SCEPTREPLUS

Final Trial Report

Trial code:	SP17 - 2017
Title:	AHDB SCEPTREplus rhubarb herbicide post-harvest screen
Crop	Group: field vegetable – Polygonaceae (rhubarb)
Target	General broadleaf weeds and grasses, 3WEEDT EPPO1/89(3) Weeds in leafy and brassica vegetables
Lead researcher:	Angela Huckle
Organisation:	RSK ADAS
Period:	24th April 2017 – 31st March 2018
Report date:	31st December 2018
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

7th January 2018
Date

Authors signature

Trial Summary

Introduction

The limited range of herbicides currently available leaves gaps in the weed control spectrum, and rhubarb growers experience problems with a wide range of weeds. Himalayan balsam (*Impatiens glandulifera*), and perennials such as docks (*Rumex* spp.) and thistles (*Cirsium arvense*) are particularly problematic for growers. As well as competing with the crop for nutrients and water, these weeds also hinder pickers, reducing harvest efficiency.

In recent years, rhubarb crown size and yield has decreased in both forced and green pull crops. Growers believe that this is a consequence of increased competition from weeds, amongst other influencing factors.

As a perennial crop, rhubarb presents a challenge for weed control as there is only a short window where the crop is fully dormant where non-selective herbicides can be applied safely. If any leaf is present, even senescent leaf crop safety of any herbicide applied over the crop needs to be considered. For example, glyphosate is an effective option for weed control over winter, with an EAMU approval for Roundup Biactive in rhubarb, but the short dormant season of the crop provides only a limited window for treatment. The crop must be completely dormant with no leaf, otherwise glyphosate will kill the sets.

The objective of this trial was to identify crop safe and effective herbicides for rhubarb weed control which could be used post-harvest, aiming to expand the options available to growers.

Method

One trial was carried out at two separate t commercial rhubarb grower sites in Hampshire (Site 1) and Yorkshire (Site 2).

Treatments were applied over the crop alone or in combinations. The rhubarb sets (var. Timperley Early) were planted in 2015 (Site 1) and 2016 (Site 2). The treatments were applied over the crop on 13th June 2017 (Site 1) and 25th July 2017 (Site 2). Treatments were applied with a 1.5m boom, with an Oxford Precision Sprayer knapsack at 200 L/ha water volume.

A randomised block design was used with four replicates of eighteen treatments, including two untreated controls, totalling 72 plots. Plots were 1.5m wide by 5m long. Plots were assessed for weed control on four occasions at both sites, with the percentage of weed ground cover recorded. Crop damage was also assessed; at one, three, eight and twelve weeks after treatment at Site 1, and two, four and seven weeks after treatment at Site 2.

Results and discussion

The two trial sites differed in levels of weed burden – untreated plots at Site 1 had an average weed cover of 7% by 12 weeks into the trial, whereas Site 2 untreated plots had an average weed cover of 68% by 7 weeks into the trial. At Site 2, ten treatments significantly reduced weed cover at 7 weeks after treatment application when compared to the untreated control ($p = 0.003$). These were: Shark, AHDB 9984, AHDB 9976, AHDB 9981, AHDB 9983 in a tank mix with AHDB 9981, AHDB 9974, AHDB 9979, AHDB 9982, AHDB 9986 + Mero, and AHDB 9975 and AHDB 9980 when applied in a tank-mix with AHDB 9978.

The change in weed cover from the baseline to the end of the trial (harvest) was assessed. The mean of the initial weed burden before treatment application at Site 2 was 21% and was variable across the field, ranging from a minimum of 11% to a maximum of 45%. While no treatment showed a decrease in weed cover when compared to the levels of the initial baseline assessment, plots where AHDB 9982 or AHDB 9986 + Mero was applied showed only very small increases in weed cover

Seven treatments were safe to the crop by harvest at both sites, these were; Shark, AHDB 9973, AHDB 9984, AHDB 9981, AHDB 9985, AHDB 9993, AHDB 9974 and AHDB 9982. All except AHDB 9985 gave transient effects which the crop grew through relatively quickly. These varied from slight yellow clouding, through chlorosis to scorch. AHDB 9979 gave unacceptable levels of stunting and discolouration at both sites, and at Site 2 AHDB 9979, AHDB 9976 and AHDB 9986 + Mero also caused the rhubarb stems to twist, split and delaminate at harvest.

Table 1. Summary of crop damage and mean percentage of weed cover per treatment (Site 1 – 8th August 2017, 12 weeks post-treatment; Site 2 – 13th September 2017, 7 weeks post-treatment) at harvest. **Weed cover data is shown as back transformed means.**

Treatment	Site 1		Site 2	
	Crop damage (0-10)	Weed cover (% cover)	Crop damage (0-10)	Weed cover (% cover)
Untreated	8.50	6.31	9.50	68.25
Shark	8.25	4.13	8.75	35.01
AHDB 9973	8.75	5.40	8.75	77.91
AHDB 9984	8.75	5.96	**7.50**	34.19
AHDB 9976	**7.00**	3.37	**5.25**	40.96
AHDB 9981	9.25	5.34	9.00	34.4
AHDB 9983 + AHDB 9981	**7.25**	4.64	**7.25**	50.98
AHDB 9985	8.50	5.82	9.00	58.11
AHDB 9993	8.75	4.64	8.00	67.37
AHDB 9974	8.75	3.50	8.75	**31.61**
AHDB 9992	8.75	4.46	**7.50**	64.92
AHDB 9979	**7.25**	3.28	**3.25**	35.91
AHDB 9982	7.75	4.45	8.00	**16.83**
AHDB 9986 + Mero	8.75	2.40	**6.75**	**13.45**
AHDB 9977 + AHDB 9978	8.75	5.45	**7.25**	64.17
AHDB 9975 + AHDB 9978	8.50	3.36	**5.75**	**31.23**
AHDB 9980 + AHDB 9978	8.00	3.41	**5.25**	**31.13**
F prob. value	0.006	0.321	<0.001	0.003
d.f.	52	52	52	52
S.E.D.	0.5764	2.225	0.809	10.30
L.S.D.	1.1567	4.465	1.623	20.66

Crop Damage – Red = unacceptable, Yellow = marginal, Green = safe.
Weed control – Red = > 50% weed cover, Yellow = 25-50% weed cover, Green = <25% weed cover
Bold = significantly different to the untreated

Conclusions

- Shark, AHDB 9981, and AHDB 9982 combine a reasonable level of weed control with being safe to the crop and warrant investigation for EAMU applications for post-harvest use
- AHDB 9974 was also safe to the crop by harvest and gave a useful level of weed control but is no longer being progressed by the company.

- AHDB 9985 is a graminicide which was crop safe to rhubarb and an approval would be useful to improve the options available for grass weed control since the loss of tepraloxydim (Aramo).

Take home message

Approvals for AHDB 9981, AHDB 9982 or Shark for post-harvest use would enable growers to improve weed control in rhubarb crops. An approval for AHDB 9985 would improve the options available for grass weed control.

