SCEPTREPLUS

Final Trial Report

Trial code:	2019.SP01
Title:	AHDB SCEPTREplus parsnip herbicide screen
Crop	Group: Field vegetables – Parsnip (apiaceae), other umbelliferous root vegetables
Target	General broadleaf weeds and grasses, 3WEEDT EPPO1/99(3) Weeds in root vegetables
Lead researcher:	Angela Huckle
Organisation:	RSK ADAS
Period:	1st April 2019 – 31st March 2020
Report date:	29th February 2020
Report author:	Angela Huckle Emily Lawrence
ORETO Number: (certificate should be attached)	409

I the undersigned, hereby declare that the work was performed according to the procedures herein described and that this report is an accurate and faithful record of the results obtained

14th April 2020
Date

……
Authors signature

Trial Summary

Introduction

New products are required to supplement the short list of actives currently available to parsnip growers. This trial focused on finding safe and effective options for post-emergence weed control and understanding how they are best included in current programmes.

While extensions of authorisation for use of isoxaben, metamitron and—most recently, in April 2019—aclonifen have been issued, these products are only approved for pre-emergence application, so identifying alternative post-emergence weed control options continues to be a priority. This trial examined the crop safety and efficacy of these recently approved actives, both in pre-emergence tank-mixes with a commercial standard and in post-emergence screens where a little and often approach was used. In addition, eight novel products were screened; carried forward from 2018 parsnip work, this trial continues to assess these products for their potential to partly or fully replace linuron—a key component of herbicide programmes for parsnips, and no longer approved.

Method

Two separate trials were sited in commercial parsnip fields on sandy soils; one in Suffolk (Site 1) and one in Nottinghamshire (Site 2). A randomised block design was used for the trial layout, with three replicates of fifteen treatments, including two untreated controls and a grower standard treatment. There were forty-five plots in total at each site, with plots measuring 2 m x 6 m.

Site 1

Treatments were applied at four timings. The first were applied on 17th April 2019 (BBCH00-03), with subsequent applications on 23rd May (BBCH10-11), 4th June (BBCH11), and 20th June (BBCH12-13).

Site 2

Treatments were applied at four timings. The first were applied on 12th May (BBCH00-03), with subsequent application on 20th June (BBCH13), 2nd July (BBCH14), and 12th July (BBCH14).

All treatments were applied with a 2m boom, using a knapsack sprayer at 200 L/ha water volume.

The plots were assessed on five occasions, focusing on weed cover and species presence, and crop phytotoxicity (i.e. treatment safety). Assessments were carried out at two of the treatment application timings, and at approximately two, four and eight weeks after the Timing D application.

Results and discussion

Of the treatments assessed in these trials, nine appeared crop safe (**Table 1**) and gave statistically significant weed control (**Table 2**)—**Anthem + Hurricane SC + Goltix 70 SC**; **Anthem + Flexidor + Goltix 70 SC**; **Anthem + Emerger + Goltix 70 SC**; **Anthem + AHDB9917**; **Anthem, then Hurricane SC**; **Anthem, then AHDB9860**; **Anthem, then Emerger**; **Anthem, then AHDB9918**; and **Anthem, then AHDB9993**. By the conclusion of the trial, eight weeks after the final treatment application, all these treatments offered a significant reduction in weed cover compared to the untreated control, with none exhibiting any concerning phytotoxic symptoms.

The differences in phytotoxic effects between the two sites was notable in this trial, with very few treatments displaying phytotoxic damage at Site 2, despite some clear treatment effects at Site 1. This can be attributed to a delay in application at Site 2, meaning a larger crop at the time of treatment which was less vulnerable to phytotoxic damage. This also explains the site differences in plant population counts. There were few significant reductions in plant population at Site 1 for most of the treatments; **Anthem + AHDB9826** was the exception, where no crop

remained by the final plant population count. At Site 2, there were no significant reductions in plant population at either assessment. This can be attributed to the treatment application delay leading to the crop's larger size and consequent increased resilience.

As well as differences in phytotoxicity between the sites for the **Anthem + AHDB9826** treated crop, plots which received this treatment at Site 2 did not have the same high weed levels as at Site 1 at the final assessment—weed cover averaged 8.2% and 80.6% for the respective sites. This can also be attributed to the advanced growth of the crop at the point of application at Site 2—as the larger crop was resistant to phytotoxic effects—so the parsnips in **Anthem + AHDB9826** treated plots crowded out the weeds; with no crop emergence at Site 1, there was no competition for the weeds.

While **AHDB9993** offered promising weed control—with an average of 3.9% weed cover in treated plots eight weeks after its final application—it was noted that this product did not control black-grass. Therefore, it would need to be applied with a graminicide either in a tank-mix or a programme.

Emerger is authorised under EAMU 1601/19 for pre-emergence use on parsnip. A post-emergence EAMU authorisation for this product would also be very useful as it was one of the best performing products in this trial.

The use of **AHDB9917**, **Hurricane SC**, **AHDB9918**, **AHDB9993** or **AHDB9860** on parsnips are not currently approved, though these products also showed promise in this trial. **AHDB9917** was screened as a pre-emergence treatment, and **Hurricane SC** was included in both a pre-emergence tank-mix (with Goltix 70 SC, an EAMU authorised product for pre-emergence use) and screened for use as a post-emergence treatment. **AHDB9860**, **AHDB9918**, and **AHDB9993** were also screened as post-emergence treatments. By the conclusion of the trial, all these products showed lasting efficacy without any persistent phytotoxic effects and would be valuable additions to parsnip growers' weed control options, and pursual of EAMUs would be useful.

Table 1. Mean phytotoxicity scores at Timing D treatment application for Sites 1 and 2, at two and eight weeks (nine weeks for Site 2) after Timing D application.

Treatment	Mean crop damage scores (0-10)					
	Site 1			Site 2		
	Timing D	+ 2 weeks	+ 8 weeks	Timing D	+ 2 weeks	+ 9 weeks
Untreated	0.8	0.7	0.1	0.2	0.0	1.8
Anthem + **Hurricane SC** + **Goltix 70 SC**	1.3	0.7	1.0	0.0	0.0	0.0
Anthem + **Flexidor** + **Goltix 70 SC**	1.3	0.7	1.2	0.0	0.0	1.3
Anthem + **Emerger** + **Goltix 70 SC**	1.0	0.3	0.8	0.0	0.0	0.0
Anthem + **AHDB9917**	1.7	0.7	0.3	0.0	0.0	0.0
Anthem + **AHDB9826**	***10.0**	***10.0**	***10.0**	0.0	0.0	0.0
Anthem, then **AHDB9975** (x3)	***4.3**	***6.3**	***4.0**	0.0	0.0	0.0
Anthem, then **Goltix 70 SC** (x3)	***3.3**	***5.7**	***3.0**	1.3	0.0	0.0
Anthem, then	2.0	2.3	***3.0**	0.0	0.0	0.0

AHDB9898 (x3)						
Anthem, then **Hurricane SC** (x3)	***4.7**	2.0	1.5	1.0	0.0	0.3
Anthem, then **AHDB9860** (x2)	0.7	0.3	1.8	0.7	0.0	0.0
Anthem, then **Emerger** (x3)	1.3	1.0	1.2	0.7	0.0	0.0
Anthem, then **AHDB9918** (x3)	1.5	0.5	0.9	0.0	0.0	0.0
Anthem, then **AHDB9993** (x3)	2.3	1.0	2.0	0.0	0.0	0.0
p-value	<0.001	<0.001	<0.001	<0.001	-	<0.001
d.f.	28	25	25	29	-	29
L.S.D.	1.355	1.301	1.126	0.5654	-	0.8929

* significantly different to untreated control AND >2.0.

Table 2. Mean percentage weed cover values (back-transformed) at Timing D treatment application, and two and eight weeks after Timing D application for Sites 1 and 2.

Trt. No.	Mean weed cover (%)									
	Site 1						Site 2			
	Timing D		+ 2 weeks		+ 8 weeks		Timing D		+ 2 weeks	
	Ang.	Back-trans	Ang.	Back-trans	Ang.	Back-trans	Ang.	Back-trans	Ang.	Back-trans
UTC	43.8	48.0	74.7	83.5	87.8	99.9	65.0	82.2	69.1	87.3
3	19.0	***10.6**	13.0	***10.8**	30.3	***25.5**	15.0	***6.7**	21.6	***13.6**
4	15.3	***7.0**	7.7	***7.2**	33.9	***31.0**	32.5	***28.8**	38.9	***39.4**
5	19.9	***11.6**	19.7	***17.8**	43.6	***47.5**	23.6	***16.0**	12.4	***4.6**
6	11.0	***3.6**	4.0	***4.0**	32.0	***28.1**	18.4	***10.0**	28.3	***22.5**
7	17.4	***8.9**	12.3	***10.8**	63.9	80.6	9.7	***2.9**	16.6	***8.2**
8	15.9	***7.5**	11.0	***9.2**	13.8	***5.7**	20.5	***12.2**	22.7	***14.9**
9	19.3	***10.9**	10.0	***9.6**	14.2	***6.0**	15.0	***6.7**	16.6	***8.2**
10	20.5	***12.2**	18.3	***16.9**	30.6	***25.9**	17.7	***9.3**	15.0	***6.7**
11	16.7	***8.3**	11.7	***11.1**	29.0	***23.5**	13.2	***5.2**	16.1	***7.7**
12	14.8	***6.5**	12.0	***11.6**	14.6	***6.4**	14.1	***5.9**	19.3	***10.9**
13	13.8	***5.7**	3.0	***2.9**	5.7	***1.0**	8.9	***2.4**	8.5	***2.2**
14	15.6	***7.3**	7.2	***7.5**	32.3	***28.5**	17.7	***9.3**	21.5	***13.5**
15	18.0	***9.6**	11.7	***10.2**	11.4	***3.9**	35.5	***33.7**	19.8	***11.5**
p-value	<0.001		<0.001		0.001		<0.001		<0.001	
d.f.	29		28		27		29		29	
L.S.D.	11.85		17.12		41.37		20.84		13.91	

UTC = untreated control; treatments 1 and 2.
* significantly different to untreated control.

