

# SCEPTREPLUS

## Final Trial Report

<b>Trial code:</b>	2018. SP 02
<b>Title:</b>	AHDB SCEPTREplus sown herb herbicide screen
<b>Crop:</b>	Leafy vegetables (herbs)
<b>Target:</b>	General broadleaf weeds and grasses, 3WEEDT EPPO1/89(3) Weeds in leafy and brassica vegetables
<b>Lead researcher:</b>	Angela Huckle
<b>Organisation:</b>	RSK ADAS
<b>Period:</b>	14 <sup>th</sup> May 2018 – 31 <sup>st</sup> December 2018
<b>Report date:</b>	16 <sup>th</sup> May 2019
<b>Report author:</b>	Angela Huckle Emily Lawrence
<b>ORETO Number: (certificate should be attached)</b>	ORETO 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

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# Trial Summary

## Introduction

The wide range of herb species grown presents a challenge for growers to identify herbicides which are crop safe to each particular species; there is often little information from manufacturers as herbs are very minor crops. While the herb sector is small, these crops are highly valuable. Any defects or discolouration can lead to rejection, as many herbs are sold as fresh cut products, so knowledge of the crop safety of potential new herbicides is very important.

Linuron has been a key component of herbicide programs for herbs along with pendimethalin, prosulfocarb and lenacil. It formed the basis of commercial programs and was used in tank mixes—both pre- and post-emergence—to complement the weed control spectrums of the other actives. With linuron now withdrawn (3<sup>rd</sup> June 2018), growers are left with very few options for weed control for which they have knowledge of crop safety. It is a high priority for growers to find potential replacement products which are safe for their crops.

The objective of this trial was to identify crop safe herbicides for weed control in a range of herb species, aiming to expand the options available to growers. These trials concentrated on potential new herbicides which may be used to partly or fully replace the current use of linuron.

## Methods

Herbs of six species were included in the trial—basil (cv. Salvo F1), chives (var. Thick leaf, CN CHI 5854), coriander (var. Cadiz), dill (var. Domino), fenugreek (variety not given) and parsley (CN FLPY 5606). These were chosen following consultation with the British Herb Trade Association. The trial was sited on an uncovered hard standing area at ADAS Boxworth. Treatments were either incorporated into the soil before sowing (Devrinol 450 SC), applied over soil in pots just after sowing (Aclonifen and AHDB 9918) or applied over the herbs once emerged (Aclonifen, Oblix 500, Centurion Max AHDB 9918, AHDB 9981 and AHDB 9887). The first treatments (Application A) were applied pre-emergence on 25<sup>th</sup> May 2018. Post-emergence (Application B) treatments were applied on 9<sup>th</sup> July (though fenugreek was treated slightly early (29<sup>th</sup> June), due to advanced growth). The treatments were applied with a 2m boom and an Oxford Precision Sprayer knapsack at 200 L/ha water volume over pots grouped by treatment. After treatment application, the pots were left in situ for a day to allow vapours to disperse, and they were then placed back into the randomised trial design.

A fully randomised block design was used with four replicates of 28 treatments, including an untreated control for comparison, totaling 672 pots. Germination was assessed on 4<sup>th</sup> July in untreated pots and those which received pre-emergence treatments. Crop safety was also assessed; on 2<sup>nd</sup> August vigour scores were recorded, comparing the overall appearance of treated and untreated pots.

## Results

**Table 1.** Mean germination counts for each pre-emergence treatment and herb variety at six weeks after sowing (4<sup>th</sup> July), with overall percent germination and percent germination relative to untreated control. (*NS* = not significant)

Treatment (incl. application rate)	Basil		Chives		Coriander		Dill		Fenugreek		Parsley	
	Overall %	Relative %	Overall %	Relative %	Overall %	Relative %	Overall %	Relative %	Overall %	Relative %	Overall %	Relative %
UTC	72.5	100.0	37.5	100.0	100.0	100.0	70.0	100.0	92.5	100.0	40.0	100.0
Devrinol 450 SC 1.4 L/ha	70.0	96.5	17.5	46.7	92.5	92.5	67.5	96.4	85.0	91.9	5.0	12.5
Devrinol 450 SC 2.8 L/ha	75.0	103.5	22.5	60.0	90.0	90.0	45.0	64.3	82.5	89.2	7.5	18.7
Devrinol 450 SC 5.6 L/ha	57.5	79.3	0.0	0.0	65.0	65.0	12.5	17.8	75.0	81.1	12.5	31.3
AHDB 9918 (0.5x)	12.5	17.3	27.5	73.3	75.0	75.0	62.5	89.3	70.0	75.7	25.0	62.5
AHDB 9918 (1x)	17.5	24.2	2.5	6.7	80.0	80.0	80.0	114.3	47.5	51.4	27.5	68.7
AHDB 9918 (2x)	0.0	0.0	7.5	20.0	82.5	82.5	75.0	107.2	40.0	43.3	7.5	18.7
Aclonifen 0.5 L/ha	62.5	86.2	27.5	73.3	92.5	92.5	75.0	107.2	82.5	89.2	45.0	112.5
Aclonifen 1.0 L/ha	45.0	62.1	45.0	120.0	92.5	92.5	87.5	125.0	95.0	102.7	25.0	62.5
Aclonifen 2.0 L/ha	17.5	24.2	35.0	93.3	97.5	97.5	90.0	128.6	52.5	56.7	27.5	68.7
<b>F prob. value</b>	<0.001		0.003		(NS) 0.092		<0.001		0.006		0.020	
<b>d.f.</b>	30		30		30		30		30		30	
<b>S.E.D.</b>	1.508		1.105		1.124		1.449		1.499		1.195	
<b>L.S.D.</b>	3.080		2.257		2.295		2.960		3.061		2.441	

**Table 2.** Mean vigour scores for each herb variety at 10 weeks after the pre-em application, and four weeks after post-em application (2<sup>nd</sup> August). Scored from 0 to 9; 0 = complete crop death, 9 = no quality reduction, <7 commercially unacceptable damage (*highlighted in red*).

Application A (pre-em)	Application B (post-em)	Basil	Chives	Dill	Fenugreek	Parsley
Untreated	-	9.0	9.0	9.0	9.0	9.0
Devrinol 450 SC 1.4 L/ha	-	7.5	8.7	8.3	6.7	no data
Devrinol 450 SC 2.8 L/ha	-	7.7	6.5	3.7	7.5	no data
Devrinol 450 SC 5.6 L/ha	-	8.7	no data	no data	1.7	6.0
AHDB 9918 (0.5x)	-	8.5	9.0	9.0	6.7	9.0
AHDB 9918 (1x)	-	6.0	9.0	8.7	7.5	9.0
AHDB 9918 (2x)	-	no data	9.0	9.0	8.0	9.0
Aclonifen 0.5 L/ha	-	9.0	8.7	7.7	7.5	9.0
Aclonifen 1.0 L/ha	-	7.5	9.0	9.0	8.5	9.0
Aclonifen 2.0 L/ha	-	8.0	8.5	9.0	8.7	9.0
-	AHDB 9918 (0.5x)	8.5	8.3	7.7	6.5	7.5
-	AHDB 9918 (1x)	9.0	8.5	8.7	6.3	8.5
-	AHDB 9918 (2x)	8.7	8.7	7.5	2.7	9.0
-	Aclonifen 0.5 L/ha	3.3	8.7	6.3	5.7	9.0
-	Aclonifen 1.0 L/ha	3.3	8.7	8.7	4.5	9.0
-	Aclonifen 2.0 L/ha	3.5	8.7	7.5	2.0	8.7
-	AHDB 9981 (0.5x)	3.7	8.7	8.0	8.7	9.0
-	AHDB 9981 (1x)	3.7	9.0	8.0	9.0	7.3
-	AHDB 9981 (2x)	3.7	8.7	7.7	8.0	4.5
-	Centurion Max 0.5 L/ha	8.7	9.0	9.0	7.7	9.0
-	Centurion Max 1.0 L/ha	8.0	8.7	8.0	9.0	9.0
-	Centurion Max 2.0 L/ha	8.3	8.7	8.7	8.7	8.7
-	Oblix 500 1.0 L/ha	9.0	9.0	8.7	7.7	9.0
-	Oblix 500 2.0 L/ha	9.0	8.5	8.3	7.0	9.0
-	Oblix 500 4.0 L/ha	8.5	9.0	8.7	4.0	9.0
-	AHDB 9887 (0.5x)	1.5	8.3	7.5	8.0	5.0
-	AHDB 9887 (1x)	1.5	8.7	4.0	9.0	0.3
-	AHDB 9887 (2x)	0.0	8.3	5.7	2.0	0.0
	<b>F prob. value</b>	<0.001	0.007	<0.001	<0.001	<0.001
	<b>d.f.</b>	73	69	79	83	56
	<b>S.E.D.</b>	0.6672	0.4797	1.035	1.419	0.961
	<b>L.S.D.</b>	1.3298	0.9569	2.061	2.822	1.924

