SCEPTREPLUS

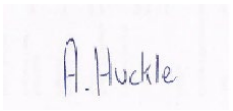
Final Trial Report

Trial code:	SP 51. 2019
Title:	AHDB SCEPTREplus asparagus herbicide screens (inter-row)
Crop	Asparagus
Target	General broadleaf weeds and grasses, 3WEEDT
Lead researcher:	Angela Huckle
Organisation:	RSK ADAS Ltd
Period:	03/2019 – 12/2019
Report date:	31st December 2020
Report author:	Sonia Newman and Angela Huckle
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

1 January 2021

Date



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Trial Summary

Introduction

Weed control in asparagus represents a significant concern for all growers, with an estimated reduction of income to the grower of up to £32,000/ha for every year of production lost if a plantation becomes overgrown with weeds and has to be 'grubbed out' early. In less extreme cases, weed competition can still significantly reduce yield as there are gaps in current control measures. Due to the restricted range of available herbicides and short windows for their application, weeds are becoming a key concern for growers of these crops.

Asparagus is a perennial stem vegetable crop with a long season of growth (up to 8 months). Therefore, through these months (March to October), opportunities for herbicide applications are limited due to harvest restrictions, or the presence of foliage sensitive to approved products. An additional problem is competition from later germinating annuals, such as black nightshade (*Solanum nigrum*) and small nettle (*Urtica urens*). Often, these only emerge after the crop itself has emerged and are challenging to control as it is difficult to apply many contact herbicides safely at this point. The loss of linuron (June 2018) leaves a gap in options for control of black nightshade in particular. Subsequently, weed can build up through the season; and to maintain effective control, new herbicide options with longevity and crop safe application methods are required. Inter-row applications are an approach which can be used to control weeds, but with glyphosate's authorisation under the spotlight, alternatives are required.

The objective of this trial was to identify crop-safe and effective herbicides for inter-row application for postharvest weed control in asparagus crops, aiming to expand the options available to growers.

Methods

The trial was sited in a ten year old asparagus (Guelph Millennium) crop in Bodicote, Oxfordshire. All treatments were applied on 2nd August 2019 after final harvest of the crop and when fern was present but not expanded – therefore it would still be accessible by a high-clearance sprayer or tractor to make the applications without excessive damage to the ferns. Four treatments – those which included Finalsan and AHDB 9838 were repeated on 23rd August 2019. All treatments were applied with 0.5 m hand lance applying the sprays up to the stem bases of the asparagus but not into the stem bases, using a precision knapsack sprayer at 200 L/ha water volume. A randomised block design was used for the trial layout, with four replicates of 14 treatments, including two untreated controls. There were 56 plots in total, each measuring 3.5 m x 5 m.

The plots were assessed on five occasions (see 'Assessment details'), focussing on weed cover and species present, and crop and weed phytotoxicity (i.e. treatment safety). Assessments were carried out approximately one, two, four and six weeks after treatments were applied.

Results

Phytotoxic effects were observed from selected treatments at one and two weeks after treatment application. The damage was most severe from AHDB 9897 at one week after application causing a severe scorch and brown spotting on the stems as well as killing any fern which was lying in the wheeling under the path of the spray. The scorch on the stems persisted until the final assessment six weeks after application (**Table 1**). However, despite the scorch the ferns continued to develop and no loss in vigour was observed. Finalsan at 17 L/ha + Shark 0.3 L/ha and AHDB 9840 also caused minor phytotoxic damage producing a scar or bleach at the stem base of the asparagus, but it was not severe in these treatments and remained below an acceptable level throughout the assessment period.

The commercial standard – Roundup Biactive 5 L/ha also caused a small kink at the stem base in a small percentage of ferns per plot in the first week after application. This is expected and is observed when used in a commercial situation. In all cases the effects were transient, and with the exception of plots treated with AHDB 9897, by four weeks after treatment the damage was no longer visible in the crop.

Table 1. Mean crop phytotoxicity scores at one, two and four weeks after the first inter-row treatment application in asparagus. Scores ≤2 deemed acceptable damage, those above 2 are highlighted in **bold**.

Treatment	Mean crop damage scores (0-10)			
	+ 1 weeks 9 August	+ 2 weeks 16 August	+ 4 weeks 30 August	+ 6 weeks 13 September
Untreated control (UTC)	0.00	0.25	0.00	0.00
Roundup Biactive 5 L/ha	1.00*	0.00	0.00	0.00
Finalsan 34 L/ha	0.00	0.00	0.00	0.00
Finalsan 17 L/ha	0.25	0.25	0.00	0.00
Finalsan 17 L/ha + Activator 90 0.2 L/ha	0.00	0.00	0.00	0.00
Shark 0.3 L/ha	0.75	0.50	0.00	0.00
Finalsan 17 L/ha + Shark 0.3 L/ha	1.25*	0.75	0.00	0.00
AHDB 9839	0.00	0.00	0.00	0.00
AHDB 9897	**3.75***	**2.00***	**2.00***	**2.00***
AHDB 9840	1.25*	1.00*	0.00	0.00
Sencorex 0.25 L/ha + Buctril 0.5 L/ha	0.25	0.25	0.00	0.00
AHDB9976	0.00	0.00	0.00	0.00
AHDB9838	0.00	0.00	0.00	0.00
p-value	<0.001	<0.001	*	*
d.f.	12	12	12	12
L.S.D.	0.833	0.657	*	*

* significantly different to untreated control.

The majority of the treatments tested appeared to be crop safe, with the exception of AHDB 9897. This product caused substantial scorch and scarring to the fern stems which remained at the end of the trial assessment period in September, and although the effects were transitory and vigour was unaffected in this trial, the damage could leave the stems open to infection by disease. The highest rate of the product was used and it would be useful to investigate if a lower rate of use would give similar efficacy with lower damage.

