SCEPTREPLUS

# Final Trial Report

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|---|---|
| **Trial code:** | SP06.2019 |
| **Title:** | **AHDB SCEPTREplus sweetcorn pre-emergence herbicide screen – grown under covers** |
| **Crop** | **Group: Field Vegetables**<br>**Sweetcorn** – *Zea mays* |
| **Target** | **General Broadleaf Weeds and Grasses**, 3WEEDT<br>EPPO1/50(3) Weeds in Maize |
| **Lead researcher:** | Angela Huckle |
| **Organisation:** | RSK ADAS |
| **Period:** | 27th March 2019 – 31st March 2020 |
| **Report date:** | 7th July 2020 |
| **Report author:** | **Angela Huckle**<br>Oliver Thomas |
| **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

……6th Jul 2020…… ……A. Huckle……
Date Authors signature

……7th July 2020…… ……B. Mulholland……
Date Managers signature

## Trial Summary

## Introduction

The limited range of herbicides available for use on sweetcorn (*Zea mays*) has left gaps in the weed control spectrum. Until recently, there was only one pre-emergence option available (pendimethalin) for sweetcorn growers, but the number of products available increased after EAMUs for Dual Gold (2834/17) and Wing-P (0917/18) were authorised from trials undertaken in the SceptrePlus project in 2017. Dual Gold in particular gave an alternative mode of action to ALS-inhibitors for grass weed control.

However, particularly problematic broad leaf weeds remain elusive targets for growers; such as knotgrass (*Polygonum)*, red shank (*Persicaria maculosa)*, pale persicaria *(Polygonum lapathifolium)*, marestail *(Equisetum arvense)*, and volunteer OSR *(Brassica napus)*, as well as blackgrass *(Alopecurus myosuroides)*, brome (*Bromus)*, common millet *(Panicum miliaceum)*, wild oats *(Avena fatua)*, and cereal volunteers. Furthermore, *Amaranthus retroflexus* is an emerging issue (AHDB Gap Analysis 2019).

The trials in 2017 were carried out on an uncovered main season crop of sweetcorn, and therefore more information was desired by growers to test the newly approved products and promising products on earlier drilled crops which would be a more sensitive situation. Early drilling is understood to increase sensitivity to herbicides, as conditions are cooler and the crop is growing slower. The sweetcorn was also grown under a biodegradable mulch, which provide a robust test for herbicides because weeds species exhibit particularly vigorous growth under crop covers.

The aim of the work was to screen pre-emergence residual herbicides in order to increase the weed control options available to sweetcorn growers for early season and main crops,

## Methods

The screen of residual herbicide products was carried out at two separate sites on a grower holding in Sussex on silty loam soils. A randomised replicated design was used to test for treatment effects. The first site was drilled on 10$^{th}$ April 2019, while the second site was drilled on 16$^{th}$ April 2019; both sites were drilled with the cultivar “Early Bird”.

All treatments at both sites were applied at a pre-emergence timing (T1) with a 3 m boom, using an Oxford Precision Sprayer (knapsack), and a water rate of 200 L/ha. The randomised block design consisted of three replicates of 16 treatments, including two untreated controls. There were 48 plots in total at each site, each measuring 3.3 m x 5.0 m (16.5 m$^2$). Each plot consisted of two beds and four crop rows—two per bed.

The trial sites were assessed on four occasions, focussing on treatment efficacy and crop phytotoxicity (safety). Weed control was assessed using weed counts; a percentage of overall plot cover of all weeds, and a percentage cover of each weed species was measured. At the second site, a 0.25 m x 0.25 m quadrat was used, and the total number of weed plants was counted for each individual weed species. Site 1 had a much higher weed burden than the second site, so a quadrat assessment wasn’t used. Crop phytotoxicity (safety) was assessed at the same timings; crop affects were scored on a 0 - 10 scale, 0 = completely healthy crop, 10 = complete crop kill.

**Site 1** assessment timings: **18**, **40**, **54** and **68** days after treatment application.
**Site 2** assessment timings: **12, 34, 48** and **62** days after treatment application.

## Results and discussion

Six pre-emergence treatments showed greater efficacy compared with Stomp Aqua 3.3 L/ha, and were also of at least equivalent safety for use in sweetcorn grown under plastic covers. These treatments were; Wing-P 4.0 L/ha, Stomp Aqua 3.3 L/ha + Dual Gold 1.4 L/ha, Stomp Aqua 3.3 L/ha + AHDB 9987, and Stomp Aqua 3.3 L/ha + AHDB 9918 (**Table 1**).

A greater effect on the crop from the treatments was seen at Site 1 compared to Site 2 (**Table 1**), likely due to the cooler weather after drilling at Site 1, therefore this crop grew slower. Despite these differences between the sites, a similar pattern of responses to the products was observed regarding effects on the crop. At nearly ten weeks after application, many treatments—with the exception of AHDB 9994, AHDB 9917, AHDB 9988 and Stomp Aqua tank-mixed with AHDB 9994, AHDB 9917 or Dual Gold at 1.6 L/ha—were safe to the crop or caused equivalent effects to the standards Stomp Aqua and Wing-P. Of the standards, Wing-P had less effect on the crop than Stomp Aqua.

Early in crop growth (V4 to V5 growth stage), at six weeks after application and four weeks after crop emergence, there moderate effects were observed in the Stomp Aqua, AHDB 9918, AHDB 9987 and AHDB 9988 treatments, particularly at Site 1. This was exhibited mainly as stunting, which the crop will grow through but would probably set back the harvest date. However, more severe effects of crop loss and moderate yellowing or chlorosis were caused by the application of AHDB 9917 and AHDB 9994. These products are therefore not suitable for use in sweetcorn.

Of the products screened in the trials, AHDB 9987, AHDB 9918 and AHDB 9988 were the safest, and caused no greater effects on the crop than the current commercial standards, Stomp Aqua or Wing-P.

**Table 1.** Assessments of crop damage (phytotoxicity) and weed efficacy (as percentage weed reduction) at 68 days after treatment application at Site 1, and 62 days after treatment application at Site 2 - 18th June. Phytotoxicity scale of 0-10; 0 = no effect, 10 = complete crop death. Scores ≤2 deemed commercially acceptable damage, and those >2 are highlighted in red. Figures in **bold** are significantly different to the untreated. Negative (-) figures indicate an increase in weed.

| Treatment | Phytotoxicity (0-10) | | % weed reduction compared to untreated | |
|---|---|---|---|---|
| | Site 1 68 DAA | Site 2 62 DAA | Site 1 68 DAA | Site 2 62 DAA |
| **Untreated** | 0.00 | 0.00 | - | - |
| **Stomp Aqua 3.30 L/ha** | 2.33 | 0.00 | **45.6** | **56.3** |
| **Stomp Aqua 1.60 L/ha** | 2.33 | 1.33 | 20.4 | **56.3** |
| **Wing-P 4.00 L/ha** | 1.67 | 1.00 | **50.8** | **77.5** |
| **Stomp Aqua 3.30 L/ha Dual Gold 1.40 L/ha** | 2.33 | 1.33 | **61.1** | **71.8** |
| **Stomp Aqua 1.60 L/ha Dual Gold 1.40 L/ha** | 2.67 | 1.00 | 18.6 | **57.5** |
| **AHDB 9994** | 2.67 | 2.00 | **33.9** | **28.2** |
| **AHDB 9987** | 2.00 | 2.33 | 3.4 | **37.5** |
| **AHDB 9918** | 2.33 | 1.33 | -1.7 | 0.0 |
| **AHDB 9917** | 3.67 | 3.67 | 16.9 | **28.2** |
| **Stomp Aqua 3.30 L/ha + AHDB 9994** | 3.00 | 2.33 | **64.4** | **60.6** |
| **Stomp Aqua 3.30 L/ha + AHDB 9987** | 1.67 | 1.67 | **61.1** | **73.7** |
| **Stomp Aqua 3.30 L/ha + AHDB 9918** | 2.00 | 1.00 | **57.6** | **76.3** |
| **Stomp Aqua 3.30 L/ha + AHDB 9917** | 3.67 | 4.00 | **55.9** | **59.4** |

| Treatment | Phytotoxicity (0-10) | | % weed reduction compared to untreated | |
|---|---|---|---|---|
| | Site 1 68 DAA | Site 2 62 DAA | Site 1 68 DAA | Site 2 62 DAA |
| **AHDB 9988** | 2.67 | 0.33 | 1.7 | **49.9** |
| **F prob. value** | **0.027** | **<0.001** | | |
| **d.f.** | **31** | **31** | | |
| **L.S.D.** | **1.147** | **1.451** | | |

The weed species and levels at each of the sites differed, with higher weed population pressure at Site 1, but with a narrower range of species. The weed species at Site 1 consisted mainly of fat hen (*Chenopodium album*) and redshank (*Polygonum persicaria*), while the key weeds at Site 2 were fat hen, chickweed (*Stellaria media*), black nightshade (*Solanum nigrum*), groundsel (*Senecio vulgaris*), and fumitory (*Fumaria officinalis*).

