SCEPTREPLUS

Final Trial Report

Trial code:	SP 42a
Title:	Control of White Mould and Smoulder in Narcissus Year 2
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 2020 – July 2020
Report date:	31st July 2020
Report author:	Dave Kaye
Report authorised by:	Barry Mulholland
ORETO Number:	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: 24th July 2020 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%.

In 2019, a field-based trial in Cornwall identified eight conventional products and one biological which provided good control of white mould and smoulder when applied four times at roughly 14-day intervals. In 2020, seven of these products were tested in programmes to establish the most effective combinations to manage these diseases.

Methods

The location selected for this work was a grower holding field in Hayle, Cornwall, a region prone to high levels of white mould and smoulder diseases. A product efficacy trial consisting of a four block, randomised design was established in a third-year-down narcissus crop of the susceptible variety 'St. Patrick's Day'. Infection was reliant on natural sources 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.

Each fungicide treatment programme comprised four application timings (A-D). The seven products selected from 2019 for further study, AHDB9914, AHDB9913, AHDB9926, AHDB9873, AHDB9927, AHDB9862 and AHDB9871, and the current industry standard, Tracker, were applied on two dates (Timing B and D, Table 2). The remaining product choices for each fungicide programme were selected based on those currently used by Narcissus growers and Fungicide Resistance Action Committee (FRAC) guidance and included Switch (timing A) and Amistar and Pencozeb (Timing C). The biological product (AHDB9871) was tested at two different times (timings B and D, and timings B and C), in separate programmes, to establish optimal application timing.

Plots were treated using a knapsack sprayer. The first application (Timing A) occurred shortly after emergence (29-Jan). The remaining three applications took place after the surrounding commercial crop was harvested at 14-day intervals, 06-Mar (Timing B), 27-Mar (Timing C) and 09-Apr (Timing D) (Table 1).

Plants were assessed for white mould and smoulder disease incidence (% plants affected) and severity (% plant area affected – across all plants) on the foliage at each treatment date and 14 days following the final treatment application. Crop safety was also assessed (0-10 scale, where 0 = dead, 10 = no damage) at each assessment. The plants in five random 1 m lengths along the central three rows in each plot were evaluated.

Table 2. Fungicide programmes evaluated in this project.

Programme number	Timing A (29-Jan)	Timing B (06-Mar)	Timing C (27-Mar)	Timing D (09-Apr)
1 (control)	Water	Water	Water	Water
2	Switch	Tracker	Amistar & Penncozeb	Tracker
3	Switch	AHDB9914	Prosaro & Penncozeb	AHDB9914
4	Switch	AHDB9913 & Prosaro	Amistar & Penncozeb	AHDB9913 & Prosaro
5	Switch	AHDB9926 & Prosaro	Amistar & Penncozeb	AHDB9926 & Prosaro
6	Switch	AHDB9873	Amistar & Penncozeb	AHDB9873
7	Switch	AHDB9927	Amistar & Penncozeb	AHDB9927
8	Switch	AHDB9862	Amistar & Penncozeb	AHDB9862
9	Switch	AHDB9871	Amistar & Penncozeb	AHDB9871
10	Switch	AHDB9871	AHDB9871	Amistar & Penncozeb

Fungicide programmes were designed according to those currently used in narcissus and FRAC guidelines. Prosaro was added to the programmes 4 and 5 as two solo SHDI fungicide applications to a crop receiving four applications in total is not recommended.

Results

White mould – The levels of white mould which established in the trial plots was low and no differences in disease incidence developed between any fungicide programme and the untreated control (Table 3).

Table 3. Effect of fungicide programmes on mean foliar white mould incidence (proportion of 1 m row lengths symptomatic of white mould) for each of five assessment dates.

Treatment	Date				
	29-Jan	06-Mar	27-Mar	09-Apr	24-Apr
Untreated	0.25	5.80	6.13	9.00	5.66
Standard programme	0.00	4.58	3.17	6.30	3.50
AHDB9914 programme	1.00	1.83	2.67	5.80	4.33
AHDB9913 programme	0.25	4.20	6.78	13.30	3.09
AHDB9926 programme	0.33	3.88	2.58	8.00	3.50
AHDB9873 programme	0.20	1.47	2.97	4.70	4.49
AHDB9927 programme	0.17	2.42	2.83	6.20	4.92
AHDB9862 programme	1.96	5.25	1.58	12.10	4.33
AHDB9871 2,4 programme	0.34	4.03	3.53	6.50	6.26
AHDB9871 2,3 programme	0.02	5.58	3.50	9.30	7.17
	Not significantly different from untreated control ($p > 0.05$)				
	Significantly different from untreated control ($p < 0.05$)				

In the untreated plots, white mould severity eventually developed to levels comparable to that seen in the Year 1 work (7.20% plant area affected in 2019 vs. 8.67% in 2020). Despite this, no statistical differences ($p > 0.05$) in white mould severity developed between untreated plots and those which received treatment fungicide programmes (Table 4).

Table 4**.** Effect of fungicide programmes on mean foliar white mould severity (% of symptomatic leaf area) for each of five assessment dates.

