SCEPTREPLUS

Final Trial Report

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|---|---|
| Trial code: | SP 42 |
| Title: | Control of White Mould and Smoulder in Narcissus |
| Crop | Group; Bulbs and outdoor flowers - Narcissus |
| Target | White Mould (*Ramularia vallisumbrosae*) and Smoulder (*Botryotinia narcissicola*) |
| Lead researcher: | Dave Kaye |
| Organisation: | RSK ADAS Ltd. |
| Period: | January 2019 – July 2019 |
| Report date: | 31 July 2019 |
| Report author: | Dave Kaye |
| ORETO Number: (certificate should be attached) | ORETO 409 |

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

Date: 31 July 2019 Authors signature: D. Kaye.

**Trial Summary**

**Introduction**

White mould (*Ramularia vallisumbrosae)* and smoulder (*Botrytis narcissicola)* represent a significant disease risk to UK narcissus production with an estimated annual cost to the industry of £1.85 million. Both diseases occur shortly following leaf/stem emergence, affecting both the foliage and flowers. This results in a loss of marketable flower yield estimated at 5% and a reduction in bulb yield of up to 10%. A field-based trial located in Cornwall was set up to identify alternative chemical and biological treatments to effectively manage these diseases.

**Methods**

A field in Hayle, Cornwall, a region prone to high levels of white mould and smoulder disease was selected as the location for this work. A product efficacy trial consisting of a four block, randomised design was established in a second-year down narcissus crop of the susceptible variety St. Patrick's Day, with infection reliant on natural levels of spore inoculum. Other than the application of the test fungicide treatments, the crop was treated as in commercial practice but was not harvested due to potential operator exposure risks associated with the products tested.

Treatment plots were treated four times with different crop protection products (eight conventional, one biological) using a knapsack sprayer at roughly 14 day intervals. Plants were assessed for white mould and smoulder disease incidence (% plants affected) and severity (% plant area affected) on the foliage, as well as crop safety (0-10 scale where 0 = dead, 10 = no damage) at each treatment date and 14 days following the final treatment application. At each assessment, the plants in five random 1 m lengths along the central three rows in each plot were evaluated.

**Results**

Consistent levels of white mould and smoulder developed in the trial area (65% of untreated row lengths with white mould, compared with 100% for smoulder) which enabled differences between treatments and the untreated to be identified. By the final assessment (16 Apr), white mould symptoms were indistinguishable from leaf senescence and so were not recorded. However, smoulder symptoms were clear and assessed at this time.

White mould - five treatments significantly reduced disease incidence compared with the untreated control on the fourth assessment (Tracker, AHDB9914, AHDB9913, AHDB9926 and AHDB9863; Table 1).

**Table 1**. Effect of fungicides on mean foliar white mould incidence (proportion of 1 m row lengths affected) for each of four assessment dates.

| Date / Treatment | 14-Feb | 28-Feb | 20-Mar | 03-Apr |
|---|---|---|---|---|
| Untreated | 20.00 | 45.00 | 35.00 | 65.00 |
| Tracker | 5.00 | 25.00 | 15.00 | 30.00 |
| AHDB9873 | 15.00 | 25.00 | 10.00 | 60.00 |
| AHDB9914 | 15.00 | 10.00 | 10.00 | 5.00 |
| AHDB9913 | 25.00 | 25.00 | 10.00 | 5.00 |
| AHDB9926 | 15.00 | 25.00 | 0.00 | 15.00 |
| AHDB9927 | 25.00 | 35.00 | 20.00 | 45.00 |
| AHDB9863 | 20.00 | 40.00 | 5.00 | 25.00 |
| AHDB9871 | 10.00 | 25.00 | 25.00 | 35.00 |
| AHDB9862 | 20.00 | 5.00 | 10.00 | 40.00 |
| | Not significantly different from untreated control (p>0.05) | | | |
| | Significantly different from untreated control (p<0.05) | | | |

Significant reductions in white mould disease severity were identified for all test products compared with the untreated control by the third and/or fourth assessments (Table 2). Only one product, AHDB9873, failed to significantly reduce disease severity by the fourth

assessment. All other products, including the biological product AHDB9871, gave results comparable with the industry standard, Tracker.

**Table 2.** Effect of fungicides on mean foliar white mould severity (% of leaf area affected) for each of four assessment dates.

| Date / Treatment | 14-Feb | 28-Feb | 20-Mar | 03-Apr |
|---|---|---|---|---|
| Untreated | 0.20 | 2.35 | 2.75 | 7.15 |
| Tracker | 0.05 | 0.75 | 0.50 | 1.20 |
| AHDB9873 | 0.25 | 0.85 | 0.50 | 5.00 |
| AHDB9914 | 0.20 | 0.20 | 0.20 | 0.10 |
| AHDB9913 | 0.68 | 0.75 | 0.75 | 0.40 |
| AHDB9926 | 0.25 | 0.30 | 0.00 | 0.60 |
| AHDB9927 | 0.30 | 1.05 | 1.40 | 3.80 |
| AHDB9863 | 0.20 | 1.70 | 0.10 | 1.65 |
| AHDB9871 | 0.35 | 1.00 | 1.65 | 3.25 |
| AHDB9862 | 0.20 | 0.10 | 0.35 | 2.10 |
| | Not significantly different from untreated control (p>0.05) | | | |
| | Significantly different from untreated control (p<0.05) | | | |

Smoulder – Four treatments, Tracker, AHDB9873, AHDB9926 and AHDB9863 reduced the incidence of smoulder compared with the untreated control 14 days after the first application (28-Feb, Table 3). This pattern continued and, apart from the biological product AHDB9871, all other treatments reduced disease incidence after two applications (20-Mar). Reductions in Smoulder severity did not continue for AHDB9873 and AHDB9927 into the fourth or fifth assessments. AHDB9926 did not reduce disease incidence two weeks after the final treatment (16-Apr) and AHDB9871 did not significantly reduce smoulder incidence at any assessment time.

**Table 3.** Effect of fungicides on mean smoulder incidence on foliage (proportion of 1m row lengths affected) for each of five assessment dates.

| Date / Treatment | 14-Feb | 28-Feb | 20-Mar | 03-Apr | 16-Apr |
|---|---|---|---|---|---|
| Untreated | 50.00 | 95.00 | 100.00 | 100.00 | 100.00 |
| Tracker | 45.00 | 60.00 | 45.00 | 45.00 | 60.00 |
| AHDB9873 | 60.00 | 55.00 | 60.00 | 85.00 | 100.00 |
| AHDB9914 | 50.00 | 80.00 | 40.00 | 30.00 | 55.00 |
| AHDB9913 | 25.00 | 70.00 | 65.00 | 50.00 | 55.00 |
| AHDB9926 | 45.00 | 55.00 | 50.00 | 50.00 | 75.00 |
| AHDB9927 | 50.00 | 70.00 | 65.00 | 90.00 | 95.00 |
| AHDB9863 | 60.00 | 65.00 | 75.00 | 70.00 | 70.00 |
| AHDB9871 | 45.00 | 70.00 | 85.00 | 100.00 | 100.00 |
| AHDB9862 | 60.00 | 80.00 | 65.00 | 65.00 | 70.00 |
| | Not significantly different from untreated control (p>0.05) | | | | |
| | Significantly different from untreated control (p<0.05) | | | | |

Significant reductions in smoulder severity occurred in plots treated with Tracker, AHDB9873, AHDB9914, AHDB9926 and AHDB9871 compared to the untreated control by assessment two after just one application (Table 4). All treatments significantly reduced smoulder incidence by assessment three (after two treatment applications, 20-Mar). Reduction in disease severity continued for all products, at each assessment date, for the duration of the trial, apart from the biological product AHDB9871 where no reduction in disease severity occurred at assessment four, but was evident at the final assessment.

