SIMULATIONS PREDICT PHEROMONE RELEASE RATES FOR CODLING MOTH DISPENSERS

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Mating disruption is a useful tactic for control of codling moth in orchards where reduced use of conventional insecticides is practised. Mating disruption relies on the release of large quantities of the insect's pheromone over large areas, disrupting the male moth's mate-finding ability. Many pheromone blends and release devices have been studied for codling moth, but the dispenser type in most common use around the Pacific rim is one manufactured by Shin Etsu Chemical Company, Tokyo. This Isomate-C dispenser consists of a sealed polyethylene tube, containing a blend of (*E*, *E*)-8,10-dodecadien-1-ol (codling moth pheromone component), dodecan-1-ol and tetradecan-1-ol (disruption enhancers). A wire fused inside the plastic allows the dispenser to be twisted securely around branches high in the tree. The dispensers are in commercial use in the Pacific States of the USA.

A major factor affecting the success of disruption is the pheromone release rate, which cannot be measured routinely. Brown *et al.* (1992) studied the emission characteristics of these dispensers using gas chromatography. They found that the main component ((*E*, *E*)-8,10-dodecadien-1-ol), degraded over time in the field at a faster rate than the other components. The differing ratio of components over time implies that more simple models of pheromone release rate, such as the one reported by Bradley *et al.* (1995) for leafrollers, cannot be used. Knight developed a mathematical model of the release rate for each component based on the equation $\ln(\text{release rate}) = a + b(1/\text{temperature}) + c(\text{degree hours})$, where *a*, *b* and *c* are regression coefficients for each component. This was later developed into a DOS programme (Knight submitted). Inputs required for the model were; application date and rate/ha of dispensers, including an optional second placement; period to be modelled; blend component (although the dispenser contains three components, only the diene is relevant for disruption (McDonough *et al.* 1993)); and a temperature data file consisting of Julian date, military time and 'dry bulb' temperature. The model's output was a summary of the input parameters, then a list of the Julian day; time of dusk; release rate of chosen component at dusk; and the cumulative release rate for the season. This model has been modified for New Zealand dusk times and Julian days. Temperatures at dusk were used for modelling as codling moth flight commences shortly after this time. Earlier methods for determining pheromone release rates produced average release rates for the day, which Knight (submitted) found to be higher than those released at dusk.

Using temperature data collected on five orchards in five regions during the 1993/1994 season, we used the model to predict release rates. Dispensers were hypothetically applied on the 20 October 1993 (although northern regions would require earlier placement), and the release rate of the pheromone component modelled until 30 April 1994. The drier climates of Hawke's Bay, Canterbury, and Central Otago had greater dusk temperature fluctuations than Auckland and Nelson. These changes in temperature caused greater fluctuations in release rate, especially during the first half of the season. Table 1 and Figure 1 show there was very little difference in the predicted total quantities of pheromone released between the regions, despite differing climates. Figure 1 shows that all regions would have had a drop in pheromone release rate after the end of January 1994. As this is a period of high flight activity, especially in North Island regions, a second application of dispensers would have been beneficial.

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FIGURE 1: Predicted release rates of (*E,E*)-8,10-dodecadien-1-ol from 1000 Isomate-C dispensers/ha in example orchards in four regions. Release rates have been smoothed by a 7 day moving average for ease of visual comparison.

TABLE 1: Codling moth flight period, mean orchard temperature and predicted total quantity of (*E,E*)-8,10-dodecadien-1-ol released per ha from 1000 Isomate-C dispensers for the period 20 October 1993 to 30 April 1994 in five regions.

	Generations per year	Flight period	Mean temperature (°C)	<i>E8,E10-12:OH</i> (g/ha)
Auckland	2-3	Sep-Apr	16.4	14.9
Hawke's Bay	1-2	Oct-Apr	15.2	15.3
Nelson	1	Oct-Mar	15.5	13.9
Canterbury	1	Oct-Mar	14.0	12.9
Central Otago	1	Oct-Feb	14.1	13.8

The effect of three hypothetical dispenser application options were examined against a single application of 1000 dispensers in October. The temperature data was from a Hawke's Bay orchard. One option involved an additional placement of 500 dispensers/ha on 15 January 1994. Figure 2 shows that 1000 and 500 dispensers in October and January respectively gave release rates generally greater than 4 mg/ha/h till mid-March. As the cost of mating disruption is often an important barrier to widespread use (Suckling *et al.* 1995), a 50% increase in the cost of materials may be unacceptable. Two options were modelled using 1000 dispensers per ha. The first option involved 500 dispensers applied in October and the remaining 500 applied in January, while the second option involved 700 and 300 dispensers on these dates. The first option (Fig. 2) gave very low release rates in the spring which may be unacceptable, as in regions where there is more than one generation per year, it is critical to control the first generation. If good control of the first generation is obtained then low release rates may be sufficient to control the lower residual codling moth population. The 700 and 300 option (Fig. 2) gave a relatively stable release through to the beginning of March, while reducing the release rate in the spring compared to a single application of 1000 dispensers. The 700/300 treatment would probably be the most economic option for single generation (South Island) regions.

This model would be most useful if the lower threshold release rate was known to achieve successful mating disruption. Unfortunately low dispenser release rates may not always be the main contributing factor to the failure of mating disruption. High codling moth populations and pressure from surrounding areas, can contribute to failure (Suckling *et al.* 1995). Another factor, very pertinent to New Zealand, is the effect of wind, which can reduce atmospheric pheromone concentration.

Dispenser release rate models are useful tools in mating disruption research. They allow testing of scenarios and examinations for weak points in a mating disruption system.

FIGURE 2: The effect on release rate of differing placement dates and dispenser/ha, in a Hawke's Bay orchard. Release rates have been smoothed by a 7 day moving average for ease of visual comparison.

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