Treatment	Date				
	29-Jan	06-Mar	27-Mar	09-Apr	24-Apr
Untreated	0.20	5.63	8.05	12.06	8.67
Standard programme	0.00	7.08	3.58	9.42	8.17
AHDB9914 programme	1.92	1.75	2.58	6.67	5.25
AHDB9913 programme	0.34	2.20	6.20	11.78	4.33
AHDB9926 programme	0.54	4.08	1.83	11.17	4.92
AHDB9873 programme	0.25	1.75	3.55	5.64	7.17
AHDB9927 programme	0.13	2.33	2.58	8.17	8.42
AHDB9862 programme	1.17	7.67	2.00	7.25	7.42
AHDB9871 2,4 programme	0.55	2.95	1.95	11.61	6.50
AHDB9871 2,3 programme	0.04	5.08	2.58	9.92	10.83
	Not significantly different from untreated control ($p > 0.05$)				
	Significantly different from untreated control ($p < 0.05$)				

Smoulder – Disease incidence remained low, with just 10% of untreated plants exhibiting symptoms by the penultimate assessment. No significant ($p < 0.05$) reductions in disease incidence developed between treatment programmes and the untreated control (Table 4).

Table 5. Effect of fungicide programmes on mean smoulder incidence on foliage (proportion of 1 m row lengths affected) for each of five assessment dates.

Treatment	Date

	29-Jan	06-Mar	27-Mar	09-Apr	24-Apr
Untreated	0.21	2.20	9.88	10.12	7.50
Standard programme	0.40	3.50	5.50	11.67	7.25
AHDB9914 programme	0.17	1.83	6.00	11.83	3.25
AHDB9913 programme	0.37	1.88	7.45	13.30	5.50
AHDB9926 programme	0.00	1.67	5.92	10.17	2.50
AHDB9873 programme	0.00	1.20	5.30	11.20	6.67
AHDB9927 programme	0.42	1.17	4.50	9.75	5.50
AHDB9862 programme	0.08	2.67	5.00	7.00	2.33
AHDB9871 2,4 programme	0.46	1.38	4.62	11.05	5.67
AHDB9871 2,3 programme	0.33	0.42	6.25	10.08	5.67
	Not significantly different from untreated control ($p > 0.05$)				
	Significantly different from untreated control ($p < 0.05$)				

As a consequence of low disease pressure in the trial area, smoulder severity was much lower than during Year 1, 6.66% vs. 27.10% respectively at the final assessment. Despite this, significant reductions ($p = 0.045$) in smoulder severity were found at the third assessment (27-Mar, Table 6). At this time, all programmes had received one application of Switch (29-Jan) and one application of the test product (06-Mar, Table 2). All products. apart from the AHDB9913 programme, significantly ($p < 0.05$) reduced smoulder severity compared with untreated plants. No programmes gave significant control at the remaining two assessments.

Table 6. Effect of fungicide programmes on mean smoulder severity score (% of leaf area affected) per treatment for each of five assessment dates.

	Date				
Treatment	**29-Jan**	**06-Mar**	**27-Mar**	**09-Apr**	**24-Apr**
Untreated	0.28	3.86	9.18	9.99	6.66
Standard programme	0.50	2.50	3.25	8.42	8.28
AHDB9914 programme	0.25	2.17	3.92	9.17	1.83
AHDB9913 programme	0.47	1.14	6.24	16.09	9.09
AHDB9926 programme	0.00	3.33	4.25	9.42	2.92
AHDB9873 programme	0.03	1.78	5.09	13.24	10.75
AHDB9927 programme	0.75	1.83	3.92	12.33	8.75
AHDB9862 programme	0.04	4.42	3.58	9.08	2.25
AHDB9871 2,4 programme	0.64	1.97	3.07	12.26	6.34
AHDB9871 2,3 programme	0.17	1.67	3.92	12.33	6.92
	Not significantly different from untreated control ($p > 0.05$)				
	Significantly different from untreated control ($p < 0.05$)				

Phytotoxicity

No symptoms attributable to phytotoxic developed in any of the fungicide programmes trialed.

Conclusions

- Promising products from Year 1 work were brought forward for further assessment in these trials to identify the best fungicide programmes to treat both white mould and smoulder.
- When applied as commercial fungicide programmes, no combination of products significantly reduced the incidence or severity of white mould compared with the untreated controlat this site due to low levels of disease.
- When applied as commercial fungicide programmes, no combination of products significantly reduced the incidence of smoulder compared with the untreated programme.
- When applied in a commercial programme, all product combinations apart from the programme with AHDB9913 significantly reduced smoulder severity at the third assessment (27/03/2020), after one treatment of Switch and one treatment of the product.

- The biological product AHDB9871 reduced the severity of smoulder infection after one application, compared with the untreated control, confirming its value as part of an integrated pest and disease management (IPDM) programme.
- No programme gave control at the remaining two assessments.
- Following on from the success of these products in Year 1 and the poor performance of the programmes in Year 2, a repeat of this work is recommended (under greater disease pressure or artificial inoculation) to establish the best fungicide programmes to treat these diseases.
- No phytotoxic damage developed in any programme.

Take home message:

The most promising products selected from Year 1 were trialed as part of commercial programmes to establish efficacy and crop safety. In the Year 2 work, no fungicide programme gave consistent control of white mould or reduced smoulder incidence. Reductions in smoulder severity compared with the untreated programme were seen at one assessment date for all programmes, except the AHDB9913 programme. No differences were seen at the final two assessments.

