USE OF A COMPUTER MODEL FOR MITICIDE SPRAY TIMING AGAINST EUROPEAN RED MITE ON APPLES

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SUMMARY

A phenology model of the European red mite was used during November and December 1987 to determine the optimum times to apply miticides in four apple growing regions of New Zealand. The model accurately predicted early season phenology of ERM, from which the timing of both ovicidal and non-ovicidal miticides was determined. The model predictions for optimum spray timing were more accurate than calendar spraying, and both less time consuming and subjective than sampling mite populations.

INTRODUCTION

Control of the European red mite (ERM), *Panonychus ulmi* is an important part of orchard pest management and may be achieved by careful management of the predator mite *Typhlodromus pyri* and when necessary, the use of selective miticides applied at key times in the season. Where miticidal control of ERM is necessary, as in the absence of effective integrated mite control, it can be improved simply by careful timing.

Just prior to the 1987-88 season, one of the commonly used organotin miticides, cyhexatin, was withdrawn from commercial use. Two ovicidal miticides, clofentezine and hexythiazox were available and although clofentezine could not be used beyond petal fall, hexythiazox could be used on export apples, up to November 25. The organotin miticide azocyclotin, and the organosulphur miticide propargite, could be used beyond this period but their long withholding periods (azocyclotin 35 days, propargite 28 days) mean that they must achieve acceptable control of ERM well before harvest.

In integrated mite control programmes, a single application of a miticide in mid-November or December is preferable to earlier application, as this allows build up of predator mites to levels which are able to add significantly to control in late summer (Walker and White unpublished data). Careful timing of miticides in November or December is important because the first two generations of ERM are quite discrete. During this period there are times when the population consists either mostly of eggs or mostly of immature stages. All miticides are, to some extent, specific in the stages of ERM that they kill and are therefore more effective if applied at times when the susceptible stages are most abundant.

THE MODEL

Preliminary simulations

A computer model has been developed which simulates the events in the ERM life cycle after winter egg hatch (Hayes 1987). This model has been shown to accurately simulate ERM phenology (the timing of events in the life cycle) until mid-summer in the major apple growing regions of New Zealand. For example, Fig. 1 shows the very good agreement found between the computer simulation and field data from Havelock North in the timing of peaks and troughs in the proportion of ERM summer eggs. The development rate of mites is highly dependent on ambient temperature, and daily temperatures alone are sufficient to drive the model, once the initial population has been sampled and its age-structure determined. The total time to produce the simulation (Fig. 1), including counting of the first field sample, in spring, and entering the temperature and population data was approximately 2 hours. By comparison, collection and analysis of the field data from the end of October to the end of February took at

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least 60 hours. Because of this great potential for time saving, use of the model as a means of predicting post-bloom miticide timing was investigated.

Fig. 1: Comparison of simulated ERM summer egg phenology (---) with field data (—■) for a block of apples at Havelock North Research Orchard. The y-axis shows summer eggs as a percentage of the total ERM population.

Accuracy of advanced predictions from the model

To be most useful, the model needed to be able to predict the timing of miticides 8-10 days in advance. This is required for dissemination of the information and to allow orchardists time to plan their spraying activities. To achieve this it was necessary to have some estimate of future temperatures. One possibility was to use the historical average maximum and average minimum daily temperatures for the required dates recorded over previous years in each region. Another possibility was to use 5-day forecasts of daily maximum and minimum temperatures supplied by the New Zealand Meteorological Service from a global weather model.

In spring 1986, the accuracy of advanced predictions from the model was investigated. The model was used to predict the timing of the first trough in the proportion of ERM summer eggs (Fig. 1) at the DSIR Havelock North Research Orchard. (This is a convenient point in the life cycle to compare simulations and field data). The timing of the generation cycles and therefore optimum spray dates vary from year to year with a maximum range of about 10-12 days (Walker *et al* 1979).

Predictions of the December summer egg trough were made at intervals, starting from 24 November, using either historical temperatures only, or 5-day forecasts plus historical temperatures beyond the day of the prediction. Simulations started on October 30, with the field determined densities of each ERM stage and used recorded maximum and minimum temperatures up to the date of the prediction.

The predicted dates of the December trough in eggs from the simulations are shown in Table 1 and were compared to the date of the mid-point of the trough from field data (Fig. 1). Simulations using temperature forecasts were, at most, 1 day more accurate than those using expected temperatures derived from historical data. Not surprisingly, the accuracy of a prediction increased as the time between the day of the prediction and the event decreased. However, all predictions made between 7 and 9 days in advance (4 and 6 December), were within 1 day of the field result and therefore suitable for forming the basis of spray recommendations.

Fig. 2: Results of a simulation showing the percentage of ERM in each stage, and the determination of optimum spray timing for ovicidal and non-ovicidal miticides.

TABLE 2: Spray times for ovicidal miticides recommended from the model and the dates they appeared in local newspapers

Region	Date of simulation	Recommended spraying dates	Date of newspaper publication
Nelson	9 Nov	Nov 17-24	18 Nov
Hawke's Bay	9 Nov	Nov 10-17	13 Nov
Canterbury	9 Nov	Nov 19-25	17 Nov
Central Otago	9 Nov	Nov 10-18	12 Nov

TABLE 3: Spray times for non-ovicidal miticides recommended from the model and the dates they appeared in the newspapers

Region	Date of simulation	Recommended spraying dates	Date of newspaper publication
Nelson	24 Nov	Dec 2-6	27 Nov
Hawke's Bay	17 Nov	Nov 26-30	20 Nov
Canterbury	1 Dec	Dec 8-12	4 Dec
Central Otago	24 Nov	Nov 30-4 Dec	26 Nov

Figures 4a-d show for each region, the two predictive simulations from which spraying dates were derived, compared with the field results and a simulation utilising actual temperatures (run retrospectively). The dates on which the predictive simulations were run (i.e. the dates beyond which they are predictive) are shown in Tables 2 and 3.

