SCEPTREPLUS

Final Trial Report

Trial code:	2019.SP01
Title:	AHDB SCEPTREplus carrot herbicide screen
Crop	Group: Field vegetables – Carrot (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

This trial was a continuation of work carried out in 2018, looking at products with the potential to partly or fully replace linuron—a key component of herbicide programmes for carrots, and no longer approved—with a focus on finding options for post-emergence weed control and understanding how they are best included in current programmes.

Carrot growers require new products to supplement their short list of currently available actives as the limited range of herbicides has created difficulties for growers to achieve good weed control in commercial crops. While extensions of authorisation for use of aclonifen and diflufenican were issued in 2019 (note: EAMUs only for pre-emergence use), finding different weed control options is always a priority. This trial examined the crop safety and efficacy of these recently approved actives in pre-emergence tank-mixes with commercial standards, as well as screening novel products in post-emergence herbicide programmes for carrots.

Method

Two separate trials were sited in commercial carrot fields on sandy soils; one in Norfolk (Site 1) and one in South Yorkshire (Site 2). A randomised block design was used for the trial layout, with three replicates of fourteen treatments, including two untreated controls and two grower standard treatments. There were forty-two 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 23rd April 2019 at pre-emergence (BBCH00-03), with subsequent post-emergence applications on 21st May (BBCH10-12), 28th May (BBCH10-12), and 5th June (BBCH11-14).

Site 2

Treatments were applied at four timings. The first were applied on 12th May at pre-emergence (BBCH00-03), with subsequent post-emergence applications on 20th June (BBCH13-14), 2nd July (BBCH14-15), and 12th July (BBCH15-16).

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 (see 'Assessment details'), focusing on weed cover and species presence, and crop phytotoxicity (i.e. treatment safety). Assessments were carried out at treatment application timings B and D, and at two, four and eight weeks after the Timing D application.

Results and discussion

The differences in phytotoxic effects between the two sites were notable in this trial, with negligible phytotoxic damage observed at Site 2, despite some clear treatment effects on the carrot foliage at Site 1. This can be attributed to a slight delay in application at Site 2, meaning that the crop was larger at the time of treatment and was then less vulnerable to phytotoxic damage from the products in the trial. Additionally, treatment efficacy was lower at Site 2 as the weeds were also larger at the delayed application timing, and many of the treatments in the screen were residual/contact products with weak contact activity better suited to controlling weeds at a very early cotyledon stage. This therefore highlights the importance of timing of applications for optimum crop safety and efficacy—treatment of a slightly larger crop is recommended for safety, but ensuring the weeds are not too large to control.

The hot and dry weather during the trial period at Site 1 is also noteworthy, as this may have increased the treatment effects apparent at this site. Temperatures were consistently higher at Site 1 than Site 2—where little crop damage was seen—and at the final assessment, the crop had been recently subject to exceptionally high temperatures, with a week-long heatwave peaking at 41°C four days earlier. There was also little precipitation or opportunity to irrigate

this site, with the only supplementary irrigation applied 50 days before the final assessment. It is likely that these conditions impacted crop vigour which may have had a confounding effect on the final assessment, where phytotoxicity scores increased for many treatments. The vigour of the untreated crop was particularly poor at the final assessment, given the challenging environmental conditions and weed competition—the high crop damage score reflects this, as opposed to indicating phytotoxic symptoms.

All four pre-emergence treatments assessed in these trials gave statistically significant weed control (**Table 1**) and appeared crop safe (**Table 2**)—**Anthem + Hurricane SC + Gamit 36CS** (grower standard); **Anthem + Flexidor + Gamit 36CS**; **Anthem + Emerger + Gamit 36CS**; and **Anthem + AHDB9917**. In addition, four of the post-emergence treatments appeared crop safe and effective by the conclusion of the trial— **Anthem, then Hurricane SC**; **Anthem, then AHDB9860**; **Anthem, then Emerger**; and **Anthem, then AHDB9918**. Crop treated with **Anthem, then AHDB9861** also appeared of acceptable quality at the final assessment, though the phytotoxic effects seen at earlier assessment were quite harsh, with significant stunting and scorch.

Hurricane SC, **Emerger** and **Flexidor** are all EAMU authorised for pre-emergence use on carrots (0180/19, 1601/19, and 0020/18 respectively). Tested in this trial as tank-mixes with label-approved Gamit 36CS, all appeared crop safe and effective treatments. In addition, **Hurricane SC** and **Emerger** were screened for post-emergence use and were similarly effective and safe by the conclusion of the trial. Post-emergence EAMU authorisation for these products would also be useful, following their promising performance in these trials.

The use of **AHDB9917** on carrots is not currently approved, and this product also showed promise in this trial as a crop safe and effective pre-emergence treatment; an EAMU authorisation for its use would be beneficial.

The use of **AHDB9860** and **AHDB9918** on carrots is not currently approved, though these products performed well in this trial. Applied post-emergence, all showed significant efficacy and no persistent phytotoxic effects. These products would be valuable additions to carrot growers' weed control options, and pursual of EAMUs would be useful.

Table 1. 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		+ 8 weeks	
	Ang.	Back-trans	Ang.	Back-trans	Ang.	Back-trans	Ang.	Back-trans	Ang.	Back-trans	Ang.	Back-trans
UTC	63.0	79.4	67.0	86.9	42.2	45.1	64.0	80.8	69.1	87.3	69.1	87.3
3	24.1	***16.6**	26.1	***7.5**	17.6	***9.1**	58.1	72.0	63.9	80.7	63.9	80.7
4	28.8	***23.2**	26.2	***7.0**	16.4	***8.0**	60.3	75.4	68.9	87.0	68.9	87.0
5	23.9	***16.4**	19.5	***8.6**	13.8	***5.7**	52.8	63.4	61.2	76.8	61.2	76.8
6	36.6	***35.5**	34.4	***24.2**	27.7	***21.6**	61.2	76.8	63.4	80.0	63.4	80.0
7	16.6	***8.2**	14.8	***7.0**	31.7	***27.7**	12.4	***4.6**	9.3	***2.6**	9.3	***2.6**
8	16.2	***7.8**	15.5	***4.5**	16.0	***7.6**	29.5	***24.3**	35.2	***33.3**	35.2	***33.3**
9	32.0	***28.1**	29.8	***33.2**	37.2	36.6	53.4	64.4	66.1	83.6	66.1	83.6
10	16.2	***7.8**	14.9	***6.9**	19.3	***10.9**	45.3	***50.5**	52.8	***63.4**	52.8	***63.4**
11	33.1	***29.8**	25.5	***13.9**	25.0	***17.9**	40.9	***42.8**	44.9	***49.9**	44.9	***49.9**
12	21.1	***13.0**	18.1	***12.6**	25.0	***17.9**	43.0	***46.5**	58.1	72.0	58.1	72.0
13	12.9	***5.0**	11.0	***3.2**	15.2	***6.9**	6.5	***1.3**	8.9	***2.4**	8.9	***2.4**
14	18.1	***9.6**	14.9	***7.7**	20.1	***11.8**	22.6	***14.8**	25.5	***18.5**	25.5	***18.5**
p-value	<0.001		<0.001		<0.001		<0.001		<0.001		<0.001	

d.f.	27	27	27	27	27	27
L.S.D.	8.520	9.199	10.370	14.39	13.50	13.50

UTC = untreated control; treatments 1 and 2.
* significantly lower than untreated control.

