HDC Project FV 121

FINAL REPORT

Forecasting cabbage aphid attacks

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Final Report:	1992-96
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GROWERS SECTION

APPLICATION

The aim of this project was to devise a method based on agrometeorological data, for forecasting the periods of peak immigration of cabbage aphids into brassica crops. A computer model to forecast the initial increase in aphid numbers was developed and a preliminary version will be tested with growers during 1996. Efforts were also made to produce a reliable forecast of the mid-season population crash in the numbers of aphids, and of the subsequent increase in aphid numbers in late summer. However, insufficient biological information was available to permit these events to be forecast accurately and further studies are required before this part of the model can be refined further.

SUMMARY

Edible brassica crops are sprayed intensively to control such pests as cabbage aphid and cabbage caterpillars. However, brassica growers are now being encouraged by retailers to adopt systems of Integrated Crop Management, and, whenever feasible, to reduce the amounts of insecticide applied to their crops. The underlying principles are that insecticides should be applied only when the pest is present, and that routine applications of insecticides, made at fixed time intervals, are not desirable. It is envisaged that a reduction in the amount of insecticide applied to brassica crops can be achieved by monitoring crops at the times indicated by pest forecasts, and then using thresholds to determine whether sufficient insects are present to merit the application of insecticide.

During spring and early summer, the small numbers of cabbage aphid, *Brevicoryne brassicae*, that overwinter successfully on cultivated brassica crops and cruciferous weeds develop into large colonies. Winged females from these colonies migrate, usually from late May onwards, into new crops. Even within a locality, however, the timing of cabbage aphid immigration can vary by several weeks from one year to the next. Hence, it can be difficult to judge accurately the optimum timing of the first sprays against this pest. There is usually also a natural 'crash' in the aphid population during late July-early August, thought to be caused by aphid predators, parasitoids, and a naturally-occurring fungus. There is no need to apply insecticide treatments during this period. Later in the summer, aphid numbers begin to increase again; the rate of increase being determined by weather conditions. Weather also determines the decline in aphid numbers prior to overwintering. Thus, if the increase in, and natural decline of, cabbage aphid populations can be predicted, crop sampling and subsequent spraying could be timed more effectively.

The aims of this project were a) to devise methods, based on weather data, to forecast the time when cabbage aphids start to infest edible brassica crops, and b) to determine the subsequent increase of populations once aphids have entered a crop.

Experimental work was done at HRI Kirton and HRI Wellesbourne (Rosemary Collier, Stan Finch) and at ADAS Arthur Rickwood (Jennie Blood Smyth).

Studies using incubators maintained at a range of constant temperatures indicated that the rates of both aphid development and aphid reproduction are temperature-dependent. During the spring and summer, cabbage aphids always produce live young. In incubator studies to determine the effect of temperature on aphid maturation, a new-born aphid took from 49 days at 7.5°C to 6 days at 30°C to mature and start to produce young. Analysis of the data from these studies showed that the low temperature threshold for aphid development was about 6°C.

Aphids produced fewer young at the extremes of their temperature range. Optimum reproduction occurred at temperatures from 12.5 to 22.5°C. Aphids reared at 17.5°C produced approximately three times as many young as aphids reared at 7.5°C. Length of life was also affected by temperature, as aphids survived on average about 77 days at 7.5°C but only 16 days at 30°C.

During 1992-95, aphid numbers were monitored in insecticide-free plots of Brussels sprouts or cabbage, at HRI Wellesbourne, ADAS Arthur Rickwood and HRI Kirton. Data collected previously at HRI Wellesbourne were re-analysed. The results showed that at all sites in all years there was an initial rapid increase in aphid numbers, followed usually by a period of rapid decline, or population 'crash', that generally occurred after periods of rainfall. A second increase in aphid numbers occurred during late summer (Figure 1). Observations in insecticide-treated crops at HRI Kirton and in commercial fields indicated that, within a given locality, the mid-season crash in aphid numbers occurred in all crops, and was independent of the size of the aphid infestations or whether the crops had been treated previously with insecticide.

The date on which > 1 aphid/plant was first recorded varied from 17 May at ADAS Arthur Rickwood in 1995 to 5 August at HRI Wellesbourne in 1987. Similarly, the date on which peak numbers of aphids were recorded prior to the mid-season crash, ranged between 11 July and 19 August. In various years, the late summer peak in aphid numbers was recorded as early as 10 September and as late as mid-December. Thus, the pattern of population increase was extremely variable from region-to-region and from year-to-year.

The numbers of aphids recorded also varied considerably from site-to-site and from year-to-year. In general, cabbage aphids were more numerous at HRI Wellesbourne and ADAS Arthur Rickwood than at HRI Kirton. However, as the absolute size of any aphid population is affected by many factors, it is difficult to make firm conclusions about the effects of weather.

The numbers of aphid mummies, that resulted from aphids being parasitised by the small wasp, *Diaeretiella rapae*, counted in the routine samples varied considerably from week-to-week and from site-to-site. In general, parasitoid activity appeared to be a direct reflection of aphid activity. However, when aphid populations crashed in mid-summer, there was usually a period when high numbers of parasitised aphids were present in the crop, after all live aphids had disappeared. These represented the immature parasitoids that still had to complete their development and emergence from the aphid mummies as adult wasps. Although parasitoid numbers varied considerably between sites, their numbers were always in proportion to the size of the aphid infestation. During each of the two peaks of aphid activity, the proportion of parasitised aphids appeared to be relatively constant over all site/year combinations.

A preliminary cabbage aphid forecast was developed using the computer modelling package 'Matlab'. The basic model used daily air maximum and minimum temperatures recorded from 1 January, to drive equations that described the rates of aphid development and aphid reproduction. The model followed the lives of individual aphids, from birth to death, together with the reproduction of each of their progeny through the generations. It simulated the development of several thousand aphids. Over half of the predictions of the rapid increase in aphid numbers at the start of the summer were accurate to within one week. However, a few of the forecasts were very late and the reasons for this require further investigation. The model predicted correctly that aphid numbers increased earlier in 1995 than in 1994, and that development of aphid infestations was particularly late in both 1986 and 1987.

The periods during which aphid numbers increased most rapidly were usually free of rainfall whereas the aphid crash generally followed periods of rainfall. This could have been due to the mechanical effects of the rain but it is more likely an indirect effect of the increased wetness and humidity favouring the development of a naturally-occurring fungus disease, probably *Erynia* spp. Attempts were made to improve the accuracy of the forecasts by incorporating rainfall data and published information on how temperature, humidity and leaf wetness influence the spread of fungus disease. This information was used with daily records of relative humidity to model the mid-season crash in aphid numbers.

The accuracy of simulations of the aphid crash based on temperature and rainfall data was variable. Incorporating published information on the biology of the fungus disease, and using daily measures of relative humidity, did not improve the consistency of the fits. More detailed biological studies must be done if the mid-season aphid crash, and the subsequent increase in aphid numbers in late summer, are to be predicted accurately.

ACTION POINTS FOR GROWERS

1. The timing of the first migration of winged cabbage aphids can vary considerably from region-to-region and from year-to-year. During this study, the date on which >1 aphid per plant was found varied from 17 May until 5 August. Thus, in some years early spray treatments may not be necessary. The cabbage aphid forecast has been developed to indicate when the first increase in aphid numbers is likely,

so that crop walking and the application of treatments can be timed more accurately.

2. Following immigration, the rapid increase in aphid numbers in early summer is usually followed by a natural 'crash' in the aphid population during late July-early August. Within a particular locality, the crash occurs at the same time in all brassica crops, regardless of the size of the aphid infestation or whether the crops have been treated previously with insecticide. MAFF-funded research has shown that insecticide treatments applied during this period are not necessary.

3. Later in the summer, aphid numbers usually increase; the rate of increase being determined by weather conditions. At this stage, the timing of insecticide treatments may be critical.

4. This year, as part of the initial validation process, growers will have the opportunity to compare forecasts, based on temperatures recorded at their nearest weather station, with their own records of aphid numbers.

BENEFITS

The aim of this work is to help growers to time their crop-walking and spray applications more effectively so that they can avoid having to make routine applications of insecticide. This is in line with the requirements of supermarkets as indicated in the ICM protocols and should, in some cases, reduce spraying costs.

SCIENCE SECTION

INTRODUCTION

Edible brassica crops are sprayed intensively to control foliar pests, particularly cabbage aphid and caterpillars. Brassica growers are now being encouraged by retailers to adopt systems of Integrated Crop Management, and, whenever feasible, to reduce the amounts of insecticide applied to crops. The underlying principles are that insecticides should be applied only when the pest is present, and that routine applications of insecticides at fixed time intervals are not desirable. It is envisaged that a reduction in the amount of insecticide applied to brassica crops can be achieved by using pest forecasts to determine the most appropriate times to inspect crops and threshold numbers of insects to decide whether any treatment is necessary.

The small numbers of cabbage aphid that overwinter successfully on cultivated brassica crops and cruciferous weeds develop into large colonies of aphids during spring and early summer. Winged females from these colonies migrate into new crops usually from late May onwards. Even within a locality, however, the timing of the cabbage aphid migration can vary by several weeks from one year to the next. Hence, the optimum timing of sprays against this pest can be difficult to judge accurately.

The objectives of this project were to devise methods, based on weather data, to forecast the time when cabbage aphids start to infest edible brassica crops and to determine the subsequent increase in cabbage aphid populations in such crops. Experimental work was done at HRI Kirton and HRI Wellesbourne (Rosemary Collier, Stan Finch) and at ADAS Arthur Rickwood (Jennie Blood Smyth).

Although considerable efforts have been made recently within MAFF and HDC funded projects to develop systems for the supervised control of cabbage aphid, all of the previous systems have been based on sampling crop plants on a calendar basis. In addition, in such systems, sprays have generally been applied only after cabbage aphid populations have been allowed to increase. Therefore, if sprays applied at such times are less than 100% effective, significant numbers of aphids can continue to produce new young. There is usually also a natural 'crash' in the aphid population during late July-early August, caused by predation, parasitism, and a naturally-occurring fungus disease. Treatment with insecticide during this period is not necessary. Later in the summer, aphid numbers usually increase; the rate of increase being determined by weather conditions. Weather also determines the decline in aphid numbers prior to overwintering. Thus, if the increase and natural decline of cabbage aphid populations can be predicted, crop sampling and subsequent spraying could be timed more effectively.

Considerable information on the field biology of the cabbage aphid exists already in the scientific literature. Most of the biological studies on the cabbage aphid have been done outside of the UK; in the Netherlands, Canada, USA, Australia and Japan (Hafez, 1961; Raworth, 1964; DeLoach, 1974; Hughes, 1963; Kawada, 1965). Although much of this information could be used to provide the basis of a forecast, it was important to study populations of cabbage aphids within the United Kingdom to make sure that there were no differences in development times, reproduction rates or other important biological factors.

MATERIALS AND METHODS

Incubator studies

The rate of aphid development, and the numbers of offspring each aphid produces, are the two major factors that determine the size of any aphid infestation. Hence, it is important to measure these two factors accurately. The relationship between the rate of development of cabbage aphid and temperature forms the basis of the current cabbage aphid forecast which was developed from experimental work done during 1992 and 1993. To obtain information on the relative rates of development and reproduction of the cabbage aphid, aphids were reared in cooling incubators at HRI Wellesbourne at a range of constant temperatures between 7.5° and 30°C.

