

SCEPTREPLUS

Final Trial Report

Trial code:	SP01
Title:	AHDB SceptrePlus carrot herbicide screens
Crop	Group: Field vegetables – Carrot (apiaceae), other umbelliferous root vegetables
Target	General broadleaf weeds and grasses
Lead researcher:	Angela Huckle
Organisation:	RSK ADAS
Period:	April 2017 – December 2017
Report date:	02 April 2018
Report authors:	Angela Huckle Emily Lawrence
ORETO Number: (certificate should be attached)	374

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

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Date

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Authors signature

Trial Summary

Introduction

Linuron has been a key component of herbicide programs for carrots and parsnips along with pendimethalin, prosulfocarb and metribuzin. It formed the basis of commercial programs and is used in a tank mix both pre- and post-emergence, to complement the weed control spectrums of the other actives. With linuron due to be withdrawn in the near future (3 June 2018) this will leave growers with only pendimethalin and clomazone for pre-emergence weed control. In addition, the changes to the approval for Defy (prosulfocarb) have also made weed control more difficult with the useful later (up to 3TL) post-emergence applications no longer being permitted. Therefore it is a high priority for growers to find potential replacement products and understand how they are best included within current programs.

These trials concentrated on potential new herbicides which may be used to partly or fully replace the current use of linuron.

Methods

Two separate identical trials were sited at commercial carrot grower sites on sandy loam soils, one in Suffolk and one in Nottinghamshire. Treatments were applied once at pre-emergence as a range of experimental tank mixes, or twice at post-emergence. The latter followed a standard pre-emergence tank mix. The six post-emergence treatments were applied at a growth stage of 1-2 true leaves and again at 3-4 true leaves. The treatments were applied with a 2m Oxford precision knapsack sprayer at 200 L/ha water volume with plots 2m wide by 8m long. A randomised block design was used with three replicates of each treatment plus two untreated controls and a pre-emergence grower standard for comparison; there were 60 treatment plots in total. Each plot was assessed for weed control on five occasions, using counts of weed species at the first two assessments and then % weed ground cover was used once the weeds were larger for the last three assessments. Crop damage was also recorded at the same time that the weed control was assessed to give five phytotoxicity measurements per plot. Estimates of gross yield were quantified by lifting roots from a 1m² area selected from a representative area of the bed 0.5m long and across the whole bed. The carrots were weighed, counted and graded by commercial size and quality parameters.

Results and discussion

Weed levels were low, with means of 11.65% and 8.06% cover in the untreated control at the final assessment at site 1 and site 2 consecutively. It proved difficult to distinguish with confidence between specific treatments to determine individual product performance on how well each controlled weeds in the treatment plots. All treatments, with the exception of that containing AHDB 9999 with Stomp Aqua and Gamit 36 CS, significantly reduced % weed cover at both sites (Site 1 $p < 0.001$, and Site 2 $p = 0.001$) when compared to the untreated. All were comparable in performance to each other and also to the standard linuron. The exception being at site 2 the treatment containing AHDB 9999 did not significantly reduce the percentage of weed cover. One of the few weeds present at the site was nettle, AHDB 9999 has a limited range of weed control and does not control nettle hence the poor performance of the product at this site.

Seven treatments combined acceptable crop safety, or close to acceptable crop safety with reasonably effective weed control when applied at a pre-emergence timing at both trial sites. These were the following each applied in a tank-mix with Stomp Aqua + Gamit 36CS: AHDB 9998, AHDB 9999, Hurricane SC, Flexidor 500, chlorpropham, aclonifen and tri-allate. Although all these treatments gave a slight check to growth, or a visible effect on the foliage of the crop such as bleaching or scorch which meant that the phytotoxicity score was below acceptable at up to 10 weeks after sprays were applied at site 2, root numbers appeared to be not greatly affected at harvest when compared to the untreated control. However, root numbers were significantly lower than those in the plots treated with the standard linuron.

No treatments combined close to acceptable crop safety with reasonably effective weed control at either site when applied at a post-emergence timing after a standard pre-

emergence of Stomp Aqua + AHDB 9947 + Gamit 36CS, but four do warrant further investigation with rates and timing of application as they were safer where there was less intense rainfall after application at Site 1. These are Sencorex Flow, Gamit 36 CS, aclonifen and AHDB 9993.

Further work with rates and timing of application is required with the promising treatments which were on the margins of crop safety, to help growers understand how these can be incorporated safely into current grower herbicide programs.

Table 1. Summary of crop damage, percentage weed cover and gross yield from key assessment timings. Weed cover data is shown as back transformed means.

Pre-emergence application	Post-emergence application 1-2 TL	Post-emergence application 3-4 TL	crop damage (0-10)		weed cover (%)		Yield (root numbers)	
			Site 1	Site 2	Site 1	Site 2	Site 1	Site 2
Site 1 – 28 May Site 2 – 18 May	Both sites: 14 th June	Both sites: 26 th June	27 th July	27 th July	21 st Aug	29 th Aug	1 st Nov	10 th Oct
Untreated	-	-	9.33	9.67	11.65	8.06	149.3	141.4
#Stomp Aqua + Afalon + Gamit 36 CS	-	-	8.67	8.00	0.45	0.00	152.7	178.0
Stomp Aqua + AHDB 9947 + Gamit 36 CS	-	-	8.67	7.00	4.28	0.00	122.0	122.6
Stomp Aqua + AHDB 9947 + Sencorex Flow	-	-	7.00	6.33	1.00	0.00	103.3	140.6
Stomp Aqua + AHDB 9947 + Sencorex Flow + Gamit 36 CS	-	-	7.00	6.67	1.00	0.00	105.3	112.6
Stomp Aqua + AHDB 9999 + Gamit 36 CS	-	-	9.00	6.33	0.45	5.18	136.7	149.4
Stomp Aqua + AHDB 9998 + Gamit 36 CS	-	-	8.33	6.33	0.11	0.00	124.0	147.4
Stomp Aqua + Venzar Flow + Gamit 36 CS	-	-	2.67	7.33	1.00	0.00	6.3	96.6
Stomp Aqua + Hurricane SC + Gamit 36 CS	-	-	8.33	7.00	0.45	0.00	154.3	160.0
Stomp Aqua + Flexidor 500 + Gamit 36 CS	-	-	9.33	6.33	1.00	0.00	149.3	142.0
Stomp Aqua + chlorpropham + Gamit 36 CS	-	-	9.67	6.33	1.00	0.00	159.7	156.6
Stomp Aqua + aclonifen + Gamit 36 CS	-	-	9.67	7.00	0.11	0.00	158.0	159.4
Stomp Aqua + tri-allate + Gamit 36 CS	-	-	10.00	7.00	0.45	0.00	134.7	175.4
Stomp Aqua +	AHDB 9947	AHDB 9947	8.67	7.00	0.45	0.00	131.3	78.6

Pre-emergence application	Post-emergence application 1-2 TL	Post-emergence application 3-4 TL	crop damage (0-10)		weed cover (%)		Yield (root numbers)	
			Site 1	Site 2	Site 1	Site 2	Site 1	Site 2
Site 1 – 28 May Site 2 – 18 May	Both sites: 14 th June	Both sites: 26 th June	27 th July	27 th July	21 st Aug	29 th Aug	1 st Nov	10 th Oct
AHDB 9947 Gamit 36 CS								
Stomp Aqua + AHDB 9947 + Gamit 36 CS	Sencorex Flow	Sencorex Flow	8.67	7.67	0.11	0.00	130.7	100.0
Stomp Aqua + AHDB 9947	Gamit 36 SC	Gamit 36 SC	8.33	6.33	1.29	0.00	156.7	88.6
Stomp Aqua + AHDB 9947 + Gamit 36 CS	9993	9993	8.67	6.33	1.00	0.00	158.3	72.6
Stomp Aqua + AHDB 9947 + Gamit 36 CS	aclonifen	aclonifen	9.00	7.00	1.45	0.00	143.3	87.4
Stomp Aqua + Afalon + Gamit 36 CS	Guillotine	Guillotine	8.33	5.33	1.00	0.00	147.7	105.4
F-prob			<0.001	0.071	<0.001	0.001	<0.001	<0.001
d.f.			39	39	39	39	39	39
S.E.D.			0.382	0.489	3.639	4.584	11.42	9.168
L.S.D.			0.772	0.989	7.360	9.271	23.09	18.542

Commercial standard

Crop Damage – Red = unacceptable, Yellow = marginal, Green = safe.

Yield – Red = > 10% reduction in root numbers, Yellow = lower yield than standard but no more than 10% reduction in root numbers, Green = equivalent or greater root numbers than the standard.

Bold = significantly different to the untreated

Conclusions

- Seven treatments show promise as alternatives to linuron at a pre-emergence timing but more work is needed to give growers confidence in safety and placement in current programmes.
 - Applications for EAMUs have been submitted for the products: Hurricane SC, Cleancrop Amigo and Intruder (chlorpropham) and Gamit 36 CS. The latter application is for post-emergence application.
 - An EAMU for Flexidor 500 was obtained in January 2018, Flexidor 500 was only tested up to a rate of 0.075 L/ha in the trials and gave a slight scorch on leaf tips. Care needs to be taken with application timing when heavy rain is forecast.
- Tri-allate was crop safe to use in a tank-mix with Stomp Aqua and Gamit 36 CS, and would provide growers with an alternative option and mode of action to clethodim for grass weed control.
- Four treatments showed promise as possible alternatives to linuron at a post-emergence timing but further work is required on rates and timing to improve crop safety.
- Further studies should be carried out to explore treatments for volunteer potato control, plus understand how the experimental treatments can be used safely in current programmes.

