MAF - Levin

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

Postharvest Insect Disinfestation of Fresh Asparagus in the Waikato

1984 Spring season

and 1985 autumn season

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Data obtained in this report was partly funded by the New Zealand Asparagus Council. This data cannot be disseminated without the express permission of the Director, Entomology Division, DSIR, Auckland.

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February 1985

ABSTRACT

1. Fenvalerate insecticide dip

The 1984 research aimed to enhance the thrip-kill of the maldison dip by adding a synthetic pyrethroid to the dip solution. Increasing the fenvalerate concentration from 1/2400 of the field rate to the field rate recommended for control of thrips and aphids, failed to give a corresponding increase in thrip mortality. The existing procedure using a maldison and citowett dip appears to offer the best alternative for use as a postharvest insecticide and wetter/spreader.

2. Controlled atmosphere containers

CA containers aim to extend the shelf life of asparagus and allow asparagus to be exported to Japan at less cost than airfreight. Small-scale CA trials showed that 14 days of CA storage at 2.0°C in 7% CO_2, 7% O_2 or 10% CO_2, 2% O_2 atmospheres gave 100% thrip mortality whether maldison dipped or not dipped prior to CA storage. High or low humidity appeared to have little influence on thrip mortality.

Inspections of 2 containers at Kobe in Japan showed no live insects were intercepted. Asparagus quality after 12 days of CA conditions appeared satisfactory, despite poor control of carbon dioxide and oxygen in one container. The shelf-life of the product after it was unloaded from the container was quite limited.

3. Inspection of asparagus and facilities at Narita Airport

Narita Plant Protection Station and Yokohama Plant Protection Station requested MAF phytosanitary certificates be attached to each export consignment stating that a maldison disinfestation process had been undertaken in New Zealand. This could be coded if necessary. This would enable MAFF to carry out a "more relaxed" inspection of the product in Japan, and avoid fumigation on arrival if no live insects were found.

Inspection of the product showed considerable variation in quality and packaging. Live insects were intercepted on both consignments imported from New Zealand, and an HCN treatment was required.

4. Methyl bromide fumigation of asparagus

Methyl bromide fumigation of asparagus gave high mortality (up to 100%) of all thrips encountered. Mortality of thrips was generally low 24 hours following fumigation. However, this increased significantly after 48 and 72 hours. For high mortality, asparagus spear temperature should be approximately at ambient during fumigation and asparagus should be stored at low temperature (3°C) following fumigation. Application of a vacuum during fumigation did not appear to increase mortality.

The 1984/85 asparagus research is reported in four parts:

PART I: Postharvest insecticide dip - evaluation of fenvalerate.

PART II: Controlled atmosphere - results of small-scale trials in New Zealand and observations on commercial shipments inspected in Japan.

PART III: Inspection of asparagus and facilities at Narita Airport.

PART IV: Fumigation - methyl bromide.

PART II: CONTROLLED ATMOSPHERE - RESULTS OF SMALL-SCALE TRIALS IN NEW ZEALAND AND OBSERVATIONS OF COMMERCIAL SHIPMENTS INSPECTED IN JAPAN

1.0 INTRODUCTION

While most of the asparagus crop was exported by airfreight in 1983, a small proportion was exported by sea using controlled atmosphere (CA) containers. At least three containers were exported, each containing about 8 tonnes of product. CA was used in order to extend the shelf-life of the product, and to enable a cheaper form of transport to be used for exports of asparagus to Japan. There were no reports of live insects being found on these shipments when the asparagus was inspected in Japan. As insect kill is one aspect of the success of this project, determination of insect mortality using CA conditions was of interest.

2.0 METHODS

Insect-infested asparagus was obtained from the Rukuhia Research Station (MAF) and Pukekohe Horticultural Research Station. Six controlled atmosphere containers approximately 0.5 m^3 capacity were filled with 3 samples of asparagus:

(1) 1 export carton of asparagus that had been dipped in maldison and diverted from export for these trials. This was assessed for changes in quality;

(2) a sample of insect-infested spears that was dipped in maldison and citowett in the standard commercial manner prior to export (at B.I. Candy's property); and

(3) a sample of insect-infested spears that were not dipped in maldison and citowett.

