CHEMICAL AND NON-CHEMICAL DISINFESTATION OF APPLE MAGGOT FLIES FROM APPLES

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The apple maggot, *Rhagoletis pomonella* (Diptera: Tephritidae), infests ripening apples and other fruits in North America, and it is a quarantine pest of significance to Japan and other trading partners. Methyl bromide is critical to the current pre-shipment quarantine treatments for export of apples to Japan and other locations. Here we investigated two methyl bromide alternatives, fumigation with phosphine gas and treatment under vacuum, to kill eggs and larvae of apple maggots infesting apples.

Phosphine. A common assumption about phosphine is that it is damaging to fresh commodities. However, many careful studies with phosphine and fresh fruits report no significant damage at gas levels and exposure times that were adequate for quarantine treatment, and damage was only seen at high doses (e.g., von Windeguth et al. 1976; Spalding et al. 1978). Cylinderized phosphine was developed in Australia during the 1980s for fumigating grain storage structures, and it allows for more precise dose regulation than traditional metallic phosphide salts. ECO_2FUME^{TM} Fumigant Gas (Cytec Industries, West Patterson, NJ) recently gained registration by the U.S. Environmental Protection Agency (EPA 2000). This product is phosphine dissolved in liquid carbon dioxide at approximately 2% PH_3 and 98% CO_2 on a w/w basis. Potential for safe treatment of fruits with ECO_2FUME was recently demonstrated (Williams et al. 2000).

We conducted studies on the effects of ECO_2FUME on eggs of the apple maggot . In each experiment groups of 30-40 apples were exposed to approximately 600 mixed sex adult flies in a cage for 8 hrs, during which time the flies stung and oviposited in the fruit. Infested apples were divided into 6 or 7 equal groups that were placed into glass fumigation chambers. One group was designated a control and the remaining six groups were exposed to 200 PPM phosphine from ECO_2FUME and held at a given temperature for various times. Survival to late larvae was assessed in treated apples relative to controls. At 22C we achieved 100% mortality of treated apple maggot eggs between 48 and 72 hours of exposure. In another series of studies we investigated a 1-day treatment in which we varied phosphine concentration at two temperatures. 100% kill was achieved at the highest concentration of 400 ppm at 34C, while the same dose gave between 85-99% kill at 25C. We suspect that a one-day phosphine treatment to disinfest apples of fruit flies would require such a high concentration that fruit damage would occur. Effects of high phosphine concentrations were apparent in a preliminary quality test with red delicious apples. Internal and external appearance of apples treated at 200 ppm were indistinguishable from untreated controls, but apples treated with 1200 ppm developed dark skins and internal damage. We are confident that an effective treatment for disinfestations of apples can be achieved at low phosphine levels with no significant effect on market quality using ECO_2FUME gas.

Vacuum. A low pressure atmosphere, in which a partial vacuum is maintained, can be insecticidal if the oxygen level is sufficiently low for a critical period of time. Low pressure has been used successfully on stored-product insects infesting durable commodities (e.g., Mbata and Phillips 2001), but studies of low pressure applied to fresh commodities have been limited to hypobaric storage of fruits for quality preservation (see Berg in Calderon and Barkai-Golan 1990). Here we report a successful attempt to disinfest apple maggots from apples using vacuum.

Apples were infested by adult apple maggot flies as described above for phosphine studies. Equal groups of infested apples were kept in gas-tight glass jars that were evacuated to 25 mm using a vacuum pump, and then held at 25°C for time intervals of 2, 4, 6, 8, 12, 16, 24, 36, and 48 hours. At the end of time intervals the glass jars were vented and apples were kept on the bed of sand in ventilated containers at 25°C and 70% humidity. Larval counts were taken after 4 weeks by dissecting the apples, and pupae deposited on the sand were also counted. The total larval and pupal count was compared with controls to determine the mortality percent. Controls consisted of similar glass jars exposed to ambient pressure and held at 25°C. Untreated control apples had an average of 33.3 insects emerge per apple, while those treated under vacuum for 24 hrs resulted in only 4.3 emerged insects (approximately 13%) surviving, and only a single insect survived at 48 hrs of treatment. Mortality data were described by an exponential dose-response curve (Fig. 1). Thus, low pressure may be a viable alternative to methyl bromide for postharvest treatment of fresh fruits.

Conclusions and Considerations

- Phosphine gas from cylinders can be used to disinfest apples of the apple maggot fly, and can probably be adapted to other post-harvest fresh fruit and insect systems.