Take home message:

There are promising alternative products which could replace linuron in herbicide programmes and EAMU applications have been submitted. A number of products identified are however on the margins of crop safety, and further work is required to understand and guide growers on how they can be used effectively to avoid commercially unacceptable levels of crop damage.

Objectives

1. To evaluate the effectiveness of 17 herbicide treatments applied in tank-mix combinations either pre-emergence or pre and post-emergence, against broad-leaved weeds and grasses in carrots as measured by weed control efficacy
2. To compare performance against the commercial standard (pendimethalin + linuron + clomazone at pre-emergence)
3. To monitor the treated crop for phytotoxicity

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
PP 1/152(3)	Design and analysis of efficacy evaluation trials	None
PP 1/135(3)	Phytotoxicity assessment	None
PP 1/181(3)	Conduct and reporting of efficacy evaluation trials including GEP	None
PP 1/214 (3)	Principles of acceptable efficacy	None
PP 1/224 (2)	Principles of efficacy evaluation for minor uses	None
PP 1/99(3)	Weeds in root vegetables	Two (see below)

There were two deviations from EPPO guidance:

PP1/99(3) Section 1.4, Design and lay-out of trial:

“Replicates: at least 4”

Study only had 3 replicates – the large number of treatments provides an acceptable number of residual degrees of freedom.

“For seeded crops the whole net plot is harvested”

Only 0.5m x 2m bed width and central section of plot of 1m² was harvested– the high drill rate provided sufficient root numbers to give adequate representation for yield assessment without the need to harvest the whole plot.

Test site

Item	Details	
Location address	Site 1 Field: New Shed, Mildenhall Alan Bartlett & Son Chatteris Suffolk Grid reference: TL714726	Site 2 Field: Bilsthorpe 19 Strawsons Ltd. Bilsthorpe Nottinghamshire Grid reference: SK635589
Crop	Carrot	
Cultivar	Nairobi	
Soil or substrate type	Site 1: Sandy loam	Site 2: Sandy loam
Agronomic practice	See Appendix A	
Prior history of site	N/D	2016: Sugar beet, 2015: Maize

Trial design

Item	Details	
Trial design:	Site 1: Fully randomised block design	Site 2: Fully randomised block – split plot design
Number of replicates:	3	
Row spacing:	4 rows 42 mm apart Triple lines 0.125m wide	
Plot size: (w x l)	2m x 8m	
Plot size: (m ²)	16m ²	
Number of plants per plot:	Approx 2,500	
Leaf Wall Area calculations	N/A	

Treatment details

AHDB Code	Active substance	Product name or manufacturer s code	Formulation batch number	Content of active substance in product (g/L)	Formulation type
N/A	Untreated	Untreated	-	-	-
N/A	pendimethalin	Stomp Aqua	OO13054353	455	Capsule suspension
N/A	linuron	Afalon	14038858	500	Suspension Concentrate
N/A	clomazone	Gamit 36 CS	160344	360	Capsule Suspension
AHDB 9947	N/D	N/D	N/D	N/D	N/D
N/A	metribuzin	Sencorex Flow	EM4H002443	600	Suspension Concentrate
AHDB 9999	N/D	N/D	N/D	N/D	N/D
AHDB 9998	N/D	N/D	N/D	N/D	N/D
N/A	lenacil	Venzar Flow	DEC16HE005	500	Suspension Concentrate
N/A	diflufenican	Hurricane SC	15068154	500	Suspension Concentrate
N/A (was AHDB 9996)	isoxaben	Flexidor	F0026G23C01	500	Suspension Concentrate
N/A	chlorpropham	Intruder	334H	400	Emulsifiable Concentrate
N/A	aclonifen	Bandur	EV56006446	600	Suspension Concentrate
AHDB 9993	N/D	N/D	N/D	N/D	N/D
N/A	tri-allate	Avadex Factor	SITAL6004	450	Capsule suspension
N/A	flumioxazin	Guillotine	N/K	300	Suspension Concentrate

Application schedule

Trt No.	Treatment: product name or AHDB code	Rate of active substance (g a.s./ha)	Rate of product (l/ha)	Application code	
				Site 1	Site 2
1	Untreated	-	-	-	-
2	Untreated	-	-	-	-
3	Stomp Aqua + Afon + Gamit 36 CS	1319.5 600 72	2.9 1.2 0.2	A	AB
4	Stomp Aqua+ AHDB 9947 + Gamit 36 CS	1319.5 480 72	2.9 1.2 0.2	A	AB
5	Stomp Aqua + AHDB 9947 + Sencorex Flow	1319.5 480 150	2.9 1.2 0.25	A	AB
6	Stomp Aqua + AHDB 9947 + Sencorex Flow + Gamit 36 CS	1319.5 480 150 72	2.9 1.2 0.25 0.2	A	AB
7	Stomp Aqua + AHDB 9999 + Gamit 36 CS	1319.5 1600 72	2.9 2.0 0.2	A	AB
8	Stomp Aqua + Gamit 36 CS + AHDB 9998	1319.5 72 1344	2.9 0.2 1.4	A	AB
9	Stomp Aqua + Gamit 36 CS + Venzar Flow	1319.5 72 500	2.9 0.2 1.0	A	AB
10	Stomp Aqua + Gamit 36 CS + Hurricane SC	1319.5 72 100	2.9 0.2 0.2	A	AB
11	Stomp Aqua + Gamit 36 CS + Flexidor	1319.5 72 37.5	2.9 0.2 0.075	A	AB
12	Stomp Aqua + Gamit 36 CS + chlorpropham	1319.5 72 1120	2.9 0.2 2.8	A	AB
13	Stomp Aqua + Gamit 36 CS + aclonifen	1319.5 72 900	2.9 0.2 1.5	A	AB
14	Stomp Aqua + Avadex Factor + Gamit 36 CS	1319.5 1620 72	2.9 3.6 0.2	A	A
15	Stomp Aqua + AHDB 9947 + Gamit 36 CS	1319.5 480 72	2.9 1.2 0.2	A	A
	AHDB 9947	240	0.6	C	C
	AHDB 9947	240	0.6	D	D
16	Stomp Aqua + AHDB 9947 + Gamit 36 CS	1319.5 480 72	2.9 1.2 0.2	A	A

Trt No.	Treatment: product name or AHDB code	Rate of active substance (g a.s./ha)	Rate of product (l/ha)	Application code	
				Site 1	Site 2
	Sencorex Flow	120	0.2	C	C
	Sencorex Flow	300	0.5	D	D
17	Stomp Aqua + AHDB 9947 +	1319.5	2.9	A	A
		480	1.2		
	Gamit 36 SC	36	0.1	C	C
	Gamit 36 SC	54	0.15	D	D
18	Stomp Aqua + AHDB 9947 +	1319.5	2.9	A	A
		480	1.2		
	Gamit 36 CS	72	0.2		
	AHDB 9993	160	1.0	C	C
	AHDB 9993	320	2.0	D	D
19	Stomp Aqua + AHDB 9947 +	1319.5	2.9	A	A
		480	1.2		
	Gamit 36 CS	72	0.2		
	Aclonifen	900	0.5	C	C
	Aclonifen	900	0.5	D	D
20	Stomp Aqua + AHDB 9947 +	1319.5	2.9	A	A
		480	1.2		
	Gamit 36 CS	72	0.2		
	Guillotine	7.5	0.025	C	C
	Guillotine	7.5	0.025	D	D

Application details – Site 1

	Application A	Application B	Application C	Application D
Application date	28/05/2017	Not applied*	14/06/2017	26/06/2017
Time of day	15:50	N/A	10:55	11:30
Crop growth stage - Average (BBCH)	pre-em, pre chit (00-03)	N/A	1-2 true leaves (11-12)	3-4 true leaves (13-14)
Crop height (cm)	N/A	N/A	3	6
Crop coverage (%)	N/A	N/A	10	60
Application Method	Spray	N/A	Spray	Spray
Application Placement	Soil	N/A	Foliar	Foliar
Application equipment	Oxford Precision Sprayer (knapsack)	N/A	Oxford Precision Sprayer (knapsack)	Oxford Precision Sprayer (knapsack)
Nozzle pressure	2 bar	N/A	2 bar	2 bar
Nozzle type	Flat fan	N/A	Flat fan	Flat fan
Nozzle size	02 F110	N/A	02 F110	02 F110
Application water volume/ha	200	N/A	200	200
Temperature of air - shade (°C)	24.4	N/A	25.1	24.7
Relative humidity (%)	58.4	N/A	52.2	41.7
Wind speed range (mph)	2.8 – 3.7	N/A	3.5 – 4.6	1.5
Dew presence (Y/N)	N	N/A	N	N
Temperature of soil - 10 cm (°C)	28.0	N/A	25.0	24.0

	Application A	Application B	Application C	Application D
Wetness of soil - 2-5 cm	Damp	N/A	Damp	Dry
Cloud cover (%)	80	N/A	0	50

* Crop grew too fast to get this application on in time, and this was not integral to the trial, more for knowledge exchange for growers.

