PREDICTING EUROPEAN RED MITE EGG HATCH ON APRICOTS

2. THE USE OF HISTORICAL TEMPERATURE DATA.

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SUMMARY

An analysis of 38 years spring temperature data from Central Otago shows that there are strong correlations between the times at which different amounts of degree-day totals are accumulated. This knowledge is used to develop a simple method for predicting the 50% hatch date of European red mite (*Panonychus ulmi*) winter eggs, based upon an already existing degree-day model. Reasonably accurate predictions are produced 2 weeks in advance, and accurate predictions can be given 1 week in advance. This method is simple and can be used by anyone possessing an accurate measure of maximum and minimum daily temperatures.

INTRODUCTION

European red mite (ERM) (*Panonychus ulmi* [Koch]) is a serious pest of young apricot fruits in spring in Central Otago. Young mites hatching during September and October feed on the developing fruit, damaging the surface and permitting the entry of bacteria (Young and McLaren 1980). Damage can be minimised by a single acaricide application timed to coincide with the day on which 50% of the mites have hatched from overwintering eggs (McLaren 1983).

A simple temperature driven model allowing prediction of the ERM egg hatching curve and 50% hatch date has been developed (Hill and McLaren 1988). This provided accurate retrospective predictions using historical temperature data. It also proved successful in 1986 and 1987, in a forecasting system which provided growers with a predicted spraying date (coinciding with 50% hatch date) a minimum of 1 week in advance. This used both historical mean temperatures and predicted maximum and minimum temperatures supplied by the New Zealand Meteorological Service (Hill and McLaren 1988).

The time of 50% hatch was predicted as the day on which 283 degree-days were accumulated above a base temperature of 3 °C starting on August 25 (Hill and McLaren 1988). Six years of observations have shown that there is a 14 day variation in the date of 50% ERM winter egg hatch (October 2-16). For a single acaricide application to be effective, it must be applied within a "tolerance band" not more than 2 days before and not later than 3 days after the actual 50% hatch date (McLaren 1980, 1983 and unpublished observations), and the usefulness of spray date predictions is based upon this criterion.

As the degree-day accumulation starts on August 25, and hatching does not begin until mid-late September, the temperatures throughout this period will affect egg development. For example, we would expect there to be a strong correlation between the predicted 50% hatch day and the day on which 270 degree-days were accumulated (only 12 degree-days earlier). This correlation should weaken as the dates of progressively smaller degree-day accumulations are chosen for comparison with the 50% hatch day. If sufficiently strong correlations are achieved between the dates on which appreciably smaller amounts of degree-days are accumulated and the predicted 50% hatch day, this information can be used to provide an advanced warning system of the predicted 50% hatch day.

To test this, maximum and minimum daily temperatures from a site in Central Otago for 38 years, 1948–1985 inclusive, were examined for evidence of correlation between dates on which the 50% egg hatch was predicted and dates on which smaller

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amounts of degree-days have been accumulated from the same starting date and temperature threshold.

METHODS

Using the starting date of 25 August and the base temperature of 3 °C, the formula below was used to calculate accumulated degree-days.

$$\text{cumulative degree-days} = \left[\frac{(\text{maximum daily temp} + \text{minimum daily temp})}{2} \right] - 3.$$

The days on which 180, 200, 230, 250 and 283 degree-days had accumulated were calculated for all years from 1948 to 1985. The data were from the Meteorological Service site at DSIR Earnscliffe from 1948 to 1982 and at DSIR Clyde from 1983 to 1985, (no temperature correction for these different sites was necessary [Hill and McLaren 1988]).

RESULTS AND DISCUSSION

There was a strong correlation between the date on which each of the smaller degree-day totals was accumulated, and the predicted date of 50% winter egg hatch (i.e. the date from August 25 on which 283 degree-days above 3 °C is reached). The correlations (Pearson's *r*) were 0.81 at 180 accumulated degree-days; 0.9 at 200; 0.96 at 230 and 0.98 at 250 accumulated degree-days (*n* = 38; *P* < 0.001).

Further analysis showed that there was no correlation between the date on which each of the smaller degree-day totals had accumulated and the time interval from that date to the predicted 50% hatch date. This was true for all four degree-day accumulations. As a result, the mean number of days between the date of accumulation of the smaller degree-day total and the predicted 50% hatch date was calculated, using all of the historical temperature data (Table 1). It follows that the predicted date of 50% egg hatch can be estimated starting from the date on which the smaller degree-day total is achieved by adding the mean time interval in days between the date of accumulation of the smaller degree-day total and the predicted 50% hatch date as calculated above.