**Table 4.** Effect of fungicides on mean smoulder severity score (% of leaf area affected) per treatment for each of five assessment dates.

| Date / Treatment | 14-Feb | 28-Feb | 20-Mar | 03-Apr | 16-Apr |
|---|---|---|---|---|---|
| Untreated | 1.03 | 6.95 | 18.30 | 24.30 | 27.10 |
| Tracker | 0.68 | 2.90 | 2.70 | 2.80 | 4.25 |
| AHDB9873 | 1.35 | 3.05 | 3.55 | 11.15 | 13.50 |
| AHDB9914 | 0.65 | 3.45 | 1.90 | 1.65 | 3.70 |
| AHDB9913 | 0.45 | 4.45 | 5.80 | 4.25 | 6.45 |
| AHDB9926 | 1.10 | 2.40 | 3.65 | 4.55 | 7.35 |
| AHDB9927 | 0.58 | 4.55 | 7.45 | 9.90 | 16.65 |
| AHDB9863 | 1.33 | 4.45 | 6.25 | 7.80 | 6.45 |
| AHDB9871 | 0.71 | 4.05 | 12.00 | 19.90 | 16.90 |
| AHDB9862 | 1.03 | 4.50 | 4.40 | 6.05 | 7.85 |
| | Not significantly different from untreated control ($p>0.05$) | | | | |
| | Significantly different from untreated control ($p<0.05$) | | | | |

**Phytotoxicity**
Although some phytotoxic symptoms developed in all treatments, these were minor and not of commercial concern.

**Conclusions**

- All test products significantly reduced white mould incidence and/or severity compared to untreated controls at one or more disease assessment dates.
- Effective test products gave comparable but not better control than the industry standard Tracker.
- The best performing products for controlling both white mould and smoulder were Tracker, AHDB9914 (FRAC code: 7 and 11), AHDB9926 (FRAC code 7), AHDB9863 (FRAC code U8) and AHDB 9913 (FRAC code 7).
- The biological product AHDB9871 (FRAC code 44) did not reduce the incidence of white mould or smoulder at any disease assessment date, but did reduce the severity of both diseases. This suggests there might be a place for this product as part of an effective integrated control programme.
- Further work is required to establish the best programmes incorporating the most effective products identified in this work
- Some phytotoxic damage developed in all treatments. This was minor and not of commercial concern.

**Take home message**:
All test products reduced white mould and smoulder incidence and/or severity. AHDB9914, AHDB9913, AHDB9926 and AHDB9863 gave the best control of both diseases, comparable with the industry standard Tracker.

**Objective**

To assess a range of conventional fungicides, biofungicides and biological products for their safety and efficacy against white mould (*Ramularia vallisumbrosae*) and smoulder (*Botrytis narcissicola*) in narcissus.

**Trial conduct**

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

| Relevant EPPO guideline(s) | | Variation from EPPO |
|---|---|---|
| PP 1/195(2) | Fungi on flower bulbs and tubers | None |
| PP 1/135(4) | Phytotoxicity assessment | None |
| PP 1/152(4) | Guideline on design and analysis of efficacy evaluation trials | None |
| PP 1/225(2) | Minimum effective dose | None |
| PP 1/181(4) | Conduct and reporting of efficacy evaluation trials including good experimental practice | None |
| PP 1/214(3) | Principles of acceptable efficacy | None |
| PP 1/224(2) | Principles of efficacy evaluation for minor uses | None |

There were no deviations from EPPO guidance.

**Test site**

| Item | Details |
|---|---|
| Location address | J H Richards & Sons,<br>Hayle,<br>Cornwall,<br>TR27 0NE<br>Grid reference: SW 61822 36536 |
| Crop | Narcissus (second-year down) |
| Cultivar | St. Patrick's Day |
| Soil or substrate type | Freely draining loam |
| Agronomic practice | Modified commercial practice – no fungicide inputs by the host grower; crop remained unharvested (operator exposure risk) |
| Prior history of site | Narcissus (2018) with a history of white mould and smoulder infection |

**Trial design**

| Item | Details |
|---|---|
| Trial design: | Randomised block |
| Number of replicates: | 4 |
| Row spacing: | 0.5 m |
| Plot size: (w x l) | 1.5 m x 5.0 m |
| Plot size: ($m^2$) | 7.5 $m^2$ |
| Number of plants per plot: | Approx. 125 |
| Leaf Wall Area calculations | N/A |

**Treatment details**

| AHDB Code | Active substance | Product name/ manufacturers code | Formulation batch number | Content of active substance in product | Formulation type |
|---|---|---|---|---|---|
| N/A | Water | Untreated | N/A | N/A | N/A |
| Approved | Boscalid & epoxiconazole | Tracker | 0015149948 | 233 g $L^{-1}$ 67 g $L^{-1}$ | Suspension concentrate |
| AHDB9873 | N/D | N/D | N/D | N/D | N/D |
| AHDB9914 | N/D | N/D | N/D | N/D | N/D |
| AHDB9913 | N/D | N/D | N/D | N/D | N/D |
| AHDB9926 | N/D | N/D | N/D | N/D | N/D |
| AHDB9927 | N/D | N/D | N/D | N/D | N/D |
| AHDB9863 | N/D | N/D | N/D | N/D | N/D |
| AHDB9871 | N/D | N/D | N/D | N/D | N/D |
| AHDB9862 | N/D | N/D | N/D | N/D | N/D |

No adjuvants were included at any treatment application.

**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 | Control (water) | - | - | A-D |
| 2 | Tracker | 155.33 & 44.67 | 1.50 | A-D |
| 3 | AHDB9873 | 500.00 | 0.90 | A-D |
| 4 | AHDB9914 | 312.50 & 312.50 | 0.80 | A-D |
| 5 | AHDB9913 | 1000.00 | 0.30 | A-D |
| 6 | AHDB9926 | 36.00 | 1.00 | A-D |
| 7 | AHDB9927 | 600.00 | 1.20 | A-D |
| 8 | AHDB9863 | 360.00 | 0.50 | A-D |
| 9 | AHDB9871 | 13.80 | 10.00 | A-D |
| 10 | AHDB9862 | Unknown | 1.50 | A-D |

