Grower Summary

FV 407a

Spinach: Further studies on forecasting migrations of Aphis fabae into spinach crops

Final 2014

Disclaimer

The results and conclusions in this report may be based on an investigation conducted over one year. Therefore, care must be taken with the interpretation of the results.

Use of pesticides

Only officially approved pesticides may be used in the UK. Approvals are normally granted only in relation to individual products and for specified uses. It is an offence to use non-approved products or to use approved products in a manner that does not comply with the statutory conditions of use, except where the crop or situation is the subject of an off-label extension of use.

Before using all pesticides check the approval status and conditions of use.

Read the label before use: use pesticides safely.

Further information

If you would like a copy of the full report, please email the HDC office (hdc@hdc.ahdb.org.uk), quoting your HDC number, alternatively contact the HDC at the address below.

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Headline

A forecast based on mean daily air temperature, averaged over a defined period in the spring-early summer, together with the latitude and longitude of the location, can be used to forecast the timing of the spring/summer migration of *Aphis fabae*.

Background

The black bean aphid (*Aphis fabae*) has a very large range of summer hosts, of which spinach is one. The principal crops involved are field beans, broad beans and sugar beet, as well as most forms of garden bean. Some common wild hosts include dock, poppies, goosefoot and fat hen.

Aphis fabae overwinters mainly as eggs on spindle bushes, and a few other shrub species, and occasionally, in warmer locations, as mobile stages on members of the pea/bean family (wild hosts or winter beans). The eggs hatch from late February to early April and colonies develop on young leaves and shoots of the winter host. Winged forms are produced in May/June and these migrate to summer hosts. Reproduction continues throughout the summer, further winged forms are produced in response to crowding and these spread within crops and invade new crops. Populations usually peak in July/August. In autumn *A. fabae* migrates back to spindle and winter eggs are laid. Winged forms of *Aphis fabae* are captured in the suction traps operated by the Rothamsted Insect Survey.

Several researchers have developed forecasting systems for infestations of *A. fabae* on beans or sugar beet. Some of these have relied on counting aphids, either eggs on overwintering hosts or mobile stages on crops. However, a paper by Way *et al* (1981) considered an approach using both egg counts and suction trap samples to forecast infestations in field beans. They concluded that information on the spring migration from spindle and also the autumn migration back to spindle was useful. The forecasting system they developed was used in the UK for a number of years.

Previous studies on other pest species indicated relationships between pest activity/abundance and weather data (either day-degree forecasts or statistical relationships). In Project FV 407, Rothamsted suction trap data from two sites and regional weather data were summarised and analysed to determine whether there were any relationships that could be developed for *A. fabae*. The timing of migration of winged aphids varied from year to year and site to site and there was a very strong correlation with the mean temperature (summarised over different periods leading up to the spring and summer migrations). The high correlation coefficients and the similarity of the fitted lines for the two sites (slope and intercept) indicated that there is a robust relationship with temperature and that the timing of key events should be highly predictable using accumulated temperatures (day-degrees). Such day-degree forecasts have been used successfully for other pest aphids that overwinter as eggs on woody hosts (e.g. willow-carrot aphid, lettuce root aphid – used on the HDC Pest Bulletin). Relationships between temperature or rainfall and aphid abundance were also investigated in FV 407 but there were no significant correlations.

Summary

The project consisted of four objectives:

Objective 1. Use suction trap data and daily weather data to develop a day-degree forecast for Aphis fabae *to predict the start of the spring migration and the timing of different stages of the summer migration.*

Two sets of aphid monitoring data from the Rothamsted Insect Survey were used to develop a day-degree forecast for *Aphis fabae*. These were records of the capture of *A. fabae* at Rothamsted Research between 1965 and 1999 and records of captures at a number of sites between 1981 and 1988. The day-degrees to the capture of the first aphid and to the capture of 10 and 50% of the total number of aphids captured up to 31st August were calculated using two methods. As the threshold temperature for development of *A. fabae* is unknown, day-degrees were accumulated using a range of threshold temperatures between -2 and 8°C. Similarly, as the end point of egg diapause (the overwintering stage) is undefined, different start dates for day-degree accumulations were tried e.g. from 1 January, 1 February or 1 March. Although there were consistent statistical relationships it was not possible to identify a constant day-degree sum that could be used to predict the aphid migration. In all instances the day-degree sum was greater when the aphid migration occurred later in the year.

An alternative approach was explored using the strong relationships between the timing of the spring/summer migration by *A. fabae* and mean air temperature identified in project FV 407. A data set consisting of 423 location x year combinations was used to explore these relationships. It became apparent that, apart from the mean air temperature, the location of the site appeared to influence the relationships quite strongly. Therefore to investigate the nature of the relationships with mean temperature (and latitude and longitude) a series of regression analyses were run on the full data set. These were:

- First aphid against Mean Temperature Jan-Apr
- 10% aphids against Mean Temperature Jan-Apr
- 10% aphids against Mean Temperature Jan-May
- 50% aphids against Mean Temperature Jan-Apr
- 50% aphids against Mean Temperature Jan-May
- 50% aphids against Mean Temperature Jan-Jun

For each of these, the analysis started with a simple linear regression for the whole data set. For the analyses of 10% aphids and 50% aphids against different explanatory variables, the 'percentage variance accounted for' indicated that using the mean temperature over a longer period provided a better fitting model. A simple linear regression 'with groups' analysis was then applied, allowing both the intercept and slope of the fitted relationship to change between locations. In every case, there was evidence for differences in the intercepts between locations, but not for differences in the slopes, therefore indicating a series of parallel lines representing the 15 locations. For each of the parallel line models, the intercept parameters for the 15 locations were extracted and a multiple linear regression was applied for these against both latitude and longitude. All showed evidence for the intercepts varying with both latitude and longitude.

