HDC Projects FV13b & FV/BOF127

REPORTS FOR 1991 & 1992

Dissemination of forecasts for cabbage root fly, carrot fly, pollen beetle and large narcissus fly

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INTRODUCTION

Growers are now well aware that the use of insecticides for crop protection is being challenged by environmentalists and that certain supermarket chains demand their vegetables to be produced with the minimum of insecticide, and in some cases without insecticide at all. In an attempt to rationalise, and possibly reduce, the amounts of insecticide applied during vegetable production, the HDC commissioned a study in 1987 to develop systems for forecasting the times of pest insect attacks, so that insecticides could be applied at the times they would have most effect. Four of these forecasts, for cabbage root fly, carrot fly, pollen beetle and large narcissus fly have now been developed.

Pest forecasts are based on the fact that insect development is directly related to temperature. Therefore, the hotter it is in a particular season, the faster an insect will pass from one generation to the next. This means there are more insect generations in the south of the British Isles than in the north. It also means that in any locality, if there are only two generations of a particular pest insect in a cool season, there may be three generations in a warm season. For reasons of this kind, it is inadvisable to apply insecticide treatments on routine calendar dates. When growers do adopt this approach, they may apply their sprays close to the optimum date in a few years, but in most years they will apply the insecticide either too early or too late. Badly-timed insecticide applications not only waste chemical and time; kill beneficial insects; contaminate the environment and the vegetable produce; but they also do not kill pest insects.

Growers regularly talk about early and late seasons. What the pest forecasts do is to indicate how early or how late the season will be, so that an appropriate insecticide treatment can be applied at the time it is likely to kill maximum numbers of pest insects.

Assuming that the grower is going to apply an insecticide, the forecasts tell him the time to apply it to have most effect. The forecasts are specifically designed for the control of insect pests on established crops, where the protection provided by insecticides applied to the soil at sowing or planting has diminished. Treatments on established crops will be most effective if they can be timed to coincide with periods when pest insects are most numerous.

At present, the forecasts cannot be used to indicate whether or not an insecticide should be applied. However, the forecasts do highlight the "insect-free" periods, when it is not necessary to apply insecticide.

The forecasts have been tested using data from most regions of the United Kingdom and in particular from the major vegetable growing areas. Much of this information was collected by ADAS colleagues, particularly by entomologists working at Cambridge and Leeds. The forecasts for most areas of the UK coincide almost exactly with the activity of the insects in the field. However, there are some difficulties with forecasting cabbage root fly attacks in southwest England, south Wales and southwest Lancashire because some of the overwintering flies emerge later in the spring than realised previously. However, provided the locality is pinpointed accurately, adequate forecasts can be produced even for such areas. Similarly, there is currently a problem with forecasting carrot fly activity in certain parts of Lancashire. With the help of Lancashire growers and ADAS colleagues it is hoped that this difficulty will be resolved soon.

The forecasts require daily records of the maximum and minimum air temperatures and the temperature of the soil at a depth of 6 cm (2.5 inches), the depth at which the larvae (maggots) of the pests spend most of their life-cycle. As temperatures

at 6 cm deep are not recorded at meteorological stations, they have to be estimated from the 10 cm deep soil temperature recorded daily at 0900 h. Unfortunately, the 10 cm deep soil temperature is not recorded at many weather stations in the UK, and so it often has to be estimated from a deeper soil temperature.

Obviously, the weather data for the current year is only available up to the day the forecasts are sent out. Therefore, the forecasts are extrapolated to the predicted dates of pest activity by including weather data from an earlier year. To ensure that the forecasts of fly activity err on the 'early' rather than on the 'late' side, weather data from a very warm year is used to extrapolate the forecasts. With just 21 temperatures a week, which can be obtained from meteorological stations near to the main growing areas, regional forecasts can be produced for all four pests.

Forecasts can be produced for individual fields provided the grower can forward the appropriate weather data on a weekly basis. The grower can then be provided with both a personal forecast and with a general forecast for his/her region. He/she can then decide whether the individual forecast is worth the extra effort.

For control purposes, we consider that pest activity has started when 10% of the insects have emerged/laid eggs and that the peak, or mid-point, of activity has occurred when 50% of the insects have emerged/laid eggs.

PEST FORECASTS IN 1991

Both the cabbage root fly and the carrot fly forecasts were run in "real time" using weather data collected daily in eight localities (data supplied by HRI, ADAS, Met Office and Morley Research Centre). The weather data were forwarded to Wellesbourne by fax or telephone and the forecasts were updated weekly. The updated forecasts were

then forwarded to ADAS entomologists for appraisal.

The forecasts can be used to estimate times of fly emergence, the start of egg-laying, or any other stage in the life-cycle of the pests. In 1991, forecasts of first generation fly activity were produced for all eight localities. The forecasts predicted the percentage of flies which had emerged and the percentage of eggs laid by the date of issue of the forecasts. The forecasts were also used to predict the times at which 10% and 50% of the eggs would be laid. This required extrapolation beyond the end of the 1991 weather data, and was achieved by using weather records from an earlier, warmer-than-average, year. By doing this it was possible to produce advanced, rather than retrospective, forecasts of the timing of egg-laying.

Cabbage root fly and carrot fly activity, monitored in several regions, by ADAS entomologists, were used to validate the 1991 forecasts. The forecasts were run on populations of 500 'insects' to provide relatively smooth patterns of activity. The pest monitoring records were usually based on much lower numbers of individuals and consequently produced more variable patterns of activity. In addition, patterns of second generation carrot fly activity may also have been influenced by mid-season applications of pesticides.

