SCEPTREPLUS

# Final Trial Report

| | |
|---|---|
| **Trial code:** | SP27. 2018 (Year 1) |
| **Title:** | AHDB SCEPTREplus brassica herbicide screen<br>AHDB SCEPTREplus brassica band spray herbicide screen |
| **Crop:** | Group: field vegetables – Brassicas (cauliflower) |
| **Target:** | General broadleaf weeds and grasses, 3WEEDT<br>EPPO1/089(3) Weeds in leafy and brassica vegetables |
| **Lead researcher:** | Angela Huckle |
| **Organisation:** | RSK ADAS |
| **Period:** | 1st May 2018 – 31st March 2019 |
| **Report date:** | 22nd April 2020 |
| **Report author:** | Angela Huckle<br>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

23rd April 2020
Date

……
Authors signature

# Trial Summary

## Introduction

The limited range of herbicides currently available for use in brassica crops leaves gaps in the weed control spectrum, and growers experience problems with a wide range of weeds. 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 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 post-planting weed control are required.

The objective of these trials was to identify crop safe and effective herbicides for weed control in brassica crops, aiming to expand the options available to growers.

## Method

The trials were sited at Elsoms Trial Ground in Lincolnshire. The trial field was planted on 26th July 2018, with cauliflower variety 'Liria'.

**Trial 1:**

Treatments were applied at two timings. There were only two pre-planting treatments, which were both applied on 26th July. Post-planting treatments were applied to the remaining plots on 14th August, when the crop was at approximately 6 true leaves. All treatments were applied with a 2 m boom, using a knapsack sprayer at 400 L/ha water volume for the pre-planting treatments, and at 300 L/ha water volume for the post-planting treatments. A randomised block design was used, with three replicates of twenty treatments, including two untreated controls. There were sixty plots in total, each measuring 2.4 m x 4 m.

The plots were assessed on four occasions, focusing on weed cover and species presence, and crop phytotoxicity (i.e. treatment safety). In addition to the baseline weed assessment prior to the first treatment application (post-planting treated plots only), assessments were carried out approximately two, four, and eight weeks after treatments were applied.

**Trial 2:**

Treatments were applied once, within one week of planting (30th July). All treatments were applied with a hand-propelled band sprayer, using flat-fan nozzles at 300 L/ha water volume. Spray was applied up to the edge of the planted row. A randomised block design was used, with three replicates of five treatments. There were fifteen plots in total, each measuring 2.4 m x 4 m.

The plots were assessed on three occasions, focusing on weed cover and species presence, and crop phytotoxicity (i.e. treatment safety). Assessments were carried out approximately two, four, and eight weeks after treatments were applied.

## Results and discussion

**Trial 1:**

Weed levels were moderate across this herbicide screen, with an average of 36.4% cover in the untreated control at the final assessment (Table 1a).

AHDB 9875 applied pre-planting at proposed label rate gave significant control of the weed species present and appeared crop safe. AHDB 9999 also improved weed control compared to the untreated plots, but the reduction was not significant. However, AHDB 9999 may have potential to control charlock. AHDB 9875 gave the greatest level of control, with a final average weed cover of 4.4% (compared to 16.9% for AHDB 9999).

AHDB 9875 was also one of the best performing products when applied post planting. In this trial, AHDB 9875 treated plots had the lowest % weed cover at the final assessment and were the only plots to show an overall decrease in weed area over the duration of the trial. AHDB 9887 and AHDB 9890 also gave a significant reduction in weed cover at label rate, but in the case of AHDB 9890 the dose response was not consistent despite reducing weed levels at all rates.

Conversely, a significant increase in weed cover was seen in plots treated post-emergence with AHDB 9921 at any of the rates tested, and where AHDB 9874 was applied at double label rate. This is because some or all of the cauliflowers were killed as the products are not safe to use and weeds flourished with the lack of competition. The weeds which populated these plots were those which were gaps for the test products such as nettles in the case of AHDB 9874, and annual meadow grass in the case of AHDB 9921. Therefore, these products are not suitable for use in cauliflower. AHDB 9874 was safer to use at half label rate but efficacy was reduced and the reduction in weed cover was not significant.

AHDB 9875 and AHDB 9999 at pre-planting, and AHDB 9875 and AHDB 9887 at a post-planting timing warrant further testing in cauliflower and other commercially grown brassica species as these show potential to improve weed control in brassicas and were safe to use over cauliflower.

There were no issues with mixing or application of any products.

**Trial 2:**

There were no significant differences observed between treatments in Trial 2, with regards to both crop safety and efficacy (Table 1b). By eight weeks after application, all treatments appeared crop safe, with phytotoxicity scores all comfortably exceeding the minimum threshold for grower-accepted quality.

Similarly, all treatments performed well in weed control, with weed levels not exceeding 10% in any plot at eight weeks after treatment application. There was plenty of moisture when the residual herbicides were applied which aided efficacy, but also showed that band spraying could be a useful alternative to over the top spraying where products could be applied at full label rates safely.

**Table 1a.** Summary of crop damage and weed cover and percentage weed reduction compared to the control at eight weeks post-treatment (24th September 2018 for pre-plant treatments, 10th October for post-plant treatments) Weed cover data is shown as back transformed means. Figures in **bold** are significantly lower than the untreated control. Figures in ***bold italic*** are significantly higher than the untreated control. Figures in red indicate an increase in weed cover.

| Treatment | | Crop damage (0-10) | Weed cover (%) | Weed cover (% reduction compared to UTC) |
|---|---|---|---|---|
| **Untreated (UTC)** | | 8.00 | 36.4 | N/A |
| ***Pre-planting*** | | | | |
| **AHDB 9999** | (N) | 9.00 | 16.9 | 53.6 |
| **AHDB 9875** | (N) | 8.67 | **4.4** | 87.8 |

| Treatment | | Crop damage (0-10) | Weed cover (%) | Weed cover (% reduction compared to UTC) |
|---|---|---|---|---|
| ***Post-planting*** | | | | |
| **AHDB 9875** | (N) | 9.33 | **2.8** | 92.4 |
| **AHDB 9890** | (½ N) | 8.33 | 19.2 | 47.2 |
| **AHDB 9890** | (N) | 9.33 | **9.6** | 73.7 |
| **AHDB 9890** | (2N) | **7.67** | 25.5 | 29.8 |
| **AHDB 9979** | (¼ N) | **7.67** | 16.5 | 54.5 |
| **AHDB 9979** | (½ N) | **7.33** | 41.0 | -12.9 |
| **AHDB 9979** | (N) | **3.67** | 63.6 | -75.0 |
| **AHDB 9921** | (¼ N) | **1.00** | ***79.4*** | -118.5 |
| **AHDB 9921** | (½ N) | **1.00** | ***75.3*** | -107.1 |
| **AHDB 9921** | (N) | **0.00** | ***72.3*** | -98.9 |
| **AHDB 9874** | (½ N) | 8.67 | 14.8 | 59.4 |
| **AHDB 9874** | (N) | **7.67** | 52.0 | -43.1 |
| **AHDB 9874** | (2N) | **6.67** | ***83.2*** | -128.7 |
| **AHDB 9887** | (½ N) | 8.00 | 18.8 | 48.2 |
| **AHDB 9887** | (N) | 8.33 | **5.6** | 84.5 |
| **AHDB 9887** | (2N) | 8.67 | **8.1** | 77.9 |
| **F prob. value** | | <0.001 | <0.001 | |
| **d.f.** | | 39 | 39 | |
| **L.S.D.** | | 1.347 | 18.05 | |

