Project title:	**Brassicas - Pre-plant herbicide screen on kale and collards**
Project number:	FV 462
Project leader:	Angela Huckle, ADAS
Report:	Annual Report 2019
Previous report:	N/A
Key staff:	NIAB, PGRO, ADAS, Duchy College
Location of project:	Elsoms Trial Ground, Spalding. Lincs
Industry Representative:	Andy Richardson, Allium & Brassica Centre Will Illiffe, Southern England Farms
Date project commenced:	01 April 2019
Date project completed (or expected completion date):	31 Mar 2020

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The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

Technology transfer

Updates of trial data were circulated to levy payers by AHDB Horticulture and to agchem companies who supported the trials with samples of products FOC.

Knowledge exchange events were also hosted on these occasions:

1. Elsoms variety field open day in Lincs – 9/10 October 2019
2. Presentation to the Brassica Growers Association – 8 October 2019
3. SW Brassica Trials presentation evening in Cornwall – 15 January 2020
4. Hutchinsons Vegetable Agronomy Update, Lincs – 21 January 2020

These events were well attended by a number of growers, agronomists, research providers, and seed producers etc.

Trials and brassica related updates are regularly featured on social media through twitter @AHDB_Hort @angela_huckle @ADAS_Hortic @ADAS_Group @BritishGrowers with a combined following of over 19,000 users.

BGA newsletters produced by AHDB are also used to circulate key dates and information.

Final Trial Report

Trial code:	FV 462
Title:	**Horticulture Strategic Centres for Field Vegetables – Brassicas (pre-plant herbicide screen)**
Crop	Group: field vegetables – Brassicas (collard greens & kale)
Target	General broadleaf weeds and grasses, 3WEEDT EPPO1/089(3) Weeds in leafy and brassica vegetables
Lead researcher:	Angela Huckle
Organisation:	RSK ADAS
Period:	1st April 2019 – 31st December 2019
Report date:	1st May 2020
Report author:	Angela Huckle Emily Lawrence
ORETO Number: (certificate should be attached)	409

I the undersigned, hereby declare that the work was performed according to the procedures herein described and that this report is an accurate and faithful record of the results obtained

…… ……

…… ……

Date Authors signature

Pre-planting herbicide screen of promising products from SceptrePlus on kale and collards

Trial Summary

Take home message

AHDB9987 appeared consistently crop-safe and effective in both kale and collard crops throughout the trials, and would warrant further investigation for a possibility of authorisation for these brassica types.

Introduction

The limited range of herbicides currently available for use in brassica crops such as kale and collards leaves gaps in the weed control spectrum, and growers experience problems with a wide range of weeds. Broad leaved weeds remain a key concern for brassica growers, particularly fat-hen, red-shank, charlock and fumitory (AHDB Gap Analysis, 2016). In addition to having a short list of approved actives, only a small subset of these offer the longevity of control required to protect longer season brassicas, such as kale. A further challenge for authorisation of products in these minor crops is the availability of crop safety and efficacy data to guide growers with their use, as products are usually only trialed over the major brassica types such as cauliflower and headed cabbage.

In hand harvested crops such as brassicas, weeds are a physical impediment to those working in the crop, and species such as nettles can deter pickers. Weeds which obscure the crop further reduce harvesting efficiency; where excessive weeds mean heads are missed, harvested yields can be reduced by up to 30%. The increased humidity in the crop canopy can also increase the risk of disease, and weed seeds can contaminate the fresh product.

While mechanical hoeing can be successfully used as an alternative weed control method, it is limited by crop growth stage and ground conditions, if soil conditions are not suitable this approach cannot always be used. Therefore, further options for weed control in minor brassica crops are required.

The objective of these trials was to identify crop-safe and effective herbicides for weed control in kale and collards testing products which have been identified as promising from the SceptrePlus work. With the aim to expand the options available to kale and collard growers, and give growers of these crops further information on use of the products.

Method

The trials were sited at Elsoms Trial Ground in Lincolnshire. The trial field was planted on 1st August 2019, with collard greens (variety ‘Duncan’) and kale (variety ‘Oldenbor’).

Treatments were applied pre-planting, on the day of planting. All treatments were applied with a 2 m boom, using a knapsack sprayed at 300 L/ha water volume. A randomised block design was used for the trial layout, with two replicates of six treatments, including an untreated control. There were twelve plots in total for each brassica cultivar, with each plot measuring 2 m x 6 m.

The plots were assessed on four occasions (see ‘Assessment details’), focussing on weed cover and species presence, and crop phytotoxicity (i.e. treatment safety).

Assessments were carried out approximately two, four, eight, and twelve weeks after treatments were applied.

Figure 1. Overview of trial area, 05/09/2019.

Results and discussion

Collard greens:
Weed levels were low in the collard greens trial, with an average of 8.5% cover (back-transformed) in the untreated control at the final assessment, twelve weeks after the pre-planting treatments were applied.

While weed levels in the trial area were relatively low, there was still sufficient cover to be able to identify differences in treatment efficacy. It is important to note that these trials were only replicated twice as they are demonstration trials. The first differences were noted eight weeks after the pre-planting treatments were applied, with all treatments showing a significantly lower weed cover than the untreated control. By twelve weeks after application, plots treated with AHDB9999, AHDB9987, AHDB9875 or AHDB9917 still showed a reduction in weed levels. Of these, AHDB9987 and AHDB9875 offered the most effective control.

Regarding the treatments' effect on the crop, those assessed in this trial generally appear safe. At four weeks after the pre-planting application of treatments, AHDB9999 and AHDB9994 showed phytotoxic effects, with some stunting noted. However, by the final assessment (twelve weeks after treatment), the crop treated with these products had grown through the early effects and was of commercially acceptable quality.