Cabbage root fly

The Wellesbourne forecast predicted that 10% and 50% first generation cabbage root fly activity would occur on 9 and 19 May. Regular sampling of flies showed they occurred on 13 and 22 May, respectively.

At Wellesbourne, 10% and 50% second generation cabbage root fly activity were predicted to occur on 15 and 25 July. Sampling showed they occurred on 17 and 26

July, respectively. Observed and forecast cabbage root fly activity at Wellesbourne are shown in Figure 1. Near to Cambridge, 10% and 50% cabbage root fly activity were predicted to occur on 16 and 25 July. Egg sampling showed that they occurred on 13 and 29 July respectively. A third generation of flies was active during September at both the Wellesbourne and Cambridge sites.

Carrot fly

The Wellesbourne forecast predicted that 10% and 50% first generation carrot fly activity would occur on 17 and 25 May respectively. Sticky trap catches indicated that 10% and 50% of flies had been trapped by 15 and 22 May.

The Wellesbourne forecast predicted that second generation carrot fly emergence would start (10%) in the week ending 28 July and second generation egg-laying in the week ending 4 August, respectively; and that fly numbers would stay high for 5-6 weeks. The numbers of flies caught on yellow sticky traps in a carrot crop started to increase during the week ending 28 July and stayed high for a further four weeks. There was some third generation carrot fly activity during October. Observed and forecast carrot fly activity at Wellesbourne are shown in Figure 1.

Forecasts were also compared with carrot fly activity monitored in Eastern England, Yorkshire and in south-west Lancashire. In Eastern England, the start of egg-laying (10%) was generally predicted to within a week. However, at several sites during the second generation, the numbers of flies trapped declined dramatically part way through the generation. This might have been due to the insecticide sprays applied against the local fly populations. Observed and forecast carrot fly activity in Eastern England and in Yorkshire are shown in Figure 2.

Large differences between the forecasted and observed times of carrot fly activity were recorded for a number of sites in Lancashire (south-west). These sites were generally where first generation fly activity was not monitored from the start of the season, because the main crop carrots were drilled in May/June rather than earlier and hence missed most of the attack by the first generation of flies.

In the major carrot growing regions, it is believed that the majority of carrot flies move only short distances (possibly less than 500 m) between crops. Therefore the population of insects in a particular crop during the first generation has the major impact on what occurs in the crop during the second generation. In areas where early carrots are not grown, flies that emerge early in the spring have no large areas of crop in which to lay their eggs. With crops drilled during May, for example, only the later-emerging flies will find suitable host crops on which to lay and this will influence the timing of emergence of the subsequent (second) generation of flies. This can be simulated using the forecast, by assuming that only the progeny of the later-emerging flies survive on the crop. The results of such a series of simulations are shown in Figure 3. They are compared with monitoring data collected at sites in south-west Lancashire where the dates of carrot drilling ranged from 16 May - 3 June. Monitoring started during the week ending 21 July.

Because of the differences between observed and forecast carrot fly activity in south-west Lancashire, a large sample of overwintering carrot fly larvae/pupae was collected from a heavily-infested field in 1992. The post-winter emergence of this population was compared at Wellesbourne with that of the Wellesbourne population under standard field and laboratory conditions.

In the laboratory, at a constant temperature of 16.5°C, the patterns of emergence

of flies from insects which had overwintered as larvae were identical (Figure 4a). However, the emergence of flies from overwintering pupae was more protracted in the Lancashire population; the insects continuing to emerge for a further two weeks (Figure 4b). Emergence of unselected populations of overwintering larvae and pupae into small field cages at Wellesbourne began at the same time, but once again, emergence of a small proportion of the Lancashire population was protracted (Figure 4c). Such discrepancies in the pattern of emergence can be incorporated readily into the current forecast program.

PEST FORECASTS IN 1992

Forecasts of the timing of peak activity of four insect pests of horticultural crops (cabbage root fly, carrot fly, pollen beetle, large narcissus fly) were sent out free on request to HDC levy payers. Weather data from 30 Agro-meteorological stations was used to produce regional forecasts which were updated weekly. The weather data for 1992 was available only to the date on which the forecasts were sent out. To ensure that the forecasts provided an 'early' warning of peak activity, weather data from a very warm year, 1990, was used to project the forecasts forward.

Cabbage root fly forecast

The cabbage root fly forecast was sent out from 13 April until the end of August. Cabbage root fly eggs and adults were monitored at Wellesbourne and adults were monitored at two sites in Essex. There was good agreement between the forecasted and the observed timing of cabbage root fly activity at both Wellesbourne and in Essex. There was third generation fly activity at all three sites, but few eggs were laid on

cabbage at Wellesbourne. Observed and forecast cabbage root fly activity at Wellesbourne are shown in Figure 5.

Carrot fly forecast

The carrot fly forecast was sent out from 13 April until the end of September 1992 (this included a forecast for the first half of October). Carrot fly activity was monitored at Wellesbourne and at four sites in Scotland (second generation only).

There was close agreement between the forecast and the actual time of first generation fly activity at Wellesbourne. The early start of the second generation at Wellesbourne was also forecast accurately, but there was no clear peak of second generation activity, probably because dry conditions during the early summer reduced survival of the earliest-developing insects. Second generation carrot fly activity continued until mid-September and there was third generation activity during October. Observed and forecast carrot fly activity at Wellesbourne are shown in Figure 5. The numbers of second generation carrot flies trapped at the four Scottish sites were extremely low, but appeared to fit reasonably well to the local forecast. Forecasts were also compared with carrot fly activity monitored at Cawood in Yorkshire and at Lelystad in the Netherlands (Figure 6).

