SULFURYL FLUORIDE: A DISINFESTATION TREATMENT FOR WALNUTS AND ALMONDS

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Introduction

In California, the codling moth, *Cydia pomonella* (Linnaeus), is the major insect pest of walnuts while the navel orangeworm, *Amyelois transitella* (Walker), is the major insect pest of almonds. The navel orangeworm is also a major pest of walnuts, particularly if populations are allowed to increase in orchards where nuts have already been damaged by the codling moth. Although these field pests are carried into the storage environment with harvested commodities, they do not thrive in storage and subsequently perish. However, their presence in the post harvest environment, albeit short lived, presents a problem for some export markets because both insects are considered quarantine pests by some countries. In addition, the European Union requires imported walnuts to be fumigated with methyl bromide to eliminate the codling moth and navel orangeworm to meet phytosanitary requirements.

Sulfuryl fluoride (=Vikane®) has been identified as a potential replacement for several methyl bromide uses. It has been registered and labeled in many parts of the world as a structural fumigant for 40 years but as yet has no food tolerance. It's insect efficacy is comparable with that of methyl bromide against the active life stages of many insects. The egg stage however is relatively tolerant to sulfuryl fluoride. The objective of this study was to evaluate the toxicity of sulfuryl fluoride to codling moth and navel orangeworm to determine if it could be used to replace methyl bromide as a treatment for nuts infested with these two pests.

Materials and Methods

The egg and larval stages of the codling moth and the navel orangeworm were used. For codling moth, last instars (2 wk in diapause) were tested as well as aged (1, 2, or 3 days old) eggs. For navel orangeworm, last instars and similarly aged eggs were used. The insects were taken from laboratory cultures reared at 27EC, 60% RH, and a 12:12 (L:D) photoperiod. Diapausing codling moth larvae were reared under diapause-inducing conditions at 18 ± 0.5EC, 60% RH, and an 8:16 (L:D) photoperiod. Fumigations were performed in 28.3-Liter Labconco® vacuum desiccators. Tests were conducted at normal atmospheric pressure (NAP) and at 100 mm Hg pressure (VAC) (Tebbets et al. 1986). Fumigant concentrations were determined by gas chromatography as described by Zettler et al. (in press). Exposure times were 2 and 4 hours at 20 and 25EC. All mortality data were analyzed by probit analysis (SPSS, Inc. 1997). Based on the LC_{99}, the CxT was calculated for each life stage tested.

Results

Results of toxicity tests with sulfuryl fluoride against codling moth and navel orangeworm are shown in Table 1. Sulfuryl fluoride was toxic to diapausing codling moth larvae at relatively low dosages. VAC fumigation reduced the CxT by about half to 68 mgh/Liter. Tebbets et al. (1986) also found that, when compared with NAP fumigation, VAC fumigation reduced LC values of this insect by half when fumigated with MB. On the other hand, eggs were relatively tolerant to SF fumigation. The tolerance differed with age (3-day> 2-day > 1 day). Whereas VAC fumigation decreased CxT values for larvae, it had no significant effect in reducing tolerance of eggs of any age. In fact, VAC fumigation was antagonistic to 1 and 2 day-old eggs resulting in CxT values higher than those for NAP fumigation.

Similar toxicity results are shown for navel orangeworm. Sulfuryl fluoride was more toxic (about 2X) to 5^{th} instars of navel orangeworm than to diapausing larvae of codling moth. VAC fumigation reduced the NAP CxT by about 82% to 26 mgh/Liter. Navel orangeworm eggs were more tolerant to sulfuryl fluoride than were codling moth eggs. Like codling moth eggs, they showed varying tolerance to the fumigant and the tolerance was age dependent. VAC had no effect in reducing the CxT values except for 3 day old eggs, the most tolerant age for eggs of both species.

Table 1. Toxicity of sulfuryl fluoride against eggs and larvae of codling moth and navel orangeworm under normal (NAP) and vacuum (VAC) fumigation.

Stage	Pressure	CxT[1] for	
		CM[2]	NOW[3]
Larvae[4]	NAP	127	141
	VAC	68	26
Egg- 1 day	NAP	516	469
	VAC	867	877
Egg- 2 day	NAP	959	717
	VAC	1221	813
Egg- 3 day	NAP	1179	1356
	VAC	951	1005

[1] Concentration times exposure time at LC_{99} (= mg hours/Liter)
[2] CM = codling moth
[3] NOW = navel orangeworm
[4] CM = diapausing fifth instars; NOW = non diapausing fifth instars

Discussion

When walnuts and almonds are harvested, first to fifth instars of codling moth and navel orangeworm are present from overlapping broods in the orchards (Quayle 1926, Curtis et al. 1984). These larvae can freely infest the nuts while on the tree. Only rarely, however, does the codling moth remain in walnuts. When it does, the fifth instars may enter diapause although this is a very rare occurrence because most larvae destined for diapause leave the nut (Hartsell et al. 1991). The fumigation treatment approved by Japan for these insects in walnuts is aimed at the diapausing larvae of codling moth because this is the most tolerant life stage that could infest the nut at harvest. The eggs don't occur naturally on walnuts or almonds at the time of harvest. Thus, based on insect toxicity and the fact that eggs are not present on exported nuts, sulfuryl fluoride appears to be a viable replacement for methyl bromide under these conditions.

References cited:

Curtis, C.E., R.K. Curtis and K.L. Andrews. 1984. Progression of navel orangeworm (Lepidoptera: Pyralidae) infestation and damage of almonds on the ground and on the tree during harvest. Environ. Entomol. 13: 146-149.

Hartsell, P.L., P.V. Vail, J.S. Tebbets, and H.O. Nelson. 1991. Methyl bromide quarantine treatment for codling moth (Lepidoptera; Tortricidae) in unshelled walnuts. J. Econ. Entomol. 84; 1289-1293.

Quayle, H.J. 1926. The codling moth in walnuts. California Agric. Exp. Sta. Bull. 402

SPSS, Inc. 1997. SPSS Professional Statistics 7.5, Chicago, IL

Tebbets, J.S., P.V. Vail, P.L. Hartsell and H.O. Nelson. 1986. Dose/response of codling moth (Lepidoptera: Tortricidae) eggs and non diapausing and diapausing larvae to fumigation with methyl bromide. J. Econ. Entomol. 79: 1039-1043.

Zettler, J.L., J.G. Leesch, R.F. Gill and J.C. Tebbets. (In press). Chemical alternatives for methyl bromide and phosphine treatments for dried fruits and nuts. Proc. 7th International Working Conf. Stored Prod. Prot. October 15-18, 1998, Beijing, China