While there were some differences in crop quality observed in this trial, it is important to note that conditions at the trial site were challenging, with heavy rain and grazing from pests. Compaction and waterlogging were issues, with crop vigour reduced as a result (**Figure 1**). Due care was taken to distinguish between treatment effects and the potentially confounding factors present.

Table 1. Summary of crop damage (0-10; 0 = no damage, 10 = complete crop death) and weed cover (back-transformed) from key assessment dates in collard greens trial. Scores significantly lower than that of the untreated are starred.

Treatment	Mean crop damage (0-10)		Mean weed cover (%)			
	4 weeks	12 weeks	8 weeks		12 weeks	
			Ang.	Back-trans	Ang.	Back-trans
Untreated	0.0	0.5	15.7	7.3	16.9	8.4
AHDB9999	*2.0	0.5	6.9	*1.5	12.2	*4.5
AHDB9987	0.5	0.0	5.7	*1.0	5.7	*1.0
AHDB9875	0.5	0.0	5.7	*1.0	5.7	*1.0
AHDB9917	0.0	1.0	6.9	*1.5	12.9	*5.0
AHDB9994	*3.0	*1.5	10.8	*3.5	16.9	8.4
F prob. value	0.025	0.126		0.011		<0.001
d.f.	6	6		6		6
L.S.D.	1.730	1.223		4.7		3.241

Kale:

Weed levels were also relatively low across the kale trial, with an average of 12.5% cover (back-transformed) in the untreated control at the final assessment, twelve weeks after pre-planting treatments were applied.

While there was a low weed burden in the trial area, differences in weed cover were apparent between the treated and untreated plots from four weeks after the pre-planting treatment application. At this timing, all treated plots had significantly lower weed cover than the untreated, and this was still the case at the final assessment, twelve weeks after treatment. Overall, AHDB9875 gave the most effective control.

While effective treatments, there were some phytotoxic effects noted for AHDB9875 and AHDB 9917. Eight weeks after application pre-planting, plants treated with either of these products were slightly stunted, though still on the margin of acceptable crop quality. However, by the final assessment—twelve weeks after application—any earlier treatment effects had been grown through and no treated crop was of significantly lower quality than the untreated control.

Table 2. Summary of crop damage (0-10; 0 = no damage, 10 = complete crop death) and weed cover (back-transformed) from key assessment dates in kale trial. Scores significantly lower than that of the untreated are starred.

Treatment	Mean crop damage (0-10)		Mean weed cover (%)			
	8 weeks	12 weeks	4 weeks		12 weeks	
			Ang.	Back-trans	Ang.	Back-trans
Untreated	0.0	0.5	11.5	3.9	20.6	12.4
AHDB9999	0.5	1.0	5.7	*1.0	8.1	*2.0
AHDB9987	0.0	1.0	5.7	*1.0	6.9	*1.5
AHDB9875	*2.0	1.0	5.7	*1.0	5.7	*1.0
AHDB9917	*2.5	1.0	5.7	*1.0	7.9	*1.9
AHDB9994	0.0	1.0	5.7	*1.0	10.5	*3.3
F prob. value	0.016	0.500		0.005		0.007
d.f.	5	5		5		5
L.S.D.	1.368	0.7421		2.187		5.479

Conclusion

- Kale and collards were more sensitive to the experimental herbicides than cauliflower when compared to the crop response in the adjacent SceptrePlus cauliflower trial, with a greater response in collards, and crop effects from different products seen in kale.

- Of the pre-planting treatments assessed on **collard greens**, AHDB9999, AHDB9987, AHDB9875, and AHDB9917 offered the most effective weed control and appeared crop safe or close to crop safe throughout the duration of the trial.

- Based on label recommendations, AHDB9875 offers control of fat-hen and red-shank—both highlighted as particular problem weeds in brassica crops—as well as annual meadow-grass, chickweed, cleavers, cranesbill, groundsel, knotgrass, mayweed, nettles, shepherd's purse, sow-thistle, and speedwell. Control of fat-hen, annual meadow-grass, and groundsel is offered by AHDB9917.

- In the **kale** trial, a treatment of AHDB9999, AHDB9987, or AHDB9994 applied pre-planting offered good weed control and did not impact crop safety.

Science section

Objectives

Collard greens: To compare and demonstrate a number of new and novel herbicides at the pre-planting application timing for selectivity (crop safety) and efficacy in collard greens.

Kale: To compare and demonstrate a number of new and novel herbicides at the pre-planting application timing for selectivity (crop safety) and efficacy in kale.

Trial conduct

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

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

Test site

Item	**Details**
Location address	Field: Elsoms Trial Ground off A16 PE11 3JG Lincolnshire Grid reference: TF 25745 25975
Crop ('cultivar')	collard greens ('Duncan'), kale ('Oldenbor')
Soil or substrate type	Loamy and clayey soil of coastal flats with naturally high groundwater
Agronomic practice	See Appendix
Prior history of site	See Appendix

Trial design

Item	**Details**
Trial design:	Fully randomised block
Number of replicates:	2
Row spacing:	0.61 m (3 rows per 2 m wide plot)
Plot size: (w x l)	2 m x 6 m
Plot size:	12 m^2
Number of plants per plot:	approx. 33

Application schedule

Trial 1:

Trt. No.	**Treatment: product name or AHDB code**	**Rate of active substance(s)** (g/ha)	**Rate of product** (L/ha)
1	Untreated	-	-
2	AHDB9999	4000	5.00
3	AHDB9987	1200	2.00
4	AHDB9875	1200 24	3.00
5	AHDB9917	N/K	0.70

