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Onion disinfestation for export

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1 Executive summary

Eco_2fume, a fumigant developed by Cytec Australia Ltd for the disinfestation of grain and flowers, was evaluated for the control of onion thrips (*Thrips tabaci*) on export onions in commercial-scale trials. Baseline data on the efficacy of methyl bromide, the traditional fumigant, were also collected. The efficacy of both methyl bromide and Eco_2fume for the control of thrips eggs on onions was then compared. The trials were carried out under tarpaulins, either at the Balle Brothers Group or the Young Wah Chong export packhouses in Pukekohe. The rate of Eco_2fume injected was at an initial concentration of 1 g phosphine/m^3 (700 ppm phosphine or 50 g product/m^3) and then declined over the period of the treatments. The target rate for methyl bromide was 40 g/m^3 for two hours.

Both methyl bromide and Eco_2fume markedly reduced thrips numbers on infested onions, allowing the onions to meet importers specifications. There was evidence to suggest Eco_2fume was more effective than methyl bromide for thrips egg control.

Eco_2fume offers a real alternative to methyl bromide for managing the risk of insect pest infestation in export onions. More work is required to better define optimum rates and duration of application of Eco_2fume. Monitoring of phosphine levels during fumigation and more residue sampling is recommended to gain the knowledge and confidence required for registration of Eco_2fume for use on export onions.

2 Introduction

Eco_2fume is a formulation of phosphine gas in liquid carbon dioxide. It is applied as a gas under high pressure. The carbon dioxide acts as the propellant. At the point of delivery, the fumigant mixture is under eight atmospheres pressure. This produces a shearing effect, giving small particles that aid the dispersal of the fumigant into the produce to be fumigated.

Phosphine has a number of advantages as a horticultural fumigant over alternatives such as methyl bromide. Recurring quality issues in Europe indicate that methyl bromide is either an unreliable onion fumigant or is not effective at rates that are safe to use on onions against thrips eggs laid in onion tissue. In addition, methyl bromide is potentially damaging to many crops, such as those in the genus *Allium*, which includes onions and garlic, and its use is being phased out so an alternative chemical must be found. Phosphine is slower to act than methyl bromide (Karunaratre 1998; Karunaratre & Moore 1998), but it has broad biocidal activity for pests of fresh produce, and is less likely to damage the produce. Phosphine is very

toxic to mammals as well as to insects. It appears to act similarly to hydrogen cyanide in inhibiting respiration. A number of enzyme systems are affected during poisoning of insects by phosphine (Stark 1994).

We completed some preliminary testing of Eco_2fume for onion fumigation in the 2000 export season (Carpenter 2000). The work reported here was planned to be an extension of the 2000 season's work, leading to the development of a Good Agricultural Practice (GAP) approach to the use of Eco_2fume for onion fumigation. Research on a registration package for Eco_2fume is continuing in parallel (Carpenter et al. 2001).

Registration documents for the use of Eco_2fume as a cut flower fumigant have been lodged with the ACVM (Agricultural Compounds and Veterinary Medicines Group) in New Zealand, and it is already registered for use as a grain fumigant. It is widely used as a grain and food fumigant in Australia, Malta, China and the USA.

How and where Eco_2fume will be used are key questions. The volume of onions exported through the large packhouses is too great to allow realistic dependence on shipping containers as temporary fumigation chambers. Also, Eco_2fume requires longer fumigation times so it may be necessary for growers to set up large sealable treatment stores.

The aim of this research was to examine the potential for use of Eco_2fume for post-harvest control of onion thrips in export consignments of onions. The performance of Eco_2fume must be compared with methyl bromide, the method currently used for post-harvest control of onion thrips.

3 *Setting a standard for onion fumigation research*

The aim of any risk management system for fumigating produce is to ensure that high quality onions move easily through the value chain and are sold at profit to the grower, packer and exporter. Onion thrips and black mould are the two key quality problems on onions exported to Europe. Because these problems occur on onions grown in Europe, they are not defined as quarantine pests, but as quality issues (EPPO 2001).

To achieve the goal of supplying quality onions to key markets, only good quality onions should be exported. Such onions are unsuitable for experiments on onion thrips control. In research projects on the effects of fumigants on onion thrips, there is a need to gather thrips mortality data so produce used in trials must have high thrips loads. Thus, our research uses onions that would not be suitable for export, especially to the high value quality markets in Europe. Setting a standard for our research is, therefore, complicated because the experiments have to be based on a situation that does not mirror commercial reality.

