

SCEPTREPLUS

Final Trial Report

Trial code:	2019-20. SP18
Title:	AHDB Sceptreplus Narcissus dormant herbicide screen 2019-2020
Crop	Bulbs and outdoor flowers (Narcissus)
Target	General broadleaf weeds and grasses, 3WEEDT PP1/088(3) Weeds in flower bulbs and flower tubers
Lead researcher:	Angela Huckle
Organisation:	RSK ADAS LTD
Period:	1 st March 2019 – 30 th September 2020
Report date:	2 nd December 2020
Report author:	Angela Huckle Guy Johnson
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

2nd December 2020

Date



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Authors signature

Trial Summary

Introduction

The limited range of herbicides available to narcissus growers for safe application during the dormant season leaves gaps in the weed control spectrum. At the time of the trial, only eleven products were approved for autumn pre-emergence use on narcissus, with several offering only limited control. Therefore weeds such as mayweed (*Tripleurospermum inodorum*), willowherb (*Epilobium spp.*), small nettle (*Urtica urens*) and shepherds purse (*Capsella bursa-pastoris*) are becoming challenging to control. While narcissus is a small sector in area, this crop is high value, so the control of weeds—which host pests and disease, interfere with harvest, and reduce yield and quality—is of high importance to the industry.

The search for new actives for weed control in narcissus has been driven most notably by the recent loss of linuron. This active has been a key component of narcissus herbicide programmes, used widely by commercial growers, including in tank mixes to complement the weed control spectrums of other actives. Since linuron's withdrawal in June 2018, finding new actives offering similar efficacy has been a priority for the sector.

The objective of this trial was to identify safe herbicides for weed control in dormant narcissus crops, aiming to expand the options available to growers, and avoiding the risk of resistance to the available actives developing.

Methods

The trial was sited and marked out in a newly planted narcissus crop, var Fortune at a commercial grower holding nr Holbeach Lincolnshire. The trial was laid out as a randomised block design replicated three times. Twenty treatments were applied pre-emergence on 21st November 2019, with a further second application to treatments eight and nine on 20th January 2020. Sprays were applied with an Oxford precision sprayer at 200 L/ha water volume and a two meter boom. At the first application timing glyphosate was also applied before the experimental treatments at 3.75 L/ha as there was 15-18% weed cover already emerged in the plots. This gave the residual herbicides a fairer test, as they would not be able to control weeds which had already emerged. These were assessed five times for weed cover as percentage of the plot covered, weed species present and crop phytotoxicity. Assessments were carried out at two, four, six, ten and sixteen weeks after treatments were applied.

Results

All treatments significantly reduced the percentage total weed cover, and the percentage plot cover of the main weed species for up sixteen weeks after the first treatment application compared with the untreated control. All treatments also had no significant effect on mean leaf height, number of buds per meter, or flower quality and size (**Table 1**). Therefore they are all safe to use at a dormant timing in narcissus. The only significant impact was from the product Hurricane SC where the number of emerged leaves per metre was significantly lower than the untreated control at the assessment on 30th January. Despite this, there was no significant reduction in bud numbers per metre from this treatment. Hurricane SC is known to be persistent and may have delayed leaf emergence at this timing.

Table 1. Mean emerged leaves, mean leaf height, mean buds per metre, mean flower width and quality score at dates as shown. First herbicide application – 21st November 2019; final herbicide application 20th January 2020. Scores: 0 = no or dead flower, 10 = excellent flower quality.