## **Conclusions**

*Note: these results are based on pot trials, and the most promising would need repeating in soil grown crops to confirm crop safety.*

### **Pre-emergence**

For those herbs where germination was greater than 70% (basil, coriander, dill and fenugreek) the following conclusions can be drawn:

- Aclonifen was safe to nearly all the herb species in the trial when applied at up to 2.0 L/ha. Basil was an exception, where aclonifen may only be safe at a lower rate of 1.0 L/ha
- Devrinol 450 SC was safe to basil and fenugreek up to an application rate of 2.8 L/ha. However, it has subsequently been approved for use at a lower rate of 0.85 L/ha, and this lower rate wasn't tested in the trial. There is a possibility that it could be safe to coriander, chives, dill and parsley at this rate, and this warrants further testing.
- AHDB 9918 was only safe to dill.

### **Post-emergence**

For those herbs where germination was greater than 70%, and where they were unaffected by the hot weather (basil, dill and fenugreek), the following conclusions can be drawn:

- AHDB 9981 was safe to dill and fenugreek, and could also be safe to use in chives.
- Oblix 500 (ethofumesate) was safe to all herbs listed above when applied up to 2.0 L/ha, and could also be safe to chives and parsley based on trends indicated in those plots (even though germination was limited).
- Centurion Max was safe to all herbs listed above when applied up to a rate of 1.0 L/ha.

### **Take Home Message**

There is at least one promising pre- and post-emergence herbicide for each herb species which can be taken forward for testing in the field, as well warranting investigation for EAMU authorisation.

## Objectives

1. To test the crop safety of pre- and post-emergence herbicides on herb species.

## 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
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(4)	Principles of acceptable efficacy	None
EPPO PP 1/224(2)	Principles of efficacy evaluation for minor uses	None

There were no deviations from EPPO guidance.

## Test site

Item	Details
Location address	ADAS Boxworth (hard standing) Battle Gate Road Boxworth CB23 4NN Cambridgeshire Grid reference: TL 34330 63366
Crop	Herbs
Cultivar	Chives (Thick leaf, CN CHI 5854), coriander (var. Cadiz), fenugreek, parsley (var. CN FLPY 5606), dill (var. Domino), basil (cv. Salvo F1)
Soil or substrate type	Sterilised loam mix (Rothamsted 'weed mix' – sterilised Kettering loam and lime free grit 3-6 mm in a 4:1 ratio, plus 2 kg/m <sup>3</sup> Osmacote mini 5-6 months 4:1 loam:grit)
Agronomic practice	N/A
Prior history of site	N/A

## Trial design

Item	Details
Trial design:	Fully randomised block
Number of replicates:	4
Plot size:	1L pot
Number of plants per plot:	Approx. 10
<i>Leaf Wall Area calculations</i>	N/A

### Treatment details

AHDB code	Active substance	Product name/ manufacturers code	Formulation batch number	Content of active substance in product (g/L)	Formulation type
N/A	Napropamide	Devrinol 450 SC	429H	450	Suspension Concentrate
AHDB 9918	N/D	N/D	N/D	N/D	N/D
N/A	Aclonifen	Bandur/ Emerger	EV56006446	600	Suspension Concentrate
AHDB 9981	N/D	N/D	N/D	N/D	N/D
N/A	Clethodim	Centurion Max	N/K	120	Emulsifiable Concentrate
N/A	Ethofumesate	Oblix 500	15018151	500	Suspension Concentrate
AHDB 9887	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/ha)	Application code
1	Untreated	-	-	-
2	Devrinol 450 SC	630	1.40	A
3	Devrinol 450 SC	1260	2.80	A
4	Devrinol 450 SC	2520	5.60	A
5	AHDB 9918	N/D	0.24	A
6	AHDB 9918	N/D	0.48	A
7	AHDB 9918	N/D	0.96	A
8	Emerger	300	0.50	A
9	Emerger	600	1.00	A
10	Emerger	900	2.00	A
11	AHDB 9918	N/D	0.24	B
12	AHDB 9918	N/D	0.48	B
13	AHDB 9918	N/D	0.96	B
14	Emerger	300	0.50	B
15	Emerger	600	1.00	B
16	Emerger	900	2.00	B
17	AHDB 9981	N/D	(kg/ha) 1.00	B
18	AHDB 9981	N/D	(kg/ha) 2.00	B
19	AHDB 9981	N/D	(kg/ha) 4.00	B
20	Centurion Max	60	0.50	B
21	Centurion Max	120	1.00	B
22	Centurion Max	240	2.00	B
23	Oblix 500	500	1.00	B
24	Oblix 500	1000	2.00	B
25	Oblix 500	2000	4.00	B
26	AHDB 9887	N/D	0.50	B
27	AHDB 9887	N/D	1.00	B
28	AHDB 9887	N/D	2.00	B

## Application details

	Application A	Application B
Application date	25/05/2018	09/07/2018
Time of day	09:30–10:30	11:30–13:00
Crop growth stage (Max, min average BBCH)	00	14
Crop height (cm)	N/A	Varies by species
Crop coverage (%)	N/A	Varies by species
Application Method	spray	spray
Application Placement	soil	foliar
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	02F110	02F110
Application water volume/ha	200	200
Temperature of air (°C)	28–36	26–35
Relative humidity (%)	28–32	30–41
Wind speed range (mph)	N/A	N/A
Dew presence (Y/N)	N	N
Temperature of soil – 10 cm (°C)	N/K	N/K
Wetness of soil – 2-5 cm	Damp, watered gently after application	Moist
Cloud cover (%)	N/A	40

## Assessment details

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)
04/07/2018	40	14	germination	Count of herb seedlings germinated
02/08/2018	69	35	vigour	Crop vigour (% size reduction compared to UTC; visual comparison, scored 0-9)

\* DA – days after Application A

## Statistical analysis

The trial design was a fully randomised block design, with four replicates of twenty-eight treatments, including an untreated control.

All data were analysed by ANOVA using Genstat 16.0 by Emily Lawrence at RSK ADAS.

## Results

### **SEEDLING GERMINATION – Pre emergence treatments**

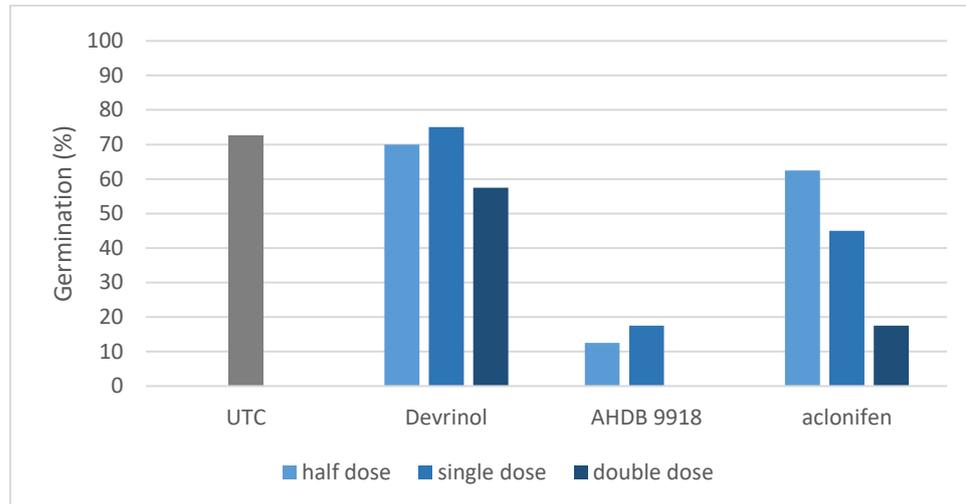
The results for the mean percentage seedling germination per treatment for each herb variety are presented in Table 3.