Field studies

Detailed records of the development of field infestations of the cabbage aphid were required to determine the pattern of aphid activity throughout the summer and to obtain data to validate the cabbage aphid forecast. Records were taken over several years from a number of locations, to produce a sufficiently wide range of conditions over which to test the forecast. Cabbage aphid studies at HRI Wellesbourne during 1968-70 (Dunn & Kempton, 1971) and 1986-87 (data collected by P.R. Ellis) provided some data, but further, more detailed, information was required. During 1992-1995, detailed records of the development of field populations of cabbage aphid on Brussels sprouts and cabbage were collected at HRI Wellesbourne (1992-95), HRI Kirton (1993-95) and ADAS Arthur Rickwood (1992-95). At intervals of 7-10 days, 15-30 plants on each test plot were examined carefully to monitor the size of the aphid infestation. All plots were insecticide-free. The numbers of aphids (winged, wingless and parasitised) and numbers and estimated diameters of aphid colonies were recorded on each plant on each occasion. These data were used to estimate the total numbers of aphids per plant. The dispersal of winged cabbage aphids was also monitored using yellow water traps placed on the ground alongside the plots.

RESULTS

Incubator studies

Aphid development

During the spring and summer, cabbage aphids always produce live young. Figure 2 shows the duration of cabbage aphid development from birth to production of the first young at a range of constant temperatures. Such studies were done with apterous (wingless) aphids which were themselves the progeny of either alate (winged) or apterous aphids. Development times ranged from 49 days at 7.5°C to 6 days at 30°C and were similar for the progeny from both alate or apterous aphids. The rate of aphid development (% development completed per day) versus temperature is shown in Figure 3. Extrapolation of the line fitted to these data showed that the low temperature threshold for aphid development was close to 6°C. Temperature also determined length of life. Aphids survived from a mean of 77 days at 7.5°C to 16 days at 30°C (Figure 4).

Numbers of offspring produced per aphid

The total numbers of live young produced by adult apterous aphids, maintained at temperatures between 7.5 and 30°C, are shown in Figure 5. Fewer young were produced at the extreme temperatures, the optimum temperature range being between 12.5° and 22.5°C. Figure 6 shows the daily production of young by adult apterous (wingless) aphids maintained at either 7.5 or 17.5°C. Aphids reared at 17.5°C produced approximately three times as many young as those reared at 7.5°C.

Studies in the field

Figure 7 shows records of the mean numbers of aphids per plant at HRI Wellesbourne, ADAS Arthur Rickwood and HRI Kirton during 1995. Figure 8 shows similar data for HRI Kirton during 1993, 1994 and 1995. At all sites, in all years, there was an initial rapid increase in aphid numbers followed by a rapid decrease, which generally followed a period of heavy rainfall. A second increase in aphid numbers occurred in late summer. Observations in treated crops at HRI Kirton, and in commercial fields, indicated that within a locality the effects of the mid-season crash were apparent in all crops regardless of the size of the aphid infestation or whether the crop had been treated previously with insecticide.

Where sufficient data were available, the timings of certain stages in the development of aphid populations are shown for each site/year combination (Table 1). The date by which an infestation of > 1 aphid per plant was first recorded ranged from 17 May at ADAS Arthur Rickwood in 1995 to 5 August at HRI Wellesbourne in 1987. Similarly the date on which peak numbers of aphids were found in early summer, prior to the mid-season crash, ranged from 10 July to 19 August. In late summer, peak numbers of aphids occurred from 10 September right through until mid-December. Thus the pattern of population increase was extremely variable from region-to-region and from year-to-year.

The numbers of aphids recorded also varied considerably from site-to-site and from year-to-year. Aphids were usually more numerous at HRI Wellesbourne and Arthur Rickwood than at HRI Kirton. However, the absolute population size depends on factors such as the location of the monitoring plots in relation to sources of infestation. Hence, firm conclusions cannot be made about the effects of weather on aphid numbers.

The numbers of parasitised aphids (aphid mummies) were also recorded routinely and varied considerably from week-to-week and from site-to-site. Parasitoid activity appeared to reflect aphid activity directly (Figure 9). However, when the aphid population crashed in mid-summer, there was usually a period when high numbers of parasitised aphids were found after all of the live aphids had disappeared. This was because the partially-mature parasitoids within the aphid mummies were still completing their development.

Although parasitoid numbers varied considerably between sites, numbers were always a direct reflection of the size of the aphid infestation (Figure 10). More aphids were usually parasitised during the early summer peak than during the late summer peak.

Forecast development

A preliminary cabbage aphid forecast was developed using a computer modelling package called 'Matlab'. The basic model used daily air maximum and minimum temperatures to drive equations that described the rates of aphid development and aphid reproduction. The model followed from birth to death the development and reproduction of individual aphids, and the development and reproduction of each of their progeny through the generations. It simulated the development of several thousand aphids.

The model used air temperatures recorded from 1 January and the start of aphid migration was triggered using an equation, developed by members of the Rothamsted Insect Survey (R. Harrington, personal communication), that estimates the start of aphid migration from the mean air temperature during January and February. The colder the winter, the more delayed the cabbage aphid migration is likely to be.

Other information incorporated into the model includes 1) the proportions of alate and apterous adults produced by cabbage aphid populations at various stages of crop infestation (Hughes 1963; Kawada 1963), and 2) the relative development rates and fecundities of alate and apterous adults (Raworth, (1984)).

The periods during which aphid numbers increased rapidly, at a rate close to the optimum, were usually free of rainfall. In contrast, the mid-season aphid crash appeared to be triggered by periods of rainfall. For example, at HRI Kirton in 1994, there was no rainfall between 15 and 23 July and peak numbers of aphids were recorded on 26 July. However, it rained on 24, 28 and 31 July and aphid numbers had declined to their lowest level by 10 August. In 1995, aphid activity was very early and peak numbers of aphids were found at HRI Kirton on 11 July. This followed a dry, warm period from 17 June to 9 July. However, it rained between 10 and 17 July and aphid numbers began to decline during the following week.

The "crash" could be due to the direct effects of the rainfall but it is more likely to be an indirect effect from the increased wetness and humidity favouring the spread of the naturally-occurring aphid-killing fungus, probably *Erynia* spp. Attempts were made to model the effects of rainfall directly and then to incorporate information on the biology of *Erynia* obtained from the literature (Schmitz *et al.*, 1993; Milner & Bourne, 1983), particularly the effects of temperature, humidity and leaf wetness, and to use this information in conjunction with daily measures of relative humidity to model the timing of the mid-season crash. Simulations using the modified program were compared with monitoring data collected in untreated plots during the course of the project.

Forecast validation

The model can simulate the development of several thousand aphids and was used to predict 1) the rapid increase in aphid numbers at the start of the summer, 2) the mid-season 'crash' in aphid numbers and 3) the subsequent increase in aphid numbers during late summer.

Forecasts of the start of the initial rapid increase in aphid numbers were compared with field observations (taken as the date by which plants were infested with an average of 10 aphids) and are shown in Table 2. The forecasts indicated correctly that aphid numbers increased earlier in 1995 than in 1994 and that development of aphid infestations was particularly late in 1986 and 1987. More than half the forecasts were accurate to within one week and the majority were accurate to within two weeks. However, forecasts for ADAS Arthur Rickwood in 1995 and HRI Wellesbourne in 1970 and 1986 all gave very late warnings of the start of aphid activity. The reasons for this require further investigation. It was not possible to forecast the overall size of the aphid infestation as this will depend on the location of the overwintering hosts, the location of the sampling plots, and the size of the local population.

Simulations of the aphid crash using combinations of daily records of rainfall, relative humidity and published data on the effects of temperature and humidity on the spread of fungus disease were less successful. When between 1-5 mm of rain per day was used as a rainfall threshold, the simulations fitted quite well for some years, but not for others (Figure 11), as indicated by the simulated population being either killed (Wellesbourne 1970, Figure 11a) or increasing exponentially, which occurred with forecasts for all sites in 1995. Using records of relative humidity instead of rainfall did not improve the consistency of the fits. More detailed information on what triggers the outbreaks of this fungus disease is required if the crash in the aphid population is to be forecast accurately.

CONCLUSIONS

1. The rate of cabbage aphid development is temperature-dependent. Cabbage aphid populations increase more rapidly when the weather is warm.

2. In *Brassica* crops monitored during this project, the development of cabbage aphid infestations always followed a similar pattern. At all sites, and in all years, there was an initial rapid increase in aphid numbers followed by a decrease. A second

increase in aphid numbers occurred in late summer. The timing of these distinct periods of development of aphid infestations varied considerably from region-to region and from year-to-year.

3. Using information on the relationship between the rate of aphid development/reproduction and temperature, a model was developed to predict each year when aphids would first be found in *Brassica* crops.

4. The periods during which aphid numbers increased rapidly, at close to the optimum rate were usually free of rainfall. The mid-season aphid crash usually occurred shortly after a period of rainfall.

5. It is thought that one of the main factors causing the mid-season crash in aphid numbers is the conditions of increased humidity and leaf-wetness during rainfall that favour outbreaks of the naturally-occurring fungus disease of aphids.

6. Efforts were made to simulate the timing of the mid-season crash in aphid numbers, by incorporating published information on the biology of the fungus into the forecast model. However, it was not possible to find a relationship which simulated adequately all site/year combinations.

7. A further detailed biological study on the interaction between cabbage aphid, the fungus disease, and other factors, such as natural enemies, is required before the model can be refined further.

ACKNOWLEDGEMENTS

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Table 1. Dates of key stages in the development of field infestations of the cabbage aphid

		Date by which > 1 aphid/plant observed	Peak aphid numbers (early summer)	Peak aphid numbers (late summer)
ADAS Arthur Rickwood	1992	before 17 Jun	11 Jul	-
	1993	before 2 Jun	27 Jul	30 Sep
	1994	27 Jun	15 Jul	15 Dec
	1995	before 17 May	10 Jul	6 Oct
HRI Wellesbourne	1968	before 25 Jun	31 Jul	17 Sep
	1969	before 7 Jul	7 Aug	7 Oct
	1970	before 14 Jun	10 Aug	8 Oct
	1986	before 17 Jul	12 Aug	-
	1987	5 Aug	19 Aug	-
	1992	12 Jun	10 Jul	18 Sep
	1993	1 Jun	28 Jul	16 Sep
	1994	14 Jun	28 Jul	20 Oct
	1995	before 2 Jun	28 Jun	19 Sep
HRI Kirton	1993	23 Jun	23 Jul	10 Sep
	1994	12 Jul	26 Jul	3 Oct
	1995	7 Jun	11 Jul	19 Sep
Range		17 May - 5 Aug	10 Jul - 19 Aug	10 Sep - 15 Dec

Table 2. Forecasts of the initial rapid increase in cabbage aphid numbers compared with observations made on insecticide-free plants in the field.

		Forecast date of start of rapid increase in aphid numbers	Estimated date by which > 10 aphids/plant observed	Difference (Observed - forecast)
ADAS Arthur Rickwood	1992	18 Jun	20 Jun	2
	1994	20 Jun	27 Jun	7
	1995	4 Jun	20 May	-15
HRI Wellesbourne	1969	6 Jul	10 Jul	4
	1970	7 Jul	14 Jun	-23
	1986	8 Aug	29 Jul	-10
	1987	29 Jul	15 Aug	17
	1992	20 Jun	19 Jun	-1
	1993	6 Jun	2 Jun	-4
	1994	19 Jun	17 Jun	-2
	1995	2 Jun	31 May	-2
HRI Kirton	1993	12 Jun	26 Jun	14
	1994	27 Jun	9 Jul	12
	1995	6 Jun	4 Jun	-2
Mean absolute difference				8.2

Figure 1. Estimated number of cabbage aphids/plant on Brussels sprouts grown at HRI Kirton in 1995. Plants were insecticide-free.

