IMPLEMENTATION OF CONTROLLED ATMOSPHERE DISINFESTATION OF EXPORT ASPARAGUS

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ABSTRACT

Three systems for controlled atmosphere disinfestation of asparagus were compared; viz. short term treatments (45°C/30 minutes); ambient treatment (ambient/3 hours) and post-packing treatment (0-2°C/4 days). Air controls were compared with nitrogen, carbon dioxide and 60% carbon dioxide + 40% air. The most effective treatment conditions for the postharvest control of adult New Zealand flower thrips (NZFT) (*Thrips obscuratus* (Crawford)) and green peach aphid (GPA) (*Myzus persicae* L.) were all atmospheres at 0-2°C/4 days and 45°C/30 minutes in carbon dioxide or nitrogen. Asparagus spear quality was only severely affected by the carbon dioxide atmosphere at 0-2°C for 4 days. **Keywords:** *Myzus persicae*, *Thrips obscuratus*, carbon dioxide, nitrogen, temperature

INTRODUCTION

In New Zealand asparagus is infested by a wide variety of arthropod pests (Watson and Townsend 1981; Townsend and Watson 1984; Carpenter and van Epenhuijsen 1993; van Epenhuijsen and Wright 1994), despite the short time (1-3 days) between emergence of the spear and its harvest at 23-25 cm height, and the minimal vegetation present in asparagus beds. New Zealand asparagus spears are known to be potentially contaminated by over 60 insect and mite species, including 16 thrips species (Carpenter unpubl.). No other exported vegetable has even 25% of this number of contaminants (Carpenter unpubl.).

Most of the 11,000 t of fresh asparagus exported from New Zealand goes to Japan where the majority of shipments are fumigated with methyl bromide. This damages the produce (Beever *et al.* 1985), adds to the growers' costs, and causes ozone depletion (MBTOC 1994). In looking at alternatives to methyl bromide we have focused on controlled atmospheres because application technology is flexible and there are potential quality gains.

In past research we have focused on implementation of controlled atmospheres in sea transit (Lill and van der Mespel 1986) and the effects of temperatures up to 20°C and carbon dioxide levels up to 18% on mortality of NZFT (Potter *et al.* 1994). Mortality of thrips and aphids in controlled atmospheres of up to 10% each of oxygen and carbon dioxide and at low temperature was too slow to fit into asparagus handling systems (Lill and van der Mespel 1986; Carpenter 1993; Potter *et al.* 1994). At higher levels of carbon dioxide, and temperatures above 24°C insect mortality was much faster (Potter *et al.* 1994; Carpenter *et al.* submitted), and perhaps fast enough to fit into a packhouse operation.

There are four points in the asparagus postharvest handling system where controlled atmosphere disinfestation can be implemented:

1. prior to grading while field heat is still in the produce so that no or little extra heat might be needed to achieve rapid thrips mortality. The disadvantage is that a lot of produce unsuitable for export would be treated;
2. after packing and before chilling;
3. in the coolstore before shipment;

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4. in transit; the technology is not available in New Zealand to implement a controlled atmosphere in aeroplanes, but it can be done in trucks and in sea containers. The latter has been ineffective in earlier trials (Lill and van der Mespel 1986).

In the research reported here we investigated implementation of controlled atmosphere disinfestation of asparagus prior to grading, after packing, and in the coolstore.

METHODS

The trials were carried out in packhouses in Napier and Poroutawhao. Asparagus was taken from the commercial crop entering the packhouses. A preliminary trial was carried out to evaluate possible treatment configuration for the short-term, high temperature treatment: NZFT and GPA were treated with nitrogen, carbon dioxide or 60% carbon dioxide + 40% air for 30 or 60 mins at 40°C. Treatments for the main trial were air, nitrogen, carbon dioxide, and 60% carbon dioxide + 40% air at 45°C for 30 months, at ambient temperature (18-21°C) for 3 h, and at 0-2°C for 4 days.

Atmospheres were supplied in pressurised cylinders by BOC Gases NZ Ltd, humidified to about 95% RH and applied to 120 litre gas tight containers. Heating of asparagus was computer controlled using small domestic fan heaters. Gastec sampling systems were used to determine when atmospheres were established (usually within 5 mins) and treatment times were taken from the point the test atmosphere was established.

Large, apterous, GPA were reared on rape plants, and adult NZFT were collected from cabbage tree flowers (*Cordyline australis*), and placed in 50 ml containers with holes in the lids covered with insect proof mesh. Asparagus and insects were treated together. There were 40 asparagus spears per treatment. Mortality was assessed 1-2 days after treatment by checking insects for any signs of movement. For evaluating potential quarantine treatments an arbitrary level of 90% mortality is used to screen out treatments for further study. Asparagus spears were loosely stacked on a grill on the bottom of the treatment cabinets. After treatment they were bundled and chilled.

Asparagus quality was assessed after 2 days cold storage, simulated air flight to Japan and 1 day simulated market life. Any fault was recorded as a damaged spear: brown bract tips, tiprot, stem deterioration, stem collapse or postharvest rot development. After shelf-life assessment, 20 spears from each of three replicates of each treatment were dissected to see if there were any live thrips under the bracts. These results were combined with those from the thrips in containers for presentation of the results. Analysis of deviance was carried out on the data (GENSTAT 1993).

