In partnership with AHDB HORTICULTURE THE UNIVERSITY OF WARWICK ROTHAMSTED RESEARCH

CUTWORM (TURNIP MOTH) 10 September 2020

In partnership with AHDB HORTICULTURE THE UNIVERSITY OF WARWICK ROTHAMSTED RESEARCH

Introduction

The 'Cutworm Risk Model'

The cutworm model is a computer program that uses weather data to predict the rate of development of turnip moth eggs and caterpillars. It also predicts the level of rain-induced mortality among the early-instar caterpillars. The cutworm model published by Bowden *et al* (1983) has been programmed into the MORPH decision-support software. This version will be used to produce cutworm forecasts in 2020, with the weather data used to produce the cabbage root fly and carrot fly forecasts.

Reference: Bowden, J., Cochrane, J., Emmett, B. J., Minall, T. E. & Sherlock, P. L. (1983). A survey of cutworm attacks in England and Wales, and a descriptive population model for *Agrotis segetum* (Lepidoptera: Noctuidae). Annals of Applied Biology 102 29-47.

Background

"Cutworm" is the name given to caterpillars of certain Noctuid moths, in particular those of the turnip moth *Agrotis segetum*. The name derives from the habit of the older caterpillars of feeding underground, damaging plant roots and stems (including the storage organs that we use for food), sometimes so badly that the plant topples.

The adult moths lay eggs on plants or on pieces of litter and debris in the soil, usually from the end of May or early June. These hatch in around 8-24 days, depending on temperature. The young caterpillars seek out and feed on the aerial parts of plants. In a further 10-20 days, again depending on temperature, the caterpillars go through their second moult, becoming "third instar" caterpillars. It is at this point that they adopt the cutworm habit, becoming subterranean and feeding on roots etc.

Unhatched turnip moth eggs and the older, subterranean cutworms are largely invulnerable to the effects of the weather and insecticides. The two early caterpillar instars differ, however. If there is substantial rainfall (defined as 10 mm or more of rain falling in showers of moderate intensity over a 24-

hour period) whilst these caterpillars are feeding above ground then this causes high mortality among them. They are also vulnerable to insecticides and irrigation whilst feeding on the foliage.

Crop Susceptibility

Crops differ in their susceptibility to cutworm damage. The most vulnerable are lettuce, leek and red beet. Young lettuce and leek plants are easily bitten through by cutworms, and though beet plants may survive an attack the bulbous root is rendered unmarketable by cutworm feeding. Moderately-susceptible crops include brassicas, carrot, celery, parsnip and sugar beet. The least susceptible of those vulnerable to damage are onion, potato, swede and turnip.

In partnership with AHDB HORTICULTURE THE UNIVERSITY OF WARWICK ROTHAMSTED RESEARCH

Numbers of moths captured in pheromone traps at Wellesbourne in 2020 (set up 19th May).

Date	Number of moths captured (2 pheromone traps)
22 May	1
26 May	7
29 May	6
2 June	7
5 June	5
9 June	6
12 June	2
16 June	2
19 June	1
23 June	0
26 June	1
30 June	0
3 July	1
7 July	0
10 July	0
14 July	0

Numbers of moths captured in pheromone traps at Wellesbourne in 2020 (set up 19th May).

Date	Number of moths captured (2 pheromone traps)
17 July	0
21 July	3
24 July	2
28 July	1
31 July	0
4 August	0
7 August	1
11 August	0
14 August	1
16 August	5
21 August	25
25 August	25
28 August	8
1 September	13
4 September	4
8 September	0

In partnership with AHDB HORTICULTURE THE UNIVERSITY OF WARWICK ROTHAMSTED RESEARCH