**Table 1b.** Summary of crop damage and weed cover and percentage weed reduction compared to the control at eight weeks post-treatment (24th September 2018) **Weed cover data is shown as back transformed means.**

| Treatment | Crop damage (0-10) | Weed cover (%) |
|---|---|---|
| **Wing-P** 4.0 L/ha | 8.33 | 1.00 |
| **Wing-P** 4.0 L/ha + **Rapsan 500** 1.5 L/ha + **Gamit 36 CS** 0.25 L/ha | 8.33 | 0.87 |
| **Stomp Aqua** 2.0 L/ha + **AHDB 9898** | 8.67 | 1.00 |
| **Stomp Aqua** 2.0 L/ha + **AHDB 9898** + **Rapsan 500** 1.5 L/ha + **Gamit 36 CS** 0.25 L/ha | 8.67 | 0.19 |
| **Rapsan 500** 1.5 L/ha + **Gamit 36 CS** 0.25 L/ha | 9.33 | 2.00 |
| **F prob. value** | 0.309 | 0.169 |
| **d.f.** | 8 | 6 |
| **L.S.D.** | 1.114 | 4.563 |

## Conclusion

- AHDB 9875 and AHDB 9999 would be useful additions pre-planting, and AHDB 9999 may bring charlock control.
- AHDB 9875, AHDB 9887 and AHDB 9890 applied post-planting could improve weed control and possibilities for authorisation should be investigated.
- AHDB 9898 appears safe and effective when applied by band sprayer and when combined with current commercial standards such as pendimethalin, metazachlor and clomazone.
- Use of band spraying allows commercial standard products to be applied at maximum authorised rates, increasing efficacy while minimising crop damage.
- This is the first time many of these products have been trialled in brassicas and therefore further evaluation would be required before a full understanding of crop safety is known

## Take home message

Four products evaluated in this trial would improve weed control in brassica crops if an authorisation for their use was gained. These are AHDB 9875, AHDB 9999, AHDB 9890 and AHDB 9887. AHDB 9999 and AHDB 9890 also offer the possibility of control of charlock

## Objectives

**Trial 1:** To compare a number of new and novel herbicides at pre- and post-emergence application timings for selectivity (crop safety) and efficacy in cauliflowers.

**Trial 2:** To compare a number of herbicide tank-mixes applied using a band sprayer for selectivity (crop safety) and efficacy in cauliflowers.

## 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 |

There were no deviations from EPPO guidance.

## Test site

| **Item** | **Details** |
|---|---|
| Location address | Field: Elsoms Trial Ground<br>W Marsh Road<br>PE11 3UW<br>Lincolnshire<br>Grid reference: TF 26192 25911 |
| Crop | Cauliflower |
| Cultivar | 'Liria' |
| 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: | 3 |
| Row spacing: | approx. 0.6 m (4 rows per 2.4 m wide plot) |
| Plot size: (w x l) | 2.4 m x 4 m |
| Plot size: | 9.6 $m^2$ |
| Number of plants per plot: | Approximately 40 |

## Treatment details

| AHDB Code | Product name | Active substance | Formulation batch number | Content of active substance (g/L) | Formulation type |
|---|---|---|---|---|---|
| **TRIAL 1:** | | | | | |
| AHDB 9999 | N/D | N/D | N/D | N/D | N/D |
| AHDB 9875 | N/D | N/D | N/D | N/D | N/D |
| AHDB 9890 | N/D | N/D | N/D | N/D | N/D |
| AHDB 9979 | N/D | N/D | N/D | N/D | N/D |
| AHDB 9921 | N/D | N/D | N/D | N/D | N/D |
| AHDB 9874 | N/D | N/D | N/D | N/D | N/D |
| AHDB 9887 | N/D | N/D | N/D | N/D | N/D |

| | | | | | |
|---|---|---|---|---|---|
| **TRIAL 2:** | | | | | |
| N/A | Wing-P | dimethenamid-p + pendimethalin | N/K | 212.5<br>250 | Emulsifiable Concentrate |
| N/A | Rapsan 500 | metazachlor | N/K | 500 | Suspension Concentrate |
| N/A | Gamit 36 CS | clomazone | N/K | 360 | Capsule Suspension |
| AHDB 9898 | N/D | N/D | N/D | N/D | N/D |
| N/A | Stomp Aqua | pendimethalin | N/K | 455 | Capsule Suspension |

## Application schedule

### Trial 1:

| Trt. No. | Treatment: product name or AHDB code | Rate of active substance(s) (g/ha) | Rate of product (L/ha) | Timing |
|---|---|---|---|---|
| 1 | Untreated | - | - | - |
| 2 | Untreated | - | - | - |
| 3 | AHDB 9999 | 4000.0 | 5.00 | A |
| 4 | AHDB 9875 | 1200.0<br>24.0 | 3.00 | |
| 5 | AHDB 9875 | 1200.0<br>24.0 | 3.00 | B |
| 6 | AHDB 9890 ½ N | 360.0 | 0.75 | |
| 7 | AHDB 9890 N | 720.0 | 1.50 | |
| 8 | AHDB 9890 2x N | 1440.0 | 3.00 | |
| 9 | AHDB 9979 ¼ N | 3.0<br>70.0 | 0.25 | |
| 10 | AHDB 9979 ½ N | 6.0<br>140.0 | 0.50 | |
| 11 | AHDB 9979 N | 12.0<br>280.0 | 1.00 | |
| 12 | AHDB 9921 ¼ N | 3.0<br>2.5 | 0.50 | |
| 13 | AHDB 9921 ½ N | 6.0<br>5.0 | 1.00 | |
| 14 | AHDB 9921 N | 12.0<br>10.0 | 2.00 | |
| 15 | AHDB 9874 ½ N | 2.4<br>12.0 | 0.25 | |
| 16 | AHDB 9874 N | 4.8<br>24.0 | 0.50 | |
| 17 | AHDB 9874 2x N | 9.6<br>48.0 | 1.00 | |

| | | | |
|---|---|---|---|
| 18 | AHDB 9887 ½ N | 0.025<br>(kg/ha) 0.375 | (kg/ha) 0.50 |
| 19 | AHDB 9887 N | 0.05<br>(kg/ha) 0.75 | (kg/ha) 1.00 |
| 20 | AHDB 9887 2x N | 0.1<br>(kg/ha) 1.5 | (kg/ha) 2.00 |

N = label rate

**Trial 2:**

| Trt. No. | Treatment: product name or AHDB code | Rate of active substance(s) (g/ha) | Rate of product (L/ha) |
|---|---|---|---|
| 1 | Wing-P | 850<br>1000 | 4.00 |
| 2 | Wing-P +<br><br>Rapsan 500 +<br>Gamit 36 CS | 850<br>1000<br>750<br>90 | 4.00<br><br>1.50<br>0.25 |
| 3 | Stomp Aqua +<br>AHDB 9898 | 910<br>- | 2.00<br>- |
| 4 | Stomp Aqua +<br>AHDB 9898 +<br>Rapsan 500 +<br>Gamit 36 CS | 910<br>-<br>750<br>90 | 2.00<br>-<br>1.50<br>0.25 |
| 5 | Rapsan 500 +<br>Gamit 36 CS | 750<br>90 | 1.50<br>0.25 |

