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Project 89-S9-Update on Low Temperature Fumigation

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Interpretive Summary:

Phosphine/methyl bromide fumigation study: Fumigation studies with phosphine and methyl bromide (MB) for control of navel orangeworm (NOW) Amyelois transitella (Walker) and Indianmeal moth (IMM) Plodia interpunctella (Hubner) at low temperatures are nearly complete and when this work is finished, the total project will be completed. In the fumigation tests for both phosphine and MB, the test insects were placed amongst the inshell almond load within the chambers as previously described.

(1) Methyl bromide: Using the new schedule dosage of 24 g/m^3 (1.5 lbs./1000 ft^3) for inshell almonds, triplicate tests were conducted at 4.4^{0}C (40^{0}F) on both NOW and IMM eggs. IMM eggs were also included because at these temperatures (winter months) IMM is the major pest. Results of these tests showed that a 16 hour exposure time provided 100% mortality to both species.

(2) Phosphine: Applying the standard dosage of 30 g/1000 ft^3, triplicate fumigation tests were conducted at 10^{0}C (50^{0}F) with NOW

pupae and IMM eggs and pupae in loads of inshell almonds. NOW eggs were not used because we found that long exposures to this temperature alone (no fumigant) caused considerable mortality. Results of these tests show that after a 7 day exposure 100% mortality of NOW and IMM pupae was obtained with only 81.6% IMM eggs killed.

Procedures and results for objective 1:

In preliminary studies at 10.0^{0}C very high mortality was obtained in the NOW egg controls when exposure was 5 days or longer. A test was conducted to determine the extent of the mortality to both NOW and IMM eggs when exposed to 10.0^{0}C for 3, 5, 7 and 9 days. The results of this test are shown in Table 1. After 5 days, mortality to NOW eggs was 77.7% and after 9 days there was almost complete mortality. This temperature also caused high mortality to IMM eggs after 9 days of exposure (70.7%). Table 2 shows the results of the fumigation tests when NOW and IMM pupae and IMM eggs were exposed to 30 g/1000 ft^3 phosphine at 10.0^{0}C for 7 days. These tests were terminated earlier than expected because after 7 days the remaining phosphine concentration was only about 10.0 ppm, which may be attributed to the high humidity in the chambers at that time (45%). As shown, only 81.6% mortality was obtained for IMM eggs and when the mortality rates from Table 1 (effects of cold temperature) for IMM eggs are subtracted only about 10.0% can apparently be attributed to the action of phosphine. Table 3 shows the phosphine concentrations obtained during the exposure period. As shown, the average concentration after 1 day of exposure was high (812.2 ppm) which, as mentioned above, is probably the result of high humidity in the chamber loads. This contributed to more rapid generation of phosphine, thereby decreasing the

length of time that sufficient concentrations of phosphine would be present. Table 4 shows the completed schedule of guidelines for fumigating almonds with phosphine. As shown, the recommended exposure time for fumigation at 10.0 ^{0}C is 11 to 12 days. This longer exposure (only 7 days in our tests) is recommended so as to increase mortality for IMM eggs. Actually, exposure should be continued as long as phosphine concentrations are 10.0 ppm or above, but some insect survival can be expected at this temperature. It must emphasized that these are guidelines only, as each commercial phosphine fumigation can be somewhat of a unique experience owing to the diverse set of conditions that may prevail at any given time under field conditions. This is especially true when plastic is used for the enclosure. However, if temperature and concentrations are monitored during exposure these guidelines should prove useful for successful deinfestation of almonds.

Procedures and results for objective 2:

Table 5 shows the results for fumigation tests at 4.4^{0}C using the new schedule MB dosage of 24 g/m^{3} (for inshell) to control NOW or IMM. As shown, 100% mortality was obtained after a 16 hour exposure period. Table 6 shows the mean MB concentrations, sorption by the nuts, and CT products obtained from the 16 hour exposure. Figure 1 gives the mean organic bromide residues found in the nutmeats at various time periods following fumigation and storage at 4.4^{0}C. As shown, it took nearly 55 days at this temperature for residues to reach 0.001 ppm (minimum detectablity). Tolerances for residual MB have not been established, but MB is in the process of being re-registered for all commodities as required by the Environmental Protection Agency and future tolerances will

be set based on the results of the re-registration studies. Table 7 shows the complete MB fumigation schedule. In order for these schedules to be efficacious, chambers should be certified on an annual basis by the California Department of Agriculture or the U.S. Department of Agriculture. Before entering the chamber after fumigation, the load must be aerated until the methyl bromide concentration within the chamber reaches 5 ppm or less.