Cutworm forecasts

The model has been run from 20th May – based on the capture of the first turnip moth at Wellesbourne (using weather data provided by Plantsystems and funded by Syngenta). The forecasts indicate that eggs will be hatching from about 2nd June. Once eggs start to hatch then rainfall becomes important for the forecast. The table below shows the predicted **percentage survival by 5th August** (the date up to which there are current rainfall data) of caterpillars from eggs hatching each day from 1st June until 30 July based on rainfall at each site. If there has been no rain at all then 100% of caterpillars are predicted to survive. The caterpillars are likely to become invulnerable to rainfall and insecticides after about 20 days (when they enter the third instar and burrow in the soil). **This is the last forecast for 2020 as the threat from the first generation of turnip moth is over. There is usually a second generation of turnip moth but this generation does not appear to be a threat to crops.**

In partnership with AHDB HORTICULTURE THE UNIVERSITY OF WARWICK ROTHAMSTED RESEARCH

	Cornwall	Kent	Suffolk	Wellesbourne	Norfolk	South Lincs	Nottingham	Lancashire	York	Scotland	Estimated date when no longer affected by rainfall or insecticides
	Percentage survival for each hatching date on left hand side										
01-Jun	0	0	0	0	0	0	0	0	0	0	21-Jun
02-Jun	0	0	0	0	0	0	0	0	0	0	22-Jun
03-Jun	0	0	0	0	0	0	0	0	0	0	23-Jun
04-Jun	0	0	0	0	0	0	0	0	0	0	24-Jun
05-Jun	0	0	0	0	0	0	0	0	0	0	25-Jun
06-Jun	0	0	0	0	0	0	0	0	0	0	26-Jun
07-Jun	0	0	0	0	0	0	0	0	0	0	27-Jun
08-Jun	0	0	0	0	0	0	0	0	0	0	28-Jun
09-Jun	0	0	0	0	0	0	0	0	0	0	29-Jun
10-Jun	0	0	0	0	0	0	0	0	0	0	30-Jun
11-Jun	0	0	0	0	0	0	0	0	0	0	01-Jul
12-Jun	0	0	0	0	0	0	0	0	0	0	02-Jul
13-Jun	0	0	0	0	0	0	0	0	0	0	03-Jul
14-Jun	0	0	0	0	0	0	0	0	0	0	04-Jul
15-Jun	0	0	0	0	0	0	0	0	0	0	05-Jul
16-Jun	0	0	0	0	0	0	0	0	0	0	06-Jul
17-Jun	0	0	0	0	0	0	0	0	0	0	07-Jul
18-Jun	0	0	0	0	0	0	0	0	0	0	08-Jul
19-Jun	0	0	0	0	0	0	0	0	0	0	09-Jul

In partnership with AHDB HORTICULTURE THE UNIVERSITY OF WARWICK ROTHAMSTED RESEARCH

	Cornwall	Kent	Suffolk	Wellesbourne	Norfolk	South Lincs	Nottingham	Lancashire	York	Scotland	Estimated date when no longer affected by rainfall or insecticides
	Percentage survival for each hatching date on left hand side										
20-Jun	0	0	0	0	0	0	0	0	0	0	10-Jul
21-Jun	0	0	0	0	0	0	0	0	0	0	11-Jul
22-Jun	0	0	0	0	0	0	0	0	0	0	12-Jul
23-Jun	0	0	0	0	0	0	0	0	0	0	13-Jul
24-Jun	0	0	0	0	0	0	0	0	0	0	14-Jul
25-Jun	0	0	0	0	0	0	0	0	0	0	15-Jul
26-Jun	0	0	0	0	0	0	0	0	0	0	16-Jul
27-Jun	0	0	0	0	0	0	0	0	0	0	17-Jul
28-Jun	0	0	0	0	0	0	0	0	0	0	18-Jul
29-Jun	0	0	0	0	0	0	0	0	0	0	19-Jul
30-Jun	0	0	0	0	0	0	0	0	0	0	20-Jul
1-Jul	0	0	0	0	0	0	0	0	0	0	21-Jul
2-Jul	0	0	0	0	0	0	0	0	0	0	22-Jul
3-Jul	0	0	0	0	0	0	0	0	0	0	23-Jul
4-Jul	0	0	0	0	0	0	0	0	0	0	24-Jul
5-Jul	0	0	0	0	0	0	0	0	0	0	25-Jul
6-Jul	0	0	0	0	0	0	0	0	0	0	26-Jul
7-Jul	0	0	0	0	0	0	0	0	0	0	27-Jul
8-Jul	0	0	0	0	0	0	0	0	0	0	28-Jul