**Table 3.** Mean germination counts for each pre-emergence treatment and herb variety, with overall percent germination and percent germination relative to untreated control. (*NS* = *not significant*)

Treatment (incl. application rate)	Basil		Chives		Coriander		Dill		Fenugreek		Parsley	
	Overall %	Relative %	Overall %	Relative %	Overall %	Relative %	Overall %	Relative %	Overall %	Relative %	Overall %	Relative %
UTC	72.5	100.0	37.5	100.0	100.0	100.0	70.0	100.0	92.5	100.0	40.0	100.0
Devrinol 450 SC 1.4 L/ha	70.0	96.5	17.5	46.7	92.5	92.5	67.5	96.4	85.0	91.9	5.0	12.5
Devrinol 450 SC 2.8 L/ha	75.0	103.5	22.5	60.0	90.0	90.0	45.0	64.3	82.5	89.2	7.5	18.7
Devrinol 450 SC 5.6 L/ha	57.5	79.3	0.0	0.0	65.0	65.0	12.5	17.8	75.0	81.1	12.5	31.3
AHDB 9918 (0.5x)	12.5	17.3	27.5	73.3	75.0	75.0	62.5	89.3	70.0	75.7	25.0	62.5
AHDB 9918 (1x)	17.5	24.2	2.5	6.7	80.0	80.0	80.0	114.3	47.5	51.4	27.5	68.7
AHDB 9918 (2x)	0.0	0.0	7.5	20.0	82.5	82.5	75.0	107.2	40.0	43.3	7.5	18.7
Aclonifen 0.5 L/ha	62.5	86.2	27.5	73.3	92.5	92.5	75.0	107.2	82.5	89.2	45.0	112.5
Aclonifen 1.0 L/ha	45.0	62.1	45.0	120.0	92.5	92.5	87.5	125.0	95.0	102.7	25.0	62.5
Aclonifen 2.0 L/ha	17.5	24.2	35.0	93.3	97.5	97.5	90.0	128.6	52.5	56.7	27.5	68.7
<b>F prob. value</b>	<0.001		0.003		(NS) 0.092		<0.001		0.006		0.020	
<b>d.f.</b>	30		30		30		30		30		30	
<b>S.E.D.</b>	1.508		1.105		1.124		1.449		1.499		1.195	
<b>L.S.D.</b>	3.080		2.257		2.295		2.960		3.061		2.441	

### Basil

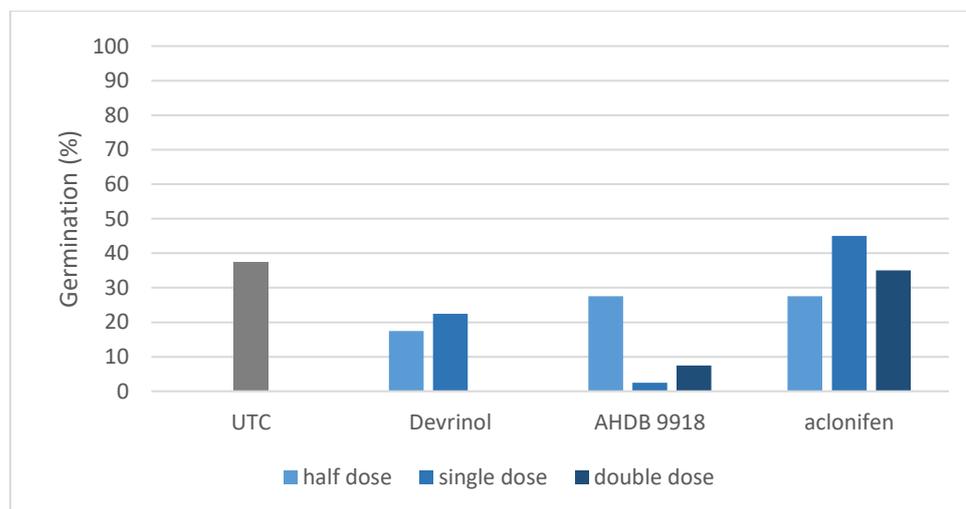
Devrinol 450 SC had very little effect on germination when applied at 2.8 L/ha (single dose) or under, and therefore may be safe to basil when applied pre-emergence at these rates, but when applied at 5.6 L/ha (double dose) it gave a significant reduction in basil germination (Table 3, Figure 1). AHDB 9918 is not safe to use pre-emergence for basil, and all rates significantly reduced germination, with no germination when AHDB 9918 was applied at twice the normal rate. Aclonifen treated pots also showed a significant reduction in seedling germination, with this effect increasing with higher rates of product application. However, there may be some promise of aclonifen being crop safe when applied at a lower rate of 0.5 L/ha (half dose).



**Figure 1.** Mean germination counts (%) for pre-emergence treatments on basil. Assessment carried out 40 days post-treatment.

### Chives

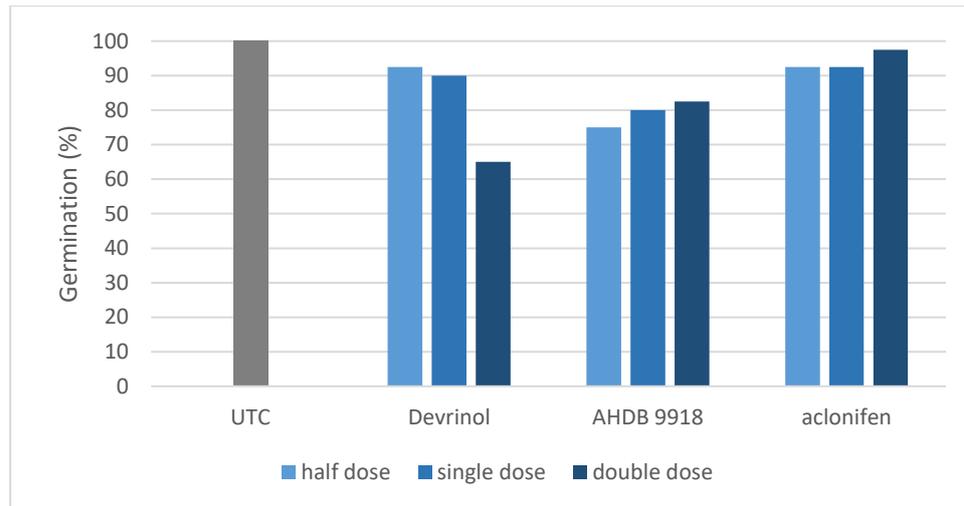
Chive germination averaged 22.2% across all treatments, and therefore it was not possible to draw any conclusions on crop safety as there was also low emergence in the untreated pots (37.5%). However, equivalent germination numbers in the aclonifen and lower rates of Devrinol 450 SC mean that these products warrant further investigation (Table 3, Figure 2).



**Figure 2.** Mean germination counts (%) for pre-emergence treatments on chives. Assessment carried out 40 days post-treatment.

