Plant & Food Research
Rangahau Ahumāra Kai

Effect of ethyl formate and phosphine fumigant as a disinfestation treatment on ‘Hass’ avocado fruit quality and target pest mortality

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The New Zealand Institute for Plant and Food Research Limited

Introduction

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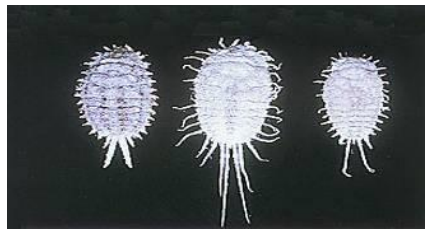
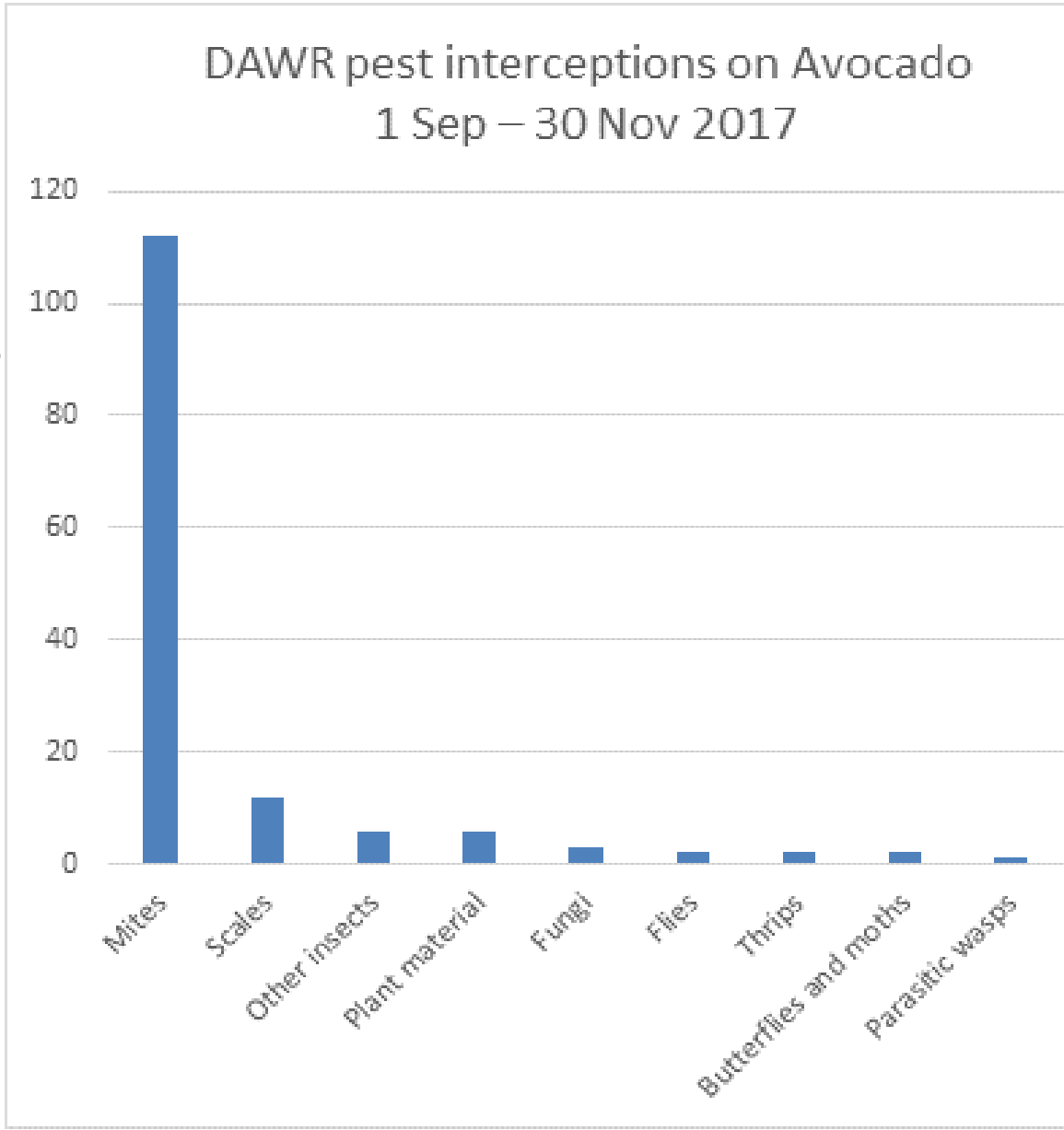
- NZ Avocado has reported quarantine issues with pests on NZ fruit in the consignments to Australian market