**Application details**

| | Application A | Application B | Application C | Application D |
|---|---|---|---|---|
| Application date | 14/02/2019 | 28/02/2019 | 19/03/2019 | 03/04/2019 |
| Time of day | 14:00 - 14:30 | 12:10 – 12:40 | 10:40 - 11:15 | 12:15 – 12:50 |
| Crop growth stage (Max, min average BBCH) | 103 | 502 | 605 | 609 |
| Crop height (cm) | 20 - 35 | 35 - 50 | 50 - 55 | 50 - 55 |
| Crop coverage (%) | 80 | 80 | 75 | 75 |
| Application Method | Spray | Spray | Spray | Spray |
| Application Placement | Foliar | Foliar | Foliar | Foliar |
| Application equipment | Oxford Precision Sprayer (Knapsack) | Oxford Precision Sprayer (Knapsack) | Oxford Precision Sprayer (Knapsack) | Oxford Precision Sprayer (Knapsack) |
| Nozzle pressure | 1.9 | 1.9 | 1.9 | 1.9 |
| Nozzle type | 02F110 | 02F110 | 02F110 | 02F110 |
| Nozzle size | Flat fan | Flat fan | Flat fan | Flat fan |
| Application water volume/ha | 200 | 200 | 200 | 200 |

| | Application A | Application B | Application C | Application D |
|---|---|---|---|---|
| Temperature of air - shade (°C) | 11.3 - 12.5 | 12.8 – 14.5 | 10.6 – 14.3 | 11.5 – 11.7 |
| Relative humidity (%) | 67.3 – 72.8 | 78.6 – 82.6 | 70.8 – 83.5 | 61.0 – 64.5 |
| Wind speed range (m/s) | 2.1 – 3.0 | 2.1 – 3.4 | 1.0 – 1.6 | 2.7 – 4.0 |
| Dew presence (Y/N) | N | N | N | N |
| *Temperature of soil - 2-5 cm (°C) | Not recorded | Not recorded | Not recorded | Not recorded |
| *Wetness of soil - 2-5 cm | Not recorded | Not recorded | Not recorded | Not recorded |
| Cloud cover (%) | 5 | 50 | 65 | 75 |

*Soil wetness and soil temperature do not impact the establishment and progression of white mould or smoulder after crop emergence and were not recorded.

**Untreated levels of pests/pathogens at application and through the assessment period**

| Common name | Scientific Name | EPPO Code | Infestation level pre-application | Infestation level at start of assessment period | Infestation level at end of assessment period |
|---|---|---|---|---|---|
| White mould | *Ramularia vallisumbrosae* | RAMUVA | 20% incidence | 20% incidence | 65% incidence |
| Smoulder | *Botryotinia narcissicola* | SCLENA | 50% incidence | 50% Incidence | 100% incidence |

No pests/pest damage were recorded on any plants at any assessment date

**Assessment details**

The narcissus crop had emerged prior to trial set-up, with early disease symptoms of white mould and smoulder already present (14/02/19). A preliminary full disease assessment was performed on this date, immediately before the first treatment application. Four additional assessments were subsequently completed at 14 day intervals (conditions allowing). At each assessment date plots were assessed for white mould and smoulder incidence and severity. Plots were assessed using five 1 m random lengths along the central three rows of crop. Severity was recorded as % plant area affected while incidence was recorded as the presence or absence of the target diseases along these lengths (1 or 0). Crop safety was also evaluated on whole plots and scored on a scale from 0 to 10, with 0 being ‘dead’, and 10 being ‘no effect’. Plots which scored 8 or above were deemed to have a commercially acceptable level of damage.

Phytotoxicity was recorded using the following scale:

**Table 5.** Scale used for the assessment of the extent of phytotoxic damage in treated plots

| Crop tolerance score | Equivalent to crop damage (% phytotoxicity) |
|---|---|
| 0 | complete crop kill 100% |
| 1 | 80-95% damage |
| 2 | 70-80% |
| 3 | 60-70% |
| 4 | 50-60% |

| | |
|---|---|
| 5 | 40-50% |
| 6 | 25-40% |
| 7 | 15-25% |
| 8* | 10-15% |
| 9 | 5-10% |
| 10 | no damage |

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

**Table 6.** White mould, smoulder and crop safety assessment schedule

| Evaluation date | Evaluation Timing (DA)* | Crop Growth Stage (BBCH) | Evaluation type (efficacy, phytotoxicity) | Assessment |
|---|---|---|---|---|
| 14/02/19 | 0 | 103 | Preliminary | - Smoulder and White Mould incidence and severity |
| 28/02/19 | 14 | 502 | Efficacy<br>Phytotoxicity | - Smoulder and White Mould incidence and severity<br>- Crop safety |
| 20/03/19 | 34 | 605 | Efficacy<br>Phytotoxicity | - Smoulder and White Mould incidence and severity<br>- Crop safety |
| 03/04/19 | 48 | 609 | Efficacy<br>Phytotoxicity | - Smoulder and White Mould incidence and severity<br>- Crop safety |
| 16/04/19 | 61 | 708 | Efficacy<br>Phytotoxicity | - Smoulder and White Mould incidence and severity<br>- Crop safety |

* DA – days after first spray application.

**Statistical analysis**

The trial was analysed by Chris Dyer (ADAS statistician) as a randomised block design with four replicates of 10 treatments using ANOVA (Genstat 18th edition). The results for each disease were analysed separately and no data transformation was required.

# Results

## Phytotoxicity

Application of all test treatments, including the industry standard Tracker, resulted in only minor phytotoxic effects in the form of spotting on open flowers. At no assessment date was the level of phytoxicity considered of commercial concern, with all treatments scoring 8 or above.

Table 7. Phytotoxicity scores for of plots treated with test products T2-T4.

| Date / Treatment | 28-Feb | 20-Mar | 03-Apr | 16-Apr |
|---|---|---|---|---|
| Untreated | 10.00 | 10.00 | 10.00 | 10.00 |
| Tracker | 10.00 | 10.00 | 8.75 | 9.00 |
| AHDB9873 | 10.00 | 10.00 | 8.25 | 8.75 |
| AHDB9914 | 10.00 | 10.00 | 9.25 | 9.00 |
| AHDB9913 | 10.00 | 10.00 | 9.00 | 9.00 |
| AHDB9926 | 10.00 | 10.00 | 9.00 | 8.75 |
| AHDB9927 | 10.00 | 10.00 | 8.50 | 8.50 |
| AHDB9863 | 10.00 | 10.00 | 9.00 | 8.75 |
| AHDB9871 | 10.00 | 10.00 | 8.50 | 8.00 |
| AHDB9862 | 10.00 | 10.00 | 9.00 | 9.00 |

* 8 = acceptable damage, i.e. damage unlikely to reduce yield, and considered commercially acceptable.

## Efficacy

White mould

*Incidence*: Significant differences in the incidence of white mould between treatments were seen two weeks after the third treatment application, at the penultimate assessment on 3-April (Table 8). White mould was not assessed at the final assessment date as it was not possible to confidently distinguish between white mould and natural senescence.

**Table 8**. Effect of fungicides on mean foliar white mould incidence (proportion of 1 m row lengths affected) for each of four assessment dates.

| Date / Treatment | 14-Feb | 28-Feb | 20-Mar | 03-Apr |
|---|---|---|---|---|
| Untreated | 20.00 | 45.00 | 35.00 | 65.00 |
| Tracker | 5.00 | 25.00 | 15.00 | 30.00 |
| AHDB9873 | 15.00 | 25.00 | 10.00 | 60.00 |
| AHDB9914 | 15.00 | 10.00 | 10.00 | 5.00 |
| AHDB9913 | 25.00 | 25.00 | 10.00 | 5.00 |
| AHDB9926 | 15.00 | 25.00 | 0.00 | 15.00 |
| AHDB9927 | 25.00 | 35.00 | 20.00 | 45.00 |
| AHDB9863 | 20.00 | 40.00 | 5.00 | 25.00 |
| AHDB9871 | 10.0 | 25.00 | 25.00 | 35.00 |
| AHDB9862 | 20.00 | 5.00 | 10.00 | 40.00 |
| P value | 0.801 | 0.345 | 0.077 | 0.001 |
| d.f. | 27 | 27 | 27 | 27 |
| s.e.d. | 11.74 | 15.87 | 10.18 | 13.98 |
| l.s.d. | 24.080 | 32.560 | 20.890 | 28.680 |
| | Not significantly different from untreated control (p>0.05) | | | |
| | Significantly different from untreated control (p<0.05) | | | |

Five treatments significantly reduced white mould incidence, Tracker, AHDB9914, AHDB9913, AHDB9926 and AHDB9863 compared to the untreated control (65%). However, the use of these products provided no additional protection compared to using Tracker.

