SCEPTREPLUS

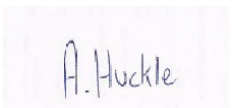
Final Trial Report

Trial code:	SP 51. 2019
Title:	AHDB SCEPTREplus asparagus herbicide screens (post-harvest)
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 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.

The objective of this trial was to identify crop-safe and effective herbicides 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 near Bodicote, Oxfordshire. Treatments were applied on 9th July 2019 after final harvest of the crop and flailing off to remove any remaining spears. Therefore no new spears were present at application. All treatments were applied with a 2 m boom, using a knapsack sprayed at 400 L/ha water volume. A randomised block design was used for the trial layout, with four replicates of 16 treatments, including an untreated control. There were 64 plots in total, each measuring 2 m x 8 m.

The post-harvest trial was flailed twice (21 June and 1 July) before herbicide application due to a late change of site agreed with the Asparagus Growers Association, after the initial site became unavailable. The fern had already expanded as shown in Figure 1, but as it was still young and not tough, and also had good vigour it was determined flailing down again would be acceptable and not affect the trial. No post-harvest herbicides had been applied, the site remained clear of weeds due to dry conditions. It was agreed to flail the crop once more – 9 July - immediately before the application of the herbicides as the spears had grown rapidly. Once mown pre application the trial site appeared as in Figure 1 on the right.

Figure 1 left. Post-harvest trial site on 11 June before first flail down carried out on 21 June
Figure 1 right. Post-harvest trial site on 9 July when post-em herbicides were applied after final flail to remove spears

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

Results

Twelve treatments in the trial significantly reduced percentage mean weed cover while causing no persistent crop damage when applied at a postharvest timing before new spears have emerged. These were Emerger 1.75 L/ha, AHDB 9900, AHDB 9977, and AHDB 9974 when used alone. As well as, all tank-mixes with AHDB 9974, Sencorex 0.5 L/ha + AHDB 9999 and Gamit 36 CS 0.25 L/ha + AHDB 9999.

In the trial area, the most common weed species present in all plots were sowthistle (*Sonchus spp.*), groundsel (*Senecio vulgaris*), fat hen (*Chenopodium album*) and creeping thistle (*Cirsium arvense*).

By six weeks after herbicide application, any crop effects observed within the first month were no longer visible, indicating that there were no persistent crop effects and all treatments were safe at a postharvest application timing (**Table 1**). Minor phytotoxic effects observed at two weeks after treatment application included kinking and twisting noted in the young spears of plants that were treated with either AHDB 9999 alone or where the product was included in a tank mix. Incidence of kinking of newly emerged spears occurred at between 1% - 3% per plot in those treatments where Stomp Aqua was included in tank mixes, and scarring and twists arose at 1-4% incidence in plots where AHDB 9999 was applied. Where AHDB 9999 was added into a tank-mix symptoms increased slightly in incidence at 2% - 7% per plot. As these effects only affected a small percentage of the spears in the plot as described above they were scored just at the acceptable threshold. Many of the other treatments also caused a little minor twisting, but this was not as severe as those above. However, in all cases the effects were transient, and by four weeks after treatment much of the damage was no longer noticeable.

Table 1. Mean crop phytotoxicity scores at two, four, six, and eight weeks after postharvest treatment application in asparagus. Scores ≤2 deemed acceptable damage, those above 2 are highlighted in **bold**.

Treatment	Mean crop damage scores			
	+ 2 weeks	+ 4 weeks	+ 6 weeks	+ 8 weeks
Untreated control	0.5	0	0	0
Stomp Aqua 2.0 + Gamit 0.25 + Sencorex Flow 0.5	0.25	0	0	0
AHDB 9900 full rate	1.5	0	0	0
AHDB 9900 half rate	0	0	0	0
Emerger 1.75 L/ha	0.75	0.25	0	0
AHDB 9977	1.25	0	0	0
AHDB 9974	0	0	0	0
AHDB 9999	**2.25**	0	0	0
Sencorex Flow 0.5 L/ha + AHDB 9974	0.25	0	0	0
Sencorex Flow 0.5 L/ha + AHDB 9999	2	0.25	0	0
Stomp Aqua 2.0 L/ha + AHDB 9974	1.25	0	0	0
Stomp Aqua 2.0 L/ha + AHDB 9999	1.25	0.25	0	0
Gamit 0.25 L/ha + AHDB 9974	0.5	0	0	0
Gamit 0.25 L/ha + AHDB 9999	1.75	0.25	0	0

Treatment	Mean crop damage scores			
	+ 2 weeks	+ 4 weeks	+ 6 weeks	+ 8 weeks
Stomp Aqua 2.0 L/ha + Gamit 0.25 L/ha + Sencorex Flow 0.5 L/ha + AHDB 9974	0.75	0	0	0
p-value	0.075	0.689	N/A	N/A
d.f.	14	14	N/A	N/A
L.S.D.	1.585	0.360	N/A	N/A

AHDB 9974 caused less crop damage and performed better at this trial site than AHDB 9999 when used alone or in equivalent tank-mixes, although the increase in weed control was not a statistically significant improvement. A further benefit of AHDB 9974 over the other products in the trial is that it offers some control of black nightshade which is a gap in weed control for asparagus growers.