0% WEED COVER 100%

Conclusion

- **Emerger**, **AHDB9860** and **AHDB9993** are promising products for post-emergence weed control in parsnips and were shown in this trial to be particularly effective and crop safe in repeated low-dose applications. EAMU authorisation for post-emergence use of these three products in parsnips would help growers improve weed control.

- Pre-emergence application of **Anthem + AHDB9826** was not crop safe to parsnips.

- To achieve effective weed control, it is important to minimise delays in treatment application, ensuring weeds are treated when small.

Take home message

EAMU authorisations for post-emergence use of **Emerger, AHDB9860** or **AHDB9993** should be applied for, to expand the range of actives available to parsnip growers. This would improve weed control and reduce the risk of resistance development.

Objective

To compare a number of herbicide tank-mixes with the current commercial standards (see "Application schedule") at one pre-emergence application timing and three post-emergence application timings for selectivity (crop safety) and efficacy in parsnips.

Trial conduct

UK regulatory guidelines were followed but EPPO guideline took precedence. The following EPPO guidelines were followed:

Relevant EPPO guideline(s)		**Variation from EPPO**
EPPO PP1/135(4)	Phytotoxicity assessment	None
EPPO PP1/152(4)	Guideline on design and analysis of efficacy evaluation trials	None
EPPO PP1/225 (2)	Minimum effective dose	None
EPPO PP1/181 (4)	Conduct and reporting of efficacy evaluation trials including good experimental practice	None
EPPO PP 1/214(3)	Principles of acceptable efficacy	None
EPPO PP 1/224(2)	Principles of efficacy evaluation for minor uses	None

Deviations from EPPO guidance:

Test sites

Item	**Details**	
Location address	**Site 1** Field: 1039 – P19 Over Road Tompsett Burgess Growers Freckenham, Bury Saint Edmunds IP28 8JB Suffolk Grid reference: TL 65994 72220	**Site 2** Field: 40 Acre (Green Mile Farm) Hammond Produce Babworth, Retford DN22 8JN Nottinghamshire Grid reference: SK 65913 81896
Crop	Parsnip	
Cultivar	Pearl	Javelin
Soil or substrate type	Freely draining slightly acid sandy soil	
Agronomic practice	See Appendix	
Prior history of site	See Appendix	

Trial design

Item	**Details**
Trial design:	Randomised block
Number of replicates:	3
Row spacing:	Site 1: 2m beds, 4 twin rows 90mm apart with 355mm row centres. Site 2: 72" beds, 4 double lines, 13" row spacing.
Plot size: (w x l)	2m x 6m
Plot size: (m^2)	$12m^2$
Number of plants per plot:	Approx. 3000
Leaf Wall Area calculations	N/A

Treatment details

AHDB Code	**Product name**	**Active substance**	**Content of active substance in product** (g/L)	**Formulation batch number**	**Formulation type**
N/A*	Anthem	pendimethalin	400	N/K	Suspension Concentrate

N/A†	Emerger	aclonifen	600	EV5600	Suspension Concentrate
AHDB9917	N/D	N/D	N/D	N/D	N/D
AHDB9993	N/D	N/D	N/D	N/D	N/D
AHDB9898	N/D	N/D	N/D	N/D	N/D
N/A†	Flexidor 500	isoxaben	500	N/K	Suspension Concentrate
N/A†	Goltix 70 SC	metamitron	700	16028107	Suspension Concentrate
N/A	Hurricane SC	diflufenican	500	17118244	Suspension Concentrate
AHDB9826	N/D	N/D	N/D	N/D	N/D
AHDB9860	N/D	N/D	N/D	N/D	N/D
AHDB9975	N/D	N/D	N/D	N/D	N/D
AHDB9918	N/D	N/D	N/D	N/D	N/D

* label approval
† EAMU approval

Application schedule

Treatment number	Treatment: product name or AHDB code	Application timing code	Rate of active substance (g/ha)	Rate of product (L/ha)
1	Untreated	-	-	-
2	Untreated	-	-	-
3	Anthem Hurricane SC Goltix 70 SC	A	1320 50 1400	3.30 0.10 2.00
4*	Anthem Flexidor 500 Goltix 70 SC	A	1320 50 1400	3.30 0.10 2.00
5	Anthem Emerger Goltix 70 SC	A	1320 60 1400	3.30 0.10 2.00
6	Anthem AHDB9917	A	1320 N/K	3.30 0.70
7	Anthem AHDB9826	A	1320 1525.5	3.30 2.70
8	Anthem	A	1320	3.30
	AHDB9975	B, C, D	578	1.25
9	Anthem	A	1320	3.30
	Goltix 70 SC	B	700	1.00
	Goltix 70 SC	C, D	1400	2.00
10	Anthem	A	1320	3.30
	AHDB9898	B	144	0.20
	AHDB9898	C, D	180	0.25
11	Anthem	A	1320	3.30
	Hurricane SC	B, C, D	25	0.05
12	Anthem	A	1320	3.30
	AHDB9860	B, C	300	0.60
13	Anthem	A	1320	3.30
	Emerger	B, C, D	300	0.50

14	Anthem	A	1320	3.30
	AHDB9918	B, C, D	80	0.16
15	Anthem	A	1320	3.30
	AHDB9993	B	80	0.50
	AHDB9993	C	160	1.00
	AHDB9993	D	320	2.00

* grower standard

Application details
Site 1

	Timing A	Timing B	Timing C	Timing D
Application date	17/04/2019	23/05/2019	04/06/2019	20/06/2019
Time of day	10:30 – 12:00	11:20 – 12:18	09:00 – 10:00	10:30 – 11:30
Crop growth stage (Max, min average BBCH)	BBCH00-03	BBCH10-11	BBCH11	BBCH12-13
Crop height (cm)	N/A	2.0	2.5	5.0
Crop coverage (%)	N/A	1.0	N/K	20.0
Application Method	spray	spray	spray	spray
Application Placement	soil	soil	foliar	foliar
Application equipment	Oxford Precision Sprayer (knapsack)	Oxford Precision Sprayer (knapsack)	Oxford Precision Sprayer (knapsack)	Oxford Precision Sprayer (knapsack)
Nozzle pressure (bar)	2.0	2.0	2.0	2.0
Nozzle type	Flat fan	Flat fan	Flat fan	Flat fan
Nozzle size	02-F110	02-F110	02-F110	02-F110
Application water volume (L/ha)	200	200	200	200
Temperature of air – shade (°C)	9.1 – 19.7	20 – 20.1	15.3 – 21.0	18.4 – 19.3
Relative humidity (%)	74.0 – 66.1	40.3 – 42	67.9 – 51.4	68.8 – 67.8
Wind speed range (mph)	2.0	5.8 – 3.3	4.2 – 10.4	4.5 – 8.7
Dew presence (Y/N)	N	N	N	N
Temperature of soil - 10cm (°C)	11.1	N/K	N/K	N/K
Wetness of soil - 2-5 cm	dry	dry	dry	damp
Cloud cover (%)	80	10	40	85

Site 2

	Timing A	Timing B	Timing C	Timing D
Application date	12/05/2019	20/06/2019	03/07/2019	12/07/2019
Time of day	12:00 – 13:00	11:00 – 11:45	11:00 – 13:00	13:00 – 13:15
Crop growth stage (min., max. BBCH)	BBCH00-03	BBCH13	BBCH14	BBCH14

Crop height (cm)	N/A	3.0	15.0	N/K
Crop coverage (%)	N/A	10.0	35.0	N/K
Application Method	spray	spray	spray	spray
Application Placement	soil	soil	foliar	foliar
Application equipment	Oxford Precision Sprayer (knapsack)	Oxford Precision Sprayer (knapsack)	Oxford Precision Sprayer (knapsack)	Oxford Precision Sprayer (knapsack)
Nozzle pressure (bar)	2.0	2.0	2.0	2.0
Nozzle type	Flat fan	Flat fan	Flat fan	Flat fan
Nozzle size	03F110	03F110	03F110	03F110
Application water (L/ha)	200	200	200	200
Temperature of air – shade (°C)	14.2 – 14.0	14.2 – 13.4	17.1 – 18.9	21.7
Relative humidity (%)	74.2 – 76.8	56.2 – 46.9	56.4 – 69.2	53.5
Wind speed range (mph)	2.4 – 1.0	7.6 – 5.9	2.3 – 3.5	5.7 – 6.1
Dew presence (Y/N)	N	N	N	N
Temperature of soil – 10cm (°C)	10.2	14.3	17.1	23.8
Wetness of soil (2-5 cm)	damp	damp	dry	dry
Cloud cover (%)	5	75	30	90

Untreated levels of pests/pathogens at application and through the assessment period

Common name	Scientific Name	EPPO Code		Infection level* at start of assessment period (Timing D)	Infection level* mid-assessment period (D + 2 weeks)	Infection level* at end of assessment period (D + 8 weeks)
Broad leaved weeds and grasses	*N/A*	3WEEDT	SITE 1	48.0%	83.5%	99.9%
			SITE 2	82.2%	87.3%	-

* average weed cover (back-transformed).