*Severity*: No treatment had any effect on white mould severity at the first two disease assessments (Table 9). Although disease levels were low at assessment three (20-Mar), a reduction in disease incidence was still observed for all treatments except for AHDB9871 compared with the untreated control (2.75%). This trend continued for the next assessment date (03-Apr), except for AHDB9873 where no significant reduction in severity was evident, (5% vs. 7.15% in the untreated); however, AHDB9871 reduced smoulder severity symptoms at this time (1.65%). No treatments outperformed Tracker.

**Table 9.** Effect of fungicides on mean foliar white mould severity (% of leaf area affected) for each of four assessment dates.

| Date / Treatment | 14-Feb | 28-Feb | 20-Mar | 03-Apr |
|---|---|---|---|---|
| Untreated | 0.20 | 2.35 | 2.75 | 7.15 |
| Tracker | 0.05 | 0.75 | 0.50 | 1.20 |
| AHDB9873 | 0.25 | 0.85 | 0.50 | 5.00 |
| AHDB9914 | 0.20 | 0.20 | 0.20 | 0.10 |
| AHDB9913 | 0.68 | 0.75 | 0.75 | 0.40 |
| AHDB9926 | 0.25 | 0.30 | 0.00 | 0.60 |
| AHDB9927 | 0.30 | 1.05 | 1.40 | 3.80 |
| AHDB9863 | 0.20 | 1.70 | 0.10 | 1.65 |
| AHDB9871 | 0.35 | 1.00 | 1.65 | 3.25 |
| AHDB9862 | 0.20 | 0.10 | 0.35 | 2.10 |
| P value | 0.657 | 0.058 | 0.025 | <0.001 |
| d.f. | 27 | 27 | 27 | 27 |
| s.e.d. | 0.266 | 0.665 | 0.756 | 1.428 |
| l.s.d. | 0.546 | 1.364 | 1.551 | 2.931 |
| | Not significantly different from untreated control (p>0.05) | | | |
| | Significantly different from untreated control (p<0.05) | | | |

Percentage reduction in white mould severity for each treatment compared to the untreated control at each assessment date clearly identified the most effective test products which included AHDB9914, AHDB9913 and AHDB9926 (Table 10). AHDB9927 also reduced white mould severity compared to the untreated control but was less effective than the other products.

**Table 10**. Percentage reduction in mean white mould severity scores for each treatment compared to the untreated control.

| Date / Treatment | 28-Feb | 20-Mar | 03-Apr |
|---|---|---|---|
| Untreated | 0.0 | 0.0 | 0.0 |
| Tracker | 68.1 | **81.8** | **83.2** |
| AHDB9873 | 63.8 | **81.8** | 30.1 |
| AHDB9914 | 91.5 | **92.7** | **98.6** |
| AHDB9913 | 68.1 | **72.7** | **94.4** |
| AHDB9926 | 87.2 | **100.0** | **91.6** |
| AHDB9927 | 55.3 | **49.1** | **46.9** |
| AHDB9863 | 27.7 | **96.4** | **76.9** |
| AHDB9871 | 57.2 | 40.0 | **54.5** |
| AHDB9862 | 95.7 | **87.3** | **70.6** |

Significant reductions in white mould severity compared with the untreated control are emboldened.

Smoulder

*Incidence*: Differences in the incidence of smoulder between treated and untreated plots had developed by assessment 2 (14 DA) with Tracker, AHDB9873, AHDB9926 and AHDB9863 being effective (Table 11). Results from the third assessment (34 DA) showed that all test products, except for AHDB9871, significantly reduced smoulder incidence. However, AHDB9873 and AHDB9927 did not result in a reduction in the incidence of smoulder at the fourth and fifth assessments, while AHDB9926 also failed to reduce incidence by the final assessment. The best performing treatments by the end of the trial when the untreated control had 100% incidence were AHDB9914 (55.00%), AHDB9913 (55.00%), AHDB9863 (70.00%) and AHDB9862 (70.00%), alongside the industry standard Tracker (60.00%). AHDB9871 did not reduce smoulder incidence at any assessment date

**Table 11.** Effect of fungicides on mean smoulder incidence on foliage (proportion of 1m row lengths affected) for each of five assessment dates.

| Date / Treatment | 14-Feb | 28-Feb | 20-Mar | 03-Apr | 16-Apr |
|---|---|---|---|---|---|
| Untreated | 50.00 | 95.00 | 100.00 | 100.00 | 100.00 |
| Tracker | 45.00 | 60.00 | 45.00 | 45.00 | 60.00 |
| AHDB9873 | 60.00 | 55.00 | 60.00 | 85.00 | 100.00 |
| AHDB9914 | 50.00 | 80.00 | 40.00 | 30.00 | 55.00 |
| AHDB9913 | 25.00 | 70.00 | 65.00 | 50.00 | 55.00 |
| AHDB9926 | 45.00 | 55.00 | 50.00 | 50.00 | 75.00 |
| AHDB9927 | 50.00 | 70.00 | 65.00 | 90.00 | 95.00 |
| AHDB9863 | 60.00 | 65.00 | 75.00 | 70.00 | 70.00 |
| AHDB9871 | 45.00 | 70.00 | 85.00 | 100.00 | 100.00 |
| AHDB9862 | 60.00 | 80.00 | 65.00 | 65.00 | 70.00 |
| P value | 0.289 | 0.030 | <0.001 | <0.001 | 0.002 |
| d.f. | 27 | 27 | 27 | 27 | 27 |
| s.e.d. | 13.08 | 11.09 | 10.82 | 13.38 | 13.05 |
| l.s.d. | 26.840 | 22.750 | 22.200 | 27.460 | 26.780 |
| | Not significantly different from untreated control (p>0.05) | | | | |
| | Significantly different from untreated control (p<0.05) | | | | |

*Severity*: At assessment two (28-Feb), five of the nine products significantly reduced smoulder disease severity compared with the untreated control (6.95%; Table 12).