## Application details

| | Trial 1 | | Trial 2 |
|---|---|---|---|
| | **Timing A** | **Timing B** | **Timing A** |
| **Application date** | 26/07/2018 | 14/08/2018 | 30/07/2018 |
| **Time of day** | 06:50 | 14:00 | 15:30 |
| **Crop growth stage** (Max, min average BBCH) | N/A (pre-planting) | BBCH16-17 | BBCH14 |
| **Crop height** (cm) | N/A | 20 | 10 |
| **Crop coverage** (%) | N/A | 50 | 35 |
| **Application Method** | spray | spray | band spray |
| **Application Placement** | soil | foliar | soil |
| **Application equipment** | Oxford Precision Sprayer (knapsack) | Oxford Precision Sprayer (knapsack) | Hand propelled band sprayer |
| **Nozzle pressure** | 2.5 | 2.5 | 2.5 |
| **Nozzle type** | Flat fan | Flat fan | Flat fan |
| **Nozzle size** | 02-F110 | 02-F110 | 02-F110 |
| **Application water volume** (L/ha) | 400 | 300 | 300 |
| **Temperature of air – shade** (°C) | 22.0 | 23.0 | 23.0 |
| **Relative humidity** (%) | 80 | 64 | 60 |
| **Wind speed range** (mph) | 6.8 | 13 | (gust) 15 |
| **Dew presence** (Y/N) | N | N | N |
| **Temperature of soil - 10cm** | 21.0 | 19.6 | 20.0 |

| | Trial 1 | | Trial 2 |
|---|---|---|---|
| | Timing A | Timing B | Timing A |
| (°C) | | | |
| **Wetness of soil - 2-5 cm** | very dry | wet | wet/moist |
| **Cloud cover** (%) | 50 | 30 | 65 |

## Levels of pests/pathogens at application and through the assessment period (untreated averages)

**Trial 1 only (no UTC in Trial 2)**

| Common name | Scientific Name | EPPO Code | Weed level at first assessment | Weed level mid-assessment period (4 weeks) | Weed level at end of assessment period (8 weeks) |
|---|---|---|---|---|---|
| Broad leaved weeds and grasses | *N/A* | 3WEEDT | 1.50%* | 20.83% | 38.33% |

* baseline assessment of Timing B treated plots

## Assessment details

**Trial 1:**

| Evaluation date | Evaluation Timing (DA)* | Crop Growth Stage (BBCH) | Evaluation type (efficacy, phytotox) | What was assessed and how (e.g. dead or live pest; disease incidence and severity; yield, marketable quality) |
|---|---|---|---|---|
| 13/08/2018 | 19 (pre-em) | 16-17 | efficacy<br>phytotox | Percentage of weed cover (whole plot score), weed counts<br>Phytotox (scale 0-10, 0 = Dead) |
| | 0 (post-em) | | baseline | Percentage of weed cover (whole plot score), weed counts |
| 28/08/2018 | 34 (pre-em) | 19 | efficacy<br>phytotox | Percentage of weed cover (whole plot score), weed species presence<br>Phytotox (scale 0-10, 0 = Dead) |
| | 15 (post-em) | | efficacy<br>phytotox | Percentage of weed cover (whole plot score), weed counts<br>Phytotox (scale 0-10, 0 = Dead) |
| 10/09/2018 | 28 (post-em) | 19 | efficacy<br>phytotox | Percentage of weed cover (whole plot score), weed species presence<br>Phytotox (scale 0-10, 0 = Dead) |
| 24/09/2018 | 61 (pre-em) | 19 | efficacy<br>phytotox | Percentage of weed cover (whole plot score), weed species presence<br>Phytotox (scale 0-10, 0 = Dead) |
| 10/10/2018 | 58 (post-em) | 41 | efficacy<br>phytotox | Percentage of weed cover (whole plot score)<br>Phytotox (scale 0-10, 0 = Dead) |

* DA – days after application

**Trial 2:**

| Evaluation date | Evaluation Timing (DA)* | Crop Growth Stage (BBCH) | Evaluation type (efficacy, phytotox) | What was assessed and how (e.g. dead or live pest; disease incidence and severity; yield, marketable quality) |
|---|---|---|---|---|
| 13/08/2018 | 14 | 16-17 | efficacy<br>phytotox | Percentage of weed cover, weed counts (3x quadrats)<br>Phytotox (scale 0-10, 0 = Dead) |

| | | | | |
|---|---|---|---|---|
| 28/08/2018 | 29 | 19 | efficacy<br>phytotox | Percentage of weed cover (whole plot score), weed species presence<br>Phytotox (scale 0-10, 0 = Dead) |
| 24/09/2018 | 56 | 41 | efficacy<br>phytotox | Percentage of weed cover (whole plot score), weed species presence<br>Phytotox (scale 0-10, 0 = Dead) |

* DA – days after application

## Statistical analysis

The trials had randomised block designs, each with treatments replicated three times. Trial 1 comprised twenty treatments, including two untreated controls, and Trial 2 comprised five treatments.

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 Abbotts formula.

All data were analysed by ANOVA using Genstat 18.4 by Emily Lawrence at RSK ADAS.

## Results

***Phytotoxicity***
Phytotoxicity was recorded using the following scale:

| Crop tolerance score | Equivalent to crop damage (% phytotoxicity) |
|---|---|
| 0 | *(complete crop kill)* 100% |
| 1 | 90% |
| 2 | 80% |
| 3 | 70% |
| 4 | 60% |
| 5 | 50% |
| 6 | 40% |
| 7 | 30% |
| *8 | 20% |
| 9 | 10% |
| 10 | *(no damage)* 0% |

* ≥8 = acceptable damage, i.e. damage unlikely to reduce yield and acceptable to the farmer.

**Trial 1:**
Phytotoxicity results are presented in Table 2 and Figure 1, and were scored according to the above scale.

The untreated showed slight crop effects and was not scored as 10 as the plots were blind scored and showed some minor plant size variability from compaction and weed competition. However, all plots were scored relative to each other using the criteria above, and the untreated control scores remained above the commercially acceptable level.
Both of the pre-planting herbicides—AHDB 9999 and AHDB 9875—were safe to use in cauliflower with no effects seen on the crop throughout any of the trial assessments at up to eight weeks after treatment, with scores equivalent or greater than the untreated controls.

Of the post-emergence herbicides, AHDB 9875, AHDB 9890 and AHDB 9887 were safe to use post-emergence in cauliflower up to label rate with commercially acceptable scores at eight weeks after application. Less weed control from quarter label rate of AHDB9887 meant that the crop was stunted in these plots due to weed competition and therefore scored lower for

phytotoxicity as the stunting was recorded as a crop effect. At double label rate of AHDB 9890 and AHDB 9887, some leaf distortion was seen, indicating that care would have to be taken to avoid overlaps with these products. Although there was leaf distortion, there was no crop loss at the higher rate when using these products.

AHDB 9874 was safe to use at half label rate over cauliflower, but at label rate or above the product caused significant leaf distortion and stunting, and at double the label rate crop loss was seen indicating that the product is on the margins of crop safety.

AHDB 9921 was too damaging for use in cauliflower and caused significant crop loss at all rates tested. AHDB 9979 was also too damaging to use at rates above quarter of the label rate, causing significant leaf distortion, and in addition caused crop loss when applied at the label rate. These two products are not suitable for use in cauliflower.

**Table 2.** Mean phytotoxicity scores at three dates throughout the Trial 1 assessment period. Values which are significantly different to untreated are starred. *(WAT = weeks after treatment)* Those with a score under 8 are in **bold,** as any score below this is deemed commercially unacceptable.

| Treatment | | Mean crop damage scores | | |
|---|---|---|---|---|
| | | 2 WAT | 4 WAT | 8 WAT |
| **Untreated*** | | 8.17 | 8.33 | 8.00 |
| ***Pre-planting treatments*** | | | | |
| **AHDB 9999** | (N) | 8.67 | 9.47 | 9.00 |
| **AHDB 9875** | (N) | 8.00 | 8.67 | 8.67 |
| ***Post-planting treatments*** | | | | |
| **AHDB 9875** | (N) | 8.33 | 8.67 | 9.33 |
| **AHDB 9890** | (½ N) | **7.00** | 8.33 | 8.33 |
| **AHDB 9890** | (N) | 8.33 | 9.00 | 9.33 |
| **AHDB 9890** | (2N) | **7.67** | 8.00 | **7.67** |
| **AHDB 9979** | (¼ N) | 8.33 | 8.33 | **7.67** |
| **AHDB 9979** | (½ N) | **6.33** | ***6.33** | **7.33** |
| **AHDB 9979** | (N) | ***5.00** | ***4.00** | ***3.67** |
| **AHDB 9921** | (¼ N) | ***2.67** | ***1.67** | ***1.00** |
| **AHDB 9921** | (½ N) | ***3.00** | ***1.33** | ***1.00** |
| **AHDB 9921** | (N) | ***2.33** | ***1.00** | ***0.00** |
| **AHDB 9874** | (½ N) | 8.67 | 9.33 | 8.67 |
| **AHDB 9874** | (N) | **7.33** | 7.67 | **7.67** |
| **AHDB 9874** | (2N) | ***4.67** | ***5.00** | **6.67** |
| **AHDB 9887** | (½ N) | **7.00** | **7.67** | 8.00 |
| **AHDB 9887** | (N) | 8.33 | 9.00 | 8.33 |
| **AHDB 9887** | (2N) | 9.00 | 8.33 | 8.67 |
| **F prob. value** | | <0.001 | <0.001 | <0.001 |
| **d.f.** | | 39 | 38 | 39 |
| **L.S.D.** | | 1.985 | 1.585 | 1.347 |