Application details – Site 2

	Application A	Application B	Application C	Application D
Application date	18/05/2017	23/05/2017	14/06/2017	26/06/2017
Time of day	10:15	9:10	14:00	14:00
Crop growth stage (Max, min average BBCH)	pre-em, pre-chit (00-03)	pre-em, post-chit (03-07)	1-2 true leaves (11-12)	3-4 true leaves (13-14)
Crop height (cm)	N/A	N/A	3	6
Crop coverage (%)	N/A	N/A	10	60
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	2 bar	2 bar	2 bar	2 bar
Nozzle type	Flat fan	Flat fan	Flat fan	Flat fan
Nozzle size	03 F110	03 F110	03 F110	03 F110
Application water volume/ha	250	250	250	250
Temperature of air - shade (°C)	16.8	19.2	14.9	19.6
Relative humidity (%)	70.8	70.0	54.2	40.6
Wind speed range (mph)	0.9	3.2 - 33	3.2 – 8.01	1.8 – 2.3
Dew presence (Y/N)	N/D	N/D	N/D	N/D
Temperature of soil – 10 cm (°C)	13.4	14.8	17.1	25.8
Wetness of soil - 2-5 cm	N/D	Damp	Damp	Damp
Cloud cover (%)	70	25	100	80

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

Site	Common name	Scientific Name	EPPO Code	Infection level pre-application	Infection level at start of assessment period	Infection level at end of assessment period
1	Broad-leaved weeds and grasses	N/A	3WEEDT	0	34 weed seedlings per m ²	13 % cover as a whole plot score
2	Broad-leaved weeds and grasses	N/A	3WEEDT	0	3.5 weed seedlings per plot (16m ²)	16.5 % cover as a whole plot score

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)
14/06/2017	0	11	efficacy, phytotox	Phytotox (scale 0-10, 0 = Dead) Counts of weed species per quadrat, 3 x 25cm x 25cm quadrats per plot)
26/06/2017	0	13-14	efficacy, phytotox	Phytotox (scale 0-10, 0 = Dead) Counts of weed species per quadrat, 3 x 25cm x 25cm quadrats per plot)
11/07/2017	15	15	efficacy, phytotox	Phytotox (scale 0-10, 0 = Dead) Percentage of weed cover, whole plot score
27/07/2017	31	45	efficacy, phytotox	Phytotox (scale 0-10, 0 = Dead) Percentage of weed cover, whole plot score
21/08/2017	56	47	efficacy, phytotox	Phytotox (scale 0-10, 0 = Dead) Percentage of weed cover, whole plot score
01/11/2017	166	49	gross yield	Number of roots, weight, marketability

* DA – days after application

Assessment details – 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)
12/06/2017	25 (app A)	12-13	efficacy, phytotox	Phytotox (scale 0-10, 0 = Dead) Counts of weed species per plot
21/06/2017	7 (app C)	13	efficacy, phytotox	Phytotox (scale 0-10, 0 = Dead) Counts of weed species per plot
07/07/2017	11 (app D)	14-15	efficacy, phytotox	Phytotox (scale 0-10, 0 = Dead) Counts of weed species per plot
27/07/2017	31	45	efficacy, phytotox	Phytotox (scale 0-10, 0 = Dead) Counts of weed species per plot
29/08/2017	64	47	efficacy, phytotox	Phytotox (scale 0-10, 0 = Dead) Percentage weed cover, weed species presence
10/10/2017	145	49	gross yield	Number of roots, weight, marketability

* DA – days after application

Statistical analysis

The trial design was a randomised block design with three replicates of 20 treatments, including two untreated controls and a grower standard. Spilt plots were included at site 2 for the pre-emergence applications (treatments 3-13) to investigate the effect of application of the residual herbicides before (timing A) and after (timing B) the seed had chit. Only the data from the plot area treated with timing A was analysed. Timing B was only demonstrated on grower open days, and brief comments noted.

As the distribution of weeds was uneven across the trial – which is not unexpected in field situations – there was a need to transform these variables prior to analysis; an angular transformation was used.

All data were analysed by ANOVA using Genstat 18.4 by Chris Dyer at RSK ADAS. For the % efficacy data calculated by Abbotts formula, an angular transformation was carried out and then the back transformed means are presented, from which Abbotts Formula was used to calculate the % reduction in weeds.

Results

Phytotoxicity

The results of phytotoxicity assessments from five dates are presented in Table 2. These were scored on a scale of 0 to 10, with 0 being dead, and 10 being no effect. Those scores at 8 or above were deemed to have commercially acceptable damage.

Phytotoxicity was recorded using the following scale:

Crop tolerance score	Equivalent to crop damage (% phytotoxicity)
0	complete crop kill 100%
1	80-95% damage
2	70-80%
3	60-70%
4	50-60%
5	40-50%
6	25-40%
7	15-25%
8	10-15% #
9	5-10%
10	no damage

#8 = acceptable damage, i.e. damage unlikely to reduce yield and acceptable to the farmer.

At Site 1 when Venzar Flow was used in a mix with Stomp Aqua and Gamit this combination caused unacceptable crop death, and at Site 2 moderately severe stunting occurred after a heavy rainfall event in early June. The crop at Site 2 appeared to recover but plant population was reduced when yield was assessed. Therefore this product is not crop safe to carrots when used as a partner in a commercial tank mix combination.

At both sites, where Sencorex Flow was included in the mix, this gave a check to crop growth which persisted up to 14 weeks after application.

There were differences in phytotoxicity responses between the two sites due to different rainfall timings and intensity between the two areas. The heavier rainfall intensity at the Nottinghamshire site caused a higher degree of phytotoxicity seen within the month after application where the residual herbicides were washed down, which was not seen at the Suffolk site where rainfall was less intense. Effects from herbicide movement in the soil should be taken into account as carrots are particularly at risk as they are grown on light soils. In Nottinghamshire there were heavy spells of rain after the Timing 1 and Timing 3 applications. This led to moderate phytotoxicity effects from six products applied pre-emergence and these effects continued up to 14 weeks after the application. Crop damage was exhibited as a slight stunting when compared to the standard, where Sencorex Flow, aclonifen or chlorpropham were included at pre-emergence. Scorch to leaf tips occurred where Flexidor was used, and stunting and patchy crop emergence was seen where AHDB 9998 and AHDB 9999 were used.

Three products applied post-emergence caused moderate phytotoxicity for up to five weeks after the application. These effects were exhibited as moderate stunting causing a patchy crop appearance at four week's after application when AHDB 9993 and Guillotine were applied post-emergence. While Gamit 36 CS caused bleaching to whole leaflets on 20% of the crop. Again, these effects appeared to be transient as the foliage regrew and recovered, but these effects may have checked root development while the photosynthetic capacity of the plant was reduced.

With the exception of the plots treated with the post-emergence Gamit 36 CS applications, all foliar effects from the herbicides were transient and the crop had grown through them by eight weeks after the final application.

Table 2. Mean phytotoxicity scores through the trial – Site 1. (Scores 8 or above deemed acceptable damage). Those below 8 and this unacceptable are marked in **bold**.

Trt No.	Timing A	Timing C	Timing D	Mean crop damage scores (0-10)				
				14 th Jun	26 th Jun	11 th Jul	27 th Jul	21 st Aug
1 + 2	Untreated	-	-	9.33	9.83	9.33	9.33	9.33
3	Stomp Aqua + Afalon + Gamit 36 CS	-	-	10.00	9.00	9.00	8.67	9.33
4	Stomp Aqua + AHDB 9947 + Gamit 36 CS	-	-	10.00	8.67	9.33	8.67	9.00
5	Stomp Aqua + AHDB 9947 + Sencorex Flow	-	-	7.00	5.00	6.00	7.00	8.67
6	Stomp Aqua + AHDB 9947 + Sencorex Flow + Gamit 36 CS	-	-	7.33	5.00	5.67	7.00	8.33
7	Stomp Aqua + AHDB 9999 + Gamit 36 CS	-	-	10.00	9.33	9.33	9.00	9.00
8	Stomp Aqua + AHDB 9998 + Gamit 36 CS	-	-	9.00	6.67	7.33	8.33	9.00
9	Stomp Aqua + Venzar Flow + Gamit 36 CS	-	-	1.00	1.00	1.33	2.67	4.00
10	Stomp Aqua + Hurricane SC + Gamit 36 CS	-	-	6.00	8.00	8.33	8.33	9.33
11	Stomp Aqua + Flexidor 500 + Gamit 36 CS	-	-	10.00	9.33	9.67	9.33	9.33
12	Stomp Aqua + chlorpropham + Gamit 36 CS	-	-	9.67	9.33	9.67	9.67	10.00
13	Stomp Aqua + aclonifen + Gamit 36 CS	-	-	9.67	9.67	9.67	9.67	9.67
14	Stomp Aqua + tri-allate + Gamit 36 CS	-	-	10.00	10.00	10.00	10.00	9.67
15	Stomp Aqua + AHDB 9947 + Gamit 36 CS	AHDB 9947	AHDB 9947	10.00	8.67	8.67	8.67	9.00
16	Stomp Aqua + AHDB 9947 + Gamit 36 CS	Sencorex Flow	Sencorex Flow	10.00	8.00	8.00	8.67	9.67
17	Stomp Aqua + AHDB 9947	Gamit 36 SC	Gamit 36 SC	10.00	8.67	8.67	8.33	9.00
18	Stomp Aqua + AHDB 9947 + Gamit 36 CS	AHDB 9993	AHDB 9993	10.00	9.00	9.00	8.67	9.33
19	Stomp Aqua + AHDB 9947 + Gamit 36 CS	Aclonifen	Aclonifen	10.00	8.67	8.33	9.00	9.33
20	Stomp Aqua + AHDB 9947 + Gamit 36 CS	Guillotine	Guillotine	9.67	9.00	8.67	8.33	9.00
F pr. value				<0.001	<0.001	<0.001	<0.001	<0.001
d.f.				39	39	39	39	39
S.E.D.				0.554	0.464	0.390	0.382	0.447
L.S.D.				1.120	0.938	0.789	0.772	0.905

Table 3 Mean phytotoxicity scores through the trial – Site 2. (Scores 8 or above deemed acceptable damage). Those below 8 and this unacceptable are marked in **bold**.