- Intercepted pests:
  - Mites
  - Scale insects
  - Thrips
  - Other





Introduction

- Ethyl formate (GRAS) and Phosphine are alternatives to methyl bromide with the potential to control surface pests of New Zealand avocados as a pre-export disinfestation treatment
- Ethyl formate (EF) is commercially available in combination with CO_2 as VAPORMATE™), BOC 2016
- Phosphine (PH_3) commercially available as ECO_2FUME® Fumigant Gas, contains 2% phosphine and 98% CO_2 (w/w); Cytec Industries, Inc.
- EF and PH_3 fumigants has been reported to control many pest species and maintain quality of fresh produce

Main aims

In this study, the potential of EF and PH_3 was assessed at the optimal storage temperature of avocados at 5-6ºC

a) as a disinfestation treatment before export

b) efficacy against surface pests of New Zealand ‘Hass’ avocado, such as mites, scale insects and thrips

c) Impact on avocado fruit quality

Methods

Ethyl formate: Fruit and Pests

- ‘Hass’ from 3 commercial orchards (O1 - O3)
- Average dry matter 27.0% (range 24 – 28%)
- Nine trays/treatment (3 replicate chambers/orchard)
- Three EF treatments and two controls at 5-6ºC

EF treatment	Duration (h)
1.2% EF + CO_2	1
1.2% EF + CO_2	2
1.2% EF + CO_2	4
CO_2 control	4
Untreated control	4

- Pests (mite and scale species)
  - Oleander scale (OS) – *Aspidiouts nerii*
  - Two-spotted spider mites (TSM) – *Tetranychus urticae*

Phosphine: Fruit and Pests

- ‘Hass’ avocados from 3 commercial orchards (O1 - O3)
- Average dry matter 24.6% (range 23 – 25%)
- Nine trays/treatment chambers (3 replicate/orchard)
- Nine PH treatments and one control at 5-6ºC

PH_3 conc. (ppm)	Duration (h)
500	24
500	48
500	72
750	24
750	48
750	72
1,500	24
1,500	48
1,500	72
Untreated control	72

- Pests (mite and scale species)
  - Mould mites – (*Tyrophagus communis)*
  - Green house thrips species (*Heliothrips haemorrhoidalis)*

Methods: Fumigation facility

- Plant & Food Research (PFR) has worked on EF and PH treatments on a range of crops

EF treatments facility (78.6-L chambers)

PH_3 treatment facility (500-L chambers)

- Treatments conducted in a multi-chamber fumigation facility (stainless steel vacuum chambers) which allow simultaneous treatment of fruit and insect samples at a range of concentrations and/or durations

Fumigation treatment

- 2017 - ‘Hass’ avocados, two-spotted mites (TSM) and oleander scale (OS) insects were fumigated together with 1.2% EF + 10% CO_2 (equivalent to 240 g VAPORMATE™/m^3) at 5-6°C

- 2019 - ‘Hass’ avocados, mould mites and greenhouse thrips were fumigated together with ECO2FUME® at 5-6°C

- Fruit were then stored at 5°C for three weeks; external and internal fruit quality was assessed after ripening at 20°C