Treat no	Treatment	Mean emerged leaves per m 30/01/20	Mean leaf height (cm) 30/01/20	Flower assessments		
				Mean buds per m 20/02/20	Quality score (0-10) 02/03/20	Diameter (cm) 02/03/20
1 + 2	Untreated control	172.0	14.9	61.2	9.0	7.89
3	Sencorex Flow 0.75 L/ha + Praxim 2.0 L/ha	186.0	16.3	69.3	9.0	7.38
4	Stomp Aqua 2.9 L/ha + Praxim 2.0 L/ha	171.3	14.9	59.0	8.7	7.36
5	Sencorex Flow 0.75 L/ha + Stomp Aqua 2.9 L/ha + Praxim 2.0 L/ha	193.7	15.5	61.7	9.0	7.82
6	Sencorex Flow 0.75 L/ha + Stomp Aqua 2.9 L/ha + Centium 360 CS 0.25 L/ha	177.0	14.5	64.3	9.0	7.89
7	Sencorex Flow 0.75 L/ha + Stomp Aqua 2.9 L/ha + AHDB 9987	170.0	15.7	65.7	9.0	7.82
8	Stomp Aqua 2.9 L/ha + Praxim 2.0 L/ha then Centium 360 CS 0.25 L/ha	169.0	15.1	55.3	9.0	7.63
9	Stomp Aqua 2.9 L/ha + Praxim 2.0 L/ha then AHDB 9987	184.0	14.2	63.3	9.0	7.46
10	Stomp Aqua 2.9 L/ha AHDB 9994	192.3	14.9	64.3	9.0	7.71
11	Sencorex Flow 0.75 L/ha AHDB 9994	190.3	15.6	68.7	9.0	7.40
12	Wing-P 4.0 L/ha	190.7	15.3	73.7	8.7	7.27
13	AHDB 9994	160.0	15.7	60.0	9.0	7.47
14	Wing-P 4.0 L/ha AHDB 9994	162.7	13.9	71.0	8.3	7.34
15	Nirvana 4.5 L/ha	152.3	13.7	60.3	9.3	7.64
16	Hurricane 0.2 L/ha	147.0	15.7	53.3	8.7	7.43
17	AHDB 9917	187.0	15.1	75.0	8.7	7.66
18	AHDB 9900 label rate	190.3	15.3	67.3	9.0	7.73
19	AHDB 9900 label rate lower rate	186.0	14.4	69.7	9.0	7.88
20	AHDB 9982	173.3	15.3	56.7	9.0	7.73
	F pr (p-value)	0.032	0.023 (NS)	0.034 (NS)	0.164 (NS)	0.573 (NS)
	d.f.	39	39	39	39	39
	L.S.D	24.5	1.139	12.385	0.52	0.6531
		not significantly different from the untreated control				
		significantly different from the untreated control				

All treatments significantly reduced the percentage of total weed cover at all assessment dates (**Table 2**). By the final assessment Wing-P 4.0 L/ha + AHDB 9994 and Hurricane 0.2 L/ha had reduced weeds to zero compared to 25.44% in the untreated control. AHDB 9917 while significantly reducing weed cover by 74.19% compared with the untreated control, caused the least reduction in weed cover at the final assessment. This is due to the narrower weed spectrum which this product controls, as its target is mainly grass weeds. The weed spectrum at the site included shepherds purse, nettle and mayweed as well as annual meadow grass, and therefore this product would perform less well on the control of broad-leaved weeds.

Table 2. Mean weed cover at four, six, ten and sixteen weeks after the first application date. First herbicide application – 21st November 2019; final herbicide application 20th January 2020. WAA = weeks after application.

Treat no	Treatment	Mean weed cover (%)			
		19/12/2019 4 WAA	02/01/2020 6 WAA	28/01/2020 10 WAA	02/03/2020 16 WAA
1 + 2	Untreated control	23.09	24.44	25.44	36.42
3	Sencorex Flow 0.75 L/ha + Praxim 2.0 L/ha	2.78	0.30	0.15	0.46
4	Stomp Aqua 2.9 L/ha + Praxim 2.0 L/ha	2.23	0.42	0.94	1.12
5	Sencorex Flow 0.75 L/ha + Stomp Aqua 2.9 L/ha + Praxim 2.0 L/ha	3.26	0.18	0.04	0.04
6	Sencorex Flow 0.75 L/ha + Stomp Aqua 2.9 L/ha + Centium 360 CS 0.25 L/ha	2.06	0.10	0.07	0.07
7	Sencorex Flow 0.75 L/ha + Stomp Aqua 2.9 L/ha + AHDB 9987	1.91	0.03	0.01	0.04
8	Stomp Aqua 2.9 L/ha + Praxim 2.0 L/ha then Centium 360 CS 0.25 L/ha	1.14	0.14	0.10	0.08
9	Stomp Aqua 2.9 L/ha + Praxim 2.0 L/ha then AHDB 9987	2.85	0.28	0.98	0.91
10	Stomp Aqua 2.9 L/ha AHDB 9994	4.21	0.65	0.04	0.03
11	Sencorex Flow 0.75 L/ha AHDB 9994	2.05	0.18	0.07	0.24
12	Wing-P 4.0 L/ha	1.91	0.37	0.23	0.28
13	AHDB 9994	5.32	0.73	0.04	0.04
14	Wing-P 4.0 L/ha AHDB 9994	2.37	0.04	0.00	0.00
15	Nirvana 4.5 L/ha	2.09	0.27	0.18	0.20
16	Hurricane 0.2 L/ha	5.10	1.98	0.00	0.00
17	AHDB 9917	3.81	2.05	6.57	6.44
18	AHDB 9900 label rate	4.91	2.13	2.83	2.90
19	AHDB 9900 label rate lower rate	3.36	0.91	1.40	1.37
20	AHDB 9982	2.65	0.17	0.04	0.02
	F pr (p-value)	<0.001	<0.001	<0.001	<0.001
	d.f.	39	39	39	39
	L.S.D	3.206	3.126	3.395	3.951
		not significantly different from the untreated control			
		significantly different from the untreated control			