In the trial area, the most common weed species present in all plots were sowthistle, groundsel, fat hen and creeping thistle. At the two week assessment after treatment application, Shark 0.3 L/ha, AHDB 9897, Roundup Biactive 5 L/ha, Finalsan at 34 L/ha, Finalsan 17 L/ha + Shark 0.3 L/ha, AHDB 9840 and Sencorex 0.25 L/ha in a tank mix with Buctril 0.5 L/ha had all killed a significant percentage of the weeds in the plots compared to the untreated control (**Table 2**). Shark and AHDB 9897 were the most effective treatments at this point, however, by the end of the trial (six weeks after application) the level of weeds had built back up in the Shark treated plots and it was no longer maintaining a significant weed reduction.

Table 2. Mean percentage of weeds killed at two weeks after inter-row treatment application.

Treatment	Mean percentage weeds killed (%)
	+ 2 weeks
UTC	0.00
Roundup Biactive 5 L/ha	**45.0***
Finalsan 34 L/ha	**40.0***
Finalsan 17 L/ha	15.0
Finalsan 17 L/ha + Activator 90 0.2 L/ha	5.0
Shark 0.3 L/ha	**78.8***
Finalsan 17 L/ha + Shark 0.3 L/ha	**50.0***
AHDB 9839	27.5
AHDB 9897	**67.5***
AHDB 9840	**43.8***
Sencorex 0.25 L/ha + Buctril 0.5 L/ha	**48.8***
AHDB9976	37.5
AHDB9838	17.5
p-value	0.002
d.f.	12
L.S.D.	34.40

* significantly different to untreated control.

By the four week assessment no phytotoxic effects were noted in any of the treatments, with the exception of AHDB 9897. By the conclusion of the trial, six weeks after the first treatment application, five of the treatments offered a statistically significant reduction in percentage weed cover compared to the untreated control, with no concerning crop damage symptoms (**Table 1** and **3**). These were Finalsan 34 L/ha, AHDB 9840, AHDB 9976, Sencorex 0.25 L/ha in a tank mix with Buctril 0.5 L/ha, and the commercial standard Roundup Biactive 5 L/ha. All reducing weed present by at least 53% compared to the untreated control.

Table 3. Mean percentage weed cover at four and six weeks after inter-row treatment application.

Treatment	Mean percentage weed cover (%)	
	+ 4 weeks	+ 6 weeks
UTC	32.5	40.0
Roundup Biactive 5 L/ha	14.3	**18.5***
Finalsan 34 L/ha	16.8	**15.5***
Finalsan 17 L/ha	31.8	40.0
Finalsan 17 L/ha + Activator 90 0.2 L/ha	28.2	26.8
Shark 0.3 L/ha	22.5	32.5
Finalsan 17 L/ha + Shark 0.3 L/ha	25.5	27.0
AHDB 9839	48.8	42.5
AHDB 9897	25.8	**21.5***
AHDB 9840	**8.5***	**9.5***
Sencorex 0.25 L/ha + Buctril 0.5 L/ha	**6.2***	**8.5***
AHDB9976	21.2	**16.2***
AHDB9838	26.2	31.2
p-value	0.040	0.001
d.f.	12	12
L.S.D.	19.47	15.96

* significantly different to untreated control.

Finalsan 34 L/ha when applied twice, AHDB 9840, AHDB 9976 and Sencorex 0.5 L/ha in a tank mix with Buctril 0.5 L/ha all performed well throughout the duration of the trial. All these treatments performed better than the current standard Roundup, although not giving significantly greater control.

Sencorex 0.25 L/ha + Buctril 0.5 L/ha and Finalsan 34 L/ha are already authorised for use in asparagus and reduced weed levels by 78% and 61% respectively and could be integrated into current weed control progammes to improve efficacy. AHDB 9840 and AHDB 9976 are not currently approved on asparagus, and these reduced weed levels by 76% and 59% respectively, and therefore EAMUs for these products would be useful to improve weed control. In addition, AHDB 9976 would bring greater suppression of field bindweed which is a key gap in weed control for asparagus growers, and AHDB 9840 would bring greater control of creeping thistle, fumitory and composite weeds.

Conclusions

- Finalsan 34 L/ha (when applied twice), and Sencorex 0.25 L/ha + Buctril 0.5 L/ha currently have authorisation for asparagus and could be included immediately in weed control programmes to improve efficacy.

- AHDB 9840 and AHDB 9976 are promising products for weed control in asparagus. They were shown in this trial to be safe and effective as inter-row herbicide treatments.

    - EAMU authorisations for inter-row use by growers would help improve weed control in asparagus crops.

Take home message:

EAMU authorisations for inter-row use of AHDB 9840 and AHDB 9976 should be applied for, to expand the range of actives available to asparagus growers. This would improve weed control and reduce the risk of resistance development.

Objectives

To compare a number of novel inter-row contact herbicides to the commercial standard (Roundup Biactive) for selectivity (crop safety) and efficacy in asparagus at a postharvest timing once ferns had expanded.

Trial conduct

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

Relevant EPPO guideline(s)		**Variation from EPPO**
PP1/135(4)	Phytotoxicity assessment	None
PP1/152(4)	Guidelines on design and analysis of efficacy evaluation trials	None
PP1/225 (2)	Minimum effective dose	None
PP1/181 (4)	Conduct and reporting of efficacy evaluation trials including good experimental practice	None
PP 1/214(3)	Principles of acceptable efficacy	None
PP 1/224(2)	Principles of efficacy evaluation for minor uses	None
PP1/290 (1)	Weeds in asparagus	None

There were no deviations from EPPO guidance.

