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POSTHARVEST TREATMENT OF FRESH FRUIT FROM CALIFORNIA WITH METHYL BROMIDE FOR POSTHARVEST CONTROL OF LIGHT BROWN APPLE MOTH (LEPIDOPTERA: TORTRICIDAE)

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ABSTRACT

Methyl bromide (MB) chamber fumigations were evaluated for postharvest control of light brown apple moth, *Epiphyas postvittana* (Walker), in fresh fruit exports from California USA. To simulate external feeding, larvae were contained in gas-permeable cages and distributed throughout loads of peaches, plums, nectarines, apples, raspberries, or grapes. Differential sorption of MB by fresh fruit types and between replicate fumigation trials of the same fruit type resulted in a range of exposures that were verified by gas-chromatographic quantification of headspace concentrations. Concentration x time products (CTPs) ≥ 60 and ≥ 72 $mgL^{-1}h$ at 10.0 ± 0.5 and 15.6 ± 0.5 °C ($\bar{x} \pm s$, AVE ± STDEV), respectively, resulted in complete mortality of ~ 6,200 larvae at each temperature. These confirmatory fumigations corroborate mortality data for the first time in relation to measured MB exposures and collectively contain the largest number of *E. postvittana* larvae tested to date. Exposures observed for each fumigation trial were used to develop a kinetic model of MB sorption for use as a tool to identify how the load factor and load geometry of different types of packaged fruit can be manipulated to ensure an applied dose results in exposures consistent with a desired insecticidal efficacy.

Key words: *Epiphyas postvittana*, postharvest fumigation, sorption kinetics

INTRODUCTION

The potential to spread *E. postvittana* through commercial distribution channels involving CA-grown fresh fruit is addressed by domestic and international quarantine. Postharvest chamber fumigation with methyl bromide (MB) has a long history of insecticidal effectiveness and is often the phytosanitary treatment that is selected to control insects on commodities affected by quarantine regulation. In fact, postharvest MB use in this quarantine capacity is exempted as outlined in the Montreal protocol of 1987 and is expected to continue, at least in the USA, until technically efficacious and economically feasible alternatives are developed and readily available (Johnson et al., 2012).

The purpose of this investigation was to establish minimum MB exposure thresholds, in the form of concentration × time cross products (CTs), for control of *E. postvittana* larvae in loads of fresh fruits packaged for exported from CA at fumigation temperatures frequently used by industry, 10.0 - 20.6°C. Moreover, a predictive kinetic model was developed from the exposure data of each efficacy trial as tool to better understand the processes underlying the sorption of MB by packaged produce; the need for, and benefits of, such a tool has been articulated previously (Banks, 1989). We report quantitative estimates of the relationship between applied dose, loads factors, and load geometries and discuss how these parameters can be modulated (i.e., tuned) to ensure an exposure of adequate insecticidal efficacy is attained when fumigating palletized-loads produce.

MATERIALS AND METHODS

Experimental procedures are as described in Walse et al. (2012).

RESULTS AND DISCUSSION

The percentage of adults that emerged from non-fumigated control larvae at 15.6 ± 0.5°C was respectively 87.9 (survivors/treated, 102/116), 97.5 (119/122), 95.7 (112/117), 94.8 (1101/1161), 96.6 (204/211), and 95.7% (203/212) for peach, plum, nectarine, apple, grape and raspberry trials. Similar adult emergence was observed for each fruit type at 10.0 ± 0.5 °C, respectively, 80.8 (101/125), 71.9 (82/114), 91.6 (110/120), 86.5 (873/1009), 99.5 (209/210), 97.2% (212/218).

Confirmatory chamber fumigations were conducted in the context of establishing efficacy of MB toward *E. postvittana* larvae over the range 10-20.6°C, which accommodates temperatures pertinent to most fresh fruit industries of CA, or at least those represented in this study. Differential sorption of MB across fruit types and between replicate trials of the same fruit type were used to generate a range of CTPs, centered on 60.0 and 71.8 $mgL^{-1}h$, for treatment regimes of 10.0-15.5 and 15.6-20.6°C, respectively (Tables 1 & 2, Figure 1). Minimum exposures of 60.0 $mgL^{-1}h$ at $15.6 < T < 20.6$°C and 71.8 $mgL^{-1}h$ at $10.0 < T < 15.5$°C are required for certification of the USDA T104-a-1 MB schedule, which is used to treat fresh fruit imports infested with “surface feeding caterpillars” on “variable hosts” (USDA, 2010). These minimum exposures were calculated by the method of Monro (1969) using the headspace concentrations that actual measurements must equal of supersede at each specified time interval as required for an APHIS certified fumigation: a 40 mgL^{-1} (2.5 lb/1000 ft^3) applied dose, 32 mgL^{-1} at 30 min, and 24 mgL^{-1} at 2 h for fumigations conducted ≥ 15.6 °C and a 48 mgL^{-1} applied dose, 38 mgL^{-1} at 30 min, and 29 mgL^{-1} at 2 h for fumigations conducted ≥ 10.0 °C.