Assessment details

Site 1

Evaluation date	Evaluation Timing (DA)*	Crop Growth Stage (BBCH)	Evaluation type (efficacy, phytotox)	What was assessed and how (e.g. dead or live pest; disease incidence and severity; yield, marketable quality)
23/05/2019	36	10-11	efficacy, phyto	Phytotoxicity (scale 0-10; 10 = dead), percentage of weed cover (whole plot score), plant population count.
20/06/2019	64	12-13	efficacy, phyto	Phytotoxicity (scale 0-10; 10 = dead), percentage of weed cover (whole plot score), plant population count.

03/07/2019	77	12-14	efficacy, phytotox	Phytotoxicity (scale 0-10; 10 = dead), percentage of weed cover (whole plot score, plus scores per weed species).
19/07/2019	93	16-17	efficacy, phytotox	Phytotoxicity (scale 0-10; 10 = dead), percentage of weed cover (whole plot score, plus scores per weed species).
16/08/2019	121	N/K	efficacy, phytotox	Phytotoxicity (scale 0-10; 10 = dead), percentage of weed cover (whole plot score, plus scores per weed species).

* DA – days after Timing A application

Site 2

Evaluation date	Evaluation Timing (DA)*	Crop Growth Stage (BBCH)	Evaluation type (efficacy, phytotox)	What was assessed and how (e.g. dead or live pest; disease incidence and severity; yield, marketable quality)
20/06/2019	39	13	efficacy	Percentage of weed cover (whole plot score, plus scores per weed species).
02/07/2019	51	14	efficacy, phytotox	Phytotoxicity (scale 0-10; 10 = dead), percentage of weed cover (whole plot score, plus scores per weed species), plant population count.
15/07/2019	64	14	efficacy, phytotox	Phytotoxicity (scale 0-10; 10 = dead), percentage of weed cover (whole plot score, plus scores per weed species), plant population count.
29/07/2019	78	N/K	efficacy, phytotox	Phytotoxicity (scale 0-10; 10 = dead), percentage of weed cover (whole plot score, plus scores per weed species).
17/09/2019	128	N/K	phytotox	Phytotoxicity (scale 0-10; 10 = dead).

* DA – days after Timing A application

Statistical analysis

The trials had randomised block designs, each comprising fifteen treatments, including two untreated controls and two grower standard treatments. Treatments were replicated three times.

As the distribution of weeds was uneven across each trial—which is not unexpected in field situations—there was a need to transform this data prior to analysis. To determine treatment efficacy, an angular transformation was performed and the back transformed means presented, from which the % reduction in weeds was calculated using Abbotts formula.

All data were analysed by ANOVA using Genstat (18th edition) by Emily Lawrence (ADAS).

Results

Phytotoxicity

The results of phytotoxicity assessments from three dates are presented in **Table 1** and **Figure 1**. These were scored on a scale from 0 to 10, with 0 being 'no effect', and 10 being 'dead'. Plots scored 2 or less were deemed to have a commercially acceptable level of damage.

Phytotoxicity was recorded using the following scale:

Crop tolerance score	(% phytotoxicity) Equivalent to crop damage
0	*(no damage)* 0%
1	10%

***2**	20%
3	30%
4	40%
5	50%
6	60%
7	70%
8	80%
9	90%
10	*(complete crop kill)* 100%

* ≤2 = acceptable damage, i.e. damage unlikely to reduce yield, and acceptable to the farmer.

There were relatively few phytotoxic effects observed from the treatments assessed in this trial.

At Site 1, seven treatments did not show any significant damage to the crop at any point during the assessment period—pre-emergence **Anthem + Hurricane SC + Goltix 70 SC**; **Anthem + Flexidor + Goltix 70 SC**; **Anthem + Emerger + Goltix 70 SC**; **Anthem + AHDB9917** and post-emergence **Anthem, then AHDB9898**; **Anthem, then AHDB9860**; **Anthem, then Emerger**; **Anthem, then AHDB9918**; and **Anthem, then AHDB9993**.

There was some damage observed at the Timing D assessment for **Anthem, then Hurricane SC—as** foliar yellowing. By the following assessment (two weeks after the Timing D treatment), the crop had grown through this effect and was of commercially acceptable quality.

While the eight aforementioned treatments showed no significant damage at the final assessment, the five remaining treatments did show persistent phytotoxic effects at Site 1.

Most notable were the phytotoxic effects observed following treatment with pre-emergence **Anthem, the AHDB9826**. This treatment has a significant impact on crop quality at Site 1, with no crop emerging following application. Also, crop treated with **Anthem, then AHDB9975**; **Anthem, then Goltix 70 SC**; or **Anthem, then AHDB9898** showed persistent phytotoxic effects. **Anthem, then AHDB9975** distorted the crop foliage and the crop remained stunted until the final assessment. For **Anthem, then Goltix 70 SC**, some foliar scorching was noted at the assessment two weeks after the final treatment application, and the crop was stunted at the final assessment. Crop treated with **Anthem, then AHDB9898** was stunted and showed slight foliar discolouration throughout the assessments.

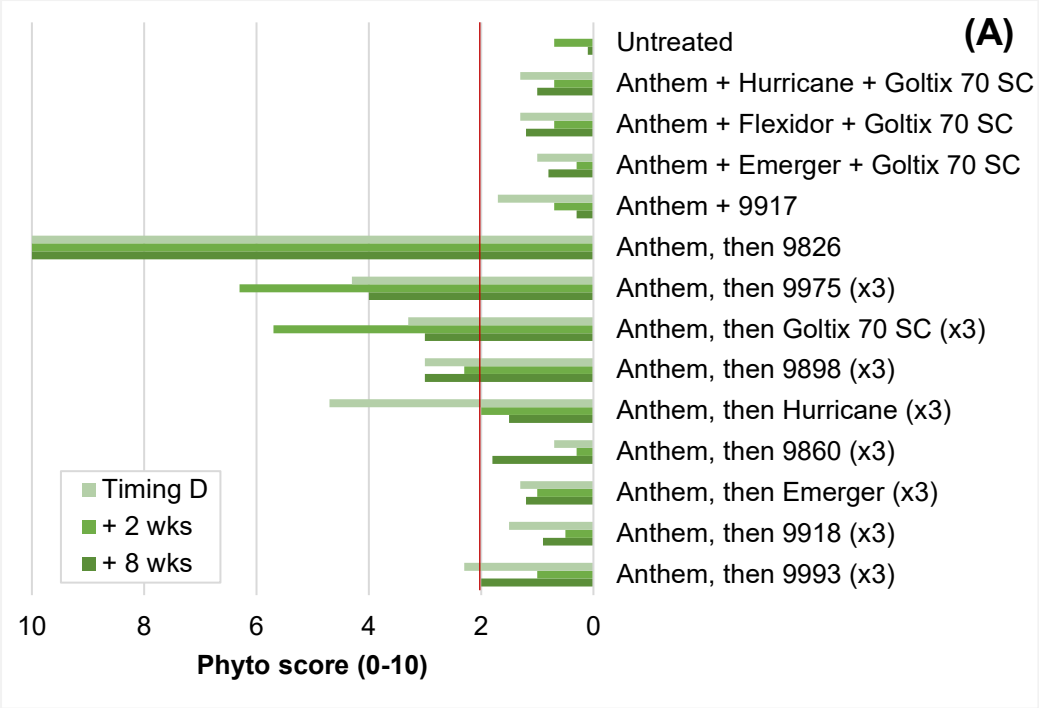
There were very few phytotoxic effects recorded at Site 2 and no significant differences between the treatments and the untreated crop.

Table 1. Mean phytotoxicity scores at Timing D treatment application for Sites 1 and 2, at two and eight weeks (nine weeks for Site 2) after Timing D application.

