both raw and processed foods. "It has a characteristic smell of rum and tastes of raspberries so it's used as a food additive and a flavouring agent," said Johnson.

Previous work on grain borers and rice weevils found that the formic acid in ethyl formate inhibits a crucial respiratory enzyme complex leading to death by suffocation. "The researchers claim that

PHOTOS: SHELLEY JOHNSON | STELLENBOSCH UNIVERSITY



development of resistance in insects is unlikely," said Johnson. "This is good news because another potential alternative to methyl bromide is phosphine — but there are a lot of resistance issues with that."

Ethyl formate is a flammable volatile liquid. Flammability can be reduced by mixing it with an inert gas. One such product is Vapormate which was developed by the Linde group. Vapormate delivers ethyl formate and carbon dioxide through a vapouriser. It is registered in several countries and Afrox is seeking approval for Vapormate in South Africa.

CINCHING THE CHINCH BUG

"We'd heard about the high efficacy of ethyl formate against insects so we thought, let's have a look at what it does to grain chinch bug," said Johnson. Her team started with small-scale trials in fourteen-litre glass desiccators. Chinch bugs were confined in perforated tubes and placed among fruit in the desiccators.

"To develop a mortality curve we tested at different concentrations of ethyl formate," explained Johnson. "There's a 100% mortality at 50 grams per metre cubed and this occurred within an hour of fumigation. This was very exciting for us — it was something that worked quickly and killed all the chinch bugs!"

Johnson also investigated phytotoxicity by exposing various fruits to ethyl formate concentrations of

SCALING-UP ETHYL FORMATE FUMIGATION

The next step was developing a system to apply ethyl formate as a fumigant in a container. With the assistance of engineers from Gas At Site, a container was adapted to allow delivery of specific concentrations of ethyl formate and nitrogen. Due to the flammable nature of ethyl formate it was necessary to maintain levels of less than 1.8% ethyl formate and less than 5% oxygen. Gas levels were analysed throughout the trials.

Johnson was able to treat grain chinch bug in the container with no phytotoxic damage to the fumigated fruit. "We're able to create a uniform distribution of fumigant inside the container and inside the fruit packaging that we've tested so far. We were also able to measure the decay of the fumigant inside the container and easily top it up if necessary," reported Johnson.

The container will be used to test fumigation of other insects and more fruit types in a variety of packaging. For industry, the main concern is how to scale up the treatment so that it can be applied to cold rooms. Johnson announced that funding has already been approved to do this research.

"Essentially we're on the right track," she concluded. "The main thing is that we have something that works for chinch bug." **FQ**

FAR LEFT The flammable ethyl formate is mixed with nitrogen as a safety measure

LEFT A container was used to test whether ethyl formate fumigation was feasible.



up to 149 grams per cubic metre for durations of up to six hours at different temperatures. Fruit were then assessed for damage after cold storage and simulated shelf life. No off-tastes were observed.

Russet Gold Bosc pears were the only fruit that developed abnormalities — stem, calyx and wound blackening — and only after treatment at 23 degrees Celsius. "We could then determine safe zones of what treatments one can apply without damaging the fruit," said Johnson. The results indicated that ethyl formate could be safely used to control chinch bug in these pears.



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Dynamic Fruit Needs Dynamic Storage

Let the product be your guide

By Anna Mouton

Frank van de Geijn is a senior consultant and post-harvest researcher at Wageningen University and Research. He is with the Agrotechnology and Food Sciences Group which focusses on all questions relating to post-harvest: processing, packing, energy, and fruit quality.

"Optimal storage and dynamic storage have the same goals," said Van de Geijn, "extended storage time, improved quality, reduction of specific disorders, and control of quality development not only during storage but especially in the shelf-life period. Product response control is a way to create not ready-to-eat but ready-to-enjoy."

According to Van de Geijn, the idea of fixed storage conditions is outdated. Storage operators should be guided by the signals that their fruit produces. Fruit responds to storage conditions by changes in respiration rate — measurable as consumption of oxygen and production of carbon dioxide and heat. Response can also be monitored through moisture and mass loss, quality development, and biomarkers such as chlorophyll fluorescence and ethanol production.

Lowering oxygen concentrations depresses respiration and reduces quality loss of fruit during storage. Dynamic response control systems aim to establish the lowest oxygen levels at which fruit will

still respire aerobically. Van de Geijn explained that the optimum oxygen concentration is that which also minimises carbon dioxide production. Once oxygen levels fall below this level, the fruit will switch to fermentation.

WHAT SYSTEMS ARE AVAILABLE?

Commercial dynamic control systems assess fruit responses by measuring respiration rate, ethanol production, skin chlorophyll fluorescence, or a combination of these. Ethanol was the original marker. Storage operators can send samples for ethanol determination to a laboratory or even test the fruit themselves. They will then manually adjust the oxygen set point depending on the ethanol levels.

Systems that automate ethanol testing are available. Van de Geijn used the example of Storex dynamic control systems where a special box containing a representative sample of fruit and an analyser is used to monitor rooms. The analyser measures ethanol as well as oxygen and carbon dioxide.

The HarvestWatch system relies on measuring chlorophyll fluorescence as a proxy for oxygen levels. "Does it have a direct link to fermentation?" asked Van de Geijn. "I'm still waiting for a good publication on that." The Fruit Observer system from the Besseling Group also relies on chlorophyll fluorescence.

The dynamic control system from Van Amerongen is based on measuring the respiratory quotient — the ratio of carbon dioxide produced to oxygen consumed — of the fruit. An elevated respiratory quotient is an indication of fermentation and ethanol synthesis.

BEST PRACTICES FOR DYNAMIC CONTROL SYSTEMS

"I think this type of close-to-the-limit technology should be applied to product that's valuable," said Van de Geijn. He advises caution when using dynamic control on new cultivars and colour mutants as these may respond in unexpected ways.

Van de Geijn's suggestion is to start with conventional controlled atmosphere conditioning and then drop the oxygen in increments of 0.2% per week for oxygen levels above 0.7%, or increments of 0.1% per week for oxygen levels below 0.7%. "The moment we go below 0.1% oxygen, we start tasting the product and checking quality in general."

Fruit held at lower oxygen levels may be more sensitive to carbon dioxide disorders. Van Geijn recommends reducing carbon dioxide to below the levels usually advised. In most cases where ethanol develops the fruit can be recovered, although this is difficult when fermentation occurs in the first month of storage.

Van Geijn reminded the audience that a gas-tight storage room is essential. To maintain oxygen levels below 0.1%, the effective leakage area should be less than 0.1 square centimetre per 100 cubic metre room.

THE BOTTOM LINE

So what system is the best? Van de Geijn doesn't have a specific recommendation but he gave some pointers. "I think there's a huge difference between suppliers in service and especially in the first year you should ask for guidance. Be aware that some systems provide more than just a signal — they provide information about the batch or the room behaviour, especially the respiration rate.

"All dynamically controlled atmosphere systems focus on lowering oxygen levels safely. I think the critical factor is the uniformity of the batches in a room and that has nothing to do with the system itself. Our advice is, it's okay that you replace your common sense by technology, but please stay in charge and check, in a basic way, your fruit." **FQ**

“Dynamic response control systems aim to establish the lowest oxygen levels at which fruit will still respire aerobically.”



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