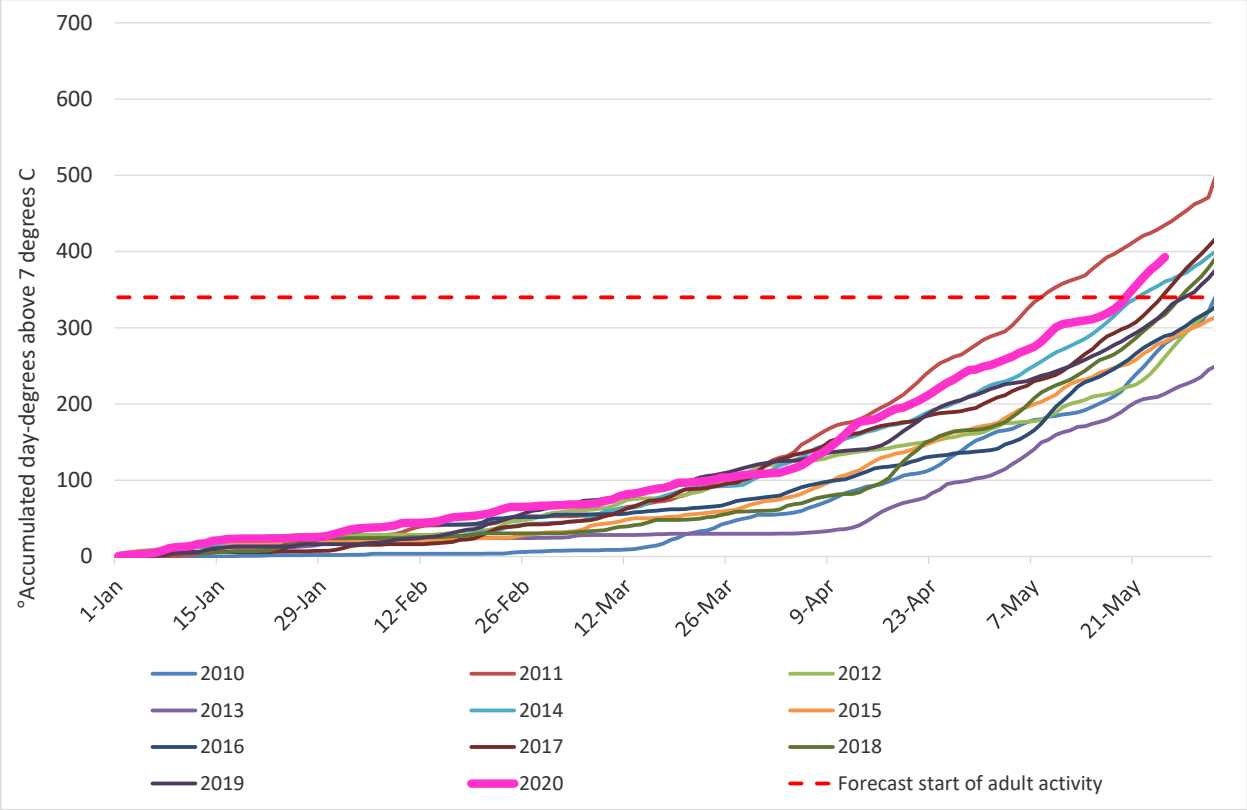
In partnership with AHDB HORTICULTURE THE UNIVERSITY OF WARWICK ROTHAMSTED RESEARCH