Treatment	Mean crop damage scores (0-10)					
	Site 1			Site 2		
	Timing D	+ 2 weeks	+ 8 weeks	Timing D	+ 2 weeks	+ 9 weeks
Untreated	0.8	0.7	0.1	0.2	0.0	1.8
Anthem + Hurricane SC + Goltix 70 SC	1.3	0.7	1.0	0.0	0.0	0.0
Anthem + Flexidor + Goltix 70 SC	1.3	0.7	1.2	0.0	0.0	1.3
Anthem + Emerger + Goltix 70 SC	1.0	0.3	0.8	0.0	0.0	0.0
Anthem + AHDB9917	1.7	0.7	0.3	0.0	0.0	0.0

Anthem + **AHDB9826**	***10.0**	***10.0**	***10.0**	0.0	0.0	0.0
Anthem, then **AHDB9975** (x3)	***4.3**	***6.3**	***4.0**	0.0	0.0	0.0
Anthem, then **Goltix 70 SC** (x3)	***3.3**	***5.7**	***3.0**	1.3	0.0	0.0
Anthem, then **AHDB9898** (x3)	2.0	2.3	***3.0**	0.0	0.0	0.0
Anthem, then **Hurricane SC** (x3)	***4.7**	2.0	1.5	1.0	0.0	0.3
Anthem, then **AHDB9860** (x2)	0.7	0.3	1.8	0.7	0.0	0.0
Anthem, then **Emerger** (x3)	1.3	1.0	1.2	0.7	0.0	0.0
Anthem, then **AHDB9918** (x3)	1.5	0.5	0.9	0.0	0.0	0.0
Anthem, then **AHDB9993** (x3)	2.3	1.0	2.0	0.0	0.0	0.0
p-value	<0.001	<0.001	<0.001	<0.001	-	<0.001
d.f.	28	25	25	29	-	29
L.S.D.	1.355	1.301	1.126	0.5654	-	0.8929

* significantly different to untreated control AND >2.0.



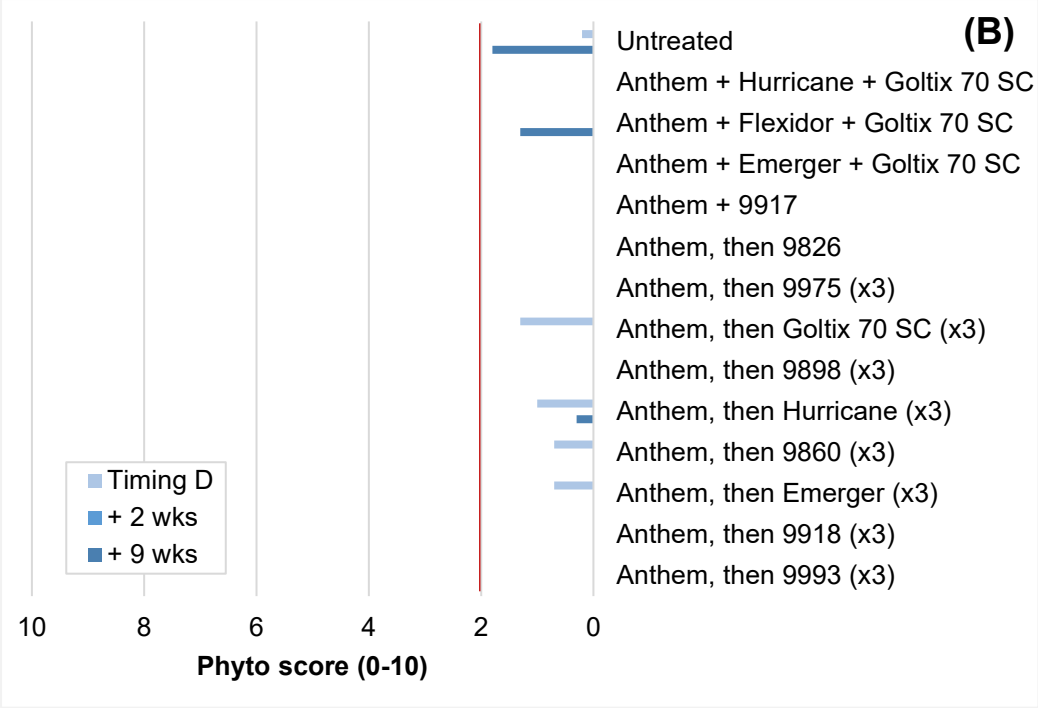


Figure 1. Mean phytotoxicity scores at Timing D treatment application for Site 1 **(A)** and Site 2 **(B)**, at two and eight weeks (nine weeks for Site 2) after Timing D application. Scores ≤2 deemed commercially acceptable damage (as indicated by red line).

Weed control – mean percentage weed cover

The results for the mean percentage weed cover per treatment are presented in **Table 2** and **Figure 2**. The percent reduction in weed cover compared to the untreated control was calculated from these figures (using Abbotts formula), and results for each treatment are listed in **Table 3**.

At Site 1, fat hen was the main weed species, with groundsel, black-grass, bindweed and potatoes also present. Groundsel, and volunteer wheat and potatoes were most common at Site 2.

At Site 1, most treatments showed significantly lower weed cover than the untreated control plots across all assessments. The best performing treatments were **Anthem, then Emerger**; **Anthem, then AHDB9993**; and **Anthem, then AHDB9860**, showing an average of 1.0%, 3.9%, and 6.4% weed cover respectively at eight weeks after the final treatment application. It was also interesting to note that **Anthem, then AHDB9993** left predominantly grass weeds after application.

Anthem + AHDB9826 was an exception as there was no significant difference between the weed cover for this treatment (80.6%) and the untreated control (99.9%) at the final assessment; with no crop emerging there was no competition for the weeds. While there was some foliar yellowing to the fat hen present in these plots at the Timing D assessment, by the final assessment eight weeks later, these plots were full of fat hen.

Similar effects were observed at Site 2. All treatments showed significantly lower weed cover than the untreated control across all assessments—including **Anthem + AHDB9826**. The difference in weed cover in **Anthem + AHDB9826** treated plots between sites 1 and 2 can be attributed to there being a healthy crop present in plots at Site 2 to compete with weeds, which wasn't the case at Site 1.

Table 2. Mean percentage weed cover values (back-transformed) at Timing D treatment application, and two and eight weeks after Timing D application for Sites 1 and 2.

Trt. No.	Mean weed cover (%)

	Site 1						Site 2			
	Timing D		+ 2 weeks		+ 8 weeks		Timing D		+ 2 weeks	
	Ang.	Back-trans	Ang.	Back-trans	Ang.	Back-trans	Ang.	Back-trans	Ang.	Back-trans
UTC	43.8	48.0	74.7	83.5	87.8	99.9	65.0	82.2	69.1	87.3
3	19.0	***10.6**	13.0	***10.8**	30.3	***25.5**	15.0	***6.7**	21.6	***13.6**
4	15.3	***7.0**	7.7	***7.2**	33.9	***31.0**	32.5	***28.8**	38.9	***39.4**
5	19.9	***11.6**	19.7	***17.8**	43.6	***47.5**	23.6	***16.0**	12.4	***4.6**
6	11.0	***3.6**	4.0	***4.0**	32.0	***28.1**	18.4	***10.0**	28.3	***22.5**
7	17.4	***8.9**	12.3	***10.8**	63.9	80.6	9.7	***2.9**	16.6	***8.2**
8	15.9	***7.5**	11.0	***9.2**	13.8	***5.7**	20.5	***12.2**	22.7	***14.9**
9	19.3	***10.9**	10.0	***9.6**	14.2	***6.0**	15.0	***6.7**	16.6	***8.2**
10	20.5	***12.2**	18.3	***16.9**	30.6	***25.9**	17.7	***9.3**	15.0	***6.7**
11	16.7	***8.3**	11.7	***11.1**	29.0	***23.5**	13.2	***5.2**	16.1	***7.7**
12	14.8	***6.5**	12.0	***11.6**	14.6	***6.4**	14.1	***5.9**	19.3	***10.9**
13	13.8	***5.7**	3.0	***2.9**	5.7	***1.0**	8.9	***2.4**	8.5	***2.2**
14	15.6	***7.3**	7.2	***7.5**	32.3	***28.5**	17.7	***9.3**	21.5	***13.5**
15	18.0	***9.6**	11.7	***10.2**	11.4	***3.9**	35.5	***33.7**	19.8	***11.5**
p-value		<0.001		<0.001		0.001		<0.001		<0.001
d.f.		29		28		27		29		29
L.S.D.		11.85		17.12		41.37		20.84		13.91

UTC = untreated control; treatments 1 and 2.
* significantly different to untreated control.

