Vapormate® sends grain chinch bug packing

A bug that lives on grain, but whose hitchhiking habits are causing fresh fruit export consignments to be rejected, has met its match in a fumigant that is enjoying a comeback.

THE GRAIN CHINCH bug is a fruit exporter's nightmare, but not because it actually damages fruit. As its name suggests, the grain chinch bug feeds on, and causes direct damage to, grain such as wheat and barley. However, when the bugs go into summer dormancy, called aestivation, they look for places to shelter. Favourite spots are under the bark of blue gum trees, and in or on fruit in cases where wheat fields are close to orchards. Their occurrence on fruit is therefore incidental.

1 Research team members Renate Smit, PhD student (left), Dr Shelley Johnson and Dr Mariana Jooste.

Having moved into an orchard in the period leading up to harvest time, the bugs are inadvertently transported to the packhouse with the fruit and thus find their way into packaging. As a phytosanitary pest, even one grain chinch bug in a carton of fruit can cause a whole consignment to be rejected.

Endemic to the Western Cape, grain chinch bug has long been a special interest for Dr Shelley Johnson, entomologist and research fellow at the University of Stellenbosch's Department of Conservation Ecology and Entomology.

Her latest study into the post-harvest elimination of this pest involved the use of Vapormate®, the commercial formulation of ethyl formate. This volatile compound that occurs naturally in a variety of products is generally recognised as safe (GRAS) by the USA Food and Drug Administration (FDA). Ethyl formate breaks down naturally into ethanol and formic acid, rendering maximum residue limits unnecessary.

Vapormate® is a non-flammable formulation of ethyl formate in liquid CO_2 and has been given "no withholding period" status by statutory authorities in countries where it is registered as a fumigant for the treatment of stored grain, fresh produce and packaged food. These countries include Australia, New Zealand, Indonesia, Korea, Philippines, Malaysia and Israel. Registration in the United States is pending.

Vapormate® is vaporised as a hot (60°C) gas and dispensed using aeration fans. Application can be done using small fumigation chambers, containers or fumigation tents.

Although Vapormate® is not new, it has been gaining favour in recent times due to the phasing out of methyl bromide. The latter has long been used across the world as a broad-spectrum, fast-acting fumigant. However, its ozone-depleting properties mean that it will ultimately be banned, hence the search for alternatives and the interest in Vapormate®.

According to Shelley, Vapormate® has already been proven effective in controlling a variety of insect pests, including mealybugs, weevils, mites and thrips on fresh fruit and vegetables in other countries. "Grain chinch bug is a phytosanitary pest for which there is currently no proven treatments other than methyl bromide," she says. "This project will therefore not only bring South Africa up to date with the broader Vapormate® research trends and phytosanitary developments, but also aims to give producers a commercially viable means of combating gain chinch bug."

Working with Shelley on this PHI Programme and Hortgro Science funded project were Matthew Addison, Dr Mariana Jooste and PhD student Renate Smit.

Project objectives and design

The overall goal of the project is to generate sufficient data to allow for the commercial application of Vapormate® to control grain chinch bug. To achieve this, two objectives were set:

1. Set up a small-scale Vapormate® fumigation system.
2. Evaluate the effect of fumigation with ethyl formate, at different concentrations and durations, on grain chinch bug survival and post-treatment fruit quality.

To investigate the effect of fumigation with ethyl formate on the mortality of grain chinch bug and on fruit quality, 'Songold' plums, 'August Red' nectarines, and 'Russet Gold Bosc' and 'Forelle' pears were fumigated inside glass desiccators. Each treatment included 40 grain chinch bugs in a perforated Eppendorf placed among the fruit in the desiccator.

Three concentrations of ethyl formate (50, 100 and 150g/m³) were applied for one hour each, and each treatment was repeated

PROJECT TITLE
Investigating the potential of ethyl formate fumigation for phytosanitary control of the grain chinch bug on pome and stone fruit

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DURATION
One year and seven months

PHI PROGRAMME & INDUSTRY CONTRIBUTIONS
R128 394 & R118 394

LEAD INSTITUTION
Hortgro Science

BENEFICIARY
The South African pome industry

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

HUMAN CAPITAL DEVELOPMENT
Additional exposure for one MSc student

PUBLICATIONS
Two

PRESENTATIONS
Two

2 The presence of only one grain chinch bug in a carton of fruit can cause a whole consignment to be rejected.
3 Dr Shelley Johnson and Renate Smit with the small-scale Vapormate® fumigation system that was set up and tested at Stellenbosch University.