RESULTS AND DISCUSSION

In the preliminary trial NZFT were more easily killed than were GPA (Table 1). The most effective atmosphere for GPA was 60% carbon dioxide + 40% air, and for both species exposure time was not a key factor. For the main trial 45°C was used in an attempt to enhance insecticidal efficacy.

TABLE 1: Percent mortality of a preliminary trial to determine the efficacy of various atmospheres on New Zealand flower thrips (NZFT) and green peach aphids at 40°C (GPA).

		30 minutes	60 minutes
Nitrogen	NZFT	100 (29) ¹	79 (62)
	GPA	10 (118)	44 (106)
Carbon dioxide	NZFT	100 (87)	100 (49)
	GPA	6 (141)	96 (52)
60% carbon dioxide + 40% air	NZFT	100 (73)	100 (25)
	GPA	90 (87)	100 (70)

¹ total number of insects treated in three tests.

Patterns of NZFT mortality under the three different sets of conditions were more complex. Five treatments gave mortalities above the arbitrary 90% threshold: carbon dioxide at 45°C for 30 mins, 60% carbon dioxide + 40% air at ambient; and carbon dioxide, nitrogen and 60% carbon dioxide + balance air, at 0-2°C for 4 days (Table 2).

The pattern of GPA mortality was similar except that there was 100% mortality in air at 0-2°C for 4 days (Table 2). There were four other treatments that were above the 90% efficacy threshold: nitrogen, carbon dioxide, and 60% carbon dioxide + 40% air at 0-2°C for 4 days and carbon dioxide at 45°C for 30 minutes.

TABLE 2: Percent mortality of adult New Zealand flower thrips and green peach aphid exposed to three controlled atmospheres.

Atmosphere	45°C /30 mins	Ambient/3 h	0-2°C /4 days
New Zealand flower thrips			
Air	54 (78) ¹	42 (112)	69 (80)
Nitrogen	56 (131)	68 (216)	100 (101)*
Carbon dioxide	91 (205)*	81 (242)	100 (148)*
60% Carbon dioxide + 40% air	61 (213)	90 (168)*	99 (140)*
Green peach aphids			
Air	49 (197)	2 (59)	100 (43)*
Nitrogen	14 (99)	36 (117)	100 (45)*
Carbon dioxide	99 (165)*	84 (109)	100 (48)*
60% Carbon dioxide + 40% air	68 (146)	37 (143)	91 (104)*

¹ total number of insects treated in three tests

* significantly more effective $P < 0.05$

TABLE 3: Percentage asparagus spears damaged by treatments, based on summarised values.

Atmosphere	45°C/30 min	Ambient/3 h	0-2°C/4 days
Air	13	18	10
Nitrogen	15	17	63
Carbon dioxide	7	26	73*
60% carbon dioxide + 40% air	13	12	67

¹ All asparagus spears in this treatment collapsed completely. In all other treatments faults were minor and spears would have been marketable.

Effects of the treatments on spear quality are shown in Table 3. The faults in air treatments except carbon dioxide at 0-2°C for 4 days, were all minor. In the carbon dioxide treatment all 40 spears collapsed completely. Most spears exhibited one fault such as feathery tip or stem dehydration. More serious faults were tiprot and stem collapse.

The aim of this project was to determine the possibility that controlled atmosphere disinfestation could be introduced at three points in the asparagus postharvest chain. The preliminary trial showed that elevated temperature treatment might be a viable option. A higher temperature was used in the main experiment in an attempt to engender a more rapid mortality. The carbon dioxide treatments were the most effective under all three sets of experimental conditions, and the 0-2°C/4 day and 45°C/30 minute treatments were the most effective overall.

Asparagus will tolerate 4 days at 0-2°C in 60% carbon dioxide + 40% air with no loss of quality in comparison with other storage regimes (Corrigan and Carpenter 1994), if marketing priorities enabled product to be held for that time between packing and shipping.

Mortality has been shown to be enhanced by elevated temperature for NZFT (Carpenter *et al.* submitted), western flower thrips (Carpenter unpub.), green peach aphid and melon aphid (Carpenter and van Epenhuijsen in prep.). At normal storage temperatures and atmospheres thrips mortalities are too slow to be of use in disinfestation systems (Lill and van der Mespel 1986; Carpenter 1993).

Carbon dioxide at high or low temperatures may offer an effective disinfestation system for fresh asparagus as its use can be integrated into a packhouse operation. Short term high temperature treatment would not disrupt packhouse systems. The duration of treatment would need to be longer than 30 minutes or warmer than 45°C to increase mortality. As mortality was high (89-100%) in the 0-2°C 4 day treatment, the time of the treatment may be able to be reduced.

CONCLUSION

The aim of this project was to compare three approaches to implementation of controlled atmosphere disinfestation of fresh asparagus. The short duration/elevated temperature and the long duration refrigerated treatments appear to offer scope for further development with the desired endpoint being a system that is 100% effective.

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