Following the highly informative results from this project's first year, it is recommended that this trial be repeated under a greater disease pressure to identify the best fungicide programmes.

Objective

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

To establish the efficacy and identify the optimal application timing of two programmes containing the biological product AHDB9871.

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, Hayle, Cornwall, TR27 0NE Grid reference: SW 61822 36536
Crop	Narcissus (third-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 (2018-2020) 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	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	15149948	233 g L^{-1} 67 g L^{-1}	Suspension concentrate
Approved	Azoxystrobin	Amistar	CHE7E60076	250 g L^{-1}	Suspension concentrate
Approved	Mancozeb	Penncozeb WDG	1902-6927/21	75% w/w	Water dispersible granules
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
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.

Treatment product name	Treatment: product AHDB code	Rate of active substance (mL or g a.s./ha)	Rate of product (L or kg/ha)
Control (water)	Control (water)	-	-
Tracker	Tracker	155.33 & 44.67	1.50
N/D	AHDB9914	312.50 & 312.50	0.80
N/D	AHDB9913	1000.00	0.30
N/D	AHDB9926	36.00	1.00
N/D	AHDB9927	600.00	1.20
N/D	AHDB9873	500.00	0.90
N/D	AHDB9871	13.80	10.00
N/D	AHDB9862	Unknown	1.50

Methods, assessments and records

Fungicides were applied following standard programme timings, with the application of the first "pre-harvest" treatment (Timing A) when the crop's third true leaf was visible (BBCH 13) (29-Jan). While the crop was not harvested in this trial, the Timing B application coincided with the completion of the surrounding commercial crop harvest (13-Mar, 44 days after the first treatment application). The Timing C application was applied 14 days later (27-Mar) and the final application, Timing D, applied after a further 13 days (09-Apr).

Five assessments were carried out over the duration of this trial, timed to coincide with treatment applications. The first full assessment was carried out on the same date as Timing A, and both white mould and smoulder were present in the trial area at this time. Subsequent assessments were carried out at the Timing B, C, and D applications, and the final assessment two weeks after the final treatment application.

Application schedule

Programme number	Timing A (29-Jan)	Timing B (13-Mar)	Timing C (27-Mar)	Timing D (09-Apr)
1	Water	Water	Water	Water
2	Switch	Tracker	Amistar & Penncozeb	Tracker

3	Switch	AHDB9914	Prosaro & Penncozeb	AHDB9914
4	Switch	AHDB9913 & Prosaro	Amistar & Penncozeb	AHDB9913 & Prosaro
5	Switch	AHDB9926 & Prosaro	Amistar & Penncozeb	AHDB9926 & Prosaro
6	Switch	AHDB9873	Amistar & Penncozeb	AHDB9873
7	Switch	AHDB9927	Amistar & Penncozeb	AHDB9927
8	Switch	AHDB9927	Amistar & Penncozeb	AHDB9927
9	Switch	AHDB9927	Amistar & Penncozeb	AHDB9927
10	Switch	AHDB9927	AHDB9927	Amistar & Penncozeb

Fungicide programmes were designed according to FRAC guidelines.

Application details

	Timing A	Timing B	Timing C	Timing D
Application date	29/01/2020	13/03/2020	27/03/2020	09/04/2020
Time of day	11:20 – 11:35	08:15 – 08:48	12:25 – 12:48	11:00 – 11:35
Crop growth stage (Max, min average BBCH)	103	605	705	708
Crop height (cm)	10 - 25	65 - 80	100	100
Crop coverage (%)	50	85	85	85
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	2.4	2.4	2.4	2.4
Nozzle type	02F110	02F110	02F110	02F110
Nozzle size	Flat fan	Flat fan	Flat fan	Flat fan
Application water volume/ha	300	300	300	300
Temperature of air - shade (°C)	11.2 – 11.4	8.6 - 9.2	10.1 – 12.7	19.8 – 20.2
Relative humidity (%)	75.3 – 75.8	75.1 – 82.3	47.2 – 53.5	78.0 – 82.0
Wind speed range (m/s)	3.2 – 3.4	0.1 – 0.5	5.0 – 8.0	58. – 7.2
Dew presence (Y/N)	N	N	N	N
Temperature of soil - 2-5 cm (°C)	5.5	9.4	10.1	9.8
Wetness of soil - 2-5 cm	Not recorded	Not recorded	Not recorded	Not recorded
Cloud cover (%)	35	70	10	30

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	• 0.25% incidence • 0.20% severity	• 0.25% incidence • 0.20% severity	• 5.66% incidence • 8.67% severity

Smoulder	*Botryotinia narcissicola*	SCLENA	• 0.21% incidence • 0.28% severity	• 0.21% Incidence • 0.28% severity	• 7.50% incidence • 6.66% severity

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

Disease assessment details

The narcissus crop had emerged shortly before trial set-up, with early disease symptoms of white mould and smoulder already present (29/01/20). A preliminary full disease assessment was performed at this time, immediately before the first treatment application was applied. The remaining disease assessments were carried out immediately before the remaining three treatment applications and 14 days after the final treatment application.