Test site

Item	**Details**
Location address	Wykham Park Farm Wykham Ln, Banbury OX16 9UP
Crop	Asparagus
Cultivar	Guelph Millennium
Soil or substrate type	Sandy clay loam
Agronomic practice	Modified – no herbicides applied pre- or post-harvest
Prior history of site	Asparagus for previous 10 years

Trial design

Item	**Details**
Trial design:	Randomised – split plot
Number of replicates:	4
Row spacing:	0.5
Plot size: (w x l)	3.5 m x 5 m
Plot size: (m^2)	17.5 m^2
Number of plants per plot:	96 crowns

Treatment details

AHDB Code	Active substance	Product name/ manufacturers code	Formulation batch number	Content of active substance in product	Formulation type	Adjuvant
Untreated	-	-	-	-	-	-
Roundup Biactive	glyphosate	Roundup Biactive	AJF072410A	360 g/L	Soluble concentrate	-
Sencorex Flow	metribuzin	Sencorex Flow	EM4H005971	600 g/L	Suspension concentrate	-
Buctril	bromoxynil	Buctril	NT57GX7887	225 g/L	Emulsifiable concentrate	-
Finalsan	pelargonic acid	Finalsan	11900432	186.7 g/L	Emulsifiable concentrate	-
Activator 90	Alcohol ethoxylates + natural fatty acids	Activator 90	N/K	750 g/kg + 150 g/kg	Emulsifiable concentrate	✓
Shark	carfentrazone-ethyl	Shark	185536	60g/L	Micro-emulsion	-
AHDB 9839	N/D	N/D	N/D	N/D	N/D	-
AHDB 9897	N/D	N/D	N/D	N/D	N/D	-
AHDB 9840	N/D	N/D	N/D	N/D	N/D	-
AHDB 9976	N/D	N/D	N/D	N/D	N/D	-
AHDB 9838	N/D	N/D	N/D	N/D	N/D	-

Application schedule

Treatment number	Treatment: product name or AHDB code	Rate of active substance (ml or g a.s./ha)	Rate of product (l or kg/ha)	Application code
1	UTC	-	-	A
2	UTC	-	-	A
3	Roundup Biactive	1.8 kg/ha	5 L/ha	A
4	Finalsan 34L	6.347 kg/ha	34 L/ha	A,B
5	Finalsan 17L	3.174 kg/ha	17 L/ha	A,B
6	Finalsan 17L + Activator 90	3.174 kg/ha + 150 g/ha + 3 g/ha	17 L/ha + 0.2 L/ha	A,B
7	Shark	18 g/ha	0.3 L/ha	A
8	Finalsan 17L + Shark	3.174 kg/ha + 18 g/ha	17 L/ha + 0.3 L/ha	A
9	AHDB 9839	16.08 kg/ha	67 L/ha	A
10	AHDB 9897	5.3 g/ha	0.2 L/ha	A
11	AHDB 9840	5.0 g/ha + 120 g/ha	1.0 L/ha	A
12	Sencorex + Buctril	120 g/ha + 112.5 g/ha	0.25 L/ha + 0.5 L/ha	A
13	AHDB9976	199 g/ha	0.6 L/ha	A
14	AHDB9838	16.08 kg/ha	67 L/ha	A,B

Application details

	Application A	Application B
Application date	02/08/2019	23/08/2019
Time of day	11:00	10:00
Crop growth stage (Max, min average BBCH)	Asparagus Fern stage	Asparagus Fern stage
Crop height (cm)	180	180
Crop coverage (%)	60	75
Application Method	Spray	Spray
Application Placement	Soil	Soil
Application equipment	Oxford Precision Sprayer (knapsack)	Oxford Precision Sprayer (knapsack)
Nozzle pressure	2.5 Bar	2.5 Bar
Nozzle type	Flat fan	Flat fan
Nozzle size	02/F110	02/F110
Application water volume/ha	200 L/ha	200 L/ha
Temperature of air - shade (°C)	23.3	18.0
Relative humidity (%)	49.7	42.7
Wind speed range (m/s)	0.3	0.15
Dew presence (Y/N)	N	N
Temperature of soil - 2-5 cm (°C)	N/K	N/K
Wetness of soil - 2-5 cm	Dry	Damp
Cloud cover (%)	N/K	85

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 A)	**Infection level mid-assessment period** (Timing A + 4 weeks)	**Infection level at end of assessment period** (Timing A + 6 weeks)
Broad leaved weeds and grasses	N/A	3WEEDT	25.5 %	32.5 %	40 %

Assessment details

Evaluation date	**Evaluation Timing (DA)***	**Crop Growth Stage (BBCH)**	**Evaluation type (efficacy, phytotox)**	**Assessment**
09/08/2019	7	Fern stage	phytotox	Phytotox on crop and weeds (scale 0-10, 0 = dead)
16/08/2019	14	Fern stage	efficacy, phytotox	Percentage of weed killed (whole plot score) Phytotox on crop and weeds (scale 0-10, 0 = dead)
30/08/2019	28	Fern stage	efficacy, phytotox	Percentage of weed cover (whole plot score) Phytotox (scale 0-10, 10 = dead)
13/09/2019	42	Fern stage	efficacy, phytotox	Percentage of weed cover (whole plot score) Phytotox (scale 0-10, 10 = dead)

* DA – days after first application

Statistical analysis

This trial was a randomised block design and comprised 14 treatments, including two untreated controls and grower standard treatment. Treatments were replicated four times.

As the distribution of weeds was generally even across the trial and there was no need to transform the data prior to analysis. The % reduction in weeds was calculated from the means using Abbott's formula.

All data were analysed by ANOVA using Genstat (18th edition) by Chris Dyer (ADAS).