The final output in each set of analyses was for a multiple linear regression model including the appropriate mean temperature variable and both latitude and longitude. These analyses again all showed significant effects of both latitude and longitude (effectively influencing the intercept of the fitted line for each location) as well as of mean temperature. These overall fitted models (Table A) could be used to predict the timing of aphid activity at any location (in the UK) in any particular year using the appropriate air temperature data.

Table A. Fitted equations for multiple linear regression models between dates of first, 10% and 50% capture and mean air temperature over different periods and latitude and longitude. All were statistically significant ($p<0.001$).

Measure of timing of aphid activity	Mean temperature during	Fitted equation (Time in days from 1 January)
First	Jan-Apr	Time=64-9.70*mean temp+2.67*latitude+4.19*longitude
10%	Jan-Apr	Time=60-7.78*mean temp+3.24*latitude+1.21*longitude
10%	Jan-May	Time=96-9.11*mean temp+2.88*latitude+1.04*longitude
50%	Jan-Apr	Time=57-5.23*mean temp+3.32*latitude+2.15*longitude
50%	Jan-May	Time=82-6.15*mean temp+3.07*latitude+2.04*longitude
50%	Jan-Jun	Time=110-7.07*mean temp+2.81*latitude+1.93*longitude

Objective 2. Validate day-degree forecast and method of predicting abundance using any available historical crop monitoring data.

To validate the forecast based on mean temperature, latitude and longitude, the predicted dates for first, 10% and 50% capture were calculated using the equations in Table A. The absolute differences between observed and predicted dates were then calculated and used to calculate the mean deviation between observed and predicted dates, shown in Table B. The predictions for the capture of the first aphid were the least consistent (January-April temperatures) and those for capture of 50% aphids were most consistent, with an average of just over a week. Consistency was improved by using weather data over a longer period of time. The predictions appeared to be least accurate for Rosewarne, followed by Preston. However, it is important to bear in mind that the trap records were from different runs of years for each site.

Table B. Mean absolute difference between observed and predicted dates of activity for all site x year combinations.

	Latitude	Longitude	First (Jan-Apr)	10% (Jan-Apr)	10% (Jan-May)	50% (Jan-Apr)	50% (Jan-May)	50% (Jan-Jun)
Starcross	50.37	3.27	10	13	13	10	9	9
Rosewarne	50.50	5.19	16	17	16	14	14	14
Wye	51.10	-0.56	11	10	9	7	7	7
Writtle	51.43	-0.25	13	10	9	8	8	8
Rothamsted	51.48	0.21	13	10	9	7	7	7
Brooms Barn	52.15	-0.33	10	9	9	8	8	8
Kirton	52.55	0.30	13	9	9	10	10	10
Hereford	52.70	2.39	18	11	11	11	10	10
Preston	53.45	2.42	19	9	8	11	11	11
High Mowthorpe	54.50	0.39	22	12	12	9	9	9
Newcastle	54.58	1.37	15	12	11	11	10	10
Ayr	55.28	4.33	19	12	12	8	9	8
East Craigs	55.57	3.18	24	13	12	7	7	6
Dundee	56.27	3.30	20	10	10	8	8	7
Elgin	57.38	3.19	19	13	12	8	8	8
Mean			16.07	11.25	10.93	9.09	8.88	8.82
Max			24	17	16	14	14	14
Min			10	9	8	7	7	6

Objective 3 . Analyse these data for relationships that might help to predict abundance.

There was no relationship between the numbers of aphids captured and latitude of the suction trap location. Nor was there any evidence of a relationship between the numbers caught in the spring/summer migration and the size of the autumn migration in the previous year. Similarly there appeared to be no relationship between the warmth of the spring and the numbers of aphids captured.

Objective 4 . Develop a method of predicting relative abundance in the summer as early as possible from real-time suction trap data.

By predicting the date of 10% activity it might be possible to use the numbers captured by that predicted date to predict the total number of aphids captured during the summer (up to 31 August). Examples of the relationship between the actual captures up to 31 August and the predicted capture up to 31 August (based on the numbers captured at the predicted date of 10% activity) showed that whilst there was a large amount of scatter, this might provide an estimate of the final numbers captured, but would not be completely reliable.

Financial Benefits

This proposal is in direct response to a request from industry and the intention is to provide information that will inform an improved control strategy for *Aphis fabae* on spinach.

Action Points

- The fitted equations describing the relationship between aphid activity and mean temperature, latitude and longitude will be used in the HDC Pest Bulletin in 2014.

- Spreadsheets containing the equations can be supplied to growers for use with their own air temperature data in 2014.

- Even without a forecast, growers can regularly update themselves on the numbers of *A. fabae* captured by Rothamsted suction traps in the current season http://www.rothamsted.ac.uk/insect-survey/STAphidBulletin.php.

- To reinforce this, information on suction trap catches will be added to the HDC Pest Bulletin updates.