The CA chambers were paired and filled with 3 atmospheres on a flow-through system (A1 = 0% CO_2, 21% O_2; A2 = 7% CO_2, 7% O_2; A3 = 10% CO_2, 2% O_2). The insect mortality was assessed in one container of each pair after 3 days, and in the remaining chamber after 14 days. At each time interval, an export carton of asparagus was assessed for quality. Comparisons of insect mortality and asparagus quality were made by reference to the three samples ((1), (2) and (3) above) stored in low (60%) and high (80%) relative humidity containers. All the containers were kept at 2.0 ± 1°C. The gas concentrations of the chambers were monitored daily.

In addition to these small-scale trials, two CA shipping containers of asparagus were exported from New Zealand on 20 October, and were inspected at Kobe, Japan, for both live insects and quality on 2 November 1984. This asparagus consignment was held for 12 days under CA conditions (recommended 7% ± 1% O_2, 7% ± 1% CO_2) and a further 2 days with cooling only prior to inspection. The gas concentrations were monitored daily. The asparagus was placed in wooden boxes each containing about 9 kg of asparagus, with about 840 boxes per container. Plastic sheeting was placed inside the outer doors to minimise gas leakage during transit. Representatives of Turners and Growers Exporters Ltd weighed and marked individual boxes in one container prior to export, and placed Ryan thermographs in the container to record temperature. The boxes were re-weighed in Japan, and the change in weight recorded.

3.0 RESULTS AND DISCUSSION

3.1 Small-scale trials

After 3 days of CA storage, there were no significant differences in

mortality between different atmospheres for both maldison-dipped and non-dipped asparagus (Table 2).

Assessment period, and postharvest treatment	CA treatment	THRIPS Total tested, N	No. affected, R	% mortality,
3-day, maldison + citowett	O(HH)[1]	59	52	88.1
	O(LH)[2]	57	50	87.7
	A1[3]	51	42	82.3
	A2[4]	52	45	86.5
	A3[5]	51	43	84.3
3-day, no maldison + citowett	O(HH)	8	3	37.5
	A1	61	59	96.7
	A2	63	58	92.1
	A3	63	61	96.8
14-day, maldison + citowett	O(HH)	61	59	96.7
	O(LH)	61	59	96.7
	A1	64	61	95.3
	A2	68	68	100.0
	A3	57	57	100.0
14-day no maldison + citowett	O[6]	62	54	53.1
	A1	68	36	52.9
	A2	60	60	100.0
	A3	58	58	100.0

1. HH = High humidity (≈80%)
2. LH = Low humidity (≈60%)
3. A1 = 0% CO_2, 21% O_2
4. A2 = 7% CO_2, 7% O_2
5. A3 = 10% CO_2, 2% O_2
6. Humidity not controlled

Table 2: Percentage mortality of thrips when stored at 2.0°C in 3 different controlled atmosphere (CA) conditions and 2 levels of humidity. The thrip-infested spears were either dipped in maldison (200 ppm) + citowett for 10 minutes or not dipped. Mortality was assessed after 3 and 14 days.

Although thrip mortality was high (82.3%-96.8%) there was incomplete kill. However, after 14 days CA storage at 2.0°C, 100% thrip mortality was achieved in atmospheres A2 and A3 i.e., 7% CO_2, 7% O_2 and 10% CO_2, 2% O_2, for both maldison-dipped and non-dipped asparagus. Incomplete mortality

was achieved after 14 days at either 60% or 80% relative humidity at 2.0°C, or with atmosphere A1 i.e., 0% CO_2, 21% O_2. It appears likely that a certain level of CO_2 may be necessary to kill thrips within 14 days at 2.0°C.