Trt No.	Timing A	Timing C	Timing D	Mean crop damage scores (0-10)				
				12 th Jun	21 th Jun	7 th Jul	27 th Jul	29 st Aug
1 + 2	Untreated	-	-	9.00	9.33	9.33	9.67	9.83
3	Stomp Aqua + Afalon + Gamit 36 CS	-	-	8.50	8.00	7.67	8.00	9.00
4	Stomp Aqua + AHDB 9947 + Gamit 36 CS	-	-	8.67	7.00	6.67	7.00	9.33
5	Stomp Aqua + AHDB 9947 + Sencorex Flow	-	-	8.17	7.00	7.00	6.33	10.00
6	Stomp Aqua + AHDB 9947 + Sencorex Flow + Gamit 36 CS	-	-	7.67	6.00	6.33	6.67	8.67
7	Stomp Aqua + AHDB 9999 + Gamit 36 CS	-	-	8.67	8.67	7.33	6.33	9.00
8	Stomp Aqua + AHDB 9998 + Gamit 36 CS	-	-	7.17	7.33	7.00	6.33	9.67
9	Stomp Aqua + Venzar Flow + Gamit 36 CS	-	-	8.00	5.67	6.33	7.33	9.00
10	Stomp Aqua + Hurricane SC + Gamit 36 CS	-	-	4.17	5.33	6.67	7.00	9.33
11	Stomp Aqua + Flexidor 500 + Gamit 36 CS	-	-	8.33	7.33	7.67	6.33	9.33
12	Stomp Aqua + chlorpropham + Gamit 36 CS	-	-	8.50	7.67	7.67	6.33	9.33
13	Stomp Aqua + aclonifen + Gamit 36 CS	-	-	7.83	6.67	7.33	7.00	9.00
14	Stomp Aqua + tri-allate + Gamit 36 CS	-	-	8.67	8.00	7.33	7.00	8.33
15	Stomp Aqua + AHDB 9947 + Gamit 36 CS	AHDB 9947	AHDB 9947	4.33	4.00	5.00	7.00	8.33
16	Stomp Aqua + AHDB 9947 + Gamit 36 CS	Sencorex Flow	Sencorex Flow	6.33	5.00	6.00	7.67	8.67
17	Stomp Aqua + AHDB 9947	Gamit 36 SC	Gamit 36 SC	5.17	5.00	6.33	6.33	7.67
18	Stomp Aqua + AHDB 9947 + Gamit 36 CS	AHDB 9993	AHDB 9993	4.67	3.00	4.67	6.33	8.67
19	Stomp Aqua + AHDB 9947 + Gamit 36 CS	Aclonifen	Aclonifen	5.50	4.67	5.67	7.00	8.67
20	Stomp Aqua + AHDB 9947 + Gamit 36 CS	Guillotine	Guillotine	5.67	2.33	2.00	5.33	9.33
F p.-value				<0.001	<0.001	<0.001	0.071	0.202
d.f.				39	39	39	39	39
S.E.D.				0.788	0.729	0.558	0.489	0.558
L.S.D.				1.595	1.474	1.128	0.989	1.129

Phytotoxicity to the barley cover crop

Phytotoxicity effects of the residual treatments on the barley cover crop were recorded at one assessment timing (12 June). Three treatments severely stunted or thinned the cover crop. These were the tank-mixes containing Venzar Flow, Hurricane SC and aclonifen.

The barley cover crop is grown to protect the carrots and if it is killed prematurely then this would need to be taken into account by growers.

Table 4 Mean phytotoxicity scores on the barley cover crop through the trial – Site 2. (Scored using same criteria as cash crop phytotoxicity). The scores marked in bold are significantly different to the untreated.

Trt No.	Timing A	Mean crop cover damage scores
		21 st June
1 + 2	Untreated	9.5
3	Stomp Aqua + Afalon + Gamit 36 CS	7.0
4	Stomp Aqua + AHDB 9947 + Gamit 36 CS	7.2
5	Stomp Aqua + AHDB 9947 + Sencorex Flow	8.0
6	Stomp Aqua + AHDB 9947 + Sencorex Flow + Gamit 36 CS	6.3
7	Stomp Aqua + AHDB 9999 + Gamit 36 CS	7.5
8	Stomp Aqua + AHDB 9998 + Gamit 36 CS	7.0
9	Stomp Aqua + Venzar Flow + Gamit 36 CS	5.5
10	Stomp Aqua + Hurricane SC + Gamit 36 CS	4.5
11	Stomp Aqua + Flexidor 500 + Gamit 36 CS	6.3
12	Stomp Aqua + chlorpropham + Gamit 36 CS	7.3
13	Stomp Aqua + aclonifen + Gamit 36 CS	3.3
14	Stomp Aqua + tri-allate + Gamit 36 CS	7.8
F pr. value		<0.001
d.f.		27
S.E.D.		0.992
L.S.D.		2.035

Efficacy

Weed levels were low and therefore it is difficult to distinguish confidently between specific treatments to determine their individual performance. However, all treatments with the exception of that containing AHDB 9999 with Stomp Aqua and Gamit 36 CS significantly reduced % weed cover at both sites and were comparable in performance compared to the untreated. At site 2 the treatment containing AHDB 9999 did not significantly reduce the percentage of weed cover. One of the few weeds present at the site was nettle, AHDB 9999 has a limited range of weed control and does not control nettle hence the poor performance of the product at this site.

Table 5 Mean percentage of weed cover per plot. Site 1. Treatments in **bold** are significantly different from the untreated control

Trt No.	Timing A	Timing C	Timing D	11 th Jul		27 th Jul		21 st Aug	
				Ang	Back trans	Ang	Back trans	Ang	Back trans
1 + 2	Untreated	-	-	24.60	17.33	31.52	27.33	19.96	11.65
3	Stomp Aqua + Afalon + Gamit 36 CS	-	-	5.74	1.00	5.18	0.81	3.83	0.45
4	Stomp Aqua + AHDB 9947 + Gamit 36 CS	-	-	11.42	3.92	13.83	5.71	11.94	4.28
5	Stomp Aqua + AHDB 9947 + Sencorex Flow	-	-	5.74	1.00	5.74	1.00	5.74	1.00
6	Stomp Aqua + AHDB 9947 + Sencorex Flow + Gamit 36 CS	-	-	5.74	1.00	5.21	0.83	5.74	1.00
7	Stomp Aqua + AHDB 9999 + Gamit 36 CS	-	-	5.74	1.00	6.54	1.30	3.83	0.45
8	Stomp Aqua + AHDB 9998 + Gamit 36 CS	-	-	5.74	1.00	5.74	1.00	1.91	0.11
9	Stomp Aqua + Venzar Flow + Gamit 36 CS	-	-	3.83	0.45	5.74	1.00	5.74	1.00
10	Stomp Aqua + Hurricane SC + Gamit 36 CS	-	-	3.83	0.45	5.18	0.81	3.83	0.45
11	Stomp Aqua + Flexidor 500 + Gamit 36 CS	-	-	6.54	1.29	6.54	1.30	5.74	1.00
12	Stomp Aqua + chlorpropham + Gamit 36 CS	-	-	5.74	1.00	5.74	1.00	5.74	1.00
13	Stomp Aqua + aclonifen + Gamit 36 CS	-	-	5.74	1.00	5.74	1.00	1.91	0.11
14	Stomp Aqua + tri-allate + Gamit 36 CS	-	-	5.18	0.82	5.74	1.00	3.83	0.45
15	Stomp Aqua + AHDB 9947 Gamit 36 CS	AHDB 9947	AHDB 9947	5.74	1.00	5.74	1.00	3.83	0.45
16	Stomp Aqua + AHDB 9947 + Gamit 36 CS	Sencorex Flow	Sencorex Flow	3.83	0.45	4.62	0.65	1.91	0.11
17	Stomp Aqua + AHDB 9947	Gamit 36 SC	Gamit 36 SC	5.74	1.00	7.33	1.63	6.54	1.29
18	Stomp Aqua + AHDB 9947 + Gamit 36 CS	AHDB 9993	AHDB 9993	5.74	1.00	5.74	1.00	5.74	1.00
19	Stomp Aqua + AHDB 9947 + Gamit 36 CS	AHDB 9994	AHDB 9994	3.83	0.45	5.18	0.81	3.83	1.45
20	Stomp Aqua + AHDB 9947 + Gamit 36 CS	Guillotine	Guillotine	3.83	0.45	3.26	0.32	5.74	1.00
F pr. value				<0.001		<0.001		<0.001	
d.f.				39		39		39	
S.E.D.				4.209		4.442		3.639	
L.S.D.				8.513		8.993		7.360	

Table 6 Mean percentage of weed cover per plot. Site 2. Data only shown from 8 week post timing D application as weed was very low. Treatments in **bold** are significantly different from the untreated control.