### Coriander

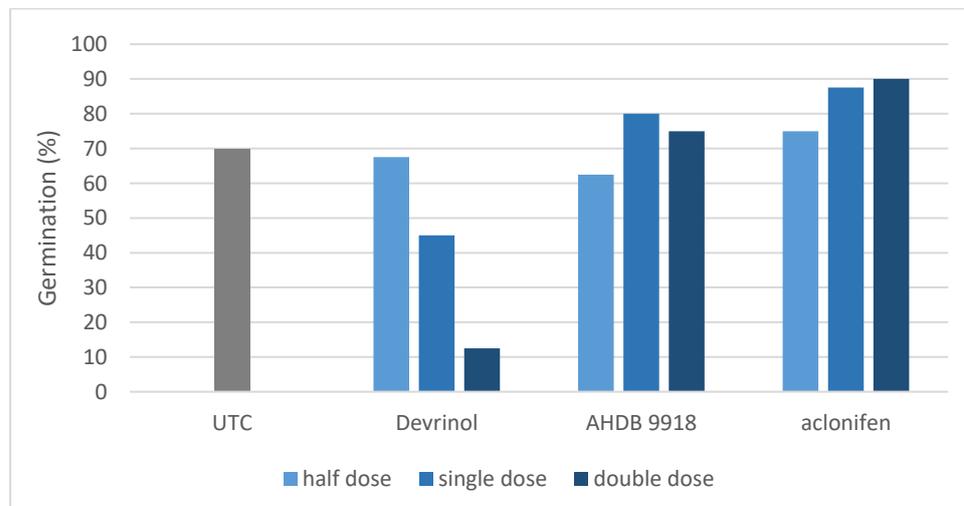
Germination rates were high in coriander, with 100% germination in untreated pots (Table 3, Figure 3). There were no significant differences in germination rate between any herbicide treatment and the untreated control, due to variation in germination in the treated pots. However, some trends could be determined to guide the products to take forward. Aclonifen applied pre-emergence had little effect on the germination rate of coriander, with these pots showing only a small reduction in the number of seedlings emerging, regardless of application rate. Therefore, this product could likely be crop safe for coriander. Germination in pots treated with AHDB 9918 and Devrinol 450 SC at 5.6 L/ha (double dose) was lower, with up to a 25% reduction seen in pots treated with AHDB 9918, even at half rate. Devrinol 450 SC could be safe to coriander at lower rates of 2.8 L/ha (single dose) or below.



**Figure 3.** Mean germination counts (%) for pre-emergence treatments on coriander. Assessment carried out 40 days post-treatment.

### Dill

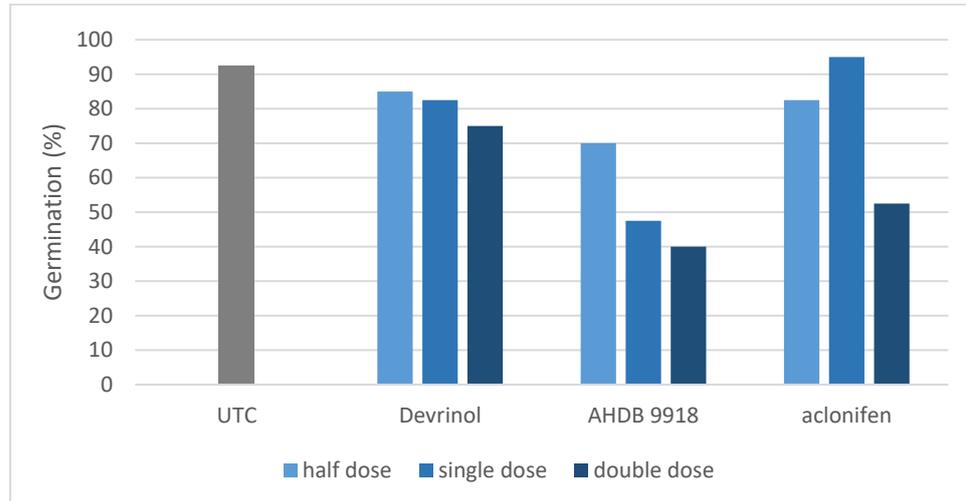
Overall dill germination averaged 66.5% across all treatments, but germination rate in treated plots was—in many cases—greater than that of the untreated, and significant differences were seen (Table 3, Figure 4). AHDB 9918 or aclonifen applied pre-emergence showed little effect on dill germination when applied at any rate, and could be crop safe pre-emergence to dill. However, Devrinol 450 SC did significantly reduce the percentage germination when applied at 2.8 L/ha (single dose) or higher. However, it may still be safe at 1.4 L/ha or lower rates.



**Figure 4.** Mean germination counts (%) for pre-emergence treatments on dill. Assessment carried out 40 days post-treatment.

### Fenugreek

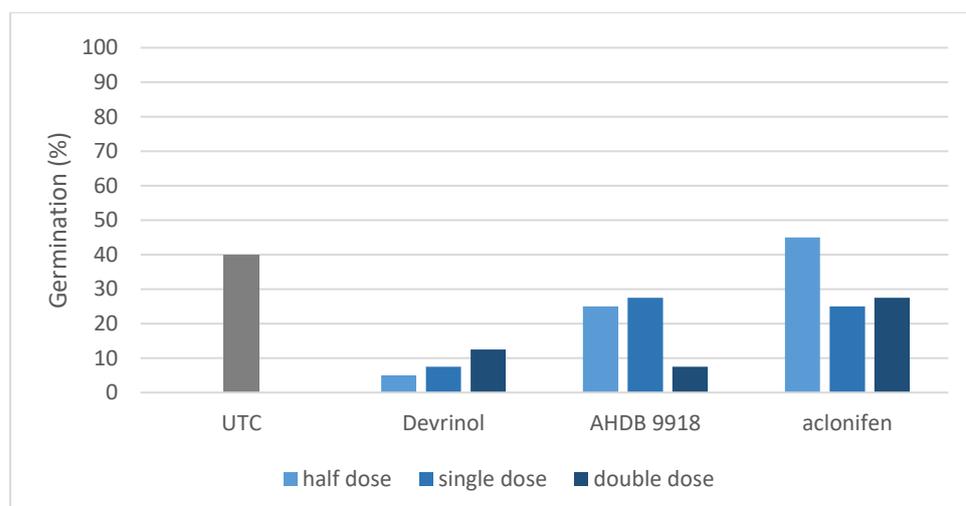
Fenugreek germination was good, with 93.5% germination in untreated plots. Pots treated with Devrinol 450 SC showed a small yet significant reduction in germination rate, with application at double normal rate having the greatest reduction—up to nearly 20% (Table 3, Figure 5). Reduction in germination rates were more noticeable in pots treated with aclonifen at 4.0 L/ha (double dose) or AHDB 9918 at all rates, with the application of these products showing greater reduction with increased treatment rate; germination in pots treated with twice the normal rate of AHDB 9918 was 52.5%, and 40% in pots treated with 4 L/ha of aclonifen. Aclonifen may be crop safe to fenugreek at rates of 2.0 L/ha or below.



**Figure 5.** Mean germination counts (%) for pre-emergence treatments on fenugreek. Assessment carried out 40 days post-treatment.

### Parsley

Parsley germination averaged only 40% in the untreated control, and therefore it was not possible to draw any firm conclusions on crop safety. However, germination numbers equivalent or near equivalent to that of the untreated control for aclonifen applied at 0.5 L/ha (single dose) and lower rates of AHDB 9918 mean that these products could warrant further investigation (Table 3, Figure 6).



**Figure 6.** Mean germination counts (%) for pre-emergence treatments on parsley. Assessment carried out 40 days post-treatment.

## VIGOUR

The results for the mean vigour per treatment for each herb variety are presented in Table 4 (Note: no data available for coriander, as the plants died in the hot, dry conditions despite irrigation).

Vigour was recorded using the following scale:

Crop vigour score	Equivalent to crop damage (% quality reduction)
0	complete crop death
1	80-90% reduction
2	70-80%
3	60-70%
4	50-60%
5	40-50%
6	30-40%
7*	20-30%
8	10-20%
9	no quality reduction

\* 7 = minimum level of acceptable vigour reduction, i.e. damage unlikely to reduce yield, and acceptable to grower.

