EVALUATION OF TWO FUMIGANTS FOR RAPID TREATMENT OF PACKAGED SEEDS

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Commodity fumigation of packaged seed stocks prior to shipping is performed with the goals of both eliminating the risk of transporting live stored-product insect pests and other incidental species, and protecting these valuable commodities from insect feeding damage. To meet industry production goals, often the turnaround times on these pre-shipment treatments needs to be very short. The overall objective of this project was to evaluate the efficacy of two relatively new fumigants against stored-product insects in pallets of packaged seed. Our goals were obtaining complete mortality of immature and adult stages of selected stored-product pest species and minimizing the exposure time. Because fumigation efficacy is influenced by the chemical compound and concentration, exposure time to target concentration (CT product), temperature, and the target insect species and life-stage, all of these factors were considered in this study.

Two fumigants were evaluated: Eco2Fume®, a cylinderized mixture of phosphine (2% by weight) and carbon dioxide (98% by weight), and Profume®, the trade name for sulfuryl fluoride. Exposure times were developed based on fumigation company recommendations for the shortest exposure times at the target temperature of 27ºC; 24 and 36 hrs for Eco2Fume and 12 and 18 hr for Profume. Two or three replicate fumigations were performed for each fumigant/exposure time. Fumigations were performed in fumigation chambers containing two pallets of cardboard boxes with each box filled with paper envelopes, in turn filled approximately halfway with corn. Insects were exposed in fumigation tubes placed inside these paper envelopes.

Four species of stored-product insects associated with corn were used to test fumigant efficacy. Two species were internal feeders (Angoumois grain moth, *Sitotroga cerealella* (Olivier) and maize weevil, *Sitophilus zeamais* Motschulsky), and two were external feeders (Indianmeal moth, *Plodia interpunctella* Hübner and red flour beetle, *Tribolium castaneum* (Herbst)). For each species, egg, larvae and adult life-stages were tested. Each species/life-stage combination was placed into fumigation tubes that also contained corn and then placed into the paper envelopes described above. One set of twelve envelopes representing each species/life-stage combination was placed in each of 27 boxes. For all external stages, ten individuals were added to a tube, but for internal stages infested corn at the appropriate age was added. After exposure to fumigant the number of alive and dead was determined, and for internal and egg stages the contents of the tubes were held and survival to adulthood was measured. Based on the findings from these exposures, we also developed a rapid screening technique using the least susceptible species and life-stage (red flour beetle eggs) glued to cards to monitor fumigation efficacy and tested this technique with some additional fumigation tests.

The results of 18 fumigations will be discussed here, eight with Eco2Fume and 10 with Profume. Eleven of these fumigations were performed using the whole suite of insect species/life-stages and seven were performed with the red flour beetle egg bioassay. There was a low level of survival for some species and stages for all Eco2Fume fumigations with exposure times of 24 (target concentration 500 ppm) and 36 hrs (target concentration 200 ppm). These survival levels were generally very low, but in none of the trials with whole suite of insects did we obtain the target 100% mortality for all species and stages. With the 24 hr exposure and 500 ppm target gas concentration, it was primarily the red flour beetle egg stage that exhibited some survival, but with 36 hr exposures with a target concentration of 200 ppm between two trials there was some survival in all the egg stage treatments and in the two species with internal feeding larvae. In the additional runs using the red flour beetle egg cards, 100% egg mortality was achieved. Some of the issues with survival may be due to difficulty in the phosphine gas penetrating into the boxes. For trials where fumigant concentration information was available, levels inside the boxes were 19±3% lower then levels in the chamber.

Profume provided a very high level of mortality even with exposures as short as 12 hrs with a target CT of 1070 oz-hr/MCF, but there was occasionally some red flour beetle egg survival. Target CT was achieved in two trials with the full complement of test insects, but in one trial there was one box location with one red flour beetle egg surviving exposure. In the additional fumigations using egg cards to assess efficacy, three out of four trials had no red flour beetle egg survival. The egg card trial with survival (4.2%) used a lower target CT than the other trials. Increasing the exposure time of Profume at 27ºC to 18 hrs (991 oz-hr/MCF target CT) gave 100% mortality of red flour beetle eggs. However, for one replicate we did see some survival of eggs of some of the internal-feeding species. Gas concentrations inside the box tended to be similar to those in the chamber, indicating good ability to penetrate into the packages.

The objective of this project was to determine the feasibility of using very short fumigation exposure times to obtain 100% mortality and therefore these trials represent challenging conditions for the use of fumigation. None of the treatments tested resulted in 100% mortality across all the trials. Even using small fumigation chambers it proved difficult to consistently obtain the same temperatures and gas concentrations, which may have contributed to the variation in results we obtained because it was impossible to precisely replicate exposures. Our study illustrates the real-world challenges of fumigating storage structures or seed stocks because of the variety of conditions encountered during fumigant application. For both Eco2Fume and Profume, our results suggest that the recommendations for gas concentration were close to a threshold in terms of providing 100% mortality of the insects inside the envelopes. It would be useful to explore the use of higher target concentrations for these short time periods to determine if a level could be reached that was more consistent, and also to conduct tests at higher temperatures. Of the species tested, red flour beetle eggs were the most difficult to kill for both fumigants. Therefore, the use of the red flour beetle egg card bioassay that we developed during this project represents an easier and faster method to test the effectiveness of the fumigant. We recommend this technique as a method to evaluate fumigations in the future, but suggest that larger numbers of eggs be exposed during the fumigations to increase detection of very low levels of survival.