Trt No.	Timing A	Timing C	Timing D	29 th Aug	
				Ang	Back trans
1 + 2	Untreated	-	-	16.50	8.06
3	Stomp Aqua + Afalon + Gamit 36 CS	-	-	0.00	0.00
4	Stomp Aqua + AHDB 9947 + Gamit 36 CS	-	-	0.00	0.00
5	Stomp Aqua + AHDB 9947 + Sencorex Flow	-	-	0.00	0.00
6	Stomp Aqua + AHDB 9947 + Sencorex Flow + Gamit 36 CS	-	-	0.00	0.00
7	Stomp Aqua + AHDB 9999 + Gamit 36 CS	-	-	13.16	5.18
8	Stomp Aqua + AHDB 9998 + Gamit 36 CS	-	-	0.00	0.00
9	Stomp Aqua + Venzar Flow + Gamit 36 CS	-	-	0.00	0.00
10	Stomp Aqua + Hurricane SC + Gamit 36 CS	-	-	0.00	0.00
11	Stomp Aqua + Flexidor 500 + Gamit 36 CS	-	-	0.00	0.00
12	Stomp Aqua + chlorpropham + Gamit 36 CS	-	-	0.00	0.00
13	Stomp Aqua + aclonifen + Gamit 36 CS	-	-	0.00	0.00
14	Stomp Aqua + tri-allate + Gamit 36 CS	-	-	0.00	0.00
15	Stomp Aqua + AHDB 9947 Gamit 36 CS	9947	9947	0.00	0.00
16	Stomp Aqua + AHDB 9947 + Gamit 36 CS	Sencorex Flow	Sencorex Flow	0.00	0.00
17	Stomp Aqua + AHDB 9947	Gamit 36 SC	Gamit 36 SC	0.00	0.00
18	Stomp Aqua + AHDB 9947 + Gamit 36 CS	9993	9993	0.00	0.00
19	Stomp Aqua + AHDB 9947 + Gamit 36 CS	9994	9994	0.00	0.00
20	Stomp Aqua + AHDB 9947 + Gamit 36 CS	Guillotine	Guillotine	0.00	0.00
F pr. value				0.001	
d.f.				39	
S.E.D.				4.584	
L.S.D.				9.271	

Weed control – % reduction in weed compared to untreated (Abbotts formula)

Abbotts formula was only calculated for Site 1 as the results at Site 2 were mainly zeros and the weed was so low and therefore the ADAS statistician advised it was not appropriate.

Table 7 Percentage reduction in weed cover using Abbotts formula – Site 1

Treatments			Dates of assessment		
Timing A	Timing C	Timing D	11 th Jul	27 th Jul	21 st Aug
Stomp Aqua + Afalon + Gamit 36 CS	-	-	94.23	97.02	96.18
Stomp Aqua + AHDB 9947 + Gamit 36 CS	-	-	77.37	79.10	63.26
Stomp Aqua + AHDB 9947 + Sencorex Flow	-	-	94.23	96.34	91.42
Stomp Aqua + AHDB 9947 + Sencorex Flow + Gamit 36 CS	-	-	94.23	96.98	91.42
Stomp Aqua + AHDB 9999 + Gamit 36 CS	-	-	94.23	95.26	96.18
Stomp Aqua + AHDB 9998 + Gamit 36 CS	-	-	94.23	96.34	99.05
Stomp Aqua + Venzar Flow + Gamit 36 CS	-	-	97.43	96.34	91.42
Stomp Aqua + Hurricane SC + Gamit 36 CS	-	-	97.43	97.02	96.18
Stomp Aqua + Flexidor 500 + Gamit 36 CS	-	-	92.52	95.26	91.42
Stomp Aqua + chlorpropham + Gamit 36 CS	-	-	94.23	96.34	91.42
Stomp Aqua + aclonifen + Gamit 36 CS	-	-	94.23	96.34	99.05
Stomp Aqua + tri-allate + Gamit 36 CS	-	-	95.30	96.34	96.18
Stomp Aqua + AHDB 9947 + Gamit 36 CS	AHDB 9947	AHDB 9947	94.23	96.34	96.18
Stomp Aqua + AHDB 9947 + Gamit 36 CS	Sencorex Flow	Sencorex Flow	97.43	97.63	99.05
Stomp Aqua + AHDB 9947	Gamit 36 SC	Gamit 36 SC	94.23	94.04	88.88
Stomp Aqua + AHDB 9947 + Gamit 36 CS	AHDB 9993	AHDB 9993	94.23	96.34	91.42
Stomp Aqua + AHDB 9947 + Gamit 36 CS	AHDB 9994	AHDB 9994	97.43	97.02	96.18
Stomp Aqua + AHDB 9947 + Gamit 36 CS	Guillotine	Guillotine	97.43	98.81	91.42

Gross yield results

Table 8 Means of gross yield in kilograms per m² and number of carrots per m². Data not transformed – Site 1.

Trt No.	Timing A	Timing C	Timing D	Fresh weight (kg/m ²)	Total number of carrots per m ²
1 + 2	Untreated	-	-	10.08	149.3
3	Stomp Aqua + Afalon + Gamit 36 CS	-	-	10.91	152.7
4	Stomp Aqua + AHDB 9947 + Gamit 36 CS	-	-	9.92	122.0
5	Stomp Aqua + AHDB 9947 + Sencorex Flow	-	-	9.75	103.3
6	Stomp Aqua + AHDB 9947 + Sencorex Flow + Gamit 36 CS	-	-	10.33	105.3
7	Stomp Aqua + AHDB 9999 + Gamit 36 CS	-	-	9.83	136.7
8	Stomp Aqua + AHDB 9998 + Gamit 36 CS	-	-	9.80	124.0
9	Stomp Aqua + Venzar Flow + Gamit 36 CS	-	-	2.19	6.3
10	Stomp Aqua + Hurricane SC + Gamit 36 CS	-	-	10.64	154.3
11	Stomp Aqua + Flexidor 500 + Gamit 36 CS	-	-	11.69	149.3
12	Stomp Aqua + chlorpropham + Gamit 36 CS	-	-	11.07	159.7
13	Stomp Aqua + aclonifen + Gamit 36 CS	-	-	11.66	158.0
14	Stomp Aqua + tri-allate + Gamit 36 CS	-	-	10.85	134.7
15	Stomp Aqua + AHDB 9947 Gamit 36 CS	AHDB 9947	AHDB 9947	9.74	131.3
16	Stomp Aqua + AHDB 9947 + Gamit 36 CS	Sencorex Flow	Sencorex Flow	9.76	130.7
17	Stomp Aqua + AHDB 9947	Gamit 36 SC	Gamit 36 SC	11.26	156.7
18	Stomp Aqua + AHDB 9947 + Gamit 36 CS	AHDB 9993	AHDB 9993	11.65	158.3
19	Stomp Aqua + AHDB 9947 + Gamit 36 CS	AHDB 9994	AHDB 9994	10.76	143.3
20	Stomp Aqua + AHDB 9947 + Gamit 36 CS	Guillotine	Guillotine	10.41	147.7
F. pr value				<0.001	<0.001
d.f.				39	39
S.E.D.				0.743	11.42
L.S.D.				1.502	23.09

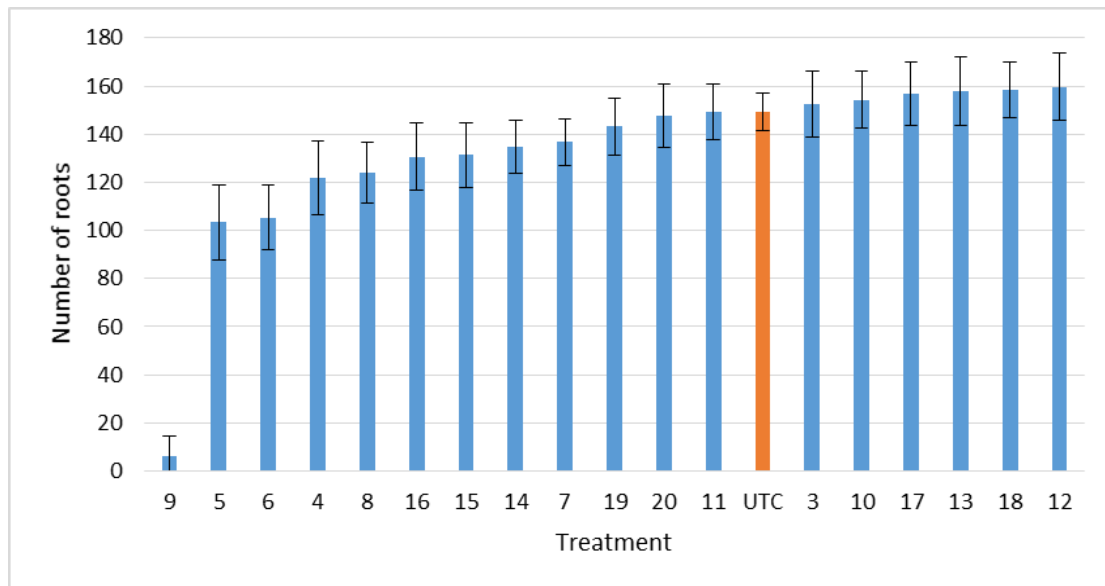


Figure 1. Gross yield as illustrated by the mean number of roots per treatment $F_{pr} = <0.001$, s.e.d. 11.42, l.s.d. 23.09 - Site 1.