Results

Phytotoxicity

The results of phytotoxicity assessments from four 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.

Phytotoxicity – asparagus

Phytotoxic effects were observed from selected treatments at one and two weeks after treatment application. The damage was most severe from AHDB 9897 at one week after application causing a severe scorch and brown spotting on the stems as well as killing any fern which was lying in the wheeling under the path of the spray. The scorch on the stems persisted until the final assessment six weeks after application (**Figure 2**). However, despite the scorch the ferns continued to develop and no loss in vigour was observed. Finalsan 17 L/ha + Shark 0.3 L/ha and AHDB 9840 also caused minor phytotoxic damage producing a scar or bleach at the stem base of the asparagus (**Figure 3**), but it was not severe in these treatments and remained below an acceptable level throughout the assessment period. The commercial standard – Roundup Biactive 5 L/ha also caused a small kink at the stem base in a small percentage of ferns per plot in the first week after application. This is expected and is observed when used in a commercial situation. In all cases the effects were only transient, and with the exception of plots treated with AHDB 9897, by four weeks after treatment the damage was no longer visible in the crop.

Table 1. Mean crop phytotoxicity scores at one, two and four weeks after the first inter-row treatment application in asparagus. Scores ≤2 deemed acceptable damage, those above 2 are highlighted in **bold**.

Treatment	Mean crop damage scores (0-10)			
	+ 1 weeks 9 August	+ 2 weeks 16 August	+ 4 weeks 30 August	+ 6 weeks 13 September
UTC	0.00	0.25	0.00	0.00
Roundup Biactive 5 L/ha	1.00*	0.00	0.00	0.00
Finalsan 34 L/ha	0.00	0.00	0.00	0.00
Finalsan 17 L/ha	0.25	0.25	0.00	0.00
Finalsan 17 L/ha + Activator 90 0.2 L/ha	0.00	0.00	0.00	0.00
Shark 0.3 L/ha	0.75	0.50	0.00	0.00
Finalsan 17 L/ha + Shark 0.3 L/ha	1.25*	0.75	0.00	0.00
AHDB 9839	0.00	0.00	0.00	0.00
AHDB 9897	**3.75***	**2.00***	**2.00***	**2.00***
AHDB 9840	1.25*	1.00*	0.00	0.00
Sencorex 0.25 L/ha + Buctril 0.5 L/ha	0.25	0.25	0.00	0.00
AHDB9976	0.00	0.00	0.00	0.00
AHDB9838	0.00	0.00	0.00	0.00
p-value	<0.001	<0.001	*	*
d.f.	12	12	12	12
L.S.D.	0.833	0.657	*	*

* significantly different to untreated control.

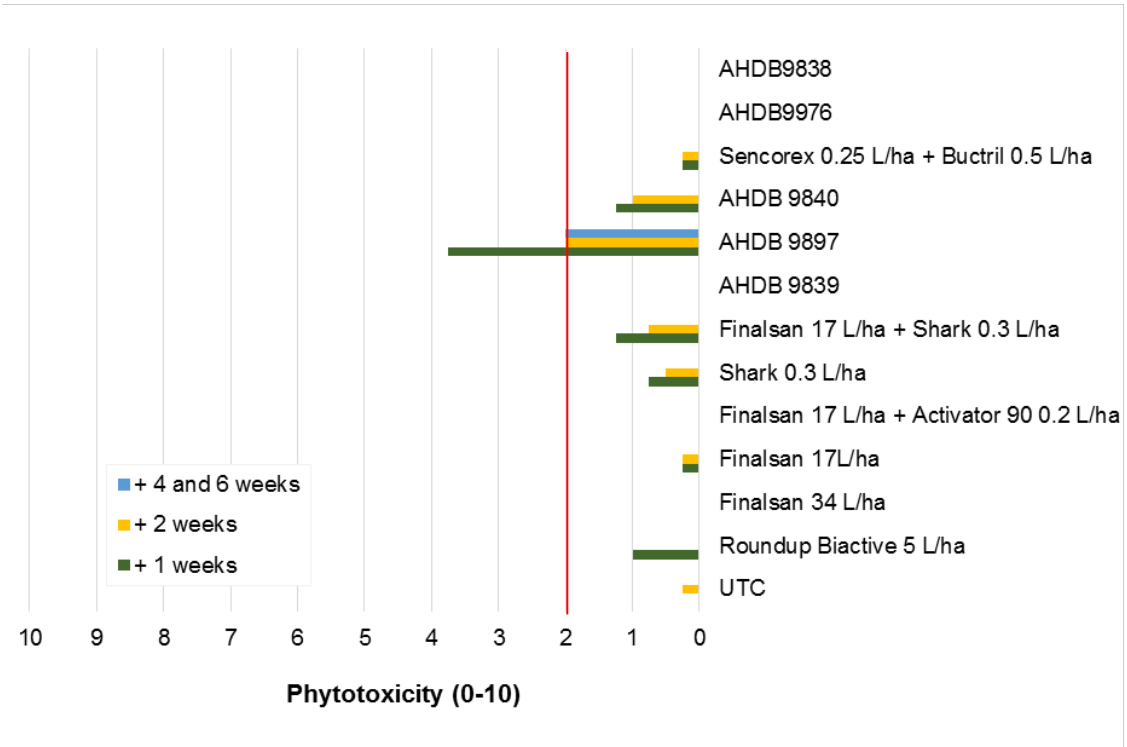

Figure 3. Mean phytotoxicity (0-10) at one and two weeks after the initial post-harvest treatment application. Scores ≤2 (marked by red line) deemed acceptable damage.

