Evaluation of synergistic effect between ethyl formate and phosphine for control of three species Aphids in perishable commodity

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Abstract

Methyl bromide (MB) as a fumigant for Quarantine and Pre-shipment (QPS) could offer eradication of target pests within shorter fumigation period and without phytotoxicity. Therefore, unlike MB alternatives for soil fumigation, there is no ideally MB alternative fumigant for QPS purpose, particularly for perishable commodities. It is critically important that within shorter fumigation time requires killing all target insect pests and without effect of quality and deliver treated fruit and vegetables to the final consumer. Aphids are pests frequently found in imported and exported fruit and vegetables. Aphids was known as quarantine pest hard to control when conduct short period fumigation with phosphine (PH_3) and low dose of ethyl formate (EF). Ethyl formate can lead to highly sorption and phytotoxic damage of some perishable commodities such as strawberries and cut flowers, especially at lower temperature (< 8°C). Here, we reported that synergistic effect between ethyl formate and phosphine at lower dosages and temperature. The mixture of ethyl formate and phosphine had synergistic effect to control adult and nymph stages of tested cotton aphid (*Aphis gossypii*), green peach aphid (*Myzus persicae*) and turnip aphid (*Lipaphis erysimi*). When 0.5 mg/L of PH_3 combined with different levels of EF at 5 and 20°C for 2 hours fumigation, there was significantly difference in terms of $LCT_{50\%}$ and $LCT_{90\%}$ values in comparison with EF or PH_3 alone. This new technology could be meet QPS requirement that is shorter exposure time and less damage of perishable commodities.

Keywords: fumigation, ethyl formate, phosphine, enhancive effect, cotton aphid, green peach aphid, turnip aphid

1. Introduction

Methyl bromide (MB) usage in Korea as a fumigant for Quarantine and Pre-shipment (QPS) is decreasing. Although MB could offer eradication of target pests within short fumigation periods, there are environmental and safety issues with MB. The Korean government is considering alternative fumigants to replace MB. Ethyl formate (EF) and phosphine (PH_3) are potential fumigants to replace MB in QPS usage. Ethyl formate and PH_3 shows low to no phytotoxicity on commoditiess.

Fumigation on perishable commodities requires shorter fumigation times to kill all target insect pests without effect on quality and to deliver treated fruit and vegetables to the final consumer. Aphids are pests frequently found in imported and exported fruit and vegetables. Aphids was known quarantine pest hard to control when conduct short period fumigation with PH_3 and low doses of EF. Ethyl formate can lead to highly sorption and phytotoxic damage of some perishable commodities such as strawberries and cut flowers, especially at lower temperature (< 8°C). Phosphine requires long fumigation times (more than 24 hours) to control aphids. To increase the efficacy Haritos et al. (2006) suggested a mixture of EF with carbon dioxide could improve the efficacy while Mueller (1994) suggested the application of phosphine in combination with carbon dioxide and heat to increase efficacy and shorten the fumigation time. Here we reported on synergistic effects of EF and PH_3 at lower dosages and temperatures.

2. Materials and Methods

2.1. Preparation of samples

In this synergistic effect test, strawberries were used because it one of the important agricultural products in Korea, but it is hard to control post harvest pests because they are easily damaged by fumigants. The variety of strawberry used for this trial was 'Seol-hyang', which is also exported.

2.2. Preparation of pests

Three aphids species - cotton aphid (*Aphis gossypii* Glover), green peach aphid (*Myzus persicae* Sulzer), and turnip aphid (*Lipaphis erysimi* Kaltenbach) – were used for synergistic effect tests. Pests were reared at the Dongbu Agriculture Research Institute (DARI), South Korea, on cucumber, bean and cabbage leaves at 25°C with 16:8[L:D]h photo period.

2.3. Fumigants

Vapormate™ (Ethyl formate 16.6% GA) was supplied from BOC Australia. ECO_2Fume™ (Phosphine 2% GA) was supplied from Cytec Industries Inc.

2.4. Preliminary fumigation tests

Preliminary fumigation tests were performed at DARI, South Korea. Desiccators (12L) were purchased from Duran™, and mini fans made with magnetic bars were located at the bottom of the desiccators to circulate air. After sealing the desiccators, calculated amounts of EF and PH_3 were injected into the desiccators to give nominal concentrations (gm^{-3}). The temperature in the fumigation room was controlled with an air conditioner. After fumigation, desiccators were ventilated for more than 1 hour.