All treatments significantly reduced the percentage cover of all the main weed species present in the trial. The weeds present were shepherds purse, small nettle and annual meadow grass. With the exception of AHDB 9917 and AHDB 9900 all of the treatments reduced the weed levels to zero, or very nearly zero for all three species. Although AHDB 9917 and AHDB 9900 significantly reduced the level of small nettle in the trial, these gave the least control of this weed species, and were the only treatments which did not reduce levels below 1%.

Therefore, there are a number of treatments which offer alternative options to use in place of linuron, including metobromuron which is already authorised for used in narcissus, and was safe and effective to use in a number of tank-mix combinations. Coded products AHDB 9987, AHDB 9994, AHDB 9900 and AHDB 9982 are not yet authorised for use on outdoor ornamentals, but they have shown promise to improve weed control in narcissus. These products showed lasting efficacy without any persistent phytotoxic effects and would be a valuable addition to growers weed control options. In addition, AHDB 9982 controls volunteer potatoes.

Conclusions

- All treatments significantly reduced the overall weed cover in every assessment ($p>0.05$); annual meadow grass, shepherds purse and small nettle were significantly reduced ($p>0.05$) on all assessment dates after the final treatment application.
- There was no significant effect on mean leaf height, number of buds per meter, or flower quality and size by any treatment.
 - The only crop effect seen was from Hurricane SC, which significantly reduced the number of emerged leaves per metre at the assessment on 30th January.
- Metobromuron (Praxim) is a useful and safe alternative to linuron when tank-mixed with Sencorex Flow and/or Stomp Aqua.
- Hurricane SC and Wing-P in tank mix with AHDB 9994 provided the best control eliminating weed cover at the final assessment.
- Nirvana was safe in this trial, and could be a useful alternative to include in programmes, but has not yet been tested in tank-mixes.
- AHDB 9987 would fill weed control gaps in shepherds purse, mayweeds and groundsel when authorised.
- AHDB 9994 would be a useful addition for shepherds purse, annual meadow grass and small nettle control.
- AHDB 9900 significantly reduced percentage weed cover and was safer at the dormant timing rather than post-cropping.

Take home message:

Praxim and Nirvana are authorised for use on narcissus and can be used to fill the gap left by the loss of linuron. There were also several other products which it would be worth pursuing for authorisation to improve weed control and the range of actives available and to reduce the risk of resistance development. These are AHDB 9994, AHDB 9987, AHDB 9900 and AHDB 9982.

Objectives

The aim of the trial is to identify safe and effective herbicides for use in narcissus at a dormant timing.

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
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 PP 1/214(3)	Principles of acceptable efficacy	None
EPPO PP 1/224(2)	Principles of efficacy evaluation for minor uses	None
EPPO PP1/135(4)	Phytotoxicity assessment	None

There was one deviation from EPPO guidance:

PP1/99(3) Section 1.4, Design and lay-out of trial:

“Replicates: at least 4”

Study only had 3 replicates – the large number of treatments provides an acceptable number of residual degrees of freedom.