Complete kill of aphids was achieved after 3 days in atmospheres A2 and A3 i.e., 7% CO_2, 7% O_2 and 10% CO_2, 2% O_2 for both maldison-dipped and non-dipped asparagus (Table 3). A small number of aphids survived in

Assessment period, and postharvest treatment	APHIDS			
	CA treatment	Total tested, N	No. affected, R	% mortality,
3-day, maldison + citowett	O(HH)[1]	9	8	88.9
	O(LH)[2]	12	12	100.0
	A1[3]	18	15	83.3
	A2[4]	8	8	100.0
	A3[5]	2	2	100.0
3-day, no maldison + citowett	O(HH)	8	8	100.0
	A1	17	17	100.0
	A2	4	4	100.0
	A3	9	9	100.0
14-day, maldison + citowett	O(HH)	18	18	100.0
	O(LH)	17	17	100.0
	A1	12	12	100.0
	A2	17	17	100.0
	A3	13	13	100.0
14-day no maldison + citowett	O[6]	20	19	95.0
	A1	38	37	97.4
	A2	17	17	100.0
	A3	18	18	100.0

1. HH = High humidity (≈80%)
2. LH = Low humidity (≈60%)
3. A1 = 0% CO_2, 21% O_2
4. A2 = 7% CO_2, 7% O_2
5. A3 = 10% CO_2, 2% O_2
6. Humidity not controlled

Table 3: Percentage mortality of aphids when stored at 2.0°C in 3 different controlled atmosphere (CA) conditions and 2 levels of humidity. The infested asparagus spears were either dipped in maldison (200 ppm) + citowett for 10 minutes or not dipped. Mortality was assessed after 3 and 14 days.

atmosphere A1 i.e., 0% CO_2, 21% O_2 (3-day maldison-dipped and 14-day non-dipped) suggesting that CO_2 may also be necessary for complete kill of aphids in less than 14 days at 2.0°C. It should be noted however that infestation levels of aphids in some asparagus treatments were very low.

There were no marked differences in quality between treatments after 3 and 14 days of CA storage (3 atmospheres) or humidity storage. The spears were assessed visually over a 5 day period at 15-22°C.

In summary, 14 days of CA storage at A2 and A3 gave 100% thrip and aphid mortality whether maldison-dipped or not dipped prior to CA storage.

3.2 Containerized asparagus

Records of oxygen and carbon dioxide levels during the 12 day voyage from Auckland to Kobe are provided (Appendix A).

EXPORTER, LOCATION, (DATE)	GENERAL: CARTON INTEGRITY	GENERAL: WATER ON SPEARS	GENERAL: DAMP PAD	GENERAL: FUNGUS	GENERAL: SPEAR TEMPERATURE	GRADING & PACKING: TIGHT, MEDIUM LOOSE PACKED	GRADING & PACKING: HEIGHT OF SPEARS	GRADING & PACKING: TIP BENDING	GRADING & PACKING: FEATHERING	WILTING: SUNKENESS	WILTING: TURGIDITY	WILTING: SPEAR SIZE	TIP ROTS: SMELL?	TIP ROTS: FUNGUS?	TIP ROTS: STICKY OOZE?	TIP ROTS: WATER SOAKING ON TIP	BUT ROT: COLOUR OF FUNGUS	BUT ROT: WATER SOAKED	BUT ROT: GREEN OR WHITE CUT	STEM ROT: STEMPH? VALLEYS? COLOUR
TURNERS & GROWERS NARITA (22.11.84)	G	Yes	Yes	No	14.5-17°C	T	Plenty of room	< 1%	5%	No	G	Even grade	No	No	No	No	No	No	White mainly	No No n/a
HORT CROP, NARITA (22.11.84)	Poor	Yes	No pad	No	14-17°C	Med side-pack	Insufficient	> 50%	> 50%	No	M	Variable	Yes	No	Yes, 5%	Yes	No	No	Mostly green	No No No
UNKNOWN EXPORTER, KOBE (2.11.84) 1. 562241 NZX 2232 GODWIT	Wooden V. good	No	Yes, not damp	No	3-4°C	Med-tight	Suff. room	< 10%	16-20%	No	Good 5 or 6 examined	Even	No	No	No	No	No	No	Green	No No Green
TURNERS & GROWERS, KOBE (2.11.84) 2. 563034 NZ 2232	Wooden V. good	No	Yes, not damp	No	3-4°C	Tight	Suff. room Spear's longer	< 5%	< 5%	= 4%	Poor/med. 3 boxes examined	Med-even some var.	No	No	No	No	No	No	40-50% white cut	No Some OK, light

TABLE 4: Inspections of Asparagus at Narita (Airfreight) and at Kobe.