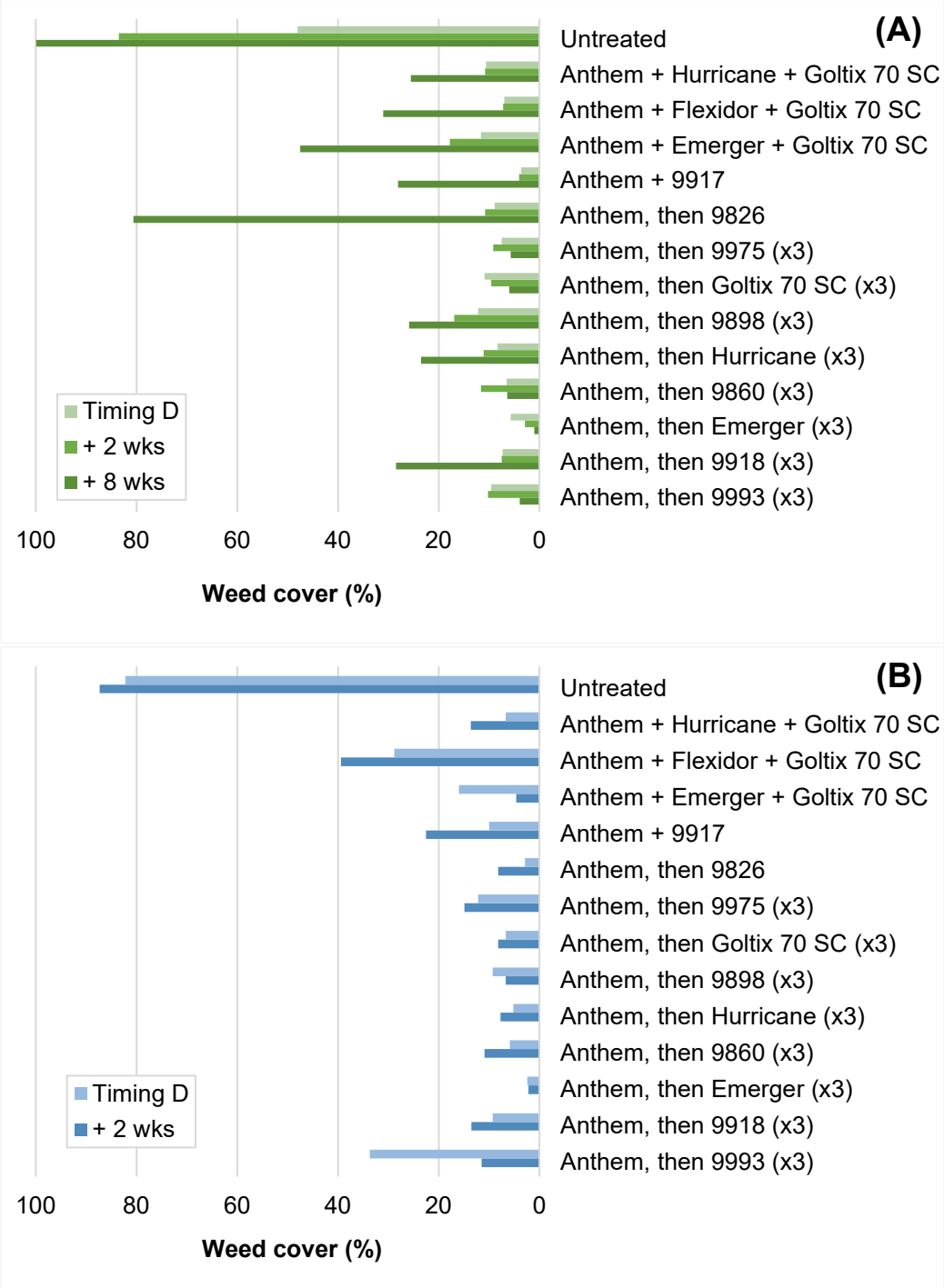


Figure 2. Mean weed cover (%; back-transformed values) at Timing D treatment application, and two and eight weeks after Timing D application for Site 1 **(A)** and Site 2 **(B)**.

Table 3. Percentage reduction in weed cover at Timing D treatment application, and two and eight weeks after Timing D application (calculated using Abbotts formula).

Treatment	Weed cover reduction (%)				
	Site 1			Site 2	
	Timing D	+ 2 weeks	+ 8 weeks	Timing D	+ 2 weeks
Anthem + Hurricane SC + Goltix 70 SC	77.8	87.0	74.5	84.4	74.5

Anthem + **Flexidor** + **Goltix 70 SC**	85.4	91.4	68.9	54.9	68.9
Anthem + **Emerger** + **Goltix 70 SC**	75.8	78.8	52.1	94.7	52.4
Anthem + **AHDB9917**	92.5	95.3	71.9	74.3	71.9
Anthem + **AHDB9826**	81.4	87.1	19.3	90.7	19.3
Anthem, then **AHDB9975** (x3)	84.3	89.0	94.3	83.0	94.3
Anthem, then **Goltix 70 SC** (x3)	77.2	88.5	94.0	90.7	94.0
Anthem, then **AHDB9898** (x3)	74.5	79.7	74.1	92.3	74.1
Anthem, then **Hurricane SC** (x3)	82.7	86.7	76.4	91.2	76.4
Anthem, then **AHDB9860** (x2)	86.5	86.1	93.6	87.5	93.6
Anthem, then **Emerger** (x3)	88.2	96.5	99.0	97.5	99.0
Anthem, then **AHDB9918** (x3)	84.9	91.0	71.4	84.6	62.7
Anthem, then **AHDB9993** (x3)	80.0	87.8	96.1	86.8	96.1

Plant population

There were no significant reductions in plant population at Site 1 for most of the treatments—presented in Table 4—with the exception of **Anthem + AHDB9826**. At both the Timing B and D assessments, the average plant population in plots which received this treatment was significantly lower than the untreated control, with a 92% reduction in population size seen at the first assessment, and no crop remaining at the second. There were no significant reductions or differences in plant population seen for any of the treatments applied at Site 2, where the application of the Timing B treatments were delayed and temperatures were consistently cooler than Site 1 throughout the trial.

Table 4. Plant population counts from two timings at each trial site; values are treatment averages of the number of parsnip plants present in a 0.5 m length of a single central row.

Trt. No.	Mean plant population (№ plants in 0.5 m of single row)			
	Site 1		Site 2	
	Timing B	Timing D	Timing C	Timing D
Untreated	3.8	10.4	14.7	16.0
Anthem + **Hurricane SC** + **Goltix 70 SC**	4.7	10.5	16.3	14.0
Anthem + **Flexidor** + **Goltix 70 SC**	3.8	10.2	14.7	14.7
Anthem + **Emerger** +	5.7	11.7	15.3	15.0

Goltix 70 SC				
Anthem + **AHDB9917**	2.5	9.3	17.7	18.0
Anthem + **AHDB9826**	***0.3**	***0.0**	14.0	14.7
Anthem, then **AHDB9975** (x3)	5.7	9.3	16.0	16.7
Anthem, then **Goltix 70 SC** (x3)	6.7	10.0	14.7	16.7
Anthem, then **AHDB9898** (x3)	2.8	10.7	17.0	20.3
Anthem, then **Hurricane SC** (x3)	4.7	8.0	19.0	16.3
Anthem, then **AHDB9860** (x2)	5.2	11.0	16.0	18.0
Anthem, then **Emerger** (x3)	4.2	10.7	16.0	15.0
Anthem, then **AHDB9918** (x3)	1.3	10.8	16.7	16.0
Anthem, then **AHDB9993** (x3)	4.0	11.5	16.3	16.7
p-value	0.048	<0.001	0.483	0.126
d.f.	29	28	29	29
L.S.D.	3.005	3.227	3.484	3.270

* significantly different to untreated control.

Discussion

Of the treatments assessed in these trials, nine appeared crop safe and gave statistically significant weed control—**Anthem + Hurricane SC + Goltix 70 SC**; **Anthem + Flexidor + Goltix 70 SC**; **Anthem + Emerger + Goltix 70 SC**; **Anthem + AHDB9917**; **Anthem, then Hurricane SC**; **Anthem, then AHDB9860**; **Anthem, then Emerger**; **Anthem, then AHDB9918**; and **Anthem, then AHDB9993**. By the conclusion of the trial, eight weeks after the final treatment application, all these treatments offered a significant reduction in weed cover compared to the untreated control, with none exhibiting any concerning phytotoxic symptoms.

The differences in phytotoxic effects between the two sites was notable in this trial, with very few treatments displaying phytotoxic damage at Site 2, despite some clear treatment effects at Site 1. This can be attributed to a delay in application at Site 2, meaning a larger crop at the time of treatment which was less vulnerable to phytotoxic damage. This also explains the site differences in plant population counts. There were few significant reductions in plant population at Site 1 for most of the treatments; **Anthem + AHDB9826** was the exception, where no crop remained by the final plant population count. At Site 2, there were no significant reductions in plant population at either assessment. This can be attributed to the treatment application delay leading to the crop's larger size and consequent increased resilience.

As well as differences in phytotoxicity between the sites for the **Anthem + AHDB9826** treated crop, plots which received this treatment at Site 2 did not have the same high weed levels as at Site 1 at the final assessment—weed cover averaged 8.2% and 80.6% for the respective sites. This can also be attributed to the advanced growth of the crop at the point of application at Site 2—as the larger crop was resistant to phytotoxic effects—so the parsnips in **Anthem + AHDB9826** treated plots crowded out the weeds; with no crop emergence at Site 1, there was no competition for the weeds.