* Treatments 1 and 2

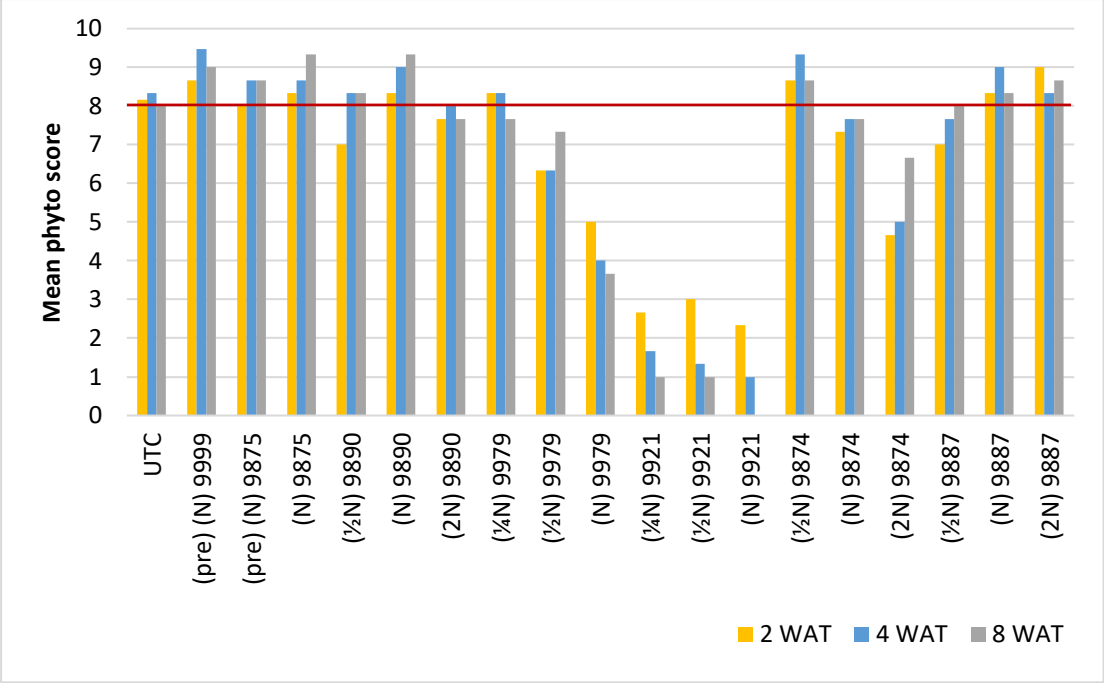



**Figure 1.** Mean phytotoxicity (0-10) at two, four, and eight weeks after treatment application to Trial 1. Scores of 8 or above (marked by red line) deemed acceptable damage. *(WAT = weeks after treatment; pre-emergence treatments labelled "pre")*

**Trial 2:**
Phytotoxicity results are presented in Table 3 and Figure 1, and were scored according to the above scale.

There was no untreated control in this trial, but the plots were scored relative to the control in Trial 1 which was adjacent to this trial. There were no significant differences between treatments, but those where Wing-P was included showed a slight check to speed of growth for up to a month after application. However, this effect was transient and the crop appeared acceptable 2 months after application, with good vigour. Rapsan 500 + Gamit 36 CS is a commercial standard usually applied over the top of the crop after planting, and this was safe to use with no effect on the cauliflower in this trial when applied as a band spray up to the edge of the planted row.

**Table 3.** Mean phytotoxicity scores at three dates throughout the Trial 2 assessment period. *(WAT = weeks after treatment).* Those with a score under 8 are in **bold** as any score below this is deemed commercially unacceptable.

| Treatment | Mean crop damage scores | | |
|---|---|---|---|
| | 2 WAT | 4 WAT | 8 WAT |
| **Wing-P** | **7.33** | **7.67** | 8.33 |
| **Wing-P** + **Rapsan 500** + **Gamit 36 CS** | **7.33** | 8.00 | 8.33 |
| **Stomp Aqua** + **AHDB 9898** | 8.67 | 8.67 | 8.67 |
| **Stomp Aqua** + **AHDB 9898** + **Rapsan 500** + **Gamit 36 CS** | 8.00 | 8.33 | 8.67 |
| **Rapsan 500** + **Gamit 36 CS** | 8.00 | 8.67 | 9.33 |
| **F prob. value** | 0.545 | 0.732 | 0.309 |

| Treatment | Mean crop damage scores | | |
|---|---|---|---|
| | 2 WAT | 4 WAT | 8 WAT |
| **d.f.** | 8 | 8 | 8 |
| **L.S.D.** | 2.004 | 1.990 | 1.114 |

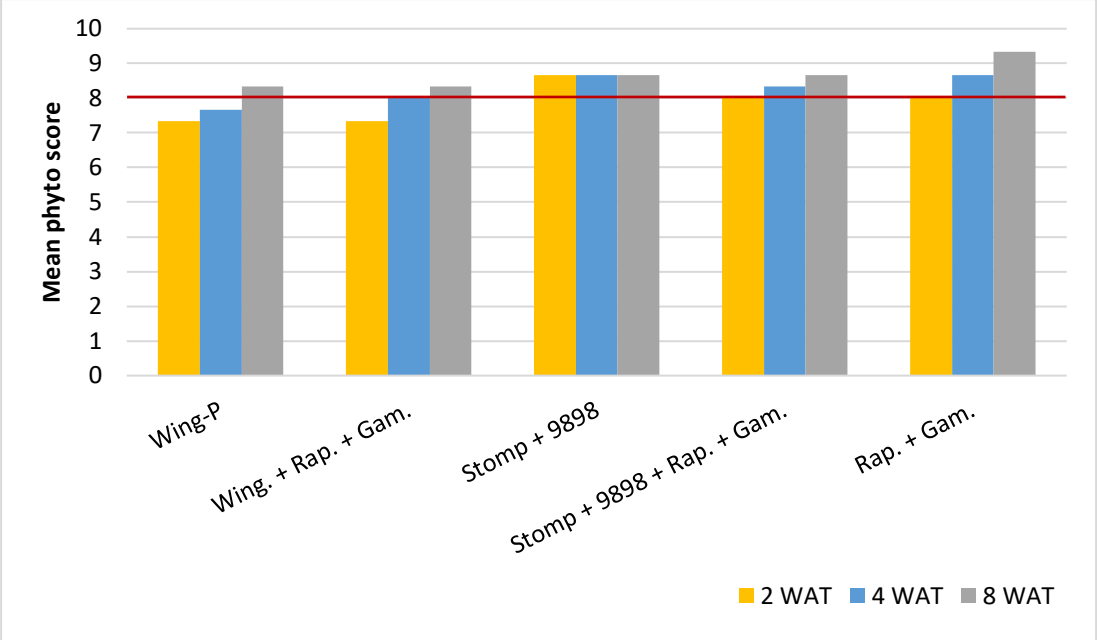



**Figure 2.** Mean phytotoxicity (0-10) at two, four, and eight weeks after treatment application to Trial 2. Scores of 8 or above (marked with red line) deemed acceptable damage. *(WAT = weeks after treatment)*

***Weed control – mean percentage weed cover***

**Trial 1:**

Weed cover results are presented in Table 4 and Figure 3. These figures were used to calculate the percent reduction in weed cover compared to the untreated control (using Abbotts formula), and these values are listed in Table 5.

