

Fumigation innovation knocks out phytosanitary pests

It is not often that one post-harvest treatment addresses a variety of challenges. Vapormate®, a fumigant that has been around for at least 90 years, could be one of those exceptions.

PHYTOSANITARY, OR QUARANTINE, pests are the bane of exporters' existence. Even one insect can cause whole consignments of export fruit to be rejected.

Trying to control these pests in the field at levels that are acceptable to some export markets is extremely difficult and compromises

integrated pest management and biological control. Hence exporters are looking to post-harvest treatments for solutions.

For several pests, extended post-harvest cold treatments are required to guarantee "clean" consignments. The cold treatments may be detrimental to the crop and, in the case of grain chinch bug, fail to kill the target pest.

Fumigants offer a relatively quick solution without the risk of chilling injury. Until a decade or two ago, methyl bromide was the post-harvest fumigant of choice. However, due to environmental issues, the use of this product has been phased out in most countries. Phosphine is increasingly being offered as a solution, but with some limitations. It is only safe for fruit in a pure gas form, blended with nitrogen, and used at temperatures below 6°C. High-tech application equipment is also required, hence the treatment can only be done in a large, equipped-for-purpose cold room, as may be found at a port.

Finding a better way

In an attempt to find a better way, Dr Tim Grout, Manager: Research and Technical at Citrus Research International (CRI), has focused his research on Vapormate®, a patented combination of ethyl formate and carbon dioxide that is a GRAS (generally recognised as safe) fumigant. It is usually effective after shorter exposure periods than phosphine, and is more effective at ambient than cold temperatures. In other countries, Vapormate® is already

being used on a variety of fruit, flowers and vegetables, and Tim's earlier research showed that it is also safe on citrus. His objective with further research was to make GRAS fumigants available to growers who can use them in their packhouses without worrying about worker safety, the requirement of high-tech equipment, or needing to pay an expert to conduct the fumigation in a cold room.

Most other uses of Vapormate® are for pests that are found on the outside of the commodity, hence research on the impact on internal phytosanitary pests also needed to be conducted, along with the possible combination of fumigation with shorter cold treatments. If successful, this would result in a reduced likelihood of the kind of chilling injury that currently prevents lemons from being exported to cold-treatment markets like the USA, China and Thailand.

"Most citrus packhouses have degreening chambers that could be used to apply a GRAS fumigant to crates of fruit on arrival, before the fruit move over the packline and are waxed," says Tim.

Project scope

With the increasing rejections for the grain chinch bug and indigenous mealybugs, and the need for an alternative to cold disinfestation for false codling moth, Tim believes that GRAS fumigants could play a role in the future, either alone or followed by a short cold treatment. With PHI Programme and industry support, he started work on a two-year project at the CRI premises in Nelspruit in January 2015. It had two objectives:

- Develop specific Vapormate® treatments that will guarantee citrus fruit to be free from external phytosanitary pests, such as the grain chinch bug, mealybugs, scale insects and Fullers rose beetle.
- Develop the most effective combination of fumigation with Vapormate® or carbon dioxide and a short cold treatment at 2,0°C for the control of fruit fly and false codling moth, both internal phytosanitary pests.

PROJECT IMPACT ON THE CITRUS INDUSTRY

It can provide a post-harvest treatment alternative to sprays in the orchard for some external pests, leading to improved integrated pest management practices.

If external insects such as mites, mealybug, grain chinch bug, or armoured scale insects are found on fruit overseas, Vapormate® could be applied to prevent the fruit from being destroyed or diverted.

Fumigation with high concentrations of CO₂, followed by a short cold treatment, allows for a shorter cold treatment time than cold alone. This will allow access to closer markets and reduce chilling injury that occurs during the current 22-day cold treatment for false codling moth.

To meet the first objective, the research team built on preliminary research and international Vapormate® registrations that have indicated approximate dosages and treatment times for the control of external pests. They bracketed the "best guess" treatments with more severe and less severe treatments and evaluated them against relatively large numbers of individuals.