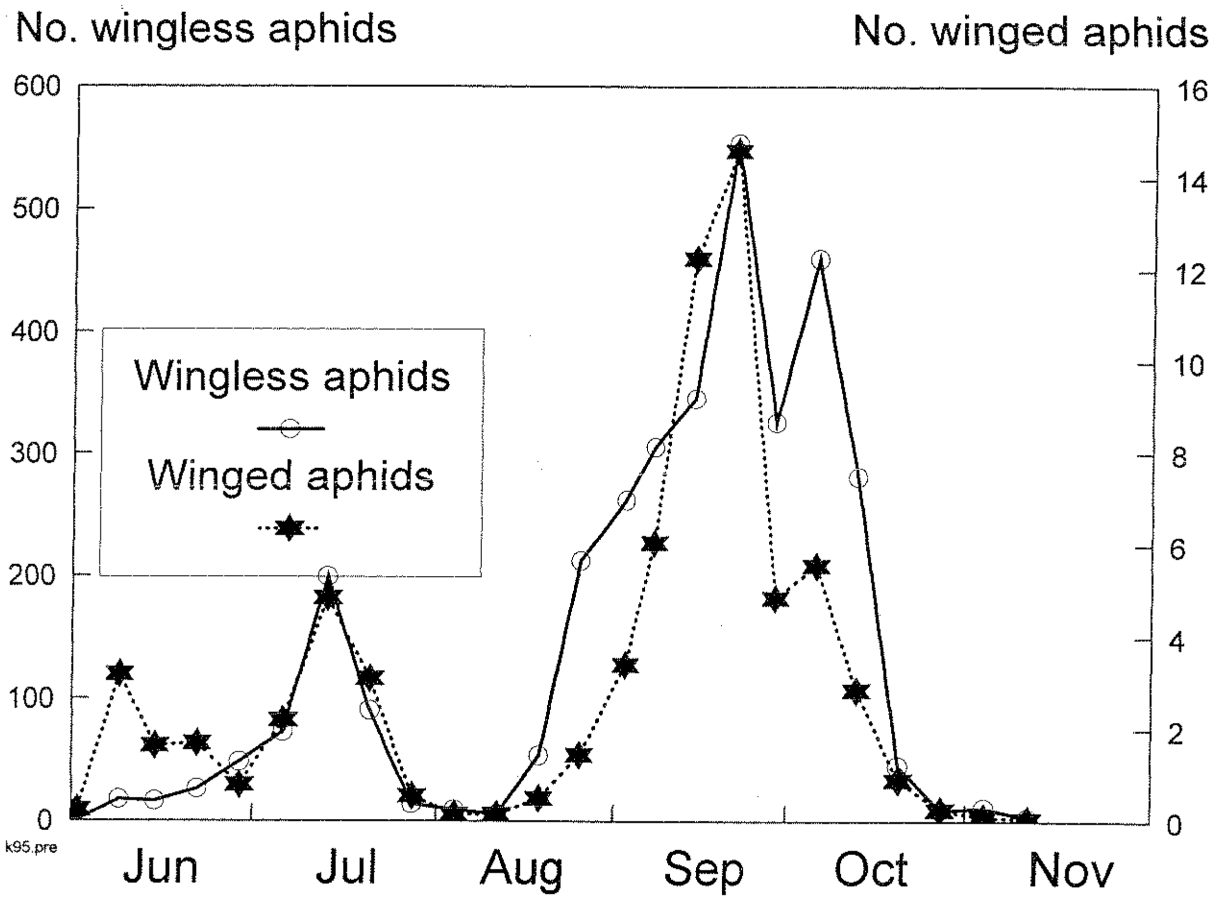


Figure 2. Days from birth to production of first young for cabbage aphids kept at a range of constant temperatures.

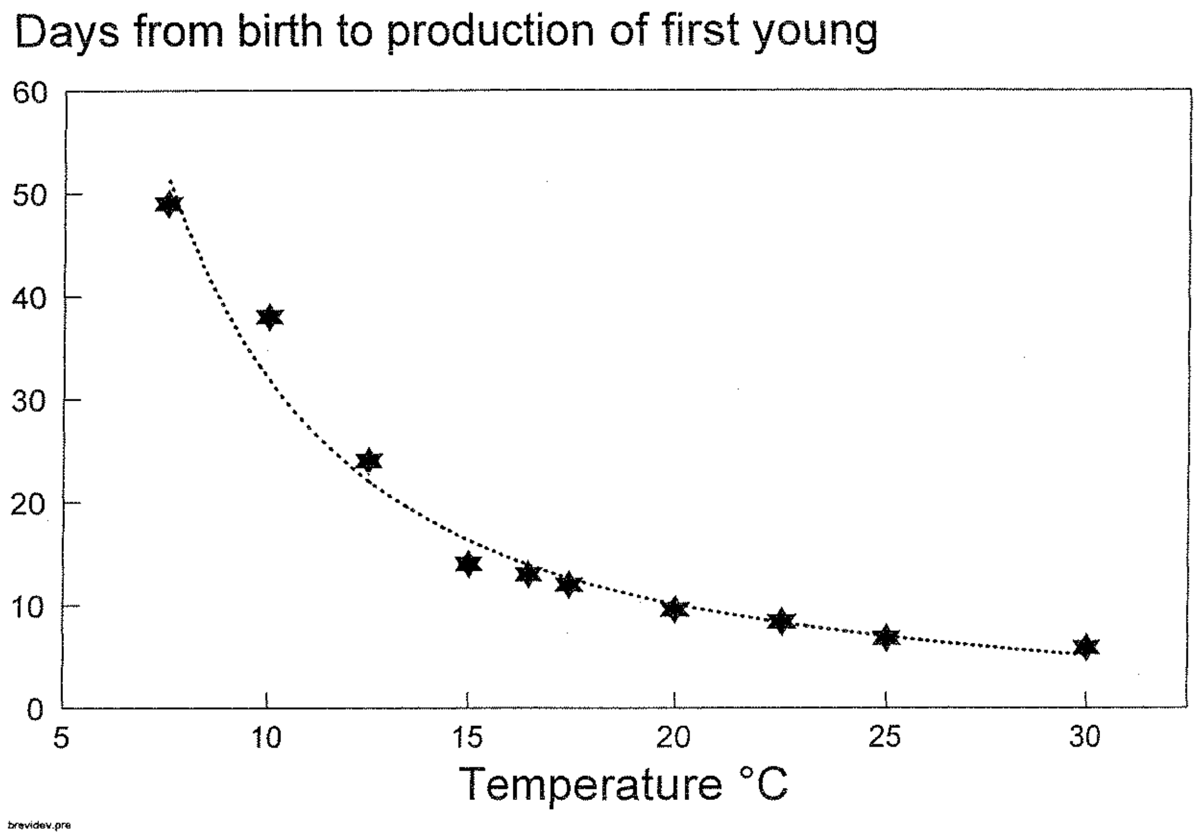


Figure 3. Relationship between rate of cabbage aphid development (100/days from birth to production of first young) and temperature.

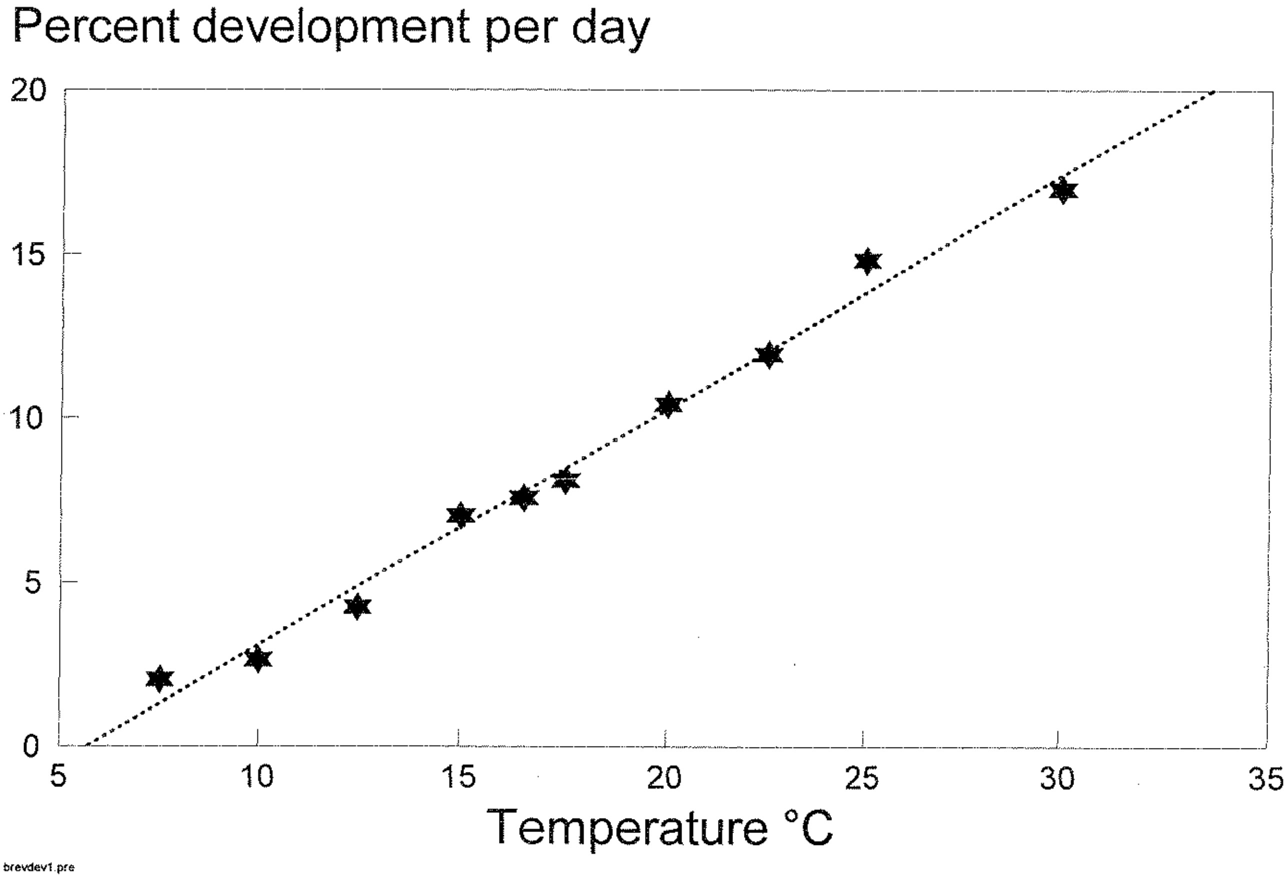


Figure 4. Mean length of life of cabbage aphids kept at a range of constant temperatures.