Pollen beetle forecast

Pollen beetle forecasts were sent out from 7 June - 26 July. Pollen beetle activity was monitored by HRI staff, colleagues in ADAS and by several growers using traps supplied from Wellesbourne. Only four of the growers caught large numbers of pollen beetles, but in three of the four cases, the timing of the beetle migration was

predicted by the forecast. The remaining growers trapped insufficient beetles (less than 1,000) for any conclusions to be derived from the data and relatively low numbers were also caught at ADAS Arthur Rickwood. At Wellesbourne the main peak of activity occurred later than predicted.

Forecast questionnaires

Growers' opinions on all four pest forecasts were sought via a questionnaire prepared in conjunction with Mary Bosley. The same questions were asked concerning each of the four forecasts. A specific question was also asked about the pollen beetle forecast and another about the large narcissus fly forecast. The results are summarised below:

Summaries of the forecast questionnaires

Pest insect	No. replies received	No. forecasts sent out	% response
Cabbage root fly	120	200	60
Carrot fly	67	124	54
Pollen beetle	16	26	62
Large narcissus fly	15	23	65

QUESTIONS

1. For the purposes of pest control, do you want to know when cabbage root fly (Gens 2-3)/carrot fly (Gens 2-3)/pollen beetle/large narcissus fly are attacking your crops?

Pest insect	Yes (%)	No (%)	Don't know (%)
Cabbage root fly	88	9	3
Carrot fly	91	8	1
Pollen beetle	100	0	0
Large narcissus fly	93	7	0

2. In which of the last five years have you had problems with pollen beetles in horticultural brassica crops?

1988	1989	1990	1991	1992
1	6	9	8	2

3. Do you have difficulty controlling the following pests?

Pest insect	Yes (%)	No (%)	Don't know (%)
Cabbage root fly	48	49	4
Carrot fly	54	43	4
Pollen beetle	38	50	12
Large narcissus fly	60	27	13

4. Do you, or does anyone else, monitor pest numbers in your crops?

Pest insect	Yes (%)	No (%)	Don't know (%)
Cabbage root fly	22	75	3
Carrot fly	39	58	3
Pollen beetle	50	44	6
Large narcissus fly	7	87	6

5. Do you make supplementary applications of pesticides to kill the pest?

Pest insect	Yes (%)	No (%)	Don't know (%)
Cabbage root fly	50	47	3
Carrot fly	79	16	5
Pollen beetle	81	6	13
Large narcissus fly	40	53	7

6. Do you use a personal computer on a regular basis?

Pest insect	Yes (%)	No (%)	Don't know (%)
Cabbage root fly	43	53	4
Carrot fly	33	64	3
Pollen beetle	50	44	6
Large narcissus fly	33	60	7

7. Did you receive the forecast?

Pest insect	Yes (%)	No (%)	Don't know (%)
Cabbage root fly	95	3	2
Carrot fly	97	0	3
Pollen beetle	81	19	0
Large narcissus fly	100	0	0

8. Was the forecast easy to understand?

Pest insect	Yes (%)	No (%)	Don't know (%)
Cabbage root fly	89	5	6
Carrot fly	89	8	3
Pollen beetle	81	0	19
Large narcissus fly	100	0	0

9. Did you think that the information given was useful?

Pest insect	Yes (%)	No (%)	Don't know (%)
Cabbage root fly	83	8	9
Carrot fly	87	8	5
Pollen beetle	75	6	19
Large narcissus fly	87	7	6

10. Did you use any of the information provided?

Pest insect	Yes (%)	No (%)	Don't know (%)
Cabbage root fly	78	17	5
Carrot fly	85	10	5
Pollen beetle	69	13	18
Large narcissus fly	67	33	0

11. Would you have liked more background explanation of the forecasting system?

Pest insect	Yes (%)	No (%)	Don't know (%)
Cabbage root fly	56	37	7
Carrot fly	61	34	5
Pollen beetle	56	31	13
Large narcissus fly	73	20	7

12. Would you have preferred the information to have been presented as graphs, tables or in words?

Pest insect	Graphs	Tables	Words
Cabbage root fly	41	23	36
Carrot fly	39	25	36
Pollen beetle	36	7	57
Large narcissus fly	37	21	42

13. Do you think the forecast helped you to control large narcissus fly effectively?

Pest insect	Yes (%)	No (%)	Don't know (%)
Large narcissus fly	60	40	0

14. Would you prefer the information just before the start of activity rather than every week?

Pest insect	Yes (%)	No (%)	Don't know (%)
Cabbage root fly	64	30	6
Carrot fly	58	39	3
Pollen beetle	50	38	12
Large narcissus fly	53	27	20

15. Would you like a forecast in future?

Pest insect	Yes (%)	No (%)	Don't know (%)
Cabbage root fly	94	5	1
Carrot fly	91	8	1
Pollen beetle	94	6	0
Large narcissus fly	100	0	0

CONCLUSIONS

1. During 1992, more than 350 forecasts were sent to over 250 growers. An average of 93% of growers received the forecast.

2. Over 50% of the growers who received the forecasts responded to the questionnaire.

3. Between 38-60% of growers admitted they had problems controlling one or other of the pests being forecasted.

4. More than 88% of growers wanted accurate information on when these pests were likely to attack their crops.

5. Between 7-50% of growers monitored pest numbers in their crops.

6. Between 40-81% of growers made supplementary applications of insecticide to control these pests.

7. Although over 80% of the recipients found the forecasts easy to follow, 56-73% would have liked a more detailed explanation of the forecasting system.

8. Between 75-87% of growers thought that the information given was useful and 67-85% made direct use of at least some of the information.

