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COMPARATIVE MORTALITY OF *LIPOSCELIS ENTOMOPHILA* (ENDERLEIN) EXPOSED TO ETHYL FORMATE IN EMPTY BINS

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ABSTRACT

Fumigation was carried out in a PVC bin that served as fumigation chamber, of 300 mm in diameter and 7500 mm in height. The bin was located in an empty horizontal warehouse. *Liposcelis entomophila* (Enderlein) served as test insect exposed to the fumigant in cages placed at heights of 7.50, 5.61, 3.74, 1.87 and 0.1 m from the bottom of the bin. Ethyl formate (EtF) was applied at a dosage of 15.1 μL/L, from different heights of 7.5, 3.74 and 0.1 m. When EtF was applied from 0.1 m height complete mortality was achieved at the height of 0.1 and 1.87 m.. While the mortality of the insects at the heights of 3.74, 5.61 and 7.5 m were near 94, 27 and 21%, respectively. When EtF was applied from 3.74 m height, 100% mortality was observed in the cages located at 0.1, 1.87 and 3.74 m high. While the mortality of the insect at height of 5.61 and 7.5 m was about 90 and 8%, respectively. When EtF was applied from 7.5 m height, complete mortality was achieved at all five heights. Results indicate that EtF can effectively control insects near the application point or when applied from top layers of the bin. Since EtF is heavier than air, it rapidly sinks after it is volatized. Therefore, for space fumigation, especially in large scale warehouses, it is necessary to assist the fumigant distribution by aid of mixing techniques.

Key words: ethyl formate, insect mortality, *Liposcelis entomophila,* space fumigation, empty warehouse fumigation, fumigant application method

INTRODUCTION

The stated owned grain in P. R. China is usually stored in large scale warehouses of 21 m to 30 m wide, more than 50 m long and 11 m high. The height of grain mass in these bulks is 6 m. Loading of grain should be carried out after the control of all insects in the empty bin. DDVP (dicholovos) is the fumigant of choice due to its quick effect in killing insects. But after dicholovos spray, there is a possibility that some survival insect population remain at top

of empty warehouse. Ethyl formate (EtF) is a liquid at normal ambient temperatures, it boils at 55°C, and vaporises readily at normal grain temperatures, its vapour was shown to be toxic to stored product insects (Muthu et al.,1984). It has the potential to serve as alternative to methyl bromide, it is faster in action than phosphine on insects and may contribute in relieving the selection pressure for resistance to phosphine. To some degree, EtF is an alternative to dichlorvos in large scale warehouses. Cao et al (2003) has reported its potential application in empty warehouses. However, the effectiveness of EtF fumigation at different heights of empty warehouses remained unclear. Vapormate™ is fumigant formulated by BOC Australia, a member of the Linde Group, and contains 16.7 wt% EtF in liquid carbon dioxide (Finkelman et al, 2010). Both EtF and Vapormate™ have not been registered and used as fumigant in China Therefore, the present work aims at investigating the differences in insect survival at different heights of a fumigated warehouse using EtF.

MATERIALS AND METHODS

1.1 Fumigation chamber

The fumigation chamber was made of PVC (to simulate a bin) of 300 mm in diameter and 7,500 mm in height and sealed at both ends by PVC material. The bin was located in an empty horizontal warehouse of 27 m wide, 60 m long and 11 m high. There was a small hatch on the 10 cm height and on the top of the PVC bin for the application of the fumigant and inserting the cages containing the test insects. The half life of pressure decay time from 500 Pa to 250 Pa was 43 seconds. The temperature was monitored by electronic sensors that were installed in the bin (Fig. 1).

1.2 Bioassays

Glass tubes of 70 mm long and 10 mm in diameter were covered at both ends by flax fabric to permit ventilation, served as insect cages. Thirty adults of *Liposcelis entomophila* (Enderlein) and some broken wheat were placed in each cage. For each height of the PVC bin, there were three replications in one group. Each group of cages was hung up with string to the heights of 7.5, 5.61, 3.74, 1.87and 0.1 m in the PVC bin that served as fumigation chamber. Another group of insect cages served as control outside the bin but located in the warehouse.

1.3 Ethyl formate and application

The fumigant EtF was analytical reagent of 98% purity produced by Bodi Chemical Plant, Tianjin, P R China. EtF was injected through a plastic pipe into an open Petri dish installed at heights of 7.50, 3.73 and 0.10 m from the bottom. The applied EtF dose of15 μL/L volatilized immediately after injection into the Petri dish. The temperature was in the range of 18^{o} to 22^{o}C during the fumigation. The mortality of insects was checked 24 h after the end of exposure to the fumigant and aeration using a small fan.

Mortality results of was analyzed by Duncan's new multiple-range test Processed with Date Processing System, edition V 7.05, developed by Hangzhou Ruifeng Information Technology Ltd., China.

