HDC Project FV 121

ANNUAL REPORT

Forecasting cabbage aphid attacks

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CONTENTS OF REPORT

SCIENCE SECTION

INTRODUCTION

The small numbers of cabbage aphid (*Brevicoryne brassicae)* that manage to overwinter successfully on cultivated brassicas and cruciferous weeds usually develop into large colonies during spring and early summer. Depending upon season and locality, winged females from these colonies migrate into new crops between June and August. Even within a locality, however, the timing of cabbage aphid migrations can vary by several weeks from one year to the next. Hence, the optimum timing of mid-to-late season sprays applied against this pest at present is difficult to judge accurately.

The objective of the project is to devise methods, based on agrometeorological data, for forecasting the peak periods of immigration of cabbage aphids into brassica crops and for determining the subsequent build-up of cabbage aphid numbers in such crops. Although considerable efforts have been made in recent years, using MAFF and HDC funding, to implement systems of supervised control, such systems are based on sampling crop plants on a calendar basis rather than on information about the development of cabbage aphid populations. In addition, sprays are generally applied only after cabbage aphid populations have built up. Therefore, if such sprays are less than 100% effective, a significant population of aphids can remain even after spraying and such aphids continue to produce new young. Thus if the build-up of cabbage aphid infestations on brassicas could be predicted, crop sampling and subsequent spraying could be timed more effectively.

MATERIALS AND METHODS

Biological data on the relationship between the rate of development of cabbage aphid populations and temperature are needed, as such information forms the basis of the

model. Considerable information on the field biology of the cabbage aphid exists already in the scientific literature. Most of the laboratory-based, biological studies on the cabbage aphid have been made in the Netherlands, France, Canada, the USA, Australia and Japan. Although much of this information can be used to provide the basis of our forecast model, development of populations of cabbage aphids within the United Kingdom must also be studied to make sure that there are no differences in development times, reproduction rates or other important biological factors in the UK populations of aphids.

Laboratory studies

The rate of aphid development and the numbers of offspring each aphid produces are the major factors that determine the build-up of aphid infestations and hence it is important to measure these two factors accurately. To obtain appropriate biological data, cabbage aphids have been reared in cooling incubators at a range of constant temperatures at Wellesbourne to determine their relative rates of development and reproduction.

Field studies

Detailed records of the development of field populations of cabbage aphid are required to validate the cabbage aphid forecast. Such records must be obtained from a number of locations over several years, to produce a sufficiently wide range of conditions over which to test the forecast. Cabbage aphid studies at Wellesbourne during 1968-70 (Dunn & Kempton, 1971) and 1986-87 have already provided some extensive sets of data, but further, more detailed, information is still required.

INTERIM RESULTS

Studies in the laboratory

The development times of cabbage aphids at Wellesbourne and the numbers of offspring each aphid produces are compared with data from four other countries in Tables 1 & 2 and Figure 1. Further biological data are required and are being collected currently at Wellesbourne.

Aphid development

Table 1 and Figure 1 show the duration of cabbage aphid development from birth to production of first young at a range of constant temperatures. Development times range from 28-43 days at 10°C to 6-11 days at 30°C. Although the development times for aphids from the different countries appear similar when looked at superficially, there are some important differences, particularly at lower temperatures.

Numbers of offspring produced per aphid

Table 2 shows the average numbers of live young produced by adult aphids during their reproductive period. There are large differences in fecundity; wingless aphids in the laboratory in Canada produced almost twice as many young as those at Wellesbourne whilst those in the USA produced only half as many.

Preliminary forecast

A preliminary cabbage aphid forecast has been developed using a computer modelling package called 'Matlab'. The model to simulate the development and reproduction of cabbage aphid populations uses daily air maximum and minimum

temperatures. The model has been developed with data collected mainly in Canada and daily temperatures calculated as day-degrees above a base temperature of 6.7°C. The model follows the development and reproduction of individual aphids, from birth to death and the development and reproduction of each of their progeny through the generations. It can simulate the development of several thousand aphids. The model is being used, in the first instance, to predict the intial rapid build-up in aphid numbers at the start of the summer. It will also be possible subsequently to incorporate information on the many other biological factors (e.g. parasitism, disease, predation, migration) whose effects often lead to a decline in aphid numbers later in the year.

