CONTROL OF FLOUR MOTHS ON COMMODITIES STORED IN SMALL WAREHOUSES USING THE IGR, FENOXYCARB

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The continued elimination of chemical pesticides that are suitable for application to stored commodities has left few effective alternatives for insect control. Insect growth regulators (IGRs) are effective biorational alternatives to hard pesticides. IGRs include agonists and antagonists of the natural insect hormones, principally, juvenile hormone (JH) and 20-hydroxyecdysone (20-E), along with the benzoylphenyl urea inhibitors of chitin synthesis (CSI).

The efficacy of using juvenile hormone agonists (JH_{Ag}) for controlling the Indianmeal moth, the most important insect pest associated with feed, food and seed storage in the U.S., has been extensively investigated. The JH_{Ag}, fenoxycarb and pyriproxyphen, are extremely effective in adversely affecting the development and reproduction of stored product moths. Our studies have focused on exploiting the vulnerability of flour moths to JH_{Ag} intoxication during embryonic and early larval development. The rationale for this approach is two fold: 1) Lower doses of the JH_{Ag} are required for effective treatments and 2) Intercepting pest development early, minimizes commodity damage. We report here our studies with the JH_{Ag}, fenoxycarb, and a strategy for its use in protecting packaged commodities from pest insects during storage in warehouses.

Our current studies are focused on evaluating the effectiveness of JH_{Ag} applications for protecting high-value, packaged commodities from flour moth infestation during warehouse storage. We previously reported that JH_{Ag} are effective in disrupting embryogenesis in the Indianmeal moth when applied directly to the egg, topically or through contact, or by transovarial exposure *via* treating the gravid female, either topically or through contact. Using these observations we formulated a protocol whereby cereal moths could be rendered infertile by a JH_{Ag} treatment that does not contact the commodity packaging.

We have conducted several experiments in simulated warehouse conditions during the past year. We placed packaged commodities inside sealed cardboard boxes and stored them at one of four treatment conditions. When the commodities were exposed to high numbers of newly-emerged Indianmeal moths, there was no infestation of commodity when the warehouse walls and the outer-surface of the cardboard boxes were treated with

15µg fenoxycarb\cm^2 (condition 1); similar results were observed when only the warehouse walls were treated (condition

2). However, the treatment where only the cardboard boxes were treated (condition 3) showed moderate infestation.

In normal warehouse situations, the boxed commodity would contribute a much greater percentage of the vertical resting surfaces (favored by moths) making the commodity-only treatment somewhat more effective and the wall-only treatment somewhat less effective. We project that for effective warehouse applications, all vertical surfaces, on the commodity and in the warehouse, will have to be treated with an appropriate JH_{Ag}. The longevity of fenoxycarb in the warehouse has been found to be about six months. When no JH_{Ag} treatment was applied (condition 4), heavy infestations were observed---but the level of infestation was very commodity dependent. This observation has prompted us to examine if heavily infested commodities result from their attractancy or nutritional adequacy. These studies are just getting underway and may be another factor that will have to be considered when managing pest insect populations without the use of hard pesticides.

We are continuing our studies on identifying the mechanism(s) whereby a single exposure of eggs to a JH_{Ag} prevents the normal completion of growth and development in the Indianmeal moth. Previously, we reported that low levels of JH_{Ag} interfered with embryogenesis and prevented hatching when freshly laid Indianmeal moth eggs were briefly exposed to low levels (ppm) of JH_{Ag}. We found also that similar treatment with even lower dosages (ppb) are lethal, but are not manifested until after embryogenesis, usually during the larval period.

The mechanism of the JH_{Ag} action during embryogenesis appears to involve the activation of a cell signalling pathway that relies upon the small GTPase, Rho. Rho is a primary regulator of cell movement and shape through its interactions with the cytoskeleton. Our studies indicate that the embryonic failures induced by fenoxycarb are the result of abnormalities in cell movement during embryogenesis. Our goal in these studies is to understand how a JH_{Ag} acts within the insect cell that enables a single treatment of an undifferentiated egg to be "remembered", not only in the short term, but for the rest of the insect's life.