While **AHDB9993** offered promising weed control—with an average of 3.9% weed cover in treated plots eight weeks after its final application—it was noted that this product did not control

black-grass. Therefore, it would need to be applied with a graminicide either in a tank-mix or a programme.

Emerger is authorised under EAMU 1601/19 for pre-emergence use on parsnip. A post-emergence EAMU authorisation for this product would also be very useful as it was one of the best performing products in this trial.

The use of **AHDB9917**, **Hurricane SC**, **AHDB9918**, **AHDB9993** or **AHDB9860** on parsnips are not currently approved, though these products also showed promise in this trial. **AHDB9917** was screened as a pre-emergence treatment, and **Hurricane SC** was included in both a pre-emergence tank-mix (with Goltix 70 SC, an EAMU authorised product for pre-emergence use) and screened for use as a post-emergence treatment. **AHDB9860**, **AHDB9918**, and **AHDB9993** were also screened as post-emergence treatments. By the conclusion of the trial, all these products showed lasting efficacy without any persistent phytotoxic effects and would be valuable additions to parsnip growers' weed control options, and pursual of EAMUs would be useful.

Conclusions

- **Emerger**, **AHDB9860** and **AHDB9993** are promising products for post-emergence weed control in parsnips and were shown in this trial to be particularly effective and crop safe in repeated low-dose applications. EAMU authorisation for post-emergence use of these three products in parsnips would help growers improve weed control.

- Pre-emergence application of **Anthem + AHDB9826** was not crop safe to parsnips.

- To achieve effective weed control, it is important to minimise delays in treatment application, ensuring weeds are treated when small.

Acknowledgements
AHDB for funding the work, and also the crop protection companies for their financial contributions as well as providing samples for the trials. Thanks should also be given to those who provided sites and crops for the trials as well as technical input, particularly Jason Ambrose of Tompsett Burgess Growers, and Philip Lilley of Hammond Produce.

Appendix

Crop diary – events related to growing crop

a. Site 1

Crop	Cultivar	Drilling date	Bed width
Parsnips	Pearl	13/04/2019	2m beds, 4 twin rows 90mm apart with 355mm row centres.

Previous cropping

Year	Crop
2018	Potatoes
2017	Winter wheat

Cultivations

Date	Description
29/01/19	Plough
12/04/19	Sub-soiling
	Destone
	Ridge
	Bed forming
	Headland cultivation
24/06/19	Hoe

Active ingredients(s)/fertiliser(s) applied to trial area

Date	Product	Rate	Unit
03/04/19	Vegetable fertiliser	1097.320	kg/ha
	Phosphate	54.000	kg/ha
	Potash	81.000	kg/ha
	Magnesium	109.000	kg/ha
19/06/19	Nitrogen – 34%	115.068	kg/ha
25/09/19	Bittersalz	2.000	kg/ha
	Opte-Manganese	2.000	L/ha
	Terasorb	2.000	L/ha
16/07/19	Nitrogen – 34%	134.921	kg/ha
19/07/19	Opte-Manganese	3.000	L/ha
	Terasorb	2.000	L/ha
	Thio-s	5.000	L/ha
03/08/19	Bittersalz	3.000	kg/ha
	Boron	3.000	L/ha

14/08/19	Opte-Manganese	3.000	L/ha
	Thio-s	2.500	L/ha
	Headland Copper	0.500	L/ha

Pesticides applied to trial area

Date	Product	Rate	Unit
13/04/19	Vydate	12.000	kg/ha
21/06/19	Minecto One	0.185	kg/ha
06/07/19	Decis Protech	0.500	L/ha
19/07/19	Minecto One	0.185	kg/ha
03/08/19	Hallmark with Zeon Technology	0.100	L/ha
	Amistar Top	1.000	L/ha
14/08/19	Hallmark with Zeon Technology	0.100	L/ha
	Reflect	0.700	L/ha

b. Site 2

Crop	Cultivar	Drilling date	Bed width
Parsnips	Javelin	30/04/2019	72” bed, 4 double lines, 13” row spacing

Previous cropping

Year	Crop
2018	Winter wheat
2017	Maize
2016	Savoy cabbage

Active ingredients(s)/fertiliser(s) applied to trial area

Date	Product	Rate	Unit
30/02/2019	Gypsum	2500.000	kg/ha
20/04/2019	15:0:25	344.403	kg/ha
19/06/2019	Ammonium nitrate	96.449	kg/ha
01/07/2019	Tecal	1.000	L/ha
	EPSO Top (bittersalz)	2.430	kg/ha
04/07/2019	Maxicrop Triple	1.000	L/ha
	TTL Plus	0.300	L/ha
	Maxicrop Triple	0.975	L/ha
	TTL Plus	0.424	L/ha
	Tecal	0.975	L/ha

	EPSO Top (bittersalz)	2.360	kg/ha
	Manganese liquid 15%	2.919	L/ha
11/07/2019	Ammonium nitrate	149.673	kg/ha
12/07/2019	EPSO Top (bittersalz)	24.910	kg/ha
25/07/2019	Boron liquid 15%	1.000	L/ha
	EPSO Top (bittersalz)	2.523	kg/ha
07/08/2019	Ammonium nitrate	95.421	kg/ha
08/08/2019	Muriate of potash	9.893	kg/ha
	Manganese liquid 15%	2.009	L/ha
	EPSO Top (bittersalz)	2.430	kg/ha
12/08/2019	TTL Plus	4.000	L/ha
23/08/2019	Omex – Bio 15	3.000	L/ha
	TTL Plus	0.500	L/ha
05/09/2019	Omex – Calmax	0.748	L/ha

Pesticides applied to trial area

Date	Product	Rate	Unit
30/04/2019	Vydate 10G	15.000	kg/ha
09/06/2019	Biscaya	0.400	L/ha
10/06/2019	SL 567A	0.940	L/ha
01/07/2019	Toledo	0.600	L/ha
	Colt 10 CS	0.150	L/ha
12/07/2019	Minecto One	0.181	kg/ha
	Reflect	0.598	L/ha
25/07/2019	Colt 10 CS	0.150	L/ha
	Amistar Top	0.692	L/ha
08/08/2019	Nativo 75 WG	0.299	kg/ha
	Hallmark with Zeon Technology	0.150	L/ha
23/08/2019	Amistar Top	1.000	L/ha
	Lambdastar	0.075	L/ha
05/09/2019	Reflect	0.393	L/ha
	Signum	0.495	kg/ha
	Hallmark with Zeon Technology	0.150	L/ha

c. Table showing sequence of events by date – this relates to treatments and assessments.

Site 1:

Date	Event
17/04/2019	Timing A treatment application.

23/05/2019	Timing B treatment application. Trial assessment; crop phyto, weed cover, population counts.
04/06/2019	Timing C treatment application.
20/06/2019	Timing D treatment application. Trial assessment; crop phyto, weed cover, population counts.
03/07/2019	Trial assessment; crop phyto, weed cover.
19/07/2019	Trial assessment; crop phyto, weed cover.
16/08/2019	Trial assessment; crop phyto, weed cover.

Site 2:

Date	Event
12/05/2019	Timing A treatment application.
20/06/2019	Timing B treatment application. Trial assessment; weed cover.
02/07/2019	Timing C treatment application. Trial assessment; crop phyto, weed cover, population counts.
12/07/2019	Timing D treatment application.
15/07/2019	Trial assessment; crop phyto, weed cover, population counts.
29/07/2019	Trial assessment; crop phyto, weed cover.
17/09/2019	Trial assessment; crop phyto.

d. Climatological data during study period.

Site 1

Date	Min. temp. (°C)	Max. temp. (°C)	Av. relative humidity (%)
17/04/2019	8.5	20.0	60.6
18/04/2019	6.0	23.0	65.0
19/04/2019	2.5	26.0	56.6
20/04/2019	2.5	27.0	61.7
21/04/2019	2.0	25.5	52.9
22/04/2019	1.0	27.0	52.8
23/04/2019	8.5	21.5	57.2
24/04/2019	5.5	23.5	64.3
25/04/2019	8.0	19.0	64.8
26/04/2019	5.0	19.5	64.6
27/04/2019	7.0	12.0	66.3
28/04/2019	4.5	13.5	75.9
29/04/2019	0.5	16.0	73.8
30/04/2019	0.0	19.0	70.2
01/05/2019	3.0	20.5	67.3
02/05/2019	9.0	18.5	73.6
03/05/2019	6.0	14.0	77.9
04/05/2019	2.0	10.5	74.7
05/05/2019	3.5	12.5	68.4