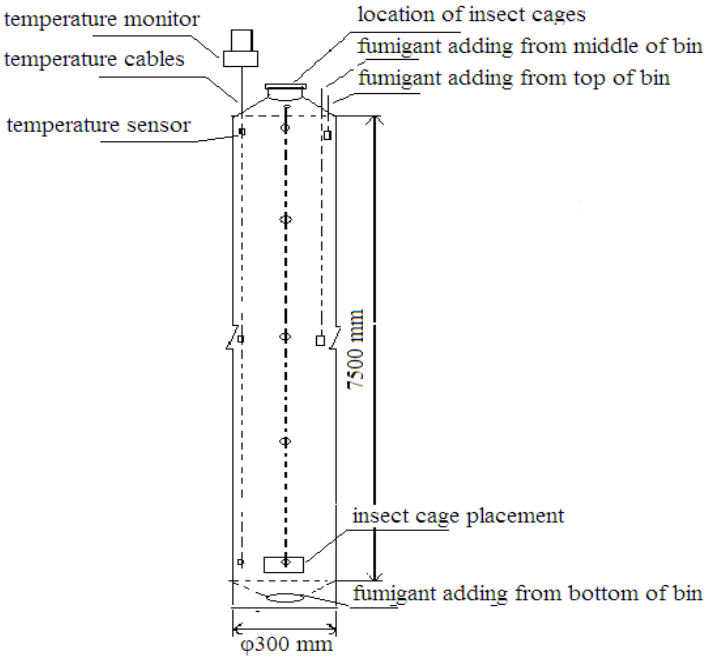

Fig. 1- Plan of PVC fumigation chamber and position of insect and fumigant introduction points.

RESULTS AND DISCUSSION

Mortality of *L. entomophila* adults exposed to EtF at different heights of the PVC chamber is shown in Fig. 2. In this fumigation, EtF was applied from the 0.10 m port. Fig. 2 indicated that the Insect mortality at 0.10 m and 1.87 m height was 100%. Whereas the mortalities at heights of 3.74, 5.61 and 7.5 m from bottom were near 94, 27 and 21%, respectively.

When the fumigant was applied from the point located at 3.74 m high, 100% mortality was observed in the cages located at 0.1, 1.87 and 3.74 m high. However, mortalities of the insects at 5.61 and 7.5 m height were about 90 and 8%, respectively.

When the fumigant was applied from the point located at 7.5 m high, complete mortality was achieved at all five tested heights.

The results indicate that it was not possible to achieve complete mortality for the height more than 2 m above the application point. As the height of fumigant application point was higher, the mortality was higher. This means that in space fumigation, EtF is more effective when applied from top layers. The natural reason is that vapor density of EtF is 2.55 times heaver than that of air (=1. The molecules would sink by gravity after application in the space.

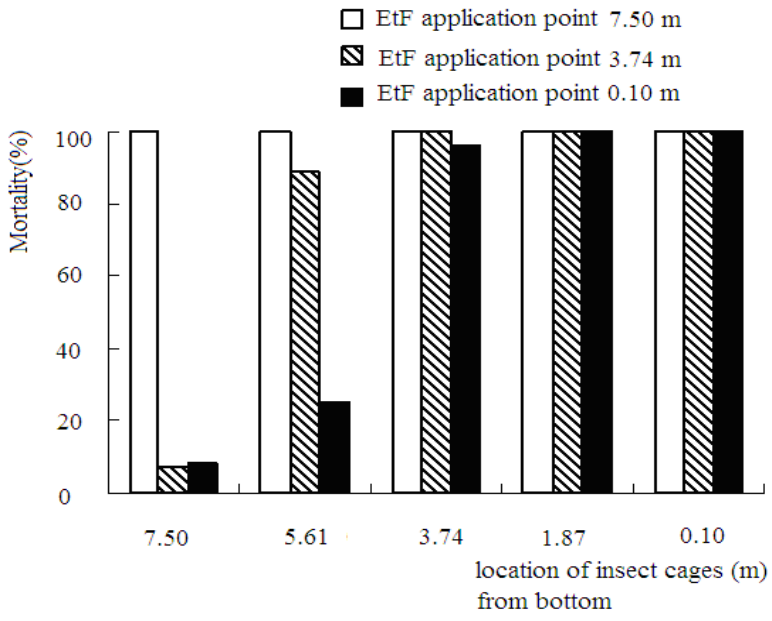

Fig. 2 - Mortality of *Liposcelis entomophila* adults exposed at different heights in the fumigation chamber and three application points of EtF. Fumigation temperature was in the range of 18° to 22°C.

EtF has been used successfully in disinfestation of food plant and machinery. Recently small-scale field trials have been carried out on dried fruits, wheat, barley, canola, and oats. All trials resulted satisfactorily without problems related to the application method, operator safety, insect control, commodity damage, ventilation, or residues at out loading (Annis, 2002). EtF fumigation has been reported using recirculation, or in combination with CO_2, or applied in a sealed system and allowed to mix freely by natural or forced air movement (Annis, 2002; Simpson et al., 2007). Vapormate™ is now fully registered for use in grain and horticultural products in Australia, in New Zealand for use in grain and for quarantine treatment of bananas and in Israel for dates and stored grains (Finkelman et al., 2010). EtF or Vapormate™ may be used as fumigation in future in China. The current results conclude further that for space fumigation in large scale warehouse, the recirculation or forced air is necessary for the even distribution of the fumigant to achieve complete insect control, especially at the top of warehouses.

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