Although there was a little moisture at herbicide application, it was subsequently dry during the first four weeks of the trial, which affected weed germination, and the initial efficacy of the products tested, especially where moisture is necessary for greatest efficacy in residual acting products such as Stomp Aqua. However, after a month, rainfall occurred and significant differences were seen in the weed cover in the majority of treated plots compared to the untreated control.

When tested alone Emerger 1.75 L/ha, AHDB 9977, and the full rate of AHDB 9990 all provided excellent weed control for up to ten weeks after postharvest application in asparagus (**Table 2**). All of the these products provided equivalent control to the grower standard tank mix of Stomp Aqua 2.0 + Gamit 0.25 + Sencorex Flow 0.5 for the weed species present in the trial. When AHDB 9974 was tank mixed with either Stomp Aqua 2.0 L/ha or Sencorex Flow 0.5 L/ha alone or Stomp Aqua 2.0 L/ha + Gamit 0.25 L/ha + Sencorex Flow 0.5 L/ha in a four way tank-mix, it also performed well in the trial.

Table 2. Mean percentage weed cover values at four, six, eight, and ten weeks after postharvest treatment application.

Treatment	Mean percentage weed cover (%)			
	+ 4 weeks	+ 6 weeks	+ 8 weeks	+ 10 weeks
Untreated control	3.6	15.4	16.88	28.8
Stomp Aqua 2.0 + Gamit 0.25 + Sencorex Flow 0.5	4.3	**4.3***	**1.1***	**4.5***
AHDB 9900 full rate	6.8	**7.8***	**3.5***	**4.5***
AHDB 9900 half rate	4.8	11.5	**4.3***	**7.8***
Emerger 1.75 L/ha	5.0	**4.5***	**1.3***	**3.5***
AHDB 9977	5.0	9.0	**2.3***	**6.5***
AHDB 9974	2.5	**6.3***	**4.0***	**12.5***
AHDB 9999	6.0	11.3	18.8	20.2
Sencorex Flow 0.5 L/ha + AHDB 9974	3.3	**4.3***	**1.5***	**3.0***
Sencorex Flow 0.5 L/ha + AHDB 9999	2.8	**4.8***	**4.5***	**8.2***
Stomp Aqua 2.0 L/ha + AHDB 9974	6.8	9.0	**2.0***	**4.5***
Stomp Aqua 2.0 L/ha + AHDB 9999	3.5	14.3	13.0	26.2
Gamit 0.25 L/ha + AHDB 9974	3.0	8.5	**5.3***	**7.5***
Gamit 0.25 L/ha + AHDB 9999	8.8	**8.3***	**6.5***	**9.0***

Stomp Aqua 2.0 L/ha + Gamit 0.25 L/ha + Sencorex Flow 0.5 L/ha + AHDB 9974	6.5	**2.5***	**2.8***	**6.5***
p-value	0.904	0.003	<0.001	<0.001
d.f.	14	14	14	14
L.S.D.	6.26	6.11	6.79	12.72

* significantly different to untreated control.

Conclusions

- All products included in the trial were safe to use at a postharvest application timing, and caused only minor transient crop effects.

- Emerger 1.75 L/ha, AHDB 9977, AHDB 9990, and AHDB 9974 are promising products for improving weed control in asparagus, either alone or as tank mix partners. All significantly reduced weed levels in this trial

- EAMU authorisations for postharvest use by growers would improve weed control in asparagus crops.

Take home message:

The use of Emerger 1.75 L/ha, AHDB 9977, AHDB 9990, or AHDB 9974 are not currently authorised for use in asparagus. By the conclusion of the trial, all showed lasting efficacy as postharvest treatments without any persistent phytotoxic effects and would be valuable additions to asparagus growers' weed control options and pursuit of EAMUs for these products would be useful.

Objectives

To compare a number of novel residual and residual/contact herbicides alone and in tank mixes with the commercial standard tank mix (Stomp Aqua + Gamit 36 CS + Sencorex Flow) for selectivity (crop safety) and efficacy in asparagus after harvest.