- Untreated control fruit stored separately

Assessment methods: Pests

Assessed under a stereo microscope after treatment, at 20°C

Ethyl formate

- Both TSM and dTsm 1 day after treatment
- Oleander scale 7 days after treatment

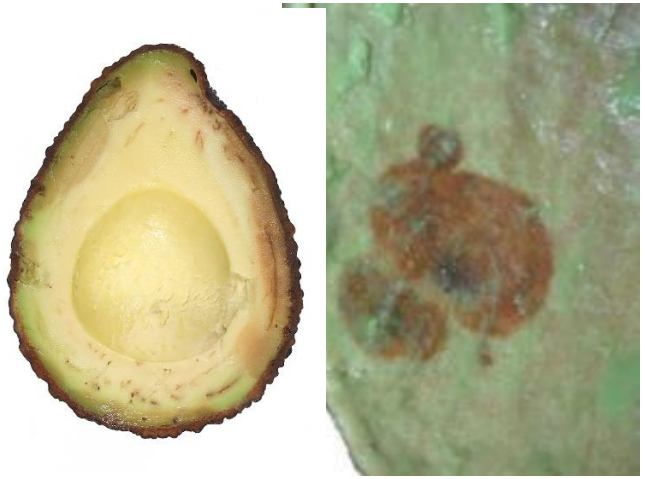
Phosphine

- Greenhouse thrips and mould mites 1 day after treatment
    - Live = active movement, walking around
    - Dead = no movement

Assessment methods: Fruit quality

- Fruit assessed when eating ripe
- External and internal quality assessment carried out using the industry-standard system
- For disorders and rots, data were analysed for fruit with a severity incidence ≥5%
- Treatment effects were assessed by analysis of variance; values not sharing a common letter differ at $p = 0.05$

Stem-end rot (SER)



Body rot (BR)

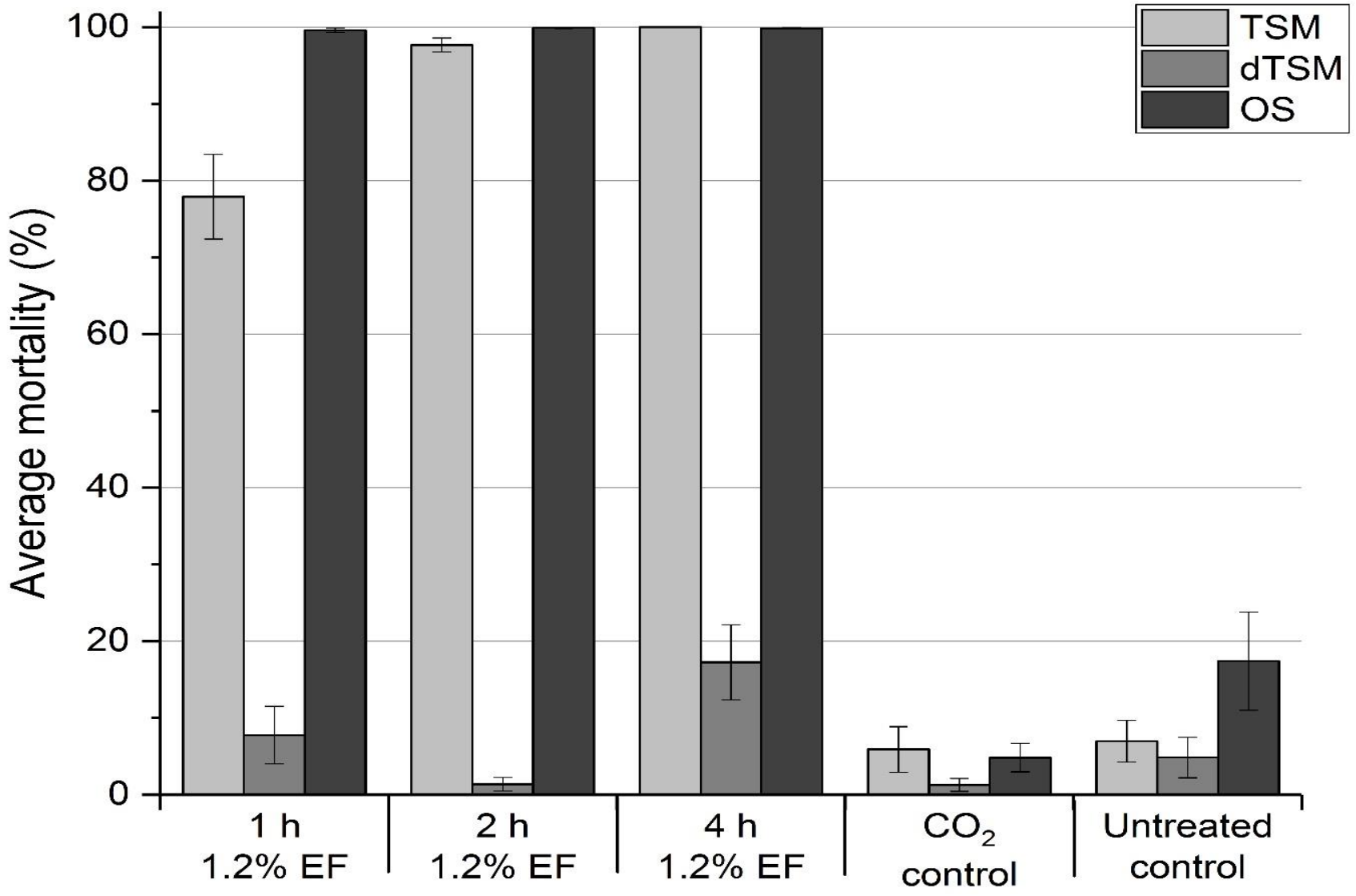
Diffuse flesh discolouration (DFD)