Table 9 Means of gross yield in kilograms per m² and number of carrots per m². Data not transformed – Site 2.

Trt No.	Timing A	Timing C	Timing D	Fresh weight (kg/m ²)	Total number of carrots per m ²
1 + 2	Untreated	-	-	16.76	141.4
3	Stomp Aqua + Afalon + Gamit 36 CS	-	-	18.02	178.0
4	Stomp Aqua + AHDB 9947 + Gamit 36 CS	-	-	15.96	122.6
5	Stomp Aqua + AHDB 9947 + Sencorex Flow	-	-	15.82	140.6
6	Stomp Aqua + AHDB 9947 + Sencorex Flow + Gamit 36 CS	-	-	16.64	112.6
7	Stomp Aqua + AHDB 9999 + Gamit 36 CS	-	-	15.18	149.4
8	Stomp Aqua + AHDB 9998 + Gamit 36 CS	-	-	15.96	147.4
9	Stomp Aqua + Venzar Flow + Gamit 36 CS	-	-	17.88	96.6
10	Stomp Aqua + Hurricane SC + Gamit 36 CS	-	-	15.40	160.0
11	Stomp Aqua + Flexidor 500 + Gamit 36 CS	-	-	16.62	142.0
12	Stomp Aqua + chlorpropham + Gamit 36 CS	-	-	16.78	156.6
13	Stomp Aqua + aclonifen + Gamit 36 CS	-	-	16.22	159.4
14	Stomp Aqua + tri-allate + Gamit 36 CS	-	-	18.22	175.4
15	Stomp Aqua + AHDB 9947 Gamit 36 CS	AHDB 9947	AHDB 9947	14.52	78.6
16	Stomp Aqua + AHDB 9947 + Gamit 36 CS	Sencorex Flow	Sencorex Flow	15.00	100.0
17	Stomp Aqua + AHDB 9947	Gamit 36 SC	Gamit 36 SC	14.56	88.6
18	Stomp Aqua + AHDB 9947 + Gamit 36 CS	AHDB 9993	AHDB 9993	11.48	72.6
19	Stomp Aqua + AHDB 9947 + Gamit 36 CS	aclonifen	aclonifen	15.06	87.4
20	Stomp Aqua + AHDB 9947 + Gamit 36 CS	Guillotine	Guillotine	11.30	105.4
F. pr value				0.006	<0.001
d.f.				39	39
S.E.D.				1.642	9.168
L.S.D.				3.322	18.542

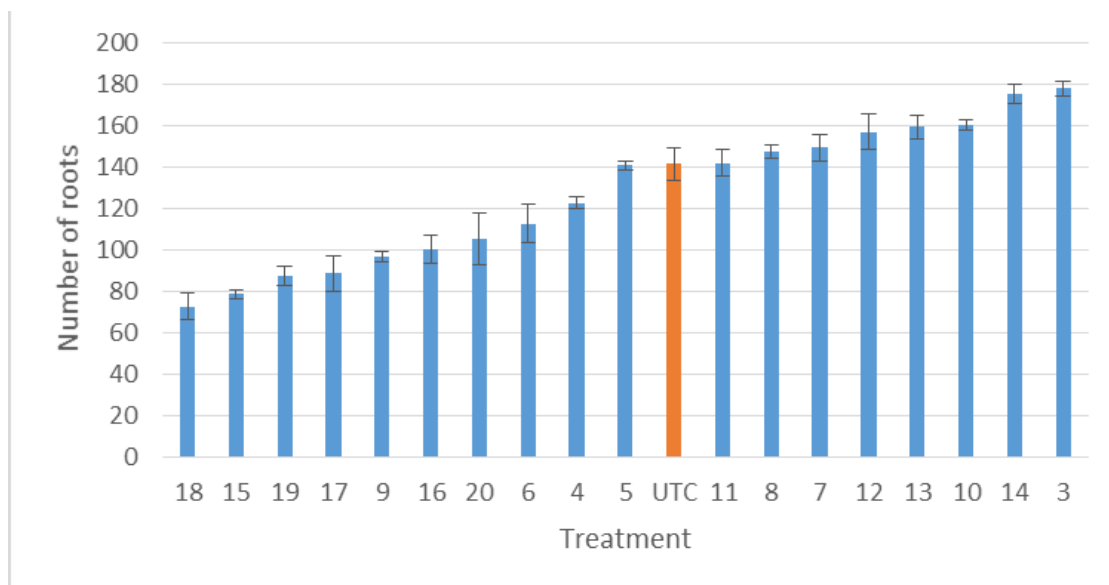


Figure 2. Gross yield as illustrated by the mean number of roots per treatment F pr = <0.001, s.e.d. 9.168, l.s.d. 18.542 - Site 2.

Discussion

Weed levels were low, with means of 11.65% and 8.06% cover in the untreated control at the final assessment at site 1 and site 2 consecutively. It proved difficult to distinguish with confidence between specific treatments to determine individual product performance on how well each controlled weeds in the treatment plots. All treatments, with the exception of that containing AHDB 9999 with Stomp Aqua and Gamit 36 CS, significantly reduced % weed cover at both sites (Site 1 $p < 0.001$, and Site 2 $p = 0.001$) when compared to the untreated. All were comparable in performance to each other and also to the standard linuron. The exception being at site 2 the treatment containing AHDB 9999 did not significantly reduce the percentage of weed cover. One of the few weeds present at the site was nettle, AHDB 9999 has a limited range of weed control and does not control nettle hence the poor performance of the product at this site.

Seven treatments combined acceptable crop safety, or close to acceptable crop safety with reasonably effective weed control when applied at a pre-emergence timing at both trial sites. These were the following each applied in a tank-mix with Stomp Aqua + Gamit 36CS: AHDB 9998, AHDB 9999, Hurricane SC, Flexidor 500, chlorpropham, aclonifen and tri-allate. Although all these treatments gave a slight check to growth, or a visible effect on the foliage of the crop such as bleaching or scorch which meant that the phytotoxicity score was below acceptable at up to 10 weeks after sprays were applied at site 2, root numbers appeared to be not greatly affected at harvest when compared to the untreated control. However, root numbers were significantly lower than those in the plots treated with the standard linuron.

No treatments combined close to acceptable crop safety with reasonably effective weed control at both sites when applied at a post-emergence timing after a standard pre-emergence of Stomp Aqua + AHDB 9947 + Gamit 36CS, but four do warrant further investigation with rates and timing of application as they were safer where there was less intense rainfall after application at Site 1. These are Sencorex Flow, Gamit 36 CS, aclonifen and AHDB 9993.

Further work is required with these promising treatments which were on the margins of crop safety to help growers understand how these can be incorporated safely into current herbicide programs.

The standard pre and post-emergence treatments performed as expected and were comparable to commercial practice. There were no issues with mixing or application of any products.

Conclusions

- Seven treatments show promise as possible alternatives to linuron at a pre-emergence timing but more work is needed to give growers confidence in their safety and placement in current programmes.
 - Applications for EAMUs have been submitted for the products: Hurricane SC, Cleancrop Amigo and Intruder (chlorpropham) and Gamit 36 CS. The latter application is for post-emergence application.
 - An EAMU for Flexidor 500 was obtained in January 2018, Flexidor 500 was only tested up to a rate of 0.075 L/ha in the trials and gave a slight scorch on leaf tips. Care needs to be taken with application timing when heavy rain is forecast.
- Tri-allate was crop safe to use in a tank-mix with Stomp Aqua and Gamit 36 CS and would provide growers with an alternative option to clethodim for grass weed control.
- Four treatments showed promise as possible alternatives to linuron at a post-emergence timing but further work is required on rates and timing to improve crop safety.
- Further studies should be carried out to explore treatments for volunteer potato control, plus understand how the experimental treatments can be used safely in current programmes.

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 the growers who provided sites and crops for the trials as well as technical input, particularly Ian Holmes of Strawsons Ltd., Peter Saunders of Alan Bartlett & son, and Howard Hinds of Root Crop Consulting Ltd. Howard should also be acknowledged for his work towards EAMUs in providing justifications for use to CRD.