The quality of the asparagus in both containers was inspected during the course of MAFF inspections for insects. In general, the quality of the asparagus from both containers appeared satisfactory (Table 4). No tip rots, butt rots or stem rots were detected from either container. However, container 563034 contained asparagus that was cut to a longer length, and showed a definite loss in spear turgidity. This was particularly apparent in spears of smaller diameter.

The differences in spear turgidity between the two containers may be related to the differences in atmosphere control (Appendix A). Although container 563034 was the only one equipped with a CO_2-scrubber, it showed poor control of CO_2 levels. This container was opened to atmosphere at least 10 times during transit when CO_2 levels exceeded those recommended in the carriage instructions (Appendix B). Oxygen levels also deviated from the recommended range. When the atmospheres were manually checked and found to be outside those recommended, the container was vented to atmosphere. These atmosphere vents may have elevated the spear temperatures, particularly when passing through the tropics. The commercial significance of this weight loss was not able to be ascertained.

Representatives of Turners and Growers Exporters Ltd who inspected the containers found the temperature was poorly controlled in container 563034 and this probably altered the respiration rate of the asparagus causing fluctuations in CO_2 and O_2 levels. Inspections of the product 3 days later showed about 20% had "softened and opened heads" suggesting rapid product deterioration and limited shelf-life.

There were no insects intercepted from either of these containers. Unfortunately it was difficult to detect any insects at all (whether live or dead) as the spears were being checked by MAFF inspectors against a black background. This is in contrast to procedures observed at Narita for airfreighted asparagus where spears were tapped by inspectors and insects examined on a white background.

PART IV: FUMIGATION WITH METHYL BROMIDE FOR SHORT TIME PERIODS

1.0 INTRODUCTION

Plant Protection Division (MAFF, Japan) has recently advised against further use of the maldison postharvest insect disinfestation procedure (M.J. Lear, NZ Embassy, Tokyo, pers. comm. 1985). Although the maldison residues are well below the tolerances governed by the Ministry of Health & Welfare in Japan, this appears to arise from concern with potential consumer reaction to the dipping of a vegetable product in an insecticide should this fact be publicised in Japan. Development of alternative disinfestation procedures more acceptable to MAFF (Japan) have therefore been pursued.