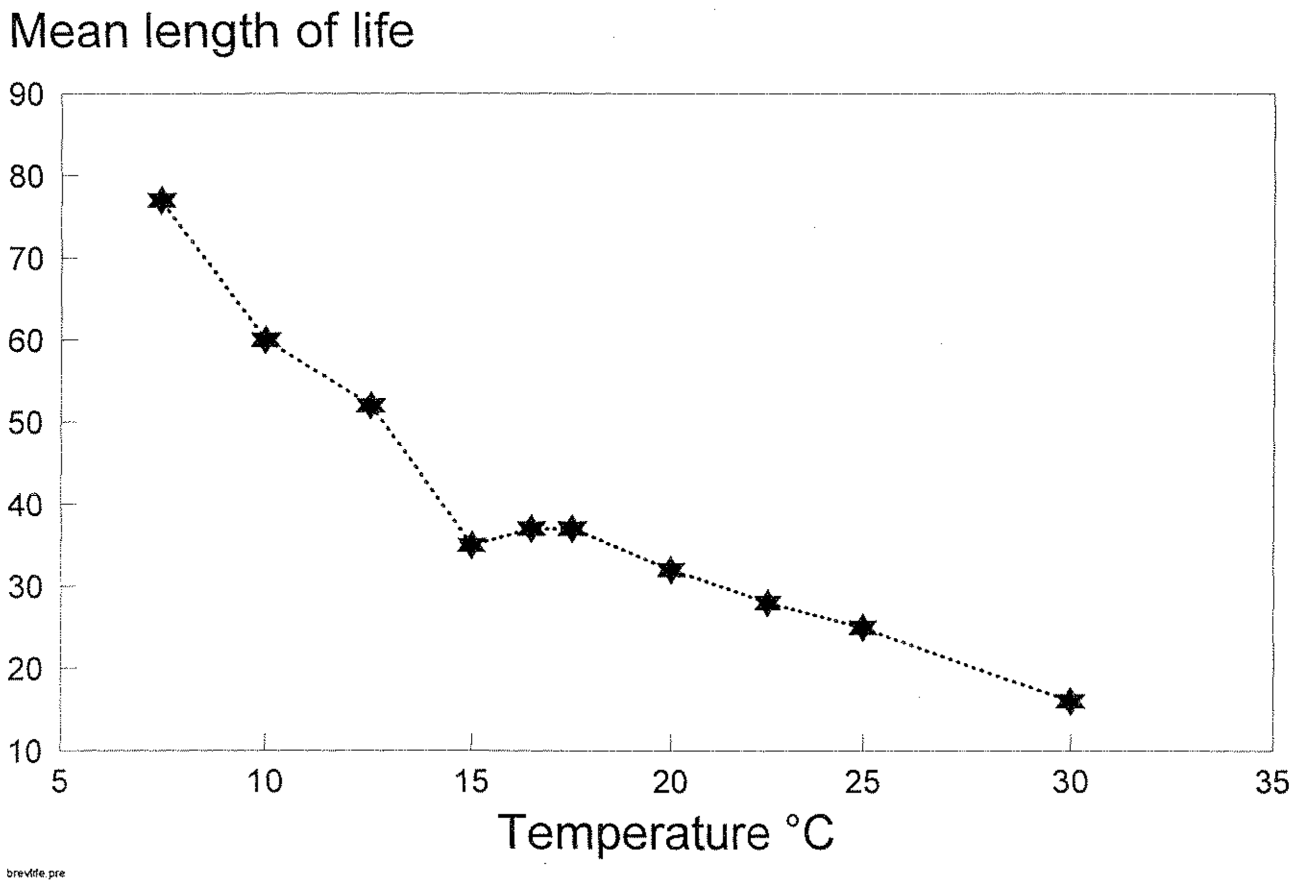


Figure 5. Mean number of young produced per female cabbage aphid at a range of constant temperatures.

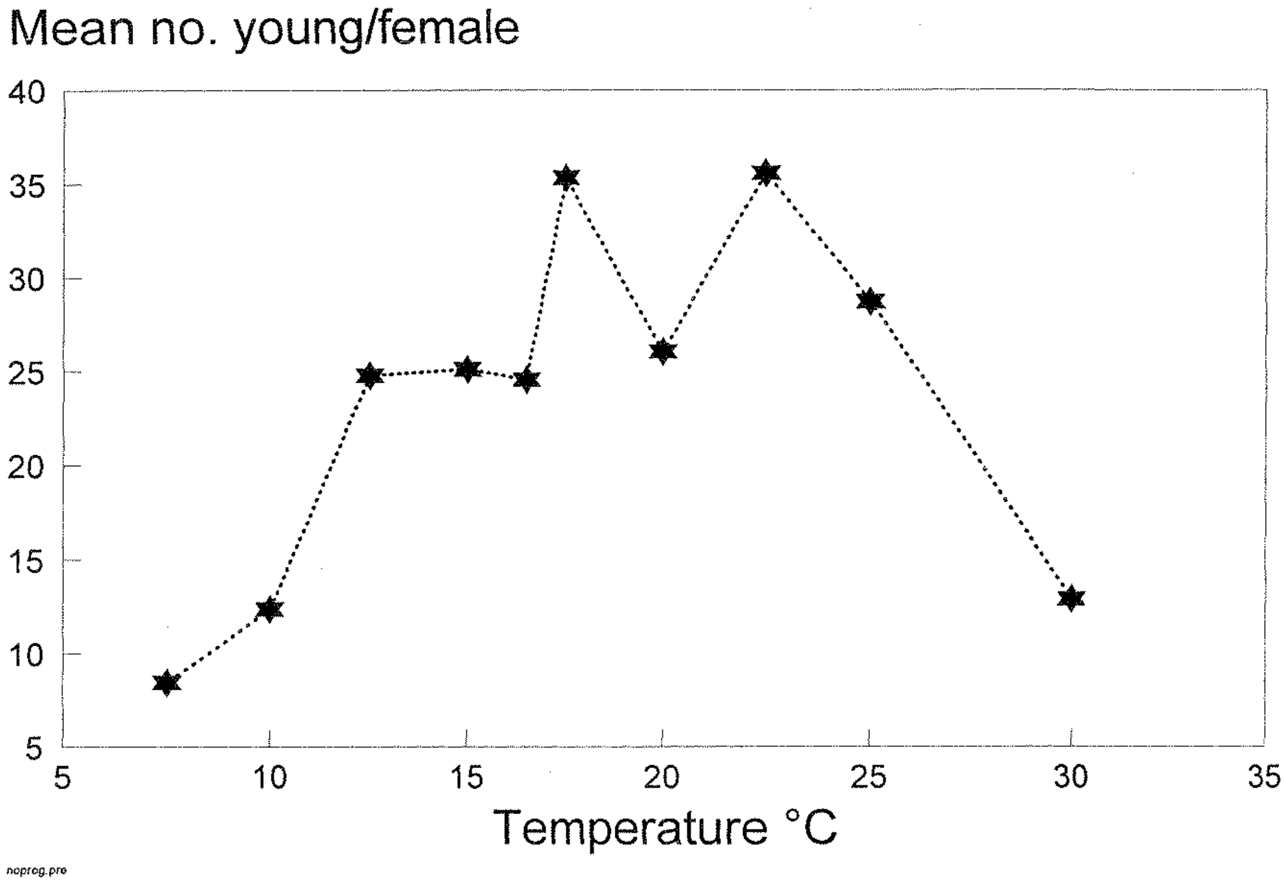


Figure 6. Cumulative production of cabbage aphid young at two constant temperatures (7.5 and 17.5°C).

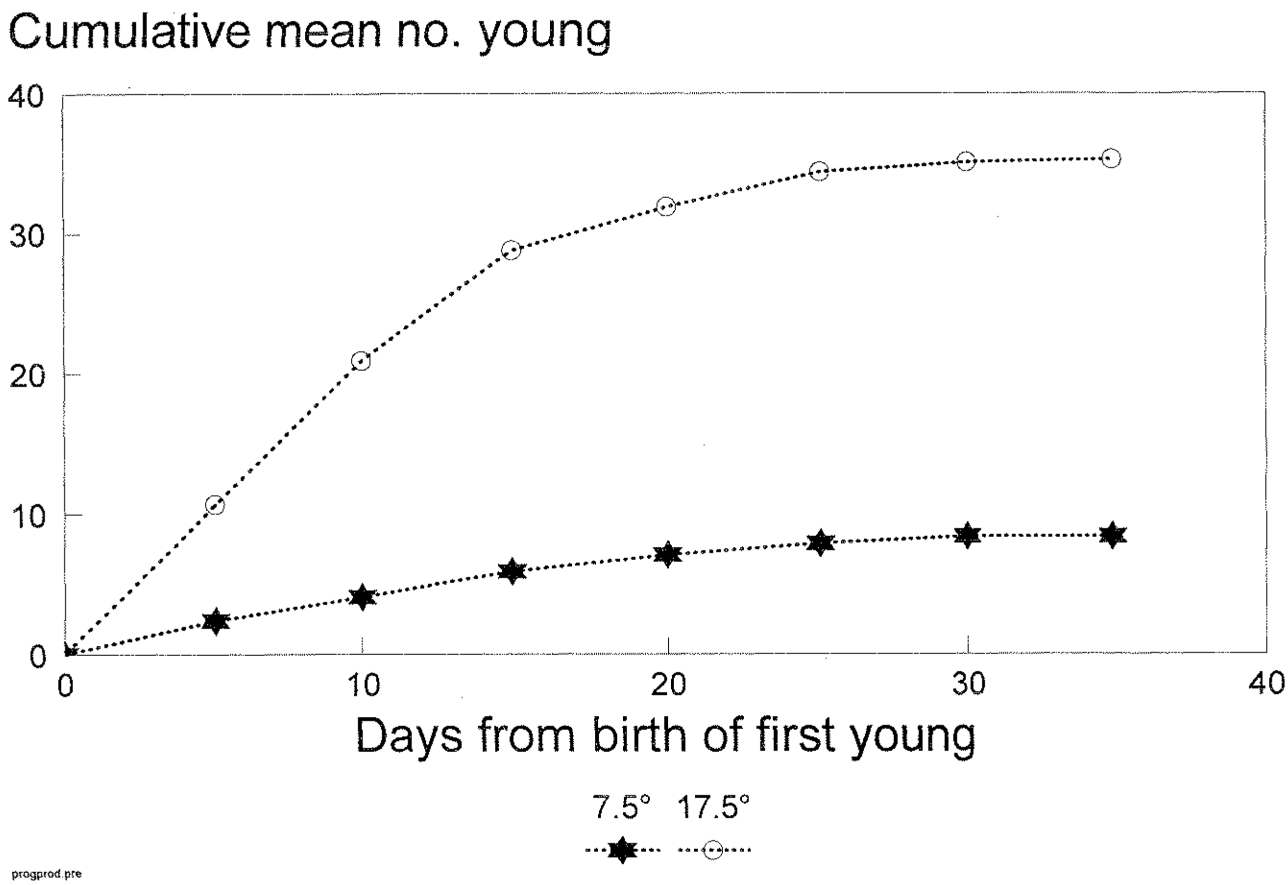
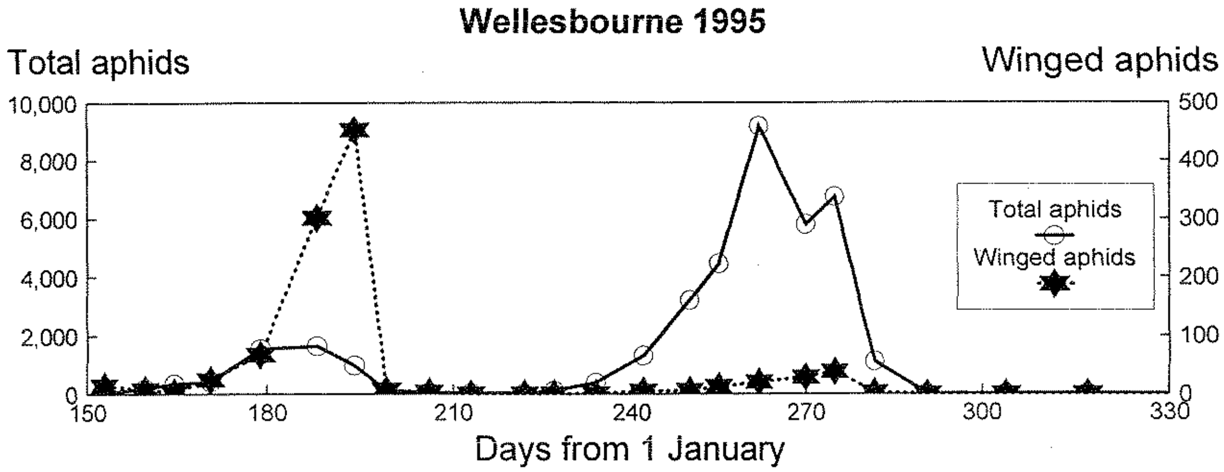
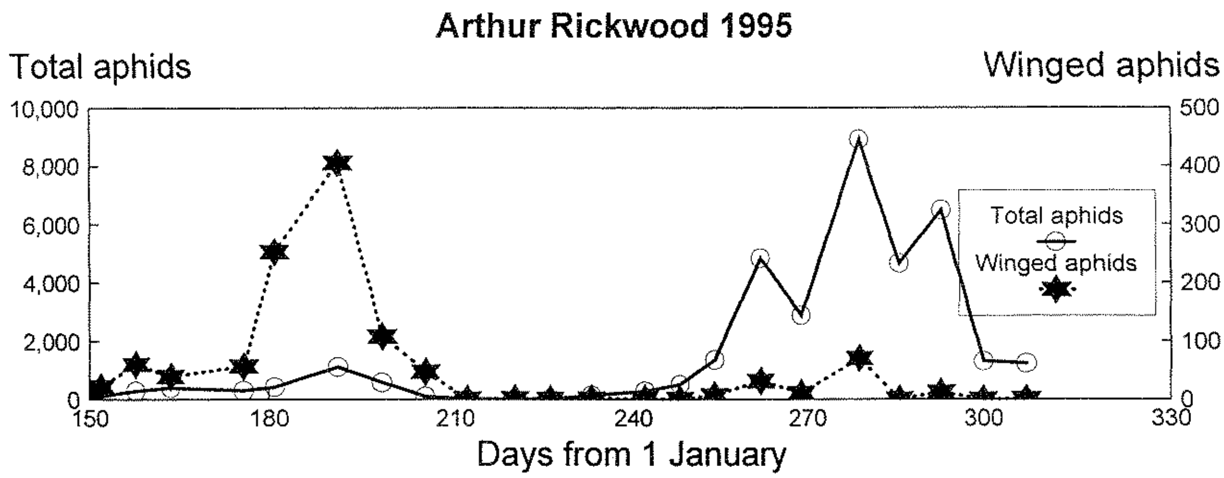


Figure 7. Estimated number of cabbage aphids/plant on Brussels sprouts grown at HRI Wellesbourne, HRI Kirton and ADAS Arthur Rickwood in 1995. All plots were insecticide-free.