Studies in the field

During the present study, the development of cabbage aphid populations on brassica crops (Brussels sprouts and cabbage) were recorded at Wellesbourne (1992,1993), ADAS Arthur Rickwood (1992,1993) and Kirton (1993). At regular intervals, 15-30 plants per plot were examined carefully on each test plot to monitor the build-up of the aphid infestation. The numbers of aphids (winged, wingless and parasitised) and numbers and diameters of aphid colonies were recorded on each plant on each occasion. All plots were pesticide-free. The activity of winged cabbage aphids was also monitored using yellow water traps placed on the ground close to the plots.

Figure 2 shows the mean colony area per plant on Brussels sprouts grown at Wellesbourne (1992-93) and Kirton (1993) and cabbage grown at ADAS Arthur Rickwood (1992). In all four crops there was an initial rapid increase in aphid numbers and then the rate of increase gradually declined. This was often followed by a decrease in aphid numbers, particularly pronounced following periods of heavy rainfall. A second

increase in aphid numbers occurred in late summer.

At Wellesbourne in 1992, aphid populations were recorded on separate plots of early and late sprouts to see whether planting date affected the increase in aphid numbers. At Kirton in 1993, separate, additional plots were sprayed with pirimicarb at two-week intervals until mid-July, early August and early September respectively, remaining unsprayed for the rest of the season, so that the development of cabbage aphid populations following spraying could be recorded. In both studies the overall pattern of cabbage aphid development was similar on all plots, although the total numbers of aphids recorded differed as a result of the various treatments.

The mean area per plant of each aphid colony was also plotted against physiological time, using the Canadian estimate of day-degrees above a base of 6.7°C. There was a rapid increase in aphid numbers at the start of the aphid infestation. This increase occurred usually between 350 and 650 day-degrees. The slope of the line describing the initial population increase was similar for all sets of data. Each year, following the initial rapid build-up, aphid populations reached a plateau and then usually declined. Any subsequent 'crash' in aphid numbers appeared to be determined by periods of heavy rainfall rather than by physiological time.

SUMMARY OF INTERIM CONCLUSIONS

1. The rate of cabbage aphid development is temperature dependent. Cabbage aphid populations increase more rapidly when the weather is warm.
2. Rates of cabbage aphid development and the numbers of offspring each aphid produces may vary with geographical location.
3. The initial rapid increase in cabbage aphid numbers can be described on a day-

degree scale.

4. The subsequent cabbage aphid 'crash' is probably related to both an increase in the numbers of natural enemies and periods of heavy rainfall.

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Table 1. Cabbage aphid - days from birth to production of first offspring at a range of constant temperatures

Temperature °C	Wellesbourne	Netherlands Hafez (1961)	Canada* Raworth (1984)	USA DeLoach (1974)	Australia* Hughes (1963)
7.5	52				
10	34.7		43	33.2	28.2
12.5	23.4				
13.1		37			
15	17		17	19.2	14.1
16	16				
17.5	11.5				
17.8		16.5			
20	12.3		10.7	12.3	9.4
22.5	11.3				
23.2		11			
25	10.1		7.8	10.4	7.1
28.2		10			
30	10		6.1	11.0	5.6
30.9		11.5			

* Estimated from day-degree requirements

Table 2. Number of offspring produced by wingless cabbage aphids

Wellesbourne	maximum of 35
Netherlands	26-29
Canada	41
USA	11
Australia	34-39

Figure 1. Cabbage aphid - days from birth to production of first offspring at a range of constant temperatures.