Eight treatments significantly reduced the percentage of weed cover at both sites for nine weeks after herbicide application, when compared with the untreated control (**Table 1**). There were no significant differences in weed control between particular treatments, but control was improved over the standard Stomp Aqua 3.3 L/ha with the addition of extra active ingredients or products, either as a co-formulation or in a tank-mix. These treatments were Wing-P 4.0 L/ha, Stomp Aqua 3.3 L/ha + Dual Gold 1.4 L/ha, Stomp Aqua 3.3 L/ha + AHDB 9994, Stomp Aqua 3.3 L/ha + AHDB 9987, Stomp Aqua 3.3 L/ha + AHDB 9918, and Stomp Aqua 3.3 L/ha + AHDB 9917.

When the rate of Stomp Aqua was reduced to 1.6 L/ha from 3.3 L/ha, this significantly reduced the efficacy of weed control at both sites, even when Dual Gold was included in the tank-mix at Site 1.

Stomp Aqua + AHDB 9987 was one of the best performing tank mixes at both trial sites reducing weed levels by 61 % at Site 1, and 73.7 % at Site 2. Weed reduction from this tank mix was lower at Site 1 compared to Site 2 because AHDB 9987 is less effective on polygonums, and redshank was a key weed at the site. Stomp Aqua 3.3 L/ha + Dual Gold 1.4 L/ha and Stomp Aqua + AHDB 9994 were the best performing tank-mixes in the pre-emergence trial at Site 1, but the latter tank-mix caused crop loss. At Site 2, Wing-P 4.0 L/ha and Stomp Aqua + AHDB 9918 were the best performing treatments, reducing weed levels by 77.5 % and 76.3 % respectively.

The new coded products were not effective when used alone, but when combined in a tank-mix with Stomp Aqua 3.3 L/ha, they improved the efficacy of using Stomp Aqua alone. Although some weed still remained after the pre-emergence applications, the level of reduction in weed cover attained means a greater level of control can be gained from post-emergence applications.

## Conclusions

- Six pre-emergence treatments showed both greater efficacy than Stomp Aqua 3.3 L/ha and were safe for use in sweetcorn grown under plastic covers. These treatments were; Wing-P 4.0 L/ha, Stomp Aqua 3.3 L/ha + Dual Gold 1.4 L/ha, Stomp Aqua 3.3 L/ha + AHDB 9987, and Stomp Aqua 3.3 L/ha + AHDB 9918.
- AHDB 9987 and AHDB 9918 would improve weed control when used in a tank-mix with Stomp Aqua (pendimethalin).
- AHDB 9987 reduced levels of black nightshade in both trials, and fat hen at Site 1.

## Take home message:

AHDB 9987 and AHDB 9918 improve weed control when used in a tank-mix with Stomp Aqua (pendimethalin) and would be useful additions for sweetcorn growers for pre-emergence use.

## Objectives

To compare a number of herbicide products and tank-mixes with the current commercial standards (Stomp Aqua or Wing-P) at one pre-emergence application timing for selectivity (crop safety) and efficacy in sweetcorn grown under covers.

## Trial conduct

This study will be conducted in compliance with the requirements of the UK Official Recognition of Efficacy Testing scheme.

Protocol conforms to **EPPO1/50(3)** for **Weeds in maize**, with the following deviations:

*"Replicates: at least 4"*
Current study to have only 3 replicates – the large number of treatments provides an acceptable number of residual degrees of freedom.

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 PP1/214(3) | Principles of acceptable efficacy | None |
| EPPO PP1/224(2) | Principles of efficacy evaluation for minor uses | None |

ADAS has Efficacy Testing Certificate No. ORETO 409.

## Test site

| **Item** | **Details** | |
|---|---|---|
| | **Site 1** | **Site 2** |
| Location address | **Broom Field**<br>Honer Lane<br>Chichester<br>W. Sussex<br>PO20 1LY | **Mile Pond Barn**<br>Stockbridge<br>Chichester<br>W. Sussex<br>PO19 8TD |
| Crop and cultivar | **Sweetcorn** – Early Bird | |
| Soil or substrate type | Silty clay loam | |
| Agronomic practice | See Appendix A | |
| Prior history of site | See Appendix A | |

## Trial design

| **Item** | **Details** |
|---|---|
| Trial design: | Fully Randomized Block |
| Number of replicates: | 3 |
| Row spacing: | 2 rows per 1.65 m bed |
| Plot size: (w x l) | 3.3 m x 5.0 m |
| Plot size: | 16.5 $m^2$ |
| Number of plants per plot: | N/K |

## Treatment details

| AHDB Code | Active substance | Product name/ manufacturers code | Formulation batch number | Content of active substance in product (g/L or g/kg) | Formulation type |
|---|---|---|---|---|---|
| N/A | pendimethalin | Stomp Aqua | ST12600518 | 455 | CS |
| N/A | pendimethalin + dimethenamid-P | Wing-P | 0014243535 | 250 + 212.5 | EC |
| N/A | s-metolachlor | Dual Gold | SMO5D0172 | 960 | EC |
| AHDB 9987 | pethoxamid | Successor | N/K | 600 | EC |
| AHDB 9994 | aclonifen | Emerger | EV56006446 | 600 | SC |
| AHDB 9917 | cinmethylin | BAS 683 03 H | FD-180618-0002 | - | EC |
| AHDB 9918 | flufenacet | Sunfire | 343825 | 500 | SC |
| AHDB 9988 | mesotrione + s-metolachlor | Camix | CHE7C00007 | 60 + 500 | SE |

## Application schedule

| Treatment number | Treatment: product name or AHDB code | Rate of active substance (ml or g a.s./ha) | Rate of product (l or kg/ha) | Application code |
|---|---|---|---|---|
| 1 | Untreated | - | - | - |
| 2 | Untreated | - | - | - |
| 3 | Stomp Aqua | 1501.5 | 3.3 | T1 |
| 4 | Stomp Aqua | 728 | 1.6 | T1 |
| 5 | Wing-P | 1000 + 850 | 4.0 | T1 |
| 6 | Stomp Aqua + Dual Gold | 1501.5 + 1344 | 3.3 + 1.4 | T1 |
| 7 | Stomp Aqua + Dual Gold | 728 + 1344 | 1.6 + 1.4 | T1 |
| 8 | AHDB9994 | 900 | 1.5 | T1 |
| 9 | AHDB9987 | 1200 | 2.0 | T1 |
| 10 | AHDB9918 | 120 | 0.24 | T1 |
| 11 | AHDB9917 | - | 0.7 | T1 |
| 12 | Stomp Aqua + AHDB9994 | 1501.5 + 900 | 3.3 + 1.5 | T1 |
| 13 | Stomp Aqua + AHDB9987 | 1501.5 + 1200 | 3.3 + 2 | T1 |
| 14 | Stomp Aqua + AHDB9918 | 1501.5 + 120 | 3.3 + 0.24 | T1 |
| 15 | Stomp Aqua + AHDB9917 | 1501.5 + | 3.3 + 0.7 | T1 |
| 16 | AHDB9988 | 108 + 900 | 1.8 | T1 |