06/05/2019	3.0	12.5	65.4
07/05/2019	4.5	16.5	63.9
08/05/2019	8.0	12.5	81.5
09/05/2019	8.0	12.5	84.6
10/05/2019	6.0	15.0	82.2
11/05/2019	7.0	14.0	78.4
12/05/2019	2.0	18.5	69.1
13/05/2019	2.0	19.0	64.6
14/05/2019	3.0	21.0	62.4
15/05/2019	3.0	22.0	59.9
16/05/2019	2.5	20.0	60.2
17/05/2019	8.5	14.0	74.0
18/05/2019	10.0	19.0	77.3
19/05/2019	7.0	20.0	75.3
20/05/2019	10.5	21.5	71.5
21/05/2019	6.0	22.5	63.3
22/05/2019	5.0	22.5	55.9
23/05/2019	7.5	25.0	55.6
24/05/2019	7.5	24.0	58.4
25/05/2019	10.0	24.5	58.6
26/05/2019	12.5	22.5	64.5
27/05/2019	8.5	19.0	65.9
28/05/2019	8.0	16.0	81.9
29/05/2019	8.0	17.0	81.3
30/05/2019	13.5	21.5	75.6
31/05/2019	11.5	22.5	68.9
01/06/2019	12.5	27.0	64.3
02/06/2019	16.0	27.5	61.2
03/06/2019	10.5	22.5	58.4
04/06/2019	9.0	19.5	72.3
05/06/2019	10.0	19.5	71.1
06/06/2019	9.5	21.5	60.6
07/06/2019	7.5	17.5	70.9
08/06/2019	11.5	15.5	78.8
09/06/2019	8.5	21.5	65.1
10/06/2019	10.5	13.5	85.0
11/06/2019	11.0	13.5	90.8
12/06/2019	10.5	14.0	88.4
13/06/2019	10.5	14.0	85.2
14/06/2019	11.5	19.0	77.0
15/06/2019	9.5	20.5	71.3
16/06/2019	9.5	22.0	71.2
17/06/2019	11.0	24.5	63.1
18/06/2019	10.5	21.5	70.1
19/06/2019	12.5	21.0	84.5
20/06/2019	13.0	20.0	73.5
21/06/2019	9.0	23.0	65.9

22/06/2019	12.0	23.5	67.3
23/06/2019	8.0	25.0	70.0
24/06/2019	17.0	27.0	68.7
25/06/2019	15.5	20.5	84.2
26/06/2019	13.5	18.0	83.1
27/06/2019	11.5	22.5	69.4
28/06/2019	12.5	23.5	67.4
29/06/2019	12.0	31.5	67.4
30/06/2019	13.5	26.0	59.3
01/07/2019	11.5	23.0	63.2
02/07/2019	7.5	27.5	62.8
03/07/2019	6.5	31.5	61.1
04/07/2019	6.5	28.5	61.6
05/07/2019	12.0	29.5	58.0
06/07/2019	12.0	21.0	75.2
07/07/2019	12.5	28.0	65.4
08/07/2019	9.5	27.5	62.9
09/07/2019	13.5	22.0	64.1
10/07/2019	15.0	28.0	65.3
11/07/2019	16.0	28.0	64.8
12/07/2019	15.0	25.5	68.3
13/07/2019	15.0	26.5	68.3
14/07/2019	12.5	26.5	69.1
15/07/2019	12.5	24.0	66.1
16/07/2019	7.0	32.5	61.5
17/07/2019	13.0	29.5	57.9
18/07/2019	14.5	25.5	68.4
19/07/2019	10.5	20.0	74.9
20/07/2019	15.5	25.5	73.9
21/07/2019	11.5	26.0	69.1
22/07/2019	15.5	32.0	63.1
23/07/2019	15.0	36.5	59.7
24/07/2019	19.0	35.5	60.8
25/07/2019	16.5	40.5	54.3
26/07/2019	20.0	31.0	59.4
27/07/2019	16.0	20.0	81.0
28/07/2019	14.5	16.0	90.0
29/07/2019	12.5	28.5	70.6
30/07/2019	16.5	23.0	69.4
31/07/2019	15.5	21.0	73.0
01/08/2019	14.5	25.0	76.7
02/08/2019	13.5	28.5	71.8
03/08/2019	12.5	28.5	68.9
04/08/2019	13.5	28.5	65.0
05/08/2019	15.5	27.0	64.6
06/08/2019	14.5	27.5	65.6
07/08/2019	14.0	25.5	67.0

08/08/2019	12.5	31.0	61.1
09/08/2019	17.5	29.5	70.5
10/08/2019	17.0	22.5	64.0
11/08/2019	13.5	24.5	66.2
12/08/2019	11.5	22.5	74.0
13/08/2019	9.0	26.5	67.0
14/08/2019	10.5	19.5	76.8
15/08/2019	12.5	23.0	74.5
16/08/2019	11.0	18.5	81.8

Site 2

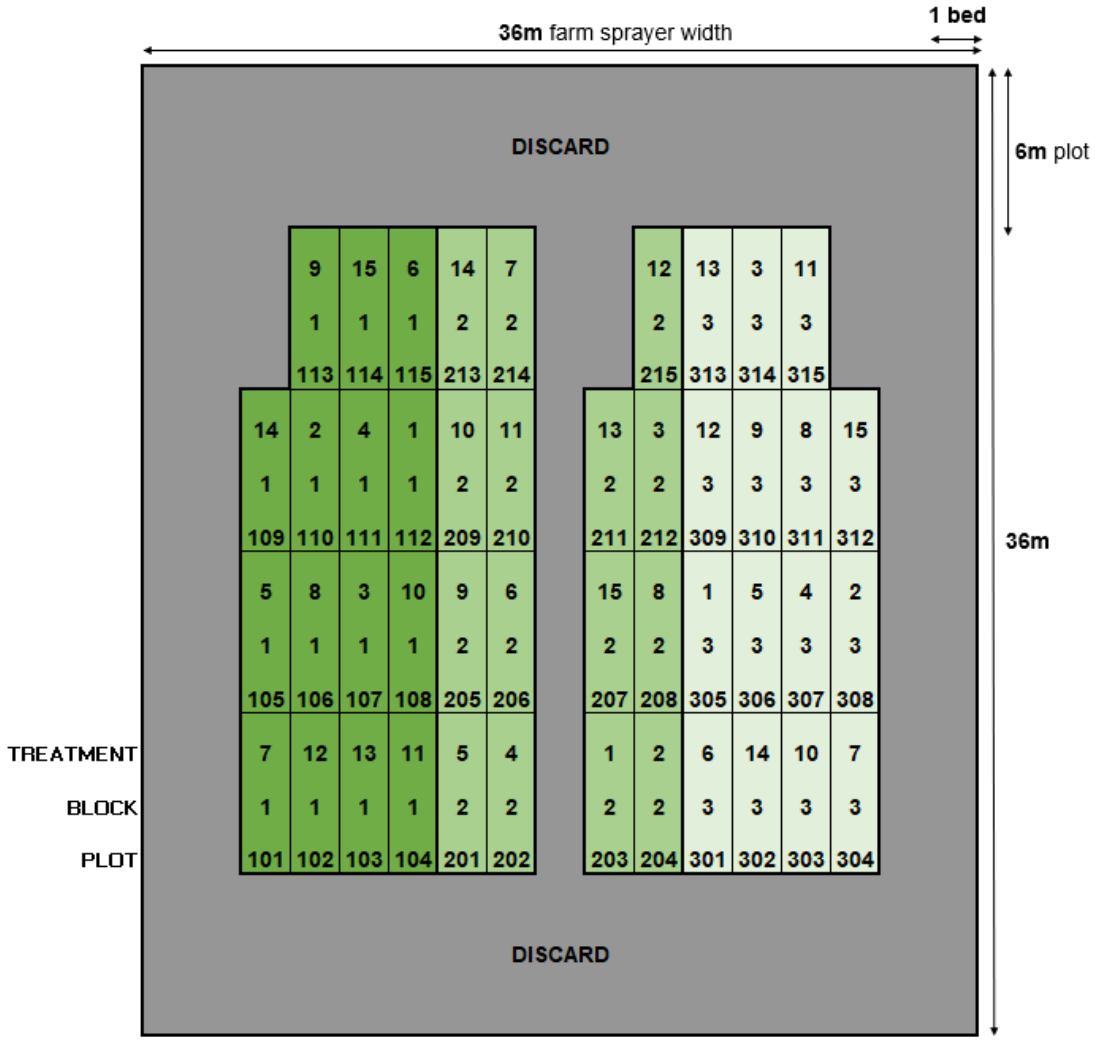
Date	Min. temp. (°C)	Max. temp. (°C)	Rainfall (mm)
12/05/2019	2	17	0
13/05/2019	5	20	0
14/05/2019	7	20	0
15/05/2019	6	20	0
16/05/2019	4	17	0
17/05/2019	9	19	0
18/05/2019	10	16	0
19/05/2019	10	19	0
20/05/2019	8	20	0
21/05/2019	9	20	0
22/05/2019	9	20	0
23/05/2019	8	21	0
24/05/2019	10	21	0
25/05/2019	11	21	0
26/05/2019	12	20	2
27/05/2019	10	18	7
28/05/2019	8	16	6
29/05/2019	5	17	2
30/05/2019	15	23	0
31/05/2019	14	22	0
01/06/2019	14	24	0
02/06/2019	12	23	2
03/06/2019	11	21	0
04/06/2019	9	18	2
05/06/2019	9	17	0
06/06/2019	8	20	0
07/06/2019	6	18	4
08/06/2019	10	14	7
09/06/2019	8	19	0
10/06/2019	9	15	12
11/06/2019	10	13	30
12/06/2019	10	16	22
13/06/2019	8	14	8
14/06/2019	8	17	6
15/06/2019	9	18	1
16/06/2019	7	19	0
17/06/2019	13	21	0
18/06/2019	12	19	2
19/06/2019	12	19	2