Appendix

- a. Crop diary – events related to growing crop

Site 1 - Suffolk Further details yet to be obtained

Crop	Cultivar	Sowing date	Row width (m)
Carrot	Nairobi	25/5/2017	Bed centres 2m Triple lines 0.125m wide Rows 42 mm apart

Previous cropping

Year	Crop

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

Date	Product	Rate	Unit

Pesticides applied to trial area

[illegible]

Details of irrigation regime

[illegible]

Site 2 - Notts

Crop	Cultivar	Sowing date	Row width (m)
Carrot	Nairobi	18/05/2017	Bed centres 2m Triple lines 0.125m wide Rows 42 mm apart

Previous cropping

Year	Crop
2016	Sugar Beet
2015	Maize

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

Date	Product	Rate	Unit
22/3/17	Omex 0:0:15.5:0:15.5NaO	1290	Kg
22/3/17	Omex Boron	2	Kg

Pesticides applied to trial area

Date	Product	Rate	Unit
19/5/17	Vydate	20	kg
3/6/17	Movento + Bandu	0.3+1.2	Litres
13/6/17	Biscaya	0.4	Litres
26/6/17	Signum + Movento	1+0.3	litres
26/6/17	SL567A	1.3	Litres
13/7/17	Rudis + Bandu	0.4+0.3	Litres
25/7/17	Reflect + Laidir	1+0.15	Litres
5/8/17	Nativo + Laidir	0.3+0.15	Litres
15/8/17	Rudis + Laidir	0.4+0.15	Litres
26/8/17	Reflect + Hallmark Zeon	1.0+0.15	Litres
9/9/17	Signum + Hallmark Zeon	1+0.15	Litres
20/9/17	Rudis + Hallmark Zeon	0.4+0.15	Litres
6/10/17	Toledo + Clayton Spigot	0.6+0.75	Litres
26/10/17	Clayton Spigot	1.0	Litres

Details of irrigation regime

Date	Type, rate and duration	Amount applied (mm)
1 June	Boom irrigation	20
13 June	Boom irrigation	20
20 June	Boom irrigation	20
15 July	Boom irrigation	20
14 July	Boom irrigation	20
24 August	Boom irrigation	20

b. Trial diary

Site 1




Date	Event
25/05/2017	Field drilled
28/05/2017	Timing A applied




14/06/2017	Timing C applied; weeds, phyto assessed
26/06/2017	Timing D applied; weeds, phyto assessed
11/07/2017	Timing D + 2 weeks assessment (weeds, phyto)
27/07/2017	Timing D + 4 weeks assessment (weeds, phyto)
21/08/2017	Timing D + 8 weeks assessment (weeds, phyto)
01/11/2017	Plots harvested




Site 2




Date	Event
18/05/2017	Timing A applied
23/05/2017	Timing B applied
12/06/2017	Post timing B assessment (weeds, phyto)
14/06/2017	Timing C applied
21/06/2017	Post timing C assessment (weeds, phyto)
26/06/2017	Timing D applied
07/07/2017	Timing D + 2 weeks assessment (weeds, phyto)
27/07/2017	Timing D + 4 weeks assessment (weeds, phyto)
29/08/2017	Timing D + 8 weeks assessment (weeds, phyto)
10/10/2017	Plots harvested




- c. Photographs of the trial plots and crop effects compared to the untreated plots and commercial standard – Photos taken from site 2 where most phyto was seen




		
Untreated	Standard – Stomp Aqua + Gamit 36 CS + Afalon	Stomp Aqua + Gamit 36 CS + AHDB 9947 (gave slight check to growth)




		
Stomp Aqua + AHDB 9947 + Sencorex Flow (slight thinning of plant population)	Stomp Aqua + AHDB 9947 + Sencorex Flow + Gamit 36 CS (reduced plant population)	Stomp Aqua + Gamit 36 CS + AHDB 9999

		
Stomp Aqua + Gamit 36 CS + AHDB 9998 (slight thinning of plant population)	Stomp Aqua + Gamit 36 CS + Venzar Flo – Site 2 (Reduction in plant population)	Stomp Aqua + Gamit 36 CS + Venzar Flo – Site 1 (Significant plant loss)

		
<p>Stomp Aqua + Gamit 36 CS + Hurricane SC</p>	<p>Bleaching on the leaflet from Hurricane SC</p>	<p>Scorch from Hurricane SC (crop later recovered, little effect on plant population)</p>

		
<p>Stomp Aqua + Gamit 36 CS + Flexidor 500</p>	<p>Flexidor scorch to leaf tips</p>	<p>Stomp Aqua + Gamit 36 CS + chlorpropham</p>

		
Stomp Aqua + Gamit 36 CS + aclonifen	Stomp Aqua + Gamit 36 CS + tri-allate	Stomp Aqua + Gamit 36 CS + Fresco followed by Fresco at 1-2 TL then 3-4 TL

		
Stomp Aqua + Gamit 36 CS + Fresco followed by Sencorex Flow at 1-2 TL then 3-4 TL (Slight bleaching of leaves)	Stomp Aqua + Fresco followed by Gamit 36 CS at 1-2 TL then 3-4 TL (Severe bleaching of leaves)	Stomp Aqua + Gamit 36 CS + Fresco followed by AHDB 9993 at 1-2 TL then 3-4 TL

	
Stomp Aqua + Gamit 36 CS + Fresco followed by aclonifen at 1-2 TL then 3-4 TL (Scorch and reduction in plant population but could be confounded by AHDB 9947 at pre-em)	Stomp Aqua + Gamit 36 CS + Fresco followed by Guillotine at 1-2 TL then 3-4 TL (Severe reduction in plant population)

- d. Climatological data during study period – Site 1 - Air max, air min and relative humidity from in field logger. No rainfall data for Suffolk. Site 2 – from Strawsons weather data.

	Site 1 (Suffolk)			Site 2 (Notts)		
Date	Temp °C (minimum)	Temp °C (maximum)	Mean relative humidity (%)	Mean Temp °C	Mean relative humidity (%)	Rainfall (mm)
18/05/2017	NA	NA	NA	11.2	88.4	4.6
19/05/2017	NA	NA	NA	10.2	94.1	8
20/05/2017	NA	NA	NA	10.5	91.4	2
21/05/2017	NA	NA	NA	12.3	84.1	0
22/05/2017	NA	NA	NA	16.1	76.6	0
23/05/2017	NA	NA	NA	15.8	76.5	0
24/05/2017	NA	NA	NA	17.8	81.4	0
25/05/2017	NA	NA	NA	19.5	79.4	0
26/05/2017	NA	NA	NA	19.2	74.9	0
27/05/2017	NA	NA	NA	17.5	84.6	0
28/05/2017	14.5	25.5	75.7	17	81.9	0
29/05/2017	15.5	21.5	92.6	13.4	99.5	6.2
30/05/2017	12.5	21.5	84.3	15.6	90.4	0
31/05/2017	13.0	23.0	76.3	15.8	75.4	0

	Site 1 (Suffolk)			Site 2 (Notts)		
Date	Temp °C (minimum)	Temp °C (maximum)	Mean relative humidity (%)	Mean Temp °C	Mean relative humidity (%)	Rainfall (mm)
01/06/2017	11.5	27.0	71.0	17.9	79.6	0
02/06/2017	14.5	25.0	85.4	16.3	89.8	5.2
03/06/2017	8.5	22.0	73.6	14.8	80.5	3.8
04/06/2017	12.0	21.0	71.3	12.4	84.6	0
05/06/2017	13.0	20.5	78.8	12	95.4	3.6
06/06/2017	10.0	13.5	88.9	11.4	95.5	10.8
07/06/2017	12.0	19.5	76.2	13.2	77.2	0
08/06/2017	11.5	18.0	86.7	14.5	93.9	6.6
09/06/2017	13.0	22.0	74.8	14.6	84.3	0
10/06/2017	17.0	26.5	70.8	15.8	92.8	3.8
11/06/2017	11.5	25.0	66.8	15.5	82.6	0.4
12/06/2017	11.0	21.0	72.0	13.9	84.3	0
13/06/2017	13.0	23.0	71.6	15.2	89.2	0
14/06/2017	13.0	27.5	65.3	18.3	78.6	0
15/06/2017	10.5	25.5	65.9	16.8	75.5	0
16/06/2017	15.5	24.0	70.6	15.8	77.9	0
17/06/2017	16.0	30.5	71.8	22.1	76.1	0
18/06/2017	17.0	33.0	64.7	22.9	67.6	0
19/06/2017	16.0	34.0	65.4	24.2	67.1	0
20/06/2017	13.5	32.0	73.1	17.2	93.1	0
21/06/2017	18.5	32.0	70.7	20	84.7	0
22/06/2017	12.0	22.0	82.6	18.2	84.1	0
23/06/2017	17.0	23.5	73.8	16.3	85.1	0
24/06/2017	13.5	26.5	72.7	16.8	82.2	0.4
25/06/2017	8.0	21.5	78.4	15.7	74.2	0
26/06/2017	13.5	24.0	65.5	15.3	65.2	0
27/06/2017	13.5	19.5	94.2	13.8	89.8	0
28/06/2017	11.5	15.0	95.8	11.3	100	31.4
29/06/2017	9.0	16.5	92.2	12.3	100	1.8
30/06/2017	13.0	19.0	90.0	14.8	97.4	8
01/07/2017	13.5	23.0	78.5	16.1	83.4	2
02/07/2017	12.0	23.5	71.4	15.9	75	0
03/07/2017	12.5	25.0	77.4	15.8	80.8	0
04/07/2017	12.0	25.0	78.3	16.6	80.9	0
05/07/2017	14.0	29.0	73.5	17.3	86	0
06/07/2017	14.5	26.0	81.3	19.7	83.4	0.8
07/07/2017	16.0	28.5	77.0	18.8	81.7	0
08/07/2017	14.0	25.5	75.4	17.6	69.8	0
09/07/2017	14.5	27.0	72.9	19.4	75.6	0.8
10/07/2017	12.5	26.5	80.6	16.3	88	1.4
11/07/2017	14.0	21.0	91.9	12.9	99.8	16.6
12/07/2017	6.5	19.5	83.9	14.9	80.3	0.4