## Application details

| | Site 1 | Site 2 |
|---|---|---|
| **Application date** | 11/04/2019 | 17/04/2019 |
| **Time of day** | 09:15 - 10:30 | 10:30 - 12:15 |
| **Crop growth stage (Max, min average BBCH)** | BBCH00 – Pre-Emergence | BBCH00 – Pre-Emergence |
| **Crop height (cm)** | N/A | N/A |
| **Crop coverage (%)** | N/A | N/A |
| **Application Method** | Spray | Spray |
| **Application Placement** | Soil | Soil |
| **Application equipment** | Oxford Precision Sprayer (knapsack) | Oxford Precision Sprayer (knapsack) |
| **Nozzle pressure** | 2-3 bar | 2-3 bar |
| **Nozzle type** | Flat Fan | Flat Fan |
| **Nozzle size** | 02F110 | 02F110 |
| **Application water volume/ha** | 200 | 200 |
| **Temperature of air - shade (°C)** | 10.0 - 9.2 | 13.6 - 15.5 |
| **Relative humidity (%)** | 64.0 - 69.2 | 58.5 - 59.4 |
| **Wind speed range (m/s)** | 0.67 - 0.27 | 1.25 - 2.28 |
| **Dew presence (Y/N)** | N | N |
| **Temperature of soil - 2-5 cm (°C)** | N/K | N/K |
| **Wetness of soil - 2-5 cm** | Dry | Dry |
| **Cloud cover (%)** | 0 | 100 |

## Untreated levels of broad-leaved weeds and grasses at through the assessment period - Site 1

| Common name | Scientific Name | EPPO Code | Weed level early-assessment period (40 days) | Weed level mid-assessment period (54 days) | Weed level end-assessment period (68 days) |
|---|---|---|---|---|---|
| Broad leaved weeds and grasses | *N/A* | 3WEEDT | 75.0 *(untreated average % coverage)* | 96.8 *(untreated average % coverage)* | 98.3 *(untreated average % coverage)* |

## Untreated levels of broad-leaved weeds and grasses at through the assessment period - Site 2

| Common name | Scientific Name | EPPO Code | Weed level early-assessment period (34 days) | Weed level mid-assessment period (48 days) | Weed level end-assessment period (62 days) |
|---|---|---|---|---|---|
| Broad leaved weeds and grasses | *N/A* | 3WEEDT | 1.23 *(untreated average % coverage)* | 9.08 *(untreated average % coverage)* | 53.3 *(untreated average % coverage)* |

## Assessment details - Site 1

| Evaluation date | Evaluation Timing (DA)* | Crop Growth Stage (BBCH) | Evaluation type | What was assessed and how (e.g. dead or live pest; disease incidence and severity; yield, marketable quality) |
|---|---|---|---|---|
| 29/04/2019 | 18 | V2 | Phytotox | Crop damage (0-10 scale; 0 = no effect, 10 = complete crop kill), all plots. |
| 21/05/2019 | 40 | V5 | Phytotox Efficacy | Crop damage (0-10 scale; 0 = no effect, 10 = complete crop kill), all plots. Percentage overall plot cover of all weeds, percentage cover of each weed species, all plots. |
| 04/06/2019 | 54 | V6 | Phytotox Efficacy | Crop damage (0-10 scale; 0 = no effect, 10 = complete crop kill), all plots. Percentage overall plot cover of all weeds, percentage cover of each weed species, all plots. |
| 18/06/2019 | 68 | V7 | Phytotox Efficacy | Crop damage (0-10 scale; 0 = no effect, 10 = complete crop kill), all plots. Percentage overall plot cover of all weeds, percentage cover of each weed species, all plots. |

* DA – days after application

## Assessment details - Site 2

| Evaluation date | Evaluation Timing (DA)* | Crop Growth Stage (BBCH) | Evaluation type | What was assessed and how (e.g. dead or live pest; disease incidence and severity; yield, marketable quality) |
|---|---|---|---|---|
| 29/04/2019 | 12 | V1 | Phytotox | Crop damage (0-10 scale; 0 = no effect, 10 = complete crop kill), all plots. |
| 21/05/2019 | 34 | V4 | Phytotox Efficacy | Crop damage (0-10 scale; 0 = no effect, 10 = complete crop kill), all plots. Percentage overall plot cover of all weeds, plus 3 quadrat readings – all weed species counted within quadrat. |
| 04/06/2019 | 48 | V6 | Phytotox Efficacy | Crop damage (0-10 scale; 0 = no effect, 10 = complete crop kill), all plots. Percentage overall plot cover of all weeds, plus 3 quadrat readings – all weed species counted within quadrat. |
| 18/06/2019 | 62 | V7 | Phytotox Efficacy | Crop damage (0-10 scale; 0 = no effect, 10 = complete crop kill), all plots. Percentage overall plot cover of all weeds, plus 3 quadrat readings – all weed species counted within quadrat. |

* DA – days after application

## Statistical analysis

Both trials were a randomised block design, each with three replicates of sixteen treatments, including two untreated controls. A grower standard was included—Stomp Aqua at 3.3 L/ha (Treatment 3) and Stomp Aqua at 1.6 L/ha (Treatment 4)—to provide a comparison for treatment efficacies and crop safety.

As the distribution of weeds was uneven across each trial—which is not unexpected in field situations—so there was a need to transform these variables prior to analysis. An angular transformation was used.

All data were analysed by ANOVA using GenStat 18.4 by Chris Dyer at RSK ADAS. For the calculation of % efficacy, an angular transformation of the data was carried out and then Abbott's formula was applied to the back transformed means, resulting in figures for the % reduction in weeds.

## Results

***Phytotoxicity***

The results of phytotoxicity assessments from four dates are presented in the tables below. These were scored on a scale from 0 to 10, with 0 being 'no effect', and 10 being 'dead'. Plots deemed to have commercially acceptable level of damage were scored 2 or below—see below for full scale:

| Crop Tolerance Score | Equivalent to Crop Damage (% Phytotoxicity) |
|---|---|
| **10** | Complete crop kill |
| **9** | 90% |
| **8** | 80% |
| **7** | 70% |
| **6** | 60% |
| **5** | 50% |
| **4** | 40% |
| **3** | 30% |
| **2*** | 20%* |
| **1** | 10% |
| **0** | No damage |

** 2 = Acceptable damage, i.e. damage unlikely to reduce yield, and acceptable to the farmer.*

A greater effect on the crop was seen at Site 1 compared to Site 2, likely due to the cooler weather after drilling at Site 1, which caused this crop to grow more slowly. Despite these differences between the sites, a similar pattern of responses to the products was observed regarding effects on the crop. At nearly ten weeks after application, many treatments—with the exception of AHDB 9994, AHDB 9917, AHDB 9988 and Stomp Aqua tank-mixed with AHDB 9994, AHDB 9917 or Dual Gold at 1.6 L/ha—were safe to the crop or caused equivalent effects to the standards Stomp Aqua and Wing-P (**Table 2** and **Table 3**). Of the standards, Wing-P had less effect on the crop than Stomp Aqua—this could be due to the lower concentration of pendimethalin applied, but the lower rate and therefore concentration of Stomp Aqua at 1.6 L/ha also caused a stunt to the crop at six weeks after application.

At six weeks after application and four weeks after crop emergence, there were moderate effects seen on the crop from Stomp Aqua, AHDB 9918, AHDB 9987 and AHDB 9988, particularly at Site 1. This was exhibited mainly as stunting, which the crop will grow through but would probably set back the harvest date. However, more severe effects of crop loss and moderate yellowing or chlorosis were caused by AHDB 9917 and AHDB 9994. Therefore, these products are not safe to use in sweetcorn.

Of the products screened in the trials, AHDB 9987, AHDB 9918 and AHDB 9988 were the safest and caused no greater effects on the crop than the current commercial standards, Stomp Aqua or Wing-P.