6	AHDB9994	1050	1.75

Application details

	Timing A
Application date	01/08/2019
Time of day	06:20 – 07:10
Crop growth stage (Max, min average BBCH)	N/A (pre-planting)
Crop height (cm)	N/A
Crop coverage (%)	N/A
Application Method	spray
Application Placement	soil
Application equipment	AZO Plot
Nozzle pressure	2.5
Nozzle type	Flat fan
Nozzle size	02-F110
Application water volume (L/ha)	300
Temperature of air (°C)	18.6
Relative humidity (%)	91
Wind speed range (kph)	(NW) 12.0
Dew presence (Y/N)	Y
Temperature of soil (°C)	15.0
Wetness of soil	wet
Cloud cover (%)	100

Assessment details

Evaluation date	**Evaluation Timing** (DA)*	**Evaluation type**	**What was assessed and how** (e.g. dead or live pest; disease incidence and severity; yield, marketable quality)
15/08/2019	14	Efficacy Phyto	Weed counts per quadrat (x3), weed species presence. Phyto (scale 0-10, 10 = Dead).
29/08/2019	28	Efficacy Phyto	Percentage of weed cover (whole plot score), weed species presence. Phyto (scale 0-10, 10 = Dead).
26/09/2019	56	Efficacy Phyto	Percentage of weed cover (whole plot score), weed species presence. Phyto (scale 0-10, 10 = Dead).
24/10/2019	84	Efficacy Phyto	Percentage of weed cover (whole plot score), weed species presence. Phyto (scale 0-10, 10 = Dead).

* DA – days after application

Statistical analysis

The trials had randomised block designs, each with treatments replicated twice. Each comprised six treatments, including an untreated control.

As the distribution of weeds was uneven across each trial—which is not unexpected in field situations—there was a need to transform this data prior to analysis. To determine treatment efficacy, an angular transformation was performed then the back transformed means presented, from which the % reduction in weeds was calculated using Abbott's formula.

All data were analysed by ANOVA using Genstat 16.0 by Emily Lawrence (ADAS).

Results

Phytotoxicity

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.

Collard greens:

Phytotoxicity results are presented in Table 1 and Figure 1, and were scored according to the above scale.

Table 1. Mean crop phytotoxicity scores at four, eight, and twelve weeks after pre-planting treatment application in collard greens trial. Values that are significantly different to untreated are starred.

Treatment	Mean crop damage scores		
	4 weeks	8 weeks	12 weeks
Untreated	0.0	0.0	0.5
AHDB9999	*2.0	0.5	0.5
AHDB9987	0.5	0.5	0.0
AHDB9875	0.5	0.0	0.0
AHDB9917	0.0	0.0	1.0
AHDB9994	*3.0	0.5	1.5
F prob. value	0.025	0.704	0.126
d.f.	6	6	6
L.S.D.	1.730	1.223	1.223

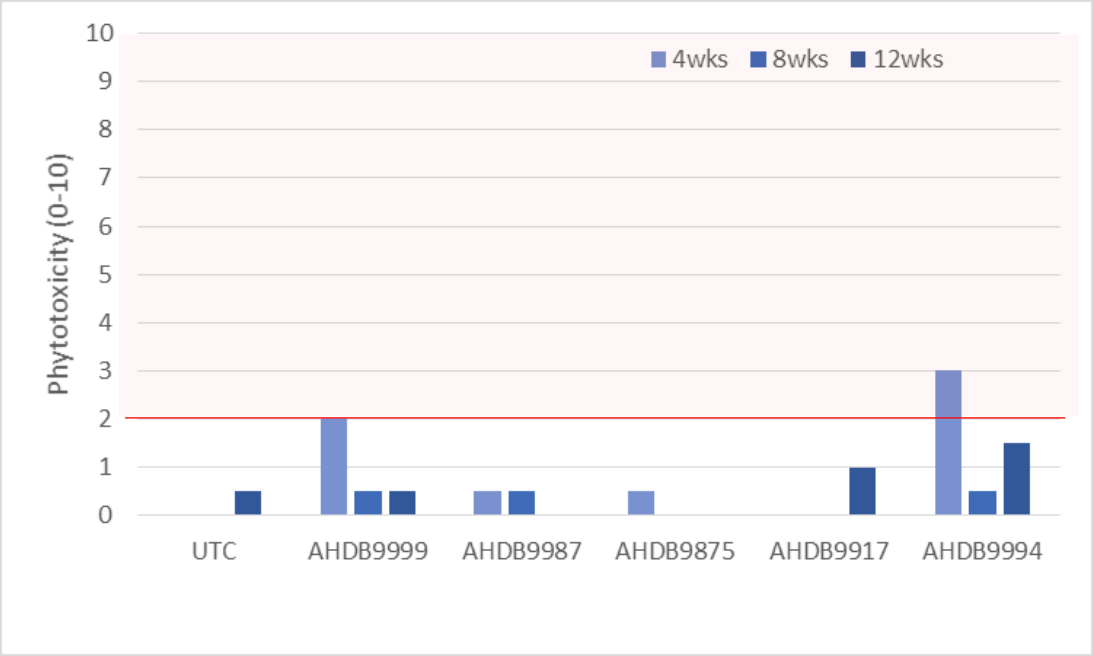


Figure 1. Mean phytotoxicity (0-10) at four, eight, and twelve weeks after pre-planting treatment application in collard greens trial. Scores ≤2 (marked by red line) deemed acceptable damage.

Kale:

Phytotoxicity results are presented in Table 2 and Figure 2, and were scored according to the above scale.

Table 2. Mean crop phytotoxicity scores at four, eight, and twelve weeks after pre-planting treatment application in kale trial. Values that are significantly different to untreated are starred.

