A PHENOLOGY MODEL OF EUROPEAN RED MITE FOR TIMING MITICIDES

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SUMMARY

A phenology model of the European red mite, *Panonychus ulmi* was developed from a generalised insect phenology model. The inputs required to run the model are maximum and minimum daily temperatures and the proportion of each developmental stage present on the leaves after hatching of ERM winter eggs. Model output was compared to field data and showed considerable success at predicting ERM phenology and the timing of miticide applications.

INTRODUCTION

The European red mite (ERM) is a major pest of apple orchards in New Zealand. Under an integrated mite control (IMC) programme, it is controlled by the azinphos-methyl resistant predator mite, *Typhlodromus pyri* combined with judicious use of selective miticides. The decision as to whether miticidal control is necessary depends on the density and ratio of predator and prey mites on the leaves (Cook 1980). For the commonly used organotin miticides, which are mainly effective against active ERM stages, there are three key times to spray (late October, early December and January), coinciding with the times when ERM active stages form the largest part of the prey population. Successful integrated control of ERM may frequently be achieved with only one selective miticide application per season (Wearing *et al* 1982). The best time to spray is often in early December, when there is a peak in the first summer generation of ERM active stages, and the predator population consists mainly of adults, which are less susceptible to miticides. However, the exact timing depends on ambient temperature, and the optimum spray period may vary from year to year by up to 7 days in Nelson (Collyer 1980), and 10 days in Hawkes Bay and Central Otago (Walker *et al* 1979).

Currently, ERM populations are monitored regularly by DSIR staff at Research Orchards, and recommendations of when to spray in that particular locality are made via grower organisations, radio or newspapers. Monitoring ERM populations is time consuming and labour intensive, and only reveals the optimum spray time as it occurs. Advanced warning can be provided only by a somewhat subjective prediction.

This paper reports on a phenology model of ERM which is driven by ambient temperatures. It requires only one or two samples to be taken from an ERM population, and using the stage distribution of this population, the phenology of ERM for a whole season may be simulated, provided up-to-date temperature data are available.

METHODS

The framework of an existing phenology model for insects (Logan and Amman 1986) was adapted for ERM populations. This model is an age-structured discrete-time simulation model driven by hourly temperatures. It requires mathematical functions describing the relationships between development rate and temperature for all of the developmental stages. The coefficient of variation (standard deviation divided by the mean) of these development rates, is used to simulate the spread in emergence from one stage to the next. In order to adapt the model for ERM, non-linear temperature-dependent development rate functions for each ERM stage were fitted to published data (Rabbinge 1976), after confirming that these agreed with development rates of ERM in New Zealand. The model was enhanced for overlapping generations of ERM by modelling the age-dependent fecundity of adult females from information presented in Rabbinge (1976). An algorithm for calculating daily temperature variation from daily

Proc. 40th N.Z. Weed and Pest Control Conf.

maximum and minimum temperatures was also incorporated. Further details of the model structure may be found in Hayes (1986). Because published data on the hatching of ERM winter eggs after periods of chilling were found to be unsuitable for the mild winter temperatures of New Zealand (Hayes 1986), the model does not include the development of overwintering eggs, but starts after winter egg hatch is complete and simulates the phenology of ERM generations on the leaves.

The inputs required to run the model are:

- i) maximum and minimum daily temperatures for the period of the simulation.
- ii) the proportion of each ERM developmental stage present on leaves after hatching of winter eggs.

The model was tested retrospectively against suitable field data of ERM populations on apples at DSIR Research Orchards in Nelson, Havelock North and Central Otago. The data were obtained by counting the number of each ERM developmental stage in leaf samples (50-150 leaves) taken twice weekly. Maximum and minimum daily temperatures were obtained from the Meteorological Service sites at the Research Orchards. The model was run from the end of October until late December, and optimum December spray times were determined from the simulated peaks in the percentage of active ERM stages. These were compared to the optimum spray periods determined from the field data.