At each assessment, plots were assessed for white mould and smoulder incidence and severity. Assessments were carried out at five random points in each plot, in 1 m sections of the central three rows of crop. Severity was recorded as % plant area symptomatic of each disease, while incidence was recorded as the proportion of plants along these lengths with symptoms (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 7. Scale used for the assessment of the extent of phytotoxic damage in treated plots.

Crop tolerance score	Equivalent to crop damage (% phytotoxicity)
0	100%, complete crop kill
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 8. White mould, smoulder and crop safety assessment schedule

Evaluation date	Evaluation Timing (DA)*	Crop Growth Stage (BBCH)	Evaluation type (efficacy, phytotoxicity)	Assessment
29/01/2020	0	103	Preliminary	• Smoulder and White Mould incidence and severity
13/03/2020	44	605	Efficacy Phytotoxicity	• Smoulder and White Mould incidence and severity • Crop safety

Evaluation date	Evaluation Timing (DA)*	Crop Growth Stage (BBCH)	Evaluation type (efficacy, phytotoxicity)	Assessment
27/03/2020	58	705	Efficacy Phytotoxicity	• Smoulder and White Mould incidence and severity • Crop safety
09/04/2020	71	708	Efficacy Phytotoxicity	• Smoulder and White Mould incidence and severity • Crop safety
24/04/2020	86	709	Efficacy Phytotoxicity	• Smoulder and White Mould incidence and severity • 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.

Disease incidence/severity was generally greater in the five plots at the end of each block. The data was analysed with a trend covariate to compensate for this variability.

Results

Phytotoxicity

No product trialed in this work led to the development of any symptoms attributable to phytoxicity at any time.

Efficacy

White mould

Incidence: The levels of white mould which established in the trial plots was low and no differences in disease incidence developed between treatment programmes and the untreated programme (Table 9).

Table 9. Effect of fungicide programmes on mean foliar white mould incidence (proportion of 1 m row lengths affected) for each of five assessment dates.

	Date				
Treatment	**29-Jan**	**06-Mar**	**27-Mar**	**09-Apr**	**24-Apr**
Untreated	0.25	5.80	6.13	9.00	5.66
Standard programme	0.00	4.58	3.17	6.30	3.50
AHDB9914 programme	1.00	1.83	2.67	5.80	4.33
AHDB9913 programme	0.25	4.20	6.78	13.30	3.09
AHDB9926 programme	0.33	3.88	2.58	8.00	3.50
AHDB9873 programme	0.20	1.47	2.97	4.70	4.49

AHDB9927 programme	0.17	2.42	2.83	6.20	4.92
AHDB9862 programme	1.96	5.25	1.58	12.10	4.33
AHDB9871 2,4 programme	0.34	4.03	3.53	6.50	6.26
AHDB9871 2,3 programme	0.02	5.58	3.50	9.30	7.17
p-value	0.535	0.668	0.406	0.840	0.820
d.f.	26	26	26	26	26
SED	0.894	2.537	2.215	5.48	2.300
LSD	1.837	5.215	4.552	11.27	4.727
	Not significantly different from untreated control (p > 0.05)				
	Significantly different from untreated control (p < 0.05)				

Severity: In the untreated plots, white mould severity levels eventually developed to levels comparable to that seen in Year 1 (8.7% in 2020 vs. 7.2% in 2019). Despite this, no statistical differences (p > 0.05) in white mould severity were found between untreated plots and those which received treatment programmes (Table 10).

Table 10. Effect of fungicide programmes on mean foliar white mould severity (% of leaf area affected) for each of five assessment dates.

	Date				
Treatment	**29-Jan**	**06-Mar**	**27-Mar**	**09-Apr**	**24-Apr**
Untreated	0.20	5.63	8.05	12.06	8.67
Standard programme	0.00	7.08	3.58	9.42	8.17
AHDB9914 programme	1.92	1.75	2.58	6.67	5.25
AHDB9913 programme	0.34	2.20	6.20	11.78	4.33
AHDB9926 programme	0.54	4.08	1.83	11.17	4.92
AHDB9873 programme	0.25	1.75	3.55	5.64	7.17
AHDB9927 programme	0.13	2.33	2.58	8.17	8.42
AHDB9862 programme	1.17	7.67	2.00	7.25	7.42
AHDB9871 2,4 programme	0.55	2.95	1.95	11.61	6.50
AHDB9871 2,3 programme	0.04	5.08	2.58	9.92	10.83
p-value	0.390	0.354	0.161	0.641	0.642
d.f.	26	26	26	26	26
SED	0.809	2.904	2.285	3.730	3.087
LSD	1.662	5.970	4.696	7.668	6.551
	Not significantly different from untreated control (p > 0.05)				
	Significantly different from untreated control (p < 0.05)				

Smoulder

Incidence: Disease incidence remained low, with 10% of untreated plants exhibiting symptoms by the penultimate assessment. No significant reductions (p < 0.05) in disease incidence developed between treatment programmes and the untreated control (Table 11).