Table 2. Mean phytotoxicity scores at Timing D treatment application, and two, four/five, and eight weeks after Timing D application for Sites 1 and 2.

Treatment	Mean crop damage scores (0-10)							
	Site 1				Site 2			
	Timing D	+ 2 weeks	+ 4 weeks	+ 8 weeks	Timing D	+ 2 weeks	+ 5 weeks	+ 8 weeks
Untreated	0.0	0.2	0.7	***6.5**	0.0	0.0	0.0	0.0
Anthem + Hurricane + Gamit	***2.3**	2.0	0.0	2.0	0.0	0.0	0.0	0.7
Anthem + Flexidor + Gamit	***2.3**	***2.3**	1.0	1.7	0.0	0.0	0.0	0.3
Anthem + Emerger + Gamit	***2.3**	1.0	0.0	1.3	0.0	0.0	0.0	0.0
Anthem + AHDB9917	***2.3**	2.0	1.7	2.0	0.0	0.0	0.0	0.0
Anthem, then **AHDB9975** (x3)	***5.7**	***6.0**	***5.0**	***5.3**	***3.0**	0.0	0.0	1.0
Anthem, then **AHDB9861** (x3)	***6.0**	***8.0**	***4.3**	0.7	0.7	0.0	0.0	0.0
Anthem, then **AHDB9898** (x3)	***4.0**	***3.7**	1.3	***4.7**	0.0	0.0	0.0	0.3
Anthem, then **Hurricane** (x3)	***4.0**	***6.0**	2.0	1.0	0.0	0.0	0.0	0.0
Anthem, then **Gamit** (x3)	***2.8**	***3.7**	1.3	***2.3**	0.0	1.3	1.3	1.3
Anthem, then **AHDB9860** (x3)	***4.0**	2.0	0.7	1.0	0.0	0.0	0.0	0.3
Anthem, then **Emerger** (x3)	***6.0**	***6.7**	1.7	0.3	0.7	0.0	0.0	1.0
Anthem, then **AHDB9918** (x3)	***2.7**	***2.3**	1.3	1.3	0.0	0.0	0.0	0.7
p-value	<0.001	<0.001	0.002	<0.001	<0.001	0.043	0.043	0.007
d.f.	27	27	27	27	26	16	16	27
L.S.D.	1.565	1.413	1.968	1.437	0.3043	0.5702	0.5702	0.6730

* significantly different to untreated control AND/OR > 2.0.

Conclusion

- **Hurricane SC**, **Emerger**, **AHDB9860** and **AHDB9918** are promising products for post-emergence weed control in carrot, observed to be effective and crop safe by the conclusion of these trials. EAMU authorisation for post-emergence use of these products in carrots would be useful.

- **AHDB9917** is a promising product for pre-emergence weed control in carrots, appearing crop safe and effective throughout these trials. EAMU authorisation for pre-emergence use of this product in carrots would be useful.

- Post-emergence application of **Anthem, then AHDB9975** was not safe to use on carrots.

Take home message

EAMU authorisations for pre-emergence use of **AHDB9917** and post-emergence use of **Hurricane SC**, **Emerger**, **AHDB9861**, **AHDB9860** and **AHDB9918** should be applied for, to expand the range of actives available to carrot growers. This would improve weed control in this crop and reduce the risk of resistance development.

Objective

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

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: C60 Alan Bartlett & Sons Pentney, King's Lynn PE32 1JL Norfolk Grid reference: TF 73178 13777	**Site 2** Field: Jackson Spetch Camella M H Poskitt Camblesforth, Selby YO8 8HA Yorkshire Grid reference: SE 64615 26605
Crop	Carrot	
Cultivar	Octavo F1	Stanhey
Soil or substrate type	Freely draining slightly acid sandy soil	
Agronomic practice	See Appendix A	
Prior history of site	See Appendix A	

Trial design

Item	**Details**
Trial design:	Randomised block
Number of replicates:	3
Row spacing:	80" beds (4 triple 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
AHDB9898	N/D	N/D	N/D	N/D	N/D
N/A*	Gamit 36 SC	clomazone	360	160344	Capsule Suspension
N/A†	Hurricane SC	diflufenican	500	17118244	Suspension Concentrate
N/A†	Flexidor 500	isoxaben	500	N/K	Suspension Concentrate
AHDB9918	N/D	N/D	N/D	N/D	N/D
N/A†	Emerger	aclonifen	600	EV5600	Suspension Concentrate
AHDB9917	N/D	N/D	N/D	N/D	N/D
AHDB9860	N/D	N/D	N/D	N/D	N/D
AHDB9861	N/D	N/D	N/D	N/D	N/D
AHDB9975	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 Gamit 36 SC	A	1320 50 90	3.30 0.10 0.25
4	Anthem Flexidor 500 Gamit 36 SC	A	1320 50 90	3.30 0.10 0.25
5	Anthem Emerger Gamit 36 SC	A	1320 60 90	3.30 0.10 0.25
6	Anthem AHDB9917	A	1320	3.30 0.70
7	Anthem	A	1320	3.30
	AHDB9975	B, C, D	578	1.25
8	Anthem	A	1320	3.30
	AHDB9861	B	700	1.00
	AHDB9861	C, D	1400	2.00
9	Anthem	A	1320	3.30
	AHDB9898	B	144	0.20
	AHDB9898	C, D	180	0.25
10	Anthem	A	1320	3.30
	Hurricane SC	B, C, D	25	0.05
11	Anthem	A	1320	3.30
	Gamit 36CS	B, C, D	18	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