Treatment	Mean crop damage scores		
	4 weeks	8 weeks	12 weeks
Untreated	0.0	0.0	0.5
AHDB9999	0.5	0.5	1.0
AHDB9987	0.0	0.0	1.0
AHDB9875	3.0	*2.0	1.0
AHDB9917	1.0	*2.5	1.0
AHDB9994	1.5	0.0	1.0
F prob. value	0.377	0.016	0.500
d.f.	5	5	5
L.S.D.	3.574	1.368	0.7421

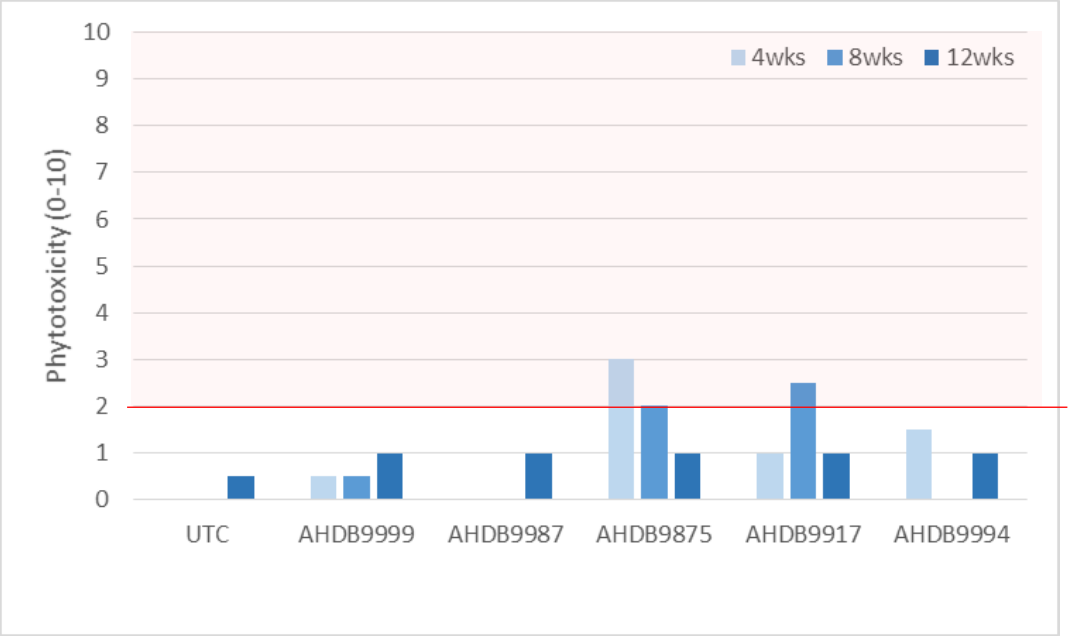


Figure 2. Mean phytotoxicity (0-10) at four, eight, and twelve weeks after pre-planting treatment application in kale trial. Scores ≤2 (marked by red line) deemed acceptable damage.

Weed control – mean percentage weed cover

Collard greens:

Weed cover results are presented in Table 3 and Figure 3. These figures were used to calculate the percent reduction in weed cover compared to the untreated control (using Abbott's formula), and these values are listed in Table 4.

Table 3. Mean percentage weed cover values (transformed) at four, eight, and twelve weeks after pre-planting treatment application in collard greens trial. Values that are significantly different to untreated are starred.

Trt. No.	Mean weed cover					
	4 weeks		8 weeks		12 weeks	
	Ang	Back-trans	Ang	Back-trans	Ang	Back-trans
Untreated	7.9	1.9	15.7	7.3	16.9	8.4
AHDB9999	5.7	1.0	6.9	*1.5	12.2	*4.5
AHDB9987	2.9	0.3	5.7	*1.0	5.7	*1.0
AHDB9875	2.9	0.3	5.7	*1.0	5.7	*1.0
AHDB9917	5.7	1.0	6.9	*1.5	12.9	*5.0
AHDB9994	5.7	1.0	10.8	*3.5	16.9	8.4
F prob. value		0.457		0.011		<0.001
d.f.		6		6		6
L.S.D.		6.467		4.7		3.241

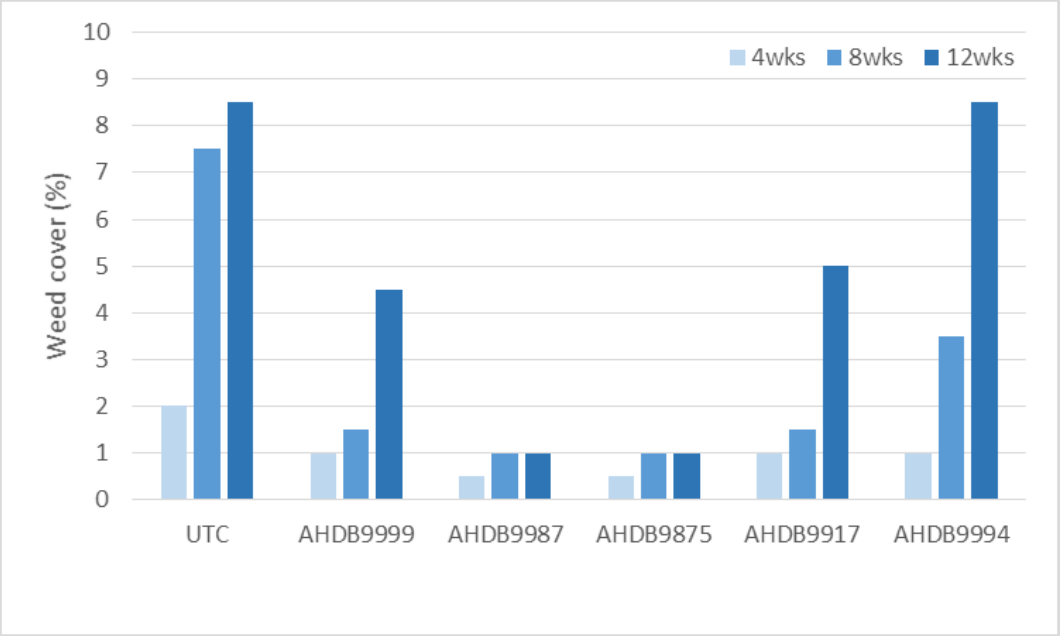


Figure 3. Mean weed cover (back transformed, %) at four, eight, and twelve weeks after pre-planting treatment application prior in collard greens trial.