	Cornwall	Kent	Suffolk	Wellesbourne	Norfolk	South Lincs	Nottingham	Lancashire	York	Scotland	Estimated date when no longer affected by rainfall or insecticides
	Percentage survival for each hatching date on left hand side										
9-Jul	0	0	0	0	0	0	0	0	0	0	29-Jul
10-Jul	0	0	0	0	0	0	0	0	0	0	30-Jul
11-Jul	0	0	0	0	0	0	0	0	0	0	31-Jul
12-Jul	0	0	0	0	0	0	0	0	24	0	01-Aug
13-Jul	0	0	0	0	0	0	0	0	24	0	02-Aug
14-Jul	0	0	0	0	0	0	0	0	24	0	03-Aug
15-Jul	0	0	0	6	0	0	0	0	24	0	04-Aug
16-Jul	0	0	55	6	0	0	0	0	24	0	05-Aug
17-Jul	0	0	55	6	0	0	0	0	24	0	06-Aug
18-Jul	0	0	55	6	0	0	0	0	24	0	07-Aug
19-Jul	0	0	55	6	0	0	0	0	24	0	08-Aug
20-Jul	0	0	55	32	0	0	0	0	26	0	09-Aug
21-Jul	0	16	59	64	0	0	0	0	26	0	10-Aug
22-Jul	0	16	59	64	0	0	0	0	26	0	11-Aug
23-Jul	0	16	59	64	0	0	0	0	26	0	12-Aug
24-Jul	0	16	59	64	0	0	0	0	26	0	13-Aug
25-Jul	0	16	59	64	0	0	0	0	32	0	14-Aug
26-Jul	0	16	59	64	0	0	0	0	34	0	15-Aug
27-Jul	26	88	87	74	30	0	50	0	40	0	16-Aug
28-Jul	36	90	89	74	30	2	50	0	44	0	17-Aug
29-Jul	100	100	100	100	100	100	100	96	100	43	18-Aug
30-Jul	100	100	100	100	100	100	100	96	100	43	19-Aug

In partnership with AHDB HORTICULTURE THE UNIVERSITY OF WARWICK ROTHAMSTED RESEARCH

Day-degree sum to start of flight activity 2020

Several years ago, data on trap captures in 2005-7 were used to estimate a day-degree (D°) sum for the start of flight activity at Wellesbourne. This was 340 D° above a base of 7°C from 1 January. The graph below shows accumulated day-degrees for 2020 at Wellesbourne compared with previous years. Flight was predicted to start on 20th May.



In partnership with AHDB HORTICULTURE THE UNIVERSITY OF WARWICK ROTHAMSTED RESEARCH

Historical information from 2019

Numbers of moths captured in pheromone traps at Wellesbourne in 2019.

Date	Number of moths captured (2 pheromone traps)
10 May	0
14 May	4
17 May	1
21 May	0
24 May	0
28 May	9
31 May	5
4 June	2
7 June	0
11 June	2
14 June	0
18 June	1
21 June	1
25 June	1

In partnership with AHDB HORTICULTURE THE UNIVERSITY OF WARWICK ROTHAMSTED RESEARCH

Date	Number of moths captured (2 pheromone traps)
28 June	3
2 July	1
5 July	2
9 July	8
12 July	1
16 July	1
19 July	0
23 July	1
26 July	0
30 July	1
2 August	3
6 August	2
9 August	2
13 August	2
16 August	0
20 August	0
23 August	0
27 August	0

In partnership with AHDB HORTICULTURE THE UNIVERSITY OF WARWICK ROTHAMSTED RESEARCH

Date	Number of moths captured (2 pheromone traps)
30 August	2
3 September	2
6 September	2
10 September	3
13 September	0
17 September	2
20 September	0
24 September	1
27 September	0
1 October	1
4 October	0
7 October	1
11 October	0
15 October	4
18 October	0
22 October	1

In partnership with AHDB HORTICULTURE THE UNIVERSITY OF WARWICK ROTHAMSTED RESEARCH

Date	Number of moths captured (2 pheromone traps)
30 August	0
3 September	1

In partnership with AHDB HORTICULTURE THE UNIVERSITY OF WARWICK ROTHAMSTED RESEARCH

