Mating Disruption/SIR

A Release-Rate Model for a Membrane-Type Codlemone Dispenser

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A model has been developed to predict release profiles of membrane-based codlemone dispensers. While initially developed for dispenser design, the model should also be useful in predicting the release from dispensers in the field based on field temperature data. With this tool, the duration of release of pheromone can be predicted based on daily temperatures so appropriate measures can be taken before the dispensers become depleted.

The release rate from membrane-based dispensers depends on the membrane composition, membrane thickness, membrane surface area, reservoir characteristics including codlemone concentration, and the environmental temperature and wind conditions. This model is based on measured release-rate data from many dispenser formulations to determine a permeability that is characteristic of the type of membrane and reservoir used. The permeability (in dimensions of mass divided by time, area, and concentration) allows calculation of the release rate when the release area, pheromone concentration within the dispenser, and environmental temperature are known.

By using permeabilities as a function of temperature, the temperature sensitivity of each membrane/reservoir combination was accounted for with the assumption of an Arrhenius temperature dependence: $P = Ae^{-Ea/RT}$ where P is the permeability, A is the pre-exponential factor, E_a is the activation energy, R is the gas constant, and T is the absolute temperature.

The only variable not accounted for in the model is the effect of changing wind on the release rate. Wind increases the driving force for diffusion across the membrane; diffusion is slower if no wind is present. In a protected orchard canopy environment, the wind was assumed to be relatively constant over the growing season and therefore its effect on the release rate was also assumed constant. In general, wind has a smaller effect on the release rate than does temperature.

With an array of daily temperatures (the model was correlated to daily maximum temperatures), the model predicts the mass of pheromone released per day based on 1) that day's temperature, 2) the current codlemone concentration in the dispenser, and 3) the release area. The model then updates the codlemone concentration before calculating the next day's release at its new temperature.

The model-generated profiles were first compared to laboratory release data. The dispensers were tested at constant and alternating temperature conditions (temperatures from 10°C to 35°C). In all cases, the model predicted release profiles that closely matched the measured pheromone release profiles.

In field tests, the CheckMate CM product, a membrane-type codlemone dispenser manufactured by Consep, Inc. (Bend, OR), had a duration of 50 to 60 days in spring-like field conditions (10°C to 35°C). Based on the daily maximum field temperatures, the model predicted the same duration of release of pheromone as was observed in the field. To increase the duration, dispensers have been made that contain more codlemone. The anticipated field profile for these new dispensers at the same field temperatures indicates that codlemone should be released for 70 to 80 days.

The predicted release profiles of another new formulation—this one specifically for hot weather use, (above 20°C to 25°C)—compared with those for CheckMate CM are shown in Figures 1 and 2 for two different locations. The new formulation has a predicted duration of 90 days or more in conditions the same as the 1995 summer temperatures of Yakima, WA, and a duration of about 70 days in conditions the same as the 1994 summer temperatures of Shafter, CA. Under the same conditions, CheckMate CM was predicted to last only 55 and 35 days, respectively.

Additional field release data will be gathered in 1996 to confirm and fine-tune the model. Based on this information, this model should be useful for monitoring the release of pheromone from membrane-based dispensers in the field and may be useful as an additional tool to provide efficacious pheromone treatment to control codling moth in orchard crops.

Figure 1: Codlemone Release at Yakima Temperatures Starting 6/30/95

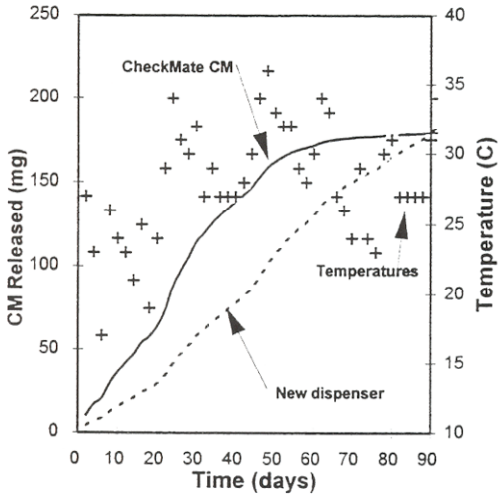

Figure 2: Codlemone Release at Shafter Temperatures Starting 5/31/94