A significant reduction in weed levels was observed for up to eight weeks after application in plots treated with AHDB 9875 at pre-planting or post-planting, or AHDB 9887 at post-planting at the label rate for these products. AHDB 9890 also gave a significant reduction in weed cover at label rate, but the dose response was not consistent despite reducing weed levels at all rates.

A significant increase in weed cover was seen in plots treated post-emergence with AHDB 9921 at any of the rates tested, and where AHDB 9874 was applied at double label rate. This is because some or all of the cauliflowers were killed, and weeds flourished with the lack of competition. The weeds which populated these plots were those which were gaps for the test products such as nettles in the case of AHDB 9874, and annual meadow grass in the case of AHDB 9921. Therefore, these are not suitable for use in cauliflower. AHDB 9874 was safer to use at half label rate but efficacy was reduced and the reduction in weed cover was not significant.

**Table 4.** Mean percentage weed cover values (transformed) for Trial 1. Figures in **bold** are significantly lower than the untreated control. Figures in ***bold italic*** are significantly higher than the untreated control. *(WAT = weeks after treatment)*

| Trt. No. | | Mean weed cover (%) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 2 WAT | | 4 WAT | | 8 WAT | |
| | | Ang | Back-trans | Ang | Back-trans | Ang | Back-trans |
| **Untreated*** | | 16.3 | 7.9 | 26.4 | 19.8 | 37.1 | 36.4 |
| ***Pre-planting treatments*** | | | | | | | |
| **AHDB 9999** | (N) | **4.6** | **0.7** | **13.7** | **5.6** | 24.3 | 16.9 |
| **AHDB 9875** | (N) | **0.0** | **0.0** | **5.7** | **1.0** | **12.1** | **4.4** |
| ***Post-planting treatments*** | | | | | | | |
| **AHDB 9875** | (N) | **10.5** | **3.3** | **10.5** | **3.3** | **9.5** | **2.8** |
| **AHDB 9890** | (½ N) | **10.3** | **3.2** | **16.6** | **8.2** | 26.0 | 19.2 |
| **AHDB 9890** | (N) | **8.0** | **1.9** | **13.7** | **5.6** | **18.0** | **9.6** |
| **AHDB 9890** | (2N) | 11.3 | 3.9 | 18.5 | 10.1 | 30.4 | 25.5 |
| **AHDB 9979** | (¼ N) | 14.0 | 5.8 | 20.8 | 12.6 | 24.0 | 16.5 |
| **AHDB 9979** | (½ N) | 12.1 | 4.4 | 19.9 | 11.6 | 39.8 | 41.0 |
| **AHDB 9979** | (N) | **8.9** | **2.4** | **18.1** | **9.6** | 52.9 | 63.6 |
| **AHDB 9921** | (¼ N) | 11.4 | 3.9 | 20.0 | 11.7 | ***63.0*** | ***79.4*** |
| **AHDB 9921** | (½ N) | 11.8 | 4.2 | 19.5 | 11.1 | ***60.2*** | ***75.3*** |
| **AHDB 9921** | (N) | 11.8 | 4.2 | **18.1** | **9.6** | ***58.2*** | ***72.3*** |
| **AHDB 9874** | (½ N) | 14.8 | 6.5 | 22.6 | 14.8 | 22.6 | 14.8 |
| **AHDB 9874** | (N) | 16.8 | 8.3 | 32.2 | 28.5 | 46.1 | 52.0 |
| **AHDB 9874** | (2N) | 16.3 | 7.9 | 31.0 | 26.4 | ***65.8*** | ***83.2*** |
| **AHDB 9887** | (½ N) | 11.3 | 3.8 | **15.6** | **7.2** | 25.7 | 18.8 |
| **AHDB 9887** | (N) | 11.0 | 3.6 | **12.9** | **5.0** | **13.7** | **5.6** |
| **AHDB 9887** | (2N) | **10.3** | **3.2** | **11.9** | **4.3** | **16.5** | **8.1** |
| **F prob. value** | | | <0.001 | | <0.001 | | <0.001 |
| **d.f.** | | | 38 | | 38 | | 39 |
| **L.S.D.** | | | 5.716 | | 8.064 | | 18.05 |

* Treatments 1 and 2

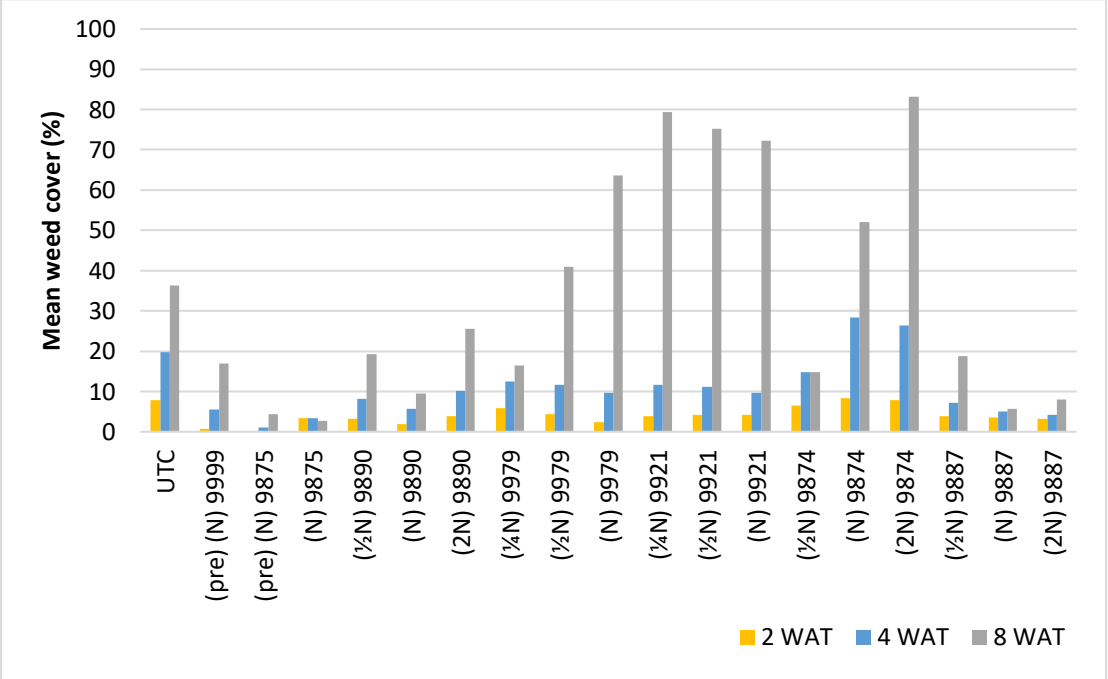


**Figure 3.** Mean weed cover (%) at two, four, and eight weeks after treatment application to Trial 1. *(WAT = weeks after treatment; pre-emergence treatments labelled "pre")*