Cutworm forecasts 2019

The model has been run from 14th May – based on the capture of the first turnip moth at Wellesbourne (using weather data provided by Plantsystems and funded by Syngenta). The forecasts indicate that eggs will be hatching from about 1st June. Once eggs start to hatch then rainfall becomes important for the forecast. The table below shows the predicted **percentage survival by 6 August** of caterpillars from eggs hatching each day from 1st June onwards. If there has been no rain at all then 100% of caterpillars are predicted to survive. The caterpillars are likely to become invulnerable to rainfall and insecticides after about 20 days (when they enter the third instar and burrow in the soil). **This is the last forecast for 2019 as the threat from the first generation of turnip moth is over. There is usually a second generation of turnip moth but this generation does not appear to be a threat to crops.**

In partnership with AHDB HORTICULTURE THE UNIVERSITY OF WARWICK ROTHAMSTED RESEARCH

	Cornwall	Kent	Suffolk	Wellesbourne	Norfolk	South Lincs	Nottingham	Lancashire	York	Scotland	Estimated date when no longer affected by rainfall or insecticides
	Percentage survival for each hatching date on left hand side										
01-Jun	0	0	0	0	0	0	0	0	0	0	21-Jun
02-Jun	0	0	0	0	0	0	0	0	0	0	22-Jun
03-Jun	0	0	0	0	0	0	0	0	0	0	23-Jun
04-Jun	0	0	0	0	0	0	0	0	0	0	24-Jun
05-Jun	0	0	0	0	0	0	0	0	0	0	25-Jun
06-Jun	0	0	0	0	0	0	0	0	0	0	26-Jun
07-Jun	0	0	0	0	0	0	0	0	0	0	27-Jun
08-Jun	0	0	0	0	0	0	0	0	0	0	28-Jun
09-Jun	0	0	0	0	0	0	0	0	0	0	29-Jun
10-Jun	0	0	0	0	0	0	0	0	0	0	30-Jun
11-Jun	0	0	0	0	0	0	0	0	0	0	01-Jul
12-Jun	0	0	0	0	0	8	0	0	0	0	02-Jul
13-Jun	0	0	0	0	0	56	0	0	0	0	03-Jul
14-Jun	0	0	0	0	0	64	0	0	0	0	04-Jul
15-Jun	0	0	0	0	0	74	0	0	0	0	05-Jul
16-Jun	0	0	0	0	0	80	0	0	0	0	06-Jul
17-Jun	0	0	0	0	0	84	0	0	0	0	07-Jul
18-Jun	0	0	0	0	0	82	0	0	0	0	08-Jul
19-Jun	0	0	0	0	0	86	0	0	0	0	09-Jul
20-Jun	44	0	0	0	0	88	0	0	0	0	10-Jul

In partnership with AHDB HORTICULTURE THE UNIVERSITY OF WARWICK ROTHAMSTED RESEARCH

	Cornwall	Kent	Suffolk	Wellesbourne	Norfolk	South Lincs	Nottingham	Lancashire	York	Scotland	Estimated date when no longer affected by rainfall or insecticides
	Percentage survival for each hatching date on left hand side										
21-Jun	34	0	0	0	0	90	0	0	0	0	11-Jul
22-Jun	56	0	0	0	0	84	0	0	0	0	12-Jul
23-Jun	56	0	0	0	0	66	0	0	0	0	13-Jul
24-Jun	76	0	0	0	0	46	0	0	0	0	14-Jul
25-Jun	76	0	0	0	0	46	0	0	0	0	15-Jul
26-Jun	76	0	66	98	68	48	0	0	30	0	16-Jul
27-Jun	4	0	66	100	68	48	0	0	24	0	17-Jul
28-Jun	4	0	48	100	49	40	0	0	12	0	18-Jul
29-Jun	0	0	48	0	19	16	0	0	0	0	19-Jul
30-Jun	0	0	0	0	0	8	0	0	0	0	20-Jul
1-Jul	0	0	0	0	0	6	0	0	0	0	21-Jul
2-Jul	0	0	0	0	0	6	0	0	0	0	22-Jul
3-Jul	0	0	0	0	0	6	0	0	0	0	23-Jul
4-Jul	0	0	0	0	0	0	0	0	0	0	24-Jul
5-Jul	0	0	0	0	0	0	0	0	0	0	25-Jul
6-Jul	0	0	0	0	0	0	0	0	0	0	26-Jul
7-Jul	0	0	0	0	0	0	0	0	0	0	27-Jul
8-Jul	0	0	0	0	0	0	0	0	0	0	28-Jul
9-Jul	0	0	0	0	0	0	0	0	0	0	29-Jul
10-Jul	0	0	0	0	0	0	0	0	0	0	30-Jul