RESULTS

The form of the output from the model is the change in relative proportions of each developmental stage over time. The comparison of simulated and actual phenology is shown for one of the field populations (Fig. 1). In this year, both the timing of the peaks and troughs of developmental stages, and the actual percentages of each stage were well predicted by the model. This is because the population suffered little predation. In populations undergoing predation by *T. pyri*, the percentage of active stages will be lower than predicted by the model, because the predator eats only active stages and not eggs. However, for the purpose of timing sprays, only the dates of the peaks and troughs are important.

The optimum spray periods for December miticide application were determined from field and simulated phenology and are compared in Table 1. They are expressed as 'spray windows' of approximately 7 days, during which time the proportion of ERM active stages is at a maximum. Sometimes the spray windows determined from the field data were longer than 7 days, due to the long periods between samples, and because the data did not always reveal distinct peaks and troughs.

TABLE 1: Comparison of optimum December spray periods for miticides, determined from phenology model and field data.

Location	Season	December spray period	
		From field data	From simulation
Appleby R.O.	1983/84	After 14th Dec*	10th-17th Dec
Appleby R.O.	1984/85	After 3rd Dec*	3rd-10th Dec
Appleby R.O.	1986/87	4th-13th Dec	11th-18th Dec
Havelock North R.O. 1st block	1986/87	7th-14th Dec	10th-17th Dec
Havelock North R.O. 2nd block	1986/87	9th-16th Dec	13th-20th Dec
Earnsclough R.O.	1979/80	7th-14th Dec	9th-16th Dec
Earnsclough R.O.	1980/81	5th-13th Dec	11th-18th Dec
Earnsclough R.O.	1981/82	29th Nov-5th Dec	2nd-9th Dec
Earnsclough R.O.	1982/83	8th-16th Dec	11th-18th Dec
Clyde R.O.	1983/84	3rd-14th Dec	7th-14th Dec

* Field sampling ended on these dates, so the beginning of the spray period only could be determined.

Fig. 1: Comparison of simulated (---) and actual (—●—) phenology of an ERM population at DSIR Research Orchard Earnsleugh, Central Otago.

DISCUSSION

The model was successful in simulating the phenology of ERM stages and the optimum December spray periods. Spray windows determined from simulated phenology were mostly within 3-4 days of those obtained from field data. Only in two simulations (Earnsleugh R.O. 1980/81 and Appleby R.O. 1986/87 seasons) did the spray window differ from field results by more than 4 days. There was a general trend for the model to predict events too late, which suggests that the simulated development rates were too low, or that the temperatures experienced by the mites were higher than those used in the model.

The model shows great potential for use by researchers and advisors in integrated mite control programmes. The advantage of using such a model in IMC is the increased flexibility it provides to decision making prior to the December spray period. In addition, by using historical and/or forecasted temperatures (New Zealand Meteorological Service), it could be very valuable in predicting spray periods in advance. Use of the model would also enable advisors to investigate the effects of unusually warm or cool conditions over the forecasted period.

The model could be used to give district-wide recommendations of optimum spray dates, although caution would have to be exercised for areas or properties experiencing temperatures different from the district average, due to their particular aspect or shelter conditions. The model has shown that temperatures consistently higher or lower by 1°C

will produce a 6-7 day shift in optimum spray dates. Another alternative therefore, is that the model could be applied to individual properties, provided temperature data and the initial ERM data are gathered.

Information can be obtained from the model quickly and cheaply and it provides a much less labour intensive method of determining ERM phenology than field sampling. Because the model simulates the phenology of all stages of ERM, after the winter egg hatch, it may be used to target any action at a particular developmental stage. For example, an ovicidal miticide could be applied at times when the population consists mainly of eggs. In addition, since the model is based on biological information, it should be transferable between different regions experiencing different temperature regimes.

Further research is currently investigating inaccuracies in the model, testing the ability of the model to predict spray periods 1 week in advance (using historical and forecasted temperatures), and incorporating ERM winter egg hatch into the model, which would obviate the need for field sampling.

ACKNOWLEDGEMENTS

I am grateful to Dr G. McLaren for providing ERM population data from Central Otago, and Ms V. White for assisting in counting mite samples from Hawkes Bay. The majority of this work was carried out during PhD studies, DSIR post-graduate award UV/3/36. I would like to thank my supervisors Drs B.H. Mcardle and C.H. Wearing for their guidance during the course of study.

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