2.5. Scale-up fumigation tests

Scale-up fumigation tests were performed at DARI, South Korea. The fumigation was performed in a small scale metal chamber (0.125 m^3) fill in with strawberries and stored 5°C. After fumigation, efficacy on aphids and phytotoxicity on strawberry was investigated.

2.6. Measurement of fumigant

EF and PH_3 gas were drawn with an electric pump at timed intervals and stored in Tedlar's gas sampling bags (1 liter) (SKC Inc.) until analysis, usually within 1 hour of sampling. The concentration of EF was determined using an Agilent Technology 7890N gas chromatograph (GC) equipped with a flame ionization detector (FID) after isothermal separation on a 30 m × 0.32 mm I.D. HP-5 (0.25 μm film)-fused silica capillary column (Restek Co. Ltd.). The GC oven, injector and detector temperature was 150, 200 and 200°C, respectively. Helium was used as the carrier gas at a rate of 2 mL/min. The concentration of PH_3 was determined using the same chromatogtaph. The GC oven, injector and detector temperature was 160, 160 and 320°C, respectively. Nitrogen was used as the carrier gas at a rate of 1 mL/min. The peak areas were calibrated periodically using a standard (injecting the known volume of ethanedinitrile in 1 L Tedlar's gas sampling bags).

2.7. Bioassays of Aphids

The mortality of aphids was determined after fumigation. After each treatment, nymph stage and adult stage of aphids were counted, and stored in incubator for 72 hours at 25±2°C. Unfumigated aphids were used as control for calculation of mortality.

3. Results and Discussion

3.1. Efficacy of PH_3 on Aphids

The cumulative Ct products of PH_3 were estimated at a 24 hr exposure time. More than 40 g h m^{-3} of PH_3 was required to control cotton aphid (Fig 1).

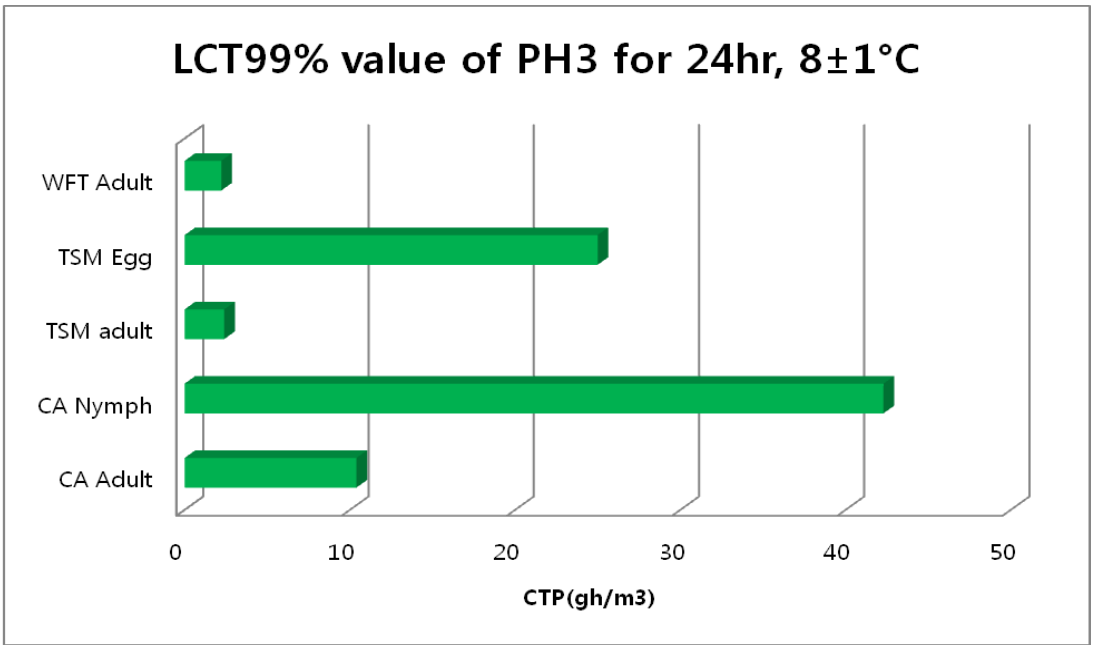

Figure 1 LCT99% of PH_3 on several insect pests of vegetables (Temperature: 8°C).

3.2. Efficacy of EF on Aphids

Less than 5 g h m^{-3} of EF was required to control cotton aphid, but phytotoxic effects occured.