**Table 12.** Effect of fungicides on mean smoulder severity score (% of leaf area affected) per treatment for each of five assessment dates.

| Date / Treatment | 14-Feb | 28-Feb | 20-Mar | 03-Apr | 16-Apr |
|---|---|---|---|---|---|
| Untreated | 1.03 | 6.95 | 18.30 | 24.30 | 27.10 |
| Tracker | 0.68 | 2.90 | 2.70 | 2.80 | 4.25 |
| AHDB9873 | 1.35 | 3.05 | 3.55 | 11.15 | 13.50 |
| AHDB9914 | 0.65 | 3.45 | 1.90 | 1.65 | 3.70 |
| AHDB9913 | 0.45 | 4.45 | 5.80 | 4.25 | 6.45 |
| AHDB9926 | 1.10 | 2.40 | 3.65 | 4.55 | 7.35 |
| AHDB9927 | 0.58 | 4.55 | 7.45 | 9.90 | 16.65 |
| AHDB9863 | 1.33 | 4.45 | 6.25 | 7.80 | 6.45 |
| AHDB9871 | 0.71 | 4.05 | 12.00 | 19.90 | 16.90 |
| AHDB9862 | 1.03 | 4.50 | 4.40 | 6.05 | 7.85 |
| P value | 0.274 | 0.029 | <0.001 | <0.001 | <0.001 |
| d.f. | 27 | 27 | 27 | 27 | 27 |
| s.e.d. | 0.3919 | 1.126 | 2.730 | 3.416 | 2.757 |
| l.s.d. | 0.804 | 0.029 | <0.001 | <0.001 | <0.001 |
| | Not significantly different from untreated control (p>0.05) | | | | |
| | Significantly different from untreated control (p<0.05) | | | | |

At each of the subsequent assessments (Table 12) all products, with the exception of AHDB9871 (03-Apr) reduced smoulder severity, with all products reducing disease severity by 14 days after the final treatment application (61 DA). AHDB9914, AHDB9913, AHDB9926, AHDB9863 and AHDB9862 provided significantly better control than AHDB9927 and AHDB9871, although these two products also reduced disease severity compared with the untreated (Figure 1).

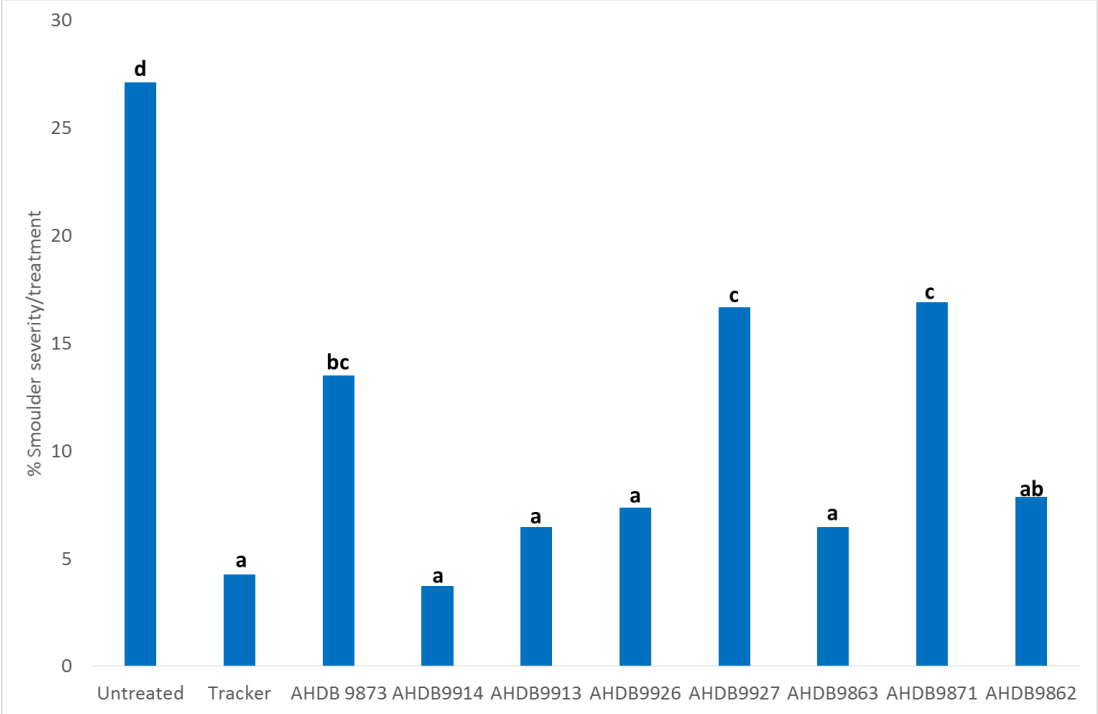



**Figure 1.** Effect of different test product treatments on mean smoulder severity (percentage foliage affected) in field grown narcissus 14 days after the fourth treatment application (16.04.19)
*Bars labelled with different letters are significantly different.

Percentage reduction in smoulder severity for treatments compared with the untreated control, at each assessment date are given in Table 13 and further highlight product efficacy at each assessment.

**Table 13.** Percentage reduction in mean smoulder severity for different test treatments compared with the untreated control (Abbots formula).

| Date / Treatment | 28-Feb | 20-Mar | 03-Apr | 16-Apr |
|---|---|---|---|---|
| Untreated | 0.0 | 0.0 | 0.00 | 0.00 |
| Tracker | **58.3** | **85.2** | **88.5** | **84.3** |
| AHDB9873 | **56.1** | **80.6** | **54.1** | **50.2** |
| AHDB9914 | **50.4** | **89.6** | **93.2** | **86.3** |
| AHDB9913 | 36.0 | **68.3** | **82.5** | **76.2** |
| AHDB9926 | **65.5** | **80.1** | **81.3** | **72.9** |
| AHDB9927 | 34.5 | **59.3** | **59.3** | **38.6** |
| AHDB9863 | 36.0 | **65.8** | **67.9** | **76.2** |
| AHDB9871 | **41.7** | **34.4** | 18.1 | **37.6** |
| AHDB9862 | 35.3 | **76.0** | **75.1** | **71.0** |

Significant reductions in smoulder severity compared with the untreated control are emboldened.

## Discussion

White mould and smoulder disease established at sufficient and consistent levels at the field trial site to allow significant differences between treatments and the untreated control to be identified. By the final assessment, white mould and smoulder disease incidence in the untreated control were 65% and 100% respectively while severity was 7.1% and 27.1%. As disease symptoms were present before the first treatment application, it is possible that greater levels of control could have been achieved with an earlier application start date. All test treatments significantly reduced disease incidence and/or severity for at least one

disease assessment time. Some treatments provided significantly better control than others, but none outperformed the industry standard Tracker.

The succinate dehydrogenase inhibitor (SDHI) fungicides AHDB9914 (FRAC codes 7+11), AHDB9913 (FRAC code 7), AHDB9926 (FRAC code 7), and Tracker (FRAC code 7), gave the best control against white mould. However, AHDB9863 (FRAC group U8) performed comparably with these products, with AHDB9862 (FRAC group 3) also reducing disease, but not quite as consistently. In a standard narcissus spray programme, SDHI fungicides can only be used twice per year and these latter two products therefore provide an alternative mode of action to growers to provide good fungicide resistance management practice.

AHDB9914, AHDB9863, AHDB9926 and Tracker were also the most effective products against smoulder. AHDB9913 performed similarly, but did not reduce smoulder severity until slightly later.

Although the biological product AHDB9871 had no impact on the incidence of the two diseases, it reduced disease severity at one white mould assessment and three smoulder assessment dates. This demonstrates that given the correct conditions, this treatment, and potentially other biological products, have a place as part of an integrated control programme. AHDB9871 could be used alone to extend the spray intervals of conventional products, or combined with other products to perhaps enhance their activity. Compatibility testing would be required prior to this approach.