**Table 2.** Mean crop damage scores at **Site 1** throughout trial period, assessed at 18, 40, 54 and 68 days after treatment application (DAA). Treatments were applied on 11th April 2019. Phytotoxicity scale of 0-10; 0 = no effect, 10 = complete crop death. Scores ≤2 deemed commercially acceptable damage, and those >2 are highlighted in red.

| Treatment | Mean Phytotoxicity Score (0-10) | | | |
|---|---|---|---|---|
| | 18 DAA 29th April | 40 DAA 21st May | 54 DAA 4th June | 68 DAA 18th June |
| **Untreated** | 0.00 | 0.00 | 0.00 | 0.00 |
| **Stomp Aqua 3.30 L/ha** | 0.67 | 5.00 | 3.00 | 2.33 |
| **Stomp Aqua 1.60 L/ha** | 0.00 | 5.00 | 3.33 | 2.33 |
| **Wing-P 4.00 L/ha** | 0.33 | 3.67 | 3.33 | 1.67 |
| **Stomp Aqua 3.30 L/ha Dual Gold 1.40 L/ha** | 0.00 | 4.33 | 4.33 | 2.33 |
| **Stomp Aqua 1.60 L/ha Dual Gold 1.40 L/ha** | 1.00 | 6.33 | 4.33 | 2.67 |
| **AHDB 9994** | 0.67 | 4.67 | 3.67 | 2.67 |
| **AHDB 9987** | 0.33 | 4.33 | 3.67 | 2.00 |
| **AHDB 9918** | 0.00 | 5.67 | 3.00 | 2.33 |
| **AHDB 9917** | 3.33 | 5.00 | 4.33 | 3.67 |
| **Stomp Aqua 3.30 L/ha + AHDB 9994** | 1.33 | 6.67 | 4.67 | 3.00 |
| **Stomp Aqua 3.30 L/ha + AHDB 9987** | 0.67 | 3.33 | 3.00 | 1.67 |
| **Stomp Aqua 3.30 L/ha + AHDB 9918** | 0.33 | 4.67 | 3.00 | 2.00 |
| **Stomp Aqua 3.30 L/ha + AHDB 9917** | 3.00 | 6.00 | 4.67 | 3.67 |
| **AHDB 9988** | 0.00 | 5.00 | 4.00 | 2.67 |
| **F prob. value** | **<0.001** | **0.039** | **0.868** | **0.027** |
| **d.f.** | **31** | **31** | **31** | **31** |
| **L.S.D.** | **1.343** | **1.867** | **2.370** | **1.147** |

**Table 3.** Mean crop damage scores at **Site 2** throughout trial period, assessed at 12, 34, 48 and 62 days after treatment application (DAA). Treatments applied on 17th April 2019. Phytotoxicity scale of 0-10; 0 = no effect, 10 = complete crop death. Scores ≤2 deemed commercially acceptable damage, and those >2 are highlighted in red.

| Treatment | Mean Phytotoxicity Score (0-10) | | | |
|---|---|---|---|---|
| | 12 DAA 29th April | 34 DAA 21st May | 48 DAA 4th June | 62 DAA 18th June |
| **Untreated** | 0.00 | 0.00 | 0.00 | 0.00 |
| **Stomp Aqua 3.30 L/ha** | 0.67 | 0.00 | 1.67 | 0.00 |
| **Stomp Aqua 1.60 L/ha** | 0.33 | 0.67 | 2.00 | 1.33 |
| **Wing-P 4.00 L/ha** | 0.33 | 0.67 | 1.67 | 1.00 |
| **Stomp Aqua 3.30 L/ha Dual Gold 1.40 L/ha** | 0.00 | 0.67 | 1.67 | 1.33 |
| **Stomp Aqua 1.60 L/ha Dual Gold 1.40 L/ha** | 0.67 | 0.67 | 1.67 | 1.00 |
| **AHDB 9994** | 1.00 | 1.00 | 1.67 | 2.00 |
| **AHDB 9987** | 0.00 | 2.00 | 2.67 | 2.33 |
| **AHDB 9918** | 0.00 | 1.00 | 2.67 | 1.33 |
| **AHDB 9917** | 3.00 | 2.00 | 2.67 | 3.67 |
| **Stomp Aqua 3.30 L/ha + AHDB 9994** | 0.67 | 1.33 | 1.33 | 2.33 |
| **Stomp Aqua 3.30 L/ha + AHDB 9987** | 1.00 | 1.33 | 1.67 | 1.67 |
| **Stomp Aqua 3.30 L/ha + AHDB 9918** | 0.00 | 1.33 | 2.33 | 1.00 |
| **Stomp Aqua 3.30 L/ha + AHDB 9917** | 2.67 | 2.33 | 4.33 | 4.00 |
| **AHDB 9988** | 0.33 | 1.00 | 2.00 | 0.33 |
| **F prob. value** | **<0.001** | **0.321** | **0.003** | **<0.001** |
| **d.f.** | **31** | **31** | **31** | **31** |
| **L.S.D.** | **1.154** | **1.932** | **1.479** | **1.451** |

***Efficacy***

The weed species and levels at each of the sites differed, with a higher weed population at Site 1, but with a narrower range of species. The weed species at Site 1 consisted mainly of fat hen (*Chenopodium album*) and redshank (*Polygonum persicaria*) (**Table 6**), while the key weeds at Site 2 were fat hen, chickweed (*Stellaria media*), black nightshade (*Solanum nigrum*), groundsel (*Senecio vulgaris*), and fumitory (*Fumaria officinalis*) (**Table 7**). Results are shown for the top three weeds only for Site 2.

Eight treatments significantly reduced the percentage of weed cover at both sites for nine weeks after herbicide application, when compared to the untreated (P <0.001) (**Table 4** and **Table 5**). There were no significant differences in weed control between particular treatments, but control was improved over the standard Stomp Aqua 3.3 L/ha with the addition of extra active ingredients or products, either as a co-formulation or in a tank-mix (**Figure 1**). These treatments were Wing-P 4.0 L/ha, Stomp Aqua 3.3 L/ha + Dual Gold 1.4 L/ha, Stomp Aqua 3.3 L/ha + AHDB 9994, Stomp Aqua 3.3 L/ha + AHDB 9987, Stomp Aqua 3.3 L/ha + AHDB 9918, and Stomp Aqua 3.3 L/ha + AHDB 9917.

When the rate of Stomp Aqua was reduced to 1.6 L/ha from 3.3 L/ha this significantly reduced the efficacy of weed control at both sites, even when Dual Gold was included in the tank-mix at Site 1.

Stomp Aqua + AHDB 9987 was one of the best performing tank mixes at both trial sites, reducing weed levels by 61 % at Site 1, and 73.7 % at Site 2 (**Table 6** and **Table 8**). Stomp Aqua 3.3 L/ha + Dual Gold 1.4 L/ha and Stomp Aqua + AHDB 9994 were the best performing tank-mixes in the pre-emergence trial at Site 1, but the latter tank-mix caused crop loss. At Site 2, Wing-P 4.0 L/ha and Stomp Aqua + AHDB 9918 were the best performing treatments, reducing weed levels by 77.5 % and 76.3 % respectively.

**Table 4.** Summary of treatment efficacies at **Site 1** throughout trial period, assessed at 40, 54 and 68 days after treatment application. Figures in **bold** are significantly different from the untreated.

| Treatment | Mean Weed Cover (% per plot) | | |
|---|---|---|---|
| | 40 DAA (21st May) | 54 DAA (4th June) | 68 DAA (18th June) |
| **Untreated** | 75.0 | 96.8 | 98.3 |
| **Stomp Aqua 3.30 L/ha** | **10.0** | **51.7** | **53.3** |
| **Stomp Aqua 1.60 L/ha** | **20.0** | 81.7 | 78.3 |
| **Wing-P 4.00 L/ha** | **13.3** | **55.0** | **48.3** |
| **Stomp Aqua 3.30 L/ha Dual Gold 1.40 L/ha** | **11.3** | **60.0** | **38.3** |
| **Stomp Aqua 1.60 L/ha Dual Gold 1.40 L/ha** | **23.3** | **70.0** | 80.0 |
| **AHDB 9994** | **13.3** | **56.7** | **65.0** |
| **AHDB 9987** | **30.0** | 81.7 | 95.0 |
| **AHDB 9918** | 80.0 | 98.3 | 100.0 |
| **AHDB 9917** | **28.3** | **57.3** | 81.7 |
| **Stomp Aqua 3.30 L/ha + AHDB 9994** | **5.7** | **16.7** | **35.0** |
| **Stomp Aqua 3.30 L/ha + AHDB 9987** | **10.7** | **53.3** | **38.3** |
| **Stomp Aqua 3.30 L/ha + AHDB 9918** | **16.7** | **60.0** | **41.7** |
| **Stomp Aqua 3.30 L/ha + AHDB 9917** | **12.7** | **40.0** | **43.3** |
| **AHDB 9988** | **35.0** | 83.3 | 96.7 |

| Treatment | Mean Weed Cover (% per plot) | | |
|---|---|---|---|
| | 40 DAA (21st May) | 54 DAA (4th June) | 68 DAA (18th June) |
| F prob. value | <0.001 | <0.001 | <0.001 |
| d.f. | 31 | 31 | 31 |
| L.S.D. | 12.36 | 23.51 | 23.52 |