Table 1. MB dose-mortality of *E. postvittana* larvae in various fruit loads at 15.6 ± 0.5°C ($\bar{x}$ ± *s*); exposures ≥ 60.0 mgL^{-1}h, which is consistent with the minimum requirement of the USDA T104-a-1 import schedule, resulted in complete mortality of 6,755 test specimens

Fruit 60 °F	Applied mgL^{-1}	Initial [MB]	1/2 hr [MB]	2 hr [MB]	% Sorp.	CxT (± 1.8)	n Obs	n Live	% Surv.
Peach	**35**	27.8	23.1	18.3	34.2	**43.8**	160	0	0.0
Plum	**27**	27.3	25.4	23.7	13.2	**50.0**	169	0	0.0
Plum	**27**	27.5	27.0	24.7	10.2	**52.4**	184	0	0.0
Plum	**27**	28.3	27.0	24.9	12.0	**52.8**	179	0	0.0
Peach	**40**	32.7	28.3	23.1	29.4	**53.8**	45	0	0.0
Nectarine	**35**	35.0	29.3	23.8	32.0	**55.9**	173	0	0.0
Nectarine	**35**	36.1	30.3	24.6	31.9	**57.9**	180	0	0.0
Apple	**33**	33.0	28.6	28.4	13.9	**58.2**	773	0	0.0
Apple	**33**	34.8	28.9	28.2	18.9	**58.7**	741	0	0.0
Nectarine	**35**	36.5	30.7	25.4	30.4	**59.0**	182	0	0.0
Apple	**34**	35.1	29.0	28.5	18.8	**59.1**	789	0	0.0
Grape	**30**	36.8	31.4	25.7	33.6	**59.5**	658	1	0.00152
Apple	**34**	35.8	29.2	29.0	19.1	**59.9**	784	0	0.0
						< 60.0	**∑ 5017**		
Minimum[1]	**40**	40.0	32.0	24.0	40.0	**60.0**	—	—	—
Apple	**35**	34.3	30.3	28.2	17.7	**60.0**	745	0	0.0
Peach	**40**	35.0	32.1	25.5	27.1	**60.2**	186	0	0.0
Plum	**30**	33.5	30.8	28.3	15.5	**60.4**	45	0	0.0
Peach	**39**	39.3	32.1	26.3	33.1	**61.9**	177	0	0.0
Plum	**31**	34.4	31.6	28.9	16.0	**61.9**	45	0	0.0
Raspberry	**42**	42.5	31.4	26.7	41.6	**62.1**	627	0	0.0
Peach	**43**	39.9	33.9	24.3	39.1	**62.1**	47	0	0.0
Raspberry	**42**	42.1	31.6	27.1	39.6	**62.5**	951	0	0.0
Grape	**31**	39.5	32.8	27.0	35.5	**62.9**	778	0	0.0
Apple	**35**	38.1	31.4	29.8	21.9	**63.2**	790	0	0.0
Grape	**31**	38.7	33.3	27.1	33.6	**63.3**	901	0	0.0
Raspberry	**43**	44.2	32.8	27.2	43.8	**64.2**	650	0	0.0
Nectarine	**40**	41.6	37.5	30.2	27.4	**70.6**	46	0	0.0
Peach	**42**	44.0	37.2	30.8	30.0	**71.3**	45	0	0.0
Nectarine	**40**	47.3	39.9	26.6	43.8	**71.7**	45	0	0.0
Nectarine	**40**	44.5	38.3	31.4	29.4	**73.0**	47	0	0.0
Plum	**40**	45.8	42.8	38.8	15.3	**83.4**	50	0	0.0
						≥ 60.0	**∑ 6175**		
						Total	**∑ 11192**		

[1] Minimum gas concentrations per USDA treatment schedule T104-a-1 (APHIS PPQ Manual)

Table 2. Observable rates (k_{OBS}) of MB loss, as well as, rates of MB sorption by packaged loads that were corrected for load factors and surface area to volume ratio of the loads (k_{SPT}); means not connected by the same letter are significantly different (Tukey-Kramer HSD, *P* = 0.05).