Vascular browning (VB)

Results: Pest mortality

Results: Pest mortality

Ethyl formate



Results: Pest mortality

Phosphine

Treatment	PH_3 conc. (ppm)	Treatment duration (h)	Mortality (%) of pest insects	
			Thrips	Mould mites
T1	500	24	-	0.0
T2	500	48	100.0	0.3
T3	500	72	-	0.6
T4	750	24	-	0.0
T5	750	48	100.0	0.1
T6	750	72	-	42.5
T7	1500	24	-	0.0
T8	1500	48	100.0	0.0
T9	1500	72	-	50.0
T10	5ºC control		35.8	0.1
T11	20ºC control		19.5	0.0

Pest mortality summary

- **Ethyl formate**
  - EF fumigation treatment has the potential to control non-diapausing mites and scale insects,

- **Phosphine**
  - PH_3 treatment has the potential to fully control thrips (100% mortality), but provided only partial control of mould mites (50% mortality)

Results: Fruit quality

Results: External skin damage

- Ethyl formate

Untreated control fruit

EF + (CO_2) for 1h

EF + (CO_2) for 2h

EF + (CO_2) for 4h

Results: External skin damage

- **Phosphine**
  - No skin damage on fruit treated with a higher concentration of phosphine, as previously observed using ethyl formate

Phosphine-treated fruit

Ethyl formate-treated fruit

Results: Fruit quality

Ethyl formate

			Disorder severity (%)			
Treatment	**Treatment details**	**Duration (h)**	**ER**	**SER**	**BR**	**VB**
T1						
T2						
T3						
T4	CO_2 control	4	0.5	12.3[a]	29.7[a]	22.2[a]
T5	Untreated control	4	3.1	15.2	30.5[a]	23.8[a]
p-values (Treatments)				<0.001	<0.001	<0.001