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 block
Number of replicates:	4
Row spacing:	0.5 m
Plot size: (w x l)	2.5 m x 8 m
Plot size: (m^2)	20 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
Stomp Aqua	pendimethalin	Stomp Aqua	ST12610518	455 g/l	Capsule suspension
Gamit 36 CS	clomazone	Gamit	173113	360 g/L	Capsule suspension
Sencorex Flow	metribuzin	Sencorex Flow	EM4H005971	600 g/L	Suspension concentrate
AHDB 9900	N/D	N/D	N/D	N/D	N/D
N/A	aclonifen	Emerger	EV54003100	600 g/L	Suspension concentrate
AHDB 9977	N/D	N/D	N/D	N/D	N/D
AHDB 9974	N/D	N/D	N/D	N/D	N/D
AHDB 9999	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	Stomp Aqua + Gamit 36 CS + Sencorex Flow	910 + 90 + 300	2.0 L/ha + 0.25 L/ha + 0.5 L/ha	A
4	AHDB 9900	19	0.1 L/ha	A
5	AHDB 9900	11.4	0.06 L/ha	A
6	Emerger	1050	1.75 L/ha	A
7	AHDB 9977	500 + 500	2.5 L/ha	A
8	AHDB 9974	800	2.0 L/ha	A
9	AHDB 9999	3200	4.0 L/ha	A
10	Sencorex Flow + AHDB 9974	300 + 800	0.5 L/ha + 2.0 L/ha	A
11	Sencorex Flow + AHDB 9999	300 + 3200	0.5 L/ha + 2.0 L/ha	A
12	Stomp Aqua + AHDB 9974	910 + 800	2.0 L/ha + 2.0 L/ha	A
13	Stomp Aqua + AHDB 9999	910 + 3200	2.0 L/ha + 2.0 L/ha	A
14	Gamit 36 CS + AHDB 9974	90 + 800	0.25 L/ha + 2.0 L/ha	A
15	Gamit 36 CS + AHDB 9999	90 + 3200	0.25 L/ha + 2.0 L/ha	A
16	Stomp Aqua + Gamit 36 CS + Sencorex Flow + AHDB 9974	910 + 90 + 300 + 800	2.0 L/ha + 0.25 L/ha + 0.5 L/ha + 2.0 L/ha	A

Application details

	Application A
Application date	09/07/2019
Time of day	12:00
Crop growth stage (Max, min average BBCH)	Post- harvest and pre-emergence of spears
Crop height (cm)	0
Crop coverage (%)	0
Application Method	Spray
Application Placement	Soil
Application equipment	Oxford Precision Sprayer (knapsack)
Nozzle pressure	2.5 Bar
Nozzle type	Flat fan
Nozzle size	02/F110
Application water volume/ha	400 L/ha
Temperature of air - shade (°C)	23.3
Relative humidity (%)	66.2
Wind speed range (m/s)	0.1-0.3
Dew presence (Y/N)	N
Temperature of soil - 2-5 cm (°C)	N/A
Wetness of soil - 2-5 cm	Moist
Cloud cover (%)	30

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 + 4 weeks)	Infection level mid-assessment period (Timing A + 6 weeks)	Infection level at end of assessment period (Timing A + 10 weeks)
Broad leaved weeds and grasses	N/A	3WEEDT	3.6%	15.4%	28.8%

Assessment details

Evaluation date	Evaluation Timing (DA)*	Crop Growth Stage	Evaluation type (efficacy, phytotox)	Assessment
18/07/2019	9	Spears, and extension and branching but no fern	phytotox	Phytotox (scale 0-10, 0 = dead)
09/08/2019	31	Young fern, not fully expanded	efficacy, phytotox	Percentage of weed cover (whole plot score) Phytotox (scale 0-10, 0 = dead)
23/08/2019	45	Fully expanded fern	efficacy, phytotox	Percentage of weed cover (whole plot score) Phytotox (scale 0-10, 10 = dead)
06/09/2019	59	Fully expanded fern	efficacy, phytotox	Percentage of weed cover (whole plot score) Phytotox (scale 0-10, 10 = dead)

Evaluation date	Evaluation Timing (DA)*	Crop Growth Stage	Evaluation type (efficacy, phytotox)	Assessment
24/09/2019	77	Fully expanded fern	efficacy	Percentage of weed cover (whole plot score)

* DA – days after application

Statistical analysis

This trial was a randomised block design and comprised 16 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 2**. 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.