* Grower standard

Application details
Site 1

	Timing A	Timing B	Timing C	Timing D
Application date	23/04/2019	21/05/2019	30/05/2019	05/06/2019
Time of day	17:00 – 18:00	11:30 – 12:30	14:10 – 14:50	13:00 – 15:00
Crop growth stage (min., max. BBCH)	BBCH00-03	BBCH10-12	BBCH10-12	BBCH11-14
Crop height (cm)	N/A	4.0	3.0 – 8.0	5.0
Crop coverage (%)	N/A	5.0	N/K	N/K
Application Method	spray	spray	spray	spray
Application Placement	soil	foliar	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	02F110	02F110	02F110	02F110
Application water (L/ha)	200	200	200	200
Temperature of air – shade (°C)	19.0 – 18.0	23.3 – 26.8	14.4 – 14.6	11.8 – 18.7
Relative humidity (%)	54.3 – 55.3	44.8 – 26.8	69.2 – 65.6	48.9 – 44.7
Wind speed range (mph)	4.6 – 4.2	3.4 – 2.3	2.6 – 4.3	6.2 – 7.1
Dew presence (Y/N)	N/K	N	N	N
Temperature of soil – 10cm (°C)	18.7 – 18.1	N/K	N/K	N/K
Wetness of soil (2-5 cm)	N/K	N/K	N/K	N/K
Cloud cover (%)	50	30	95	70

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	09:00 – 10:00	11:00 – 11:45	11:00 – 13:00	11:45 – 12:15
Crop growth stage (min., max. BBCH)	BBCH00-03	BBCH13-14	BBCH14-15	BBCH15-16
Crop height (cm)	N/A	3.0	15.0	15.0 – 20.0
Crop coverage (%)	N/A	10.0	35.0	Various
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	22.4 – 22.6
Relative humidity (%)	74.2 – 76.8	56.2 – 46.9	56.4 – 69.2	61.7 – 57.8

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	25.7
Wetness of soil (2-5 cm)	damp	damp	dry	dry
Cloud cover (%)	5	75	30	40

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	79.4%	86.8%	45.1%
			SITE 2	80.0%	87.3%	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)
21/05/2019	28	10-12	efficacy, phytotox	Phytotoxicity (scale 0-10, 10 = Dead), percentage of weed cover (whole plot score), plant population count.
05/06/2019	43	10-12	efficacy, phytotox	Phytotoxicity (scale 0-10, 10 = Dead), percentage of weed cover (whole plot score), plant population count.
17/06/2019	54	11-14	efficacy, phytotox	Phytotoxicity (scale 0-10, 10 = Dead), percentage of weed cover (whole plot score, plus weeds species presence), plant population count.
01/07/2019	69	13-16	efficacy, phytotox	Phytotoxicity (scale 0-10, 10 = Dead), percentage of weed cover (whole plot score, plus weeds species presence).
29/07/2019	97	18	efficacy, phytotox	Phytotoxicity (scale 0-10, 10 = Dead), percentage of weed cover (whole plot score, plus weeds species presence).

* 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	13-14	efficacy	Percentage weed cover (whole plot score and per species)

02/07/2019	52	14-15	efficacy, phytotox	Phytotoxicity (scale 0-10, 10 = Dead), percentage of weed cover (whole plot score and per species), plant population count.
15/07/2019	64	15-16	efficacy, phytotox	Phytotoxicity (scale 0-10, 10 = Dead), percentage of weed cover (whole plot score and per species).
29/07/2019	78	N/K	efficacy, phytotox	Phytotoxicity (scale 0-10, 10 = Dead), percentage of weed cover (whole plot score and per species).
15/08/2019	95	N/K	efficacy, phytotox	Phytotoxicity (scale 0-10, 10 = Dead), percentage of weed cover (whole plot score and per species).
06/09/2019	117	N/K	efficacy, phytotox	Phytotoxicity (scale 0-10, 10 = Dead), percentage of weed cover (whole plot score and per species).

* DA – days after Timing A application

Statistical analysis

The trials had randomised block designs, each comprising fourteen 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 Abbott's 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.

At Site 1, crop damage was recorded across all treatments at the Timing D assessment, with varying levels of foliar yellowing and scorch. However, a graminicide was applied to the trial six days prior to this assessment—in order to clear the barley cover crop—which was likely picked

up by the crop and responsible for these phytotoxic symptoms across all the treatments. The crop grew through these effects, with eight of the twelve treatments appearing crop safe by the final assessment, eight weeks after Timing D, these were **Anthem + Hurricane SC + Gamit 36CS**; **Anthem + Flexidor + Gamit 36CS**; **Anthem + Emerger + Gamit 36CS**; **Anthem + AHDB9917**; **Anthem, then Hurricane SC**; **Anthem, then AHDB9860**; **Anthem, then Emerger**; **Anthem, then AHDB9918**. Crop treated with **Anthem, then AHDB9861** also appeared of acceptable quality at the final assessment, though the phytotoxic effects seen at earlier assessment were quite harsh, with significant stunting and scorch.

By this final assessment, only three treatments showed an unacceptable level of crop damage—**Anthem, then AHDB9975**; **Anthem, then AHDB9898**; and **Anthem, then Gamit 36CS**. Following some foliar distortion at earlier assessments, these treatments still appeared stunted at the conclusion of the trial.

At the final assessment, the untreated crop was also of low quality and stunted, though this is attributed to low crop vigour due to weed competition and harsh weather, as opposed to phytotoxic damage.

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

Table 1. Mean phytotoxicity scores at Timing D treatment application, and two, four/five, and eight weeks after Timing D application for Sites 1 and 2.