	Site 1 (Suffolk)			Site 2 (Notts)		
Date	Temp °C (minimum)	Temp °C (maximum)	Mean relative humidity (%)	Mean Temp °C	Mean relative humidity (%)	Rainfall (mm)
13/07/2017	14.0	22.0	74.9	16	78.6	0
14/07/2017	12.5	20.5	78.7	15.4	78.1	0.4
15/07/2017	15.5	21.0	86.8	17.2	88.1	0
16/07/2017	8.0	24.0	87.3	19.1	77.4	0
17/07/2017	13.0	28.5	73.2	19	64.1	0
18/07/2017	16.5	27.0	76.9	17.9	77.6	0
19/07/2017	16.0	24.5	88.9	18.8	92.6	0
20/07/2017	10.5	20.5	84.1	15.5	85.3	14.8
21/07/2017	13.5	22.5	76.4	16.5	77.1	0.8
22/07/2017	11.5	21.0	90.0	14.8	90.8	18.8
23/07/2017	13.0	20.0	92.3	13.8	92.7	5.2
24/07/2017	13.5	16.5	97.8	14.6	92.1	0.8
25/07/2017	12.5	23.0	91.7	15.8	84.9	0
26/07/2017	12.0	22.0	89.5	16.1	92.8	5.2
27/07/2017	12.5	20.0	84.6	14.5	85	0.2
28/07/2017	13.5	20.5	85.3	15.3	88.7	6.4
29/07/2017	13.5	21.0	88.2	16.2	82.7	2
30/07/2017	12.0	21.5	87.4	15.1	88.9	6.6
31/07/2017	9.5	22.5	83.1	15.1	85.8	2.2
01/08/2017	14.0	22.5	81.5	15.5	82	1.8
02/08/2017	15.0	19.5	91.0	15.8	94.9	4.6
03/08/2017	13.5	21.5	80.5	17	86.4	4.2
04/08/2017	12.0	24.5	80.6	16.7	72.6	0
05/08/2017	7.0	23.0	88.2	15	73.2	0
06/08/2017	12.5	22.0	78.3	15.3	78.7	0
07/08/2017	13.0	21.0	91.7	16.2	81.2	4.2
08/08/2017	13.0	20.0	96.2	12.4	97.1	42
09/08/2017	10.5	17.0	98.9	13.8	88.6	10.4
10/08/2017	6.0	21.0	91.2	15.2	77.1	0
11/08/2017	15.0	23.5	82.6	14.6	87.9	0
12/08/2017	7.5	22.5	84.7	16	82.3	0
13/08/2017	10.5	27.0	79.6	14.9	72.2	0
14/08/2017	13.0	24.0	80.4	15.6	83.6	0
15/08/2017	8.0	26.5	78.3	16.6	76.6	0
16/08/2017	14.5	23.0	76.2	15.3	78.7	0
17/08/2017	14.5	25.0	83.8	17.8	83.3	8.8
18/08/2017	9.5	23.0	84.1	14.5	82.2	0.8
19/08/2017	9.0	19.5	85.3	13.6	81.4	0
20/08/2017	12.5	23.0	85.2	14.5	80.1	0
21/08/2017	15.5	20.0	89.2	14.5	95.4	0
22/08/2017	15.0	25.5	89.0	17.9	94.3	1
23/08/2017	11.0	24.0	88.3	16.8	90	0.4

	Site 1 (Suffolk)			Site 2 (Notts)		
Date	Temp °C (minimum)	Temp °C (maximum)	Mean relative humidity (%)	Mean Temp °C	Mean relative humidity (%)	Rainfall (mm)
24/08/2017	8.0	25.0	82.8	14.6	83.9	0
25/08/2017	9.5	28.0	77.1	15.2	83.9	0
26/08/2017	9.5	28.0	82.2	17.6	76.3	0
27/08/2017	11.0	30.0	75.0	16.6	77.6	0
28/08/2017	11.5	29.0	76.5	18.7	77.7	0
29/08/2017	12.0	30.0	81.0	15.3	85.2	0
30/08/2017	6.0	13.5	95.7	11.8	96	10.6
31/08/2017	5.5	23.0	86.3	11.8	88	1.2
01/09/2017	6.5	24.0	80.4	12.9	85.7	0.8
02/09/2017	10.5	26.5	79.5	13.3	85.6	0
03/09/2017	12.5	21.0	82.9	12.6	93.2	2
04/09/2017	16.0	21.5	94.6	16.5	94.2	1.6
05/09/2017	10.0	20.5	93.6	15.8	98.2	16.8
06/09/2017	7.5	18.5	88.4	12.7	88.7	0
07/09/2017	13.5	20.5	83.3	13.8	92	0.8
08/09/2017	8.0	18.5	95.5	13.8	87.6	1.8
09/09/2017	6.0	19.0	93.0	11.8	94	1.4
10/09/2017	10.0	17.0	90.7	11.5	94.7	0.4
11/09/2017	9.0	18.5	92.6	12.6	89.8	6.2
12/09/2017	11.5	18.5	84.1	12.8	83.6	6
13/09/2017	6.5	17.0	89.0	11.7	84.5	0.6
14/09/2017	4.5	17.0	94.5	11.5	82.3	0
15/09/2017	5.0	15.5	97.2	10.7	88.3	0
16/09/2017	6.0	14.5	98.5	10.9	90.4	1.2
17/09/2017	7.0	16.5	98.8	11.4	96.2	6.4
18/09/2017	6.5	14.0	98.4	11.5	91.5	1
19/09/2017	5.5	20.0	94.0	10.5	87.8	0.2
20/09/2017	11.5	18.5	90.4	13	89.1	0
21/09/2017	7.0	20.0	91.0	12.9	98.9	8.2
22/09/2017	10.0	20.5	85.4	10.7	90.5	1
23/09/2017	10.0	19.5	89.0	13.8	94.8	0
24/09/2017	12.5	22.0	85.6	14.5	85.5	0
25/09/2017	13.0	21.0	92.2	14.5	98.4	18.2
26/09/2017	9.5	21.5	93.8	14.1	96.4	0.2
27/09/2017	12.0	21.0	92.6	14.5	95.6	7.8
28/09/2017	11.0	22.0	94.3	14.9	91.3	6
29/09/2017	9.0	18.5	94.4	13.7	91.6	1.8
30/09/2017	11.0	20.5	88.8	11.5	94.2	5
01/10/2017	12.0	18.0	92.4	14.8	97.6	4
02/10/2017	7.0	17.0	86.0	13.2	79.7	0
03/10/2017	7.5	15.5	85.1	11.3	80.8	0
04/10/2017	10.0	14.5	86.6	11	87.9	1.2

	Site 1 (Suffolk)			Site 2 (Notts)		
Date	Temp °C (minimum)	Temp °C (maximum)	Mean relative humidity (%)	Mean Temp °C	Mean relative humidity (%)	Rainfall (mm)
05/10/2017	6.0	17.0	85.5	12.2	82.3	0.6
06/10/2017	7.0	16.5	84.4	9.9	82.6	0
07/10/2017	6.5	17.0	94.9	12.4	91.7	0.2
08/10/2017	8.5	18.5	95.6	11.7	92.8	0
09/10/2017	9.5	17.0	95.9	12.5	94	0
10/10/2017	12.5	19.0	91.6	14.6	86.6	0
11/10/2017	8.0	17.5	89.6	14.1	89.3	0.2
12/10/2017	8.5	18.5	88.3	11.5	84.8	0
13/10/2017	14.5	21.0	90.7	16.6	90.4	0
14/10/2017	10.0	22.0	90.9	17.1	88.4	0
15/10/2017	8.5	20.5	92.4	14.1	94.9	0
16/10/2017	9.0	22.5	81.9	14.8	85.8	0.2
17/10/2017	9.5	16.5	87.8	12.2	75.4	0
18/10/2017	10.0	14.0	98.3	10.2	97.3	0.4
19/10/2017	11.5	17.0	96.4	12.7	100	7.8
20/10/2017	9.0	16.0	94.5	11.9	95.6	0.2
21/10/2017	9.0	16.0	84.6	12.3	91.1	4.8
22/10/2017	6.5	13.0	87.3	9.8	87.7	0
23/10/2017	10.0	16.0	95.8	11.8	98.7	0
24/10/2017	13.5	19.0	91.6	15.3	96.2	1.2
25/10/2017	5.0	19.0	89.4	12.8	90.8	0.4
26/10/2017	7.5	23.5	77.1	11.5	95.2	0
27/10/2017	15.0	24.5	59.1	9.1	88.6	0
28/10/2017	15.0	16.5	65.8	11.7	92.9	0.2
29/10/2017	13.0	17.5	65.8	9.5	82.9	0

e. Raw data from assessments

All treatment means included in the main body of the report

Site 2 trial plan

ADAS GT CARROTS 2017 - STRAWSONS

PLOT SIZE= 8 x 1.85m
 SPLIT PLOTS A= 6 x 1.85m
 B = 2 x 1.85m

sprayer width 36m

SPRAY RUN

Plot 25 mis-sprayed with Treat 15

g. 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
Biologicals and Semiochemicals
Stored Crops**

Date of issue: 16 December 2016

Effective date: 5 December 2016

Expiry date: 17 March 2018

Signature

Authorised signatory

Certification Number

ORETO 374



Chemicals Regulation Division



Department of
**Agriculture and
Rural Development**