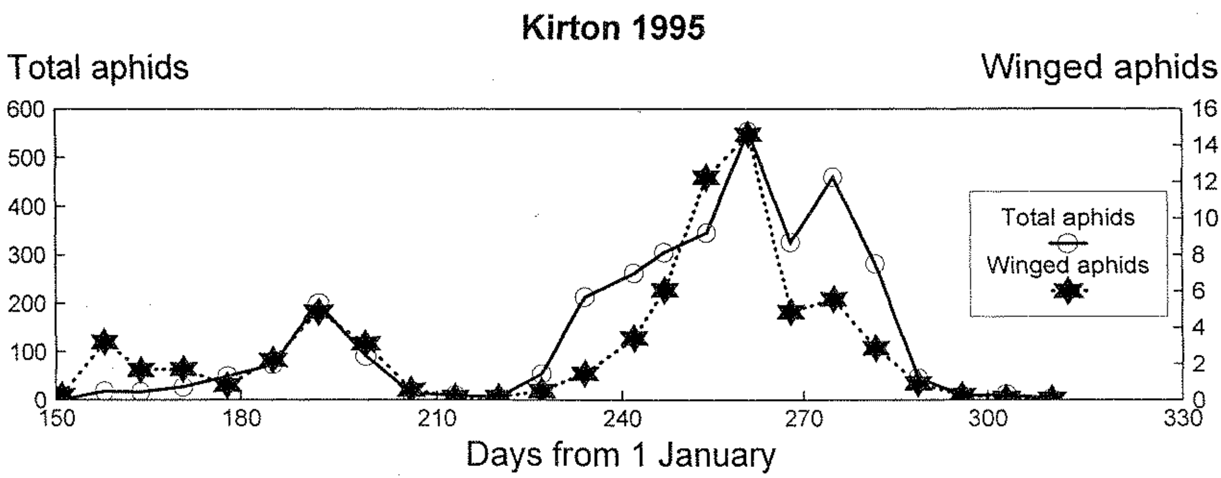


Figure 8. Estimated number of cabbage aphids/plant on Brussels sprouts grown at HRI Kirton in 1993-1995. All plots were insecticide-free.

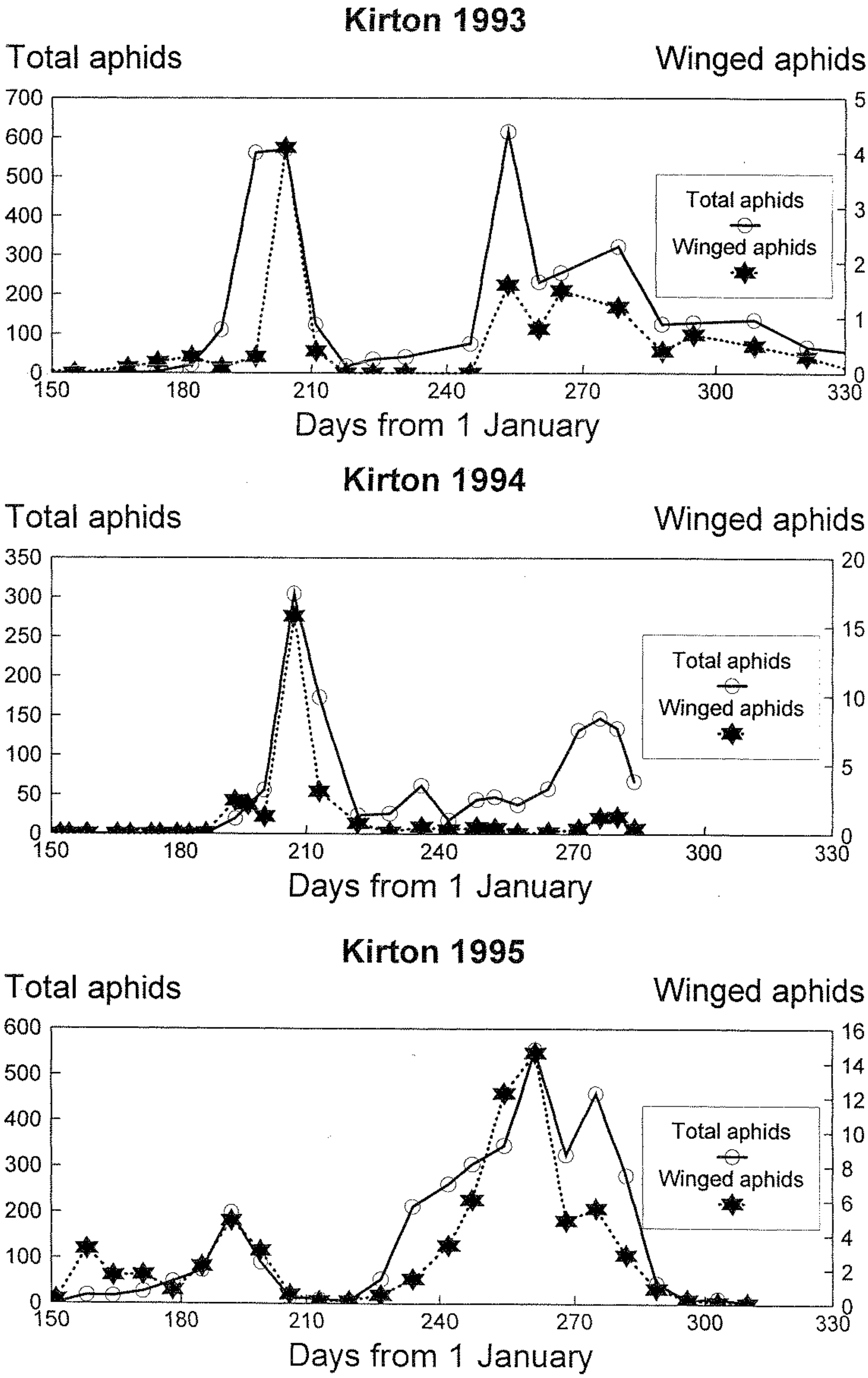


Figure 9. Estimated total number of healthy and parasitised cabbage aphids/plant at HRI Kirton in 1995.

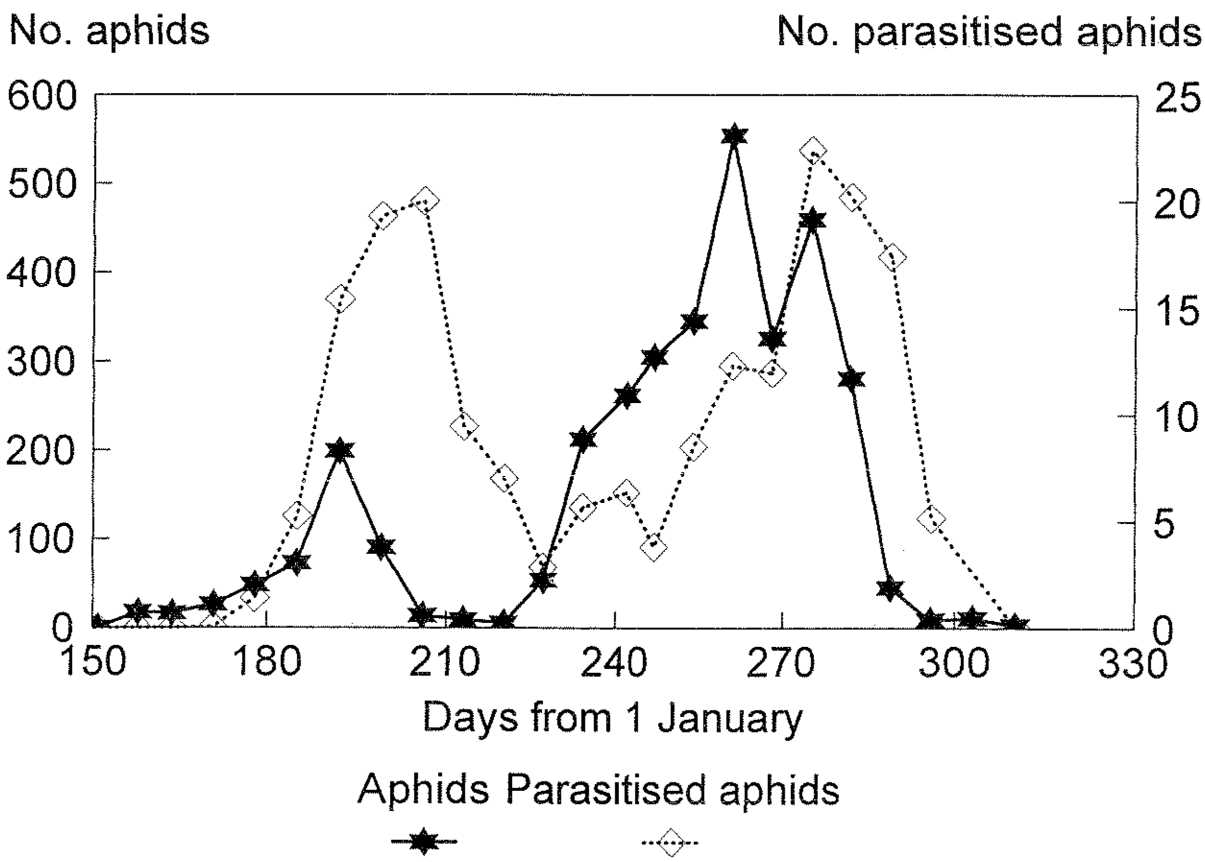


Figure 10. Maximum numbers of parasitised cabbage aphids vs maximum numbers aphids at the time of both the early and late summer peaks of activity on plots sampled during 1992-1995.