Test site

Item	Details
Location address	Field site: Off Crowdyke Gate, Nr Holbeach O.A. Taylor & Sons Bulbs, Washway House Farm, Washway Road, Holbeach PE12 7PP
Crop	Narcissus
Cultivar	Fortune
Soil or substrate type	Silty/Clay loam
Agronomic practice	See appendix
Prior history of site	Winter wheat 2018/19

Trial design

Item	Details
Trial design:	Complete randomized block
Number of replicates:	3
Row spacing:	Approx 1m
Plot size: (w x l)	3m x 4m
Plot size: (m ²)	12m
Number of plants per plot:	N/K
<i>Leaf Wall Area calculations</i>	

Treatment details

AHDB Code	Active substance	Product name/ manufacturers code	Formulation batch number	Content of active substance in product	Formulation type
Untreated					
N/A	metribuzin	Sencorex Flow	EM4H004177	600g/L	Suspension concentrate
N/A	pendimethalin	Stomp Aqua	ST12610518	455g/L	Capsule suspension
N/A	metobromuron	Praxim	17FB0346	500 g/L	Suspension concentrate
AHDB9987	N/D	N/D	N/D	N/D	N/D
N/A	clomazone	Centium 360 CS	173113	360g/L	Capsule suspension
N/A	dimethenamid -P	Wing-P	N/K	212.5g/L	Emulsifiable concentrate
N/A	imazamox + pendimethalin	Nirvana	N/K	16.7 g/L 250 g/L	Emulsifiable concentrate
AHDB9994	N/D	N/D	N/D	N/D	N/D
N/A	diflufenican	Hurricane SC	586	500 g/L	Suspension concentrate
AHDB9917	N/D	N/D	N/D	N/D	N/D
AHDB9900	N/D	N/D	N/D	N/D	N/D
AHDB9982	N/D	N/D	N/D	N/D	N/D
N/A	glyphosate	Motif	103910383	360 g/L	Soluble concentrate

Application schedule

Glyphosate was applied just before application of all the treatments at timing A at 3.75 L/ha

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+2	Untreated			
3	Sencorex Flow Praxim	450 1000	0.75 L/ha 2.0 L/ha	A
4	Stomp Aqua Praxim	1319.5 1000	2.9 L/ha 2.0 L/ha	A
5	Sencorex Flow Stomp Aqua Praxim	450 1319.5 1000	0.75 L/ha 2.9 L/ha 2.0 L/ha	A
6	Sencorex Flow Stomp Aqua Centium 360 CS	450 1319.5 90	0.75 L/ha 2.9 L/ha 0.25 L/ha	A
7	Sencorex Flow Stomp Aqua AHDB 9987	450 1319.5 1200	0.75 L/ha 2.9 L/ha 2.0 L/ha	A
8	Stomp Aqua Praxim	1319.5 1000	2.9 L/ha 2.0 L/ha	A
	Centium 360 CS	90	0.25 L/ha	B
9	Stomp Aqua Praxim	1319.5 1000	2.9 L/ha 2.0 L/ha	A
	AHDB 9987	1200	2.0 L/ha	B
10	Stomp Aqua AHDB 9994	1319.5 1050	2.9 L/ha 1.75 L/ha	A
11	Sencorex Flow AHDB 9994	450 1050	0.75 L/ha 1.75 L/ha	A
12	Wing-P	850	4.0 L/ha	A
13	AHDB 9994	1050	1.75 L/ha	A

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
14	Wing-P AHDB 9994	850 1050	4.0 L/ha 1.75 L/ha	A
15	Nirvana	75.15 + 1125	4.5 L/ha	A
16	Hurricane	100	0.2 L/ha	A
17	AHDB 9917	N/K	0.7 L/ha	A
18	AHDB 9900 label rate	20	0.1 L/ha	A
19	AHDB 9900 label rate lower rate	10	0.05 L/ha	A
20	AHDB 9982	250	0.5 L/ha	A

Application details

	Application A	Application B
Application date	21/11/2019	20/01/2020
Time of day	11:30	10:30
Crop growth stage (Max, min average BBCH)	GS 0 Dormant bulb	GS 09-12
Crop height (cm)	N/A	6.7
Crop coverage (%)	N/A	20%
Application Method	Spray	Spray
Application Placement	Soil	Soil/foliar
Application equipment	Oxford precision sprayer	Oxford precision sprayer
Nozzle pressure	2.0	2.0
Nozzle type	Flat fan	Flat fan
Nozzle size	02F110	02F110
Application water volume/ha	200.00 L/ha	200.00 L/ha
Temperature of air - shade (°C)	7.7	3.6
Relative humidity (%)	78	70.95
Wind speed range (m/s)	5.35	2.4
Dew presence (Y/N)	N	N
Temperature of soil - 2-5 cm (°C)	3.6	1.8
Wetness of soil - 2-5 cm	Damp	Damp
Cloud cover (%)	80%	10%