Objectives

1. To compare a number of novel post-emergence contact herbicides for selectivity (crop safety) and efficacy in rhubarb.
2. 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**
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: None

Test site

Item	**Details**	
Location address	**Site 1** Field: Coldharbour Lane Barfoots Broadlands, Romsey Hampshire Grid reference: SU 36710 17121	**Site 2** Field: Jaw Bones E Oldroyd & Sons Rothwell, Leeds LS26 0ZL Yorkshire Grid reference: SE 32809 29009
Crop	Rhubarb	
Cultivar	Timperley Early	
Soil or substrate type	Freely draining sandy clay loam	Lime-rich clay loam soil with naturally high groundwater
Agronomic practice	See Appendix A	
Prior history of site	See Appendix A	

Trial design

Item	**Details**
Trial design:	Fully randomised block
Number of replicates:	4
Row spacing:	0.85m (2 rows per plot)
Plot size: (w x l)	1.65m x 5m (Site 1), 1.72m x 6m (Site 2)
Plot size: (m^2)	8.25m^2 (Site 1), 10.32m^2 (Site 2)
Number of plants per plot:	Approx. 10
Leaf Wall Area calculations	N/A

Treatment details

AHDB Code	Active substance	Product name	Formulation batch number	Content of active substance in product (g/L or g/kg)	Formulation type
N/A	carfentrazone-ethyl	Shark	620131	60	Emulsifiable Concentrate
AHDB 9984	N/A	N/A	N/A	N/A	N/A
AHDB 9976	N/A	N/A	N/A	N/A	N/A
AHDB 9981	N/A	N/A	N/A	N/A	N/A
AHDB 9983	N/A	N/A	N/A	N/A	N/A
AHDB 9985	N/A	N/A	N/A	N/A	N/A
AHDB 9993	N/A	N/A	N/A	N/A	N/A
AHDB 9974	N/A	N/A	N/A	N/A	N/A
AHDB 9982	N/A	N/A	N/A	N/A	N/A
AHDB 9986	N/A	N/A	N/A	N/A	N/A
N/A	oil (rapeseed fatty acid esters)	Mero (adjuvant)	EFKH004146	733	Emulsifiable Concentrate
AHDB 9973	pelargonic acid	Finalsan	536515	186.7	Emulsifiable Concentrate
N/A	diquat	Reglone	N/K	200	Soluble Concentrate
AHDB 9977	N/A	N/A	N/A	N/A	N/A
AHDB 9975	N/A	N/A	N/A	N/A	N/A
AHDB 9980	N/A	N/A	N/A	N/A	N/A
AHDB 9992	N/A	N/A	N/A	N/A	N/A
AHDB 9979	N/A	N/A	N/A	N/A	N/A

Application schedule

Treatment number	Treatment: product name or AHDB code	Rate of active substance(s) (ml/ha or g/ha)	Rate of product (L/ha or kg/ha)
1	Untreated	-	-
2	Untreated	-	-
3	Shark	18	0.3
4	AHDB 9973	6347	34.0
5	AHDB 9984	270	1.2
6	AHDB 9976	288	0.6
7	AHDB 9981	900	2.0
8	AHDB 9983+ AHDB 9981	200 900	0.5 2.0
9	AHDB 9985	180	1.5
10	AHDB 9993	480	3.0
11	AHDB 9974	1200	3.0
12	AHDB 9992	625 375	2.0
13	AHDB 9979	6 140	0.5
14	AHDB 9982	45	0.75
15	AHDB 9986 + Mero	45 1.5	0.15

Treatment number	Treatment: product name or AHDB code	Rate of active substance(s) (ml/ha or g/ha)	Rate of product (L/ha or kg/ha)
		45	1% volume
16	AHDB 9977 + Reglone	500 500 300	2.5 1.5
17	AHDB 9975+ Reglone	850 1000 300	4.0 1.5
18	AHDB 9980 + Reglone	1125 75.15 300	4.5 1.5

Application details

	Site 1	Site 2
Application date	13/06/2017	25/07/2017
Time of day	08:00 – 10:00	10:45 – 12:45
Crop growth stage (Max, min average BBCH)	31 – 32 Rosette 10-20% of final size	20 – 21 Regrowth of first leaf just visible
Crop height (cm)	40	50
Crop coverage (%)	30	60
Application Method	spray	spray
Application Placement	foliar	foliar
Application equipment	Oxford Precision Sprayer (knapsack)	Oxford Precision Sprayer (knapsack)
Nozzle pressure	2.4 bar	2.4 bar
Nozzle type	Flat fan	Flat fan
Nozzle size	02F110	02F110
Application water volume/ha	200	200
Temperature of air - shade (°C)	14.1 – 21.4	16.0 – 17.5
Relative humidity (%)	62.0 – 84.4	76.3 – 78.1
Wind speed range (mph)	1.3 – 4.5	1.9 – 3.8
Dew presence (Y/N)	N	N
Temperature of soil - 10cm (°C)	20.0	14.0 – 15.0
Wetness of soil - 2-5 cm	Dry	Wet
Cloud cover (%)	0	100

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

Site 1:

Common name	Scientific Name	EPPO Code	Infection level at start of assessment period (baseline)	Infection level mid-assessment period (3 weeks)	Infection level at end of assessment period (12 weeks)
Broad leaved	*N/A*	3WEEDT	5.13%	7.35%	6.31%

weeds and grasses			*(untreated average)*	*(untreated average)*	*(untreated average)*

Site 2:

Common name	Scientific Name	EPPO Code	Infection level at start of assessment period (2 weeks)	Infection level mid-assessment period (4 weeks)	Infection level at end of assessment period (7 weeks)
Broad leaved weeds and grasses	*N/A*	3WEEDT	25.45% *(untreated average)*	60.71% *(untreated average)*	68.25% *(untreated average)*

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)
13/06/2017	0	31 – 32	baseline	Percentage of weed cover, whole plot score; weed species presence
20/06/2017	7	42	phytotox	Phytotox (scale 0-10, 0 = Dead)
06/07/2017	23	43	efficacy, phytotox	Phytotox (scale 0-10, 0 = Dead) Percentage of weed cover, whole plot score; weed species presence
21/07/2017	38	47	efficacy, phytotox	Phytotox (scale 0-10, 0 = Dead) Percentage of weed cover, whole plot score; weed species presence
08/08/2017	56	49	efficacy, phytotox	Phytotox (scale 0-10, 0 = Dead) Percentage of weed cover, whole plot score; weed species presence

* DA – days after application
** used general scale

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)
24/07/2017	0	20 - 21	baseline	Weed species presence
09/08/2017	16	31 – 32	efficacy, phytotox	Phytotox (scale 0-10, 0 = Dead) Percentage of weed cover, whole plot score
25/08/2017	32	45	efficacy, phytotox	Phytotox (scale 0-10, 0 = Dead) Percentage of weed cover, whole plot score

13/09/2017	51	49	efficacy, phytotox	Phytotox (scale 0-10, 0 = Dead) Percentage of weed cover, whole plot score

* DA – days after application
** used general scale

Statistical analysis

The design of both trials were randomised block designs, each with four replicates of eighteen treatments, including two untreated controls. There was no commercial standard but Shark was included to provide a comparison with performance in the previous herbicide trials (SF 161).

As the distribution of weeds was uneven across each trial, which is not unexpected in field situations, so 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 back transformed means presented, from which Abbotts formula was used to calculate the % reduction in weeds.

