METEOROLOGICAL DATA FOR PREDICTING APPLE PEST PHENOLOGY

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SUMMARY

Daily maximum temperatures collected inside orchards or by New Zealand Meteorological Service (NZMS) stations were compared for day-degree summation and operating a pest phenology model for codling moth. One case is discussed in detail. Over summer months (December-March) maximum temperatures inside orchards tended to slightly exceed those recorded at NZMS sites. These differences are insufficient to prevent at least some existing sites providing the data required to operate these models reliably. It will not, therefore, usually be necessary to establish separate stations to record weather data inside orchards.

A biophenometer which automatically records temperature and determines day-degrees was also evaluated. This instrument was found to be a reliable and rapid method for collecting data.

INTRODUCTION

In many fruit growing areas, optimisation of the use of insecticides especially those directed against codling moth, is in progress. A key factor is the improved timing of insecticide application. Wearing and Charles (1978) have already shown the potential for pheromone traps to improve control of codling moth in New Zealand. An alternative is the use of thermal summation to predict pest phenology. Glenn (1922) was the first to show the potential of this technique to assist codling moth control. In New Zealand, Wood (1965) has discussed the relationship between accumulated day-degrees and events in codling moth life-history. In recent years, models have been developed which are driven by daily temperature data to predict apple pest phenology. One of the most widely used is the PETE (Predictive Extension Timing Estimator) model described by Welch *et al* (1978).

Phenology models require a reliable source of temperature data correlated with that which the insects experience. When a study was initiated to evaluate PETE in Canterbury, two possible obstacles to the use of local weather data were foreseen. Firstly, the model would fail to simulate daily temperature patterns due to the rapid changes in hourly temperature which can occur in some parts of New Zealand. This was found to occur (Worner and Penman 1983). Secondly, the climatic data collected at New Zealand Meteorological Service (NZMS) stations might differ from that occurring inside orchards.

To investigate the second aspect, five meteorological stations were established inside orchards located in districts throughout north Canterbury. Results from one of these orchards is discussed in detail in this paper.

Overseas growers are using automatic devices to record accumulated day-degrees for pest, disease and plant development in order to time key management practices. One of these instruments, a biophenometer (Omnidata Inc, Utah, USA) was evaluated in this study. At 10 minute intervals, this instrument determines the air temperature and uses these data to calculate day-degrees accumulated above temperature thresholds set by the operator.

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METHODS

Recording equipment

A Stevenson screen (size: 600 x 400 x 50 mm) supported 1 m above ground was placed at an exposed site inside each orchard. Temperature was recorded with a thermohygrograph (Hisomatsu model 3) which was calibrated weekly against a reference dry bulb thermometer inside the screen. At one site (Lincoln College) a biophenometer was placed inside the screen and operated over the 1981-82 season.

Sites

To obtain data to validate model predictions, pheromone traps (Pherocon 1C, Zoecon Co, Alto Palo, USA) were placed inside commercial and unsprayed orchards to monitor codling moth flight.

Daily maximum and minimum temperature data were obtained from the NZMS stations closest to the study orchards. The geographical location of the sites compared were: Washington's orchard (43° 14'S, 172° 36'E) with Ashley State Forest (43° 14'S, 172° 36'E), Eyrewell State Forest (43° 23'S, 172° 16'E) and Rangiora township (43° 19'S, 172° 34'E). Other NZMS stations used for comparison were at Lincoln College (43° 38'S, 172° 30'E) and Harewood Airport (43° 29'S 172° 32'E).

Day-degrees (D°) were calculated from temperature data using the method of Baskerville and Emin (1969) incorporated in the PETE Model. The thermal constants and threshold temperatures for codling moth development determined by Glenn (1922) were used to operate the model.

Fig. 1: Comparison of mean monthly maximum and minimum temperatures recorded in 1979-80.

Fig. 2: Comparison of accumulated day-degrees determined by PETE model or biophenometer using temperature data collected in Lincoln College orchard, 1981-82.