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

	Date				
Treatment	**29-Jan**	**06-Mar**	**27-Mar**	**09-Apr**	**24-Apr**
Untreated	0.21	2.20	9.88	10.12	7.50
Standard programme	0.40	3.50	5.50	11.67	7.25
AHDB9914 programme	0.17	1.83	6.00	11.83	3.25
AHDB9913 programme	0.37	1.88	7.45	13.30	5.50
AHDB9926 programme	0.00	1.67	5.92	10.17	2.50
AHDB9873 programme	0.00	1.20	5.30	11.20	6.67
AHDB9927 programme	0.42	1.17	4.50	9.75	5.50
AHDB9862 programme	0.08	2.67	5.00	7.00	2.33
AHDB9871 2,4 programme	0.46	1.38	4.62	11.05	5.67

AHDB9871 2,3 programme	0.33	0.42	6.25	10.08	5.67
p-value	0.624	0.877	0.516	0.924	0.541
d.f.	26	26	26	26	26
SED	0.0274	1.776	2.353	3.727	2.963
LSD	0.564	3.650	4.837	7.661	6.090
	Not significantly different from untreated control (p > 0.05)				
	Significantly different from untreated control (p < 0.05)				

Severity: As a consequence of low disease pressure in the trial area, smoulder severity was much lower than during Year 1, 6.66% vs. 27.10% respectively at the final assessment. Despite this, significant reductions (p = 0.045) in smoulder severity were found at the third assessment (27-Mar, Table 12). At this time, all programmes had received one application of Switch (29-Jan) and one application of the test product (06-Mar). All products, apart from the AHDB9913 programme, reduced smoulder severity compared with untreated plants. No programmes resulted in significant control at the remaining two assessments.

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

	Date				
Treatment	**29-Jan**	**06-Mar**	**27-Mar**	**09-Apr**	**24-Apr**
Untreated	0.28	3.86	9.18	9.99	6.66
Standard programme	0.50	2.50	3.25	8.42	8.28
AHDB9914 programme	0.25	2.17	3.92	9.17	1.83
AHDB9913 programme	0.47	1.14	6.24	16.09	9.09
AHDB9926 programme	0.00	3.33	4.25	9.42	2.92
AHDB9873 programme	0.03	1.78	5.09	13.24	10.75
AHDB9927 programme	0.75	1.83	3.92	12.33	8.75
AHDB9862 programme	0.04	4.42	3.58	9.08	2.25
AHDB9871 2,4 programme	0.64	1.97	3.07	12.26	6.34
AHDB9871 2,3 programme	0.17	1.67	3.92	12.33	6.92
p-value	0.485	0.961	0.045	0.467	0.104
d.f.	26	26	26	26	26
SED	0.379	2.650	1.705	3.432	3.214
LSD	0.779	5.446	3.505	7.055	6.606
	Not significantly different from untreated control (p > 0.05)				
	Significantly different from untreated control (p < 0.05)				

Discussion

Following the promising outcomes from the Year 1 work, the results for Year 2 were not conclusive due to low disease levels. The trial was placed adjacent to the commercial area used in Year 1 (2019), where high levels of white mould and smoulder had established, but this did not occur in this trial in 2020. This was most likely due to environmental conditions being less favourable for disease development.

White mould overwinters as microsclerotia on leaf debris, and smoulder as sclerotia on bulbs/fungal mycelium on bulb necks. The continued presence of these two pathogens in the field enables infection to occur during or shortly after stem emergence. Inevitably, given the perennial nature of narcissus crops, inoculum builds up over time and both white mould and smoulder infections are typically more significant in older crops.

Incidence of white mould was very low, although disease severity did increase to levels comparable to 2019. Despite this, no fungicide programme (including the industry standard programme) resulted in any control at any date. This may have been related to the much lower disease incidence and therefore reduced disease pressure.

The reduction in smoulder in 2020 was comparable with the results from 2019. At the final assessment, smoulder severity in the untreated developed to just 6.66%, versus 27.10% in 2019. Despite this, significant differences developed between all treatment programmes and

the untreated plots (apart from the AHDB9913 programme) after the second treatment application. At this time, these programmes had received one application of Switch and one application of the trial products. These programmes gave comparable control of smoulder compared to the industry standard programme. Although reductions in severity were not seen at the remaining two assessments, this supports the individual product efficacy results observed in Year 1. Had the disease pressure been comparable to 2019, it is anticipated that differences in smoulder incidence and severity would have been observed. To confirm this, a repeat of this work under a greater disease pressure is recommended.

As differences between the programmes and untreated plots were seen after one application of the trial products only, it was not possible to distinguish which biological programme gave the best control. However, as significant differences in smoulder severity were seen in plots treated with AHDB9871, this further highlights the value of including biological products into fungicide treatment programmes.

Conclusions

- Promising products from Year 1 work were brought forward for further assessment in these trials to identify the best fungicide programmes to treat both white mould and smoulder.
- When applied as commercial fungicide programmes, no combination of products significantly reduced the incidence or severity of white mould compared with the untreated controlat this site due to low levels of disease.
- When applied as commercial fungicide programmes, no combination of products significantly reduced the incidence of smoulder compared with the untreated programme.
- When applied in a commercial programme, all product combinations apart from the programme with AHDB9913 significantly reduced smoulder severity at the third assessment (27/03/2020), after one treatment of Switch and one treatment of the product.
- The biological product AHDB9871 reduced the severity of smoulder infection after one application, compared with the untreated control, confirming its value as part of an integrated pest and disease management (IPDM) programme.
- No programme gave control at the remaining two assessments.
- Following on from the success of these products in Year 1 and the poor performance of the programmes in Year 2, a repeat of this work is recommended (under greater disease pressure or artificial inoculation) to establish the best fungicide programmes to treat these diseases.
- No phytotoxic damage developed in any programme.