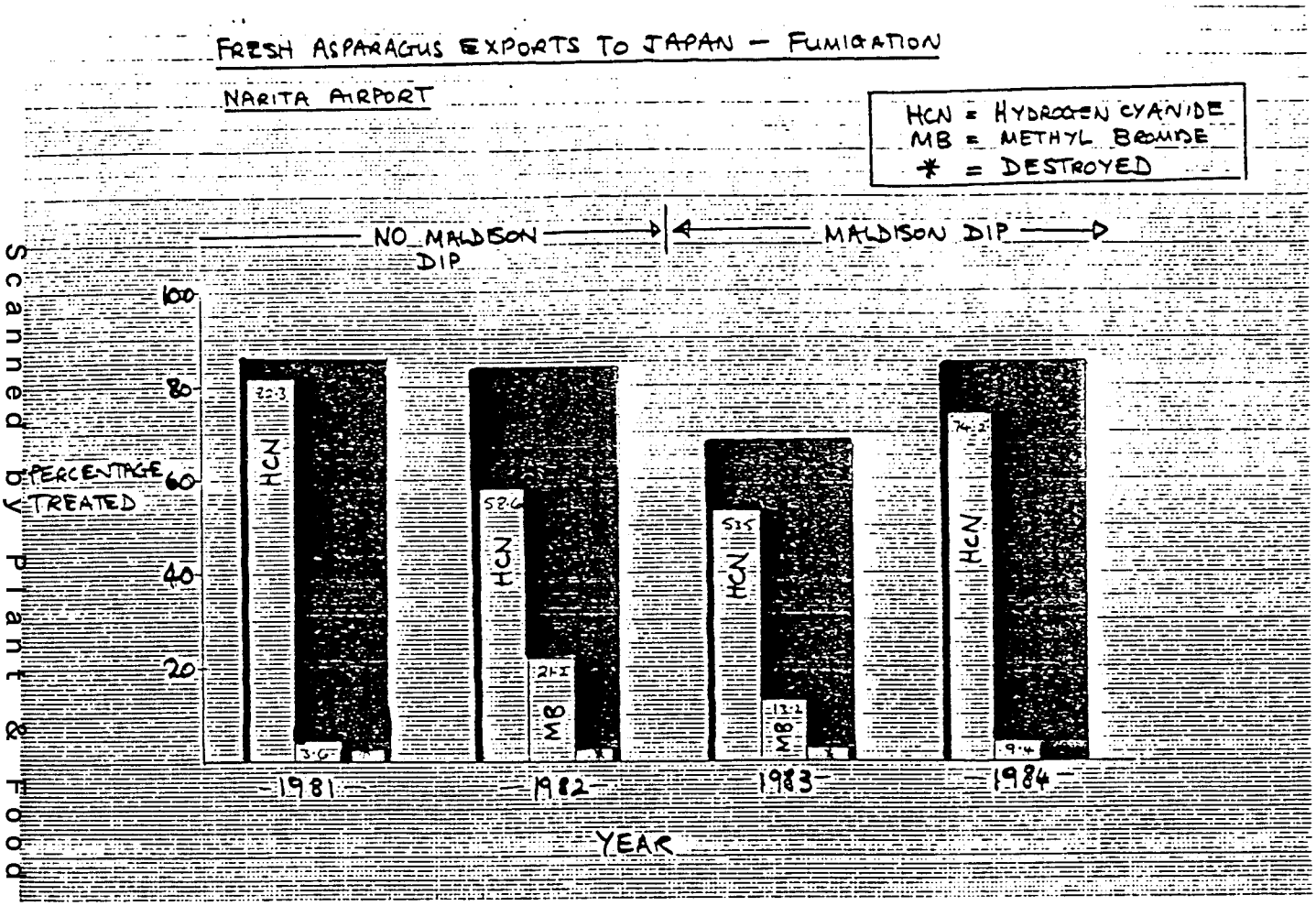
In addition, recently obtained statistics show that since the introduction of the maldison dip in 1982, there has not been a change in the amount of asparagus fumigated in Japan due to the presence of live insects (Table 5, Figure 1). However, there is little information as to the extent of dip usage in commercial practise in New Zealand.

Table 5: Annual exports (tonnes) of fresh asparagus to Japan. The percentage fumigated with methyl bromide (MB) and hydrogen cyanide is shown.

YEAR	TONNES	Percentage fumigated	
		HCN	MB
1975	27	-	-
1976	68	-	-
1977	83	-	-
1978	72	-	-
1979	81	-	-
1980	106	-	-
1981	203(131?)	82.3	3.6
1982	197	58.6	21.2
1983†	270	53.5	13.2
1984†	620	74.2	9.4

† Introduction of maldison + citowett dip.

Figure 1: Fresh asparagus exports to Japan - Fumigations at Narita airport



A preliminary investigation of asparagus fumigation with methyl bromide (Batchelor et al. 1984) showed that high mortality of all arthropods encountered on the asparagus could be obtained after 24 hours at rates close to those likely to cause damage to the commodity (see below). It was therefore considered useful to study the individual contributions of the time period following fumigation, spear temperature during fumigation, post-fumigation storage temperature, and the effects of vacuum during fumigation on the mortality of various insect species in order to lower the

methyl bromide dose (concentration and/or time). Lowering of the dose by reducing fumigation time is likely to be beneficial to both asparagus quality (after fumigation) and the processing time associated with fumigation.