Results

Phytotoxicity

The results of phytotoxicity assessments from four dates are presented in Table 2~~Table 2~~ and Figure 1~~Figure 1~~. These were scored on a scale from 0 to 10, with 0 being 'dead', and 10 being 'no effect'. Plots deemed to have a commercially acceptable level of damage were scored 8 or above.

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.

Site 1

Eleven of the sixteen treatments caused crop effects such as scorching and distortion at two weeks after application, but by four weeks after treatment most crop effects had reached a level which would be acceptable to the grower or had an equivalent crop quality score to the untreated (Table 2~~Table 2~~ and Figure 1~~Figure 1~~). At the final assessment at 12 weeks after application, all except coded treatments AHDB 9976, AHDB 9983 + AHDB 9981, and AHDB 9979 had crop quality scores of an acceptable level or equivalent to the untreated. The untreated was scored below 10 as there was some natural discolouration at leaf edges which was difficult to distinguish between slight scorch. In the treatments where phytotoxic effects remained at harvest this was exhibited as scorching to leaves and variability in the final size of crop as some plants remained stunted.

Table 2. Mean phytotoxicity scores at four dates throughout the trial period at Site 1 (0 to 10; 0 = complete crop death, 10 = no damage). Scores ≥8 deemed commercially acceptable damage, those <8 (unacceptable damage) are highlighted in red.

SITE 1	Mean crop damage scores			
	20th June	6th July	21st July	8th Aug
Untreated	8.19	8.50	8.25	8.50
Shark	**6.00**	9.25	8.25	8.25
AHDB 9973	**6.25**	9.00	8.50	8.75
AHDB 9984	**5.25**	8.00	8.25	8.75
AHDB 9976	**6.88**	**5.75**	**6.50**	**7.00**
AHDB 9981	8.00	8.25	8.25	9.25
AHDB 9983 + AHDB 9981	**7.00**	7.75	**6.75**	**7.25**
AHDB 9985	8.50	8.75	8.25	8.50
AHDB 9993	8.00	9.00	8.00	8.75
AHDB 9974	**6.00**	8.00	8.00	8.75
AHDB 9992	**6.25**	8.00	7.75	8.75
AHDB 9979	**5.75**	**6.00**	**6.75**	**7.25**
AHDB 9982	7.75	8.00	7.75	7.75
AHDB 9986 + Mero	8.00	7.50	8.00	8.75
AHDB 9977 + AHDB 9978	**4.75**	8.50	8.00	8.75
AHDB 9975 + AHDB 9978	**5.50**	9.50	8.00	8.50
AHDB 9980 + AHDB 9978	**4.50**	8.50	8.50	8.00
F pr. value	<0.001	<0.001	<0.001	0.006
d.f.	52	52	52	52
S.E.D.	0.602	0.5141	0.4342	0.5764
L.S.D.	1.208	1.0316	0.8714	1.1567

Values in **bold** are significantly different to untreated

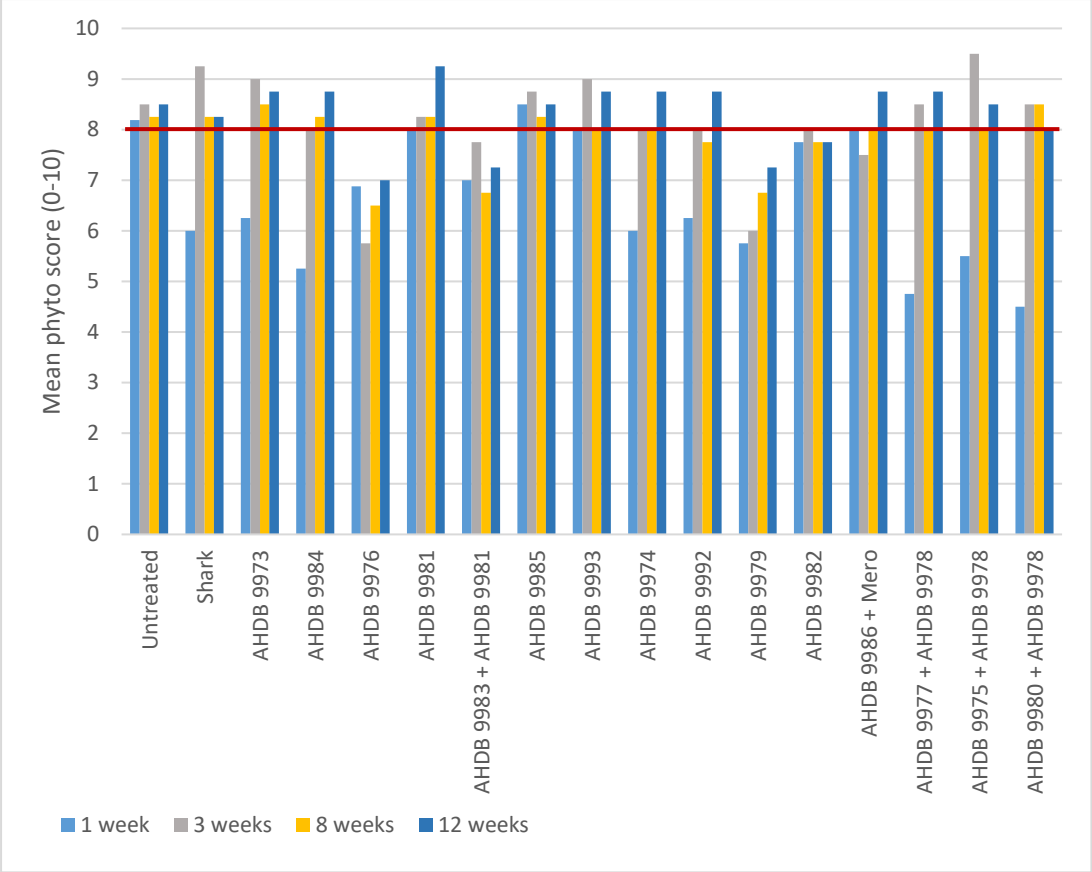


Figure 1. Mean phytotoxicity scores at 2, 4, 6 and 9 weeks after treatment application at Site 1. Scores of 8 or above deemed acceptable damage (as indicated by red line).

Site 2

At this site there was a greater persistence of crop effects, and there were clear differences in crop safety between treatments at the final assessment at seven weeks after treatment application. Nine treatments had an average phytotoxicity score significantly lower than that of the untreated control and below a crop quality score of eight which is the level of damage deemed acceptable to the grower (Table 3~~Table 3~~ and Figure 2~~Figure 2~~). Most notably, crop treated with AHDB 9979 appeared severely stunted with foliar discolouration. This treatment and AHDB 9986 also showed twisting and splitting/delamination of the stems. Other treatments with low phytotoxicity scores showed stunting and discolouration but not to the level of severity of those plots treated with AHDB 9979.

Those treatments which were crop safe at seven weeks after application (harvest) were Shark, AHDB 9973, AHDB 9981, AHDB 9985, AHDB 9993, AHDB 9974 and AHDB 9982.

Table 3. Mean phytotoxicity scores at three dates throughout the trial period at Site 2 (0 to 10; 0 = complete crop death, 10 = no damage). Scores ≥8 deemed commercially acceptable damage, those <8 indicate unacceptable damage.