**Table 5.** Summary of treatment efficacies at **Site 2** throughout trial period, assessed at 40, 54 and 68 days after treatment application. Figures in **bold** are significantly different from the untreated.

| Treatment | Mean Weed Cover (% per plot) | | |
|---|---|---|---|
| | 34 DAA (21st May) | 48 DAA (4th June) | 62 DAA (18th June) |
| Untreated | 1.23 | 9.08 | 53.3 |
| Stomp Aqua 3.30 L/ha | **0.30** | **3.33** | **23.3** |
| Stomp Aqua 1.60 L/ha | **0.53** | **4.17** | **23.3** |
| Wing-P 4.00 L/ha | **0.43** | **2.83** | **12.0** |
| Stomp Aqua 3.30 L/ha Dual Gold 1.40 L/ha | **0.33** | **1.83** | **15.0** |
| Stomp Aqua 1.60 L/ha Dual Gold 1.40 L/ha | **0.47** | **2.27** | **22.7** |
| AHDB 9994 | **0.50** | **4.67** | **38.3** |
| AHDB 9987 | 0.77 | **4.17** | **33.3** |
| AHDB 9918 | 1.50 | 9.00 | 53.3 |
| AHDB 9917 | **0.57** | 6.17 | **38.3** |
| Stomp Aqua 3.30 L/ha + AHDB 9994 | **0.37** | **1.83** | **21.0** |
| Stomp Aqua 3.30 L/ha + AHDB 9987 | **0.50** | **1.77** | **14.0** |
| Stomp Aqua 3.30 L/ha + AHDB 9918 | **0.27** | **1.60** | **12.7** |
| Stomp Aqua 3.30 L/ha + AHDB 9917 | **0.43** | **2.00** | **21.7** |
| AHDB 9988 | 0.63 | **5.00** | **26.7** |
| F prob. value | **0.005** | **<0.001** | **<0.001** |

| Treatment | Mean Weed Cover (% per plot) | | |
|---|---|---|---|
| | 34 DAA (21st May) | 48 DAA (4th June) | 62 DAA (18th June) |
| d.f. | 31 | 31 | 31 |
| L.S.D. | 0.635 | 3.378 | 11.75 |

**Figure 1.** Percentage weed cover at Broom (**Site 1**) and Mile Pond (**Site 2**) at 68 and 62 days after the pre-emergence application.

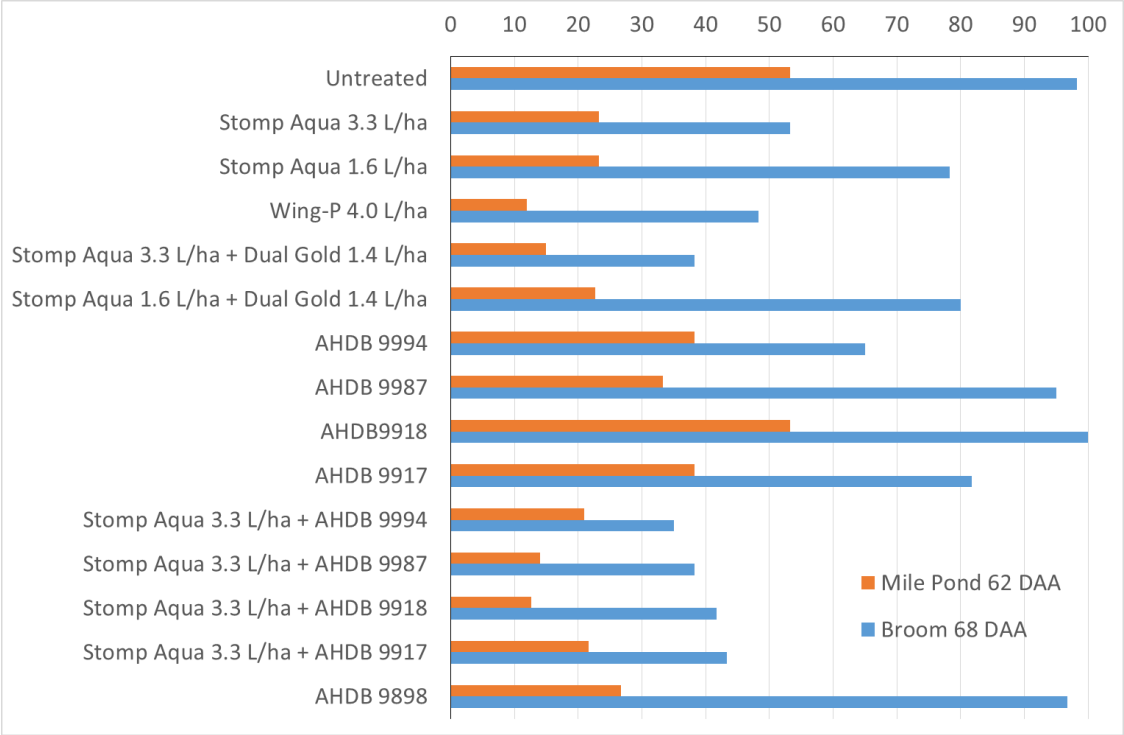



**Table 6.** Mean levels of main weed species present at **Site 1** throughout the trial period, at 68 days after treatment application. Figures in **bold** are significantly different from the untreated.

| Treatment | Mean % weed species cover | | % weed reduction compared to untreated | |
|---|---|---|---|---|
| | Redshank | Fat hen | Redshank | Fat hen |
| **Untreated** | 60.0 | 38.3 | - | - |
| **Stomp Aqua 3.30 L/ha** | **32.0** | **24.0** | **46.7** | **37.4** |
| **Stomp Aqua 1.60 L/ha** | 47.7 | **30.7** | 20.5 | **19.9** |
| **Wing-P 4.00 L/ha** | **35.0** | **13.3** | **41.7** | **65.2** |
| **Stomp Aqua 3.30 L/ha Dual Gold 1.40 L/ha** | **20.0** | **18.3** | **66.7** | **52.2** |
| **Stomp Aqua 1.60 L/ha Dual Gold 1.40 L/ha** | 53.3 | **26.7** | 11.2 | **30.4** |
| **AHDB 9994** | **38.3** | **26.7** | **36.2** | **30.4** |

| Treatment | Mean % weed species cover | | % weed reduction compared to untreated | |
|---|---|---|---|---|
| | Redshank | Fat hen | Redshank | Fat hen |
| **AHDB 9987** | 55.0 | 40.0 | 8.3 | -4.4 |
| **AHDB 9918** | 61.7 | 38.3 | -2.8 | 0.0 |
| **AHDB 9917** | 63.3 | **18.3** | -5.5 | **52.2** |
| **Stomp Aqua 3.30 L/ha + AHDB 9994** | **17.7** | **17.3** | **70.5** | **54.8** |
| **Stomp Aqua 3.30 L/ha + AHDB 9987** | **26.0** | **12.3** | **56.7** | **67.8** |
| **Stomp Aqua 3.30 L/ha + AHDB 9918** | **24.3** | **17.3** | **59.5** | **54.8** |
| **Stomp Aqua 3.30 L/ha + AHDB 9917** | **26.0** | **17.3** | **56.7** | **54.8** |
| **AHDB 9988** | 48.0 | 48.7 | 20.0 | -26.98 |
| **F prob. value** | **0.002** | **<0.001** | | |
| **d.f.** | **31** | **31** | | |
| **L.S.D.** | **12.86** | **6.84** | | |

**Table 7.** Mean % cover of main weed species present at **Site 2** throughout the trial period, at 68 days after treatment application. Figures in **bold** are significantly different from the untreated.