Figure 2. Scorch from AHDB 9897 at 1 week after application (L) and 6 weeks after application (R)

Figure 3. Scorch (L) and bleach (R) at 1 week after application from product AHDB 9840

Phytotoxicity – weeds

The phytotoxic effects on weeds was also recorded at one and two weeks after the first treatment application (presented in **Table 2** and **Figure 4**).

All treatments caused significant damage at one week after application to the weeds present when compared to the untreated control, with the exception of Finalsan at 17 L/ha and Finalsan 17 L/ha + Activator 90 0.2 L/ha. Shark 0.3 L/ha and AHDB 9976 caused the highest initial damage to the weeds after one week, with the former increasing weed damage at two weeks after treatment. The damage caused by AHDB 9897 also increased at the second assessment. Damage was mainly exhibited as severe scorch to the weeds, and in the case of Roundup Biactive 5 L/ha, Sencorex 0.25 L/ha + Buctril 0.5 L/ha, AHDB 9840 and AHDB 9976 the growing point was also affected by deformation or killed.

Although products AHDB 9839 and AHDB 9838 caused a moderate initial scorch to foliage, the weeds rapidly recovered a week later.

Table 2. Mean weed phytotoxicity scores at one and two weeks after the first inter-row treatment application in asparagus. The second Finalsan treatments had not been applied by the time of these assessments

Treatment	Mean weed damage scores	
	+ 1 weeks 9 August	+ 2 weeks 16 August
UTC	0.00	0.00
Roundup Biactive 5 L/ha	**4.00***	**3.50***
Finalsan 34 L/ha	**4.25***	**4.00***
Finalsan 17 L/ha	1.00	1.50
Finalsan 17 L/ha + Activator 90 0.2 L/ha	1.25	1.00
Shark 0.3 L/ha	**5.50***	**6.50***
Finalsan 17 L/ha + Shark 0.3 L/ha	**3.25***	**4.25***
AHDB 9839	**4.00***	2.75
AHDB 9897	**4.75***	**5.25***
AHDB 9840	**3.75***	**4.25***
Sencorex 0.25 L/ha + Buctril 0.5 L/ha	**4.75***	**4.50***
AHDB9976	**5.00***	**3.75***
AHDB9838	**3.25***	1.50
p-value	<0.001	0.003
d.f.	12	12
L.S.D.	2.278	2.892

* significantly different to untreated control.

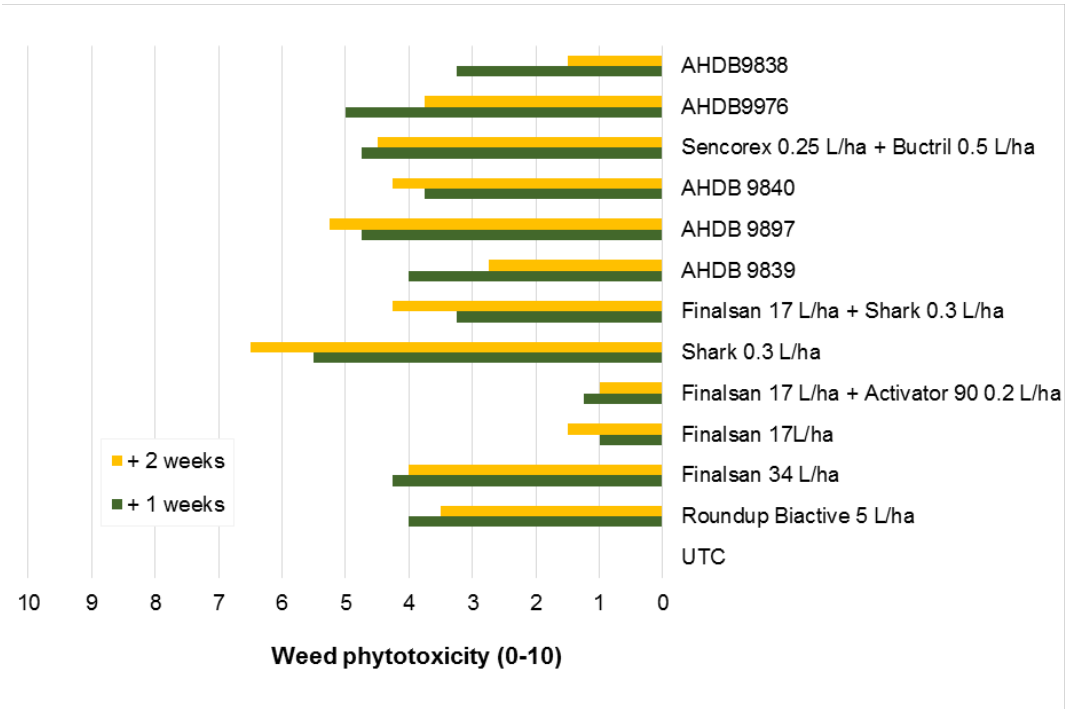

Figure 4. Mean phytotoxicity to weeds in trial (0-10) at one and two weeks after inter-row treatment application.

Efficacy

Weed control – percentage killed

The percentage of weeds killed by the treatments was recorded two weeks after the treatments were applied (**Table 3**). Seven of the treatments applied significantly reduced the weed population after two weeks when compared to the untreated contrrol. Shark 0.3 L/ha and AHDB 9897 were most effective at reducing the weed population, killing 78.8 % and 67.5 % of weeds respectively. Roundup Biactive 5 L/ha, Finalsan at 34 L/ha rate, Finalsan 17 L/ha + Shark 0.3 L/ha, AHDB 9840 and Sencorex 0.25 L/ha + Buctril 0.5 L/ha also killed a significant percentage of the weeds compared to the control at this initial assessment.

Table 3. Mean percentage of weeds killed at two weeks after inter-row treatment application.