SITE 2	Mean crop damage scores		
	9th Aug	28th Aug	13th Sep
Untreated	9.00	9.38	9.50
Shark	**5.50**	8.75	8.75
AHDB 9973	**7.25**	8.75	8.75
AHDB 9984	**5.50**	**7.25**	**7.50**
AHDB 9976	**6.50**	**4.75**	**5.25**
AHDB 9981	8.25	9.00	9.00

SITE 2	Mean crop damage scores		
	9th Aug	28th Aug	13th Sep
AHDB 9983 + AHDB 9981	**7.25**	**7.25**	**7.25**
AHDB 9985	8.00	9.00	9.00
AHDB 9993	**7.25**	8.75	8.00
AHDB 9974	**6.75**	8.50	8.75
AHDB 9992	**7.00**	**7.00**	**7.50**
AHDB 9979	**6.25**	**2.75**	**3.25**
AHDB 9982	**6.00**	**7.25**	8.00
AHDB 9986 + Mero	**5.50**	**6.25**	**6.75**
AHDB 9977 + AHDB 9978	**4.00**	**6.50**	**7.25**
AHDB 9975 + AHDB 9978	**4.00**	**5.00**	**5.75**
AHDB 9980 + AHDB 9978	**4.50**	**5.75**	**5.25**
F pr. value	<0.001	<0.001	<0.001
d.f.	52	52	52
S.E.D.	0.789	0.940	0.809
L.S.D.	1.582	1.886	1.623

Values in **bold** are significantly different to untreated

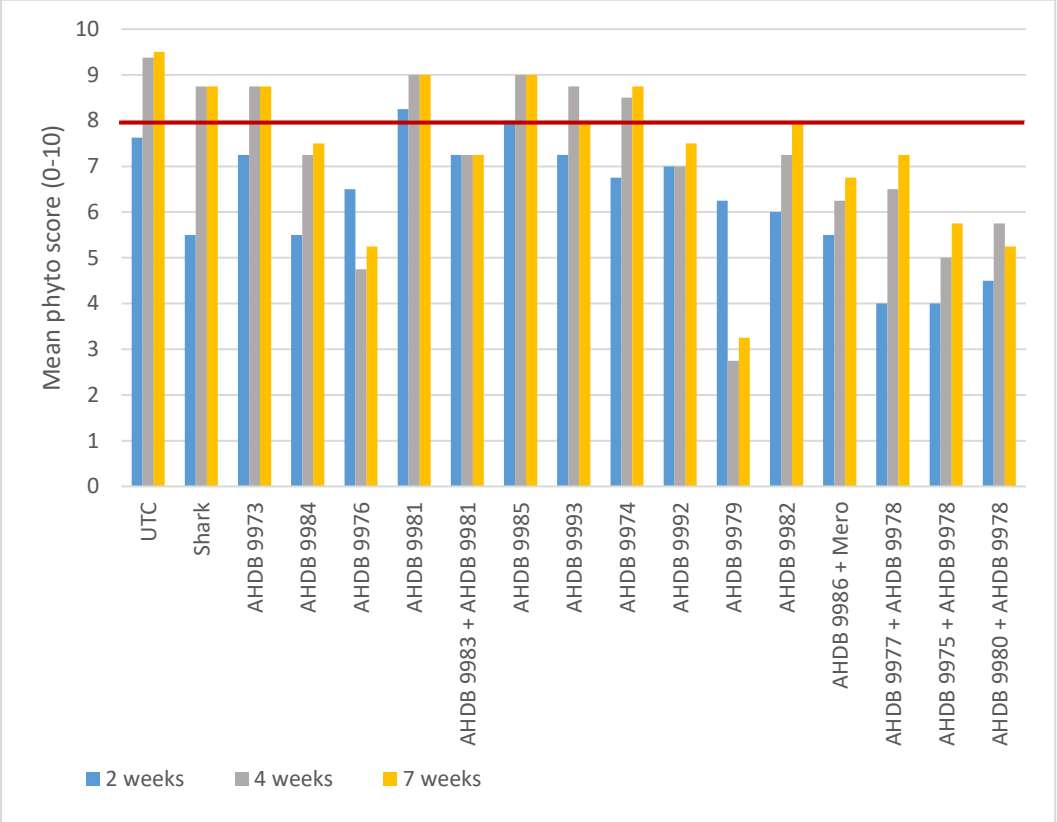


Figure 2. Mean phytotoxicity scores at 2, 4, and 7 weeks after treatment application at Site 2. Scores of 8 or above deemed acceptable damage (as indicated by red line).

Weed control – mean percentage weed cover

Site 1

The results for the mean percentage weed cover per treatment are presented in Table 4~~Table 4~~ and Figure 3~~Figure 3~~. The percent reduction in weed cover compared to the untreated control was calculated from these figures (using Abbotts formula), and results for each treatment are listed in Table 5~~Table 5~~.

Weed levels at this site were low and therefore it is difficult to distinguish confidently between specific treatments to determine their individual performance. The mean of the initial weed burden in the trial field was 4.4%, ranging from a minimum of 2.6% to a maximum of 6.5%. The change in weed cover from the baseline assessment to the final assessment, 12 weeks after the first treatment application, was assessed.

There were no significant differences in efficacy between treatments, and the weed distribution across the trial remained uneven. Levels of % weed cover in the untreated plots varied from 2% to 15% at twelve weeks after the first application.

Table 4. Mean percentage weed cover values from Site 1 (transformed).

Trt. No.	Mean weed cover – SITE 1							
	13th June		6th July		21st July		8th August	
	Ang	Back-trans	Ang	Back-trans	Ang	Back-trans	Ang	Back-trans
UTC*	13.09	5.13	15.73	7.35	14.75	6.48	14.55	6.31
3	10.99	3.64	9.67	2.82	11.31	3.85	11.73	4.13
4	11.45	3.94	12.79	4.90	10.64	3.41	13.44	5.40
5	12.79	4.90	14.06	5.90	12.79	4.90	14.13	5.96
6	11.13	3.72	11.60	4.04	11.42	3.92	10.57	3.37
7	12.79	4.90	13.82	5.71	11.14	3.73	13.36	5.34
8	12.92	5.00	15.51	7.15	14.13	5.96	12.44	4.64
9	10.71	3.45	13.84	5.72	11.84	4.21	13.95	5.82
10	14.74	6.47	17.37	8.91	15.51	7.15	12.44	4.64
11	10.71	3.45	14.13	5.96	10.99	3.63	10.78	3.50
12	10.99	3.64	15.57	7.20	14.77	6.50	12.20	4.46
13	10.99	3.64	12.93	5.01	12.76	4.88	10.43	3.28
14	12.18	4.45	12.51	4.69	10.39	3.25	12.18	4.45
15	13.56	5.50	11.42	3.92	10.39	3.26	8.92	2.40
16	13.39	5.37	13.82	5.71	16.06	7.66	13.49	5.45
17	13.56	5.50	13.22	5.23	14.45	6.23	10.56	3.36
18	9.33	2.63	9.31	2.62	6.93	1.46	10.64	3.41
F pr. value		0.423		0.225		0.148		0.321
d.f.		52		50		52		52
S.E.D.		1.983		2.693		2.830		2.225
L.S.D.		3.980		5.409		5.679		4.465