The outcomes of our research must be compared with a standard that is generally acceptable to importing partners. Feedback from exporters has suggested that border control in Europe requires that less than 10% of

assessed onions have quality problems, including live thrips. Under this standard, if the end point of our fumigation trial gives us fewer than 10 live thrips in a minimum of 400 onions we have met the general requirement for efficacy. As only onions with low or nil thrips numbers will be exported, in practice there will be very few thrips on exported onions and even fewer if the onions have been fumigated as a precaution. In the final analysis, any fumigation method must be proved in a commercial situation. User experience will set standards that meet the needs for a balance between meeting market demand for volume and the risk that significant volumes of onions fail to meet quality standards. At some point, research trials must be conducted on large numbers of export onions, which will have low thrips numbers, to obtain a statistically valid sample of the effectiveness of any recommended fumigation.

4 Thrips on onions

Growers believe the most heavily infested onion cultivars are Dominator and Predator. They find more thrips in onions that have cracked outer skins. Generally, thrips are found between the inner, dry (brown) skin and the first fleshy bulb scale. As soon as the first fleshy bulb scale begins to dry up, all of the thrips appear to move to other onions. Thrips are not generally found on any bulbs that have been attacked by fungi, apparently because the fungal attack makes the onion tissue too wet for thrips to survive. Onions that had intact skins seldom have thrips present.

Thrips larvae were usually found at the base of onion bulbs, close to the root area. The larvae appeared able to fit into the grooves in the fleshy scales. This may facilitate their survival. Thrips are rarely found in the inner layers of the onions.

Handling appears to kill many thrips that have been living high up on the bulbs. This observation was supported by the large reduction in thrips numbers on onions that have been passed over a grader.

5 Methods

5.1 Methyl bromide experiments

Two trials on the use of methyl bromide for onion fumigation were carried out: one in early March at Balle Brothers packhouse (Helvetia Road, Pukekohe) and one in late March at Young Wah Chong packhouse (Union Road, Pukekohe).

Eighteen bins of onions (each containing approximately 950 kg of onions) were used in each trial. The stacks of bins were covered with a large tarpaulin secured on the ground with double lines of sandbags for a gas tight seal. Methyl bromide was applied (40 g/m^3). The duration of the fumigations was 2 hours.

5.2 *Eco$_2$fume experiments*

Two stacks of eighteen bins of onions (each containing approximately 950 kg of onions) were set up on a hard stand at Balle Brothers onion packhouse. The stacks of bins were covered with a large tarpaulin secured on the ground with double lines of sandbags to create a gas-tight seal. Eco$_2$fume (2% phosphine and 98% CO_2) was introduced at 1 g phosphine/m^3 (or 50 g product/m^3). Onions infested with thrips (a 20 kg bag) were placed on the top of the stack. One stack was kept cooler using shade cloth (the aim of this treatment was to reduce the chances of condensation, which can initiate fungal infections). Onions were kept covered for four days. Samples for phosphine residue analysis were taken after fumigation.

5.3 *Assessing the effects of the fumigants on thrips adults and eggs*

Samples of onions were taken after each fumigation and placed in paper sacks to prevent thrips from moving and contaminating adjacent samples of onions. A minimum of 1200 onions was taken from each methyl bromide treatment and Eco$_2$fume treatment, along with matching untreated samples. Then approximately 400 onions from each treatment were sampled immediately, as described above. The onions were held at 27°C in 24 hours light, in their paper sacks. Thrips counts were made immediately after treatment (within 5 days) and, where required, again 2 and 6 weeks after treatment.

5.4 *Thrips counting methods*

Each onion was cut in half across its equator. The undersides of the dry skins were checked for both adults and larvae. When thrips were found on the top of the bulb the assessment was continued to include the first three fleshy scales. When thrips were found at this stage, or when the central fleshy scales were loose, all the layers were checked by cutting the onions into quarters and fully dissecting the bulb.

Six weeks after treatment, onions had very high numbers of pale cream or yellow larval thrips. The adults were also pale in colour, suggesting that they had emerged recently and were unlikely to have laid eggs.

5.5 *Phosphine residues*

Onions were held at 27°C after treatment and a sub-sample was collected after 0, 3, 7, 10, 14, 21 and 28 days. The sub-sample was frozen and held at -18°C in labelled plastic bags. Once all sub-samples were collected they were sent, frozen, to Analytical Laboratories Ltd, Napier, for residue analysis.

6 Results

6.1 Onion quality

The effects of the fumigants on onion quality was not assessed in these experiments but will be assessed in 2002.