**Table 4.** Mean vigour scores for each herb variety. Scored from 0 to 9; 0 = complete crop death, 9 = no quality reduction, scores <7 deemed commercially unacceptable damage (*indicated in red*).

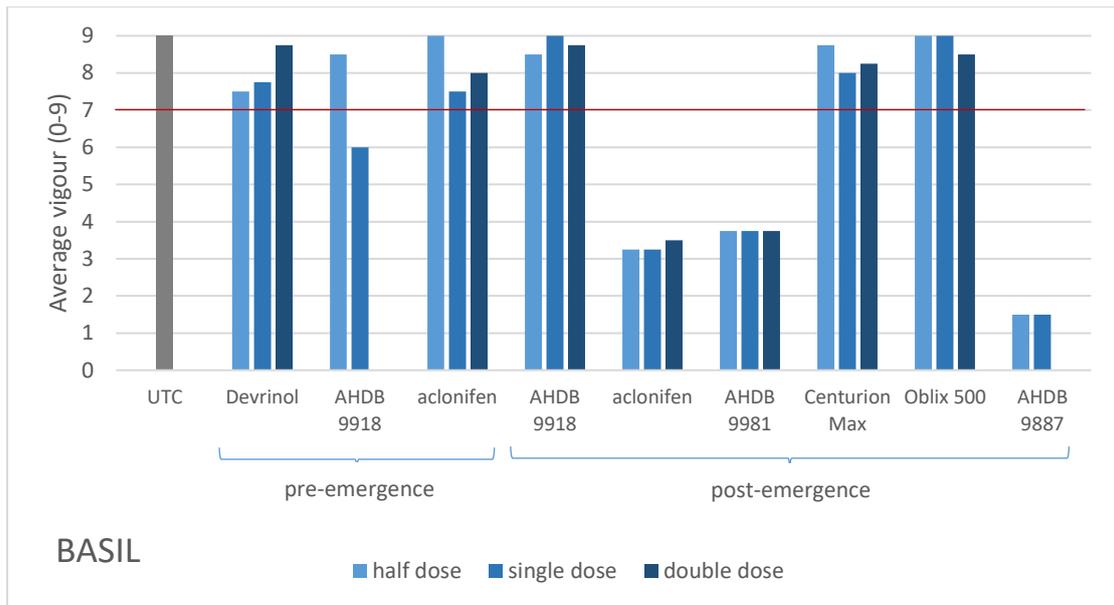
Application A (pre-em)	Application B (post-em)	Basil	Chives	Dill	Fenugreek	Parsley
Untreated	-	9.0	9.0	9.0	9.0	9.0
Devrinol 450 SC (0.5x)	-	7.5	8.7	8.3	6.7	<i>no data</i>
Devrinol 450 SC (1x)	-	7.7	6.5	3.7	7.5	<i>no data</i>
Devrinol 450 SC (2x)	-	8.7	<i>no data</i>	<i>no data</i>	1.7	6.0
AHDB 9918 (0.5x)	-	8.5	9.0	9.0	6.7	9.0
AHDB 9918 (1x)	-	6.0	9.0	8.7	7.5	9.0
AHDB 9918 (2x)	-	<i>no data</i>	9.0	9.0	8.0	9.0
Aclonifen (0.5x)	-	9.0	8.7	7.7	7.5	9.0
Aclonifen (1x)	-	7.5	9.0	9.0	8.5	9.0
Aclonifen (2x)	-	8.0	8.5	9.0	8.7	9.0
-	AHDB 9918 (0.5x)	8.5	8.3	7.7	6.5	7.5
-	AHDB 9918 (1x)	9.0	8.5	8.7	6.3	8.5
-	AHDB 9918 (2x)	8.7	8.7	7.5	2.7	9.0

Application A (pre-em)	Application B (post-em)	Basil	Chives	Dill	Fenugreek	Parsley
-	Aclonifen (0.5x)	3.3	8.7	6.3	5.7	9.0
-	Aclonifen (1x)	3.3	8.7	8.7	4.5	9.0
-	Aclonifen (2x)	3.5	8.7	7.5	2.0	8.7
-	AHDB 9981 (0.5x)	3.7	8.7	8.0	8.7	9.0
-	AHDB 9981 (1x)	3.7	9.0	8.0	9.0	7.3
-	AHDB 9981 (2x)	3.7	8.7	7.7	8.0	4.5
-	Centurion Max (0.5x)	8.7	9.0	9.0	7.7	9.0
-	Centurion Max (1x)	8.0	8.7	8.0	9.0	9.0
-	Centurion Max (2x)	8.3	8.7	8.7	8.7	8.7
-	Oblix 500 (0.5x)	9.0	9.0	8.7	7.7	9.0
-	Oblix 500 (1x)	9.0	8.5	8.3	7.0	9.0
-	Oblix 500 (2x)	8.5	9.0	8.7	4.0	9.0
-	AHDB 9887 (0.5x)	1.5	8.3	7.5	8.0	5.0
-	AHDB 9887 (1x)	1.5	8.7	4.0	9.0	0.3
-	AHDB 9887 (2x)	0.0	8.3	5.7	2.0	0.0
	<b>F prob. value</b>	<0.001	0.007	<0.001	<0.001	<0.001
	<b>d.f.</b>	73	69	79	83	56
	<b>S.E.D.</b>	0.6672	0.4797	1.035	1.419	0.961
	<b>L.S.D.</b>	1.3298	0.9569	2.061	2.822	1.924

## Basil

Pre-emergence application of Devrinol 450 SC, and post-emergence application of Centurion Max and Oblix 500 appeared to have little effect on vigour of basil (Table 4, Figure 7). Aclonifen had little effect on vigour of the basil which managed to emerge, but it should be noted that germination was reduced at 1.0 L/ha or above. Pre-emergence application of AHDB 9918 caused poor germination at all rates (see germination results in previous section), and also reduced vigour in surviving crop at label rate or above.

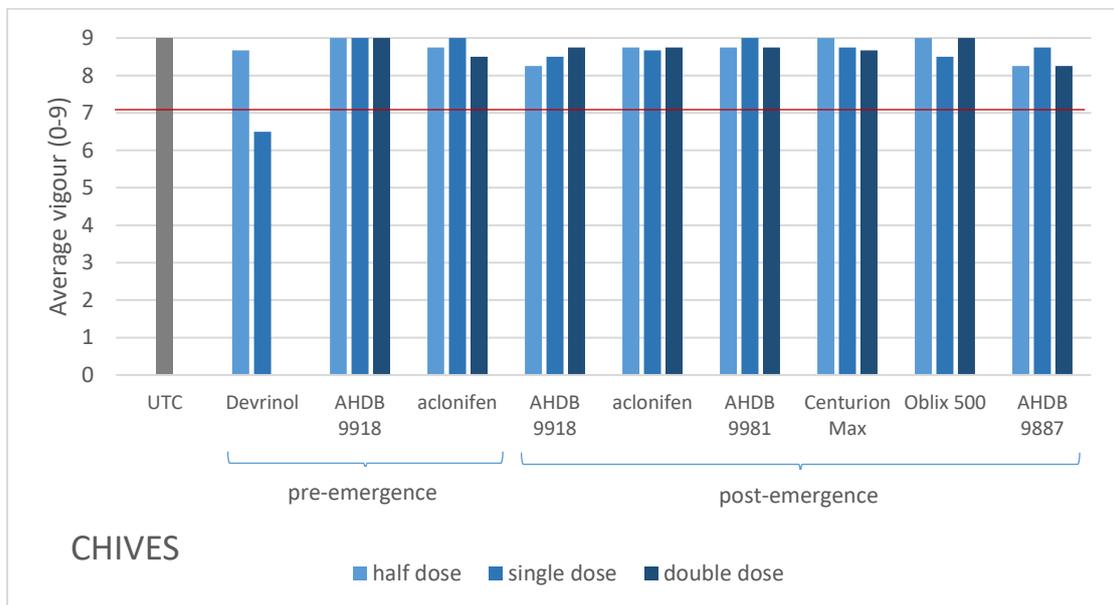
Post-emergence application of aclonifen or AHDB 9981 at any rate had a significant effect on the vigour of the basil, causing foliar yellowing. Basil treated with a post-emergence application of AHDB 9887 showed a significant reduction in vigour and is not safe to basil, regardless of application rate. At half rate, AHDB 9887 treated plants showed foliar scorching and yellowing; at normal rate some plants were scorched, while others had died. No plants survived when treated post-emergence with AHDB 9887 at double rate.