Table 1

Mortality of NOW & IMM Eggs in Inshell Almond Load Exposed to 10 °C for Up to 9 Days

Exposure Time (days)	% Egg Mortality	
	NOW	IMM
3	27.2	14.4
5	77.7	18.9
7	96.0	46.1
9	99.1	70.7
Control	5.7	5.8

Temperature exposure only; no fumigant.
0 to 24 h old eggs; data from 1 replication only.

Table 2

Mortality of NOW & IMM Pupae or Eggs Fumigated in Inshell Almond Load with PH_3 for 7 Days @ 10°C

Insect	% Mortality
NOW Pupae	100.0 ± 0.0
IMM Pupae	100.0 ± 0.0
IMM Eggs	81.6 ± 5.7
Untreated:	
NOW Pupae	4.0
IMM Pupae	0.0
IMM Eggs	32.1 *

* Mortality also reflects effect of temperature alone.
30 g/1000 ft^3 PH_3 dosage; data represents 3 reps.

Table 3

Phosphine Concentration during Fumigation of NOW & IMM Pupae or Eggs in Inshell Almond Load @ 10 °C

Phosphine Concentration (ppm)						
2 hr	1 day	2 days	3 days	5 days	6 days	7 days
93.0	812.2	531.3	434.8	165.1	26.9	10.1

Data represent mean of 3 replications.
Dosage: 30 g/1000 ft^3 for 7 days

Table 4. Guidelines for fumigating almonds with phosphine for control of navle orangeworm and Indianmeal moth.

Fumigation temperature ^{o}C	Minimum exposure time	Recommended ending concentration
10-15	11-12 days	10 ppm
16-20	8-9 days	50 ppm
21-26	4 days	50 ppm
27-32	3 days	50 ppm
32+	2 days	50 ppm

Dosage: Use the dosage from the aluminum phosphide label: 30 g/1000 ft^3 which is 30 tablets or 150 pellets/1000 ft^3.

Fumigation structure: Make sure the structure is sufficiently sealed to hold phosphine gas.

Safety: Carefully follow all instructions covering safety listed on the aluminum phosphide label.

Table 5

Mortality of NOW & IMM Eggs Fumigated in Inshell Almonds with Methyl Bromide for 16 h @ 4.4° C

	% Egg Mortality	
	NOW	IMM
Treated	100.0	100.0
Untreated	19.4	12.3

Dosage: 24 g/m^3 MB, 16 h fum., 16 h aer.
Data represent mean of 3 replications.

Table 6

Methyl Bromide Concentration during Fumigation of NOW & IMM Eggs in Inshell Almonds @ 4.4° C

Methyl Bromide Concentration (g/m^3)						
0 h	0.5 h	1 h	2 h	4 h	6 h	16 h
22.2	17.5	14.7	12.0	9.5	8.9	6.6

% Sorption = 70.2, CT Product = 148.7 g h/m^3

0 to 24 h old NOW & IMM eggs treated with 24 g/m^3 for 16 h.

Data represent mean of 3 replications.

Table 7. Revised methyl bromide fumigation schedules for control of navel orangeworm and Indianmeal moth in almonds.