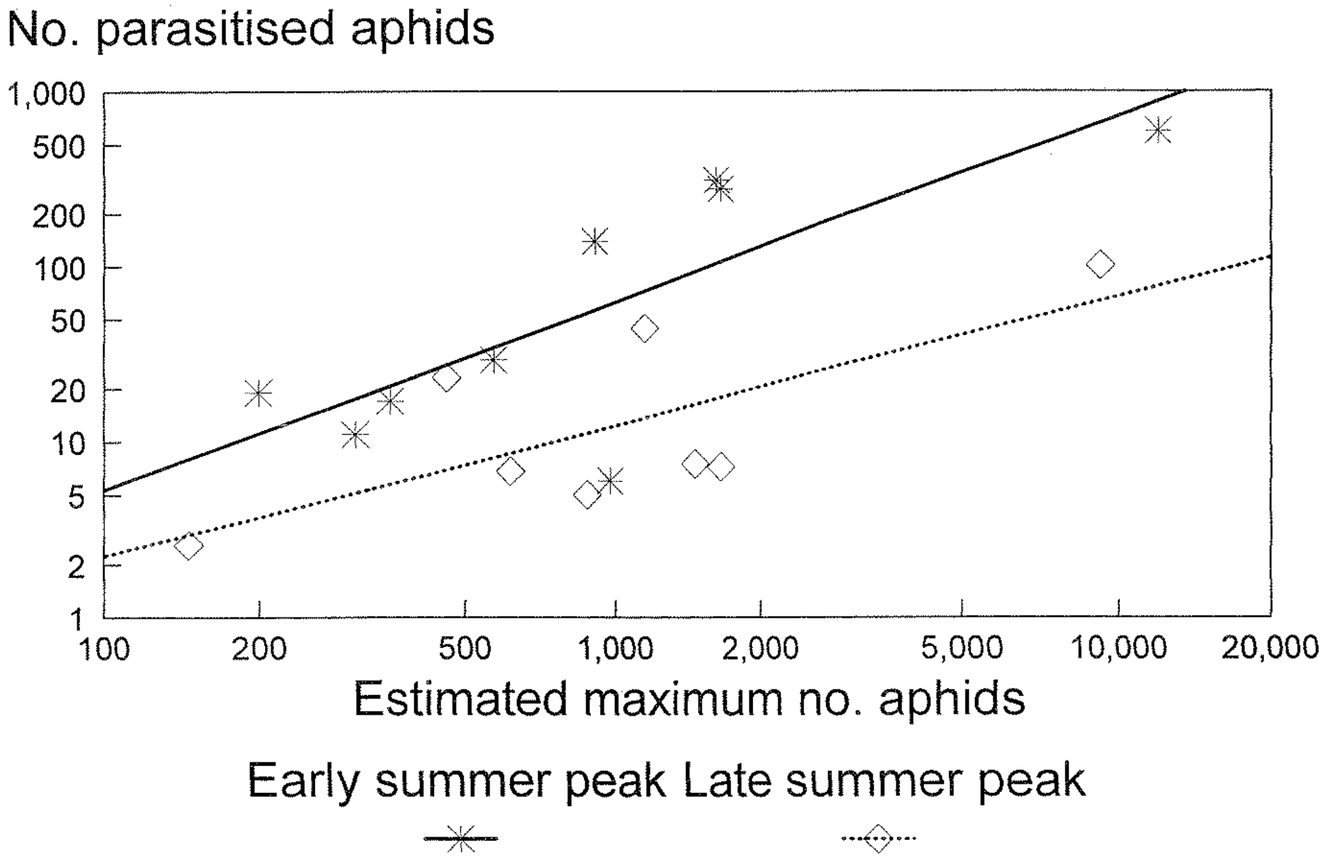


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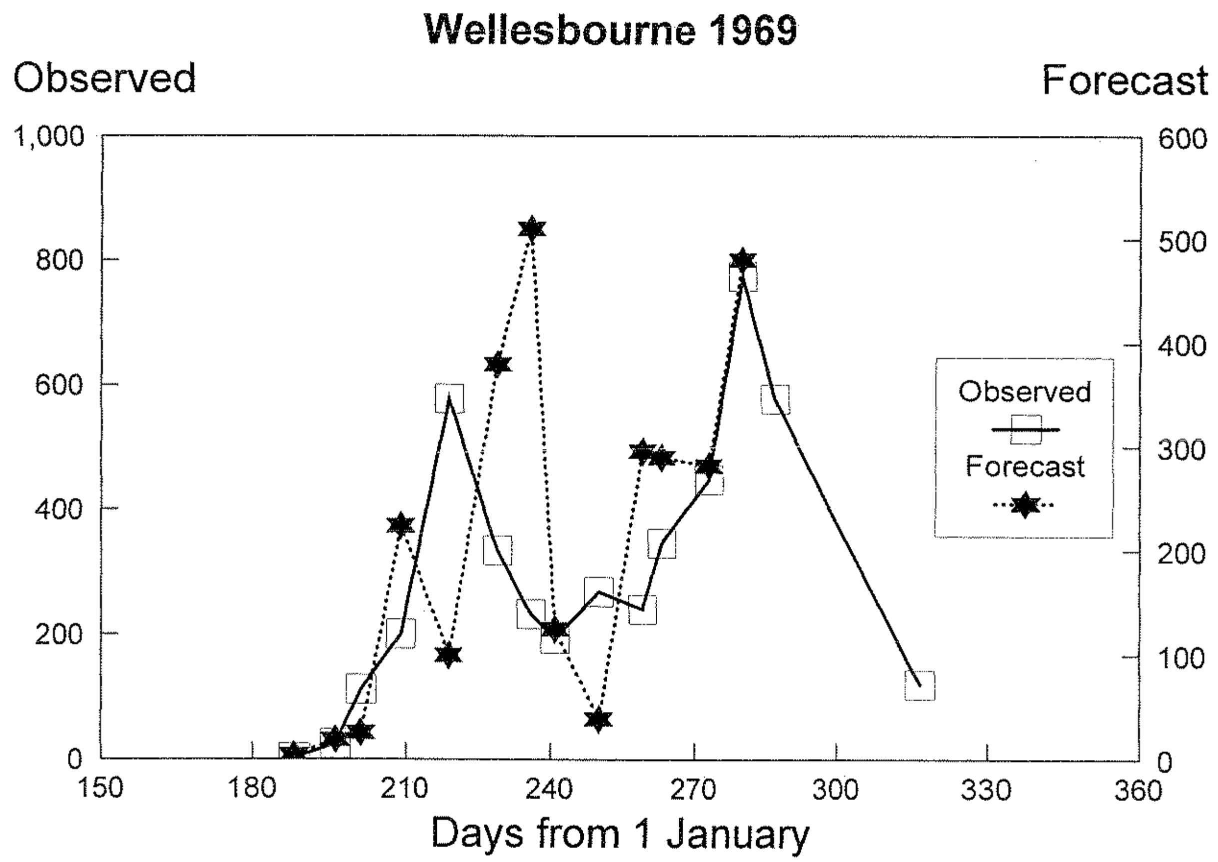
Figure 11a. Forecasts of the pattern of cabbage aphid activity throughout the summer based on using 3mm of rain/day as the threshold to trigger development of an outbreak of fungus.



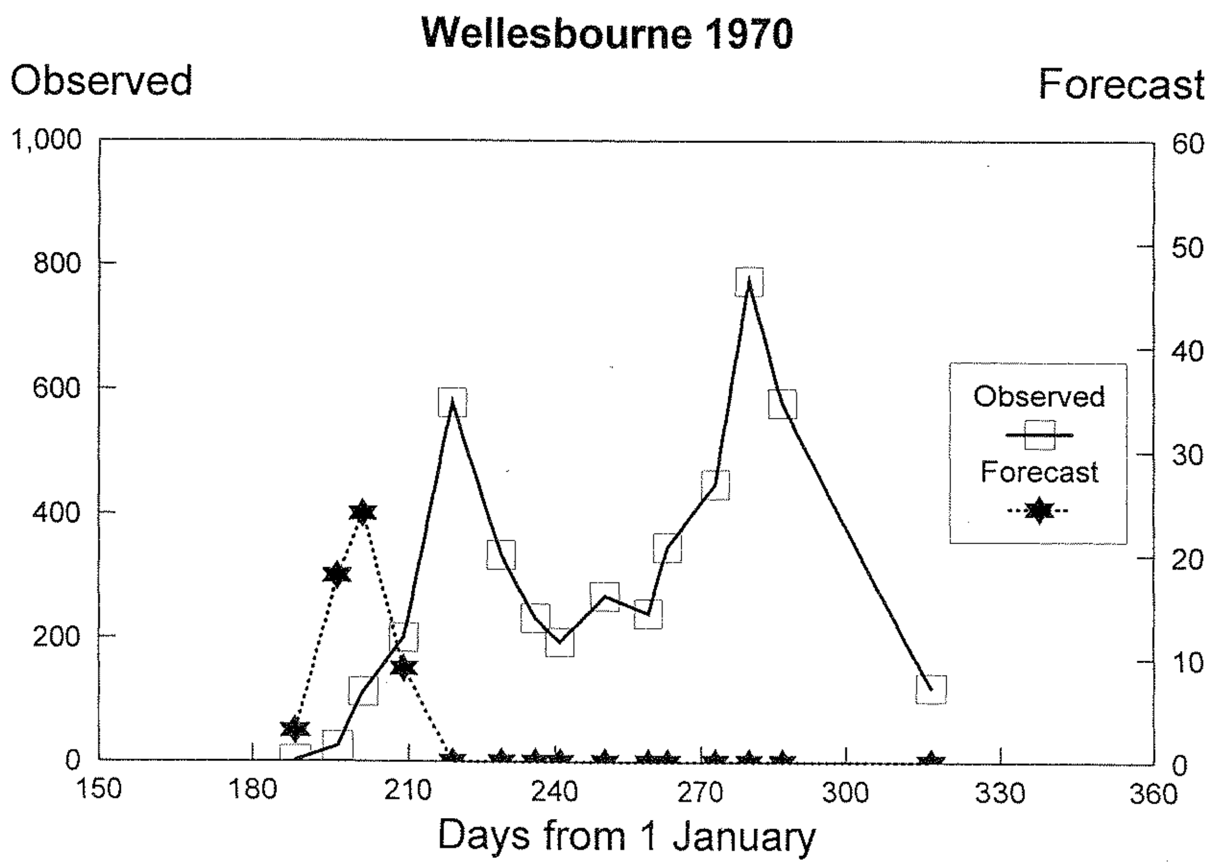
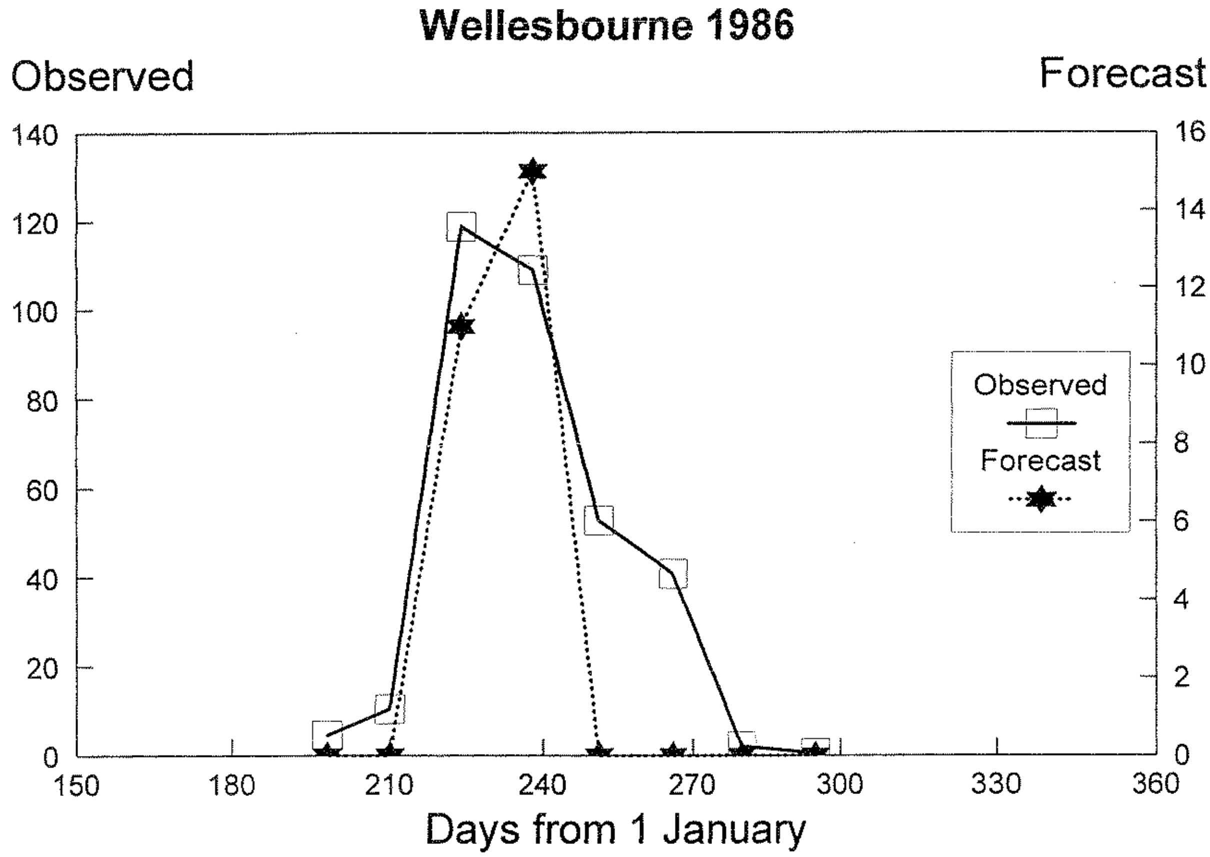


Figure 11b. Forecasts of the pattern of cabbage aphid activity throughout the summer based on using 3mm of rain/day as the threshold to trigger development of an outbreak of fungus.