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
Broad leaved weeds and grasses	N/A	3WEEDT	23.09%	24.43%	36.42%

Assessment details

Evaluation date	Evaluation Timing (DA)*	Crop Growth Stage (BBCH)	Evaluation type (efficacy, phytotox)	Assessment
21/11/2019	N/A	N/A	preliminary	Percentage of weed cover (whole plot score), plant population count.
19/12/2019	29	Dormant 0	efficacy, phyto	Phytotoxicity (scale 0-10; 10 = dead), percentage of weed cover (whole plot score), plant population count.
02/01/2020	50	09	efficacy, phyto	Phytotoxicity (scale 0-10; 10 = dead), percentage of weed cover (whole plot score), plant population count.
15/01/2020	63	09 and 12	phyto	Phytotoxicity (scale 0-10; 10 = dead), Recording crop leaf emergence and leaf height.
28/01/2020	76	12	efficacy	Percentage of weed cover (whole plot score), plant population count
30/01/2020	78	12 with some 52	phyto	Recording crop leaf emergence and leaf height.
07/02/20 and 20/02/20	86 99	53-55	phyto	Bud counts
02/03/20	111	64	efficacy, phyto	Percentage of weed cover (whole plot score), flower quality

* DA – days after application (Timing 1)

Statistical analysis

The trial design was a fully randomised block design, with three replicates of twenty treatments including two untreated controls.

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

All data was analysed by ANOVA using Genstat (18th edition) by Chris Dyer at RSK ADAS UK Ltd.

Results

Phytotoxicity

There was no significant impact on the mean leaf height, buds per metre, flower quality or diameter of the flowers from any treatment when compared with the untreated control (**Table 1**). However, in the plots treated with Hurricane SC there are significantly less emerged leaves per metre at the assessment on 30th January.

Table 1. Mean emerged leaves, mean leaf height, mean buds per metre, mean flower width and quality score at dates as shown. First herbicide application – 21st November 2019; final herbicide application 20th January 2020. Scores: 0 = no or dead flower, 10 = excellent flower quality.

Treat no	Treatment	Mean emerged leaves per m 30/01/20	Mean leaf height (cm) 30/01/20	Flower assessments		
				Mean buds per m 20/02/20	Quality score (0-10) 02/03/20	Diameter (cm) 02/03/20
1 + 2	Untreated control	172.0	14.9	61.2	9.0	7.89
3	Sencorex Flow 0.75 L/ha + Praxim 2.0 L/ha	186.0	16.3	69.3	9.0	7.38
4	Stomp Aqua 2.9 L/ha + Praxim 2.0 L/ha	171.3	14.9	59.0	8.7	7.36
5	Sencorex Flow 0.75 L/ha + Stomp Aqua 2.9 L/ha + Praxim 2.0 L/ha	193.7	15.5	61.7	9.0	7.82
6	Sencorex Flow 0.75 L/ha + Stomp Aqua 2.9 L/ha + Centium 360 CS 0.25 L/ha	177.0	14.5	64.3	9.0	7.89
7	Sencorex Flow 0.75 L/ha + Stomp Aqua 2.9 L/ha + AHDB 9987	170.0	15.7	65.7	9.0	7.82
8	Stomp Aqua 2.9 L/ha + Praxim 2.0 L/ha then Centium 360 CS 0.25 L/ha	169.0	15.1	55.3	9.0	7.63
9	Stomp Aqua 2.9 L/ha + Praxim 2.0 L/ha then AHDB 9987	184.0	14.2	63.3	9.0	7.46
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11	Sencorex Flow 0.75 L/ha AHDB 9994	190.3	15.6	68.7	9.0	7.40
12	Wing-P 4.0 L/ha	190.7	15.3	73.7	8.7	7.27
13	AHDB 9994	160.0	15.7	60.0	9.0	7.47
14	Wing-P 4.0 L/ha AHDB 9994	162.7	13.9	71.0	8.3	7.34
15	Nirvana 4.5 L/ha	152.3	13.7	60.3	9.3	7.64
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19	AHDB 9900 label rate lower rate	186.0	14.4	69.7	9.0	7.88
20	AHDB 9982	173.3	15.3	56.7	9.0	7.73
	F pr (p-value)	0.032	0.023 (NS)	0.034 (NS)	0.164 (NS)	0.573 (NS)
	d.f.	39	39	39	39	39
	L.S.D	24.5	1.139	12.385	0.52	0.6531
		not significantly different from the untreated control				
		significantly different from the untreated control				