Treatment	Mean crop damage scores (0-10)							
	Site 1				Site 2			
	Timing D	+ 2 weeks	+ 4 weeks	+ 8 weeks	Timing D	+ 2 weeks	+ 5 weeks	+ 8 weeks
Untreated	0.0	0.2	0.7	***6.5**	0.0	0.0	0.0	0.0
Anthem + Hurricane + Gamit	***2.3**	2.0	0.0	2.0	0.0	0.0	0.0	0.7
Anthem + Flexidor + Gamit	***2.3**	***2.3**	1.0	1.7	0.0	0.0	0.0	0.3
Anthem + Emerger + Gamit	***2.3**	1.0	0.0	1.3	0.0	0.0	0.0	0.0
Anthem + AHDB9917	***2.3**	2.0	1.7	2.0	0.0	0.0	0.0	0.0
Anthem, then **AHDB9975** (x3)	***5.7**	***6.0**	***5.0**	***5.3**	***3.0**	0.0	0.0	1.0
Anthem, then **AHDB9861** (x3)	***6.0**	***8.0**	***4.3**	0.7	0.7	0.0	0.0	0.0
Anthem, then **AHDB9898** (x3)	***4.0**	***3.7**	1.3	***4.7**	0.0	0.0	0.0	0.3
Anthem, then **Hurricane** (x3)	***4.0**	***6.0**	2.0	1.0	0.0	0.0	0.0	0.0
Anthem, then **Gamit** (x3)	***2.8**	***3.7**	1.3	***2.3**	0.0	1.3	1.3	1.3
Anthem, then **AHDB9860** (x3)	***4.0**	2.0	0.7	1.0	0.0	0.0	0.0	0.3
Anthem, then **Emerger** (x3)	***6.0**	***6.7**	1.7	0.3	0.7	0.0	0.0	1.0
Anthem, then **AHDB9918** (x3)	***2.7**	***2.3**	1.3	1.3	0.0	0.0	0.0	0.7
p-value	<0.001	<0.001	0.002	<0.001	<0.001	0.043	0.043	0.007
d.f.	27	27	27	27	26	16	16	27

L.S.D.	1.565	1.413	1.968	1.437	0.3043	0.5702	0.5702	0.6730

* significantly different to untreated control AND/OR > 2.0.

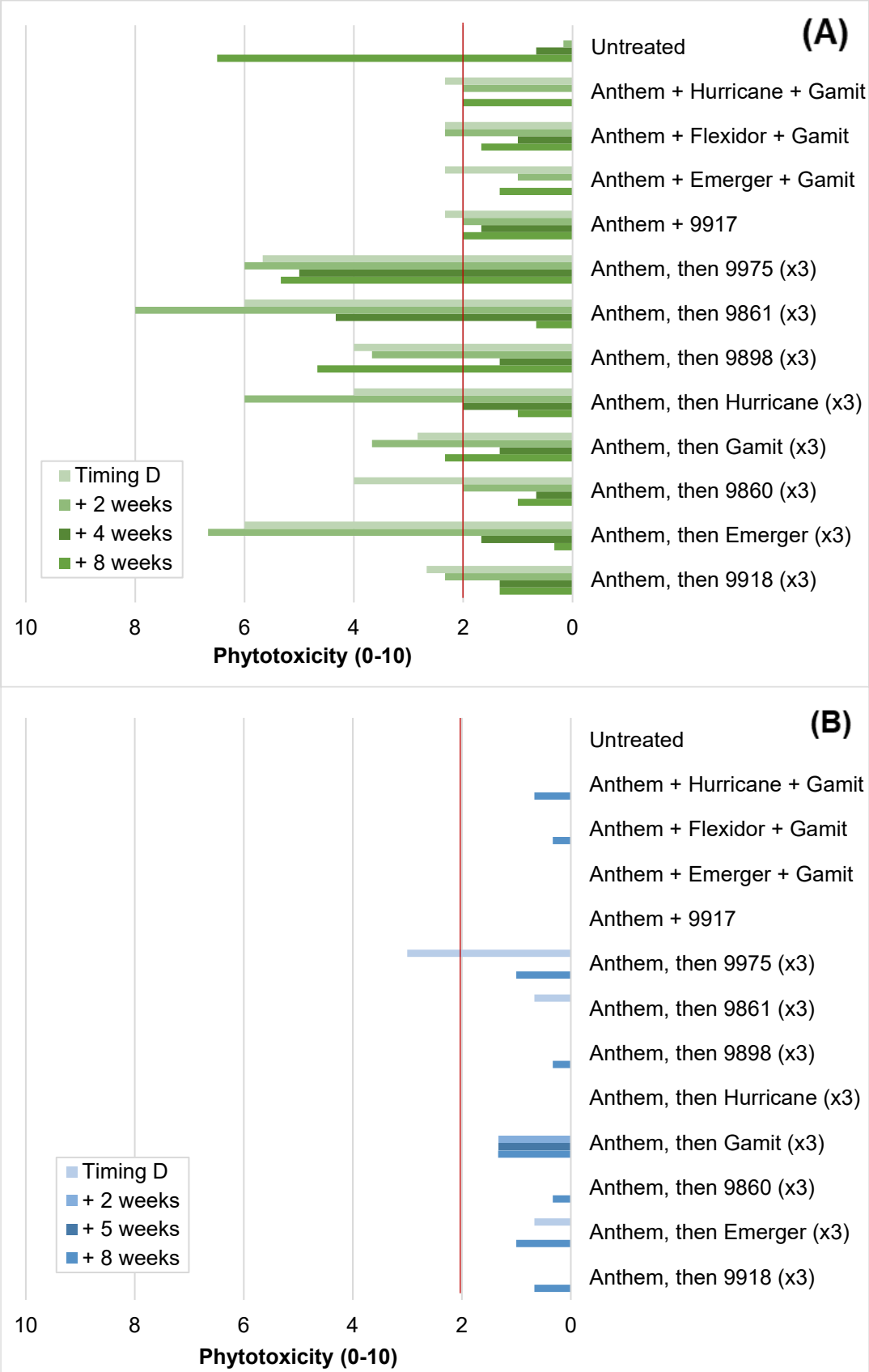


Figure 1. Mean phytotoxicity scores at Timing D treatment application, and two, four/five, and eight weeks after Timing D application for Site 1 **(A)** and Site 2 **(B)**. Scores ≤2 deemed commercially acceptable damage (as indicated by red line).

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 Abbott's formula), and results for each treatment are listed in **Table 3**.

The main weed species at Site 1 were charlock, cranesbill, mugwort, and fool's parsley; most common at Site 2 were fat hen, sow thistle, knotgrass, and mayweed.

At Site 1, all treatments showed significantly lower weed cover than the untreated control plots across all assessments. Most effective were **Anthem + Emerger + Gamit 36CS**; **Anthem, then AHDB9861**; and **Anthem, then Emerger**, respectively offering 87.4%, 83.1%, and 84.8% reductions in weed cover compared to the untreated control at the final assessment, eight weeks after treatment application.

Fewer treatments appeared effective at Site 2, with half not showing any significant control compared to the untreated control. The remaining treatments were effective—**Anthem, then AHDB9975**; **Anthem, then AHDB9861**; **Anthem, then Hurricane SC**; **Anthem, then Gamit 36CS**; **Anthem, then Emerger**; and **Anthem, then AHDB9918** showed significant reductions in weed cover compared to the untreated throughout the assessment period. Of these, **Anthem, then Emerger** was particularly effective, with a 97.2% weed cover reduction recorded at the final assessment, eight weeks after the final treatment application. Treatment with **Anthem, then AHDB9975** appeared similarly effective, though this treatment was too harsh on crop.