Acknowledgements

We would like to thank Andrew Richards and all staff 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 (third-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
29/01/2020	Trial set-up Disease assessment 1 Timing A treatment application
06/03/2020	Crop safety assessment 1 Disease assessment 2 Timing B treatment application
13/03/2020	Crop safety assessment 2 Disease assessment 3 Timing C treatment application
09/04/2020	Crop safety assessment 3 Disease assessment 4 Timing D treatment application
24/04/2020	Crop safety assessment 4 Disease assessment 5
14/05/2019	Senescence monitored Closure of trial site

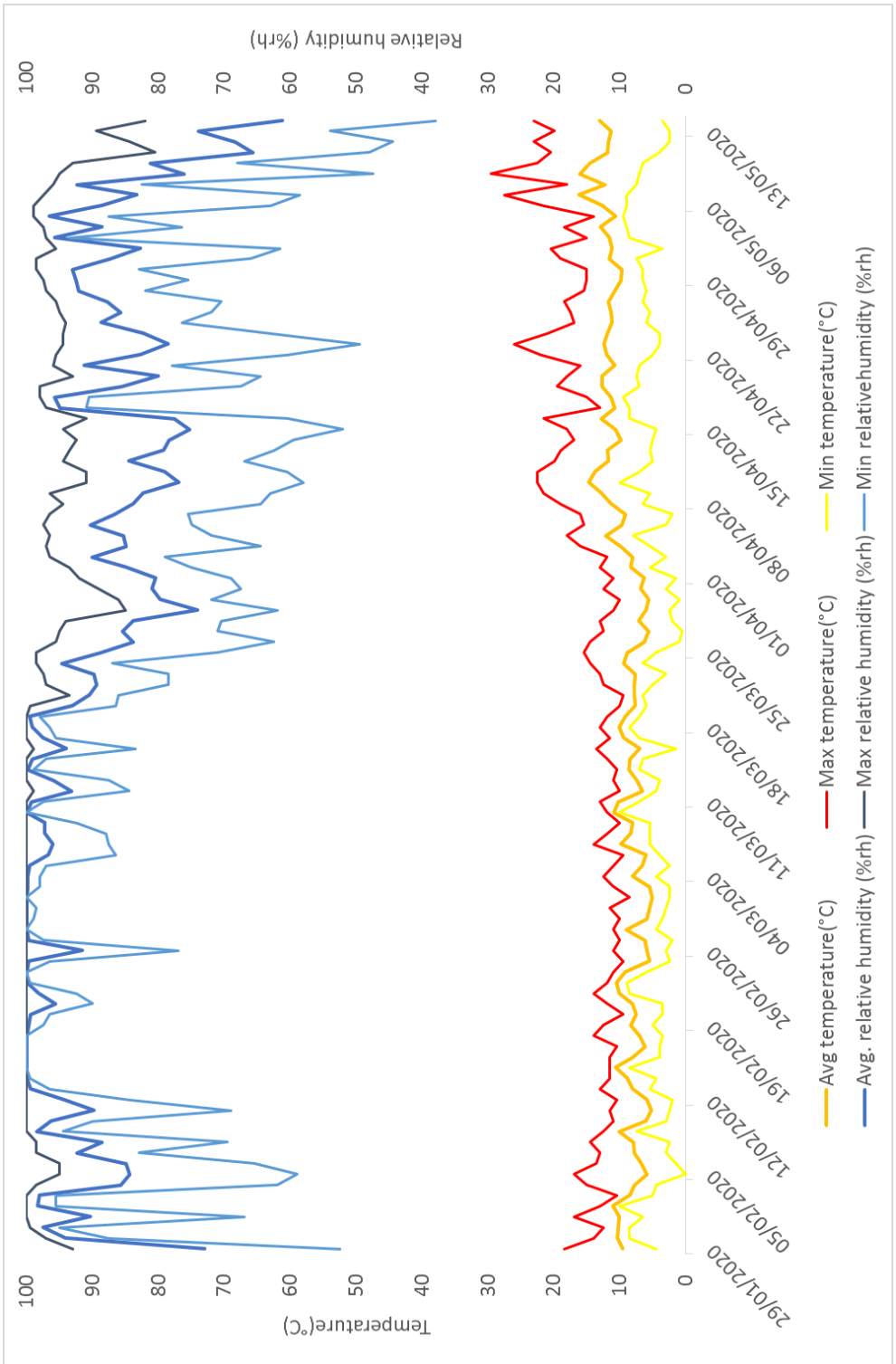
c. Trial images

Trial area at set-up (29-Jan).

Trial area at early-flower (06-Mar).