6.2 Efficacy of methyl bromide for thrips control

The results of the trial investigating the efficacy of methyl bromide for thrips control on onions are shown in Table 1. Generally, the results were very good. Some variations may or may not be related to the cultivar involved because there are differences between cultivars in their susceptibility to thrips, suggesting that inherent quality factors may affect thrips survival. Even on the most severely infested onions that we assessed, there were only 19 live thrips amongst 538 onions from the Balle Brothers trial, and 28 live thrips from 398 onions from the Young Wah Chong trial. Both these outcomes appear to meet the importers' specifications.

The data for independent data sets are presented as pseudo–replicates. Where possible, cultivars and packhouse lines have been recorded separately, even though they were treated in the same fumigation.

Table 1: Efficacy of methyl bromide for thrips control on onions.

(Source of onions: BBG = Balle Brothers Group, YWC = Young Wah Chong)

Cultivar (site)	Treatment/Rep	No. of onions assessed	Total dead thrips found	Total live thrips found	Live thrips per onion	Mortality (%)
Dominator (BBG)	Untreated	372	434	213	0.57	67
	MeBr	538	116	19	0.03	86
Dominator (YWC)	Untreated	367	771	436	1.19	64
	MeBr Rep 1	392	67	28	0.07	70
	MeBr Rep 2	384	287	7	0.02	98
Unknown CV (BBG)	Untreated	412	783	440	1.07	64
	MeBr Rep 1	500	129	0	0	100
	MeBr Rep 2	346	516	28	0.08	98
Predator (BBG)	MeBr	184	113	0	0	100
Reject (BBG)	MeBr	104	15	0	0	100

6.3 Eco_2fume fumigation

The results of the Eco_2fume fumigation under tarpaulin are shown in Table 2. The most infested bulbs following fumigation had 14 live thrips on 471 export onions. This would have met the efficacy test outlined above. The control mortalities were consistent across both Eco_2fume and methyl bromide trials.

Table 2: Efficacy of Eco_2fume fumigation for thrips control under tarpaulin.

Treatment	Rep	No. of onions examined	Total dead thrips found	Total live thrips found	Live thrips per onion	Mortality (%)
Untreated	1	367	434	213	0.58	67
	2	539	773	440	0.81	63
Eco_2fume	1	471	167	14	0.03	92
	2	94	41	0	0	100
	3	294	67	4	0.01	94
	4	359	82	5	0.01	94

6.4 *Efficacy of methyl bromide for the control of thrips eggs*

The number of live thrips present in both trials 6 weeks after fumigation indicates that there was significant hatch of thrips eggs in this time (Table 3). Two weeks after treatment, numbers were intermediate between those immediately after chemical control and those after 6 weeks. This supports the conclusion that there had been significant egg hatch.

Table 3: Efficacy of methyl bromide for the control of thrips eggs (counts after 2 and 6 weeks in storage).

Grower	Treatment	Onion number	Total dead thrips	Total live thrips	Live thrips per onion	Mortality (%)
	Untreated 2 weeks	601	313	232	0.39	57.4
	Untreated 6 weeks	300	3564	817	2.72	74.4
	Treated 2 weeks	392	67	28	0.07	70.5
BBG	Treated 6 weeks	424	1115	346	0.81	73.3
YWC	Untreated 2 weeks	372	434	213	0.57	67.1
	Untreated 6 weeks	300	1105	817	2.72	81.7
	Treated 2 weeks	355	281	7	0.02	97.6
	Treated 6 weeks	300	2236	281	0.94	74.4

BBG = Balle Brothers Growers, YWC = Young Wah Chong.

6.5 *Thrips egg control with Eco_2fume*

The reduction in the levels of thrips six weeks after treatment was much greater than it was for onions that had been treated with methyl bromide (Table 4). All onions would have met our arbitrary import standard.

Table 4: Efficacy of Eco_2fume for the control of thrips eggs. All research carried out at Balle Brothers Group.

Treatment	Period between treatment and count	Onion number	Total dead thrips	Total live thrips	Live thrips per onion	Mortality (%)
Untreated	2 weeks, sample 1	601	313	232	0.38	57.4
	2 weeks, sample 2	400	533	191	0.48	73.6
	6 weeks	363	951	605	1.67	61.2
Treated	2 weeks, sample 1	294	67	4	0.01	94.4
	2 weeks, sample 2	237	219	2	0.01	99.1
	6 weeks	836	1787	68	0.08	96.3

From this data it seems that Eco_2fume offers a viable alternative to methyl bromide for thrips eggs control.