Table 4. Percentage reduction in weed cover compared to the untreated control at four, eight and twelve weeks after pre-planting treatment application in collard greens trial.

Treatment	Weed cover reduction (%)		
	4 weeks	8 weeks	12 weeks
AHDB9999	46.5	80.0	46.8
AHDB9987	86.6	86.3	88.2
AHDB9875	86.6	86.3	88.2
AHDB9917	46.5	80.0	40.8
AHDB9994	46.5	52.3	0.0

All values are positive, indicating lower levels of weed cover than the untreated control (e.g. 86.6% of the cover of UTC).

The initial weed burden in the collard greens trial area was low, with a mean of 1.9% and little variation across the field (range of 1.6%). The change in weed cover from the first assessment to the final assessment—twelve weeks after treatment application—was assessed. All treatments showed a net increase in weed cover over the assessment period (Figure 4), though four of the five herbicide treatments were observed to reduce the rate of weed cover increase (relative to the untreated control). Treatments of 9987 or 9875 resulted in the greatest reduction in rate of increase in weed cover, though it should be noted that there was low weed levels in the trial.

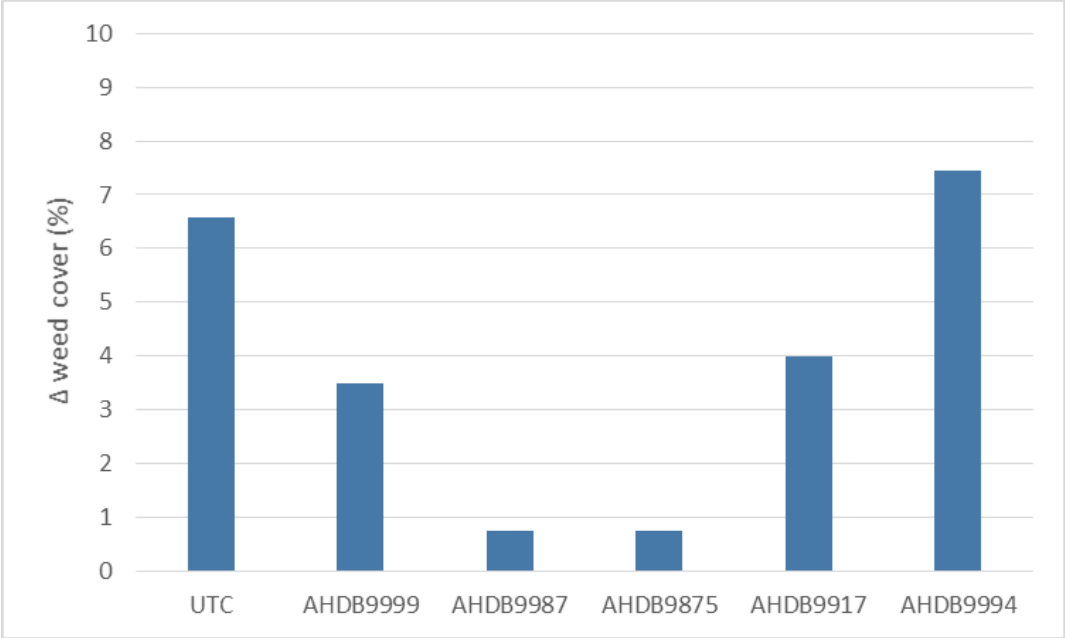


Figure 4. Percentage change in average weed cover over six-week assessment period of collard greens trial. *(+ve change = weed cover increase)*

Kale:

Weed cover results are presented in Table 5 and Figure 5. These figures were used to calculate the percent reduction in weed cover compared to the untreated control (using Abbott's formula), and these values are listed in Table 6.

Table 5. Mean percentage weed cover values (transformed) at four, eight, and twelve weeks after pre-planting treatment application in kale trial. Values that are significantly different to untreated are starred.

Trt. No.	Mean weed cover					
	4 weeks		8 weeks		12 weeks	
	Ang	Back-trans	Ang	Back-trans	Ang	Back-trans
Untreated	11.5	3.9	22.5	14.6	20.6	12.4
AHDB9999	5.7	*1.0	5.7	*1.0	8.1	*2.0
AHDB9987	5.7	*1.0	2.9	*0.3	6.9	*1.5
AHDB9875	5.7	*1.0	5.7	*1.0	5.7	*1.0
AHDB9917	5.7	*1.0	5.7	*1.0	7.9	*1.9
AHDB9994	5.7	*1.0	5.7	*1.0	10.5	*3.3
F prob. value		0.005		0.011		0.007
d.f.		5		5		5
L.S.D.		2.187		8.051		5.479