- Initial work suggests that phosphine has minimal negative effects on apples, but tolerance limits for phosphine treatments to apples will need to be determined.

- Existing infrastructure for methyl bromide treatment of apples should e easily convertible to treatment with phosphine; treatment schedules and protocols will need to be determined.

- Low pressure can kill apple maggots infesting apples; preliminary studies suggest that negative quality effects from vacuum can be reduced at cool temperatures and short exposure times.

- Future research will address critical temperatures, pressures and hold times for killing flies that will also avoid fruit damage.

- Practical application of low pressure to cases or field bins of apples will require use of an effective rigid vacuum chamber or a flexible chamber such as the Grainpro "Cocoon".

Literature Cited

Calderon, M. and R. Barkai-Golan (eds.). 1990. Food preservation by modified atmospheres. CRC Press, Boca Raton, Fla.

Environmental Protection Agency. 2000. Pesticide product registrations; conditional approval. Federal Register. 65: 15,634-15,635.

Mbata, G. N. and T. W. Phillips. 2001. Effects of temperature and exposure time on mortality of stored-product insects exposed to low pressure. J. Econ. Entomol. 94: 1302-1307.

Spalding, D. H., J. R. King, C. A. Benschoter, D. L. von Windeguth, W. F. Reeder and A.K. Burditt, Jr.. 1978. Ethylene dibromide, methyl bromide and phosphine fumigation of tomatoes. Proc. Fla. State Hort. Soc. 91: 156-158.

von Windeguth, D. L., A.K. Burditt, Jr., and D. H. Spaulding. 1977. Phosphine as a fumigant for grapefruit infested by Caribbean fruit fly larvae. Proc. Fla. State Hort. Soc. 90: 144-147.

Williams, P., G. Hepworth, F. Goubran, M. Muhunthan and K. Dunn. 2000. Phosphine as a replacement for methyl bromide for postharvest disinfestation of citrus. Postharvest Biol. and Techn. 19: 193-199.

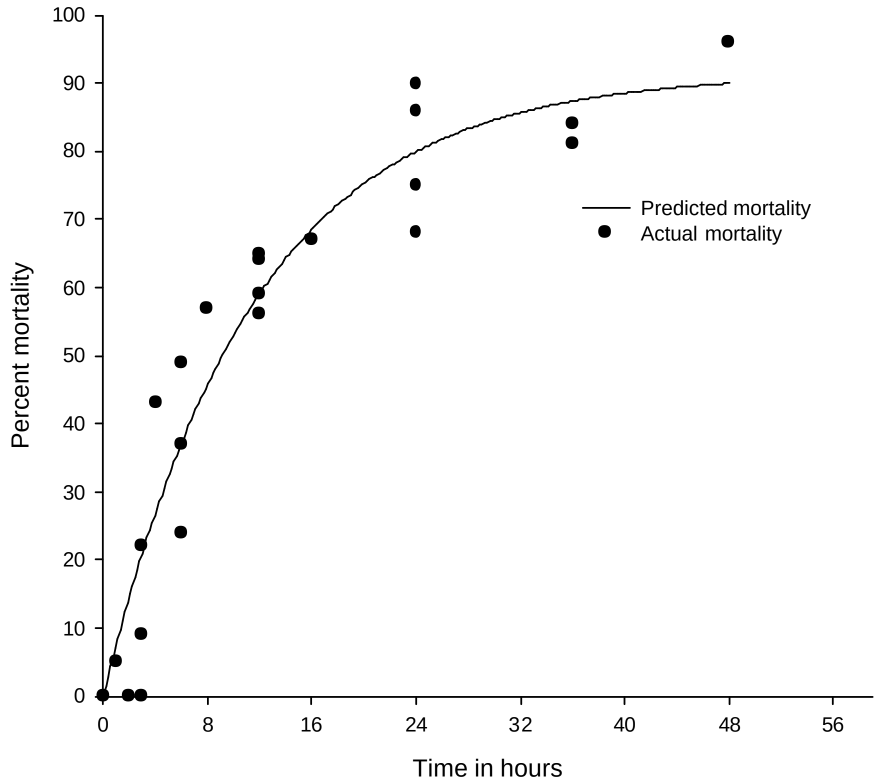

Fig. 1. Mortality of eggs of the apple maggot fly in fresh apples treated with a vacuum of 25-40 mm Hg at 25° C.