9. More growers would like the information presented in graphs or in words rather than in tables.

10. More growers would prefer the forecasts to be sent out just prior to the start of pest activity rather than each week of the season.

11. More then 90% of growers would like to continue receiving a forecast.

SUMMARY

Weekly forecasts of the timing of cabbage root fly and carrot fly activity were produced in 1991 using weather data collected weekly from eight localities. The forecasts were sent to ADAS entomologists for appraisal.

During 1992, pest forecasts were offered free to HDC levy payers and forecasts for cabbage root fly, carrot fly, pollen beetle and large narcissus fly were sent weekly to growers. More than 350 forecasts were sent out to over 250 growers.

Growers' opinions on all four forecasts were sought using a questionnaire. More than 50% of recipients responded. More than 88% of growers wanted to know when these insect pests were attacking their crops and 38-60% admitted they had problems controlling one or other of the pests. Between 40-81% of growers made supplementary applications of pesticide to control these pests.

Over 80% of recipients found the forecasts easy to understand but between 56-73% would have liked more background explanation of the forecasting system. From 75-87% of growers thought that the information given was useful and 67-85% used at least some of the information provided. More growers would prefer the information just before the start of fly activity rather than every week. More than 90% of growers would like to receive a forecast in future.

ACKNOWLEDGEMENTS

We are extremely grateful to colleagues in ADAS (National Agromet Unit, Arthur Rickwood), HRI (Littlehampton, Wellesbourne, Kirton, Stockbridge House, Efford, East Malling), Brooms Barn Experimental Station and Morley Research Centre for supplying the weekly weather data and to all participating growers for their considerable co-operation in the development of this series of pest forecasts. We are also indebted to ADAS colleagues, particularly Dr J. Blood-Smyth, Mr B. Emmett, Dr S. Tones and Dr W. Parker, and to ADAS Arthur Rickwood and HRI Stockbridge House for providing much useful information on pest activity.

Figure 1. Observed and forecast cabbage root fly and carrot fly activity at Wellesbourne in 1991.