**Table 5.** Percentage reduction in weed cover compared to the untreated control at two, four and eight weeks after treatment application to Trial 1—highlighted values show an increase in weed cover. *(WAT = weeks after treatment)*

| Treatment | | Weed cover reduction (%) | | |
|---|---|---|---|---|
| | | 2 WAT | 4 WAT | 8 WAT |
| ***Pre-planting treatments*** | | | | |
| **AHDB 9999** | (N) | 91.7 | 71.8 | 53.6 |
| **AHDB 9875** | (N) | 100.0 | 94.9 | 87.8 |
| ***Post-planting treatments*** | | | | |
| **AHDB 9875** | (N) | 57.6 | 83.1 | 92.4 |
| **AHDB 9890** | (½ N) | 59.1 | 58.7 | 47.2 |
| **AHDB 9890** | (N) | 75.7 | 71.5 | 73.7 |
| **AHDB 9890** | (2N) | 50.9 | 49.0 | 29.8 |
| **AHDB 9979** | (¼ N) | 26.0 | 36.4 | 54.5 |
| **AHDB 9979** | (½ N) | 43.9 | 41.2 | -12.9 |
| **AHDB 9979** | (N) | 69.4 | 51.4 | -75.0 |
| **AHDB 9921** | (¼ N) | 50.5 | 40.7 | -118.5 |
| **AHDB 9921** | (½ N) | 47.2 | 43.6 | -107.1 |
| **AHDB 9921** | (N) | 47.2 | 51.4 | -98.9 |
| **AHDB 9874** | (½ N) | 17.6 | 25.3 | 59.4 |
| **AHDB 9874** | (N) | -5.5 | -44.1 | -43.1 |
| **AHDB 9874** | (2N) | -0.5 | -33.9 | -128.7 |
| **AHDB 9887** | (½ N) | 51.4 | 63.5 | 48.2 |
| **AHDB 9887** | (N) | 54.1 | 74.7 | 84.5 |
| **AHDB 9887** | (2N) | 59.1 | 78.3 | 77.9 |

The initial weed burden in the Trial 1 field was low, with a mean of 1.7% and little variation across the field (min. = 0.8%, max. = 3.0%). The change in weed cover from this baseline assessment to the final assessment, eight weeks after the first treatment application, was assessed. All treatments, with the exception of AHDB 9875 applied post-planting showed a net increase in weed cover over this period (Figure 4), though eleven treatments were observed to reduce the rate of weed cover increase (relative to the untreated control) by between 47% and 92%, depending on the treatment (Table 5, Figure 4). Treatments of AHDB 9875 or 9887 performed particularly well, with an increase in weed cover of less than 5% over the eight week duration of the trial when applied at label rate.

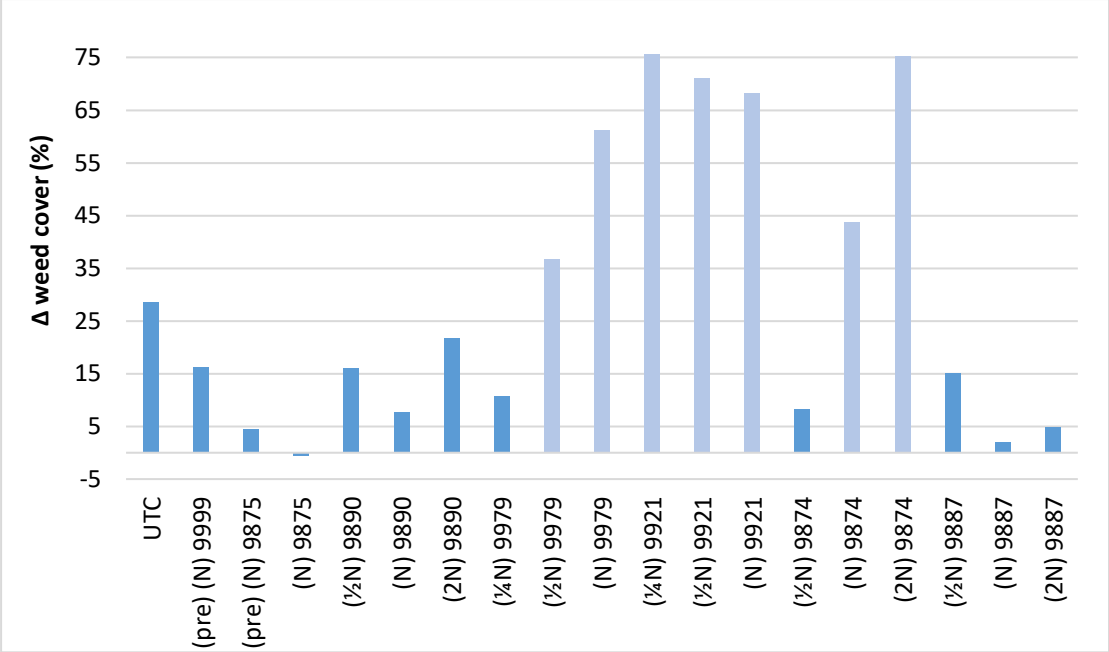



**Figure 4.** Percentage change in average weed cover over six-week assessment period of Trial 1. Light blue bars indicate treatments where weed cover increase was greater than that of untreated control. *(+ve change = weed cover increase, -ve change = weed cover decrease)*

**Trial 2:**
Weed cover results are presented in Table 6 and Figure 5. All band-sprayed treatments gave good weed control, keeping weed levels across the whole trial below 10% mean weed cover.

**Table 6.** Mean percentage weed cover values (transformed).

| Trt. No. | Mean weed cover (%) | | | | | |
|---|---|---|---|---|---|---|
| | 2 WAT | | 4 WAT | | 8 WAT | |
| | Ang | Back-trans | Ang | Back-trans | Ang | Back-trans |
| **Wing-P** | 1.56 | 0.07 | 5.74 | 1.00 | 5.74 | 1.00 |
| **Wing-P** + **Rapsan 500** + **Gamit 36 CS** | 1.10 | 0.04 | 5.74 | 1.00 | 5.34 | 0.87 |
| **Stomp Aqua** + **AHDB 9898** | 1.10 | 0.04 | 5.74 | 1.00 | 5.74 | 1.00 |
| **Stomp Aqua** + **AHDB 9898** + **Rapsan 500** + **Gamit 36 CS** | 2.66 | 0.22 | 5.74 | 1.00 | 2.47 | 0.19 |
| **Rapsan 500** + **Gamit 36 CS** | 4.68 | 0.67 | 5.74 | 1.00 | 8.13 | 2.00 |
| **F prob. value** | | 0.293 | | - | | 0.169 |
| **d.f.** | | 8 | | - | | 6 |
| **L.S.D.** | | 4.058 | | - | | 4.563 |

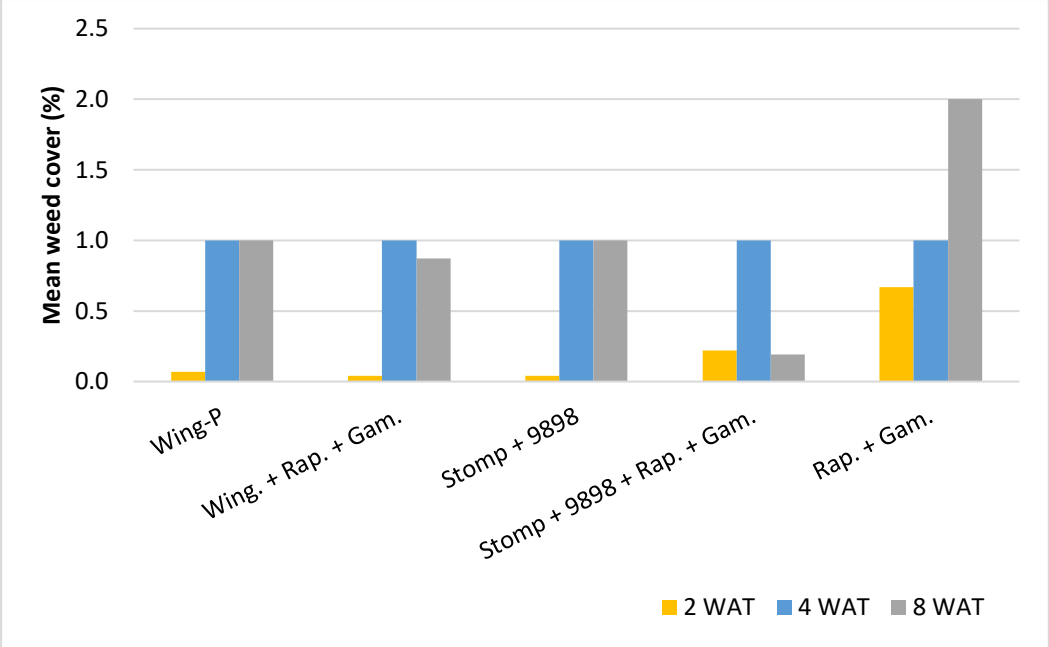



**Figure 5.** Mean weed cover (%) at two, four, and eight weeks after treatment application to Trial 2. Note: y-axis max. value of 2.5%. *(WAT = weeks after treatment)*

## Discussion

**Trial 1:**

Weed levels were moderate across this herbicide screen, with an average of 36.4% cover in the untreated control at the final assessment.