| Treatment | Mean % weed species cover | | |
|---|---|---|---|
| | Fat hen | Chickweed | Black nightshade |
| **Untreated** | 30.8 | 5.2 | 4.5 |
| **Stomp Aqua 3.30 L/ha** | **11.0** | 3.0 | 3.7 |
| **Stomp Aqua 1.60 L/ha** | 12.3 | 2.0 | 3.0 |
| **Wing-P 4.00 L/ha** | **5.3** | 2.3 | 1.3 |
| **Stomp Aqua 3.30 L/ha Dual Gold 1.40 L/ha** | **6.3** | 3.0 | 2.0 |
| **Stomp Aqua 1.60 L/ha Dual Gold 1.40 L/ha** | 12.0 | 3.7 | 3.3 |
| **AHDB 9994** | **21.0** | 3.3 | 4.0 |
| **AHDB 9987** | 20.7 | 6.0 | 2.0 |
| **AHDB 9918** | 33.3 | 6.0 | 3.3 |
| **AHDB 9917** | 16.7 | 3.3 | 9.7 |
| **Stomp Aqua 3.30 L/ha + AHDB 9994** | **8.0** | 2.3 | 3.0 |
| **Stomp Aqua 3.30 L/ha + AHDB 9987** | **4.7** | 4.3 | 1.7 |

| Treatment | Mean % weed species cover | | |
|---|---|---|---|
| | Fat hen | Chickweed | Black nightshade |
| **Stomp Aqua 3.30 L/ha + AHDB 9918** | **5.0** | 1.7 | 2.7 |
| **Stomp Aqua 3.30 L/ha + AHDB 9917** | **8.7** | 5.0 | 2.3 |
| **AHDB 9988** | 16.0 | 5.3 | 2.3 |
| **F prob. value** | **0.002** | **NS** | **NS** |
| **d.f.** | **31** | **31** | **31** |
| **L.S.D.** | **6.780** | **4.244** | **3.687** |

**Table 8.** Mean % cover of main weed species present at **Site 2** throughout the trial period, at 68 days after treatment application. Figures in **bold** are significantly different from the untreated.

| Treatment | % weed reduction compared to untreated | | |
|---|---|---|---|
| | Fat hen | Chickweed | Black nightshade |
| **Stomp Aqua 3.30 L/ha** | 64.3 | 41.9 | 18.5 |
| **Stomp Aqua 1.60 L/ha** | 60.1 | 61.3 | 33.3 |
| **Wing-P 4.00 L/ha** | 82.7 | 54.8 | 70.4 |
| **Stomp Aqua 3.30 L/ha Dual Gold 1.40 L/ha** | 79.5 | 41.9 | 55.6 |
| **Stomp Aqua 1.60 L/ha Dual Gold 1.40 L/ha** | 61.1 | 29.1 | 25.9 |
| **AHDB 9994** | 31.8 | 35.5 | 11.1 |
| **AHDB 9987** | 32.9 | -16.2 | 55.6 |
| **AHDB 9918** | -8.11 | -16.2 | 25.9 |
| **AHDB 9917** | 45.9 | 35.5 | -114.8 |
| **Stomp Aqua 3.30 L/ha + AHDB 9994** | 74.1 | 54.8 | 33.3 |
| **Stomp Aqua 3.30 L/ha + AHDB 9987** | 84.8 | 16.2 | 62.9 |
| **Stomp Aqua 3.30 L/ha + AHDB 9918** | 83.8 | 67.7 | 40.7 |
| **Stomp Aqua 3.30 L/ha + AHDB 9917** | 71.8 | 3.3 | 48.2 |
| **AHDB 9988** | 48.1 | -3.2 | 48.2 |

## Discussion

Six pre-emergence treatments showed greater efficacy compared with Stomp Aqua 3.3 L/ha, and were also of at least equivalent safety for use in sweetcorn grown under plastic covers. These treatments were; Wing-P 4.0 L/ha, Stomp Aqua 3.3 L/ha + Dual Gold 1.4 L/ha, Stomp Aqua 3.3 L/ha + AHDB 9987, and Stomp Aqua 3.3 L/ha + AHDB 9918.

A greater crop effect from the treatments was seen at Site 1 compared to Site 2, likely due to the cooler weather after drilling at Site 1, therefore this crop grew slower. Despite these differences between the sites, a similar pattern of responses to the products was observed regarding effects on the crop. At nearly ten weeks after application, many treatments—with the exception of AHDB 9994, AHDB 9917, AHDB 9988 and Stomp Aqua tank-mixed with AHDB 9994, AHDB 9917 or Dual Gold at 1.6 L/ha—were safe to the crop or caused equivalent effects to the standards Stomp Aqua and Wing-P. Of the standards, Wing-P had less effect on the crop than Stomp Aqua, and this could be due to the lower concentration of pendimethalin applied, but the lower rate and therefore concentration of Stomp Aqua at 1.6 L/ha also caused a stunt to the crop at six weeks after application.

Early in crop growth (V4 to V5 growth stage), at six weeks after application and four weeks after crop emergence, there were moderate effects seen on the crop from Stomp Aqua, AHDB 9918, AHDB 9987 and AHDB 9988, particularly at Site 1. This was exhibited mainly as stunting which the crop will grow through, but would probably set back the harvest date. However, more severe effects of crop loss and moderate yellowing or chlorosis were caused by AHDB 9917 and AHDB 9994.Therefore these products are not safe to use in sweetcorn.

Of the products screened in the trials, AHDB 9987, AHDB 9918 and AHDB 9988 were the safest, and caused no greater effects on the crop than the current commercial standards, Stomp Aqua or Wing-P.

The weed species and levels at each of the sites differed, with a higher weed burden at Site 1, but with a narrower range of species. The weed species at Site 1 consisted mainly of fat hen (*Chenopodium album*) and redshank (*Polygonum persicaria*) (**Table 6**), while the key weeds at Site 2 were fat hen, chickweed (*Stellaria media*), black nightshade (*Solanum nigrum*), groundsel (*Senecio vulgaris*), and fumitory (*Fumaria officinalis*) (**Table 7**). Results are shown for the top three weeds only for Site 2.

Eight treatments significantly reduced the percentage of weed cover at both sites for nine weeks after herbicide application, when compared to the untreated ($P<0.001$) (**Table 4** and **Table 5**). There were no significant differences in weed control between particular treatments, but control was improved over the standard Stomp Aqua 3.3 L/ha with the addition of extra active ingredients or products, either as a co-formulation or in a tank-mix (**Figure 1**). These treatments were Wing-P 4.0 L/ha, Stomp Aqua 3.3 L/ha + Dual Gold 1.4 L/ha, Stomp Aqua 3.3 L/ha + AHDB 9994, Stomp Aqua 3.3 L/ha + AHDB 9987, Stomp Aqua 3.3 L/ha + AHDB 9918, and Stomp Aqua 3.3 L/ha + AHDB 9917.

When the rate of Stomp Aqua was reduced to 1.6 L/ha from 3.3 L/ha, this significantly reduced the efficacy of weed control at both sites, even when Dual Gold was included in the tank-mix at Site 1.

Stomp Aqua + AHDB 9987 was one of the best performing tank mixes at both trial sites reducing weed levels by 61 % at Site 1, and 73.7 % at Site 2 (**Table 6** and **Table 8**). Weed reduction from this tank mix was lower at Site 1 compared to Site 2 because AHDB 9987 is less effective on polygonums, and redshank was a key weed at the site. Stomp Aqua 3.3 L/ha + Dual Gold 1.4 L/ha and Stomp Aqua + AHDB 9994 were the best performing tank-mixes in the pre-emergence trial at Site 1, but the latter tank-mix caused crop loss. At Site 2, Wing-P 4.0 L/ha and Stomp Aqua + AHDB 9918 were the best performing treatments reducing weed levels by 77.5 % and 76.3 % respectively.

The new coded products were not effective when used alone, but when combined in a tank-mix with Stomp Aqua 3.3 L/ha, they improved the efficacy of using Stomp Aqua alone. Although

some weed still remained after the pre-emergence applications, the level of reduction attained means a greater level of control can be gained from post-emergence applications.

## Conclusions

- Six pre-emergence treatments showed both greater efficacy than Stomp Aqua 3.3 L/ha and were safe for use in sweetcorn grown under plastic covers. These treatments were; Wing-P 4.0 L/ha, Stomp Aqua 3.3 L/ha + Dual Gold 1.4 L/ha, Stomp Aqua 3.3 L/ha + AHDB 9987, and Stomp Aqua 3.3 L/ha + AHDB 9918.
- AHDB 9987 and AHDB 9918 would improve weed control when used in a tank-mix with Stomp Aqua (pendimethalin)
- AHDB 9987 reduced levels of black nightshade in both trials, and fat hen at Site 1

## Acknowledgements

AHDB for funding the work, and the crop protection companies for their financial contributions as well as providing samples for the trials. Thanks should also be given to the growers who provided sites and crops for the trials as well as technical input, particularly Grant Lumsden, Jim Smith and Neil Caims from Barfoots, Sussex.