Treatment	**Mean percentage weeds killed (%)**
	+ 2 weeks (16 August)
UTC	0.00
Roundup Biactive 5 L/ha	**45.0***
Finalsan 34 L/ha	**40.0***
Finalsan 17 L/ha	15.0
Finalsan 17 L/ha + Activator 90 0.2 L/ha	5.0
Shark 0.3 L/ha	**78.8***
Finalsan 17 L/ha + Shark 0.3 L/ha	**50.0***
AHDB 9839	27.5
AHDB 9897	**67.5***
AHDB 9840	**43.8***
Sencorex 0.25 L/ha + Buctril 0.5 L/ha	**48.8***
AHDB9976	37.5
AHDB9838	17.5
p-value	0.002
d.f.	12
L.S.D.	34.40

* significantly different to untreated control.

Weed control – mean percentage weed cover

The results for the mean percentage weed cover per treatment are presented in **Table 4** and **Figure 5**. 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 5**. The percentage cover of the most common weed species at the final assessment six weeks after treatment are presented in **Table 6**.

In the trial area, the most common weed species present in all plots were sowthistle, groundsel, fat hen and creeping thistle.

At four weeks after application only AHDB 9840 and the Sencorex 0.25 L/ha + Buctril 0.5 L/ha tank mix had significantly lower weed cover compared to the untreated plots. At six weeks after treatment these two treatments plus Roundup Biactive 5 L/ha and AHDB 9976 had all significantly reduced the weed burden lower than in the untreated control by at least 46.25%. The additional application of Finalsan at 34 L/ha also led to a significant reduction in weed levels at the end of the trial, reducing weed cover by 61.25%

The best performing treatments – AHDB 9840 and Sencorex 0.25 L/ha + Buctril 0.5 L/ha reduced weed cover by 76.25 and 78.75 % respectively.

Table 4. Mean percentage weed cover at four and six weeks after inter-row treatment application.

Treatment	Mean percentage weed cover (%)	
	+ 4 weeks 30 August	+ 6 weeks 13 September
UTC	32.5	40.0
Roundup Biactive 5 L/ha	14.3	**18.5***
Finalsan 34 L/ha	16.8	**15.5***
Finalsan 17 L/ha	31.8	40.0
Finalsan 17 L/ha + Activator 90 0.2 L/ha	28.2	26.8
Shark 0.3 L/ha	22.5	32.5
Finalsan 17 L/ha + Shark 0.3 L/ha	25.5	27.0
AHDB 9839	48.8	42.5
AHDB 9897	25.8	**21.5***
AHDB 9840	**8.5***	**9.5***
Sencorex 0.25 L/ha + Buctril 0.5 L/ha	**6.2***	**8.5***
AHDB9976	21.2	**16.2***
AHDB9838	26.2	31.2
p-value	0.040	0.001
d.f.	12	12
L.S.D.	19.47	15.96

* significantly different to untreated control.

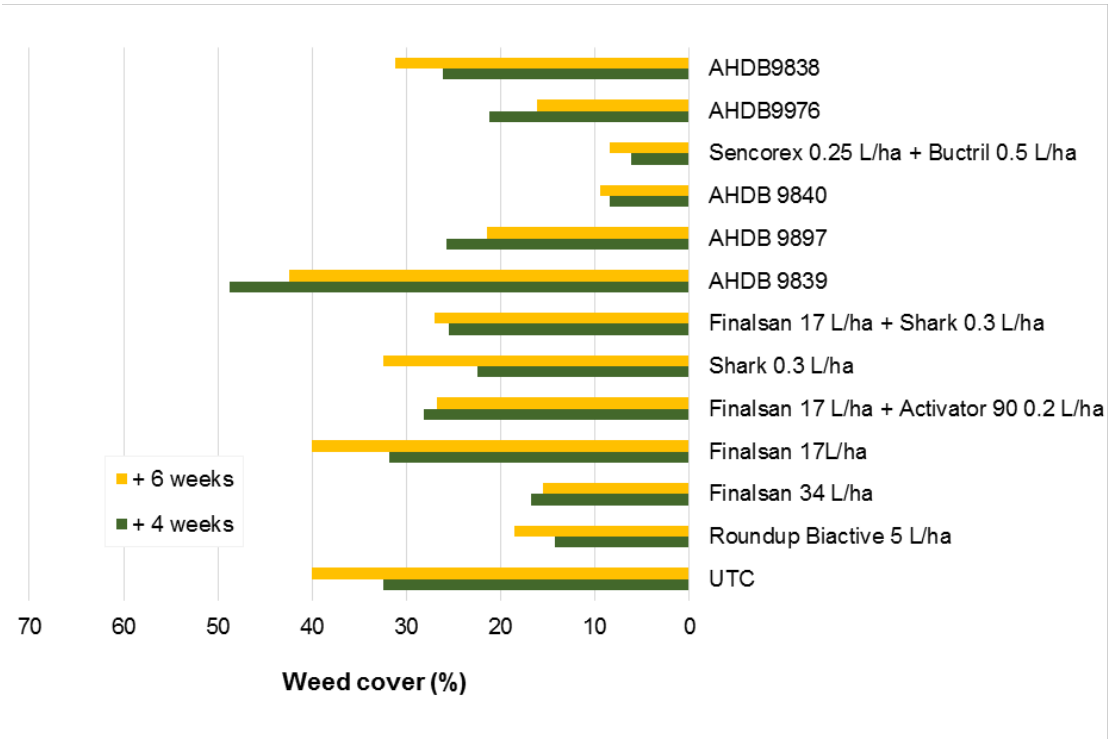

Figure 5. Mean percentage weed cover at four and six weeks after inter-row treatment application in asparagus.

Table 5. Percentage reduction in weed cover compared to the untreated control at four and six weeks after inter-row treatment application (calculated using Abbotts formula).