AHDB 9875 applied pre-planting at proposed label rate gave significant control of the weed species present and appeared crop safe. AHDB 9999 also improved weed control compared to the untreated plots, but the reduction was not significant. However, AHDB 9999 may have potential to control charlock. AHDB 9875 gave the greatest level of control, with a final average weed cover of 4.4% (compared to 16.9% for AHDB 9999).

AHDB 9875 was also one of the best performing products when applied post planting. In this trial, AHDB 9875 treated plots had the lowest % weed cover at the final assessment and were the only plots to show an overall decrease in weed area over the duration of the trial. AHDB 9887 and AHDB 9890 also gave a significant reduction in weed cover at label rate, but in the case of AHDB 9890 the dose response was not consistent despite reducing weed levels at all rates.

Conversely, a significant increase in weed cover was seen in plots treated post-emergence with AHDB 9921 at any of the rates tested, and where AHDB 9874 was applied at double label rate. This is because some or all of the cauliflowers were killed as the products are not safe to use and weeds flourished with the lack of competition. The weeds which populated these plots were those which were gaps for the test products such as nettles in the case of AHDB 9874, and annual meadow grass in the case of AHDB 9921. Therefore, these products are not suitable for use in cauliflower. AHDB 9874 was safer to use at half label rate but efficacy was reduced and the reduction in weed cover was not significant.

AHDB 9875 and AHDB 9999 at pre-planting, and AHDB 9875 and AHDB 9887 at a post-planting timing warrant further testing in cauliflower and other brassica crops as these show potential to improve weed control in brassicas and were safe to use over cauliflower.

There were no issues with mixing or application of any products.

**Trial 2:**
There were no significant differences observed between treatments in Trial 2, with regards to both crop safety and efficacy. By eight weeks after application, all treatments appeared crop safe, with phytotoxicity scores all comfortably exceeding the minimum threshold for grower-accepted quality.

Similarly, all treatments performed well in weed control, with weed levels not exceeding 10% in any plot at eight weeks after treatment application. There was plenty of moisture when the residual herbicides were applied which aided efficacy, but also showed that band spraying could be a useful alternative to over the top spraying where products could be applied at full label rates safely.

## Conclusions

- AHDB 9875 and AHDB 9999 would be useful additions pre-planting, and AHDB 9999 may bring charlock control.
- AHDB 9875, AHDB 9887 and AHDB 9890 applied post-planting could improve weed control and possibilities for authorisation should be investigated.
- AHDB 9898 appears safe and effective when applied by band sprayer and when combined with current commercial standards such as pendimethalin, metazachlor and clomazone.
- Use of band spraying allows commercial standard products to be applied at maximum authorised rates, increasing efficacy while minimising crop damage.

## Acknowledgements

AHDB for funding the work, and the crop protection companies for their financial contributions and provision of samples for the trials. Thanks should also be given 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.

**Site 1:**

| **Crop** | **Cultivar** | **Planting date** | **Row width** (m) |
|---|---|---|---|
| Cauliflower | Liria | 26/07/2018 | |

**Previous cropping**

| **Year** | **Crop** |
|---|---|
| 2018 | N/D |
| 2017 | N/D |
| 2016 | N/D |
| 2015 | N/D |

**Cultivations**

| **Date** | **Description** | **Depth** (cm) |
|---|---|---|
| | N/D | |
| | N/D | |

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

| **Date** | **Product** | **Rate** (kg/ha) |
|---|---|---|
| | N/D | |
| | N/D | |
| | N/D | |

**Pesticides applied to trial area**

| **Date** | **Product** | **Rate** (L/ha) |
|---|---|---|
| N/D | | |
| N/D | | |
| N/D | | |

**Details of irrigation regime**

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

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

| | Date | Event |
|---|---|---|
| TRIAL 1 | 26/07/2018 | Pre-planting treatments applied.<br>Crop planted. |
| | 13/08/2018 | Pre-planting treated plots assessed – phyto/weeds at two weeks after treatment.<br>Post-planting treated plots assessed – baseline weeds prior to treatment. |
| | 14/08/2018 | Post-planting spray applied. |
| | 28/08/2018 | Pre-planting treated plots assessed – phyto/weeds at four weeks after treatment.<br>Post-planting treated plots assessed – phyto/weeds at two weeks after treatment. |
| | 10/09/2018 | Post-planting treated plots assessed – phyto/weeds at four weeks after treatment. |
| | 24/09/2018 | Pre-planting treated plots assessed – phyto/weeds at eight weeks after treatment. |
| | 10/10/2018 | Post-planting treated plots assessed – phyto/weeds at eight weeks after treatment. |
| TRIAL 2 | 30/07/2018 | Treatments applied. |
| | 13/08/2018 | Two weeks after treatment assessment (phyto/weeds). |
| | 28/08/2018 | Four weeks after treatment assessment (phyto/weeds). |
| | 24/09/2018 | Eight weeks after treatment assessment (phyto/weeds). |

c. Climatological data during study period from each site.

| Date | Temperature °C (minimum) | Temperature °C (maximum) | Rainfall (mm) |
|---|---|---|---|
| 31/07/2018 | 23.0 | 26.0 | |
| 01/08/2018 | 22.5 | 26.0 | |
| 02/08/2018 | 23.0 | 28.0 | |
| 03/08/2018 | 23.0 | 25.5 | |
| 04/08/2018 | 24.0 | 27.5 | |
| 05/08/2018 | 23.5 | 28.0 | |
| 06/08/2018 | 23.5 | 26.5 | |
| 07/08/2018 | 22.0 | 26.0 | |
| 08/08/2018 | 22.0 | 26.0 | |
| 09/08/2018 | 22.5 | 24.5 | |
| 10/08/2018 | 20.5 | 23.5 | |
| 11/08/2018 | 19.5 | 23.0 | |
| 12/08/2018 | 20.5 | 21.5 | |
| 13/08/2018 | 16.5 | 23.0 | |
| 14/08/2018 | 13.5 | 23.0 | |
| 15/08/2018 | 14.5 | 26.0 | |
| 16/08/2018 | 12.5 | 20.0 | |
| 17/08/2018 | 9.5 | 21.0 | |
| 18/08/2018 | 15.5 | 24.5 | |
| 19/08/2018 | 17.0 | 23.0 | |
| 20/08/2018 | 15.5 | 25.5 | |
| 21/08/2018 | 17.5 | 26.5 | |
| 22/08/2018 | 15.0 | 27.5 | |
| 23/08/2018 | 12.5 | 20.0 | |
| 24/08/2018 | 9.5 | 18.0 | |
| 25/08/2018 | 8.0 | 19.5 | |
| 26/08/2018 | 8.5 | 17.0 | |
| 27/08/2018 | 13.0 | 19.0 | |
| 28/08/2018 | 14.5 | 19.0 | |
| 29/08/2018 | 11.0 | 19.5 | |
| 30/08/2018 | 9.0 | 20.5 | |
| 31/08/2018 | 6.0 | 21.5 | |
| 01/09/2018 | 10.0 | 26.0 | |
| 02/09/2018 | 10.5 | 26.0 | |
| 03/09/2018 | 9.0 | 25.5 | |
| 04/09/2018 | 11.5 | 16.5 | |
| 05/09/2018 | 11.0 | 19.5 | |
| 06/09/2018 | 8.0 | 22.0 | |
| 07/09/2018 | 6.5 | 17.5 | |
| 08/09/2018 | 9.5 | 18.0 | |
| 09/09/2018 | 13.5 | 22.5 | |
| 10/09/2018 | 12.0 | 19.5 | |
| 11/09/2018 | 15.5 | 19.5 | |
| 12/09/2018 | 6.5 | 18.0 | |
| 13/09/2018 | 3.5 | 21.0 | |
| 14/09/2018 | 11.0 | 19.5 | |
| 15/09/2018 | 8.0 | 21.0 | |
| 16/09/2018 | 12.5 | 23.5 | |
| 17/09/2018 | 16.0 | 25.5 | |
| 18/09/2018 | 13.5 | 23.5 | |
| 19/09/2018 | 15.5 | 24.5 | |
| 20/09/2018 | 11.0 | 19.5 | |
| 21/09/2018 | 9.0 | 17.5 | |
| 22/09/2018 | 8.5 | 13.5 | |
| 23/09/2018 | 4.0 | 14.0 | |