Previous research (Beever et al. 1983) has shown that asparagus quality and storage life are adversely affected by methyl bromide fumigation at rates above 48 gm^{-3} for 3 hours at >12°C. This rate was used as a guide to the upper practical limit of dose (for both concentration and time).

We report here a study on the methyl bromide fumigation of thrips on asparagus.

2.0 METHODS

2.1 Asparagus and insects

Fresh asparagus was obtained from a commercial property in the Waikato during February-March 1985. The natural infestation level of thrips was sufficiently high to preclude further artificial infestation. While a large number of species of thrips are found on Waikato asparagus, by far the greater proportion of thrips numbers are due to one species, Thrips tabaci (Watson and Townsend 1981, Batchelor and Foster unpublished). For the purposes of this work individual species were not differentiated. Few other arthropods were encountered.

Asparagus was brought to the required temperature immediately prior to fumigation; spear temperature was measured by a thermistor probe. Following fumigation the asparagus was immediately stored at 3°C (except for one treatment (q.v.) at 12°C) until assessment. All the atmospheric fumigations were conducted at an air temperature of 12°C. However, spear temperature was not found to change by more than 1 or 2°C by the end of each fumigation.

2.2 Fumigation

Atmospheric pressure fumigations were conducted in 23.4 litre perspex containers using 2 kg of asparagus per chamber. Circulation was maintained by an internally-mounted electric fan. Vacuum fumigations were performed with 4 kg of asparagus in a 50 litre steel chamber. Pressure was monitored by an attached Class A vacuum gauge (0--101 KPa). Circulation was achieved by a Cole Parmer air cadet diaphragm pump (pump rate of 6 litres min^{-1} at atmospheric pressure) connected in series with two valves at either end of the chamber.

Methyl bromide was admitted as a gas (to both chamber types) by gastight syringe (Hamilton model S-500). Fumigations were timed following admission of gas. At the completion of the fumigation, the atmosphere in the chamber was vented and flushed with air at a rate of approximately one air change per three minutes, for 15 minutes.

2.3 Assessment

Individual asparagus spears were assessed under a binocular microscope using forceps to remove the bracts (Batchelor and Harris 1983). Insects were scored, after prodding with a fine camel hair brush, as 'dead' if no signs of movement, 'moribund' if the insect was not capable of moving but slight motion of the legs was observed, and 'live' if the insect moved.

3.0 RESULTS

The effects on mortality of thrips to a wide range of treatments that investigated the contribution of time after fumigation before mortality assessment, dose (concentration and time of fumigation), spear temperature and post-fumigation storage temperature, and application of a vacuum are

listed in Table 6. Statistical analyses of these data are being undertaken and will be reported in full in a later publication.

6 - Percentage mortality of thrips on asparagus with various methyl bromide fumigations

ment[2]	CT PRODUCT (gh)	12 hours[1] N	Moribund	% Mortality	36 hours N	Moribund	% Mortality	60 hours N	Moribund	% Mortality	80 hours N	Moribund	% Mortality
/3/	16	130		27.7	118		46.6	78		41.0			
/	0	71		12.7	106		11.3			-			
	16	54		29.6	60		41.7	75		45.3			
/12.5/	0	123		26.0	124		16.1	131		20.6			
2.5/					88	11	45.5	71		97.5			
0/21/	16				87		17.2	86		39.5			
21/	0												
				44.0	108	1	41.1	96		63.5			
0/21/ °C[3]	16	193		33.9	33		42.4	45		40.0			
21/12 °C[3]	0	115								-			
				36.4	80	6	57.5			-			
30/3/	32	56		16.1	131		20.6						
/3/	0	124								98.6			
				11.6	71		81.7	70		100.0			
45/19/	24	69		8.3	81		91.4	73		8.6			
60/19	32	109		5.7	93		18.3	93					
/19/	0	87											
				39.4	69		97.1						
/30/21	24	71		27,3	87		98.9						
/45/21/	36	77		69.0	72		98.6						
/60/21/	48	71		15.7	71		28.2						
0/21/	0	70											
					142		100.0						
/60/20/	48				130		100.0						
/90/21/	72				9		10.2				77		100.0
0/20/	0										95		93.7
				34.4							72		20.8
2/30/21/-8KPa	16	180	7	43.7									
2/30/2 /-95KPa	16	190		24.1									
/0/0/0KPa	0	137											