* Untreated control; treatments 1 and 2

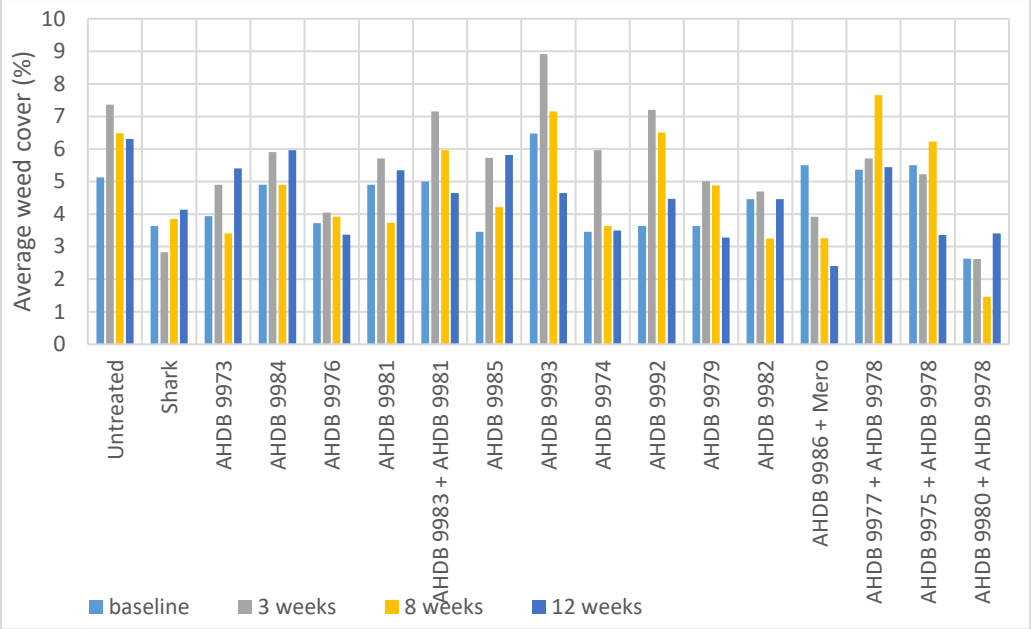


Figure 3. Mean weed cover (%) at baseline assessment and 3, 8, and 12 weeks after treatment application at Site 1. *Note: y-axis max. value of 10%.*

Table 5. Percentage reduction in weed cover at Site 1 (calculated using Abbotts formula) – highlighted values show an increase in weed cover.

SITE 1	Weed cover reduction (%)			
	25th Jul	9th Aug	25th Aug	13th Sep
Shark	29.12	61.61	40.62	34.50
AHDB 9973	23.23	33.37	47.41	14.40
AHDB 9984	4.50	19.77	24.41	5.55
AHDB 9976	27.44	45.02	39.51	46.68
AHDB 9981	4.50	22.42	42.43	15.39
AHDB 9983 + AHDB 9981	2.55	2.77	8.04	26.43
AHDB 9985	32.68	22.18	35.07	7.86
AHDB 9993	-26.12	-21.21	-10.31	26.43
AHDB 9974	32.68	18.94	43.97	44.57
AHDB 9992	29.12	2.05	-0.31	29.27
AHDB 9979	29.12	31.87	24.70	48.03
AHDB 9982	13.19	36.21	49.83	29.42
AHDB 9986 + Mero	-7.19	46.68	49.78	61.94
AHDB 9977 + AHDB 9978	-4.60	22.38	-18.13	13.72
AHDB 9975 + AHDB 9978	-7.19	28.92	3.95	46.74
AHDB 9980 + AHDB 9978	48.78	64.44	77.51	45.98

Site 2

Ten treatments significantly reduced weed cover at eight weeks after treatment application when compared to the untreated control (p = 0.003). These were: Shark, AHDB 9984, AHDB 9976, AHDB 9981, AHDB 9983 in a tank mix with AHDB 9981, AHDB 9974, AHDB 9979, AHDB 9982, AHDB 9986 + Mero, and AHDB 9975 and AHDB 9980 when applied in a tank-mix with AHDB 9978.

The change in weed cover from the baseline to the final assessment was assessed. The mean of the initial weed burden before treatment application at this site was 20.6% and was variable across the field, ranging from a minimum of 10.5% to a maximum of 44.6%. While no treatment showed a decrease in weed cover when compared to the levels of the initial baseline assessment, plots treatment with AHDB 9982 or AHDB 9986 + Mero showed only very small increases in weed cover.

Table 6. Mean percentage weed cover values from Site 2 (transformed). Values in **bold** are significantly different to untreated control.

Trt. No.	Mean weed cover – SITE 2					
	9th August		28th August		13th September	
	Ang	Back-trans	Ang	Back-trans	Ang	Back-trans
UTC*	30.30	25.45	51.2	60.71	55.7	68.25
3	22.64	14.82	31.1	26.66	**36.3**	35.01
4	41.89	44.58	56.7	69.91	62.0	77.91
5	24.15	16.74	32.6	29.05	**35.8**	34.19
6	24.68	17.43	36.8	35.88	**39.8**	40.96
7	24.41	17.07	32.5	28.93	**35.9**	34.4
8	25.25	18.2	40.2	41.68	**45.6**	50.98
9	29.71	24.56	48.3	55.72	49.7	58.11
10	36.06	34.65	48.7	56.38	55.2	67.37
11	23.98	16.52	38.0	37.85	**34.2**	31.61
12	32.61	29.04	51.1	60.52	53.7	64.92
13	25.53	18.58	36.8	35.91	**36.8**	35.91
14	22.01	14.05	**24.4**	17.13	**24.2**	16.83
15	**19.79**	11.47	**20.8**	12.55	**21.5**	13.45
16	28.53	22.81	47.7	54.26	53.2	64.17
17	21.24	13.12	**28.9**	23.33	**34.0**	31.23
18	18.92	10.51	31.0	26.46	**33.9**	31.13
F pr. value		0.001		0.013		0.003
d.f.		52		52		52
S.E.D.		4.936		10.15		10.30
L.S.D.		9.905		20.36		20.66

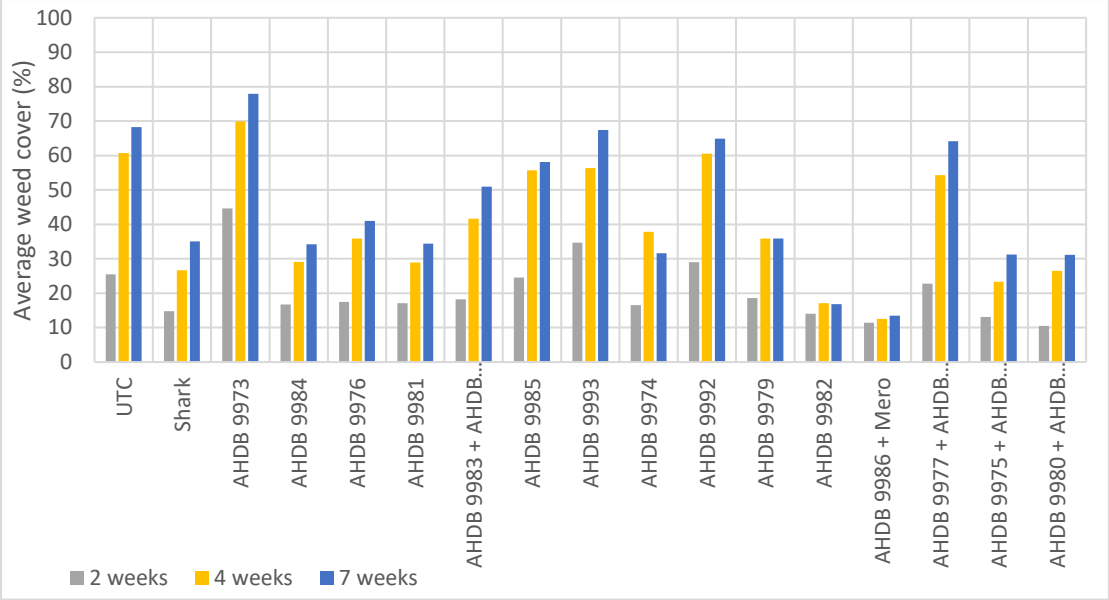


Figure 4. Mean weed cover (%) at 2, 4, and 7 weeks after treatment application at Site 2.