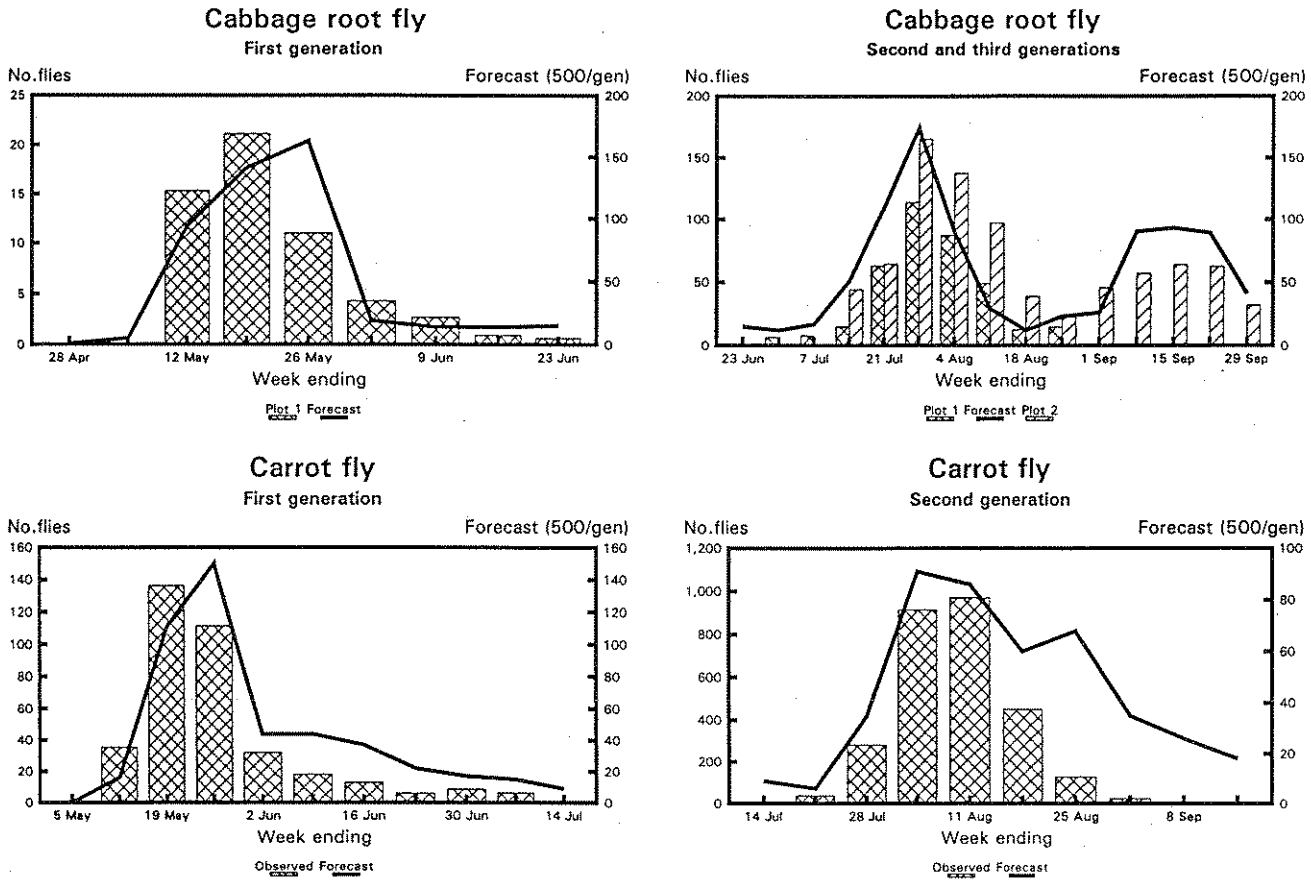
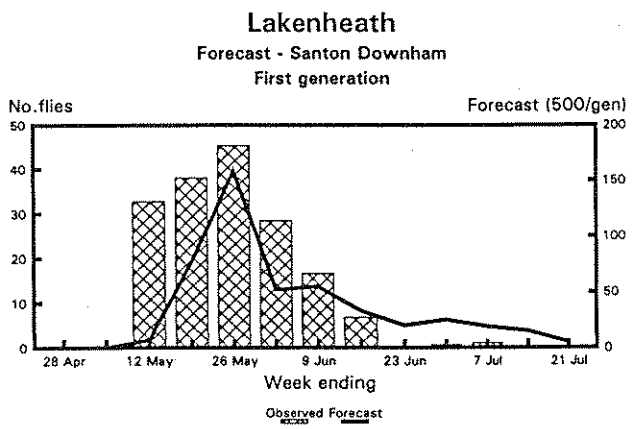
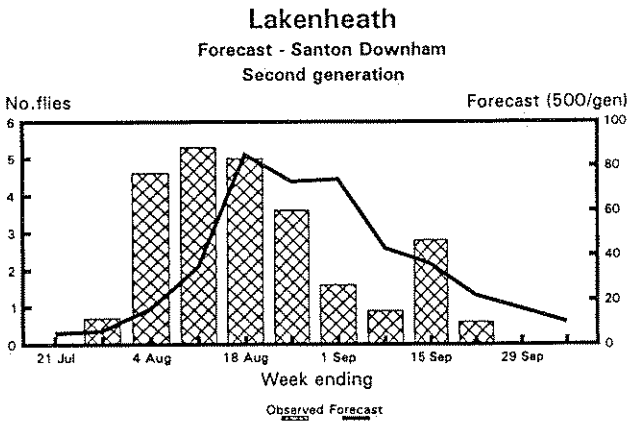
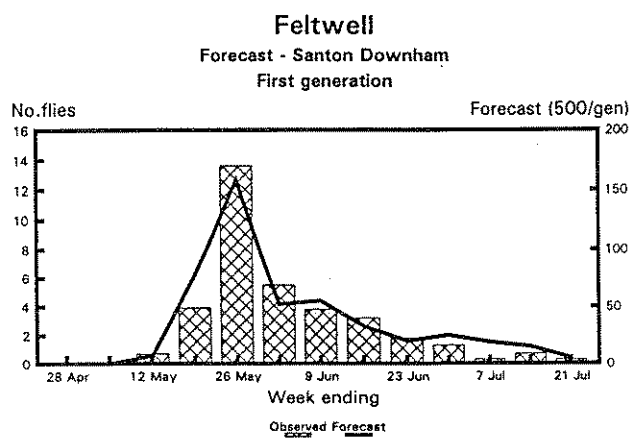
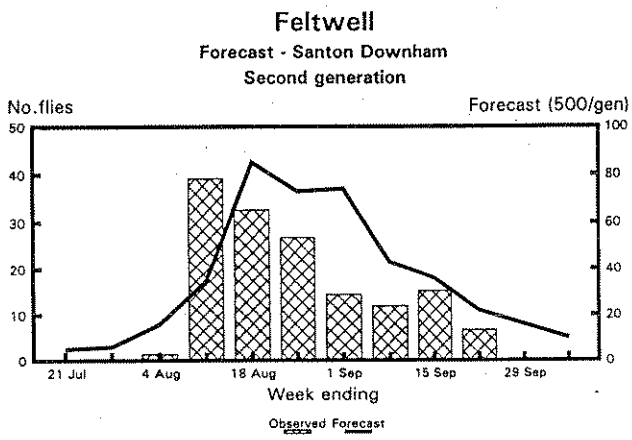


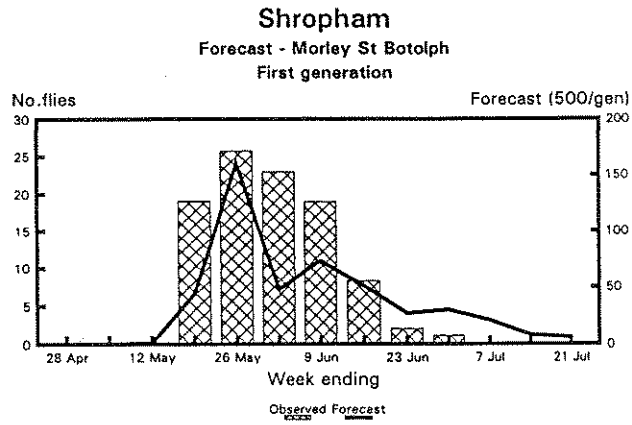
Figure 2. Observed and forecast carrot fly activity at 4 sites in 1991.