[1] Time following fumigation
[2] MeBr concentration (gm^{-3}) / Fumigation time (min) / Spears temperature (°C) / Other
[3] Placed at 12°C after fumigation

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3.1 Effect of time following fumigation

All treatments showed a significant increase in thrip mortality with an increase in time following fumigation. Assessment after 12 hours for virtually all treatments showed little difference between treated and control mortalities. After 36, hours however, virtually all treatments showed significant increases in mortality (relative to the controls). Complete or virtually complete mortality was achieved within 60 hours in

the more effective treatments. No consistent significant differences in control mortalities were observed within this period.

3.2 Effect of dose (concentration and time)

An increase in methyl bromide concentration from 32 gm^{-3} to 48 gm^{-3} gave little apparent increase in mortality after 12 hours except for the longest fumigation time (60 minutes). For an increase from 32 gm^{-3} to 64 gm^{-3} (spear temperature 3°C) over a 30 minute fumigation time, no significant increase in mortality after 12 hours was detected.

After 36 hours significant increases in mortality with the increase from 32 gm^{-3} to 48 gm^{-3} were apparent. No significant difference in mortality for the increase from 32 gm^{-3} to 64 gm^{-3} was detected presumably because of the low spear temperature (3°C) at fumigation (see following).

Increase in fumigation time from 30-60 minutes also gave no significant difference in mortality after 12 hours, except at the highest rate used (48 gm^{-3} for 60 minutes). However, increases with increase in fumigation time were apparent at 36 hours at the lower rate of 32 gm^{-3}. At 48 gm^{-3}, mortalities at 36 hours were high for all treatments regardless of fumigation time.

3.3 Effect of asparagus spear temperature

Significantly higher mortality of thrips in fumigations with an initial asparagus spear temperature of 21°C (relative to the fumigations with the lower spear temperatures of 3°C and 12.5°C) was detected. This difference while not detected up to 36 hours was quite marked at 60 hours.

Asparagus stored at 3°C immediately following fumigation showed higher mortality of thrips than when stored initially (for a period of 12 hours) at 12°C then at 3°C.

3.4 Effect of vacuum

The effect of application of a moderate vacuum (-98 KPa) throughout fumigation was investigated. While there was an indication that mortality after 12 hours was slightly increased in the vacuum treatment, after 84 hours there were still survivors from this treatment (no survivors were recorded from the slight vacuum treatment at this time).

A relatively high number of moribund thrips was detected after 12 hours from the moderate vacuum treatment.

4.0 DISCUSSION

Fumigation with methyl bromide at the low doses reported here was an effective method for disinfestation of live thrips from asparagus. Very high mortalities (up to 100%) can be achieved at these doses providing certain conditions are met; asparagus spear temperature should be around 20°C (ambient) when fumigated and asparagus should be stored at low temperature (3°C) following fumigation for a period of at least 36 hours.

The lesser doses of methyl bromide used here are well below those in which damage to asparagus quality and shelf life has been observed (Beever *et al* 1983). It should be noted, however, that these fumigations were conducted at an asparagus spear temperature of 12°C as opposed to the ambient temperature (~20°C) necessary for high thrip mortality, and that direct correlation of the quality data may not be strictly valid. The large reduction in fumigant dose should, however, allow a sufficient margin of safety.

It should also be emphasised that this work has dealt solely with thrips. As noted previously, in addition to thrips a large variety of

arthropods are found on asparagus including aphids and mites. It has been found that aphids on asparagus are more susceptible to methyl bromide fumigation than thrips (Batchelor and Foster unpublished). However, little is known concerning the effects of methyl bromide fumigation on the various mite species or indeed on the other arthropods likely to be found on asparagus. While the relative importance of thrips (and aphids) as a reason for fumigation by Japanese Quarantine services has not been quantified, it may be suggested by their relative abundance on freshly cut asparagus (Batchelor and Foster unpublished) and by the relatively high proportion of HCN fumigations (relative to MeBr fumigations) in Japan.