Efficacy

Total weed cover

The results for the mean percentage of weed cover are presented in **Table 2** and **Figure 1**. The percentage reduction in weed cover compared with the untreated control was calculated from these figures (using Abbotts formula) and results for are listed in **Table 3**.

All treatments significantly reduced the percentage of total weed cover at all assessment dates. By the final assessment Wing-P 4.0 L/ha + AHDB 9994 and Hurricane 0.2 L/ha had reduced weeds to zero compared with 25.44% in the untreated control. AHDB 9917 while significantly reducing weed cover by 74.19% compared with the untreated control, caused the least reduction in weed cover at the final assessment. This is due to the narrower weed spectrum which this product controls, as its target is mainly grass weeds. The weed spectrum at the site included shepherds purse, nettle and mayweed as well as annual meadow grass, and therefore this product would perform less well on the control of broad-leaved weeds.

Table 2. Mean weed cover at four, six, ten and sixteen weeks after the first application date. First herbicide application – 21st November 2019; final herbicide application 20th January 2020. WAA = weeks after application.

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5	Sencorex Flow 0.75 L/ha + Stomp Aqua 2.9 L/ha + Praxim 2.0 L/ha	3.26	0.18	0.04	0.04
6	Sencorex Flow 0.75 L/ha + Stomp Aqua 2.9 L/ha + Centium 360 CS 0.25 L/ha	2.06	0.10	0.07	0.07
7	Sencorex Flow 0.75 L/ha + Stomp Aqua 2.9 L/ha + AHDB 9987	1.91	0.03	0.01	0.04
8	Stomp Aqua 2.9 L/ha + Praxim 2.0 L/ha then Centium 360 CS 0.25 L/ha	1.14	0.14	0.10	0.08
9	Stomp Aqua 2.9 L/ha + Praxim 2.0 L/ha then AHDB 9987	2.85	0.28	0.98	0.91
10	Stomp Aqua 2.9 L/ha AHDB 9994	4.21	0.65	0.04	0.03
11	Sencorex Flow 0.75 L/ha AHDB 9994	2.05	0.18	0.07	0.24
12	Wing-P 4.0 L/ha	1.91	0.37	0.23	0.28
13	AHDB 9994	5.32	0.73	0.04	0.04
14	Wing-P 4.0 L/ha AHDB 9994	2.37	0.04	0.00	0.00
15	Nirvana 4.5 L/ha	2.09	0.27	0.18	0.20
16	Hurricane 0.2 L/ha	5.10	1.98	0.00	0.00
17	AHDB 9917	3.81	2.05	6.57	6.44
18	AHDB 9900 label rate	4.91	2.13	2.83	2.90
19	AHDB 9900 label rate lower rate	3.36	0.91	1.40	1.37
20	AHDB 9982	2.65	0.17	0.04	0.02
	F pr (p-value)	<0.001	<0.001	<0.001	<0.001
	d.f.	39	39	39	39
	L.S.D	3.206	3.126	3.395	3.951
		not significantly different from the untreated control			
		significantly different from the untreated control			