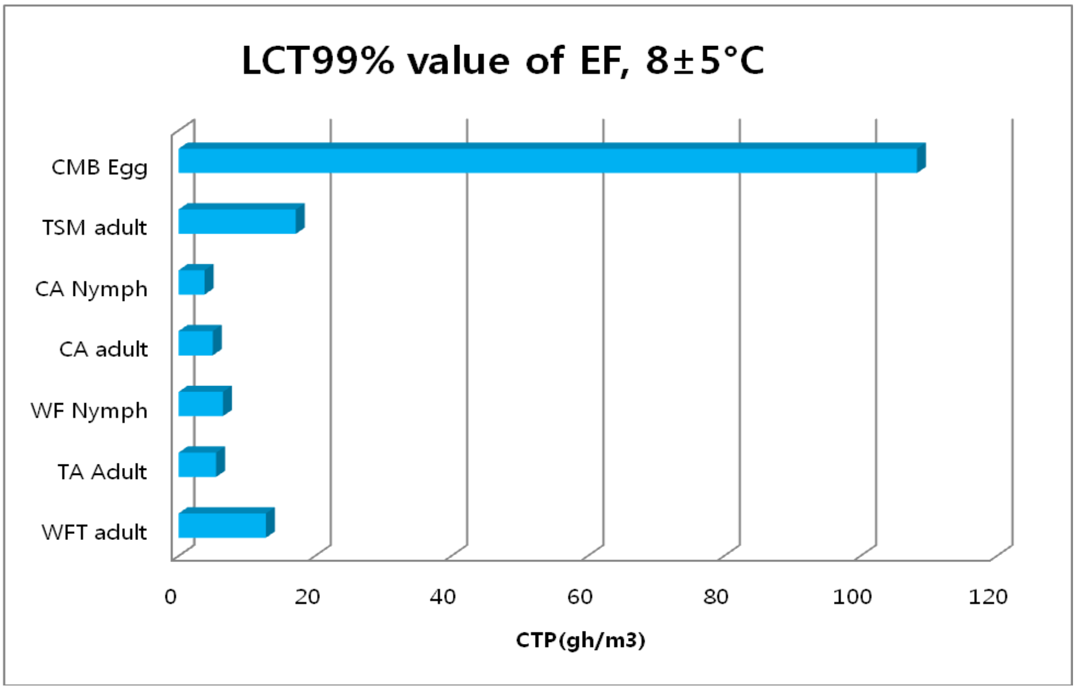

Figure 2 LCT99% of EF on several insect pests of vegetables (Temperature: 8°C).

3.3. Enhancive study with EF and PH_3

When fumigated with both EF and PH_3 gas, the efficacy on aphids were increased. On adult stage of cotton aphids, the $LCT_{99\%}$ value was decreased from 4.44 to 1.89 g h m^{-3} at 5°C and 4.42 to 3.40 g h m^{-3} at 20°C (Fig. 3). This synergistic effect occurred on green peach aphid and turnip aphid when treated with EF and PH_3 at the same times (Fig. 4, 5).

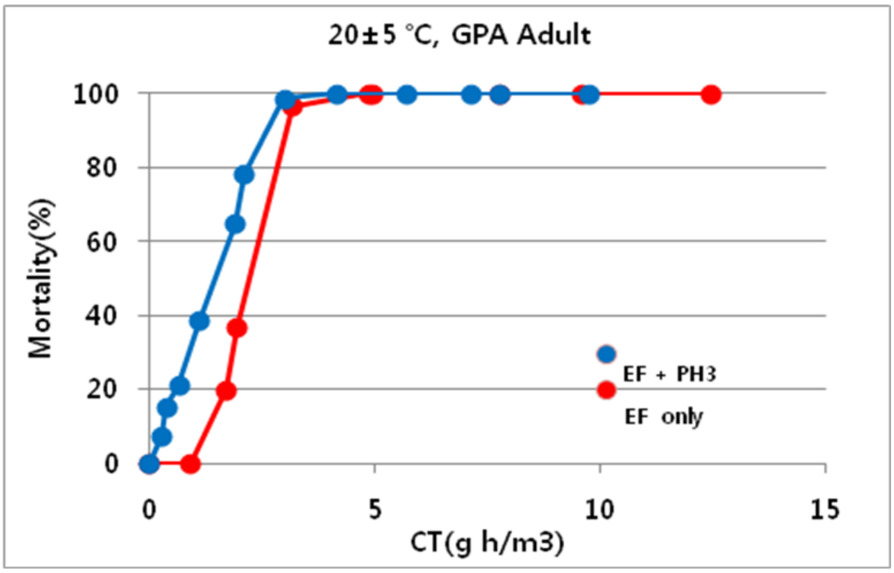

Figure 3 Comparison of efficacy of EF on cotton aphid when treated alone and treated with PH_3.