6.6 *Phosphine fumigation residues*

Figures 1 and 2 show phosphine residue levels in onions treated under tarpaulin and in containers. Residue levels look high. An MRL (maximum residue level) of 10 µg/kg is required prior to acceptance by an importer. After 4 weeks storage the phosphine residue levels were 14 µg/kg for the tarpaulin fumigation and 28 µg/kg for the container fumigation. Shipping times to Europe are 5-6 weeks.

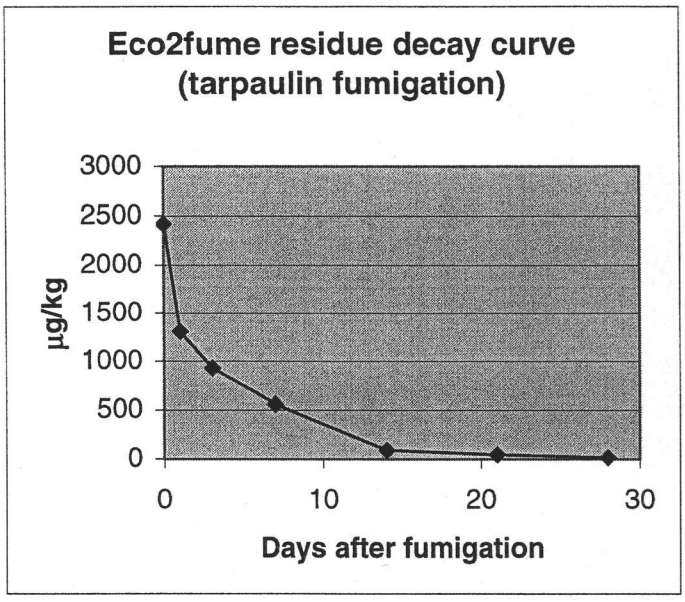

Figure 1: Phosphine residue decay curve for a fumigation carried out under a tarpaulin.

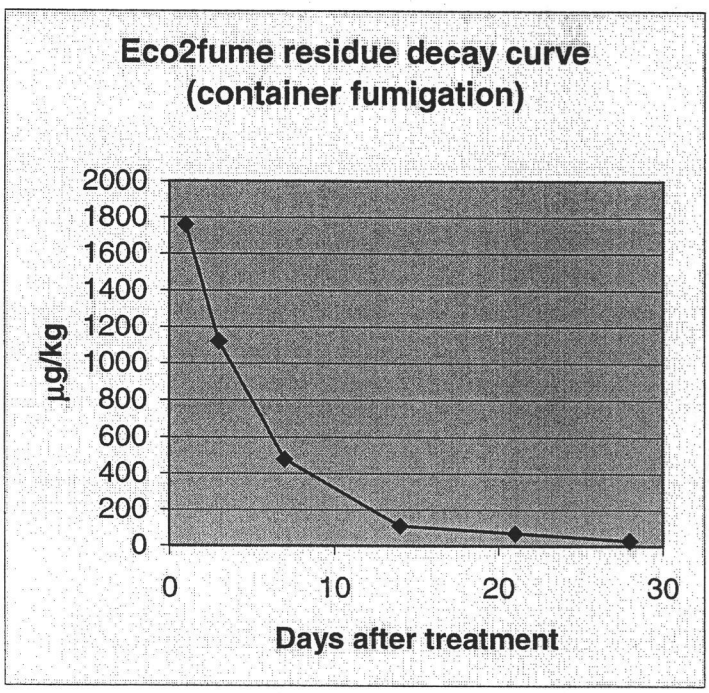

Figure 2: Phosphine residue decay curve for a fumigation carried out in a shipping container.

We recommend more residue testing to check these results. The laboratory used no longer offers a phosphine analysis service.

7 Discussion

The efficacy data presented here must be interpreted with some care. Determination of the efficacy of a fumigant for the control of thrips eggs cannot be confirmed until we have a reliable method for detecting eggs. Our experience in the trials reported here does not agree with the experience of Ecolab fumigators, who find methyl bromide does control egg hatch. It may be that a proportion of methyl bromide fumigations fail to control thrips eggs for some yet to be determined reason. It does offer an explanation for problems that exporters have experienced with onion quality.

8 Conclusions

The trials show that Eco_2fume may offer a real alternative to methyl bromide. More work is required to better define optimum rates and duration of application of Eco_2fume. Monitoring of phosphine levels during fumigation and more residue sampling is recommended to gain the knowledge and confidence required for registration of Eco_2fume for use on export onions.

9 References

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