## Appendix

### a. Crop diary – events related to growing crop

**Crop details**

| Site 1 | | | |
|---|---|---|---|
| **Crop** | **Cultivar** | **Planting date** | **Row width (m)** |
| Sweetcorn | Early Bird | 10/04/2019 | 2 rows per 1.65 m bed |

**Previous cropping**

| Site 1 | |
|---|---|
| **Year** | **Crop** |
| 2014 | TBC |
| 2015 | TBC |

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

| Site 1 | | |
|---|---|---|
| **Date** | **Product** | **Rate (kg/ha)** |
| 01/04/2019 | MOP | 250 |
| 01/04/2019 | OEN 39.0N 0.0P | 270 |

**Pesticides applied to trial area**

No chemical inputs applied to trial area.

**Details of irrigation regime**

Irrigation regime was weather-dependent—no official scheme followed.

**Crop details**

| Site 2 | | | |
|---|---|---|---|
| **Crop** | **Cultivar** | **Planting date** | **Row width (m)** |
| Sweetcorn | Early Bird | 16/04/2019 | 4 rows per 1.65 m bed |

**Previous cropping**

| Site 2 | |
|---|---|
| **Year** | **Crop** |
| 2014 | |
| 2015 | |

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

| Site 2 | | |
|---|---|---|
| **Date** | **Product** | **Rate (kg/ha)** |
| 01/04/2019 | MOP | 250 |
| 01/04/2019 | OEN 39.0N 0.0P | 270 |

**Pesticides applied to trial area**

No chemical inputs applied to trial area.

**Details of irrigation regime**

Irrigation regime was weather-dependent—no official scheme followed.

**b. Trial diary**

| Site 1 | |
|---|---|
| **Date** | **Event** |
| 11/04/2019 | Plots drilled and treatment application. |
| 29/04/2019 | Phytotox assessment. |
| 21/05/2019 | Weeds, phytotox assessment. |
| 04/06/2019 | Weeds, phytotox assessment. |
| 18/06/2019 | Weeds, phytotox assessment. |

| Site 2 | |
|---|---|
| **Date** | **Event** |
| 17/04/2019 | Plots drilled and treatment application. |
| 29/04/2019 | Phytotox assessment. |
| 21/05/2019 | Weeds, phytotox assessment. |
| 04/06/2019 | Weeds, phytotox assessment. |
| 18/06/2019 | Weeds, phytotox assessment. |

**c. Climatological data during study period**

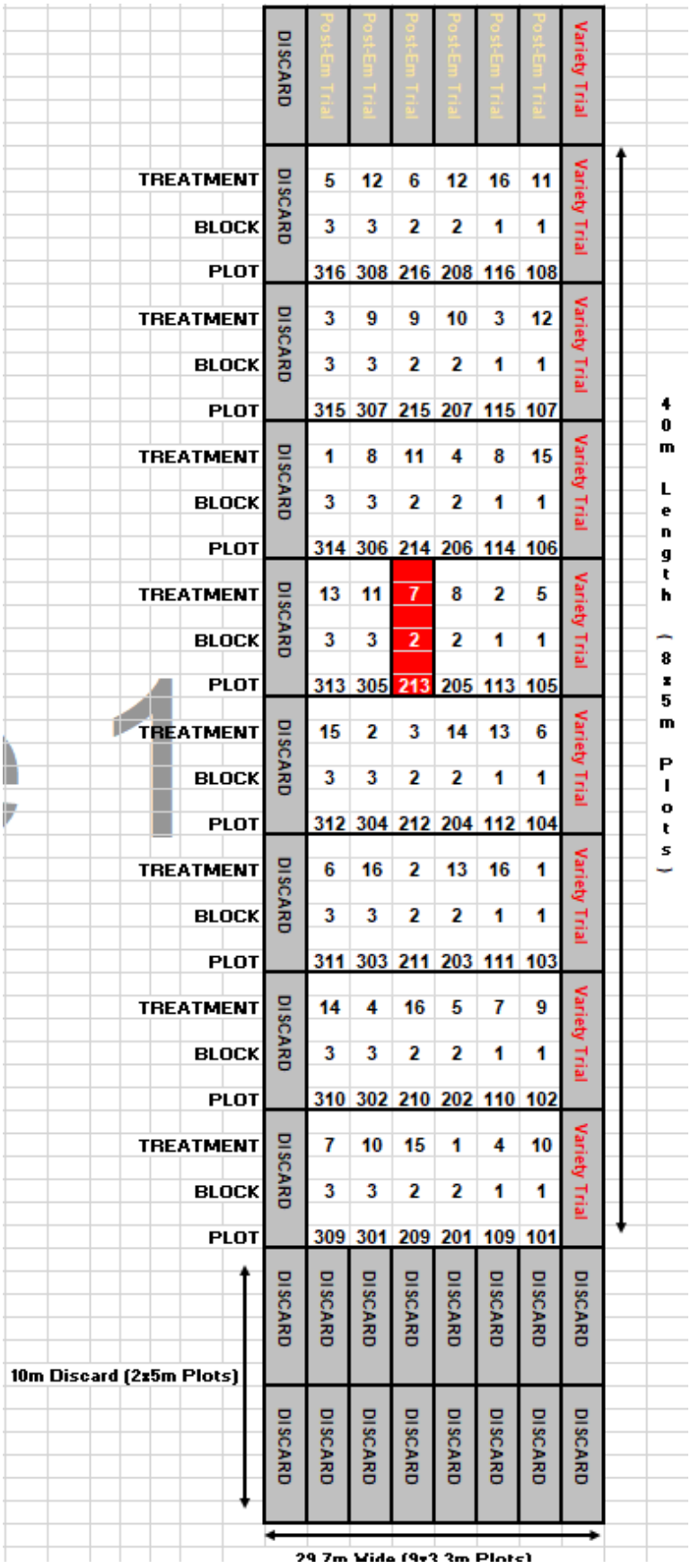
| Site 2 | | | |
|---|---|---|---|
| **Date** | **Temperature °C (minimum)** | **Temperature °C (maximum)** | **Rainfall (mm)** |
| 16/04/2019 | 14 | 23 | |
| 17/04/2019 | 7 | 24 | |
| 18/04/2019 | 10 | 25 | |
| 19/04/2019 | 8 | 26 | |
| 20/04/2019 | 9 | 28 | |
| 21/04/2019 | 5 | 27 | |
| 22/04/2019 | 6 | 23 | |
| 23/04/2019 | 10 | 24 | |
| 24/04/2019 | 9 | 17 | |
| 25/04/2019 | 9 | 18 | |
| 26/04/2019 | 7 | 17 | |
| 27/04/2019 | 9 | 16 | |
| 28/04/2019 | 7 | 18 | |
| 29/04/2019 | 4 | 19 | |
| 30/04/2019 | 4 | 18 | |
| 01/05/2019 | 7 | 17 | |
| 02/05/2019 | 7 | 18 | |
| 03/05/2019 | 5 | 17 | |
| 04/05/2019 | 5 | 15 | |