The importance of asparagus spear and post-fumigation storage temperatures as factors that affect mortality are of particular interest. While it appears that elevated spear temperatures during fumigation increase thrip mortality, the same appears not to apply to the post-fumigation storage temperature for the first twelve hours. In fact, mortality was increased by a lower post-fumigation storage temperature.

The effect of an increase in fumigation temperature increasing mortality is well documented (Pradhan and Govindan 1953, 1954) and arises primarily from an increase in insect respiration rate. It is conceivable that in this case the increased respiration rate of the asparagus at higher temperatures producing more carbon dioxide (Platenius 1942) also stimulates insect respiration (Cotton and Young 1929) and contributes to the increase in mortality.

The general effect of post-fumigation temperature on insects is less well-studied and the reasons for the effects less clear. It has been suggested that factors such as a lower rate of desorption of the fumigant by both the commodity and insect at lower temperatures may contribute to an

increase in mortality (Sun 1947).

The general effects noted here are clearly caused by a number of factors; further refinement of MeBr fumigation of thrips on asparagus would benefit by considering the individual and combined effects of these factors.

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Appendix A: Container Shipping Records for CO_2 & O_2

DATE	TIME	NO CO_2 SCRUBBER NZCU 562224/6 (260)		CO_2 SCRUBBER NZSV 563034/6 (261)	
		% O_2	% CO_2	% O_2	% CO_2
20/10	1300	8	6.2	7	7
21/10	1000	8.5	6.0	5.2	8.0
22/10	0600	9.5	6.5	5.0	8.0
	1500			4.0 → 7.5	9.0 → 7.5 VENT OPEN
23/10	0600	8.5	6.3	10.0	8.2
	1230			4.0 → 7.5	9.0 → 7.5 OPEN
24/10	0600	9.2	6.6	13.0	8.9
	1600			3.8 → 7.5	10.0 → 7.5 OPEN
25/10	0800	8.0	6.6	4.0 → 8.0	9.5 → 8.0 OPEN
	1500			6.0 → 13.0	9.5 → 7.0 OPEN
26/10	0800	9.0	6.2	5.0 → 14.0	9.5 → 6.0 OPEN
27/10	0800	9.4	6.5	5.0 → 13.0	9.5 → 7.0 OPEN
	1500			5.0 → 13.0	9.5 → 6.5 OPEN
28/10	1000	11.5	4.5	6.0 → 12	9.0 → 7 OPEN
	2300			11.0	9.0 OPEN
29/10	0800	11.0	5.6	15.0	6.0
30/10	0800	8.5	7.5	7.0 → 11.0	9.0 → 7.0
31/10	1230	10 VENT	7.9 OPEN	17.0 SW OFF	7.0

Inspected Friday 2.11.84 0930.

Shanghd by Plant & Food Research

Appendix B

The Shipping Corporation New Zealand
In-transit Carriage Instructions

Containers NZSU 563034/6 and NACU 562224/6, Auckland to Kobe,
Contents - asparagus under controlled atmosphere.

Carriage Instructions

1. Temperature - The temperature set point is to be + 1.0°C.

2. Atmospheres - The oxygen indicator should read 7% ± 1%.

   There is no upper danger level for oxygen.

   The lowest indicated oxygen level should be 4%. If oxygen falls below this level, the fresh air vents on the container should be opened fully, and the container run with vents open.

   The carbondioxide indicator should read 7% ± 1%.

   There is no lower danger level for carbondioxide.

   The highest indicated carbondioxide level should be 9%. If carbondioxide rise to this level, the fresh air vents on the container should be opened fully, and the container run with vents open.

3. Enclosed is an atmosphere log sheet. We request that ship's officers log the oxygen and carbondioxide levels from the indicators once a day. We would like you to return the log sheet to SCNZ Auckland please, or I will collect it on your next visit.

4. One day prior to port discharge, we request the ship's officers open the fresh air vents on each container, and run with vents open as normal reefer.