**Figure 7.** Mean vigour scores for basil treated with various herbicides, at half, single or double dose rate. Assessment carried out 69 days after treatment. Scores of 7 or above deemed acceptable vigour (as indicated by red line).

### Chives

Chives had a very low germination rate of an average of 37.5% in the untreated and 22.5% across all treatments, therefore the results presented in (Table 4, Figure 8) are just a guide, and further work is required to confirm any trends. All post-emergence treatments appeared to be crop-safe to chives but this would need to be repeated to be confirmed.



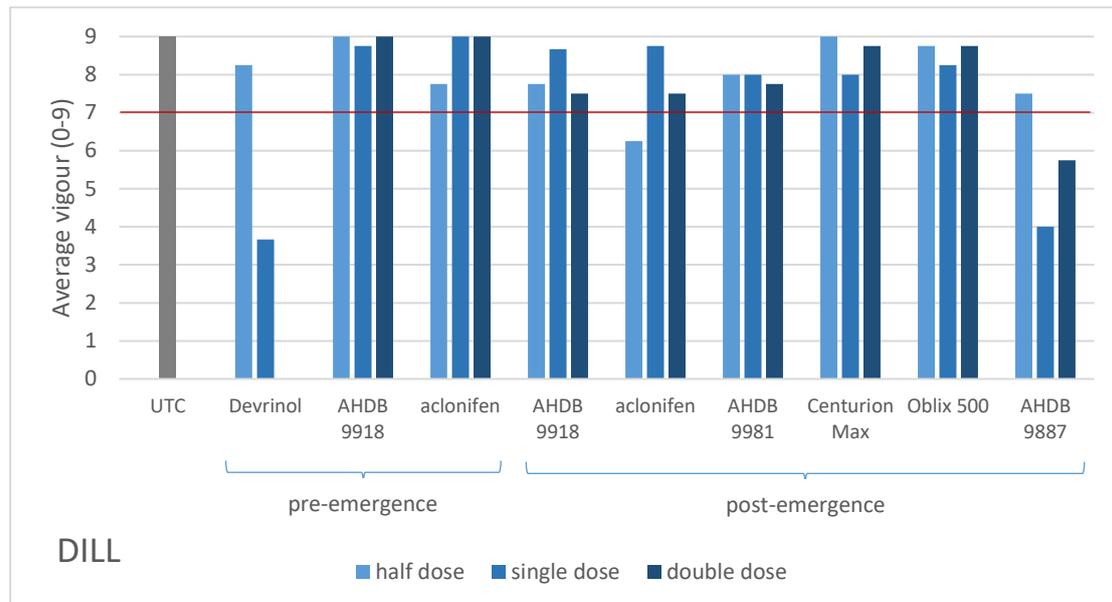
**Figure 8.** Mean vigour scores for chives treated with various herbicides, at half, single or double dose rate. Assessment carried out 69 days after treatment. Scores of 7 or above deemed acceptable vigour (as indicated by red line).

### Coriander

No vigour assessment could be carried out for coriander, as all plants died in very hot weather.

## Dill

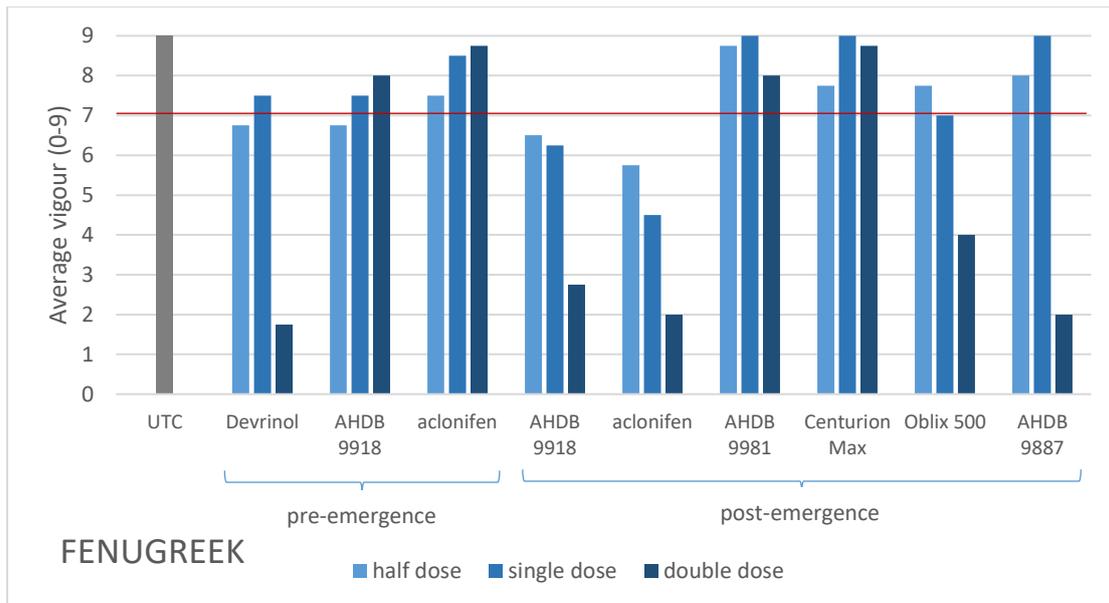
Pre-emergence application of AHDB 9918 and aclonifen, and post-emergence application of AHDB 9918, AHDB 9981, Centurion Max or Oblix 500 had little effect on dill vigour, and could be safe to this herb species (Table 4, Figure 9). Pre-emergence application of Devrinol 450 SC at 1.4 L/ha appeared crop safe, but when applied at 2.8 L/ha or above it caused some stunting and poor germination. The response of dill to a post-emergence application of aclonifen was variable, with some reduction in vigour at 0.5 L/ha and 2.0 L/ha (half and double dose respectively), causing stunting, reddened foliage and scorched leaf tips. However, at 1.0 L/ha there appeared to be little effect. Effects on the herbs from the hot weather could have caused confounding effects. Post-emergence application of AHDB 9887 at half the normal rate appeared crop safe, but at full and twice full rates, scorching and foliar twisting was observed in dill plants.



**Figure 9.** Mean vigour scores for dill treated with various herbicides, at half, single or double dose rate. Assessment carried out 69 days after treatment. Scores of 7 or above deemed acceptable vigour (as indicated by red line).

## Fenugreek

Pre-emergence application of aclonifen at 2.0 L/ha or below, and post-emergence application of AHDB 9981 and AHDB 9985 appeared to have little effect on fenugreek vigour (Table 4, Figure 10). Although the seedlings which managed to emerge after treatment with AHDB 9918 were not significantly affected with respect to vigour, germination was reduced (see germination results in previous section), therefore AHDB 9918 is not crop safe to fenugreek. Post-emergence application of AHDB 9918 or aclonifen to fenugreek caused significant foliar scorching, with damage increasing with increasing rate of application. Post-emergence application of Oblix 500 or AHDB 9887 at half or full normal rate appeared crop safe. However, fenugreek treated with Oblix 500 4.0 L/ha (double dose) showed some stunting, twisting and burned leaf tips. AHDB 9887 applied to fenugreek post-emergence at twice normal rate appeared to cause foliar twisting.