| | | | |
|---|---|---|---|
| 05/05/2019 | 3 | 15 | |
| 06/05/2019 | 6 | 16 | |
| 07/05/2019 | 5 | 16 | |
| 08/05/2019 | 10 | 16 | |
| 09/05/2019 | 8 | 15 | |
| 10/05/2019 | 4 | 18 | |
| 11/05/2019 | 7 | 19 | |
| 12/05/2019 | 6 | 19 | |
| 13/05/2019 | 5 | 19 | |
| 14/05/2019 | 8 | 22 | |
| 15/05/2019 | 6 | 21 | |
| 16/05/2019 | 6 | 21 | |
| 17/05/2019 | 8 | 14 | |
| 18/05/2019 | 9 | 23 | |
| 19/05/2019 | 7 | 23 | |
| 20/05/2019 | 12 | 24 | |
| 21/05/2019 | 9 | 28 | |
| 22/05/2019 | 9 | 26 | |
| 23/05/2019 | 6 | 26 | |
| 24/05/2019 | 9 | 27 | |
| 25/05/2019 | 13 | 26 | |
| 26/05/2019 | 10 | 24 | |
| 27/05/2019 | 8 | 23 | |
| 28/05/2019 | 8 | 21 | |
| 29/05/2019 | 7 | 16 | |
| 30/05/2019 | 14 | 25 | |
| 31/05/2019 | 12 | 25 | |
| 01/06/2019 | 8 | 26 | |
| 02/06/2019 | 14 | 27 | |
| 03/06/2019 | 11 | 23 | |
| 04/06/2019 | 10 | 19 | |
| 05/06/2019 | 11 | 20 | |
| 06/06/2019 | 11 | 22 | |
| 07/06/2019 | 12 | 19 | |
| 08/06/2019 | 11 | 19 | |
| 09/06/2019 | 8 | 22 | |
| 10/06/2019 | 10 | 13 | |
| 11/06/2019 | 10 | 20 | |
| 12/06/2019 | 11 | 20 | |
| 13/06/2019 | 12 | 17 | |
| 14/06/2019 | 13 | 19 | |
| 15/06/2019 | 11 | 18 | |
| 16/06/2019 | 10 | 18 | |
| 17/06/2019 | 12 | 21 | |
| 18/06/2019 | 11 | 19 | |
| 19/06/2019 | 14 | 21 | |
| 20/06/2019 | 11 | 20 | |
| 21/06/2019 | 9 | 23 | |
| 22/06/2019 | 8 | 23 | |
| 23/06/2019 | 12 | 26 | |
| 24/06/2019 | 16 | 23 | |
| 25/06/2019 | 15 | 27 | |
| 26/06/2019 | 17 | 26 | |

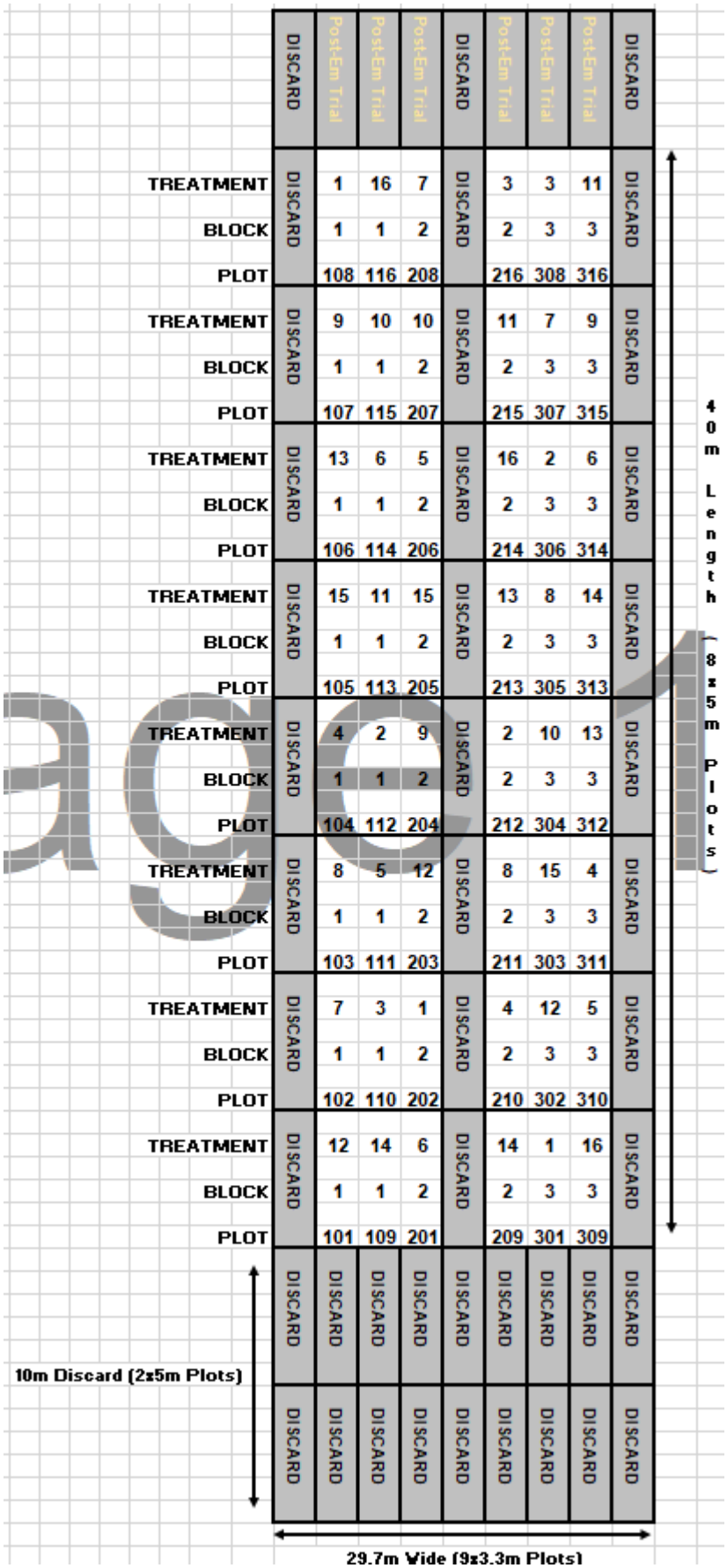
| | | | |
|---|---|---|---|
| 27/06/2019 | 14 | 26 | |
| 28/06/2019 | 14 | 29 | |
| 29/06/2019 | 17 | 32 | |
| 30/06/2019 | 14 | 25 | |
| 01/07/2019 | 13 | 28 | |
| 02/07/2019 | 11 | 26 | |
| 03/07/2019 | 13 | 24 | |
| 04/07/2019 | 10 | 26 | |
| 05/07/2019 | 13 | 29 | |
| 06/07/2019 | 15 | 27 | |
| 07/07/2019 | 16 | 19 | |
| 08/07/2019 | 14 | 22 | |
| 09/07/2019 | 15 | 24 | |
| 10/07/2019 | 13 | 26 | |
| 11/07/2019 | 16 | 28 | |
| 12/07/2019 | 16 | 28 | |
| 13/07/2019 | 15 | 27 | |
| 14/07/2019 | 14 | 24 | |
| 15/07/2019 | 11 | 25 | |
| 16/07/2019 | 11 | 25 | |
| 17/07/2019 | 11 | 26 | |
| 18/07/2019 | 16 | 24 | |
| 19/07/2019 | 11 | 19 | |
| 20/07/2019 | 15 | 23 | |
| 21/07/2019 | 12 | 24 | |
| 22/07/2019 | 16 | 26 | |
| 23/07/2019 | 15 | 30 | |
| 24/07/2019 | 19 | 29 | |
| 25/07/2019 | 17 | 31 | |
| 26/07/2019 | 19 | 24 | |
| 27/07/2019 | 17 | 24 | |
| 28/07/2019 | 14 | 24 | |
| 29/07/2019 | 13 | 24 | |
| 30/07/2019 | 18 | 20 | |
| 31/07/2019 | 17 | 24 | |
| 01/08/2019 | 12 | 25 | |
| 02/08/2019 | 15 | 27 | |
| 03/08/2019 | 15 | 23 | |
| 04/08/2019 | 15 | 25 | |
| 05/08/2019 | 17 | 26 | |
| 06/08/2019 | 17 | 24 | |

## d. Trial design

### Site 1



**Site 2**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Post-Em Trial
Post-Em Trial
Post-Em Trial
DISCARD
Post-Em Trial
Post-Em Trial
Post-Em Trial
DISCARD
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TREATMENT 13 6 5 16 2 6
BLOCK 1 1 2 2 3 3
PLOT 106 114 206 214 306 314
TREATMENT 15 11 15 13 8 14
BLOCK 1 1 2 2 3 3
PLOT 105 113 205 213 305 313
TREATMENT 4 2 9 2 10 13
BLOCK 1 1 2 2 3 3
PLOT 104 112 204 212 304 312
TREATMENT 8 5 12 8 15 4
BLOCK 1 1 2 2 3 3
PLOT 103 111 203 211 303 311
TREATMENT 7 3 1 4 12 5
BLOCK 1 1 2 2 3 3
PLOT 102 110 202 210 302 310
TREATMENT 12 14 6 14 1 16
BLOCK 1 1 2 2 3 3
PLOT 101 109 201 209 301 309
40m Length (8x5m Plots)
10m Discard (2x5m Plots)
29.7m Wide (9x3.3m Plots)

**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** *Authorised signatory*

**Certification Number**
ORETO 409

HSE
Chemicals Regulation Division

Department of Agriculture and Rural Development