White mould and smoulder symptoms on an untreated plot (06-Mar).

d. Climatological data during study period (29/01/20 – 13/05/20)

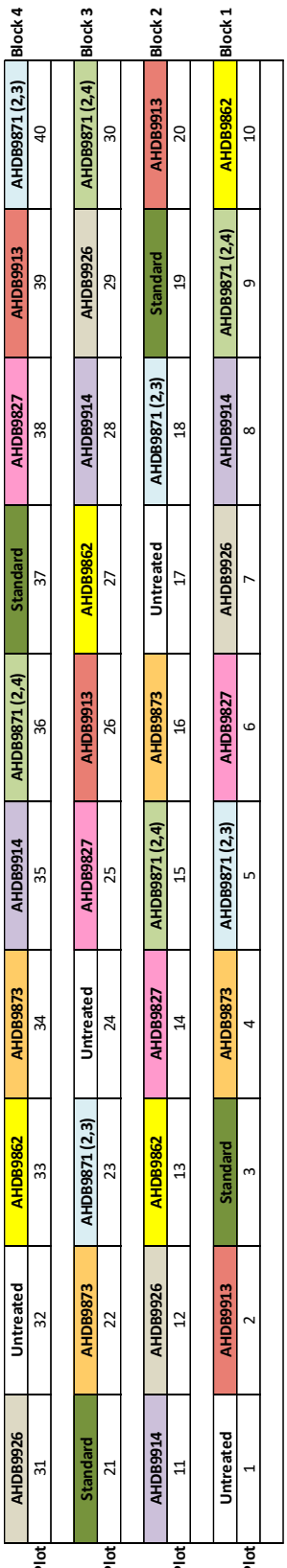


e. Raw data from assessments

		White Mould									
		29/01/2020		06/03/2020		27/03/2020		09/04/2020		24/04/2020	
Plot	Programme	Incidence	Severity	Incidence	Severity	Incidence	Severity	Incidence	Severity	Incidence	Severity
1	1	0.0	0.0	5.0	2.3	9.7	15.7	11.7	18.3	4.7	7.3
2	4	0.2	0.7	4.7	2.3	11.7	6.7	6.7	13.3	0.3	0.3
3	2	0.0	0.0	1.7	3.3	0.7	1.7	2.7	5.0	5.0	8.3
4	6	0.2	0.3	1.7	1.7	2.3	5.3	0.7	1.7	5.0	8.3
5	10	0.1	0.2	3.7	2.3	0.0	0.0	5.3	8.3	7.0	16.7
6	7	0.0	0.0	1.7	1.7	1.7	2.3	9.0	6.0	4.7	8.3
7	5	0.3	0.7	1.7	0.7	2.0	1.0	9.7	17.3	3.0	5.0
8	3	3.0	6.7	5.0	4.0	4.0	2.3	2.7	6.7	4.7	5.3
9	9	1.3	2.3	13.3	3.7	3.0	1.7	20.0	30.0	14.0	6.3
10	8	7.8	4.7	11.7	21.7	2.3	4.3	41.0	17.3	10.0	15.7
11	3	1.0	1.0	0.7	2.3	0.7	0.7	0.0	0.0	3.0	3.7
12	5	0.0	0.0	1.3	5.0	2.7	1.3	4.0	3.3	1.3	3.3
13	8	0.0	0.0	1.7	3.3	1.0	0.7	0.3	1.7	1.3	2.3
14	7	0.0	0.0	1.7	1.7	1.0	0.7	0.7	2.7	3.7	3.7
15	9	0.0	0.0	0.7	1.7	0.3	0.3	1.0	2.3	1.7	4.3
16	6	0.0	0.0	0.0	0.0	3.7	4.0	7.7	10.7	4.0	4.0
17	1	0.3	0.2	10.7	13.3	5.0	6.7	6.7	9.3	4.7	9.7
18	10	0.0	0.0	7.7	3.0	10.7	6.7	7.3	7.7	2.0	4.3
19	2	0.0	0.0	8.3	11.7	5.7	6.7	9.7	8.7	2.3	9.0
20	4	1.0	0.7	13.3	6.7	7.7	7.3	24.0	14.0	11.3	16.7
21	2	0.0	0.0	0.7	3.3	0.3	0.3	2.7	8.3	2.7	5.0
22	6	0.0	0.0	0.0	0.0	0.0	0.0	1.3	1.7	2.7	7.7
23	10	0.0	0.0	5.3	5.0	0.3	0.3	7.7	9.3	4.0	4.0
24	1	0.0	0.0	0.7	0.3	1.7	0.7	5.7	8.7	5.0	8.0
25	7	0.7	0.5	3.7	2.0	0.7	0.7	6.3	7.3	4.0	5.0
26	4	0.0	0.0	0.0	0.0	0.0	0.0	2.7	5.0	2.3	2.3
27	8	0.0	0.0	3.7	1.3	2.7	2.3	5.3	7.7	3.7	4.0
28	3	0.0	0.0	1.7	0.7	3.3	4.0	18.3	15.0	8.0	10.0
29	5	0.7	0.8	11.7	8.3	5.7	5.0	10.7	17.3	8.0	8.3
30	9	0.3	0.2	5.0	8.3	9.3	7.0	9.7	12.7	6.0	10.7
31	5	0.3	0.7	0.8	2.3	0.0	0.0	7.7	6.7	1.7	3.0
32	1	0.0	0.0	3.3	3.0	5.7	6.7	3.7	5.0	5.3	6.0
33	8	0.0	0.0	4.0	4.3	0.3	0.7	1.7	2.3	2.3	7.7
34	6	0.0	0.0	0.7	1.8	3.3	2.3	0.7	1.7	3.3	5.0
35	3	0.0	0.0	0.0	0.0	2.7	3.3	2.3	5.0	1.7	2.0
36	9	0.3	0.3	0.7	1.7	4.0	1.3	3.7	8.3	6.3	8.3
37	2	0.0	0.0	7.7	10.0	6.0	5.7	10.0	15.7	4.0	10.3
38	7	0.0	0.0	2.7	4.0	8.0	6.7	9.0	16.7	7.3	16.7
39	4	0.5	0.7	2.3	3.3	10.3	13.3	28.3	21.7	1.3	1.7
40	10	0.0	0.0	5.7	10.0	3.0	3.3	16.7	14.3	15.7	18.3