Regarding the second objective, preliminary research had shown variable levels of



PROJECT TITLE
GRAS fumigants for phytosanitary pests

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DURATION
Two years

PHI PROGRAMME & INDUSTRY CONTRIBUTIONS
R307 218 & R297 218

LEAD INSTITUTION
Citrus Research International (Pty) Ltd

BENEFICIARY
The citrus, table grape and pome fruit industries

FOCUS AREA
Post-harvest disease and insect control including phytosanitary compliance

PUBLICATIONS
One

PRESENTATIONS
Two



1 Dr Tim Grout, project leader.
2 Grain chinch bug take refuge in the navel opening of an orange.





1 After 14 days in storage, the untreated orange on the left displays young, white mussel scale (*Lepidosaphes beckii*) around adult scale. The orange on the right was fumigated with Vapormate® for four hours and then stored for 14 days. The scale on it is all dead and there is no sign of young scale developing.



2 Grain chinch bug in the cavity of a cut pear.
3 'Forelle' pears infested with grain chinch bug before fumigation.
4 Grain chinch bugs on the bark of a blue gum tree.

penetration into different citrus cultivars with both Vapormate® and carbon dioxide alone. The new study wanted to determine whether differences in permeability between cultivar types were consistent, or whether fruit condition and time after harvest played a role.

Results and conclusions

In total, 38 861 grain chinch bug adults were killed, with no survivors, using 250g/m³ Vapormate® for four hours at 15°C. The treatment did not damage Valencia oranges,

stone fruit or 'Packham's Triumph' pears, but did increase waste in 'Abate Fetel' pears that had been badly handled and kept in cold-storage.

Vapormate® at 250g/m³ for four hours at 25°C killed 100% of *Siculobata sicula*, a beetle mite that was under the calyx of Valencia's in KwaZulu-Natal and responsible for export rejections. It was also very effective in controlling two different armoured scale insects on citrus.

Vapormate® was effective at low dosages against motile mealybug life stages. However,

at 250g/m³ for four hours at 25°C, 2% of citrus mealybug eggs still hatched. Extending fumigation time to 24 hours still resulted in 0,1% egg hatch. The team concluded that Probit 9 assurance for the control of citrus mealybug using Vapormate® would not be possible within an economical time frame. Similarly, egg hatching in vine mealybug was not completely prevented with Vapormate® at 250g/m³ for 24 hours at 25°C; 3,4% of eggs still hatched.

Waxing fruit before fumigation with Vapormate® had no effect on treatment efficacy against internal pests. However, variability in efficacy between citrus cultivars, and within the same cultivar between seasons, was too extreme for further research to be justified.

Carbon dioxide fumigation alone gave more consistent results against internal pests than Vapormate®. The sequential combination of carbon dioxide fumigation with a short cold treatment was synergistic and could be developed into a commercial treatment.



MORE ABOUT VAPORMATE®

The use of ethyl formate as a fumigant on dried fruit dates back to 1927. However, the compound can be explosive at higher concentrations. As a result, its popularity and use were limited until the CSIRO in Australia thought to eliminate the explosion risk by adding carbon dioxide to ethyl formate. The result is Vapormate®, a patented fumigant that is generally recognised as a safe (GRAS), eco-friendly, non-residual fumigant.

However, it was methyl bromide's fall from grace that rekindled interest in ethyl formate, leading to research into its potential. In 1987, Vapormate® was proven effective to kill California red scale on

citrus. A 2013 study confirmed that it was effective against all stages of the scale insect and that fumigation periods could be quite short.

It has also been evaluated for the control of cereal pests in silos where it proved effective against beetles.

Vapormate® does not penetrate plant tissue readily, which restricts its efficacy against internal pests like fruit fly larvae and false codling moth. Commercial use will therefore largely be for external pests.