Minor phytotoxic effects were observed at two weeks after treatment application. Kinking and twisting was noted in the young spears of plants that were treated with either AHDB 9999 alone or where the product was included in a tank mix (**Figure 1**). Incidence of kinking of newly emerged spears occurred at between 1% - 3% per plot in those treatments where Stomp Aqua was included in tank mixes, and scarring and twists arose at 1-4% incidence in plots where AHDB 9999 was applied (**Figure 1a**). Where AHDB 9999 was added into a tank-mix these symptoms increased slightly in incidence at 2% - 7% per plot (**Figure 1b and 1c**). As these effects only affected a small percentage of the spears in each plot they were scored just at the acceptable threshold. Many of the other treatments also caused a little minor twisting, but this was not as severe as those above. However, in all cases the effects were only transient, and by four weeks after treatment much of the damage was no longer noticeable. At six weeks after treatment no phytotoxic effects were visible in the crop.

Figure 1a. Scarring in AHDB 9999 treated plots.

Figure 1b. Twisting and kinking in Stomp Aqua + AHDB 9999 plots.

Figure 1c. Kinking in Sencorex Flow + AHDB 9999 plots.

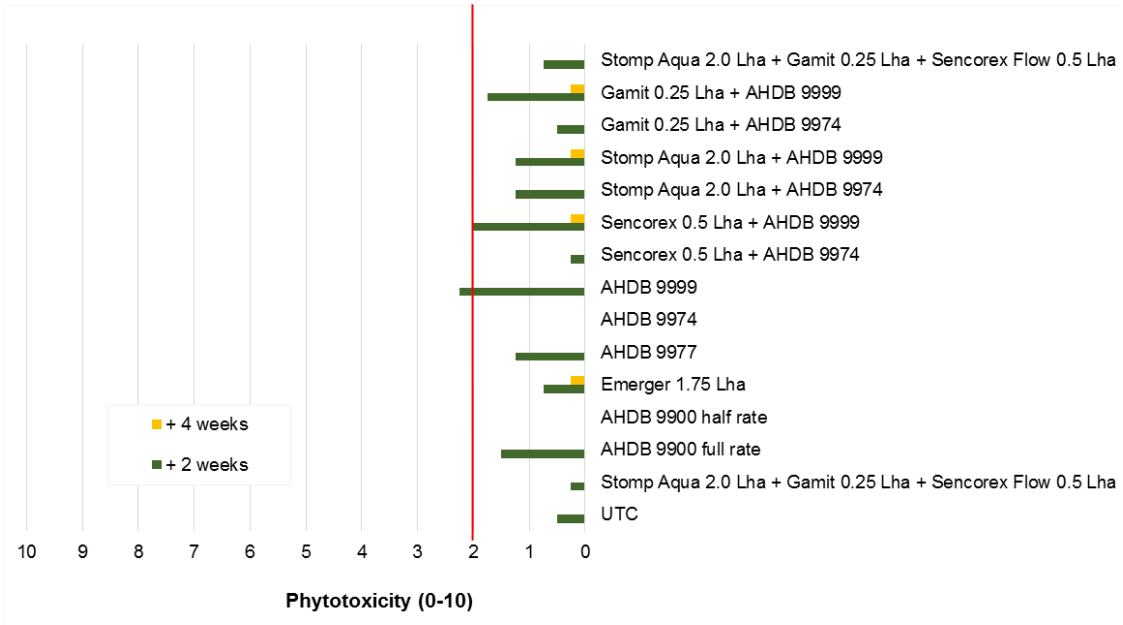


Figure 2. Mean phytotoxicity (0-10) at two and four weeks after post-harvest treatment application. Scores ≤2 (marked by red line) deemed acceptable damage.

Table 1. Mean crop phytotoxicity scores at two, four, six, and eight weeks after postharvest treatment application in asparagus. Scores ≤2 deemed acceptable damage, those above 2 are highlighted in **bold**.

Treatment	Mean crop damage scores (0-10)			
	+ 2 weeks	+ 4 weeks	+ 6 weeks	+ 8 weeks
Untreated control	0.5	0	0	0
Stomp Aqua 2.0 + Gamit 0.25 + Sencorex Flow 0.5	0.25	0	0	0
AHDB 9900 full rate	1.5	0	0	0
AHDB 9900 half rate	0	0	0	0
Emerger 1.75 L/ha	0.75	0.25	0	0
AHDB 9977	1.25	0	0	0
AHDB 9974	0	0	0	0
AHDB 9999	**2.25**	0	0	0
Sencorex Flow 0.5 L/ha + AHDB 9974	0.25	0	0	0
Sencorex Flow 0.5 L/ha + AHDB 9999	2	0.25	0	0
Stomp Aqua 2.0 L/ha + AHDB 9974	1.25	0	0	0
Stomp Aqua 2.0 L/ha + AHDB 9999	1.25	0.25	0	0
Gamit 0.25 L/ha + AHDB 9974	0.5	0	0	0
Gamit 0.25 L/ha + AHDB 9999	1.75	0.25	0	0
Stomp Aqua 2.0 L/ha + Gamit 0.25 L/ha + Sencorex Flow 0.5 L/ha + AHDB 9974	0.75	0	0	0
p-value	0.075	0.689	N/A	N/A
d.f.	14	14	N/A	N/A
L.S.D.	1.585	0.360	N/A	N/A