	Cornwall	Kent	Suffolk	Wellesbourne	Norfolk	South Lincs	Nottingham	Lancashire	York	Scotland	Estimated date when no longer affected by rainfall or insecticides
	Percentage survival for each hatching date on left hand side										
11-Jul	0	0	0	0	0	0	0	0	0	0	31-Jul
12-Jul	0	0	0	0	0	0	0	0	0	0	01-Aug
13-Jul	0	0	0	0	0	0	0	0	0	0	02-Aug
14-Jul	0	0	0	0	0	0	0	0	0	0	03-Aug
15-Jul	0	0	0	0	0	0	0	0	0	0	04-Aug
16-Jul	0	0	0	0	0	0	0	0	0	0	05-Aug
17-Jul	0	0	0	0	0	0	0	0	0	0	06-Aug
18-Jul	0	0	0	0	0	0	0	0	0	0	07-Aug
19-Jul	0	0	0	0	0	0	0	0	0	0	08-Aug
20-Jul	0	0	0	0	0	0	0	0	0	0	09-Aug
21-Jul	0	0	0	0	0	0	0	0	0	0	10-Aug

In partnership with AHDB HORTICULTURE THE UNIVERSITY OF WARWICK ROTHAMSTED RESEARCH

	Cornwall	Kent	Suffolk	Wellesbourne	Norfolk	South Lincs	Nottingham	Lancashire	York	Scotland	Estimated date when no longer affected by rainfall or insecticides
	Percentage survival for each hatching date on left hand side										
22-Jul	0	0	0	0	0	0	0	0	0	0	11-Aug
23-Jul	0	0	0	0	0	0	0	0	0	0	12-Aug
24-Jul	0	0	0	0	0	0	0	0	0	0	13-Aug
25-Jul	0	0	0	0	0	0	0	0	0	0	14-Aug
26-Jul	0	3	3	0	9	0	0	0	0	0	15-Aug
27-Jul	0	3	3	0	11	0	0	0	0	0	16-Aug
28-Jul	0	96	96	0	63	0	0	0	86	0	17-Aug
29-Jul	0	96	96	0	65	0	0	0	86	0	18-Aug
30-Jul	0	96	96	0	65	0	0	0	98	0	19-Aug
31-Jul	28	96	96	92	65	0	24	0	100	0	20-Aug
1-Aug	28	100	100	92	87	44	34	74	100	0	21-Aug
2-Aug	28	100	100	100	87	76	34	74	100	0	22-Aug
3-Aug	28	100	100	100	87	76	34	74	100	0	23-Aug
4-Aug	30	100	100	100	87	76	34	74	100	0	24-Aug
5-Aug	54	100	100	100	87	84	84	84	100	0	25-Aug
6-Aug	100	100	100	100	100	100	100	100	100	100	26-Aug

In partnership with AHDB HORTICULTURE THE UNIVERSITY OF WARWICK ROTHAMSTED RESEARCH

Day-degree sum to start of flight activity 2019

Several years ago, data on trap captures in 2005-7 were used to estimate a day-degree (D°) sum for the start of flight activity at Wellesbourne. This was 340 D° above a base of 7°C from 1 January. The graph below shows accumulated day-degrees for 2019 at Wellesbourne compared with previous years.