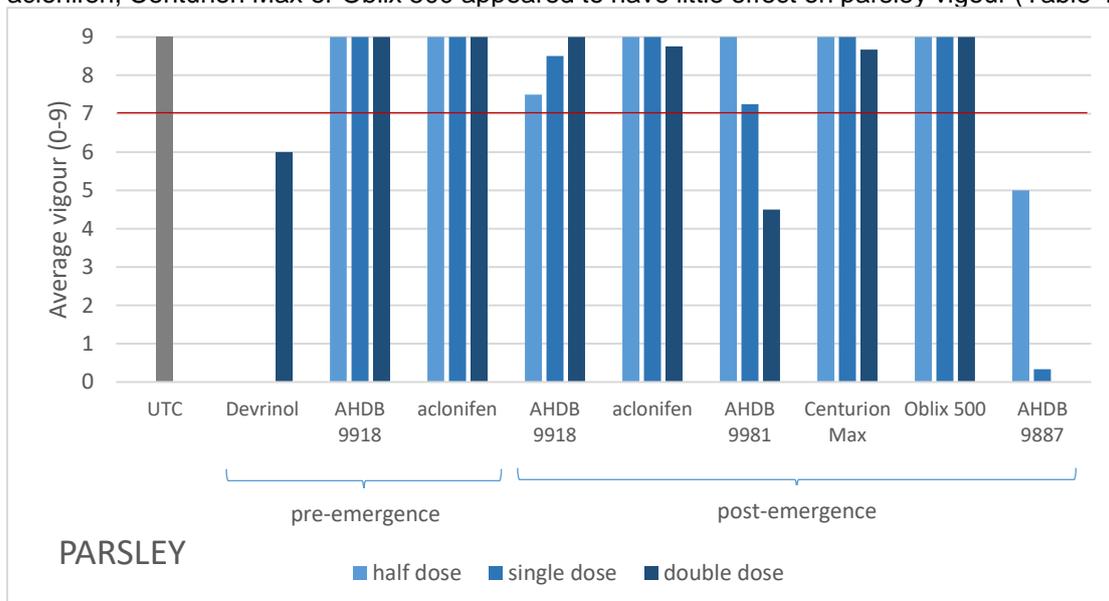


**Figure 10.** Mean vigour scores for fenugreek treated with various herbicides, at half, single or double dose rate. Assessment carried out 69 days after treatment. Scores of 7 or above deemed acceptable vigour (as indicated by red line).

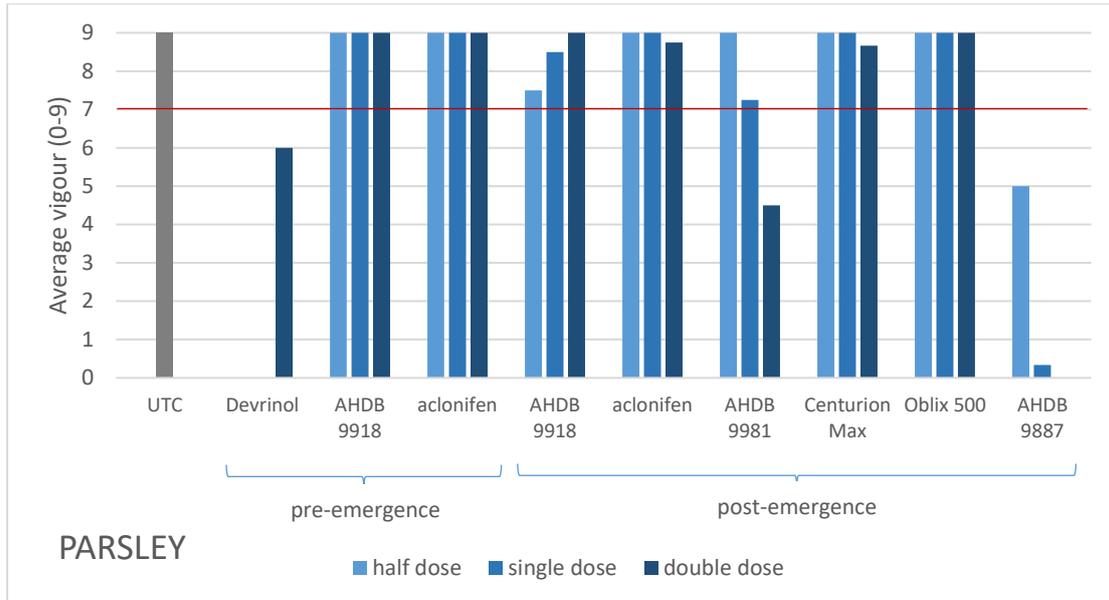
### Parsley

Parsley germination averaged only 40% in the untreated control, and therefore it was not possible to draw any firm conclusions on crop safety. However, germination numbers equivalent or near equivalent to that in plots where aclonifen at 0.5 L/ha (half dose) or lower rates of AHDB 9918 were applied (see previous section on germination results) mean that these products could warrant further investigation. These pre-emergence treatments also showed little effect on the vigour of the parsley.

Although no firm conclusions can be made from the results on parsley, the following trends were noted for post-emergence treatments. Post-emergence application of AHDB 9918, aclonifen, Centurion Max or Oblix 500 appeared to have little effect on parsley vigour (Table 4,



**Figure 11).** Post-emergence application of AHDB 9981 at half and full label rate appeared crop safe, but some pale foliage and scorch was noted at full rate. Crop effects were greater at double label rate. Post-emergence application of AHDB 9887 at any rate had a notable negative effect on the vigour of the parsley, with some twisted foliage seen in plants which received the treatments even at half normal rate.



**Figure 11.** Mean vigour scores for parsley treated with various herbicides, at half, single or double dose rate. Assessment carried out 69 days after treatment. Scores of 7 or above deemed acceptable vigour (as indicated by red line).

## Conclusions

*Note: these results are based on pot trials, and the most promising would need repeating in soil grown crops to confirm crop safety.*

### Pre-emergence

For those herbs where germination was greater than 70% (basil, coriander, dill and fenugreek) the following conclusions can be drawn:

- Aclonifen was safe to nearly all the herb species in the trial when applied at up to 2.0 L/ha (double dose). Basil was an exception, where it may only be safe at a lower rate of 1.0 L/ha (single dose).
- Devrinol 450 SC was safe to basil and fenugreek up to an application rate of 2.8 L/ha (single dose). However, it has subsequently been approved for use at a lower rate of 0.85 L/ha, and this rate wasn't tested in the trial. There is a possibility that it could still be safe to coriander, chives, dill and parsley, and this warrants further testing.
- AHDB 9918 was only safe to dill.

### Post-emergence

For those herbs where germination was greater than 70%, and where they were unaffected by the hot weather (basil, dill and fenugreek), the following conclusions can be drawn:

- AHDB 9981 was safe to dill and fenugreek, and could also be safe to use in chives.
- Oblix 500 (ethofumesate) was safe to all herbs listed above when applied up to 2.0 L/ha (single dose), and could also be safe to chives and parsley based on trends indicated in those plots (even though germination was limited).
- Centurion Max was safe to all herbs listed above when applied up to a rate of 1.0 L/ha (single dose).

## 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 BHTA, particularly Claire Donkin and Rob Gibb for their technical input.

## Appendix

- a. Crop diary – events related to growing crop

Crop	Cultivar	Planting date
Herbs	Basil	<b>22/05/2018</b>
	Chives	<i>(all pots sown except those to be treated with treatments 2, 3 and 4)</i>
	Coriander	
	Dill	
	Fenugreek	<b>25/05/2018</b>
	Parsley	<i>(remaining pots sown)</i>

### Details of irrigation regime

Date	Type, rate and duration	Amount applied (mm)
N/A	Watered by hand as necessary	Not recorded

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

Date	Event
25/05/2018	Applied pre-emergences treatments (Application A, treatments 2 to 10).
29/06/2018	Applied post-emergence sprays to fenugreek only (Application B, treatments 11 to 28).
04/07/2018	3-4 week post-emergence spray counts completed.
09/07/2018	Applied post-emergence sprays to the remaining herbs (Application B, treatments 11 to 28).
02/08/2018	Carried out vigour assessment.

- c. Climatological data during study period from each site.