All test products were applied alone at full rate, and generally more frequently than is permitted during commercial cropping, e.g. four rather than two applications of SDHI fungicides per year. Symptoms of phytotoxicity developed in all treatments, but never developed to levels of commercial concern despite the intense test programme and all products can be considered crop safe on field-based narcissus.

Due to unknown operator exposure risks the trial area could not be harvested. This was necessary, but a deviation from standard commercial practice. Normal production would have crop workers walking rows on several occasions, harvesting stems and so resulting in frequent plant wounding. Products tested in this work were demonstrated to provide good control against white mould and smoulder in unharvested narcissus, but it is possible that they may have had other effects on the crop, which could not be established in this work. This could be evaluated, alongside spray programmes incorporating the most efficacious products identified in this project in the future.

## Conclusions

- All chemical products tested reduced white mould and smoulder incidence and/or severity for at least one disease assessment date in a narcissus field trial.
- The SDHI based fungicides, AHDB9914, AHDB9913, AHDB9926 gave the best control against white mould, alongside AHDB9863 (FRAC group U8) and AHDB9862 (FRAC group 3). The performance for each of these products was comparable to the industry standard Tracker.
- AHDB9914, AHDB9913, AHDB9863, AHDB9926 and AHDB9862 gave the best control of smoulder alongside Tracker.
- AHDB9873 and AHDB9927 gave control of smoulder, but were not as consistent as the other products tested
- The biological product AHDB9871 reduced white mould and smoulder severity, but had no impact on disease incidence. However, it could be a useful component of an integrated control programme.
- Minor phytotoxic effects were seen in plots treated with all treatments. This damage was slight and not of commercial concern.
- Further work is required to establish programmes using the most appropriate products identified in this work e.g. AHDB9914, AHDB9863 and AHDB9871. If possible, this work should be performed on a harvested crop (once operator exposure risks have been resolved) to confirm product efficacy under exact commercial practices, including frequent wounding from crop walking/flower harvest. This could

also include a bulb harvest to establish any differences in bulb yields for each treatment.

## Acknowledgements

We would like to thank Andrew Richards and all at J H Richards & sons for hosting and maintaining the trial. We would also like to thank Chris Dyer for performing the statistical analysis, and AHDB Horticulture and participating crop protection companies for advice on product selection and use, and for supporting the SCEPTREplus program.

## Appendix

### a. Crop diary

Species – Narcissus
Cultivar – St. Patrick's Day
Planted – 2017 (second-year-crop)

Cultivations, fertilisers, etc. – The trial was cultivated following normal commercial practices (fertiliser and insecticides) with the exception of the application of grower fungicides. The trial crop was not harvested.

**Fertiliser inputs to trial area**

| Date | Product | Rate |
|---|---|---|
| n/a | n/a | n/a |

**Insecticide inputs to trial area**

| Date | Product | Rate |
|---|---|---|
| n/a | n/a | n/a |

### b. Trial diary

| Date | Event |
|---|---|
| 14/02/19 | Trial set-up<br>Disease assessment 1<br>Treatment application 1 |
| 28/02/19 | Disease assessment 2<br>Crop safety assessment 1<br>Treatment application 2 |
| 20/03/19 | Disease assessment 3<br>Crop safety assessment 2<br>Treatment application 3 |
| 03/04/19 | Disease assessment 4<br>Crop safety assessment 3<br>Treatment application 4 |
| 16/04/19 | Disease assessment 5<br>Crop safety assessment 4 |
| 02/05/19 | Open day - SCEPTREplus workshop |
| 29/05/19 | Senescence monitored<br>Closure of trial site |

## c. Trial images

Trial area at set-up (14-Feb).

Trial area at Mid-flower (20-Mar).

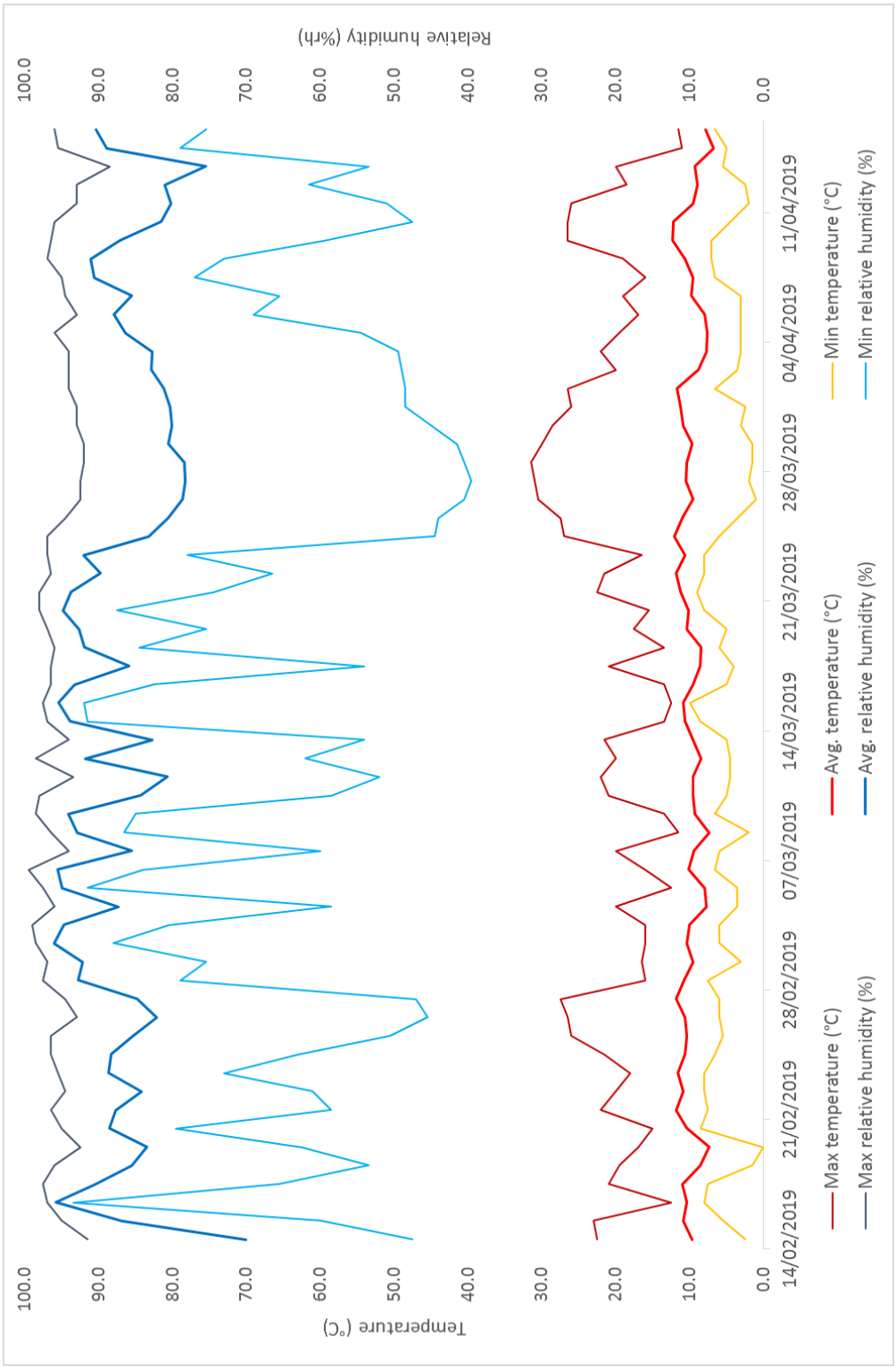
Trial area at senescence (29-May).