Efficacy

Weed control – mean percentage weed cover

The results for the mean percentage weed cover per treatment are presented in **Table 2** and **Figure 3**. The percent reduction in weed cover compared to the untreated control was calculated from these figures (using Abbott's formula), and results for each treatment are listed in **Table 3**. The percentage cover of the most common weed species at the final assessment ten weeks after spray application are presented in **Table 4**.

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

Twelve treatments significantly reduced percentage weed cover by up to 56%, to below 13% plot cover for up to ten weeks after application. The only treatments which did not significantly reduce mean percentage weed cover were AHDB 9999 and Stomp Aqua in a tank mix with AHDB 9999. During the first four weeks the weed level across the trial was low, with only 3.6% weed cover in the untreated plots at the week four assessment. Subsequently, the weed levels increased steadily during the latter six weeks of the experiment and by the ten week assessment there was a moderate level of mean weed cover in the untreated plots of 28.8%.

Table 2. Mean percentage weed cover values at four, six, eight, and ten weeks after postharvest treatment application on 9 July.

Treatment	Mean percentage weed cover (%)			
	+ 4 weeks	+ 6 weeks	+ 8 weeks	+ 10 weeks
Untreated control	3.6	15.4	16.88	28.8
Stomp Aqua 2.0 + Gamit 0.25 + Sencorex Flow 0.5	4.3	**4.3***	**1.1***	**4.5***
AHDB 9900 full rate	6.8	**7.8***	**3.5***	**4.5***
AHDB 9900 half rate	4.8	11.5	**4.3***	**7.8***
Emerger 1.75 L/ha	5.0	**4.5***	**1.3***	**3.5***
AHDB 9977	5.0	**9.0***	**2.3***	**6.5***
AHDB 9974	2.5	**6.3***	**4.0***	**12.5***
AHDB 9999	6.0	11.3	18.8	20.2
Sencorex Flow 0.5 L/ha + AHDB 9974	3.3	**4.3***	**1.5***	**3.0***
Sencorex Flow 0.5 L/ha + AHDB 9999	2.8	**4.8***	**4.5***	**8.2***
Stomp Aqua 2.0 L/ha + AHDB 9974	6.8	**9.0***	**2.0***	**4.5***
Stomp Aqua 2.0 L/ha + AHDB 9999	3.5	14.3	13.0	26.2
Gamit 0.25 L/ha + AHDB 9974	3.0	**8.5***	**5.3***	**7.5***
Gamit 0.25 L/ha + AHDB 9999	8.8	**8.3***	**6.5***	**9.0***
Stomp Aqua 2.0 L/ha + Gamit 0.25 L/ha + Sencorex Flow 0.5 L/ha + AHDB 9974	6.5	**2.5***	**2.8***	**6.5***
p-value	0.904	0.003	<0.001	<0.001
d.f.	14	14	14	14
L.S.D.	6.26	6.11	6.79	12.72

* significantly different to untreated control.