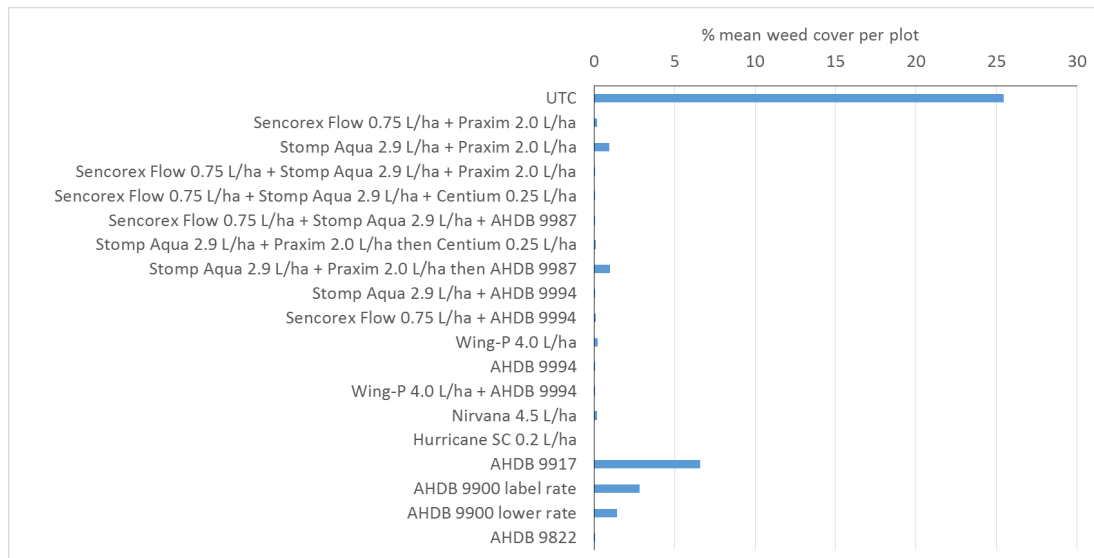


Figure 1. Mean percentage of weed cover values (back transformed means) at ten weeks after the final treatment. F pr. <0.001, L.S.D = 3.395.

Table 3. Percentage of reduction of weed cover compared to untreated control at four, six, ten and sixteen weeks after the first application date (calculated using Abbotts formula). First herbicide application – 21st November 2019; final herbicide application 20th January 2020. WAA = weeks after first application.

Treat no	Treatment	Weed reduction (%) Abbotts formula			
		19/12/2019 4 WAA	02/01/2020 6 WAA	28/01/2020 10 WAA	02/03/2020 16 WAA
3	Sencorex Flow 0.75 L/ha + Praxim 2.0 L/ha	87.95	98.76	99.4	98.73
4	Stomp Aqua 2.9 L/ha + Praxim 2.0 L/ha	90.33	98.28	96.32	96.92
5	Sencorex Flow 0.75 L/ha + Stomp Aqua 2.9 L/ha + Praxim 2.0 L/ha	85.88	99.28	99.83	99.89
6	Sencorex Flow 0.75 L/ha + Stomp Aqua 2.9 L/ha + Centium 360 CS 0.25 L/ha	91.09	99.58	99.72	99.81
7	Sencorex Flow 0.75 L/ha + Stomp Aqua 2.9 L/ha + AHDB 9987	91.73	99.88	99.96	99.88
8	Stomp Aqua 2.9 L/ha + Praxim 2.0 L/ha then Centium 360 CS 0.25 L/ha	95.06	99.44	99.62	99.77
9	Stomp Aqua 2.9 L/ha + Praxim 2.0 L/ha then AHDB 9987	87.67	98.84	96.16	97.49
10	Stomp Aqua 2.9 L/ha AHDB 9994	81.78	97.34	99.85	99.91
11	Sencorex Flow 0.75 L/ha AHDB 9994	91.12	99.26	99.71	99.34
12	Wing-P 4.0 L/ha	91.73	98.5	99.1	99.23
13	AHDB 9994	76.95	97.01	99.85	99.90
14	Wing-P 4.0 L/ha AHDB 9994	89.72	99.85	99.99	100.0
15	Nirvana 4.5 L/ha	90.94	98.9	99.29	99.46
16	Hurricane 0.2 L/ha	77.92	91.9	100	100.0
17	AHDB 9917	83.51	91.62	74.19	82.32
18	AHDB 9900 label rate	78.74	91.27	88.86	92.04
19	AHDB 9900 label rate lower rate	85.45	96.28	94.5	96.25
20	AHDB 9822	88.54	99.3	99.83	99.94

Weed species

The results for the percentage mean cover of shepherd purse, meadow grass and small nettle at the final assessment are presented in **Table 4**.

All treatments significantly reduced the percentage cover of all the main weed species present in the trial. The weeds present were shepherds purse, small nettle and annual meadow grass. With the exception of AHDB 9917 and AHDB 9900 all of the treatments reduced the weed levels to zero, or very nearly zero for all three species. Although AHDB 9917 and AHDB 9900 significantly reduced the level of small nettle in the trial, these gave the least control of this weed species, and were the only treatments which did not reduce levels below 1%.