Table 7. Percentage reduction in weed cover at Site 2 (calculated using Abbotts formula) – highlighted values show an increase in weed cover.

SITE 2	Weed cover reduction (%)		
	9th Aug	28th Aug	13th Sep
Shark	41.77	56.09	48.70
AHDB 9973	-75.17	-15.15	-14.15
AHDB 9984	34.22	52.15	49.90
AHDB 9976	31.51	40.90	39.99
AHDB 9981	32.93	52.35	49.60
AHDB 9983 + AHDB 9981	28.49	31.35	25.30
AHDB 9985	3.50	8.22	14.86
AHDB 9993	-36.15	7.13	1.29
AHDB 9974	35.09	37.65	53.68
AHDB 9992	-14.11	0.31	4.88
AHDB 9979	26.99	40.85	47.38
AHDB 9982	44.79	71.78	75.34
AHDB 9986 + Mero	54.93	79.33	80.29
AHDB 9977 + AHDB 9978	10.37	10.62	5.98
AHDB 9975 + AHDB 9978	48.45	61.57	54.24
AHDB 9980 + AHDB 9978	58.70	56.42	54.39

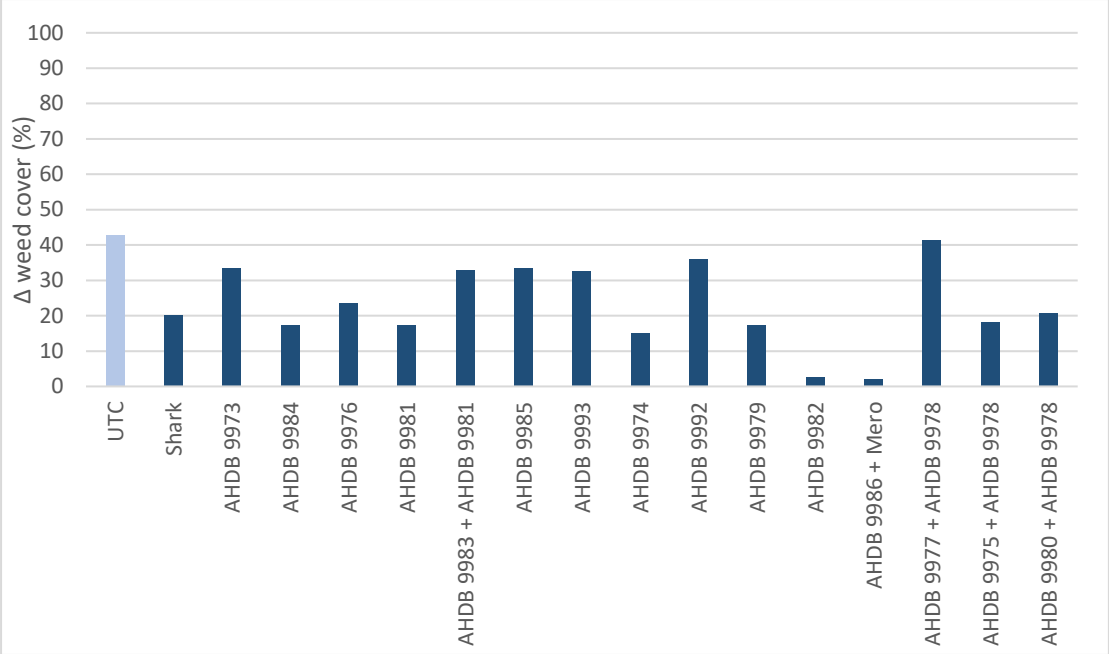


Figure 5. Percentage change in weed cover over 7 week assessment period, i.e. increase in weed cover, at Site 2.

Discussion

The two trial sites differed in levels of weed burden – untreated plots at Site 1 had an average weed cover of 6.48% at eight weeks into the trial, whereas Site 2 untreated plots had an average weed cover of 68.25% at a similar point in the trial. At site 2, ten treatments significantly reduced weed cover at eight weeks after treatment application when compared to the untreated control ($p = 0.003$). These were: Shark, AHDB 9984, AHDB 9976, AHDB 9981, AHDB 9983 in a tank mix with AHDB 9981, AHDB 9974, AHDB 9979, AHDB 9982, AHDB 9986 + Mero, and AHDB 9975 and AHDB 9980 when applied in a tank-mix with AHDB 9978.

The change in weed cover from the baseline to the final assessment was assessed. The mean of the initial weed burden before treatment application at this site was 20.6% and was variable across the field, ranging from a minimum of 10.5% to a maximum of 44.6%. While no treatment showed a decrease in weed cover when compared to the levels of the initial baseline assessment, plots treatment with AHDB 9982 or AHDB 9986 + Mero showed only very small increases in weed cover.

Seven treatments were safe to the crop by harvest at both sites, these were; Shark, AHDB 9973, AHDB 9984, AHDB 9981, AHDB 9985, AHDB 9993, AHDB 9974 and AHDB 9982. All except AHDB 9985 gave transient effects which the crop grew through relatively quickly. These varied from slight yellow clouding, through chlorosis to scorch. AHDB 9979 gave unacceptable levels of stunting and discolouration at both sites, and at Site 2 AHDB 9979, AHDB 9976 and AHDB 9986 + Mero also caused the rhubarb stems to twist, split and delaminate at harvest.

Conclusions

- Shark, AHDB 9981, and AHDB 9982 combine a reasonable level of weed control with being safe to the crop and warrant investigation for EAMU applications for post-harvest use
- AHDB 9974 was also safe to the crop by harvest and gave a useful level of weed control but is no longer being progressed by the company.
- AHDB 9985 is a graminicide which was crop safe to rhubarb and an approval would be useful to improve the options available for grass weed control since the loss of tepraloxydim (Aramo).

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 Neil Cairns of Barfoots (Hants) and Lindsay Hulme, of E. Oldroyd and Sons (Yorks).