The field results demonstrated that the simulations were accurate for the period they were predicting. The recommended timing for ovicidal miticides coincided with the time when the population consisted mostly of eggs. Similarly, the timing of the egg troughs from the simulations predicting non-ovicide use were within 2-3 days of those

This demonstrated that the model could be used to give reliable predictions of ERM phenology and hence spray times, and in spring 1987 it formed the basis of a prediction service for the timing of different types of miticides in Hawke's Bay, Nelson, Canterbury and Central Otago.

TABLE 1: Predicted dates of the trough in ERM summer eggs during December 1986 at Havelock North, from simulations run at intervals beforehand.

Date of simulation	Date of predicted trough using	
	historical temperatures	forecasted temperatures
24 Nov	9 Dec	10 Dec
29 Nov	10 Dec	11 Dec
4 Dec	12 Dec	13 Dec
6 Dec	13 Dec	13 Dec
Field data	11-15 Dec (mid-point 13th)	

Miticide timing recommendations in 1987

In its present form, the computer model requires ERM population data to begin a simulation in the spring. The best time to sample the population, is around mid to end October, when winter egg hatch is almost complete, and mites are present on the leaves. Between 25 and 100 apple leaves with ERM were collected from a research or commercial orchard in each of the areas and the numbers of different mite stages were counted. These numbers, along with the appropriate temperature data — recorded temperatures, 5-day forecasted temperatures and historical temperatures — were entered. At intervals leading up to the expected spray periods, the model was run, and results were used to determine optimum spray times for ovicidal miticides during November, and non-ovicidal miticides in late November/early December. When the optimum spray period was within the next 8-10 days, the results were passed on to the newspapers for publication.

The ovicidal miticides, clofentezine and hexythiazox, are highly effective against eggs and larvae but do not kill adults, and their effect against nymphs is uncertain. Optimum dates for use of this type of miticide were determined as 8-day periods when summer eggs of the first generation formed the largest proportion of the population, and when the number of adult female ERM was starting to decline, but before protonymphs started to emerge (Fig. 2). In the 1987/88 season, hexythiazox was the only ovicidal miticide registered for post-bloom use on export apples during November.

The miticides azocyclotin and propargite are most effective against motile stages of ERM, but have little effect on eggs. To assist in determining spray times for these miticides, the model was adjusted to provide the daily ERM oviposition rate (Fig. 3). The objective was to wait until most of the eggs of the first generation had hatched and to then apply miticides to prevent a massive increase in egg production from the second generation of adult females. The optimum spray timing in relation to the population composition and the oviposition rate is shown in Figures 2 and 3.

The recommended spray dates appeared in local newspaper articles in the four districts. Information on spray dates was also given in the foyer of the Fruitgrowers Federation building in both Hawkes Bay and Clyde. Field sampling of ERM populations, particularly in late November and early December was carried out at one orchard in each of the areas, to assess the accuracy of the predictions.

RESULTS

Table 2 shows the recommended spray periods for ovicidal miticides and the dates on which they appeared in local newspapers. The timing of non-ovicidal miticides is more critical than for the ovicides so spray times within a shorter period of only 5 days were advised for these. Table 3 shows the recommended spray times for non-ovicides and the dates they appeared in the newspapers.

determined from field data. The exception to this was in Canterbury where no trough was demonstrated in the field data. However, there was a suggestion that some of the eggs in these samples were dead, which would mask the appearance of a trough.

Fig. 3: Predictive simulation for Hawkes Bay on 17 November, showing the optimum spray period just prior to the increase in ERM oviposition.

Fig. 4a-d: Predictive simulations for different regions of New Zealand used to determine spray timing of ovicidal (—) and non-ovicidal (---) miticides, compared with field data (↔) and a simulation carried out afterwards with actual temperatures (—). For details of the dates of the predictive simulations see Tables 2 and 3.

DISCUSSION

The model has been shown to be reliable at giving advanced predictions of early season ERM development, and hence optimum spray times for different miticides. The advantages it has over manual assessment of mite population development are that it is less time consuming and reduces the subjective nature of making predictions.

Because of the long period in November when ERM populations are composed mostly of eggs, ovicidal miticides can be effective over a longer period than non-ovicidal products. Calendar spraying dates for ovicides in each district may then be sufficient, if recommended spray dates have a sufficient margin for error to allow for temperature variations from year to year.

Timing of non-ovicides is more critical however, with a critical band for use of only about 5 days. If calendar spraying had been practised this year, then the 'usual' spray dates for Clyde, Nelson and Canterbury would have been adequate and should have given good control. However, the 'usual' spray period for Hawkes Bay of the first few days in December would have been at least a week late, because of the exceptionally warm spring temperatures in this region. Miticides applied during the first few days in December would have been less effective because of the proportion of new summer eggs already in the population (Fig. 3). It is for these atypical seasons that the predictive system is most useful.

As the model does not simulate hatching of winter eggs, it is necessary to take one mite sample, in mid to late October, to determine the age-structure of the population. This adds to the cost and time involved in running simulations and produces limitations.

One limitation of the present system is that it does not cater for local temperature variations within districts. The areas from which temperature data are obtained are assumed to be representative of the region. More districts could be accommodated in the scheme (assuming suitable temperature data were available), but this would increase the costs of operating the system.

Another limitation is the use of local newspapers to publicise spray times, because of the inevitable time lag between making the prediction and the appearance of an article. A more efficient method of getting the information to the orchardist is needed. on how many smaller areas the model can be run for. The next development of the model will be to investigate incorporating this feature.

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