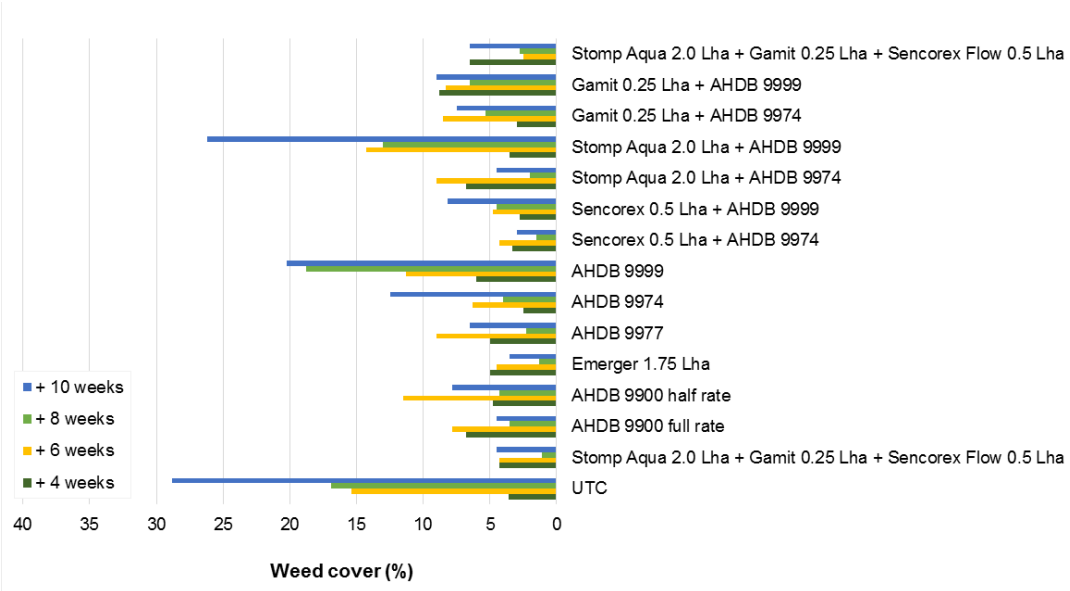


Figure 3. Mean percentage weed cover at four, six, eight and ten weeks after postharvest treatment application in asparagus.

Table 3. Percentage reduction in weed cover compared to the untreated control at four, six, eight, and ten weeks after postharvest treatment application.

Treatment	Weed cover reduction (%)			
	+ 4 weeks	+ 6 weeks	+ 8 weeks	+ 10 weeks
Stomp Aqua 2.0 + Gamit 0.25 + Sencorex Flow 0.5	-17.24	72.36	93.33	84.35
AHDB 9900 full rate	-86.21	49.59	79.26	84.35
AHDB 9900 half rate	-31.03	25.20	74.81	73.04
Emerger 1.75 L/ha	-37.93	70.73	92.59	87.83
AHDB 9977	-37.93	41.46	86.67	77.39
AHDB 9974	31.03	59.35	76.30	56.52
AHDB 9999	-65.52	26.83	-11.11	29.57
Sencorex Flow 0.5 L/ha + AHDB 9974	10.34	72.36	91.11	89.57
Sencorex Flow 0.5 L/ha + AHDB 9999	24.14	69.11	73.33	71.30
Stomp Aqua 2.0 L/ha + AHDB 9974	-86.21	41.46	88.15	84.35
Stomp Aqua 2.0 L/ha + AHDB 9999	3.45	7.32	22.96	8.70
Gamit 0.25 L/ha + AHDB 9974	17.24	44.72	68.89	73.91
Gamit 0.25 L/ha + AHDB 9999	-141.38	46.34	61.48	68.70
Stomp Aqua 2.0 L/ha + Gamit 0.25 L/ha + Sencorex Flow 0.5 L/ha + AHDB 9974	-79.31	83.74	83.70	77.39

There were significant reductions in all of the commonly occurring species present in the trial area. Fat hen was the most difficult to control weed species in the plots with only half of the treatments significantly reducing weed levels compared to the untreated plots. Emerger 1.75 L/ha, AHDB 9977, AHDB 9974 when included in a tank mix with Sencorex 0.5 L/ha, Stomp Aqua 2.0 L/ha, or Gamit 0.25 L/ha, and Sencorex 0.5 L/ha + AHDB 9999, and Stomp Aqua 2.0 L/ha + Gamit 0.25 L/ha + Sencorex Flow 0.5 L/ha + AHDB 9974 all performed at least as well as the grower standard across the most common weed species.

Table 4. Percentage weed cover of the most common weed species (fat hen, groundsel, sowthistle and creeping thistle) at the final assessment ten weeks after postharvest treatment application.

Treatment	Mean percentage cover (%) at final assessment			
	Fat hen	Groundsel	Sowthistle	Creeping Thistle
Untreated control	6.12	7.62	10.50	5.75
Stomp Aqua 2.0 + Gamit 0.25 + Sencorex Flow 0.5	**1.00***	**1.00***	**2.25***	**0.00***
AHDB 9900 full rate	3.00	**0.50***	**0.75***	**0.25***
AHDB 9900 half rate	2.25	**1.25***	**3.00***	**1.25***
Emerger 1.75 L/ha	**0.62***	**0.62***	**1.88***	**0.12***
AHDB 9977	**1.00***	**0.50***	**4.00***	**0.25***
AHDB 9974	3.75	**2.75***	**5.50***	**0.50***
AHDB 9999	5.00	4.25	**5.25***	6.00