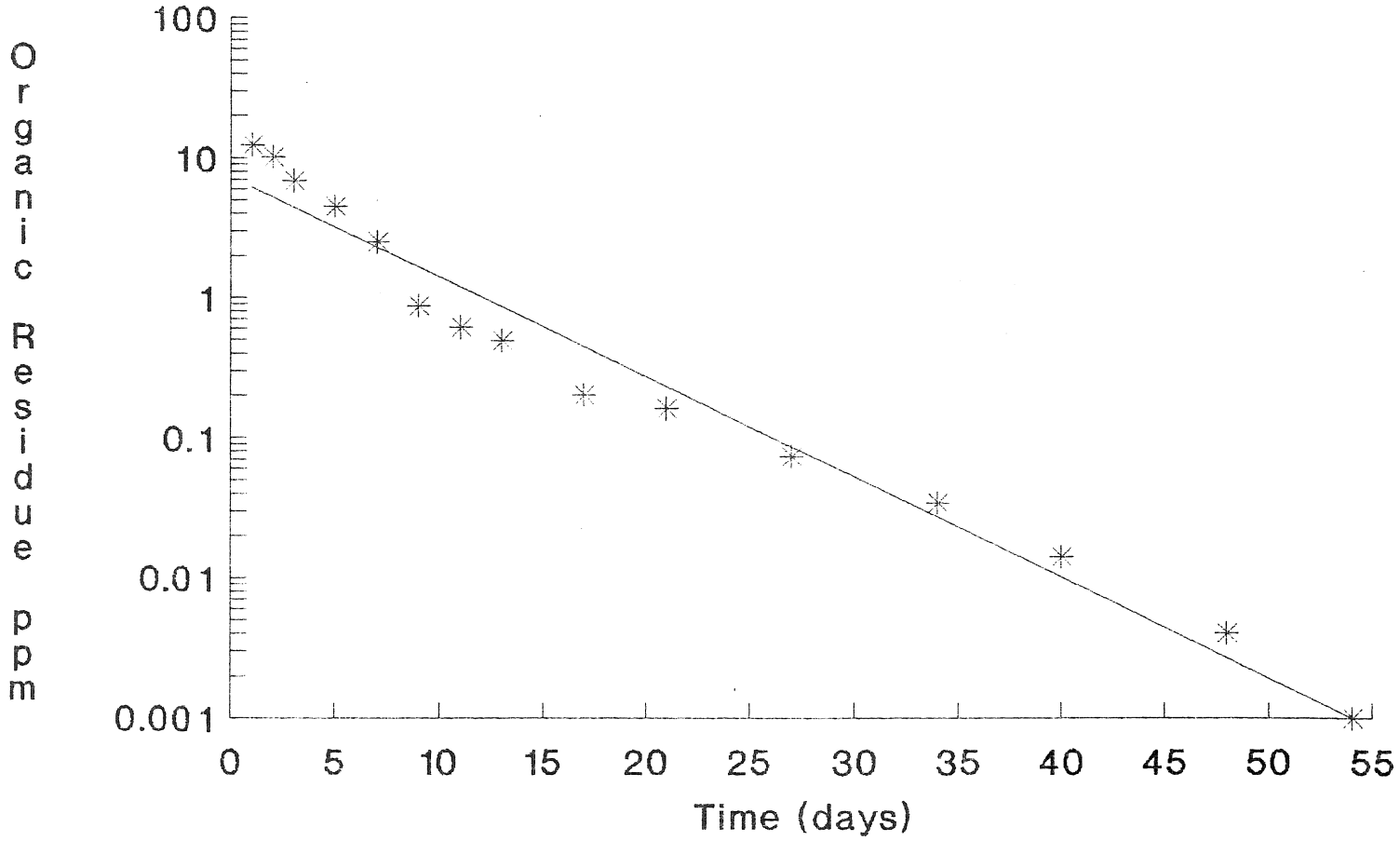
Fumigation temperature ^{o}C	Exposure time (hours)	Dosage: oz/1000 ft^3 (g/m^3) Meats	Inshell
4-9	16	16	24
10-15	12	16	24
16-20	8	16	24
21-26	6	16	24
27+	4	16	24

Aeration: Before entering the chamber, the load must be aerated until the methyl bromide concentration within the chamber reaches 5 ppm or less.

Safety: Carefully follow all instruction covering safety listed on the methyl bromide label.

Figure 1

Methyl Bromide Desorption from Inshell Almond Meats Fumigated & Stored in Wooden Bins at 4.4° C



Dosage: 24 g/m^3, 16 h @ 4.4° C