New tools to bash bugs

Two novel techniques hold great potential for mitigating the most persistent pests troubling the export of South African *Proteaceae* to stricter markets.

1 Dr Shelley Johnson and MSc student Anton Huysamer (right) with the laboratory-scale controlled atmosphere and temperature treatment systems (CATTS) unit at Stellenbosch University.
2 Core temperatures of 'Barbi's' (*Protea magnifica*) are recorded throughout the CATTS treatments.
3 *Protea* scarlet butterfly found in 'Barbi's' receptacle was raised from larval stage to assist in its identification.
4 'Barbi' proteas subjected to various ethyl formate (EF) fumigation treatments inside 14 litre desiccators.
5 Toxicity with sugar pulsing in Leucospermum leaves was induced under intensive temperature ramping protocols.

IN SOUTH AFRICA, Cape flora cut flowers are grown and harvested in their natural environment, which includes the insect communities that live there. The insects of the Cape flora biome are diverse, even between growing regions, and are so poorly understood and understudied that many have not been identified scientifically.

The complexity and arrangement of *Proteaceae* floral structures, not to mention the impressive size of some, provide ample hiding places for a massive array of arthropods. They may inhabit the stem, leaves, receptacle or inflorescence, and can occur in staggering numbers.

Regardless, Cape flora is an internationally renowned and highly sought after floricultural product, with more than 20 million stems exported in the 2015/2016 season.

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The European Union receives around 80% of Cape flora exports, but this does not imply that the flowers are not in demand elsewhere. However, access to other markets proves more challenging, due to phytosanitary regulations that are particularly strict, resulting in the danger and harsh reality of consignment rejection.

This is particularly true for countries whose climatic conditions are, in places, similar to the Western Cape's Mediterranean climate, and those that have their own *Proteaceae* or similar floral families. The risk of South African insects establishing in overseas crops is too great for them to accept our flowers without intensive phytosanitary inspections and regulations, and many have a zero-tolerance approach to living and dead insect pests within consignments.

The direct and indirect costs of consignment rejection and subsequent damage to the reputation of the Cape flora cut flower industry are astronomical.

Current mitigation techniques for phytosanitary pests include various pre- and post-harvest protocols. These protocols, although sufficient for flowers intended for some markets, have not yet fully met the high standards required for others that have stricter phytosanitary requirements. Effective, reliable and preferably greener post-harvest techniques are required to ensure that consignments arrive pest-free, containing only the breathtaking flowers the world has come to expect from the Cape Floral Kingdom.

Looking further afield for answers, Dr Shelley Johnson, research fellow at the Department of Conservation Ecology and Entomology, Stellenbosch University, realised that two post-harvest techniques that have been approved for and are used in other industries have great potential for use on Cape flora cut flowers:

- Controlled atmosphere and temperature treatment systems, known as CATTS, use the stresses created by high temperatures

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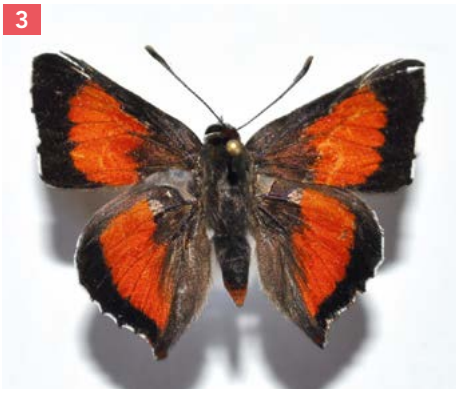

in combination with controlled atmospheres (consisting of 1% oxygen, 15% carbon dioxide in nitrogen) to eliminate pests.

- Ethyl formate (EF) is a naturally occurring compound that, in high enough doses, prevents oxygen reaching the cells of insects, ultimately leading to their demise through asphyxiation.

Both these methods are considered environmentally friendly, as CATTS is essentially chemical free, and EF breaks down into naturally occurring, harmless products.

Shelley and Dr Lynn Hoffman, lecturer at the Department of Horticultural Sciences, Stellenbosch University, designed a study that received PHI funding to achieve two objectives:

1. Identify the insect categories that are of highest concern to the Cape flora cut flower industry.
2. Establish the efficacy of various CATTS and EF fumigation treatments on problematic phytosanitary pests, while maintaining post-treatment flower quality.

Methodology and results

Early in 2016, before the start of the peak export season, numerous pilot trials were performed.

Cut stems from the species *Protea magnifica* (also known as 'Queen' or 'Barbi') were subjected to regular atmosphere heat treatments to assess the flowers' response to heat stress. These proved far too harsh. The flowers lost an average of 13g in water mass and yielded unsatisfactory results from an aesthetic perspective, particularly in terms of leaf damage.

With these results in mind, amendments were made. The 'Barbi's' were kept at 4°C for no longer than 24 hours after harvesting before treatments commenced. The flowers were pulsed using a sucrose solution, and subjected to much faster temperature ramps for shorter durations. The flowers then underwent 10-day vase life studies, during which they were graded for both leaf blackening and bract browning of the flower head.

These brief yet intense treatments, in combination with controlled atmospheres,

PROJECT TITLE
Novel technologies for post-harvest treatment of Cape flora flowers for control of phytosanitary insect pests

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DURATION
Two years

PHI CONTRIBUTION
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LEAD INSTITUTION
Cape Flora SA

BENEFICIARY
The Cape flora industry

FOCUS AREA
Post-harvest insect control, including phytosanitary compliance, and post-harvest physiology

HUMAN CAPITAL DEVELOPMENT
One MSc student

PUBLICATIONS
Two

PRESENTATIONS
Three

4

5

yielded far better results than the standard regimes used on fruit overseas, which were followed in the pilot trials.