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		+ 8 weeks	
	Ang.	Back-trans	Ang.	Back-trans	Ang.	Back-trans	Ang.	Back-trans	Ang.	Back-trans	Ang.	Back-trans
UTC	63.0	79.4	67.0	86.9	42.2	45.1	64.0	80.8	69.1	87.3	69.1	87.3
3	24.1	***16.6**	26.1	***7.5**	17.6	***9.1**	58.1	72.0	63.9	80.7	63.9	80.7
4	28.8	***23.2**	26.2	***7.0**	16.4	***8.0**	60.3	75.4	68.9	87.0	68.9	87.0
5	23.9	***16.4**	19.5	***8.6**	13.8	***5.7**	52.8	63.4	61.2	76.8	61.2	76.8
6	36.6	***35.5**	34.4	***24.2**	27.7	***21.6**	61.2	76.8	63.4	80.0	63.4	80.0
7	16.6	***8.2**	14.8	***7.0**	31.7	***27.7**	12.4	***4.6**	9.3	***2.6**	9.3	***2.6**
8	16.2	***7.8**	15.5	***4.5**	16.0	***7.6**	29.5	***24.3**	35.2	***33.3**	35.2	***33.3**
9	32.0	***28.1**	29.8	***33.2**	37.2	36.6	53.4	64.4	66.1	83.6	66.1	83.6
10	16.2	***7.8**	14.9	***6.9**	19.3	***10.9**	45.3	***50.5**	52.8	***63.4**	52.8	***63.4**
11	33.1	***29.8**	25.5	***13.9**	25.0	***17.9**	40.9	***42.8**	44.9	***49.9**	44.9	***49.9**
12	21.1	***13.0**	18.1	***12.6**	25.0	***17.9**	43.0	***46.5**	58.1	72.0	58.1	72.0
13	12.9	***5.0**	11.0	***3.2**	15.2	***6.9**	6.5	***1.3**	8.9	***2.4**	8.9	***2.4**
14	18.1	***9.6**	14.9	***7.7**	20.1	***11.8**	22.6	***14.8**	25.5	***18.5**	25.5	***18.5**
p-value		<0.001		<0.001		<0.001		<0.001		<0.001		<0.001
d.f.		27		27		27		27		27		27
L.S.D.		8.520		9.199		10.370		14.39		13.50		13.50

UTC = untreated control; treatments 1 and 2.
* significantly lower than untreated control.

0% WEED COVER 100%

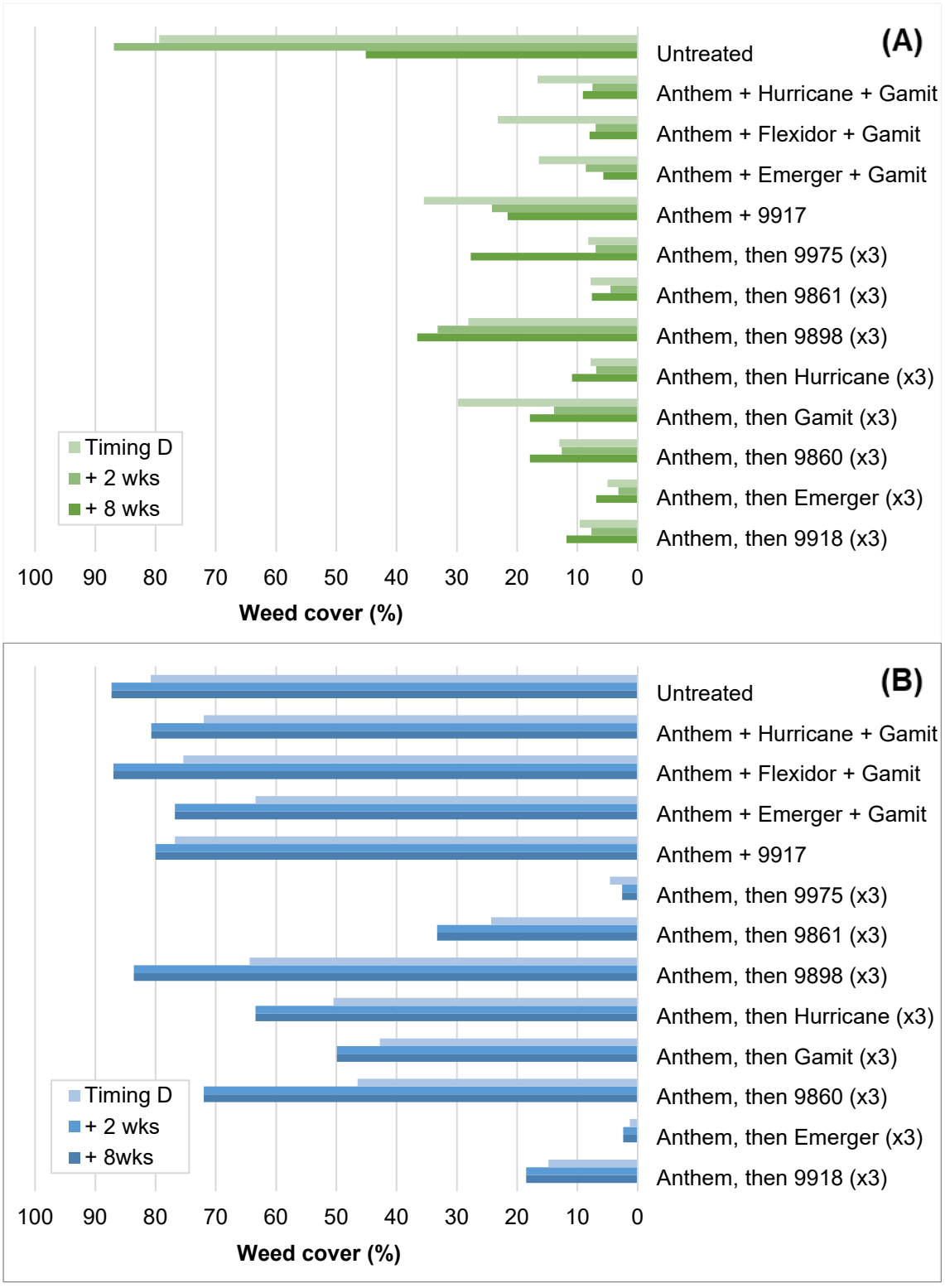


Figure 2. Mean weed cover (%; back-transformed values) at Timing D treatment application, and two and eight weeks after Timing D application for Site 1 **(A)** and Site 2 **(B)**.