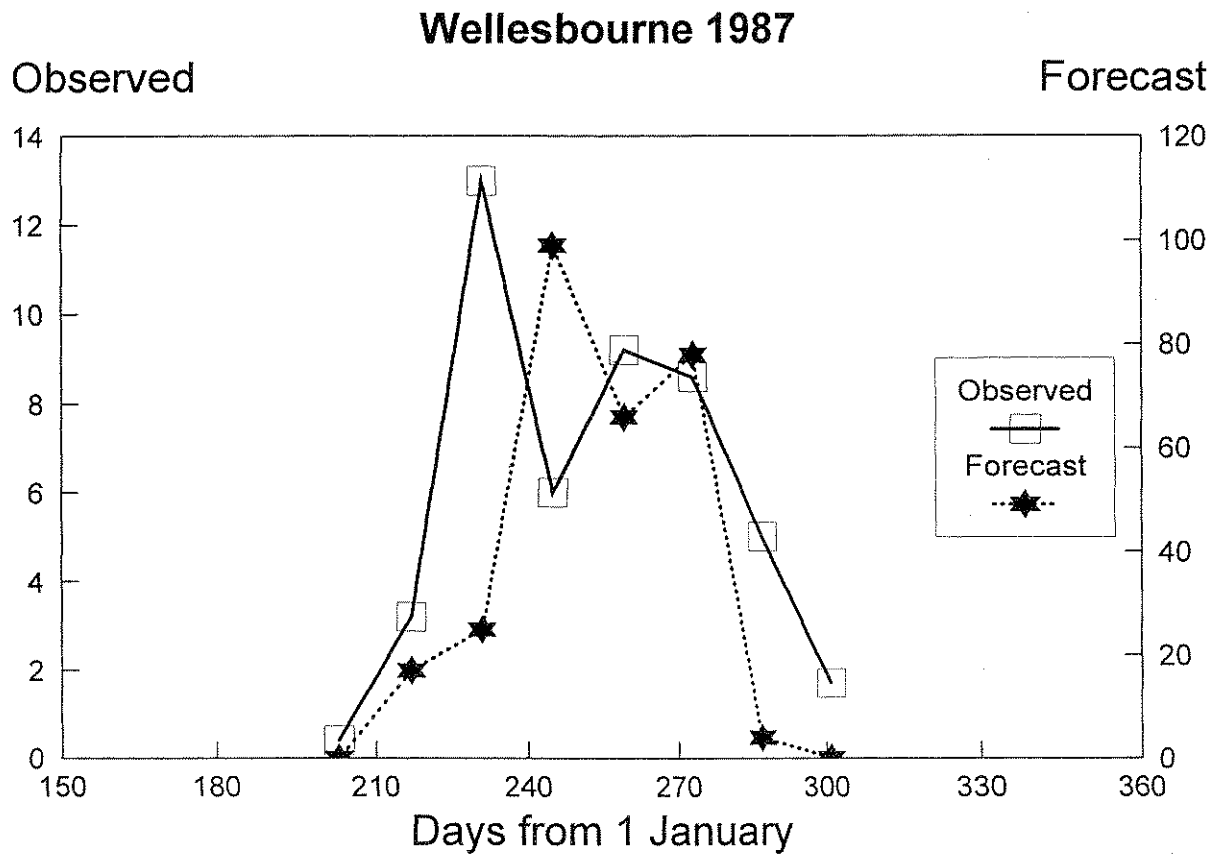
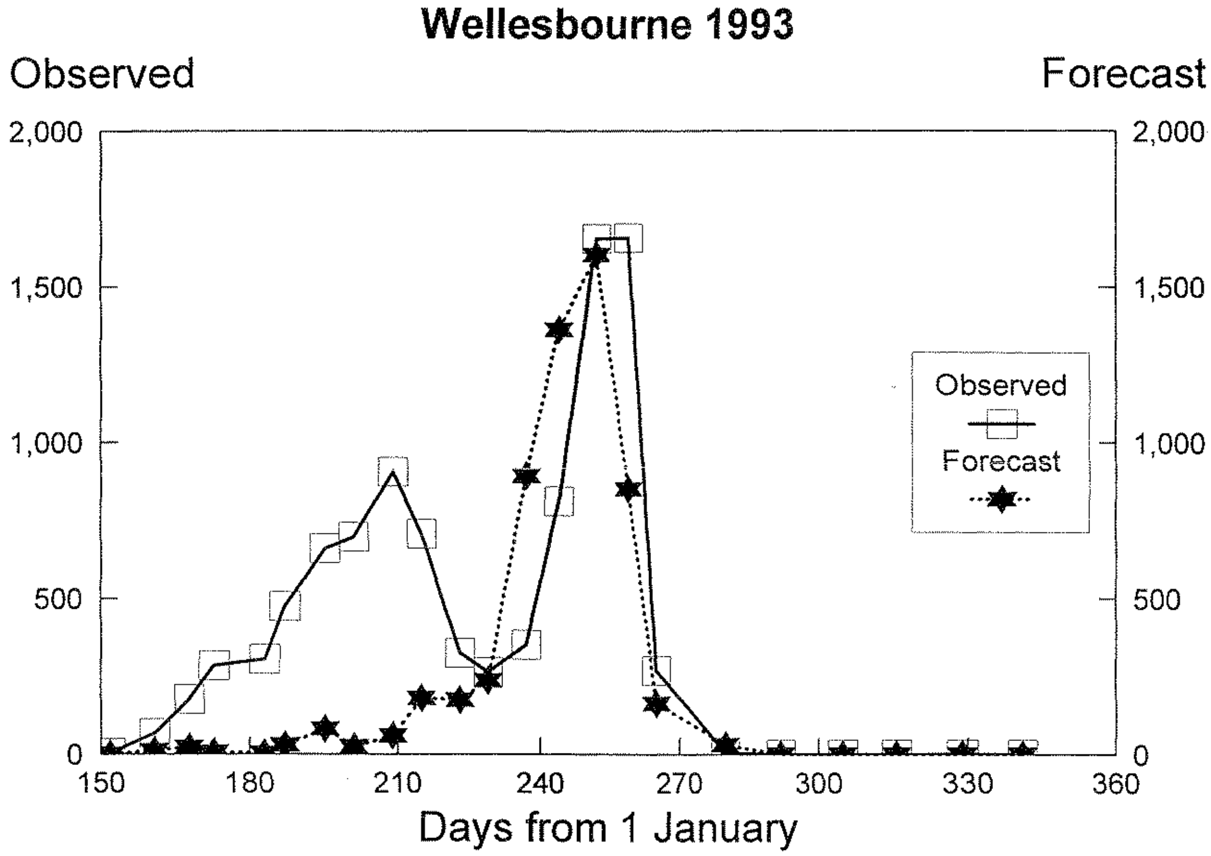


Figure 11c. Forecasts of the pattern of cabbage aphid activity throughout the summer based on using 3mm of rain/day as the threshold to trigger development of an outbreak of fungus.