The *Leucospermum* 'Veldfire' cultivar was subjected to the amended CATTS regimes, and also yielded more promising results with regard to leaf damage. However, the controlled atmosphere protocols did result in significant pin wilting not seen in the same heat treatments performed with regular atmospheres.

Although these treatments improved the quality of both 'Barbi' and 'Veldfire' compared to the pilot trials results, they require adjustment to further minimise post-treatment damage and ensure standard vase life quality.

EF fumigation was initially performed on 'Veldfire', using the same concentrations that were stipulated in an unpublished pilot study in which Australian wild flowers were fumigated. Once again, the treatments were far too extreme, and considerable damage resulted from all concentrations but the lowest one.

When repeated on 'Barbi', the same aesthetic challenges were experienced.

A diverse range of insects, from stem borers and leaf miners to pollen visitors, were subjected to different treatments to determine their overall tolerance to both heat treatments and fumigation concentrations.

Living insects were collected over a period of two months during official phytosanitary inspections at the airport in the peak export season. Adult specimens were identified, and larval stages were reared to allow for easier and more accurate identification.

A total of 10 species were collected, of which four occurred regularly.

The western flower thrip, *Frankliniella occidentalis*, was of particular concern due to the sheer numbers in which it was present, resulting in multiple rejections. Living specimens were collected from commercial plantations and subjected to the amended CATTS treatments, as well as the lowest concentration of EF fumigation. In both cases 100% mortality was achieved.

This was followed closely by the *Protea* itch mite, *Proctolaelaps vandenbergi*, which too occurred in vast quantities. Both regular atmosphere treatments and EF fumigation resulted in 100% mortality.

The banded fruit weevil (*Phlyctinus callosus*) and Fuller's rose weevil (*Naupactus godmanni*) were often found, and also in unacceptable numbers. These insects will also be subjected to both CATTS and EF treatments.

1 'Barbi' proteas subjected to a 10-day vase life study after EF fumigation treatments.
2 Severe leaf damage and pin wilting in 'Veldfire' after higher EF concentrations.
3 Typical post-treatment quality in 'Veldfire' subjected to regular atmosphere heat treatments.
4 Unacceptable leaf damage experienced due to higher concentrations of EF.
5 Vast numbers of monkey beetles, leaf beetles and mites were collected from wild-growing flowers and subjected to varying CATTS and EF treatments.
6 American bollworm caterpillar found boring within the receptacle of a 'Veldfire' pincushion flower head.

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A noteworthy insect was the Protea hister beetle, *Platysoma capensis*. Although there were never more than two individuals per inspection, it has proven to be incredibly hardy and resistant, with 0% mortality in regular atmosphere treatments and 40% mortality rate achieved using EF fumigation.

Finally, receptacle-boring *Lepidopteran* caterpillars, such as the Protea scarlet butterfly larvae (*Capys alpheus*) and American bollworm larvae (*Helicoverpa armigera*) managed to survive all treatments. The CATTS temperature regimes necessary to raise the core of the flower enough to kill them results in severe and unacceptable damage to the flowers, and EF fumigation does not penetrate deeply enough to result in their death.

Conclusions and future research

The research results indicate that, in terms of flower quality, fumigation with EF has the potential to be developed as a post-harvest treatment. CATTS has also proven an effective measure with which to control a vast range of insect pests that target *Proteaceae*.

However, post-treatment flower quality is still not satisfactory. "We have to fine-tune different pre- and post-treatment techniques by, for instance, introducing forced air cooling directly after CATTS treatments, and optimise EF fumigation concentrations and durations," says Shelley.

She also highlights the need for a greater understanding of the range and complexity of insect pests that trouble the Cape flora industry. "To this end, we will include more *Protea* and *Leucospermum* cultivars in our research trials in the last phase of this project. We will continue collecting live problematic insects, particularly during peak season, to identify and then subject them to different CATTS and EF treatments to see which techniques are the most effective while still maintaining flower quality. Only then will rejections of Cape flora be reduced," Dr Johnson concludes.

DID YOU KNOW?

According to Tony Rebelo, author of the book *A field guide to the Proteas of South Africa*, there are currently about 1400 species in more than 60 genera in the *Proteaceae* family. Virtually all the species occur in the Southern Hemisphere, mostly in Australia which harbours 800 species representing 45 genera. About 400 species occur in Africa, of which more than 330 species are in the South-Western Cape. Central and South America host about 90 species, while 80 species occur on the islands east of New Guinea, 45 species in New Caledonia and a few species in Madagascar, Southeast Asia, New Guinea and New Zealand.

Taxonomy
Family: *Proteaceae*
Genus: *Proteaceae* (The Sugarbushes), *Leucadendron* (The Conebushes), *Serruria* (The Spiderheads), *Orothamnus* (The Marsch Rose), *Vexatorella* (The Vexators), *Leucospermum* (The Pincushions), *Hakea* (The Needlebushes), *Diastella* (The Silkypuffs), *Brabejum* (The Wild Almond), *Grevillea* (The Silky Oaks), *Aulax* (the Featherbushes), *Mimetes* (The Pagodas), *Faurea* (The Beechwoods), *Paranomus* (The Sceptres), *Spatalla* (The Spoons) and *Sorocephalus* (The Clusterheads)

A 'protea' is any member of the *Proteaceae* family. In order to distinguish between a member of the *Proteaceae* family and a member of the *Protea* genus, the latter is sometimes referred to as a 'sugarbush'.

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