I. Biology/Phenology

A MODEL FOR DETERMINING CODLING MOTH RESPONSE TO HEATING RATE DURING HIGH TEMPERATURE QUARANTINE TREATMENTS

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Codling moth, *Cydia pomonella* (L.) is a quarantine pest on North American-produced pome fruit, stone fruit, and walnuts destined for export markets. Currently, the only proposed and certified treatments for codling moth involves fumigation with methyl bromide, which has been identified as an ozone depletor by the U.S. EPA under the Federal Clean Air Act (1990). In accordance with the Clean Air Act (1990), the production and use of methyl bromide in the U. S. will be banned by the year 2001. The loss of methyl bromide as a means of guaranteeing quarantine security will greatly impact foreign trade balance unless suitable alternatives are developed. We are currently investigating the use of heat treatments for the disinfestation of apples, pears, and cherries. A crucial aspect of developing a heat treatment is defining the effects of the application of heat (vapor, moist, or dry forced air, water dips. etc.) on the rate of heating in the fruit and the subsequent effects on insect mortality. More rapid rates of heating (8-12°C/h) using hot forced air provide quicker treatments to control codling moth larvae, but in turn are not tolerated as well by apples and pears. Thus, there is a trade off between faster heating rate treatments to achieve insect mortality and slower heating rates to ensure fruit quality. It became necessary to develop a model to predict larval mortality as a function of heating rate so that we could ‘prescribe’ heat treatments in accordance with fruit tolerances. We previously found a correlation between heating rate and larval mortality of fifth instar codling moth in response to heat treatments. The more rapid the rate of heating, the less time it takes to achieve 95% mortality at the final treatment temperature. From these findings we were able to derive a mathematical model which described the effect of heating rate on insect mortality. We then tested this model in a simulated heating system in which we could control the rate of heating. Results from this study were compared against the model. Although the old model provided a good estimate of larval mortality, a new model more accurately described the response of fifth instar codling moth to the heating rate. We are currently developing a similar model to describe fruit tolerances as a function of heating rate. The final goal of this research is to develop a working model in which heat treatments can be ‘prescribed’ to disinfest fruit of codling moth while ensuring fruit quality.

OLD MODEL:

$$\log_e(LT_{95}) = 4.900558 + 2.86748 * \log_e(\text{heat rate}) - 1.182104 * [\log_e(\text{heat rate})]^2$$

To find values for 42°C, multiply by 3.2114.
To find values for 44°C, multiply by 2.0083.
To find values for 46°C, multiply by 1.0.

NEW MODEL:

$$\ln(LT_{95}) = b_0 + b_1\ln(\text{heat rate}) + b_2(\text{treatment temperature})$$

Where:

$b_0 = 22.4462 + 1.0486$ SE
$b_1 = -1.5745 + 0.09844$ SE
$b_2 = -0.297036 + 0.02339$ SE
$R^2 = 0.972$

Figure 1. Predicted LT_{95} values from the old model (-■-), the new model (-●-) and experimental LT_{95} from water bath studies (-▲-). A=42°C, B=44°C, C=46°C.