Date	Min. temp. (°C)	Max. temp. (°C)	Rainfall (mm)
20/06/2019	8	21	1
21/06/2019	7	19	0
22/06/2019	8	22	0
23/06/2019	11	20	3
24/06/2019	14	21	0
25/06/2019	13	17	6
26/06/2019	9	15	0
27/06/2019	8	21	0
28/06/2019	12	20	0
29/06/2019	10	29	0
30/06/2019	15	23	0
01/07/2019	11	19	0
02/07/2019	9	19	0
03/07/2019	9	21	0
04/07/2019	11	23	0
05/07/2019	15	23	0
06/07/2019	12	21	1
07/07/2019	10	20	0
08/07/2019	11	19	0
09/07/2019	12	19	0
10/07/2019	15	23	0
11/07/2019	15	24	1
12/07/2019	13	24	2
13/07/2019	13	22	3
14/07/2019	10	19	2
15/07/2019	10	23	0
16/07/2019	11	24	0
17/07/2019	15	25	1
18/07/2019	14	20	0
19/07/2019	10	19	4
20/07/2019	12	21	2
21/07/2019	12	22	0
22/07/2019	17	27	0
23/07/2019	14	30	0
24/07/2019	18	28	3
25/07/2019	16	35	0
26/07/2019	19	23	0
27/07/2019	15	19	19
28/07/2019	15	19	2
29/07/2019	14	23	1
30/07/2019	15	24	3
31/07/2019	16	20	12
01/08/2019	14	23	0
02/08/2019	14	21	0
03/08/2019	10	24	0
04/08/2019	16	25	0
05/08/2019	14	22	3
06/08/2019	13	22	3
07/08/2019	13	21	0
08/08/2019	12	23	0
09/08/2019	16	24	16

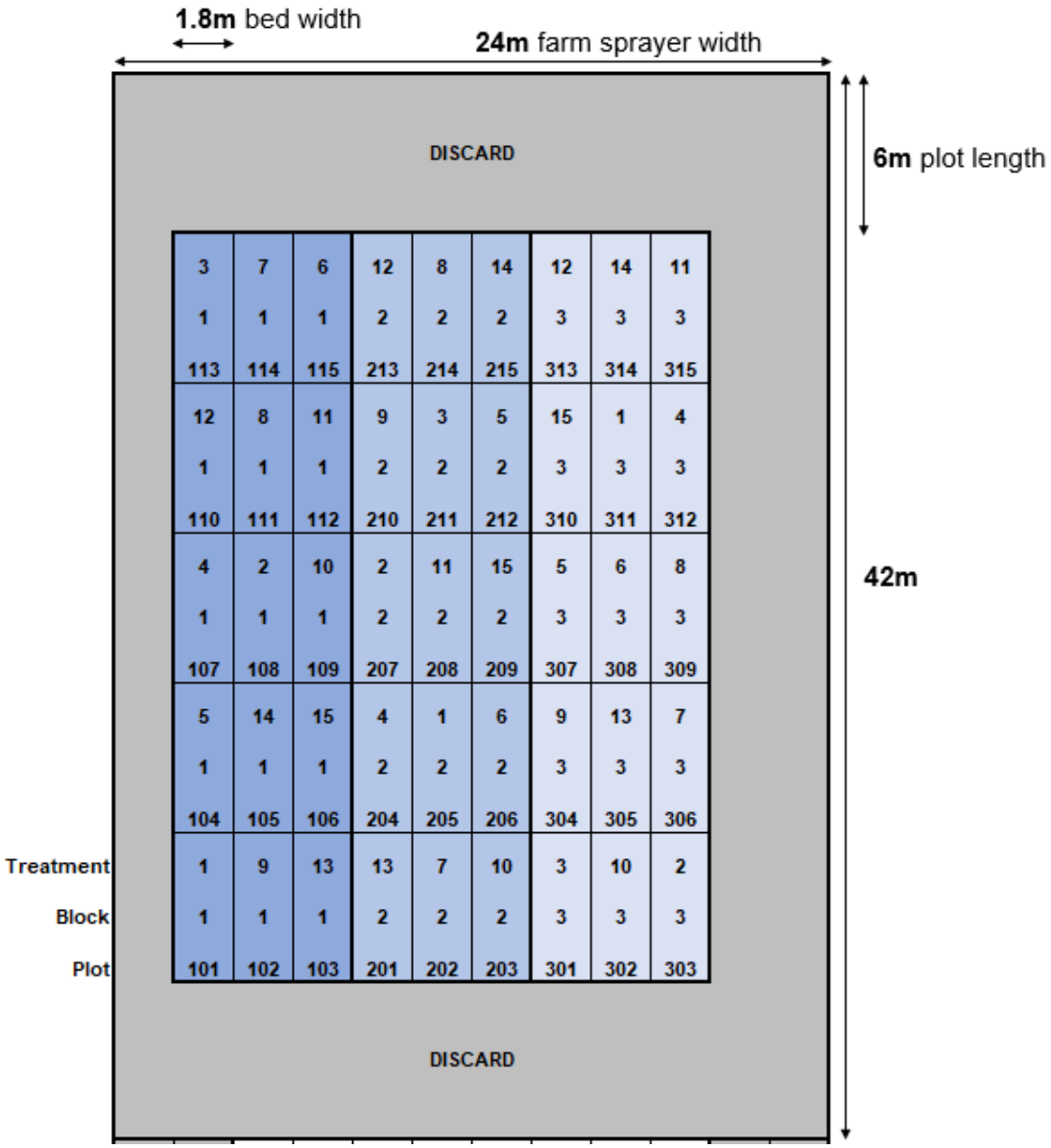
Date	Min. temp. (°C)	Max. temp. (°C)	Rainfall (mm)
10/08/2019	15	21	2
11/08/2019	11	20	0
12/08/2019	9	17	0
13/08/2019	10	18	1
14/08/2019	10	16	7
15/08/2019	11	19	0
16/08/2019	11	17	16
17/08/2019	13	21	0
18/08/2019	12	21	1
19/08/2019	11	20	0
20/08/2019	10	18	1
21/08/2019	12	21	0
22/08/2019	15	22	0
23/08/2019	15	25	0
24/08/2019	13	27	0
25/08/2019	12	30	0
26/08/2019	14	29	0
27/08/2019	15	29	0
28/08/2019	11	20	5
29/08/2019	9	21	0
30/08/2019	15	22	0
31/08/2019	9	19	1
01/09/2019	9	17	2
02/09/2019	10	19	1
03/09/2019	15	22	0
04/09/2019	12	17	2
05/09/2019	9	17	0
06/09/2019	12	18	0
07/09/2019	6	16	0
08/09/2019	4	18	0
09/09/2019	10	15	2
10/09/2019	8	17	0
11/09/2019	12	21	3
12/09/2019	13	23	0
13/09/2019	7	19	0
14/09/2019	5	21	0
15/09/2019	11	20	11
16/09/2019	9	17	0
17/09/2019	6	17	0

e. Trial design

Site 1:


36m farm sprayer width
1 bed
DISCARD
6m plot
36m
9 15 6 14 7
1 1 1 2 2
113 114 115 213 214
12 13 3 11
2 3 3 3
215 313 314 315
14 2 4 1 10 11
1 1 1 1 2 2
109 110 111 112 209 210
13 3 12 9 8 15
2 2 3 3 3 3
211 212 309 310 311 312
5 8 3 10 9 6
1 1 1 1 2 2
105 106 107 108 205 206
15 8 1 5 4 2
2 2 3 3 3 3
207 208 305 306 307 308
TREATMENT 7 12 13 11 5 4 1 2 6 14 10 7
BLOCK 1 1 1 1 2 2 2 2 3 3 3 3
PLOT 101 102 103 104 201 202 203 204 301 302 303 304
DISCARD

Site 2:



f. ORETO certificate

Certificate of

Official Recognition of Efficacy Testing Facilities or Organisations in the United Kingdom

This certifies that

RSK ADAS Ltd

complies with the minimum standards laid down in Regulation (EC) 1107/2009 for efficacy testing.

The above Facility/Organisation has been officially recognised as being competent to carry out efficacy trials/tests in the United Kingdom in the following categories:

Agriculture/Horticulture
Stored Crops
Biologicals and Semiochemicals

Date of issue: 1 June 2018
Effective date: 18 March 2018
Expiry date: 17 March 2023

Signature *Authorised signatory*

Certification Number
ORETO 409

HSE
Chemicals Regulation Division

Department of Agriculture and Rural Development