		Smoulder									
		29/01/2020		06/03/2020		27/03/2020		09/04/2020		24/04/2020	
Plot	Programme	Incidence	Severity	Incidence	Severity	Incidence	Severity	Incidence	Severity	Incidence	Severity
1	1	0.0	0.0	0.7	1.7	9.3	15.0	8.3	6.7	0.0	0.0
2	4	0.2	0.7	0.0	0.0	10.0	10.0	20.0	21.7	8.3	14.0
3	2	0.0	0.3	6.7	5.0	3.3	1.7	11.7	6.7	0.0	0.0
4	6	0.0	0.0	1.7	0.7	3.0	6.7	13.3	15.0	5.0	6.3
5	10	0.0	0.0	0.0	0.0	4.0	5.0	7.7	16.7	3.3	1.7
6	7	0.8	2.3	0.7	1.7	8.3	8.3	8.3	6.0	5.0	7.3
7	5	0.0	0.0	0.0	0.0	8.0	6.0	16.7	12.7	3.3	2.3
8	3	0.0	0.0	5.0	5.0	15.0	10.0	30.0	16.7	10.7	2.3
9	9	0.5	2.0	3.3	1.7	9.0	6.7	15.7	12.7	11.0	6.7
10	8	0.0	0.0	10.0	16.7	8.3	6.7	17.7	17.7	0.0	0.0
11	3	0.3	0.7	0.0	0.0	1.7	1.3	2.0	3.3	0.0	0.0
12	5	0.0	0.0	0.0	0.0	3.3	4.3	5.0	6.7	1.0	1.7
13	8	0.3	0.2	0.0	0.0	1.3	1.0	2.0	2.0	0.7	0.7
14	7	0.2	0.3	0.7	1.7	1.3	1.7	6.7	16.7	6.3	9.0
15	9	0.7	0.3	0.0	0.0	0.3	0.7	4.0	8.0	2.3	4.3
16	6	0.0	0.0	0.0	0.0	9.3	6.7	9.7	15.7	11.0	17.3
17	1	0.0	0.0	5.0	8.3	9.7	6.7	14.3	13.7	18.3	14.0
18	10	0.3	0.2	0.0	0.0	10.3	6.0	10.7	10.0	10.3	18.3
19	2	0.1	0.3	7.3	5.0	11.0	8.3	17.3	11.7	13.0	15.7
20	4	0.3	0.3	6.7	3.3	15.0	8.3	12.0	18.3	5.3	6.7
21	2	0.0	0.0	0.0	0.0	0.0	0.0	2.0	3.7	3.7	6.7
22	6	0.0	0.0	0.3	1.7	0.7	0.3	5.7	9.3	4.3	10.0
23	10	1.0	0.5	0.0	0.0	3.3	1.7	8.0	6.7	9.0	7.7
24	1	0.3	0.3	0.0	0.0	4.3	4.0	4.3	6.0	5.3	6.0
25	7	0.7	0.3	0.0	0.0	1.7	0.7	5.7	7.3	8.3	15.3
26	4	0.0	0.0	0.0	0.0	4.0	2.7	9.7	16.7	5.0	5.3
27	8	0.0	0.0	0.3	0.3	8.3	4.0	5.3	10.0	5.3	5.0
28	3	0.3	0.3	2.3	3.7	5.7	3.7	13.3	13.3	0.0	0.0
29	5	0.0	0.0	6.7	13.3	11.0	5.7	18.3	16.7	2.7	4.3
30	9	0.7	0.3	2.3	5.0	15.0	7.7	25.0	25.0	5.0	8.3
31	5	0.0	0.0	0.0	0.0	1.3	1.0	0.7	1.7	3.0	3.3
32	1	0.5	0.7	0.7	1.7	10.3	8.3	5.0	8.0	3.0	4.3
33	8	0.0	0.0	0.3	0.7	2.0	2.7	3.0	6.7	3.3	3.3
34	6	0.0	0.0	0.3	1.0	2.3	4.0	7.7	7.3	7.0	7.0
35	3	0.0	0.0	0.0	0.0	1.7	0.7	2.0	3.3	2.3	5.0
36	9	0.0	0.0	2.3	5.0	0.0	0.0	8.0	9.0	7.7	8.3
37	2	1.5	1.3	0.0	0.0	7.7	3.0	15.7	11.7	12.3	10.7
38	7	0.0	0.0	3.3	4.0	6.7	5.0	18.3	19.3	2.3	3.3
39	4	1.0	1.0	3.3	5.0	6.7	6.7	20.0	13.3	6.7	12.7
40	10	0.0	0.0	1.7	6.7	7.3	3.0	14.0	16.0	0.0	0.0

f. Trial design



g. ORETO certification.

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Expiry date: 17 March 2023

Signature Alison Richardson
Authorised signatory

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