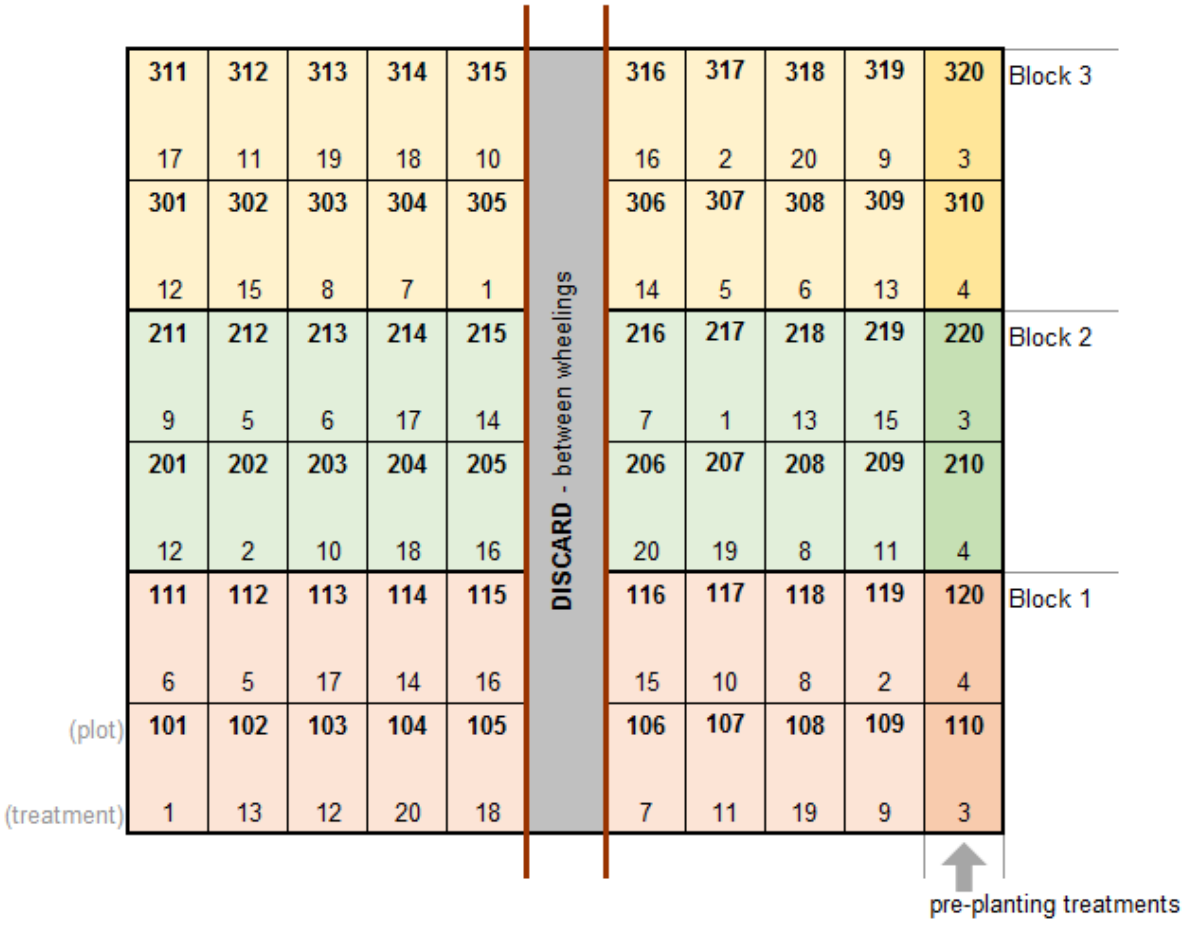
| | | | |
|---|---|---|---|
| 24/09/2018 | 3.0 | 17.5 | |
| 25/09/2018 | 0.5 | 18.5 | |
| 26/09/2018 | 9.0 | 24.0 | |
| 27/09/2018 | 10.5 | 25.5 | |
| 28/09/2018 | 2.0 | 17.5 | |
| 29/09/2018 | -0.5 | 19.0 | |
| 30/09/2018 | 5.5 | 15.5 | |
| 01/10/2018 | 4.5 | 16.5 | |
| 02/10/2018 | 9.0 | 19.5 | |
| 03/10/2018 | 7.0 | 18.0 | |
| 04/10/2018 | 11.5 | 22.0 | |
| 05/10/2018 | 11.5 | 19.5 | |
| 06/10/2018 | 6.0 | 12.0 | |
| 07/10/2018 | 2.5 | 14.5 | |
| 08/10/2018 | 5.0 | 16.5 | |
| 09/10/2018 | 10.5 | 21.5 | |
| 10/10/2018 | 4.5 | 24.0 | |

d. Photos of phytotoxic effects 10th September 2018

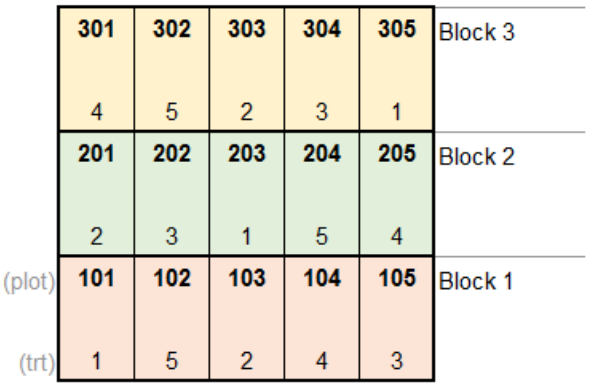
| | |
|---|---|
|  |  |
| Untreated control | AHDB 9921 at label rate - Crop death |
|  |  |
| AHDB 9979 at half label rate - Crop stunting | AHDB 9874 at label rate - Crop distortion and loss |

e. Trial design

**Trial 1:**




**Trial 2:**




f. ORETO certificate

# *Certificate of*

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

*This certifies that*

**RSK ADAS Ltd**

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

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

**Agriculture/Horticulture**
**Stored Crops**
**Biologicals and Semiochemicals**

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

**Signature** *Authorised signatory*

**Certification Number**
ORETO 409

HSE
Chemicals Regulation Division

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