Treatment	Weed cover reduction (%)	
	+ 4 weeks 30 August	+ 6 weeks 13 September
Roundup Biactive 5 L/ha	56.15	53.75
Finalsan 34 L/ha	48.46	61.25
Finalsan 17 L/ha	2.31	0.00
Finalsan 17 L/ha + Activator 90 0.2 L/ha	13.08	33.13
Shark 0.3 L/ha	30.77	18.75
Finalsan 17 L/ha + Shark 0.3 L/ha	21.54	32.50
AHDB 9839	-50.00	-6.25
AHDB 9897	20.77	46.25
AHDB 9840	73.85	76.25
Sencorex 0.25 L/ha + Buctril 0.5 L/ha	80.77	78.75
AHDB9976	34.62	59.38
AHDB9838	19.23	21.88

When the weeds present at six weeks after application were assessed at a species level, there were significant differences in all of the commonly occurring species except for creeping thistle. Finalsan applied twice at 34 L/ha performed well against groundsel, fat hen and sowthistle along with AHDB 9897, AHDB 9840, Sencorex + Buctril and AHDB9976.

Table 6. Percentage weed cover of the most common weed species (fat hen, groundsel, sowthistle and creeping thistle) at the final assessment six weeks after the initial inter-row treatment application.

Treatment	Mean percentage cover (%) at final assessment			
	Fat hen	Groundsel	Sowthistle	Creeping Thistle
UTC	7.0	6.3	10.0	14.9
Roundup Biactive 5 L/ha	4.8	4.5	5.3	2.8
Finalsan 34 L/ha	**3.3***	**2.3***	**2.4***	2.4
Finalsan 17 L/ha	**2.8***	**2.5***	8.8	18.3
Finalsan 17 L/ha + Activator 90 0.2 L/ha	**3.0***	3.5	**4.5***	15.5
Shark 0.3 L/ha	5.8	5.8	8.3	7.0
Finalsan 17 L/ha + Shark 0.3 L/ha	**3.0***	3.0	**2.3***	13.8
AHDB 9839	4.3	4.0	9.5	18.3
AHDB 9897	**2.3***	**1.8***	**3.8***	13.5
AHDB 9840	**1.8***	**2.8***	**2.3***	2.8
Sencorex 0.25 L/ha + Buctril 0.5 L/ha	**1.0***	**1.0***	**2.8***	3.5
AHDB9976	**3.0***	**2.0***	**3.3***	8.0
AHDB9838	5.0	5.5	12.0	6.5
p-value	0.012	0.020	<0.001	0.208
d.f.	12	12	12	12
L.S.D.	2.96	2.94	4.56	13.12

* significantly different to untreated control.

Discussion

The majority of the treatments tested appeared to be crop safe, with the exception of AHDB 9897. This product caused substantial scorch and scarring to the fern stems which remained at the end of the trial assessment period in September, and although the effects were transitory and vigour was unaffected in this trial, the damage could leave the stems open to infection by disease. The highest rate of the product was used and it would be useful to investigate if a lower rate of use would give similar efficacy with lower damage.

At the two week assessment after treatment application, Shark 0.3 L/ha, AHDB 9897, Roundup Biactive 5 L/ha, Finalsan at 34 L/ha, Finalsan 17 L/ha + Shark 0.3 L/ha, AHDB 9840 and Sencorex 0.25 L/ha in a tank mix with Buctril 0.5 L/ha had all killed a significant percentage of the weeds in the plots compared to the untreated control. Shark and AHDB 9897 were the most effective treatments at this point, however, by the end of the trial (six weeks after application) the level of weeds had built back up in the Shark plots and it was no longer maintaining a significant weed reduction.

By the four week assessment no phytotoxic effects were noted in any of the treatments, with the exception of AHDB 9897. By the conclusion of the trial, six weeks after the first treatment application, five of the treatments offered a statistically significant reduction in percentage weed cover compared to the untreated control, with no concerning crop damage symptoms. These were Finalsan 34 L/ha, AHDB 9840, AHDB 9976, Sencorex 0.25 L/ha in a tank mix with Buctril 0.5 L/ha, and the commercial standard Roundup Biactive 5 L/ha. All reducing weed present by at least 53% compared to the untreated control.

Finalsan 34 L/ha when applied twice, AHDB 9840, AHDB 9976 and Sencorex 0.5 L/ha in a tank mix with Buctril 0.5 L/ha all performed well throughout the duration of the trial. All these treatments performed better than the current standard, although not giving significantly greater control.

Sencorex 0.25 L/ha + Buctril 0.5 L/ha and Finalsan 34 L/ha are already authorised for use in asparagus and reduced weed levels by 78% and 61% respectively and could be integrated into current weed control progammes to improve efficacy. AHDB 9840 and AHDB 9976 are not currently approved on asparagus, and these reduced weed levels by 76% and 59% respectively, and therefore EAMUs for these products would be useful to improve weed control. In addition, AHDB 9976 would bring greater suppression of field bindweed which is a key gap in weed control for asparagus growers, and AHDB 9840 would bring greater control of creeping thistle, fumitory and composite weeds.

Conclusions

- Finalsan 34 L/ha (when applied twice), and Sencorex 0.25 L/ha + Buctril 0.5 L/ha currently have authorisation for asparagus and could be included immediately in weed control programmes to improve efficacy.

- AHDB 9840 and AHDB 9976 are promising products for weed control in asparagus. They were shown in this trial to be safe and effective as inter-row herbicide treatments.

    - EAMU authorisations for inter-row use by growers would help improve weed control in asparagus crops.