Ethyl formate was administered in different concentrations to 'Songold' plums (**1**) and 'August Red' nectarines (**2**). The fruit was placed in a desiccator with grain chinch bugs contained in a perforated micro centrifuge tube to determine the most effective minimum dosage in order to develop treatment protocols.

three times. A control sample of fruit was placed in a desiccator and left for one hour.

Following treatment, the fruit was exposed to commercial cold-storage regimes.

The samples were evaluated at harvest, after treatment, after cold-storage and after a cold-storage plus shelf-life simulation. Maturity parameters, namely hue, flesh firmness, titratable malic acid and % Brix, were measured at each evaluation. For all the cultivars, external (shrivel, decay and phytotoxic damage) and internal (phytotoxic damage and over ripeness) quality parameters were recorded. For 'Songold' plums, gel breakdown and internal browning were also examined. In addition, mealiness and pulpiness were evaluated for 'August Red' nectarines, and astringency and mealiness for the two pear cultivars.

An informal tasting panel was convened to assess whether the treatments had affected the flavour profile and fruit texture of the fruit.

The panel evaluated fruit after treatment, after cold-storage and after cold-storage plus shelf-life simulation.

To determine the dose, duration and treatment temperature that would completely eliminate grain chinch bug with no phytotoxic effect on 'Russet Gold Bosc' pears, a central composite design (CCD) model was used. The pears were fumigated inside glass desiccators at different concentrations and treatment durations for different temperatures. As with the efficacy trial, each treatment contained 40 grain chinch bugs in a perforated Eppendorf tube placed among the fruit in the desiccator.

After treatment, the fruit was stored for 12 weeks at -0,6°C, plus seven days at 20°C to simulate shelf life. Fruit was evaluated at harvest, after treatment, after cold-storage and shelf-life simulation, and the same maturity, external and internal quality parameters were recorded as in the efficacy trial.

INTERNAL VS EXTERNAL PESTS

Where a pest is found on fruit, is a deciding factor in the best way to treat it. False codling moth is an example of an internal fruit pest as the larvae bore into, and feed inside the fruit. The grain chinch bug and banded fruit weevil are external pests as they remain on the surface of the fruit.

Fumigation is commonly used to destroy external pests, while cold sterilisation is the standard method used to control false codling moth. Cold temperature as a phytosanitary treatment is effective against a variety of pests, but some stone fruit cultivars are chill-sensitive and thus cannot be exported using existing cold sterilisation regimes.

In research conducted for her PhD, Renate Smit investigated the use of CATTS (controlled atmosphere temperature treatment system) and ethyl formate fumigation as potential post-harvest mitigation treatments for false codling moth, grain chinch bug and banded fruit weevil on chill-sensitive Japanese plums.

She concluded that CATTS could be more effective in controlling internal insects, whereas ethyl formate could be used to control external insects without influencing fruit quality. Depending on the insect pest that requires control, CATTS technology in combination with different cold-storage regimes could be used to help maintain fruit quality and provide phytosanitary security for chill-sensitive cultivars.

Results and conclusions

All the concentrations tested in the efficacy trials killed all the grain chinch bugs. Hue angle, flesh firmness, titratable malic acid and % Brix did not differ significantly between treatments for all cultivars, neither did the internal and external quality parameters.

The tasting panel could not distinguish the treated fruit from the control, which confirmed that the fumigation did not affect taste at all.

The CCD model provided guidelines with regards to the dose range and duration that did not cause phytotoxic effect after cold-storage plus shelf-life simulation. The pulp temperature of the pears played a role in susceptibility to phytotoxicity, as did higher concentrations of ethyl formate for extended treatment durations.

In terms of the way forward, Shelley notes that getting Vapormate® registered in South Africa is time consuming and labour intensive, but that the process has started. "Our other challenge relates to the application of the technology, either as ethyl formate on its own or ensuring availability of Vapormate®."

Despite these challenges, the good news remains that the project has put an effective and environmentally friendly alternative on the table for the elimination of grain chinch bug.

> "Vapormate® technology gives the South African export fruit industry access to an environmentally friendly option for post-harvest treatment of grain chinch bug.
>
> Dr Shelley Johnson

3 The project team conducted trials to create a central composite design (CCD) model.
4 Putting fruit quality to the taste test are (from left) Dr Mariana Jooste, Renate Smit and Dr Shelley Johnson.