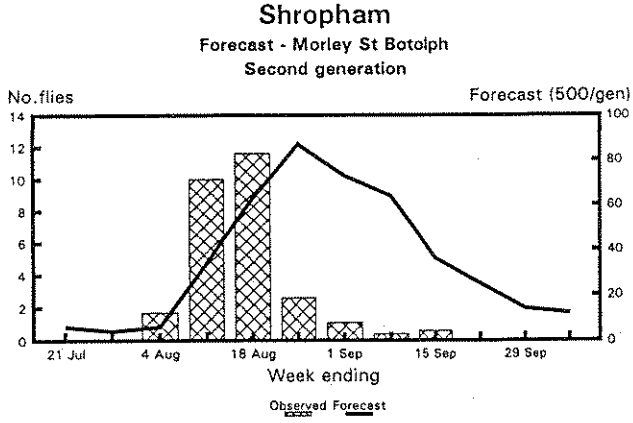


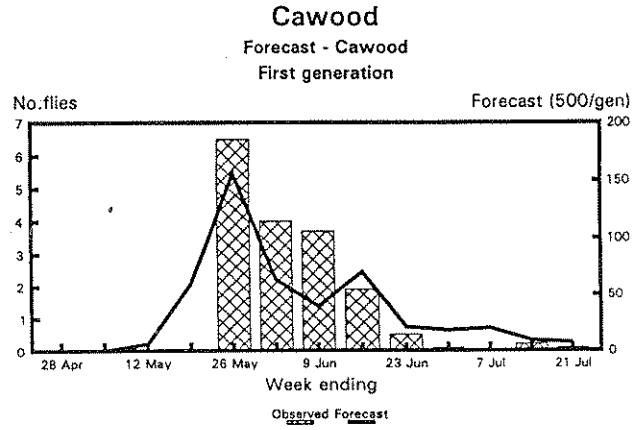












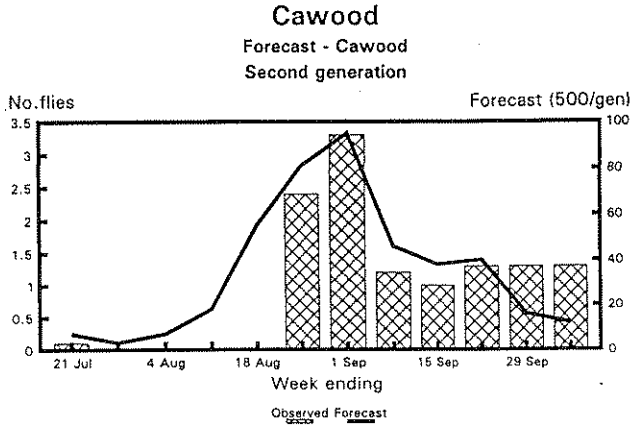
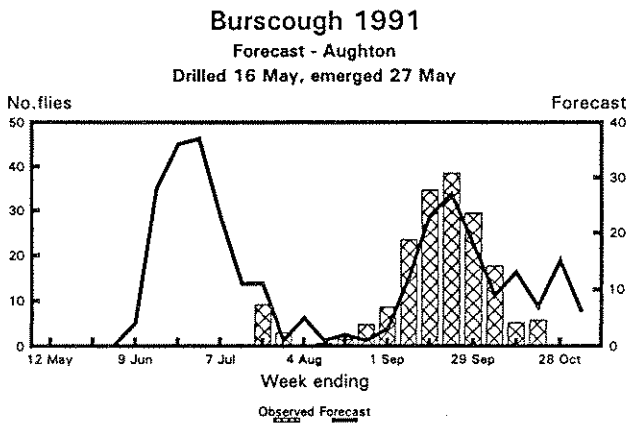
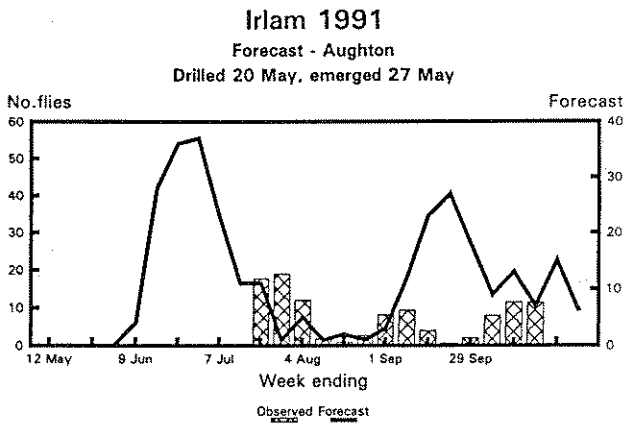


Figure 3. Observed and forecast carrot fly activity in south-west Lancashire after a correction factor has been incorporated into the forecast to allow for the relatively late time carrot crops are normally drilled in the locality. Monitoring started during the week ending 21 July.





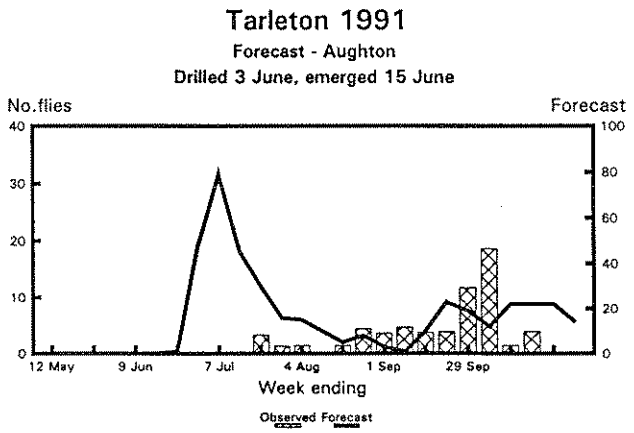
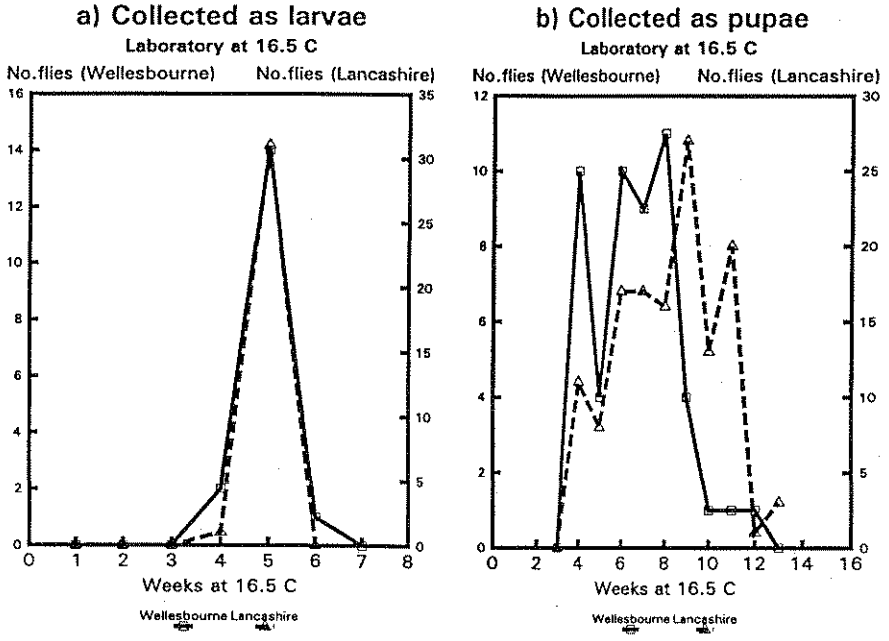