TABLE 1: Statistics of days remaining to the predicted 50% egg hatch date from the date on which 180, 200, 230 and 250 degree-days had accumulated above a 3 °C threshold starting on August 25. Based on 38 years mean daily temperature data.

	degree-days accumulated			
	180	200	230	250
mean	13.9	10.9	6.7	4.1
median	13.5	11.0	7.0	4.0
standard error	0.43	0.32	0.22	0.14
range	9—21	7—15	4—9	2—6

The mean number of days between events in Table 1 were used to provide estimates of the predicted 50% hatch date for each of the 38 years data starting from the dates on which each of the smaller degree-day totals had accumulated. These estimates were compared with the predicted date of 50% hatch calculated using the full 283 degree-day accumulation. The closeness of the predictions from all four smaller degree-day accumulations are shown in Fig 1, as the deviation of the estimated prediction from the actual prediction. From the 180 degree-day point, the estimates are given on average 14 days in advance of the predicted 50% hatch date, and provide estimates within the "tolerance band" of 2 days early and 3 days late in 29 out of 38 years (76%). From the 200 degree-day point, the estimates are 11 days in advance, and were within the tolerance band in 32 out of 38 years (84%). At the 230 degree-day point, the estimates are 7 days in advance of the event, and were within the tolerance band in every year (100%). Finally, the 250 degree-day point estimates are on average 4 days in advance

and were also all within the tolerance band (100%).

Thus, the predicted 50% hatch date can be estimated in advance with a reasonable degree of accuracy. Predictions of the 50% egg hatch from the 283 degree-day accumulation have been shown to agree closely with actual field observations (Hill and McLaren 1988). When actual dates are compared with the estimates from smaller degree-day accumulation dates (Table 2), these estimates are still found to be sufficiently accurate for predicting 50% egg hatch in 1986 and 1987.

TABLE 2: Differences between actual date of 50% egg hatch, that predicted from a model (Hill and McLaren 1988), and advanced predictions from 4 earlier dates on which 180, 200, 230 and 250 degree-days had accumulated from August 25. Negative values are late predictions, positive values are early predictions.

Year	Difference (in days) between observed-predicted 50% ERM egg hatch				
	degree-day accumulation				model prediction 283
	180	200	230	250	
1986	-1	0	0	0	0
1987	-1	-1	0	+1	+1

Fig. 1: Deviations (in days) from predicted 50% ERM egg hatch date and estimated date from accumulated degree-day totals of

250 (solid black) 230 (diagonal lines) 200 (horizontal lines) 180 (vertical lines) degree-days

above the base of 3°C starting from August 25, for 38 years temperature data. Negative values are for late predictions, positive values for early predictions. Vertical dashed lines mark off the "tolerance band", representing the accuracy required for the prediction.

This method will not take into account occurrence of very hot or very cold days within a few days of 50% egg hatch. Unusually hot days occurred in 1980, culminating in the earliest 50% hatch date within the last 10 years of observations (McLaren 1985; Hill and McLaren 1988). The prediction of such hot days can be achieved by interpreting long range weather forecasts produced by the Meteorological Service which are published in newspapers.

Fifty three degree-days must accumulate between the 7-day forecast (i.e., the 230 degree-day accumulation point) and the date of the predicted 50% egg hatch. Years in which the actual 50% egg hatch date falls outside the "tolerance band" for the 7-day forecast will be years of unusually hot or unusually cold temperatures during the week before the 50% hatch date. In the 8 years between 1978 and 1985, the time required to accumulate 53 degree-days ranged from 4-9 days. Thus published long range forecasts could be used to estimate the likelihood of unusually hot or cold periods over the coming week, and the prediction 'fine-tuned' to allow for this.

Estimates of the 50% hatch date from the 250 degree-days accumulation point, while only on average 4 days away from the 50% hatch date, should be within the "tolerance band" for a very high proportion of the time.

This method is simpler to operate than one relying upon Meteorological Service temperature forecasts, and can be used by anyone who possesses a reliable measurement of orchard maximum and minimum temperatures.

At present, the Meteorological Service weather system forecasting model provides temperature predictions only 5 days in advance. Predictions longer than this rely on historical mean daily temperatures. Thus, the longer range predictions of 14 and 11 days in advance provided by the method described here are likely to be as reliable as those based on the Meteorological Service forecasts which rely on historical mean daily temperatures for periods more than 5 days in advance.

This system should prove accurate enough to provide preliminary spray forecasting dates 2 weeks in advance and accurate forecasts 1 week in advance, with a final more accurate check within 4 days of 50% hatch.

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