Treatment	Mean percentage cover (%) at final assessment			
	Fat hen	Groundsel	Sowthistle	Creeping Thistle
Sencorex Flow 0.5 L/ha + AHDB 9974	**0.75***	**0.75***	**1.25***	**0.25***
Sencorex Flow 0.5 L/ha + AHDB 9999	**1.87***	**1.88***	**4.38***	**0.12***
Stomp Aqua 2.0 L/ha + AHDB 9974	**1.12***	**1.12***	**1.50***	**0.75***
Stomp Aqua 2.0 L/ha + AHDB 9999	4.50	5.50	11.25	2.50
Gamit 0.25 L/ha + AHDB 9974	**1.88***	**1.88***	**1.75***	1.75
Gamit 0.25 L/ha + AHDB 9999	3.73	**2.50***	**3.00***	**0.50***
Stomp Aqua 2.0 L/ha + Gamit 0.25 L/ha + Sencorex Flow 0.5 L/ha + AHDB 9974	**0.12***	**0.00***	**0.12***	**0.00***
p-value	0.043	0.002	<0.001	0.043
d.f.	14	14	14	14
L.S.D.	3.59	3.58	4.66	1.99

* significantly different to untreated control.

Discussion

Twelve treatments in the trial significantly reduced percentage mean weed cover while causing no persistent crop damage when applied at a postharvest timing before new spears have emerged. These were Emerger 1.75 L/ha, AHDB 9900, AHDB 9977, and AHDB 9974 when used alone. As well as, all tank-mixes with AHDB 9974, Sencorex 0.5 L/ha + AHDB 9999 and Gamit 36 CS 0.25 L/ha + AHDB 9999.

By six weeks after herbicide application, any crop effects observed within the first month were no longer visible, indicating that there were no persistent crop effects and all treatments were safe at a postharvest application timing. Minor phytotoxic effects observed at two weeks after treatment application included kinking and twisting noted in the young spears of plants that were treated with either AHDB 9999 alone or where the product was included in a tank mix. Incidence of kinking of newly emerged spears occurred at between 1% - 3% per plot in those treatments where Stomp Aqua was included in tank mixes, and scarring and twists arose at 1-4% incidence in plots where AHDB 9999 was applied. Where AHDB 9999 was added into a tank-mix symptoms increased slightly in incidence at 2% - 7% per plot. As these effects only affected a small percentage of the spears in the plot as described above they were scored just at the acceptable threshold. Many of the other treatments also caused a little minor twisting, but this was not as severe as those above. However, in all cases the effects were transient, and by four weeks after treatment much of the damage was no longer noticeable.

AHDB 9974 caused less crop damage and performed better at this trial site than AHDB 9999 when used alone or in equivalent tank-mixes, although the increase in weed control was not a statistically significant improvement. A further benefit of AHDB 9974 over the other products in the trial is that it offers some control of black nightshade which is a gap in weed control for asparagus growers.

Although there was a little moisture at herbicide application, it was subsequently dry during the first four weeks of the trial, which affected weed germination, and the initial efficacy of the products tested, especially where moisture is necessary for greatest efficacy in residual acting products such as Stomp Aqua. However, after a month, rainfall occurred and significant

differences were seen in the weed cover in the majority of treated plots compared to the untreated control.

When tested alone Emerger 1.75 L/ha, AHDB 9977, and the full rate of AHDB 9990 all provided excellent weed control up to ten weeks after postharvest application in asparagus. All of the these products provided equivalent control to the grower standard tank mix of Stomp Aqua 2.0 + Gamit 0.25 + Sencorex Flow 0.5 for the weed species present in the trial. When AHDB 9974 was tank mixed with either Stomp Aqua 2.0 L/ha or Sencorex Flow 0.5 L/ha alone or Stomp Aqua 2.0 L/ha + Gamit 0.25 L/ha + Sencorex Flow 0.5 L/ha in a four way tank-mix, it also performed well in the trial.

The use of Emerger 1.75 L/ha, AHDB 9977, AHDB 9990, or AHDB 9974 are not currently authorised for use in asparagus. By the conclusion of the trial, all showed lasting efficacy as postharvest treatments without any persistent phytotoxic effects and would be valuable additions to asparagus growers' weed control options and pursuit of EAMUs for these products would be useful.

Conclusions

- All products included in the trial were safe to use at a postharvest application timing, and caused only minor transient crop effects.