Figure 4. Emergence of carrot flies collected in Lancashire and at Wellesbourne during February 1992. Insects collected as larvae (a) or pupae (b) and kept in the laboratory at 16.5°C or buried in field soil at Wellesbourne (c) and confined in emergence cages.



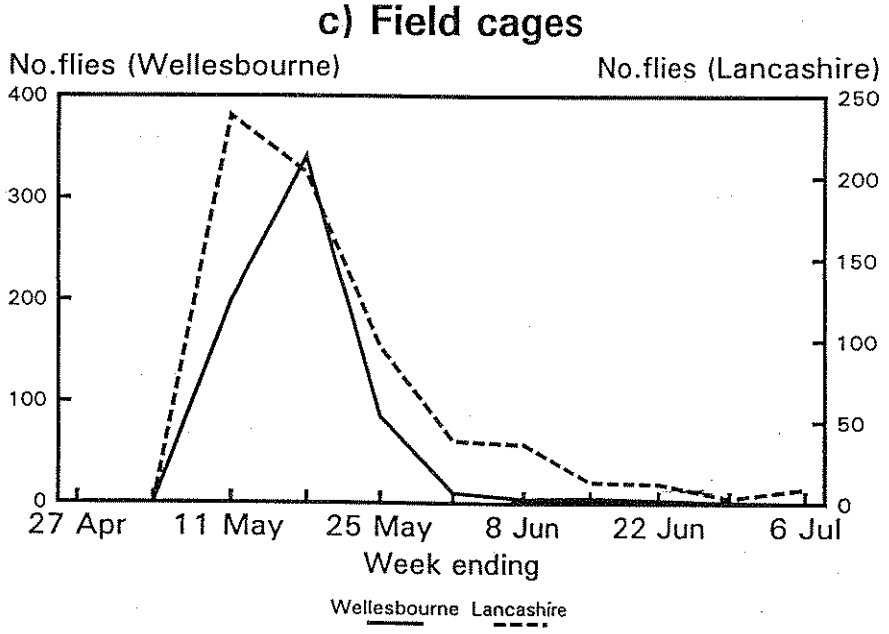


Figure 5. Observed and forecast cabbage root fly and carrot fly activity at Wellesbourne in 1992.