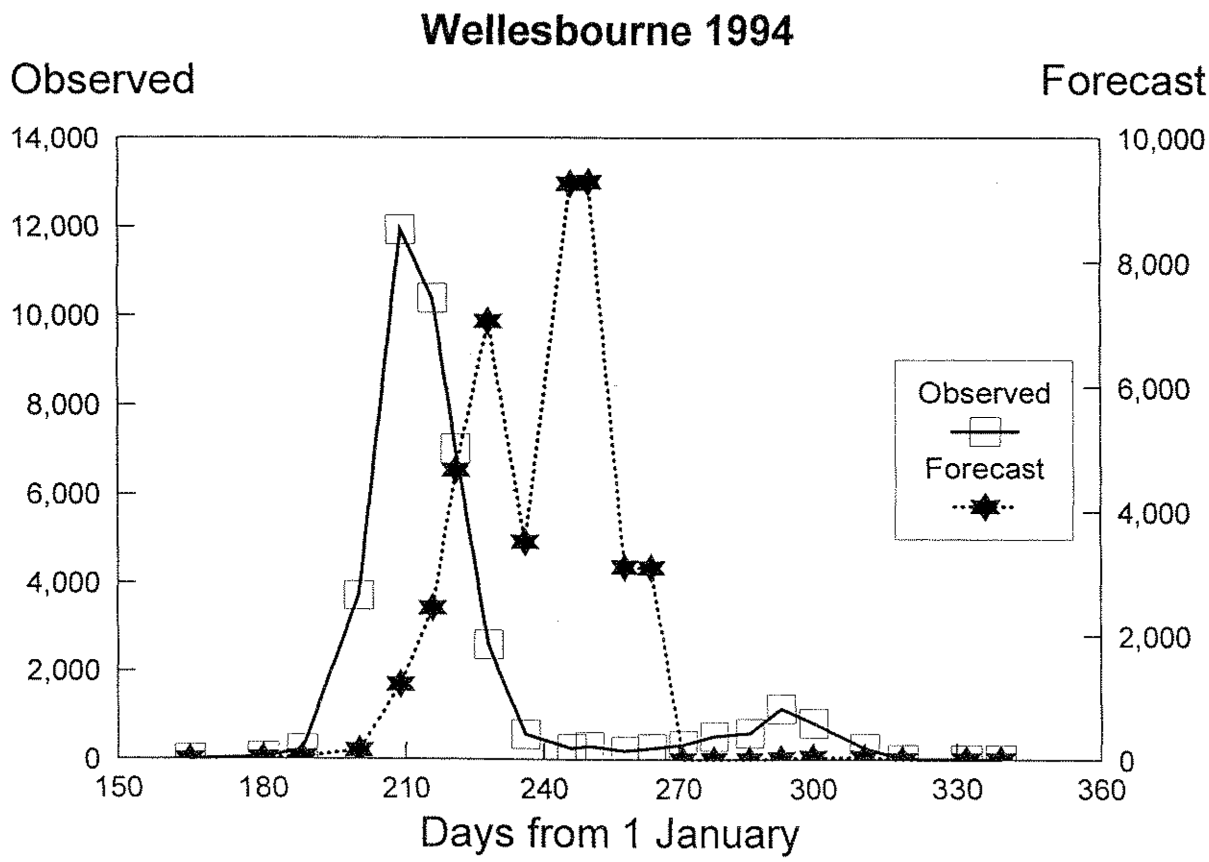
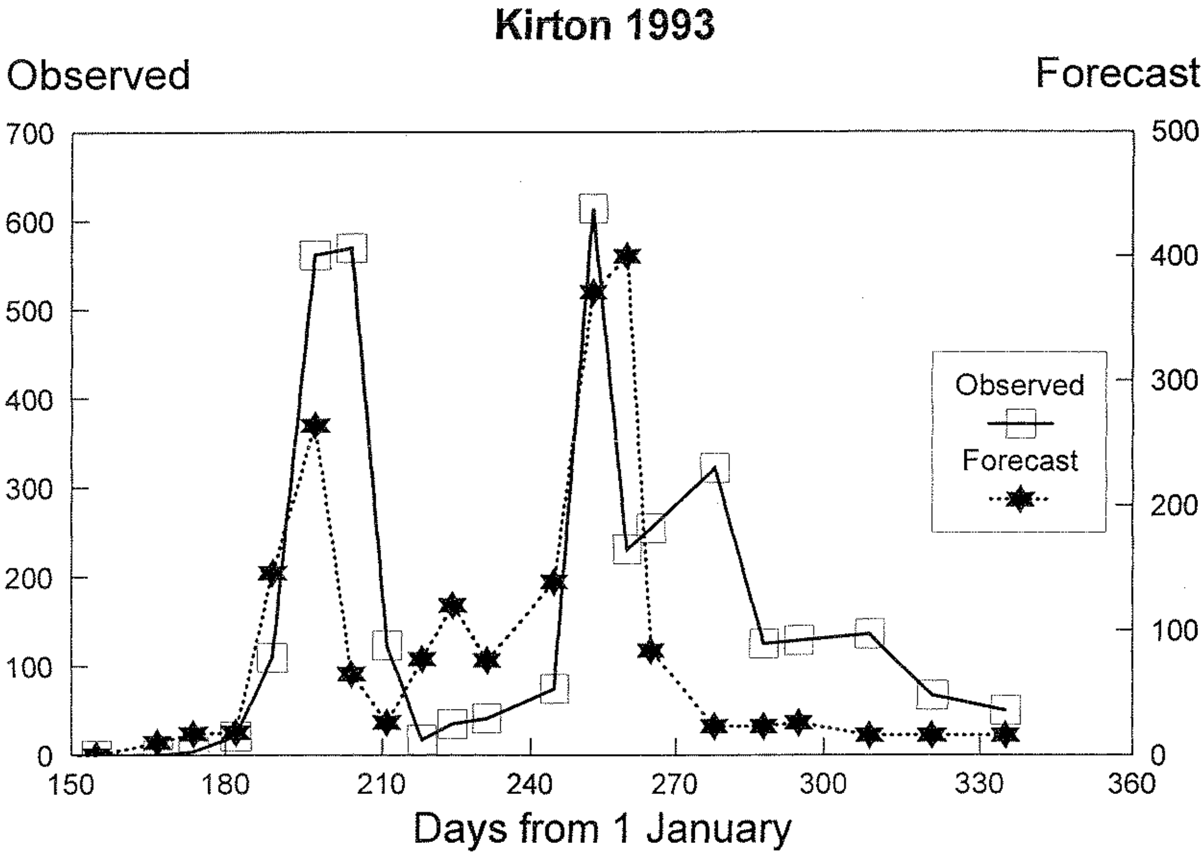
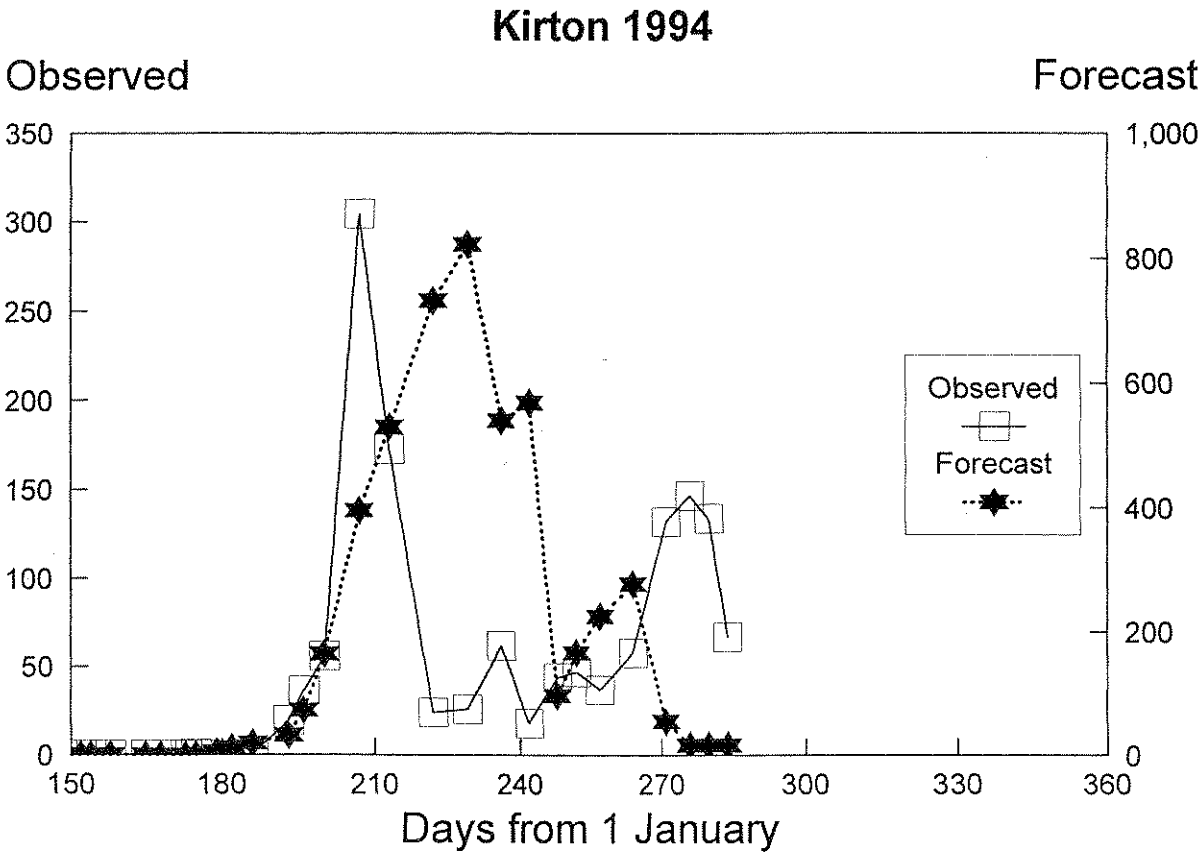


Figure 11d. Forecasts of the pattern of cabbage aphid activity throughout the summer based on using 3mm of rain/day as the threshold to trigger development of an outbreak of fungus.





Contract between HRI & ADAS (hereinafter called the "Contractors") and the Horticultural Development Council (hereinafter called "the Council") for a research/development project.

PROPOSAL

1. TITLE OF PROJECT Contract No: FV 121

FORECASTING CABBAGE APHID ATTACKS

2. BACKGROUND AND COMMERCIAL OBJECTIVE

The small numbers of cabbage aphids that 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, the timing of these migrations can vary by several weeks from one year to the next, making the optimum timing of mid-to late-season sprays against this pest difficult to judge accurately.

Although dual-component granules (eg Twinspan, Sheriff), that kill both the cabbage root fly and the cabbage aphid can be applied at planting, many operatives refuse to work on machines that dispense such granules because of the odours given off from the insecticide. In addition, although aphid control from these granules is good in wet seasons, there are doubts about the efficacy of the granules in dry seasons. Given the choice, it appears that the majority of growers still prefer to control cabbage aphids by applying insecticides from tractor-mounted sprayers.

The objective of this project is to devise a method based on agrometeorological data for forecasting the peak periods of immigration of cabbage aphids into brassica crops. Although considerable efforts have been made in recent years to adopt Dutch-based systems of supervised control, such systems have not been accepted too readily because of the amount of time required for adequate crop scouting. The advice from the supervised approach is that sprays should be applied only after aphid infestations are well-established, because many brassica crops are able to tolerate relatively high aphid infestations without loss of yield (refers to quantity not quality). Such advice may not be appropriate for aphids, as even highly-effective insecticides rarely kill more than 90% of any pest population. Therefore, if at certain phases during growth of crops like Brussels sprouts, aphids are allowed to build up to populations of say 1000 aphids per plant (not an excessive number), then there will still be 100 aphids/plant directly after a spray has been applied. With insects like aphids that breed parthenogenetically, it is essential to keep infestations low at all times if the final produce is to be both insect-free and of high quality. An increased spray programme is not advocated. Instead, it is proposed that if insecticide were applied earlier, fewer applications could do a far better job by killing the aphids shortly after they enter the crop - instead of waiting until they are well-established and then trying, often in vain, to control the vast numbers of their grand- and great grand-offspring. Obviously, sampling crops adequately to find the low numbers of aphids that start the initial infestations would be a difficult task for consultants and/or growers. Such sampling would not be necessary, however, if the times of attacks by this pest could be forecast accurately from weather data.

3. POTENTIAL FINANCIAL BENEFIT TO THE INDUSTRY

Actual cost benefits are difficult to estimate but a means of accurately forecasting the timing of attacks by the cabbage aphid would inevitably help to save the costs associated with all the mis-timed mid- to late-season spraying done against this pest at the moment.

4. SCIENTIFIC/TECHNICAL TARGET OF THE WORK

To produce a model that will enable cabbage aphid attacks to be forecasted accurately for any brassica-growing area within the United Kingdom.

5. CLOSELY RELATED WORK - COMPLETED OR IN PROGRESS

Models, funded by the HDC, for accurately forecasting the times of attack by the cabbage root fly and the carrot fly have been developed at HRI Wellesbourne and validated extensively using data collected by ADAS colleagues. Regional and farm-specific forecasts for both pests will be available to growers from the start of 1992. Forecasts of attacks by narcissus bulb fly and pollen beetle attacks on horticultural brassicas will be available to growers from June 1992.

Two major groups of North American entomologists have recently published extensive data to show that it is possible to forecast the timing of cabbage aphid attacks. The two groups are led by John Trumble and co-workers in California and by Dick Haworth and co-workers in Canada. What it is hoped to do is to use the data collected by these two groups, and by several workers in eastern Europe and India, to develop an aphid forecasting model. The advantages we have over the other groups is that we know the type of information required to produce a successful forecast. We also have a considerable body of highly-relevant and extremely detailed data on the cabbage aphid. This large body of data was collected by Arnold Dunn, at HRI Wellesbourne and elsewhere, using MAFF funding during the late 1960s through to the early 1980s.

Rothamsted currently monitor cabbage aphid in the Insect Survey but the data is not suitable for developing a cabbage aphid forecast. It is possible that the survey data could be of use for validating the forecast, once the detailed aphid development work has been completed. Whether the Rothamsted data would be appropriate would also depend on the cost of the data and whether it would be sufficiently detailed to be of use. For example, there has been a tendency in recent years for publications from the Insect Survey to show only monthly totals of aphid numbers. Presumably the current data are being collected solely to illustrate long term changes in insect populations. Their usefulness, therefore, will depend upon whether aphids numbers are shown as monthly figures, merely for clarity in publications, or whether the samples are combined prior to counting. In addition, there are only 4 suction traps in the present system that catch adequate numbers of cabbage aphid, and the trap from Starcross (a favoured site) is no longer in operation.

It is hoped that data from FV119 will be used late in the programme to validate the forecast.

6. DESCRIPTION OF THE WORK

Biological and agrometeorological data already collected from extensive field trials will be used to generate the initial model. Considerable use will also be made of the simulation models already published, mainly by Canadian entomologists, on the developmental rates of the various phases in the life-cycle of this pest.

7. COMMENCEMENT DATE AND DURATION

Work to commence on 1 May 1992 and to last 2 years in the first instance.

8. STAFF RESPONSIBILITIES

Project Leader: Dr S Finch, HRI Wellesbourne

Experiment Leaders: Dr R H Collier, HRI Wellesbourne
Dr J Blood Smyth, ADAS Cambridge

9. LOCATION

All data handling and controlled-environment experiments on aphid development required for the model will be done at HRI Wellesbourne. ADAS colleagues will collect aphid samples in year 1 (season 1992) and help to validate the preliminary forecast in years 2 and 3 (seasons 1993 & 1994).