- Emerger 1.75 L/ha, AHDB 9977, AHDB 9990, and AHDB 9974 are promising products for improving weed control in asparagus, either alone or as tank mix partners. All significantly reduced weed levels in this trial

- EAMU authorisations for postharvest use by growers would 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

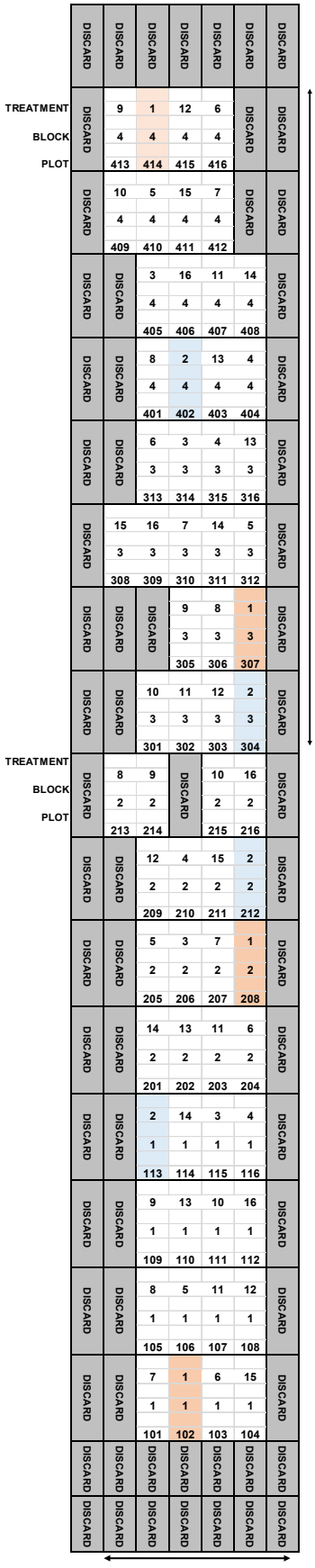
b. Trial diary

Date	**Event**
09/07/2019	Application A spray.
18/07/2019	Assessment, two weeks after treatment (phyto).
09/08/2019	Assessment, four weeks after treatment (phyto/weeds).
23/08/2019	Assessment, six weeks after treatment (phyto/weeds).
06/09/2019	Assessment, eight weeks after treatment (phyto/weeds).
24/09/2019	Assessment, ten weeks after treatment (weeds).

c. Climatological data during study period

Date	Min. temp. (°C)	Max. temp. (°C)	Precip. (mm)
02/07/2019	18.5	9.2	0.00
03/07/2019	21.1	8.1	0.00
04/07/2019	24.1	8.8	0.00
05/07/2019	24.3	12.7	0.00
06/07/2019	18.7	12.0	0.00
07/07/2019	20.7	12.8	0.00
08/07/2019	21.4	11.5	0.00
09/07/2019	22.2	14.1	0.00
10/07/2019	23.3	16.0	0.00
11/07/2019	21.8	13.9	1.02
12/07/2019	21.3	14.8	0.00
13/07/2019	19.8	13.0	0.00
14/07/2019	19.6	12.6	0.00
15/07/2019	19.5	8.7	0.00
16/07/2019	25.3	9.0	0.00
17/07/2019	23.7	11.9	0.00
18/07/2019	21.0	14.4	1.02
19/07/2019	18.5	10.5	13.46
20/07/2019	20.6	14.2	0.00
21/07/2019	21.7	12.1	0.00
22/07/2019	24.2	15.2	0.00
23/07/2019	31.2	14.2	0.00
24/07/2019	28.6	18.5	6.60
25/07/2019	34.4	15.5	0.00
26/07/2019	24.1	18.1	0.00
27/07/2019	18.8	14.7	8.13
28/07/2019	19.0	13.7	0.00
29/07/2019	24.5	10.4	0.00
30/07/2019	19.8	14.9	8.38
31/07/2019	19.7	14.7	0.00
01/08/2019	22.9	14.9	0.00
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
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
14/09/2019	21.8	6.9	0.00
15/09/2019	16.7	12.8	0.00
16/09/2019	17.3	7.6	0.00
17/09/2019	18.3	3.6	0.00
18/09/2019	21.6	5.7	0.00
19/09/2019	21.2	5.2	0.00
20/09/2019	24.8	7.8	0.00
21/09/2019	19.7	12.2	4.32
22/09/2019	19.0	12.1	3.30
23/09/2019	18.8	14.2	20.3
24/09/2019	18.1	14.2	3.56
25/09/2019	18.5	12.7	2.29

d. Trial design



e. ORETO certificate

Certificate of

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This certifies that

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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 Alison Richardson
Authorised signatory

Certification Number
ORETO 409

HSE
Chemicals Regulation Division

Department of Agriculture and Rural Development