Results: Fruit quality

Ethyl formate

			Disorder severity (%)			
Treatment	**Treatment details**	**Duration (h)**	**ER**	**SER**	**BR**	**VB**
T1	1.2% EF + CO_2	1	3.3	47.1^{b}	50.5^{b}	61.0^{b}
T2	1.2% EF + CO_2	2	6.5	79.0^{c}	87.9^{c}	85.5^{c}
T3	1.2% EF + CO_2	4	4.9	82.5^{c}	90.8^{c}	87.9^{c}
T4	CO_2 control	4	0.5	12.3^{a}	29.7^{a}	22.2^{a}
T5	Untreated control	4	3.1	15.2	30.5^{a}	23.8^{a}
p-values (Treatments)				<0.001	<0.001	<0.001

Increase

Results: Fruit quality

Treatment	PH_3 conc.(ppm)	Duration (h)	Disorder severity (%)				
			ER	SER	BR	VB	DFD
T1	500	24	1.1	14.4^{cde}	19.4^{d}	58.3^{c}	24.4^{bc}
T2	500	48	0.0	8.9^{abc}	18.9^{cd}	52.2^{c}	24.4^{ab}
T3	500	72	1.1	6.1^{ab}	11.7^{abcd}	33.9^{b}	22.8^{bc}
T4	750	24	2.2	20.0^{e}	31.1^{e}	58.3^{c}	28.3^{bcd}
T5	750	48	1.7	10.0^{abcd}	15.0^{bcd}	51.1^{c}	37.2^{d}
T5	750	72	1.7	4.4^{a}	6.7^{a}	21.1^{a}	12.8^{a}
T7	1,500	24	1.7	16.7^{de}	21.1^{de}	51.1^{c}	33.9^{cd}
T8	1,500	48	1.1	10.0^{bcd}	11.1^{abc}	34.4^{b}	28.3^{bcd}
T9	1,500	72	1.7	5.0^{ab}	8.3^{ab}	20.6^{a}	20.6^{ab}
T10	Untreated control	72	1.1	11.7^{bcd}	17.8^{cd}	54.4c	31.1^{bcd}
p- values (Treatments)			0.906	<0.001	<0.001	<0.001	0.002

Results: Fruit quality

Treatment	PH_3 conc. (ppm)	Duration (h)	Disorder severity (%)				
			ER	SER	BR	VB	DFD
T1	500	24	1.1	14.4^{cde}	19.4^{d}	58.3^{c}	24.4^{bc}
T2	500	48	0.0	8.9^{abc}	18.9^{cd}	52.2^{c}	24.4^{ab}
T3	500	72	1.1	6.1^{ab}	11.7^{abcd}	33.9^{b}	22.8^{bc}
T4	750	24	2.2	20.0^{e}	31.1^{e}	58.3^{c}	28.3^{bcd}
T5	750	48	1.7	10.0^{abcd}	15.0^{bcd}	51.1^{c}	37.2^{d}
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Fruit quality summary

Ethyl formate

- EF treatment increased avocado skin damage
- Longer duration treatment increased stem-end, body rots and vascular browning expression (SER, BR and VB)
- The resultant fruit quality was unacceptable

Phosphine

- PH_3 treatment has no impact on external quality of fruit
- Significant reduction (~50-60%) in stem-end, body rots and vascular browning!
- Extended and higher PH_3 treatments improved the fruit quality compared with that in control fruit

Conclusions

Conclusions

- PH_3 treatment may be a better alternative to methyl bromide and ethyl formate for maintaining the quality of ‘Hass’ avocados
- PH_3 treatment has the potential to control thrips fully and mould mites partially
- Extended treatment duration and higher PH_3 concentrations improved ripe fruit quality compared with that of control fruit
- The overall improvement in ripe fruit quality was primarily due to the reduction in incidence and severity of body rots and stem end rots

Pidakala et al, 2018. Potential use of ethyl formate treatment to control surface pests of ‘Hass’ avocado fruit. New Zealand Plant Protection 71: 121-128.

Pidakala et al, 2022. Effects of phosphine (ECO2FUME®) on ‘Hass’ avocado fruit quality and target pest mortality. New Zealand Journal of Crop and Horticultural Science (Published 14-08-2022). DOI: 10.1080/01140671.2022.2111446

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Rangahau Ahumāra Kai

Thank you

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