White mould and smoulder symptoms on an untreated plot (02-Apr).

Untreated (left) vs. AHDB9914 (right) at the final assessment (16-Apr).

Untreated (left) vs. AHDB9871 (right) at the final assessment (16-Apr).

**d. Climatological data during study period (14/02/19 – 16/04/19)**



## e. Raw data from assessments

| | | White mould | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 14.02.19 | | 28.02.19 | | 20.03.19 | | 03.04.19 | | 16.04.19 | |
| Plot | Treatment | Incidence | severity | Incidence | severity | Incidence | severity | Incidence | severity | Incidence | severity |
| 1 | 9 | 0.2 | 1.0 | 40.0 | 2.0 | 0.0 | 0.0 | 20.0 | 2.0 | No data | No data |
| 2 | 5 | 0.6 | 2.1 | 20.0 | 1.0 | 20.0 | 2.0 | 0.0 | 0.0 | No data | No data |
| 3 | 6 | 0.2 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 20.0 | 0.4 | No data | No data |
| 4 | 10 | 0.4 | 0.4 | 0.0 | 0.0 | 20.0 | 0.4 | 40.0 | 1.4 | No data | No data |
| 5 | 7 | 0.0 | 0.0 | 60.0 | 2.2 | 20.0 | 0.6 | 40.0 | 2.6 | No data | No data |
| 6 | 4 | 0.2 | 0.2 | 20.0 | 0.2 | 20.0 | 0.4 | 20.0 | 0.4 | No data | No data |
| 7 | 8 | 0.4 | 0.4 | 80.0 | 3.4 | 0.0 | 0.0 | 0.0 | 0.0 | No data | No data |
| 8 | 2 | 0.0 | 0.0 | 20.0 | 1.0 | 20.0 | 0.4 | 60.0 | 3.6 | No data | No data |
| 9 | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 20.0 | 1.0 | 80.0 | 10.0 | No data | No data |
| 10 | 1 | 0.2 | 0.2 | 40.0 | 1.6 | 60.0 | 5.6 | 60.0 | 8.0 | No data | No data |
| 11 | 4 | 0.0 | 0.0 | 20.0 | 0.6 | 20.0 | 0.4 | 0.0 | 0.0 | No data | No data |
| 12 | 3 | 0.2 | 0.4 | 20.0 | 1.0 | 20.0 | 1.0 | 40.0 | 2.0 | No data | No data |
| 13 | 8 | 0.2 | 0.2 | 60.0 | 3.0 | 0.0 | 0.0 | 40.0 | 3.6 | No data | No data |
| 14 | 6 | 0.2 | 0.2 | 40.0 | 0.4 | 0.0 | 0.0 | 20.0 | 1.6 | No data | No data |
| 15 | 5 | 0.2 | 0.2 | 60.0 | 1.8 | 20.0 | 1.0 | 0.0 | 0.0 | No data | No data |
| 16 | 1 | 0.2 | 0.2 | 60.0 | 3.6 | 0.0 | 0.0 | 100.0 | 9.6 | No data | No data |
| 17 | 7 | 0.2 | 0.4 | 20.0 | 0.4 | 0.0 | 2.0 | 60.0 | 5.0 | No data | No data |
| 18 | 9 | 0.2 | 0.4 | 20.0 | 0.4 | 20.0 | 1.0 | 80.0 | 8.0 | No data | No data |
| 19 | 2 | 0.2 | 0.2 | 20.0 | 0.4 | 20.0 | 0.6 | 0.0 | 0.0 | No data | No data |
| 20 | 10 | 0.0 | 0.0 | 0.0 | 0.0 | 20.0 | 1.0 | 40.0 | 3.0 | No data | No data |
| 21 | 3 | 0.0 | 0.0 | 60.0 | 1.4 | 0.0 | 0.0 | 80.0 | 5.0 | No data | No data |
| 22 | 4 | 0.4 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | No data | No data |
| 23 | 2 | 0.0 | 0.0 | 20.0 | 0.6 | 0.0 | 0.0 | 40.0 | 0.8 | No data | No data |
| 24 | 8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 60.0 | 3.0 | No data | No data |
| 25 | 10 | 0.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 60.0 | 3.0 | No data | No data |
| 26 | 5 | 0.2 | 0.4 | 20.0 | 0.2 | 0.0 | 0.0 | 20.0 | 1.6 | No data | No data |
| 27 | 6 | 0.2 | 0.4 | 20.0 | 0.2 | 0.0 | 0.0 | 20.0 | 0.4 | No data | No data |
| 28 | 7 | 0.4 | 0.4 | 20.0 | 0.2 | 20.0 | 1.0 | 60.0 | 6.6 | No data | No data |
| 29 | 1 | 0.2 | 0.2 | 0.0 | 0.0 | 40.0 | 2.2 | 40.0 | 4.0 | No data | No data |
| 30 | 9 | 0.0 | 0.0 | 0.0 | 0.0 | 40.0 | 4.0 | 40.0 | 3.0 | No data | No data |
| 31 | 2 | 0.0 | 0.0 | 40.0 | 1.0 | 20.0 | 1.0 | 20.0 | 0.4 | No data | No data |
| 32 | 1 | 0.2 | 0.2 | 80.0 | 4.2 | 40.0 | 3.2 | 60.0 | 7.0 | No data | No data |
| 33 | 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | No data | No data |
| 34 | 10 | 0.2 | 0.2 | 20.0 | 0.4 | 0.0 | 0.0 | 20.0 | 1.0 | No data | No data |
| 35 | 9 | 0.0 | 0.0 | 40.0 | 1.6 | 40.0 | 1.6 | 0.0 | 0.0 | No data | No data |
| 36 | 3 | 0.4 | 0.6 | 20.0 | 1.0 | 0.0 | 0.0 | 40.0 | 3.0 | No data | No data |
| 37 | 7 | 0.4 | 0.4 | 40.0 | 1.4 | 40.0 | 2.0 | 20.0 | 1.0 | No data | No data |
| 38 | 6 | 0.0 | 0.0 | 40.0 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | No data | No data |
| 39 | 4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | No data | No data |
| 40 | 8 | 0.2 | 0.2 | 20.0 | 0.4 | 20.0 | 0.4 | 0.0 | 0.0 | No data | No data |