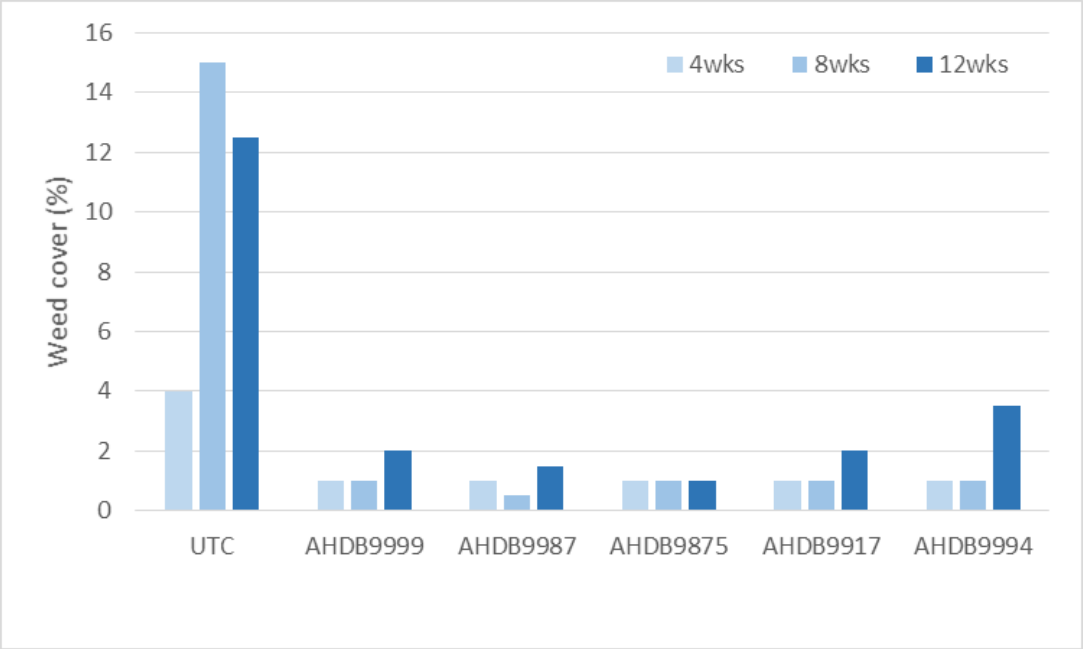


Figure 5. Mean weed cover (back transformed, %) at four, eight, and twelve weeks after pre-planting treatment application prior in kale trial.

Table 6. Percentage reduction in weed cover compared to the untreated control at four, eight and twelve weeks after pre-planting treatment application in kale trial.

Treatment	Weed cover reduction (%)		
	4 weeks	8 weeks	12 weeks
AHDB9999	74.6	93.2	83.9
AHDB9987	74.6	98.3	88.2
AHDB9875	74.6	93.2	91.9
AHDB9917	74.6	93.2	84.9
AHDB9994	74.6	93.2	73.1

All values are positive, indicating lower levels of weed cover than the untreated control (e.g. 74.6% of the cover of UTC).

The initial weed burden in the kale trial area was low, with a mean of 3.9% and little variation across the field (range of 2.9%). The change in weed cover from the first assessment to the final assessment—twelve weeks after treatment application—was assessed. All treatments showed a small net increase (or no change) in weed cover over the assessment period (Figure 6), though all of the herbicide treatments were observed to reduce the rate of weed cover increase (relative to the untreated control). Treatments of 9999, 9987, 9875, or 9917 performed particularly well.

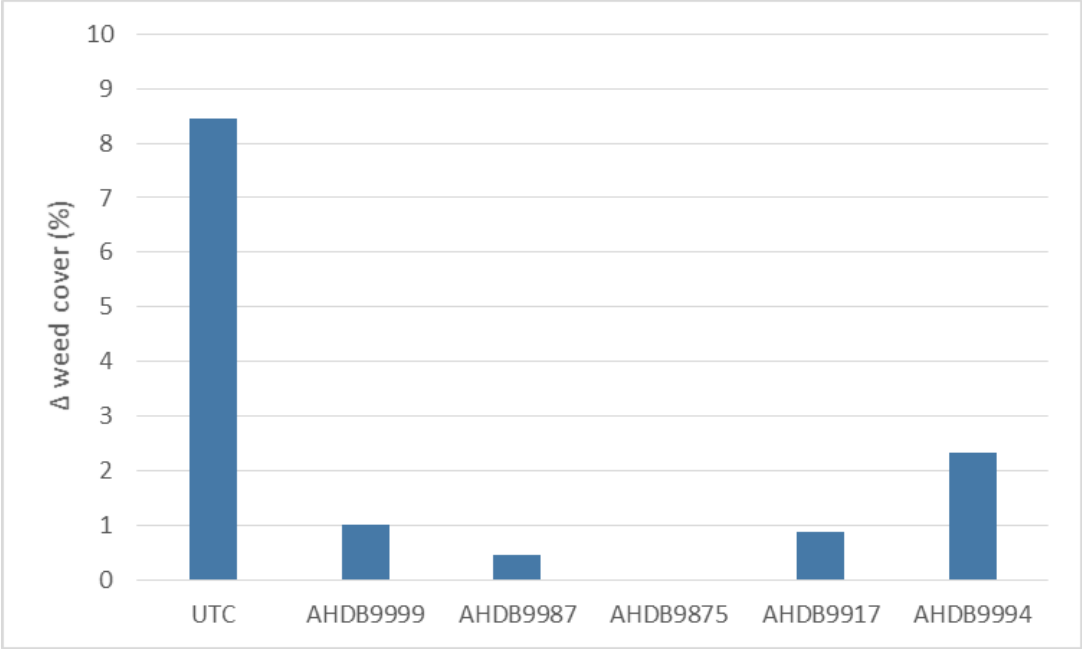


Figure 6. Percentage change in average weed cover over eight-week assessment period of kale trial. *(+ve change = weed cover increase)*

Discussion

Collard greens:
Weed levels were low in the collard greens trial, with an average of 8.5% cover (back-transformed) in the untreated control at the final assessment, twelve weeks after the pre-planting treatments were applied.