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

Treatment	Weed cover reduction (%)					
	Site 1			Site 2		
	Timing D	+ 2 weeks	+ 8 weeks	Timing D	+ 2 weeks	+ 9 weeks
Anthem + **Hurricane** + **Gamit**	79.1	77.2	79.8	10.9	7.6	7.6
Anthem + **Flexidor** + **Gamit**	70.8	77.0	82.3	6.7	0.3	0.3
Anthem + **Emerger** + **Gamit**	79.4	86.8	87.4	21.6	12.0	12.0
Anthem + **AHDB9917**	55.3	62.4	52.1	5.0	8.3	8.3
Anthem, then **AHDB9975** (x3)	89.7	92.3	38.6	94.3	97.0	97.0
Anthem, then **AHDB9861** (x3)	90.2	91.6	83.1	69.9	61.9	61.9
Anthem, then **AHDB9898** (x3)	64.6	70.8	18.9	20.3	4.2	4.2
Anthem, then **Hurricane** (x3)	90.2	92.2	75.8	37.5	27.4	27.4
Anthem, then **Gamit** (x3)	62.5	78.2	60.4	47.0	42.9	42.9
Anthem, then **AHDB9860** (x3)	83.6	88.7	60.4	42.5	17.5	17.5
Anthem, then **Emerger** (x3)	93.7	95.7	84.8	98.4	97.2	97.2
Anthem, then **AHDB9918** (x3)	87.9	92.2	73.8	81.7	78.8	78.8

Plant population

Results from carrot plant counts are presented in Table 4. There were no significant reductions in plant population by any of the treatments applied at either site.

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

Trt. No.	Mean plant population (№ plants in 0.5 m of single row)		
	Site 1		Site 2
	(05/06/19) **Timing D**	Timing D **+ 2 weeks**	(02/07/19) **Timing C**
Untreated	33.2	40.3	31.5
Anthem + **Hurricane** + **Gamit**	37.0	40.8	38.3

Anthem + Flexidor + **Gamit**	36.3	39.7	37.5
Anthem + **Emerger** + **Gamit**	38.3	40.7	35.3
Anthem + **AHDB9917**	36.7	41.0	34.5
Anthem, then **AHDB9975** (x3)	35.7	34.7	33.8
Anthem, then **AHDB9861** (x3)	34.7	26.2	30
Anthem, then **AHDB9898** (x3)	34.3	38.5	33.8
Anthem, then **Hurricane** (x3)	33.2	40.8	36
Anthem, then **Gamit** (x3)	37.2	37.2	30
Anthem, then **AHDB9860** (x3)	37.5	41.2	30.8
Anthem, then **Emerger** (x3)	33.7	39.7	34.5
Anthem, then **AHDB9918** (x3)	33.0	40.0	36.8
p-value	0.480	<0.001	0.591
d.f.	27	27	14
L.S.D.	4.958	4.964	8.084

Discussion

The differences in phytotoxic effects between the two sites were notable in this trial, with negligible phytotoxic damage observed at Site 2, despite some clear treatment effects on the carrot foliage at Site 1. This can be attributed to a slight delay in application at Site 2, meaning that the crop was larger at the time of treatment and was then less vulnerable to phytotoxic damage from the products in the trial. Additionally, treatment efficacy was lower at Site 2 as the weeds were also larger at the delayed application timing, and many of the treatments in the screen were residual/contact products with weak contact activity better suited to controlling weeds at a very early cotyledon stage. This therefore highlights the importance of timing of applications for optimum crop safety and efficacy—treatment of a slightly larger crop is recommended for safety, but ensuring the weeds are not too large to control.

The hot and dry weather during the trial period at Site 1 is also noteworthy, as this may have increased the treatment effects apparent at this site. Temperatures were consistently higher at Site 1 than Site 2—where little crop damage was seen—and at the final assessment, the crop had been recently subject to exceptionally high temperatures, with a week-long heatwave peaking at 41°C four days earlier. There was also little precipitation or opportunity to irrigate this site, with the only supplementary irrigation applied 50 days before the final assessment. It is likely that these conditions impacted crop vigour which may have had a confounding effect on the final assessment, where phytotoxicity scores increased for many treatments. The vigour of the untreated crop was particularly poor at the final assessment, given the challenging environmental conditions and weed competition—the high crop damage score reflects this, as opposed to indicating phytotoxic symptoms.

All four pre-emergence treatments assessed in these trials gave statistically significant weed control (**Table 1**) and appeared crop safe (**Table 2**)—**Anthem + Hurricane SC + Gamit 36CS** (grower standard); **Anthem + Flexidor + Gamit 36CS**; **Anthem + Emerger + Gamit 36CS**; and **Anthem + AHDB9917**. In addition, four of the post-emergence treatments appeared crop safe and effective by the conclusion of the trial— **Anthem, then Hurricane SC**; **Anthem, then AHDB9860**; **Anthem, then Emerger**; and **Anthem, then AHDB9918**. Crop treated with **Anthem, then AHDB9861** also appeared of acceptable quality at the final assessment, though the phytotoxic effects seen at earlier assessment were quite harsh, with significant stunting and scorch.

Hurricane SC, **Emerger** and **Flexidor** are all EAMU authorised for pre-emergence use on carrots (0180/19, 1601/19, and 0020/18 respectively). Tested in this trial as tank-mixes with label-approved Gamit 36CS, all appeared crop safe and effective treatments. In addition, **Hurricane SC** and **Emerger** were screened for post-emergence use and were similarly effective and safe by the conclusion of the trial. Post-emergence EAMU authorisation for these products would also be useful, following their promising performance in these trials.

The use of **AHDB9917** on carrots is not currently approved, and this product also showed promise in this trial as a crop safe and effective pre-emergence treatment; an EAMU authorisation for its use would be beneficial.

The use of **AHDB9860** and **AHDB9918** on carrots is not currently approved, though these products performed well in this trial. Applied post-emergence, all showed significant efficacy and no persistent phytotoxic effects. These products would be valuable additions to carrot growers' weed control options, and pursual of EAMUs would be useful.

Conclusions

- **Hurricane SC**, **Emerger**, **AHDB9860** and **AHDB9918** are promising products for post-emergence weed control in carrot, observed to be effective and crop safe by the conclusion of these trials. EAMU authorisation for post-emergence use of these products in carrots would be useful.