Appendix

a. Crop diary – events related to growing crop

Site 1: Barfoots

Crop	Cultivar	Planting date	Row width (m)
Rhubarb	Timperley Early	2015	0.83

Previous cropping

Year	Crop
2014	N/D
2015	N/D

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

Date	Product	Rate (kg/ha)
N/D		

Pesticides applied to trial area

Date	Product	Rate (L/ha)
N/D		

Details of irrigation regime

Date	Type, rate and duration	Amount applied (mm)
N/D		

Site 2: E. Oldroyd

Crop	Cultivar	Planting date	Row width (m)
Rhubarb	Timperley Early	29/01/2016	0.75

Previous cropping

Year	Crop
2014	Winter wheat
2015	Winter barley

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

Date	Product	Rate (kg/ha)
21/02/2016	Nitram	85
19/06/2016	Nitram	60
01/03/2017	Nitram	80

Pesticides applied to trial area

Date	Product	Rate (L/ha)
14/02/16	Gamit 36 CS	0.25
	Stomp Aqua	3.00
05/11/16	Roundup Flex	2.00
15/02/17	Gamit 36 CS	0.25
	Stomp Aqua	3.00

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

SITE 1	
Date	**Event**
13/06/2017	Baseline assessment (weeds) Treatment application
20/06/2017	1 week assessment (phyto)
06/07/2017	3 week assessment (weeds, phyto)
21/07/2017	8 week assessment (weeds, phyto)
08/08/2017	12 week assessment (weeds, phyto)

SITE 2	
Date	**Event**
24/07/2018	Baseline assessment (weeds)
25/07/2017	Treatment application
09/08/2017	2 week assessment (weeds, phyto)
25/08/2017	4 week assessment (weeds, phyto)
13/09/2017	7 week assessment (weeds, phyto)

c. Climatological data during study period from each site.

SITE 1			
Date	**Temperature °C (minimum)**	**Temperature °C (maximum)**	**Rainfall (mm)**
13/06/2017	7	29	0
14/06/2017	8.5	28.5	0
15/06/2017	10	27.5	0
16/06/2017	10	28.5	0
17/06/2017	11.5	33.5	0
18/06/2017	13.5	35	0
19/06/2017	14	35	0
20/06/2017	15.5	36	0
21/06/2017	16.5	34	0
22/06/2017	15	26	0
23/06/2017	12	25.5	0
24/06/2017	16	24.5	0

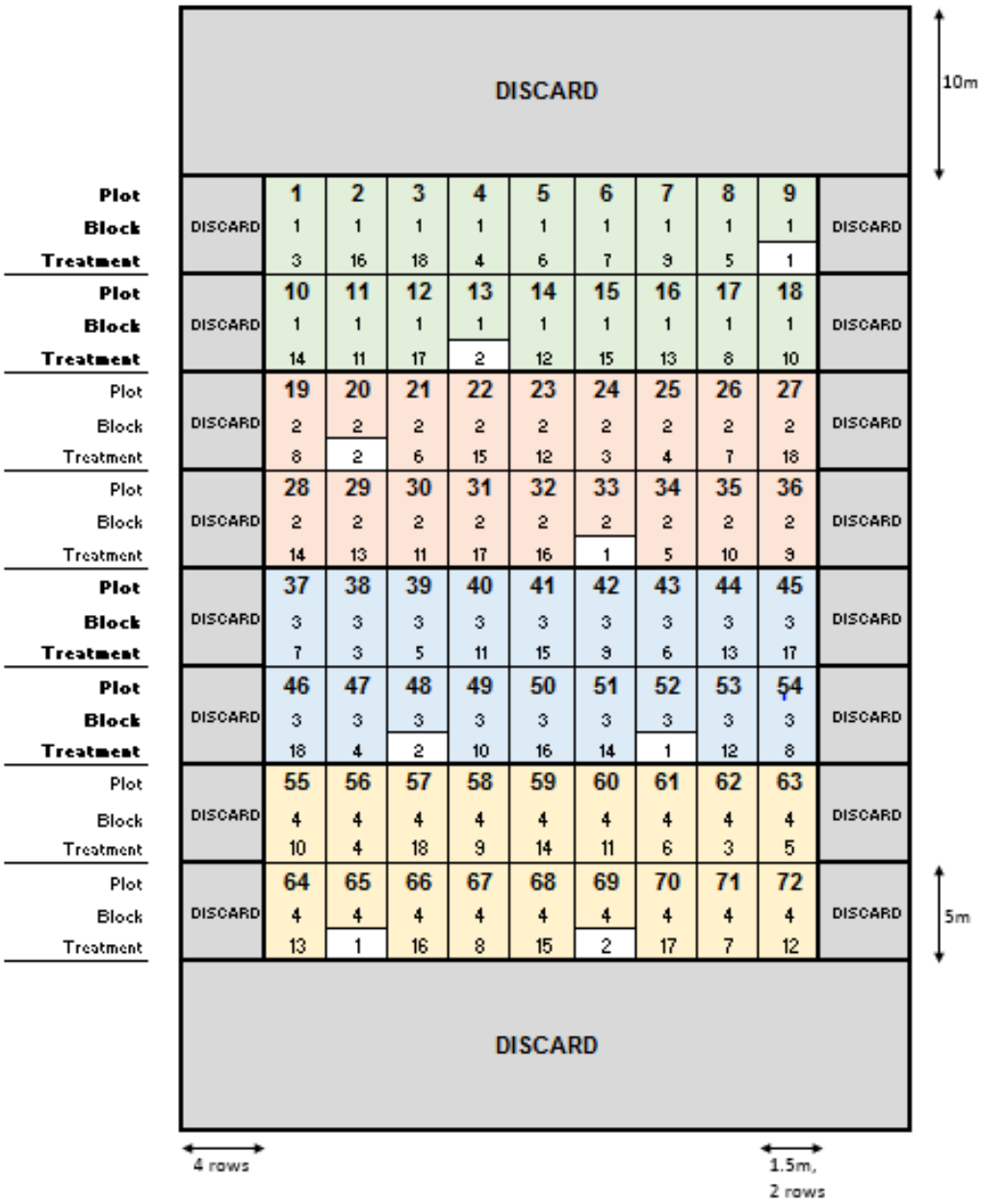
25/06/2017	13	27	0
26/06/2017	11	28	0
27/06/2017	13	26.5	4.6
28/06/2017	13.5	18.5	6.7
29/06/2017	12.5	17.5	1.5
30/06/2017	13.5	22.5	0
01/07/2017	14.5	26	0
02/07/2017	16	29	0
03/07/2017	14	26	0.3
04/07/2017	11.5	26.5	0
05/07/2017	11.5	34	0
06/07/2017	14.5	36.5	0
07/07/2017	13	32.5	0
08/07/2017	15	32.5	0
09/07/2017	14.5	33.5	0
10/07/2017	14.5	29	0
11/07/2017	14	19.5	14.4
12/07/2017	14.5	21	13
13/07/2017	14	24	0
14/07/2017	12.5	24.5	0
15/07/2017	13	22.5	0
16/07/2017	17	26	0
17/07/2017	15.5	30	0
18/07/2017	15	32	23.5
19/07/2017	17	20	16.7
20/07/2017	13.5	21.5	0.4
21/07/2017	13.5	21	16.6
22/07/2017	11.5	18	9.3
23/07/2017	9.5	18.5	10.2
24/07/2017	13	22	0.1
25/07/2017	11.5	24.5	0
26/07/2017	14	19.5	6.9
27/07/2017	13.5	22	0
28/07/2017	14	19.5	2.6
29/07/2017	13.5	18	7.8
30/07/2017	13.5	21	24.6
31/07/2017	12.5	22	0
01/08/2017	12.5	22	0
02/08/2017	14	18	24.2
03/08/2017	15	20.5	0.7
04/08/2017	13.5	20	0.6
05/08/2017	11.5	22	0
06/08/2017	9	20	0
07/08/2017	12.5	20.5	2.3
08/08/2017	14	19	14.6