While weed levels in the trial area were relatively low, there was still sufficient cover to be able to identify differences in treatment efficacy. It is important to note that these trials were only replicated twice as they are demonstration trials. The first differences were noted eight weeks after the pre-planting treatments were applied, with all treatments showing a significantly lower weed cover than the untreated control. By twelve weeks after application, plots treated with AHDB9999, AHDB9987, AHDB9875 or AHDB9917 still showed a reduction in weed levels. Of these, AHDB9987 and AHDB9875 offered the most effective control.

Regarding the treatments' effect on the crop, those assessed in this trial generally appear safe. At four weeks after the pre-planting application of treatments, AHDB9999 and AHDB9994 showed phytotoxic effects, with some stunting noted. However, by the final assessment (twelve weeks after treatment), the crop treated with these products had grown through the early effects and was of commercially acceptable quality.

While there were some differences in crop quality observed in this trial, it is important to note that conditions at the trial site were challenging, with heavy rain and grazing from pests. Compaction and waterlogging were issues, with crop vigour reduced as a result. Due care was taken to distinguish between treatment effects and the potentially confounding factors present.

Kale:
Weed levels were also relatively low across the kale trial, with an average of 12.5% cover (back-transformed) in the untreated control at the final assessment, twelve weeks after pre-planting treatments were applied.

While there was a low weed burden in the trial area, differences in weed cover were apparent between the treated and untreated plots from four weeks after the pre-planting treatment application. At this timing, all treated plots had significantly lower weed cover than the untreated, and this was still the case at the final assessment, twelve weeks after treatment. Overall, AHDB9875 gave the most effective control.

While effective treatments, there were some phytotoxic effects noted for AHDB9875 and AHDB 9917. Eight weeks after application pre-planting, plants treated with either of these products were slightly stunted, though still on the margin of acceptable crop quality. However, by the final assessment—twelve weeks after application—any earlier treatment effects had been grown through and no treated crop was of significantly lower quality than the untreated control.

Conclusions

- Kale and collards were more sensitive to the experimental herbicides than cauliflower when compared to the crop response in the adjacent SceptrePlus cauliflower trial, with a greater response in collards, and crop effects from different products seen in kale.

- Of the pre-planting treatments assessed on **collard greens**, AHDB9999, AHDB9987, AHDB9875, and AHDB9917 offered the most effective weed control and appeared crop safe or close to crop safe throughout the duration of the trial.

- Based on label recommendations, AHDB9875 offers control of fat-hen and red-shank—both highlighted as particular problem weeds in brassica crops—as well as annual meadow-grass, chickweed, cleavers, cranesbill, groundsel, knotgrass, mayweed, nettles, shepherd's purse, sow-thistle, and speedwell. Control of fat-hen, annual meadow-grass, and groundsel is offered by AHDB9917.

- In the **kale** trial, a treatment of AHDB9999, AHDB9987, or AHDB9994 applied pre-planting offered good weed control and did not impact crop safety.

Acknowledgements

AHDB for funding the work, and also the crop protection companies for their financial contributions and provision of samples for the trials. Thanks too to Elsoms Seeds, who provided sites and crop for the trials, and to Carl Sharp of the Allium and Brassica Centre, for site management and treatment application.

Appendix

a. Crop diary – events related to growing crop

Crop	**Cultivar**	**Planting date**	**Row width** (m)
Collard greens	Duncan	01/08/2019	0.61 m
Kale	Oldenbor	01/08/2019	0.61 m

Previous cropping

Year	**Crop**
2018	PSB/cauliflower (half of the trial area)
2017	Rye (cover crop)
2016	Bare ground

Cultivations

Date	**Description**
Mar 2019	Power harrowed and rolled prior to planting.
Dec 2018	Subsoiled and winter ploughed.

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

Date	**Product**	**Rate** (kg/ha)
Mar 2019	Base fertiliser	250 kg/ha 10-15-21 + 20SO3
Mar 2019	Top dressing	80 kg/ha N 26N + 35SO3

Pesticides applied to trial area

Date	**Product**	**Rate** (L/ha)
15/10/2019	Biscaya	0.5 L/ha

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

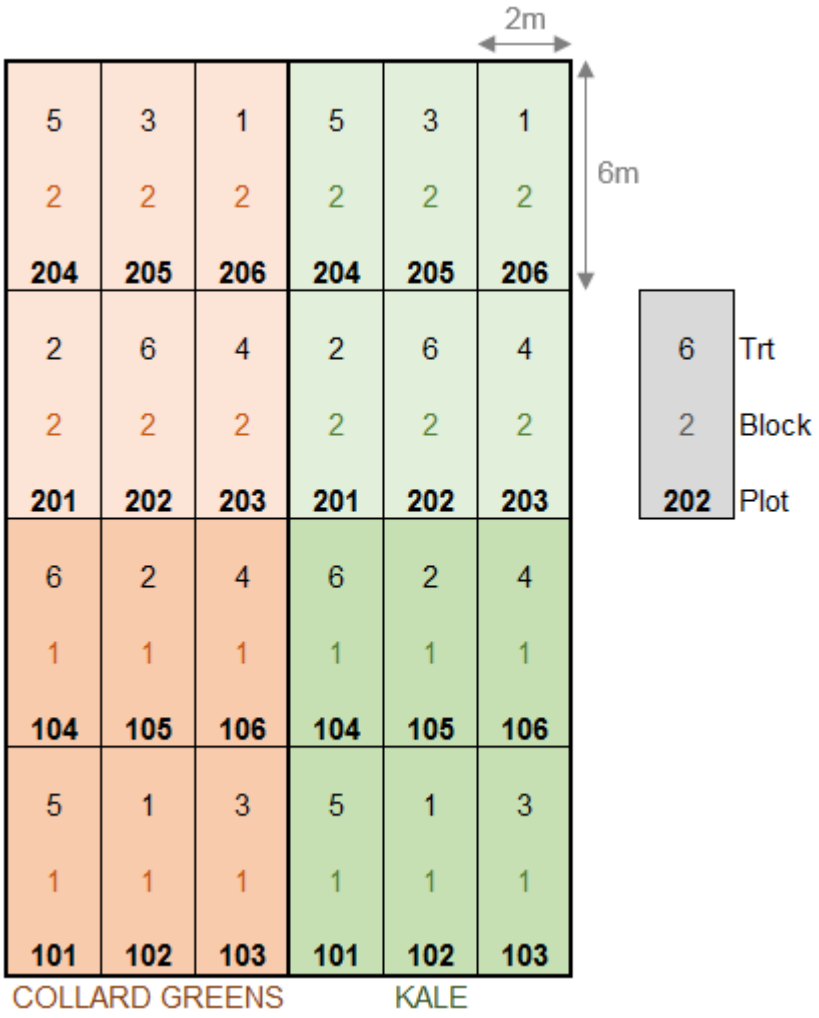
	Date	**Event**
TRIAL 1	01/08/2019	Pre-planting treatments applied. Crop planted.
	15/08/2019	Assessment, two weeks after treatment (phyto/weeds).
	29/08/2019	Assessment, four weeks after treatment (phyto/weeds).
	26/09/2019	Assessment, eight weeks after treatment (phyto/weeds).
	24/10/2019	Assessment, twelve weeks after treatment (phyto/weeds).