Date	Min. temp. (°C)	Max. temp. (°C)	Av. Humidity (%)	Total rainfall (mm)
25/05/2018	9.2	15.9	94.0	5.3
26/05/2018	10.5	22.6	72.1	0.0
27/05/2018	9.6	24.8	75.3	1.1
28/05/2018	10.5	22.6	88.4	0.0
29/05/2018	9.6	13.6	97.4	0.5
30/05/2018	9.6	16.8	92.8	3.5
31/05/2018	12.7	22.2	85.8	0.0
01/06/2018	14.1	22.2	83.9	0.1
02/06/2018	15.0	16.4	93.6	0.0
03/06/2018	14.5	23.0	68.5	0.0
04/06/2018	10.5	14.5	90.6	0.1
05/06/2018	6.8	14.1	78.7	0.2
06/06/2018	5.6	19.1	73.4	0.0
07/06/2018	8.4	17.3	76.1	1.0
08/06/2018	8.4	18.2	77.1	0.0
11/06/2018	13.2	23.0	51.2	0.0
12/06/2018	9.2	16.4	78.6	0.0

Date	Min. temp. (°C)	Max. temp. (°C)	Av. Humidity (%)	Total rainfall (mm)
13/06/2018	19.5	20.9	47.0	0.0
14/06/2018	10.0	18.2	67.1	0.0
15/06/2018	7.6	20.4	58.7	0.0
16/06/2018	10.5	19.1	68.5	0.0
17/06/2018	9.2	17.3	75.8	0.0
18/06/2018	13.2	23.0	71.2	0.0
19/06/2018	15.0	23.0	71.5	0.0
20/06/2018	11.8	22.6	72.9	0.0
21/06/2018	7.6	17.7	54.9	0.0
22/06/2018	6.8	19.1	52.9	0.0
23/06/2018	8.0	21.3	55.7	0.0
24/06/2018	7.6	23.0	59.7	0.0
25/06/2018	10.5	27.4	50.3	0.0
26/06/2018	8.8	26.5	58.9	0.0
27/06/2018	10.0	24.8	63.7	0.0
28/06/2018	8.4	24.3	73.0	0.0
29/06/2018	9.6	24.3	69.8	0.0
30/06/2018	11.4	26.1	57.5	0.0
01/07/2018	9.6	27.0	52.8	0.0
02/07/2018	11.4	26.1	47.8	0.0
03/07/2018	9.2	23.5	54.6	0.0
04/07/2018	8.8	24.3	57.2	0.0
05/07/2018	13.2	28.3	55.1	0.0
06/07/2018	13.2	26.5	62.4	0.0
07/07/2018	15.0	27.8	58.1	0.0
08/07/2018	13.6	27.4	57.3	0.0
09/07/2018	13.6	25.2	60.9	0.0
10/07/2018	11.8	17.3	74.1	0.0
11/07/2018	10.5	18.6	80.2	0.0
12/07/2018	10.0	19.5	77.1	0.0
13/07/2018	9.2	23.0	67.5	0.0
14/07/2018	11.4	26.5	61.8	0.0
15/07/2018	12.3	28.7	50.6	0.0
16/07/2018	12.7	27.8	50.5	0.0
17/07/2018	12.3	22.2	57.1	0.0
18/07/2018	13.2	23.5	50.0	0.0
19/07/2018	14.5	26.1	50.9	0.0
20/07/2018	13.6	25.2	59.5	0.0
21/07/2018	13.6	26.1	59.4	0.0
22/07/2018	14.5	23.9	62.4	0.0
23/07/2018	15.9	29.6	53.5	0.0
24/07/2018	15.5	27.8	54.5	0.0
25/07/2018	15.5	28.3	54.2	0.0
26/07/2018	16.4	31.7	57.6	2.5
27/07/2018	17.3	31.1	67.8	16.6
28/07/2018	13.6	21.3	63.9	0.5
29/07/2018	13.6	19.5	82.3	0.5
30/07/2018	15.0	22.6	71.1	0.1
31/07/2018	14.1	23.5	62.5	0.7
01/08/2018	10.9	24.3	55.0	0.0
02/08/2018	12.3	28.3	57.7	0.0

d. Trial design (extract, block 1 of 4 as an example)

BLOCK 1														
PLOT	1 24 Dill	2 18 Par	3 10 Fen	4 3 Par	5 9 Fen	6 24 Par	7 16 Cor	8 6 Par	9 7 Cor	10 5 Cor	11 19 Dill	12 17 Par	13 14 Fen	14 17 Dill
PLOT	15 26 Fen	16 6 Cor	17 3 Chiv	18 23 Chiv	19 11 Par	20 20 Cor	21 2 Cor	22 17 Fen	23 5 Bas	24 19 Par	25 12 Par	26 8 Bas	27 5 Chiv	28 23 Dill
PLOT	29 21 Cor	30 23 Fen	31 10 Cor	32 9 Cor	33 4 Bas	34 22 Chiv	35 25 Cor	36 11 Cor	37 27 Chiv	38 5 Par	39 2 Dill	40 14 Cor	41 11 Chiv	42 15 Chiv
PLOT	43 5 Dill	44 1 Dill	45 25 Par	46 22 Dill	47 10 Bas	48 21 Chiv	49 8 Par	50 14 Par	51 16 Par	52 10 Chiv	53 14 Bas	54 28 Bas	55 17 Bas	56 15 Dill
PLOT	57 3 Bas	58 4 Cor	59 14 Chiv	60 15 Bas	61 25 Fen	62 15 Cor	63 10 Par	64 24 Bas	65 7 Par	66 13 Dill	67 24 Fen	68 19 Cor	69 19 Fen	70 26 Cor
PLOT	71 9 Chiv	72 26 Bas	73 2 Bas	74 8 Dill	75 9 Dill	76 6 Bas	77 13 Fen	78 5 Fen	79 18 Chiv	80 2 Chiv	81 16 Chiv	82 7 Bas	83 20 Fen	84 28 Par
PLOT	85 26 Chiv	86 24 Cor	87 4 Chiv	88 6 Chiv	89 11 Fen	90 27 Dill	91 28 Chiv	92 25 Bas	93 19 Chiv	94 2 Par	95 23 Cor	96 22 Par	97 16 Bas	98 9 Par
PLOT	99 25 Dill	100 7 Dill	101 1 Bas	102 13 Bas	103 26 Par	104 18 Fen	105 20 Par	106 1 Cor	107 14 Dill	108 21 Dill	109 3 Cor	110 23 Par	111 23 Bas	112 6 Fen
PLOT	113 9 Bas	114 10 Dill	115 8 Chiv	116 15 Fen	117 11 Bas	118 12 Bas	119 28 Dill	120 6 Dill	121 27 Cor	122 18 Cor	123 1 Fen	124 8 Cor	125 13 Par	126 22 Bas
PLOT	127 17 Cor	128 12 Dill	129 12 Cor	130 20 Dill	131 21 Bas	132 22 Fen	133 3 Dill	134 3 Fen	135 7 Fen	136 1 Par	137 16 Dill	138 27 Bas	139 27 Fen	140 20 Bas
PLOT	141 17 Chiv	142 12 Fen	143 4 Par	144 4 Fen	145 21 Fen	146 26 Dill	147 25 Chiv	148 15 Par	149 13 Cor	150 12 Chiv	151 22 Cor	152 13 Chiv	153 8 Fen	154 1 Chiv
PLOT	155 16 Fen	156 4 Dill	157 2 Fen	158 20 Chiv	159 11 Dill	160 7 Chiv	161 19 Bas	162 18 Dill	163 18 Bas	164 28 Fen	165 28 Cor	166 27 Par	167 21 Par	168 24 Chiv

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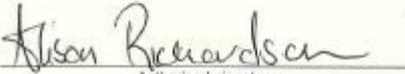
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**Effective date: 18 March 2018**  
**Expiry date: 17 March 2023**

**Signature**   
*Alison Richardson*  
Authorised signatory

<b>Certification Number</b> <b>ORETO 409</b>
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