SITE 2			
Date	**Temperature °C (minimum)**	**Temperature °C (maximum)**	**Rainfall (mm)**
24/07/2017	12.2	18.0	2.7
25/07/2017	11.9	22.6	1.1
26/07/2017	11.7	23.3	1.9
27/07/2017	11.7	19.1	2.2
28/07/2017	13.2	21.3	2.2
29/07/2017	13.2	20.4	1.9
30/07/2017	12.6	21.1	1.7
31/07/2017	12.8	20.9	2.3
01/08/2017	12.6	20.7	4.2
02/08/2017	13.7	20.3	2.4
03/08/2017	15.1	20.9	0.2
04/08/2017	13.4	20.0	0.0
05/08/2017	10.6	19.8	0.0
06/08/2017	11.6	19.7	12.4
07/08/2017	12.4	20.7	2.4
08/08/2017	11.7	13.9	12.6
09/08/2017	11.1	18.4	2.4
10/08/2017	9.4	21.9	0.0
11/08/2017	10.8	19.3	0.0
12/08/2017	12.4	21.3	0.0
13/08/2017	9.6	21.2	0.0
14/08/2017	13.6	21.1	1.2
15/08/2017	12.8	21.1	0.2
16/08/2017	11.3	21.6	2.4
17/08/2017	14.1	24.1	9.0
18/08/2017	11.7	18.1	0.8
19/08/2017	11.7	18.4	0.0
20/08/2017	11.9	19.8	0.0
21/08/2017	11.1	19.6	1.0
22/08/2017	16.2	22.7	0.2
23/08/2017	14.1	21.7	13.4
24/08/2017	12.4	19.9	0.0
25/08/2017	13.2	20.4	0.2
26/08/2017	12.3	22.2	0.2
27/08/2017	11.5	24.0	0.0
28/08/2017	15.8	23.7	0.0
29/08/2017	12.3	19.3	0.6
30/08/2017	10.8	18.3	0.0
31/08/2017	9.8	19.8	0.2
01/09/2017	9.2	19.9	2.2
02/09/2017	8.8	20.8	0.0
03/09/2017	10.8	17.3	0.2
04/09/2017	12.7	21.8	0.8
05/09/2017	12.7	19.7	8.4
06/09/2017	11.4	17.1	1.4
07/09/2017	12.3	16.8	1.2
08/09/2017	11.8	18.2	9.0
09/09/2017	10.1	17.3	2.8

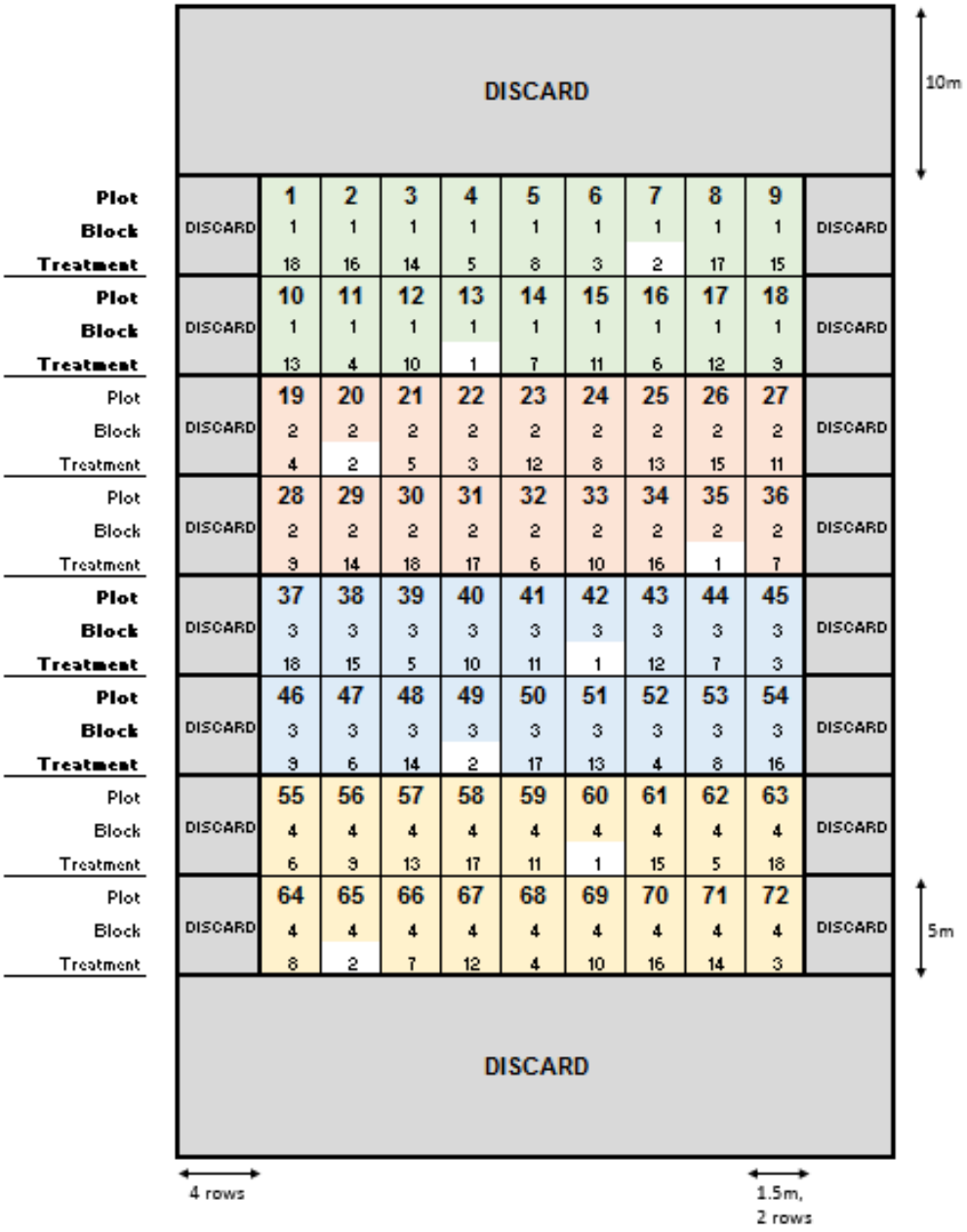
10/09/2017	9.6	17.1	4.4
11/09/2017	10.6	18.3	4.6
12/09/2017	10.9	17.2	6.4
13/09/2017	8.8	16.4	0.2

d) Trial design

SITE 1



SITE 2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1.5m,
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e) Phytotoxic effects:

Crop treated with AHDB 9985 1.5 L/ha, (crop pictured 32 days after treatment, 25/08/2017). Average phyto score for treatment = 9.00.

Crop treated with AHDB 9979 0.5 L/ha, (crop pictured 32 days after treatment, 25/08/2017). Average phyto score for treatment = 2.75.

Crop treated with AHDB 9986 (crop pictured 51 days after treatment, 13/09/2017)

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