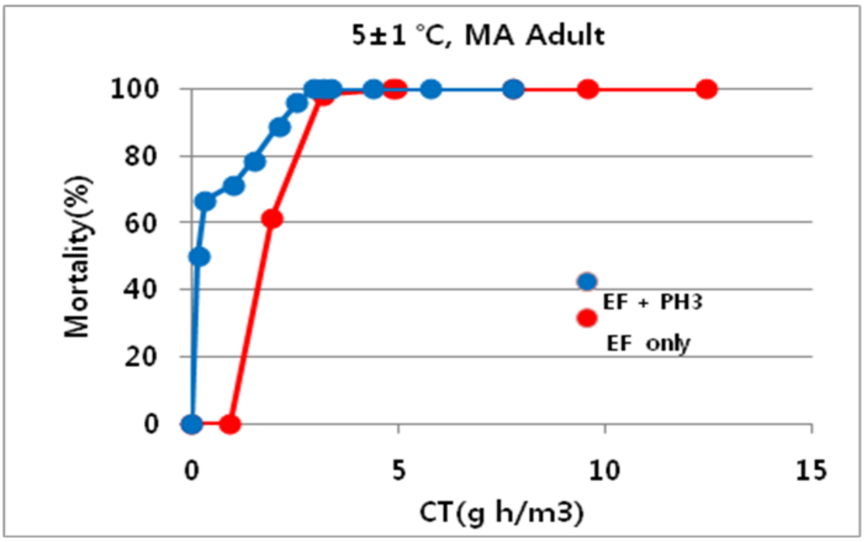

Figure 4 Comparison of efficacy of EF on green peach aphid when treated alone and treated with PH_3.

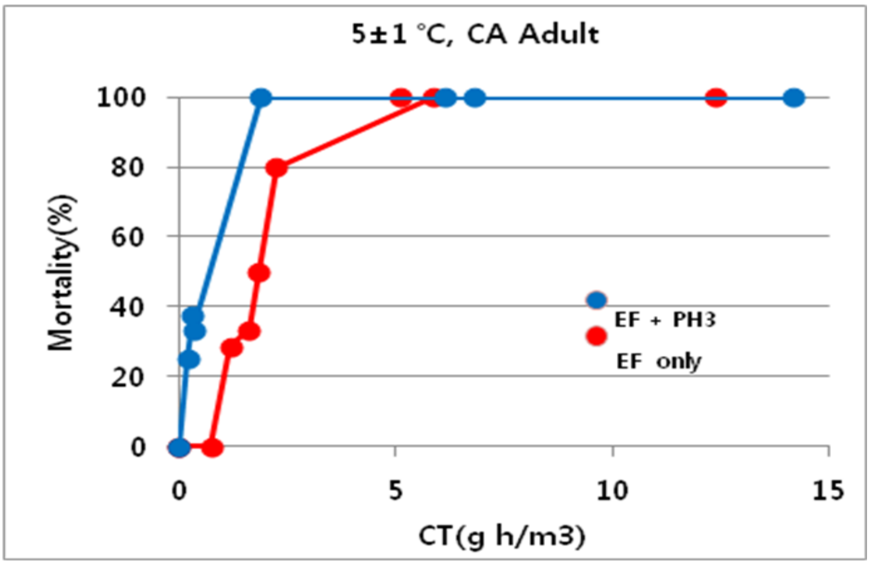

Figure 5 Comparison of efficacy of EF on turnip aphid when treated alone and treated with PH_3.

3.4. Scale-up trials to certify the synergistic effect of EF and PH_3

In a small scale fumigation, treatment of 4.28 g h/m^3 CT product of EF and 0.97 g h/m^3 CT product of PH_3 killed cotton aphid and two spotted spider mite (*Tetranychus urticae*) within 2 hours.

4. Conclusions

Based on trial results, fumigation of EF with PH_3 would provide greater efficacy on aphids when used on perishable commodities. In this trial, we've found the synergistic effect of EF and PH_3, and we'll proceed with the scale-up fumigation trials on other insect pests of perishable commodities.

References

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