c. Climatological data during study period from each site, including conditions prior to planting. Planting date 1/08/20

Date	Min. temp. (°C)	Max. temp. (°C)	Precip. (mm)
01/07/19	12	20	0
02/07/19	9	20	0
03/07/19	10	20	0
04/07/19	9	25	0
05/07/19	12	25	0
06/07/19	12	19	2
07/07/19	12	19	0
08/07/19	12	19	0
09/07/19	14	20	0
10/07/19	16	23	0
11/07/19	16	24	2
12/07/19	14	23	6
13/07/19	14	20	0
14/07/19	12	19	3
15/07/19	12	22	0
16/07/19	11	25	0
17/07/19	14	25	0
18/07/19	13	23	1
19/07/19	10	18	9
20/07/19	12	22	10
21/07/19	10	23	0
22/07/19	16	29	0
23/07/19	14	29	0
24/07/19	19	30	2
25/07/19	18	34	0
26/07/19	19	26	1
27/07/19	15	19	24
28/07/19	15	20	1
29/07/19	14	25	2
30/07/19	16	24	5
31/07/19	16	20	2
01/08/19	15	22	4
02/08/19	15	22	1
03/08/19	12	23	0
04/08/19	15	26	0
05/08/19	14	24	2
06/08/19	13	23	4
07/08/19	13	24	0
08/08/19	12	25	0
09/08/19	16	26	16
10/08/19	16	23	1
11/08/19	11	20	1
12/08/19	9	19	0
13/08/19	10	19	2
14/08/19	9	17	22
15/08/19	10	20	2
16/08/19	9	18	12
17/08/19	12	22	5
18/08/19	12	22	2
19/08/19	10	22	0
20/08/19	9	20	0
21/08/19	12	22	0
22/08/19	13	24	0
23/08/19	13	26	0
24/08/19	12	27	0
25/08/19	14	30	0
26/08/19	15	30	0
27/08/19	16	30	0

Date	Min. temp. (°C)	Max. temp. (°C)	Precip. (mm)
28/08/19	13	23	2
29/08/19	11	22	1
30/08/19	14	24	0
31/08/19	9	22	0
01/09/19	9	17	0
02/09/19	8	19	0
03/09/19	12	24	0
04/09/19	13	19	2
05/09/19	8	19	0
06/09/19	10	19	0
07/09/19	7	17	0
08/09/19	5	18	0
09/09/19	8	14	2
10/09/19	10	18	0
11/09/19	11	22	1
12/09/19	9	24	0
13/09/19	8	20	0
14/09/19	6	22	0
15/09/19	10	20	3
16/09/19	10	17	7
17/09/19	7	17	0
18/09/19	6	18	0
19/09/19	6	22	0
20/09/19	8	20	0
21/09/19	10	24	0
22/09/19	12	23	3
23/09/19	12	20	1
24/09/19	14	18	16
25/09/19	13	18	35
26/09/19	12	20	5
27/09/19	11	16	9
28/09/19	11	18	16
29/09/19	12	19	26
30/09/19	8	16	14
01/10/19	7	14	48
02/10/19	5	13	0
03/10/19	3	12	7
04/10/19	10	15	8
05/10/19	9	16	0
06/10/19	9	14	15
07/10/19	7	13	1
08/10/19	9	16	0
09/10/19	8	16	0
10/10/19	5	16	0
11/10/19	12	16	6
12/10/19	10	15	0
13/10/19	8	14	22
14/10/19	6	13	20
15/10/19	10	13	11
16/10/19	5	15	1
17/10/19	3	13	1
18/10/19	9	14	1
19/10/19	7	14	1
20/10/19	7	12	1
21/10/19	9	13	1
22/10/19	3	14	0
23/10/19	4	14	1
24/10/19	7	12	10

d. Trial design



e. ORETO certificate

Certificate of

Official Recognition of Efficacy Testing Facilities or Organisations in the United Kingdom

This certifies that

RSK ADAS Ltd

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

The above Facility/Organisation has been officially recognised as being competent to carry out efficacy trials/tests in the United Kingdom in the following categories:

Agriculture/Horticulture
Stored Crops
Biologicals and Semiochemicals

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

Signature Alison Richardson
Authorised signatory

Certification Number
ORETO 409

HSE
Chemicals Regulation Division

Department of Agriculture and Rural Development