Methyl bromide fumigation kinetics

	Temp. (°C)	k_{OBS} (h^{-1}) ave	± stdev	means comparison	k_{SPT} (Lm^{-2}h^{-1}) ave	± stdev
raspberries	10.0	0.2275	0.0118	A	0.0334	0.0018
	15.6	0.2130	0.0118	A B	0.0318	0.0017
peaches	10.0	0.1984	0.0272	A B C	0.0324	0.0045
	15.6	0.1783	0.0163	B C	0.0290	0.0020
nectarines	10.0	0.1990	0.0182	A B C	0.0327	0.0031
	15.6	0.1741	0.0101	C	0.0286	0.0016
grapes	10.0	0.1198	0.0141	D	0.0132	0.0016
	15.6	0.1772	0.0043	B C	0.0196	0.0004
apples	10.0	0.0777	0.0159	E	0.0154	0.0032
	15.6	0.0832	0.0143	D E	0.0165	0.0028
plums	10.0	0.0769	0.0150	E	0.0163	0.0031
	15.6	0.0698	0.0109	E	0.0154	0.0018

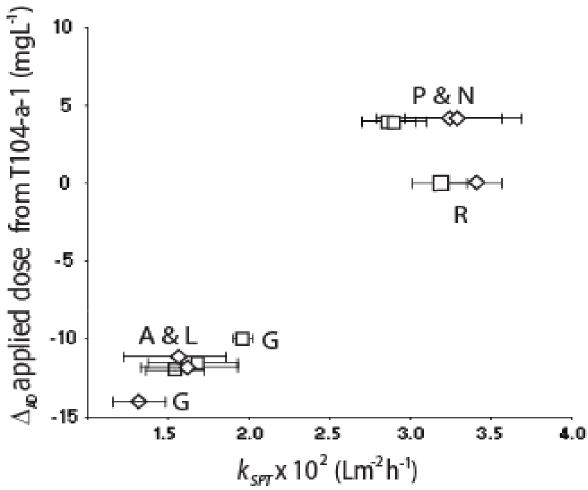

Fig. 1- Adjustments in the amount of applied MB, Δ_{AD}, from USDA T104-a-1 (40 mgL^{-1} at 15.6 < T < 20.6°C and 48 mgL^{-1} at 10.0 < T < 15.5°C) that is required at load factors of 0.5 to achieve exposures ± 5 mgL^{-1} h from those targeted for *E. postvittana* control, respectively 71.8 and 60.0 mgL^{-1}h at 10.0 < T < 15.5 and 15.6 < T < 20.6°C. Fruit and packaging recommended by industry were consistent with export scenarios from California: P, peach; N, nectarine; R, raspberry; A, Apple; L, plum; G, grape.

REFERENCES

Banks, H.J. (1989) Needs for R & D in fumigation and controlled atmospheres for grain storage. In: Champ, B.R., Highley, E. and Banks, H.J. (eds) *Fumigation and Controlled Atmosphere Storage of Grain*. Australia Centre for International Agricultural Research, National University of Singapore, Singapore.

Johnston, J.A.; Walse, S.S; Gerik, J.S. (2012) Status of Alternatives for Methyl Bromide in the United States. *Outlooks on Pest Management.* 23(2), 53-56.

Monro, H. A. U. (1969) Manual of Fumigation for Insect Control. FAO Agricultural Studies 79, 381 pp.

(USDA) U.S. Department of Agriculture. (2010) USDA-APHIS-PPQ Treatment manual. http://www.aphis.usda.gov/import_export/plants/manuals/ports/downloads/treatment.pdf. Date accessed, Dec. 20, 2010.

Walse, S.S; Liu, Y.B.; Myers, S.W.; Bellamy, D.E., Obenland, D; Simmons, G.S.; Tebbets, J.S. (2012) The treatment of fresh fruit from California with methyl bromide for postharvest control of light brown apple moth, *Epiphyas postvittana* (Walker) *J. Econ. Entomol.* In press