Acknowledgements

AHDB for funding the work, and the crop protection companies for their financial contributions and provision of samples for the trials. Thanks too to John and Lizzie Colegrave, who provided the site and crop for the trials, and also Claire Donkin and Phil Langley for technical input to the trials.

Appendix

a. Crop diary – events related to growing crop

Crop	**Cultivar**	**Planting date**	**Row width** (m)
Asparagus	Guelph Millennium	2008	0.85

Previous cropping

Year	**Crop**
2008 -2019	Asparagus

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

Date	**Product**	**Rate** (kg/ha)
N/K	N/K	N/K
N/K	N/K	N/K

Pesticides applied to trial area

Date	**Product**	**Rate** (L/ha)
N/K	N/K	N/K

b. Trial diary

Date	**Event**
02/08/2019	Application A spray
09/08/2019	Assessment, one week after treatment (phyto).
16/08/2019	Assessment, two weeks after treatment (phyto/weeds).
23/08/2019	Application B spray
30/08/2019	Assessment, four weeks after treatment (phyto/weeds).
13/09/2019	Assessment, six weeks after treatment (phyto/weeds).

c. Climatological data during study period

Date	Min. temp. (°C)	Max. temp. (°C)	Precip. (mm)
02/08/2019	23.5	14.5	0.00
03/08/2019	23.9	13.0	0.00
04/08/2019	24.6	13.0	0.00
05/08/2019	22.7	14.8	1.52
06/08/2019	21.8	12.9	3.81
07/08/2019	21.0	13.8	0.00
08/08/2019	24.0	10.6	3.05
09/08/2019	21.9	15.5	16.51

Date	Min. temp. (°C)	Max. temp. (°C)	Precip. (mm)
10/08/2019	19.7	14.7	1.02
11/08/2019	20.9	12.7	7.87
12/08/2019	18.3	11.2	0.25
13/08/2019	20.0	9.9	0.00
14/08/2019	16.9	12.0	12.95
15/08/2019	20.2	12.8	0.00
16/08/2019	20.2	13.8	0.00
17/08/2019	19.7	11.8	0.00
18/08/2019	19.9	11.5	1.27
19/08/2019	19.1	8.3	0.00
20/08/2019	21.6	11.3	0.00
21/08/2019	21.4	11.5	0.00
22/08/2019	24.9	12.1	0.00
23/08/2019	28.4	9.6	0.00
24/08/2019	30.9	12.7	0.00
25/08/2019	30.0	12.6	0.00
26/08/2019	29.6	14.5	1.02
27/08/2019	21.6	12.4	8.64
28/08/2019	20.2	8.6	0.25
29/08/2019	22.7	12.7	0.00
30/08/2019	19.7	11.0	1.27
31/08/2019	17.9	10.2	0.00
01/09/2019	19.5	6.8	0.00
02/09/2019	20.8	11.3	0.00
03/09/2019	18.2	12.5	3.56
04/09/2019	16.1	10.2	0.00
05/09/2019	17.7	9.2	0.00
06/09/2019	16.3	6.8	0.00
07/09/2019	16.5	2.7	0.00
08/09/2019	14.7	8.9	0.00
09/09/2019	17.2	7.1	0.00
10/09/2019	22.8	12.1	1.02
11/09/2019	22.9	11.4	0.00
12/09/2019	18.7	8.6	0.00
13/09/2019	22.3	4.4	0.00

d. Trial design

TREATMENT	DISCARD	DISCARD	DISCARD	DISCARD	DISCARD	DISCARD
BLOCK						
PLOT						
TREATMENT	DISCARD	10	3	7	1	DISCARD
BLOCK		4	4	4	4	
PLOT		411	412	413	414	
TREATMENT	DISCARD	2	13	4	9	DISCARD
BLOCK		4	4	4	4	
PLOT		407	408	409	410	
TREATMENT	DISCARD	5	8	14	6	DISCARD
BLOCK		4	4	4	4	
PLOT		403	404	405	406	
TREATMENT	DISCARD	9	3	12	11	DISCARD
BLOCK		3	3	4	4	
PLOT		313	314	401	402	
TREATMENT	DISCARD	6	11	1	4	DISCARD
BLOCK		3	3	3	3	
PLOT		309	310	311	312	
TREATMENT	DISCARD	10	5	7	12	DISCARD
BLOCK		3	3	3	3	
PLOT		305	306	307	308	
TREATMENT	DISCARD	8	2	13	14	DISCARD
BLOCK		3	3	3	3	
PLOT		301	302	303	304	
TREATMENT	DISCARD	7	9	10	8	DISCARD
BLOCK		2	2	2	2	
PLOT		211	212	213	214	
TREATMENT	DISCARD	14	13	11	1	DISCARD
BLOCK		2	2	2	2	
PLOT		207	208	209	210	
TREATMENT	DISCARD	2	5	12	3	DISCARD
BLOCK		2	2	2	2	
PLOT		203	204	205	206	
TREATMENT	DISCARD	12	7	4	6	DISCARD
BLOCK		1	1	2	2	
PLOT		113	114	201	202	
TREATMENT	DISCARD	3	10	1	4	DISCARD
BLOCK		1	1	1	1	
PLOT		109	110	111	112	
TREATMENT	DISCARD	6	8	5	14	DISCARD
BLOCK		1	1	1	1	
PLOT		105	106	107	108	
TREATMENT	DISCARD	13	11	2	9	DISCARD
BLOCK		1	1	1	1	
PLOT		101	102	103	104	

e. ORETO certificate should be pasted in at end.

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This certifies that

RSK ADAS Ltd

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

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Agriculture/Horticulture
Stored Crops
Biologicals and Semiochemicals

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

Signature *Alison Richardson*
Authorised signatory

Certification Number
ORETO 409

HSE
Chemicals Regulation Division

Department of Agriculture and Rural Development