- **AHDB9917** is a promising product for pre-emergence weed control in carrots, appearing crop safe and effective throughout these trials. EAMU authorisation for pre-emergence use of this product in carrots would be useful.

- Post-emergence application of **Anthem, then AHDB9975** was not safe to use on carrots.

Acknowledgements
AHDB for funding the work, and 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 Peter Saunders of Alan Bartlett & Sons, and James Bramley of MH Poskitt Ltd.

Appendix

Crop diary – events related to growing crop

a. Site 1

Crop	Cultivar	Drilling date	Bed width
Carrots	Octavo F1	18/04/19	80”, 4 triple lines, 13” row spacing

Previous cropping

Year	Crop
2018	Winter wheat
2017	Beet
2016	Potatoes

Cultivations

Year	Crop
16/04/19	Subsoil/plough/ridge/destone

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

Date	Product	Rate	Unit
20/02/19	Laws 0N-60P-80K-160NaO-40MgO-2B-60SO_3-80 CaO	875.000	kg/ha
04/06/19	Master Manganese Plus	1.500	kg/ha
27/06/19	Laws Top Dressing C: N-13 P-0 K-11 2Mg	375.000	kg/ha
04/07/19	Nutrel Fastmix K-Mag	5.000	kg/ha
	OptE B	1.500	L/ha
	Master Manganese Plus	2.500	kg/ha
24/07/19	Master Managanese Plus	2.500	kg/ha
	Nutrel Fastmix K-Mag	4.000	kg/ha
	Zinic	2.000	L/ha

Pesticides applied to trial area

Date	Product	Rate	Unit
18/04/19	Vydate 10G	30.000	kg/ha
30/05/19	Fusilade Max	2.000	L/ha
04/06/19	Clayton Cayman	0.400	L/ha
	Decis Protech	0.500	L/ha
27/06/19	SL 567A	1.300	L/ha
04/07/19	Minecto One	0.185	kg/ha
24/07/19	Signum	0.750	kg/ha
	Hallmark with Zeon Technology	0.150	L/ha

	Teppeki	0.140	kg/ha

Details of irrigation regime

Date	**Type, rate and duration**	**Amount applied** (mm)
09/06/19	Overhead gun	25.0
09/08/19	Overhead gun	25.0
23/09/19	Overhead gun	25.0

b. Site 2

Crop	**Cultivar**	**Drilling date**	**Bed width**
Carrots	Stanhey	06/05/19	72", 4 triple lines

Previous cropping

Year	**Crop**
2018	Maize
2017	Swede
2016	Sugar beet

Cultivations

Date	**Description**	**Depth (cm)**
04/05/19	Sumo	30
	Plough	24
	Ridge	45
05/05/19	Destone	30
06/06/19	Bedform	18

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

Date	**Product**	**Rate**	**Unit**
23/06/2019	Yara Axan	225	kg/ha

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

Site 1:

Date	**Event**
23/04/2019	Timing A treatment application.
21/05/2019	Timing B treatment application. Trial assessment; crop phyto, weed cover, population counts.
28/05/2019	Timing C treatment application.
05/06/2019	Timing D treatment application. Trial assessment; crop phyto, weed cover, population counts.

17/06/2019	Trial assessment; crop phyto, weed cover, population counts.
01/07/2019	Trial assessment; crop phyto, weed cover.
29/07/2019	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.
29/07/2019	Trial assessment; crop phyto, weed cover.
15/08/2019	Trial assessment; crop phyto, weed cover.
06/09/2019	Trial assessment; crop phyto, weed cover.

d. Climatological data during study period.

Site 1

Date	Min. temp. (°C)	Max. temp. (°C)	Precip. (mm)
24/04/2019	11.5	25.0	0
25/04/2019	8.0	18.5	2
26/04/2019	3.0	20.5	0
27/04/2019	7.0	11.0	2
28/04/2019	4.5	14.0	0
29/04/2019	0.5	15.0	0
30/04/2019	-0.5	18.0	0
01/05/2019	1.0	20.5	1
02/05/2019	9.5	16.0	1
03/05/2019	6.0	10.0	0
04/05/2019	1.5	10.5	6
05/05/2019	5.0	13.0	1
06/05/2019	2.0	13.5	0
07/05/2019	5.5	17.0	0
08/05/2019	8.0	12.5	20
09/05/2019	7.5	12.0	0
10/05/2019	6.5	14.0	4
11/05/2019	7.0	14.0	6
12/05/2019	1.5	17.5	0
13/05/2019	2.0	20.0	0
14/05/2019	3.0	21.0	0
15/05/2019	4.0	21.0	0

16/05/2019	5.0	20.0	0
17/05/2019	10.0	15.5	1
18/05/2019	10.0	16.0	2
19/05/2019	5.0	20.0	0
20/05/2019	10.0	20.5	1
21/05/2019	8.0	21.0	0
22/05/2019	4.5	22.0	0
23/05/2019	6.5	24.0	0
24/05/2019	5.0	23.5	0
25/05/2019	8.5	23.5	0
26/05/2019	12.5	20.5	1
27/05/2019	8.0	17.5	2
28/05/2019	9.0	16.0	7
29/05/2019	6.5	18.5	7
30/05/2019	13.0	23.5	1
31/05/2019	10.0	21.5	0
01/06/2019	10.5	27.5	0
02/06/2019	15.5	27.5	0
03/06/2019	9.5	22.0	0
04/06/2019	7.0	20.5	1
05/06/2019	10.0	20.0	0
06/06/2019	10.5	22.0	0
07/06/2019	6.5	20.0	2
08/06/2019	11.0	13.0	14
09/06/2019	6.5	21.5	0
10/06/2019	11.0	13.5	33
11/06/2019	10.5	12.0	23
12/06/2019	11.0	15.5	6
13/06/2019	10.5	14.0	13
14/06/2019	11.5	20.0	5
15/06/2019	8.5	21.5	0
16/06/2019	8.5	21.5	0
17/06/2019	11.5	23.5	0
18/06/2019	9.0	22.0	8
19/06/2019	13.0	21.0	14
20/06/2019	12.0	20.0	4
21/06/2019	6.5	22.5	0
22/06/2019	9.5	24.0	0
23/06/2019	10.5	26.0	0
24/06/2019	17.0	29.0	0
25/06/2019	14.5	20.0	16
26/06/2019	13.0	17.0	0
27/06/2019	10.5	21.5	0
28/06/2019	12.5	24.0	0
29/06/2019	10.5	32.0	0