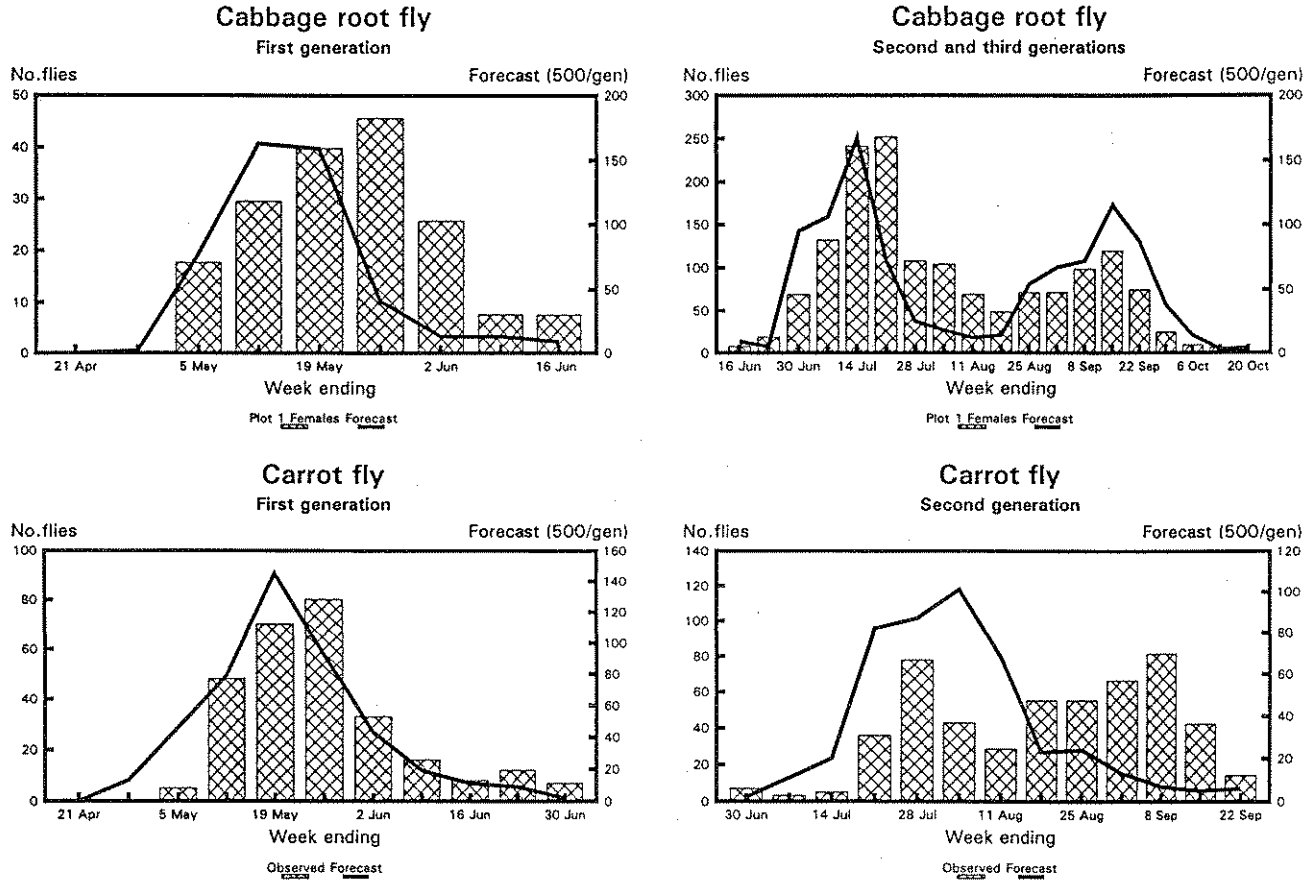


Figure 6. Observed and forecast carrot fly activity at two sites in 1992.

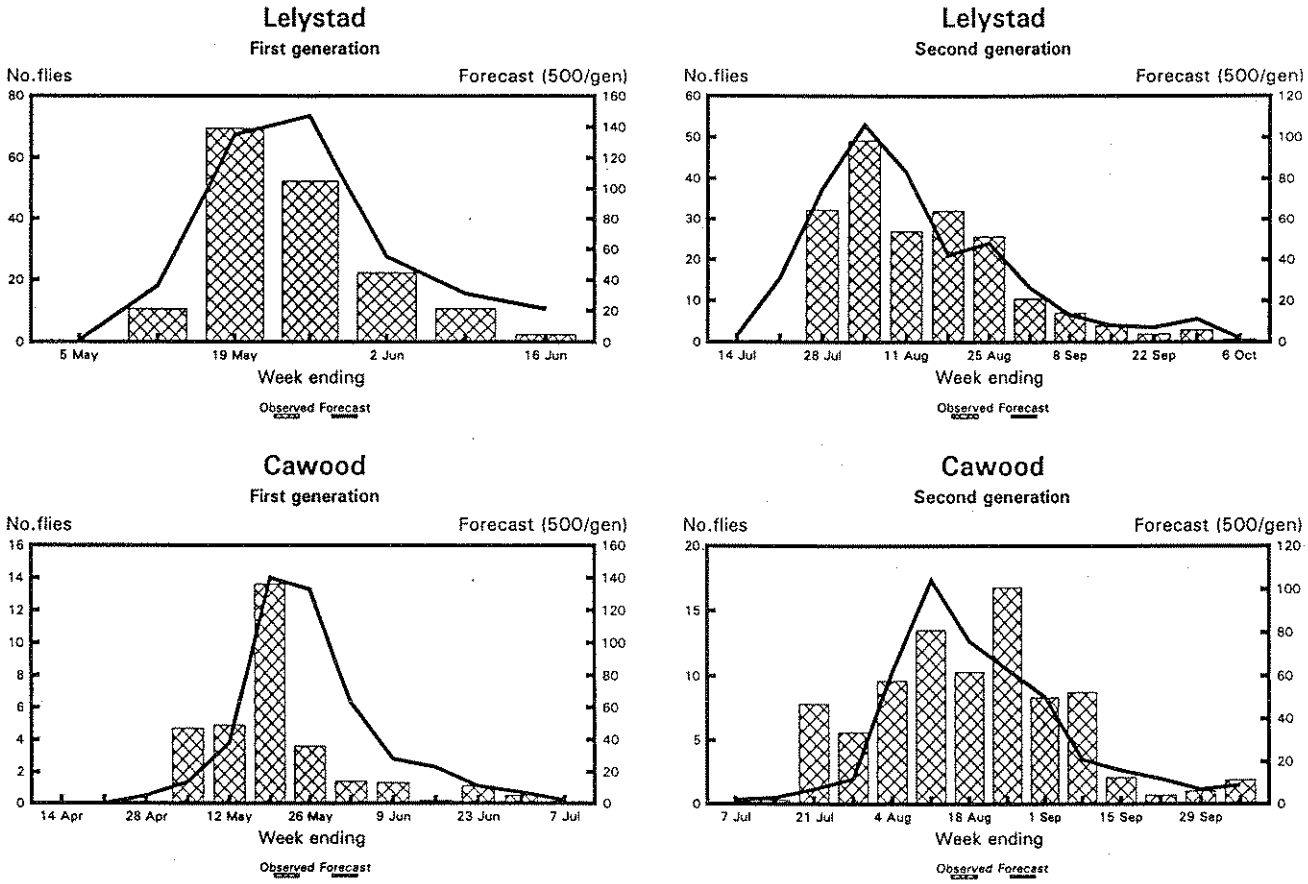


Figure 7. Observed and forecast pollen beetle activity in 1992.