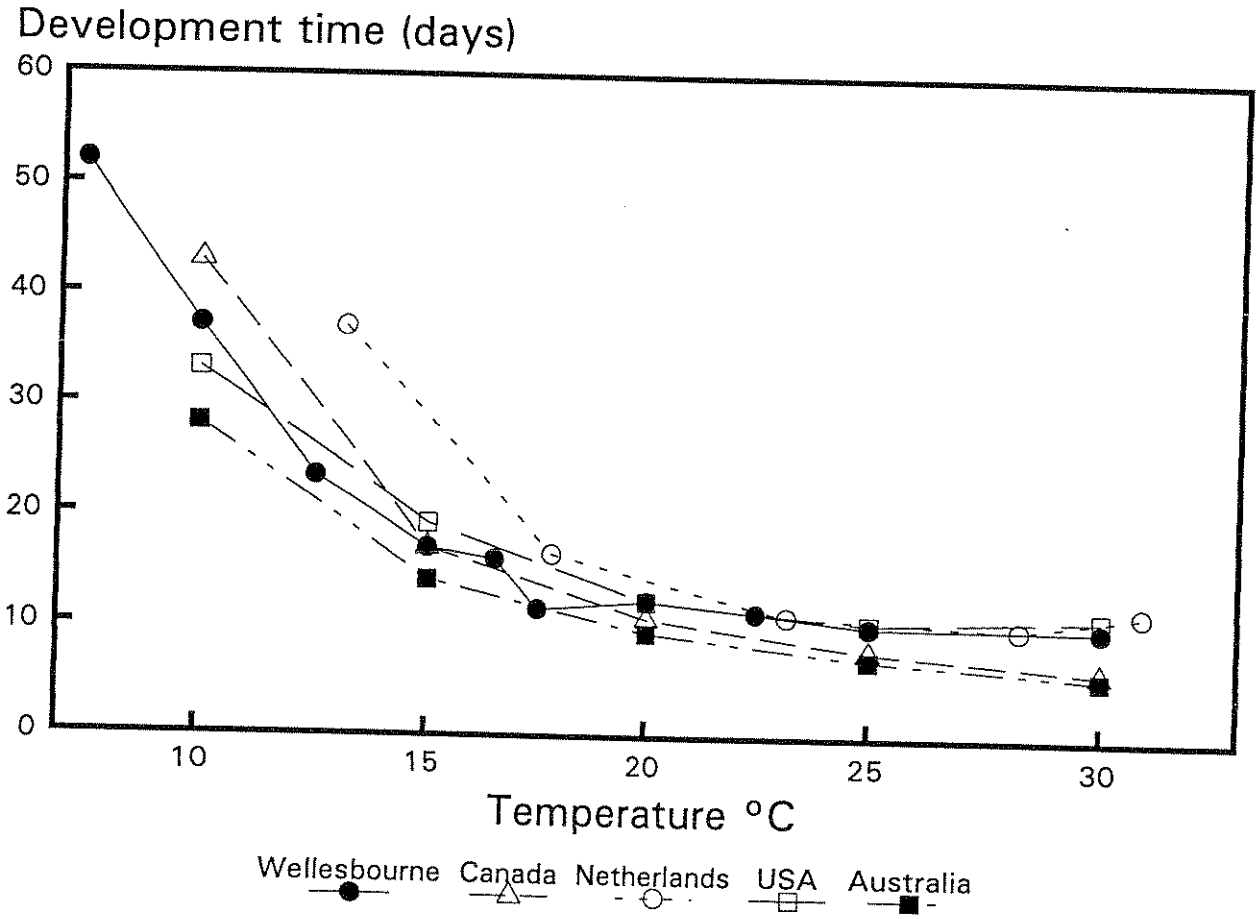

Figure 2. Cabbage aphid - mean area per plant of aphid colonies on brassica crops (Brussels sprouts or cabbage) grown at Wellesbourne and ADAS Arthur Rickwood in 1992, and at Wellesbourne and Kirton in 1993. All plots were pesticide-free.