RESULTS AND DISCUSSION

Daily temperatures

In Canterbury, heat accumulated above 10.0°C which is the lower threshold for codling moth's development, may vary widely between seasons (Goulter and Hurnard 1979). The effects of such variation were seen in this study. At Harewood airport, the day-degrees (D°) accumulated in October were 70.5, 134.2 and 91.4 in 1979, 1980 and 1981 respectively. As a result, the dates when codling moths began to fly in Canterbury were affected. Pheromone traps placed inside the orchards began to catch adults on 7-14 October in 1980 and 5-17 November in 1979 and 1981. Used in these circumstances, a phenology model for codling moth might enable orchardists to adjust the timing of insecticide applications.

The monthly mean maximum temperatures recorded inside orchards were generally higher than those recorded at NZMS sites. Between October and March when codling moths may be active in Canterbury, orchard monthly maximum temperatures were higher than those of NZMS sites by between 0.1-1.3 °C. However, at some sites, orchard temperatures were up to 1.0°C lower. Figure 1 compares the maximum and minimum temperatures recorded in the 1979-80 season at Washington's orchard and the nearest NZMS sites. In this case, the orchard's maximum temperatures were usually higher by between 0.1-1.2°C. A similar pattern was observed in the following two seasons. Temperatures inside Washington's orchard were the most and least similar to those recorded at Eyrewell and Ashley respectively.

Unlike the maximum temperatures, the minimum temperatures inside the orchard were not comparatively higher.

Accumulated heat

The slight differences in temperatures between sites were reflected by the amount of heat accumulated. From October 1979 to March 1980 inclusive, at Washington's orchard 799.0 D° were accumulated which was 69.4, 39.3 and 5.4 more than at Ashley, Eyrewell and Rangiora respectively.

The D° determined by the biophenometer differed from that calculated from the daily temperature records with the method of Baskerville and Emin (1969) used in the PETE model, in November (Figure 2). This might affect predictions of codling moth phenology for the entire season. Worner and Penman (1983) have already shown how the model's D° calculation method overestimates D° in the latter part of the season under Canterbury's conditions. The biophenometer appears to be a reliable instrument for growers to determine D°. It could be used in conjunction with charts of pest phenology to time insecticide sprays in a system similar to that developed by Minks and de Jong (1975).

Predicted pest phenology

Table 1 compares predictions of codling moth flight with that recorded by pheromone traps placed inside Washington's orchard. The date of 50% emergence recorded at Washington's orchard may be erroneous due to the low numbers of moths trapped. At another site, where large numbers of moths were caught the date was closer to 8 December.

TABLE 1: Actual dates of key events compared with predicted phenology of codling moth in Canterbury using different sources of temperature data for the 1979-80 season.

Event	Actual		Predicted data source		
	Washington's	Ashley	Eyrewell	Rangiora	Washington's
50% adult flight	27 December	13 December	16 December	9 December	11 December
End of flight	23 February	12 March	19 March	26 February	28 February
50% oviposition		28 December	23 December	23 December	23 December
50% egg hatch		16 January	12 January	11 January	9 January

The effects of using the different sources of temperature data on predictions of pest phenology were not marked. Insecticides applied to control codling moth must be timed to prevent hatching larvae from penetrating fruit. The predicted dates of 50% egg hatch using Washington's orchard temperature data differed by 8, 3 and 1-2 days from the dates predicted using the Ashley, Eyrewell and Rangiora data respectively. Clearly some sources of data from NZMS sites near to orchards may be unsuitable and this can only be found by studies such as these. However, in this case it would not have been necessary to operate a meteorological station in Washington's orchard as predictions made using the data from Rangiora township or Eyrewell would have sufficed.

These results were confirmed by comparisons made between other sources of temperature data. For example, the day-degrees accumulated from October to March inclusive at Lincoln College NZMS and at a nearby orchard only differed by 19.8 D°. Such variation may well be less than between NZMS sites at least some of which are suitable for operating phenology models such as the PETE model.

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