| | | Smoulder | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 14.02.19 | | 28.02.19 | | 20.03.19 | | 03.04.19 | | 16.04.19 | |
| Plot | treatment | Incidence | severity | Incidence | severity | Incidence | severity | Incidence | severity | Incidence | severity |
| 1 | 9 | 0.4 | 0.1 | 100.0 | 6.6 | 60.0 | 6.0 | 100.0 | 14.0 | 100.0 | 24.0 |
| 2 | 5 | 0.4 | 0.8 | 80.0 | 8.6 | 80.0 | 11.0 | 40.0 | 5.0 | 100.0 | 12.0 |
| 3 | 6 | 0.4 | 1.2 | 60.0 | 2.8 | 60.0 | 6.2 | 40.0 | 2.6 | 60.0 | 3.6 |
| 4 | 10 | 0.8 | 0.9 | 100.0 | 9.2 | 80.0 | 5.0 | 60.0 | 2.2 | 80.0 | 7.0 |
| 5 | 7 | 0.8 | 0.9 | 100.0 | 9.2 | 60.0 | 4.2 | 60.0 | 6.0 | 100.0 | 18.6 |
| 6 | 4 | 0.6 | 0.8 | 80.0 | 4.6 | 60.0 | 2.6 | 40.0 | 2.2 | 60.0 | 4.6 |
| 7 | 8 | 0.8 | 1.1 | 80.0 | 5.6 | 100.0 | 11.2 | 100.0 | 15.0 | 100.0 | 8.8 |
| 8 | 2 | 0.8 | 1.8 | 80.0 | 3.8 | 60.0 | 3.8 | 40.0 | 3.0 | 60.0 | 4.6 |
| 9 | 3 | 0.8 | 2.4 | 80.0 | 5.2 | 60.0 | 3.0 | 80.0 | 13.0 | 100.0 | 18.4 |
| 10 | 1 | 0.2 | 0.4 | 80.0 | 7.0 | 100.0 | 25.0 | 100.0 | 37.0 | 100.0 | 27.6 |
| 11 | 4 | 0.6 | 0.8 | 100.0 | 4.4 | 40.0 | 2.6 | 40.0 | 2.0 | 60.0 | 4.2 |
| 12 | 3 | 0.6 | 1.2 | 80.0 | 3.2 | 60.0 | 2.2 | 100.0 | 12.0 | 100.0 | 10.0 |
| 13 | 8 | 0.8 | 1.4 | 100.0 | 7.6 | 80.0 | 5.2 | 60.0 | 5.0 | 40.0 | 2.0 |
| 14 | 6 | 0.6 | 2.2 | 60.0 | 2.2 | 60.0 | 4.6 | 80.0 | 10.0 | 80.0 | 6.2 |
| 15 | 5 | 0.4 | 0.6 | 80.0 | 5.0 | 80.0 | 7.0 | 100.0 | 8.0 | 20.0 | 1.6 |
| 16 | 1 | 0.6 | 1.6 | 100.0 | 6.6 | 100.0 | 14.6 | 100.0 | 17.6 | 100.0 | 28.6 |
| 17 | 7 | 0.6 | 0.8 | 60.0 | 3.2 | 80.0 | 11.6 | 100.0 | 11.6 | 100.0 | 20.6 |
| 18 | 9 | 0.8 | 2.2 | 80.0 | 4.0 | 100.0 | 9.4 | 100.0 | 20.0 | 100.0 | 14.0 |
| 19 | 2 | 0.4 | 0.4 | 60.0 | 3.6 | 40.0 | 3.2 | 60.0 | 4.6 | 40.0 | 2.6 |
| 20 | 10 | 0.8 | 1.8 | 80.0 | 3.0 | 100.0 | 8.4 | 100.0 | 14.0 | 100.0 | 16.6 |
| 21 | 3 | 0.6 | 1.0 | 20.0 | 1.2 | 60.0 | 4.6 | 60.0 | 7.0 | 100.0 | 13.6 |
| 22 | 4 | 0.4 | 0.6 | 60.0 | 3.0 | 40.0 | 1.8 | 20.0 | 1.6 | 40.0 | 3.0 |
| 23 | 2 | 0.2 | 0.2 | 60.0 | 2.2 | 60.0 | 2.8 | 20.0 | 1.0 | 80.0 | 4.4 |
| 24 | 8 | 0.6 | 2.2 | 40.0 | 2.6 | 60.0 | 5.6 | 40.0 | 3.6 | 60.0 | 5.0 |
| 25 | 10 | 0.6 | 1.0 | 60.0 | 3.2 | 40.0 | 2.0 | 60.0 | 5.0 | 20.0 | 1.0 |
| 26 | 5 | 0.0 | 0.0 | 60.0 | 2.4 | 40.0 | 2.6 | 20.0 | 1.0 | 40.0 | 3.2 |
| 27 | 6 | 0.4 | 0.6 | 60.0 | 3.2 | 60.0 | 2.8 | 60.0 | 4.6 | 80.0 | 6.6 |
| 28 | 7 | 0.2 | 0.2 | 40.0 | 1.6 | 60.0 | 7.0 | 100.0 | 11.0 | 80.0 | 11.8 |
| 29 | 1 | 0.8 | 1.2 | 100.0 | 6.8 | 100.0 | 17.2 | 100.0 | 28.0 | 100.0 | 26.6 |
| 30 | 9 | 0.2 | 0.2 | 40.0 | 1.0 | 100.0 | 25.0 | 100.0 | 20.0 | 100.0 | 18.6 |
| 31 | 2 | 0.4 | 0.3 | 40.0 | 2.0 | 20.0 | 1.0 | 60.0 | 2.6 | 60.0 | 5.4 |
| 32 | 1 | 0.4 | 0.9 | 100.0 | 7.4 | 100.0 | 16.4 | 100.0 | 14.6 | 100.0 | 25.6 |
| 33 | 5 | 0.2 | 0.4 | 60.0 | 1.8 | 60.0 | 2.6 | 40.0 | 3.0 | 60.0 | 9.0 |
| 34 | 10 | 0.2 | 0.4 | 80.0 | 2.6 | 40.0 | 2.2 | 40.0 | 3.0 | 80.0 | 6.8 |
| 35 | 9 | 0.4 | 0.3 | 60.0 | 4.6 | 80.0 | 7.6 | 100.0 | 25.6 | 100.0 | 11.0 |
| 36 | 3 | 0.4 | 0.8 | 40.0 | 2.6 | 60.0 | 4.4 | 100.0 | 12.6 | 100.0 | 12.0 |
| 37 | 7 | 0.4 | 0.4 | 80.0 | 4.2 | 60.0 | 7.0 | 100.0 | 11.0 | 100.0 | 15.6 |
| 38 | 6 | 0.4 | 0.4 | 40.0 | 1.4 | 20.0 | 1.0 | 20.0 | 1.0 | 80.0 | 13.0 |
| 39 | 4 | 0.4 | 0.4 | 80.0 | 1.8 | 20.0 | 0.6 | 20.0 | 0.8 | 60.0 | 3.0 |
| 40 | 8 | 0.2 | 0.6 | 40.0 | 2.0 | 60.0 | 3.0 | 80.0 | 7.6 | 80.0 | 10.0 |

f. Trial design

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tracker | Control | AHDB9913 | AHDB9862 | AHDB9871 | AHDB9873 | AHDB9927 | AHDB9926 | AHDB9914 | AHDB9863 | Block 4 |
| Plot | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | |
| | | | | | | | | | | | |
| | AHDB9873 | AHDB9914 | Tracker | AHDB9863 | AHDB9862 | AHDB9913 | AHDB9926 | AHDB9927 | Control | AHDB9871 | Block 3 |
| Plot | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | |
| | | | | | | | | | | | |
| | AHDB9914 | AHDB9873 | AHDB9863 | AHDB9926 | AHDB9913 | Control | AHDB9927 | AHDB9871 | Tracker | AHDB9862 | Block 2 |
| Plot | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | |
| | | | | | | | | | | | |
| | AHDB9871 | AHDB9913 | AHDB9926 | AHDB9862 | AHDB9927 | AHDB9914 | AHDB9863 | Tracker | AHDB9873 | Control | Block 1 |
| Plot | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |

**g. ORETO certification.**

# Certificate of

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**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