30/06/2019	15.0	26.0	0
01/07/2019	11.5	23.0	0
02/07/2019	10.5	22.0	0
03/07/2019	7.0	27.5	0
04/07/2019	6.0	29.0	0
05/07/2019	12.5	30.5	0
06/07/2019	11.5	19.0	1
07/07/2019	10.0	26.5	0
08/07/2019	12.0	23.5	0
09/07/2019	13.0	22.5	0
10/07/2019	15.0	25.0	0
11/07/2019	15.5	26.5	0
12/07/2019	14.5	27.0	2
13/07/2019	14.5	25.5	0
14/07/2019	13.5	23.5	1
15/07/2019	12.5	27.5	0
16/07/2019	7.0	33.0	0
17/07/2019	13.5	33.0	0
18/07/2019	15.0	25.0	6
19/07/2019	8.5	20.0	3
20/07/2019	16.0	25.5	7
21/07/2019	9.5	24.5	0
22/07/2019	15.5	33.5	0
23/07/2019	13.0	40.5	0
24/07/2019	19.0	36.5	2
25/07/2019	16.5	41.0	0
26/07/2019	18.5	35.5	1
27/07/2019	15.5	19.0	27
28/07/2019	15.0	18.0	10
29/07/2019	13.0	29.5	0

Site 2

Date	Min. temp. (°C)	Max. temp. (°C)	Precip. (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	1
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	1
23/05/2019	8	21	0
24/05/2019	10	21	0
25/05/2019	11	21	0

Date	Min. temp. (°C)	Max. temp. (°C)	Precip. (mm)
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	1
17/06/2019	13	21	0
18/06/2019	12	19	2
19/06/2019	12	19	2
20/06/2019	8	17	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

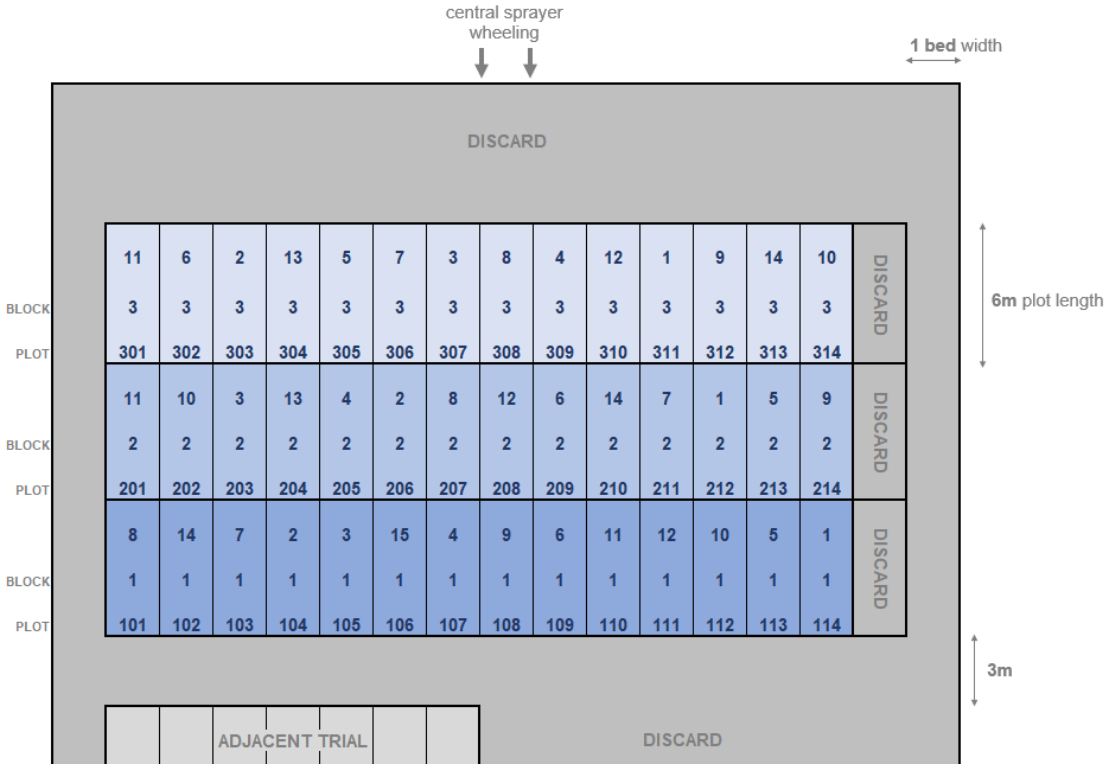
Date	Min. temp. (°C)	Max. temp. (°C)	Precip. (mm)
16/07/2019	11	24	0
17/07/2019	15	25	1
18/07/2019	14	20	1
19/07/2019	10	19	4
20/07/2019	12	21	2
21/07/2019	12	22	0
22/07/2019	17	27	0
23/07/2019	14	30	0
24/07/2019	18	28	3
25/07/2019	35	16	0
26/07/2019	23	19	0
27/07/2019	19	15	19
28/07/2019	19	15	2
29/07/2019	23	14	1
30/07/2019	24	15	3
31/07/2019	20	16	12
01/08/2019	23	14	0
02/08/2019	21	14	0
03/08/2019	24	10	0
04/08/2019	25	16	0
05/08/2019	22	14	3
06/08/2019	22	13	3
07/08/2019	21	13	0
08/08/2019	24	12	0
09/08/2019	25	16	16
10/08/2019	21	15	2
11/08/2019	20	11	0
12/08/2019	17	9	0
13/08/2019	18	10	1
14/08/2019	16	10	7
15/08/2019	19	11	0
16/08/2019	17	11	16
17/08/2019	21	13	0
18/08/2019	21	12	1
19/08/2019	20	11	0
20/08/2019	18	10	1
21/08/2019	21	12	0
22/08/2019	22	15	0
23/08/2019	25	15	0
24/08/2019	27	13	0
25/08/2019	30	12	0
26/08/2019	29	14	0
27/08/2019	29	15	0
28/08/2019	20	11	5
29/08/2019	21	9	0
30/08/2019	22	15	0
31/08/2019	19	9	1
01/09/2019	17	9	2
02/09/2019	19	10	1
03/09/2019	22	15	0
04/09/2019	17	12	2

Date	Min. temp. (°C)	Max. temp. (°C)	Precip. (mm)
05/09/2019	17	9	0
06/09/2019	18	12	0

e. Trial design

Site 1:

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