Table 4. Mean percentage cover of shepherds purse, small nettle and annual meadow grass at the final assessment date on 2nd March 2021 – sixteen weeks after the first application, and six weeks after the final application.

Treat no	Treatment	Mean weed cover (%) at 02/03/2020		
		Shepherds purse	Small nettle	Annual meadow grass
1 + 2	Untreated control	19.83	6.83	7.83
3	Sencorex Flow 0.75 L/ha + Praxim 2.0 L/ha	0.00	0.10	0.33
4	Stomp Aqua 2.9 L/ha + Praxim 2.0 L/ha	0.53	0.57	0.00
5	Sencorex Flow 0.75 L/ha + Stomp Aqua 2.9 L/ha + Praxim 2.0 L/ha	0.00	0.00	0.00
6	Sencorex Flow 0.75 L/ha + Stomp Aqua 2.9 L/ha + Centium 360 CS 0.25 L/ha	0.00	0.00	0.00
7	Sencorex Flow 0.75 L/ha + Stomp Aqua 2.9 L/ha + AHDB 9987	0.03	0.00	0.00
8	Stomp Aqua 2.9 L/ha + Praxim 2.0 L/ha then Centium 360 CS 0.25 L/ha	0.03	0.00	0.00
9	Stomp Aqua 2.9 L/ha + Praxim 2.0 L/ha then AHDB 9987	0.73	0.13	0.00
10	Stomp Aqua 2.9 L/ha AHDB 9994	0.00	0.00	0.00
11	Sencorex Flow 0.75 L/ha AHDB 9994	0.13	0.00	0.07
12	Wing-P 4.0 L/ha	0.07	0.20	0.00
13	AHDB 9994	0.00	0.00	0.00
14	Wing-P 4.0 L/ha AHDB 9994	0.00	0.10	0.00
15	Nirvana 4.5 L/ha	0.03	0.10	0.00
16	Hurricane 0.2 L/ha	0.00	0.00	0.00
17	AHDB 9917	1.4	5.00	0.00
18	AHDB 9900 label rate	0.00	2.90	0.00
19	AHDB 9900 label rate lower rate	0.00	1.37	0.00
20	AHDB 9982	0.00	0.00	0.00
	F pr (p-value)	<0.001	<0.001	<0.001
	d.f.	39	39	39
	L.S.D	2.706	1.462	2.875
		not significantly different from the untreated control		
		significantly different from the untreated control		

Discussion

All treatments significantly reduced the percentage total weed cover (of all weed species), and the percentage plot cover of the main weed species individually for up sixteen weeks after the first treatment application compared with the untreated control. All treatments also had no significant effect on mean leaf height, number of buds per meter, or flower quality and size. Therefore they are all safe to use at a dormant timing in narcissus. The only significant impact was from the product Hurricane SC where the number of emerged leaves per metre was significantly lower than the untreated control at the assessment on 30th January. Despite this, there was no significant reduction in bud numbers per metre from this treatment. Hurricane SC is known to be persistent and may have delayed leaf emergence at this timing.

All treatments significantly reduced the percentage of total weed cover at all assessment dates. By the final assessment Wing-P 4.0 L/ha + AHDB 9994 and Hurricane 0.2 L/ha had reduced weeds to zero compared to 25.44% in the untreated control. AHDB 9917 while significantly reducing weed cover by 74.19% compared with the untreated control, caused the least reduction in weed cover at the final assessment. This is due to the narrower weed spectrum which this product controls, as its target is mainly grass weeds. The weed spectrum at the site included shepherds purse, nettle and mayweed as well as annual meadow grass, and therefore this product would perform less well on the control of broad-leaved weeds.

All treatments significantly reduced the percentage cover of all the main weed species present in the trial. The weeds present were shepherds purse, small nettle and annual meadow grass. With the exception of AHDB 9917 and AHDB 9900 all of the treatments reduced the weed levels to zero, or very nearly zero for all three species. Although AHDB 9917 and AHDB 9900 significantly reduced the level of small nettle in the trial, these gave the least control of this weed species, and were the only treatments which did not reduce levels below 1%.

Therefore, there are a number of treatments which offer alternative options to use in place of linuron, including metobromuron which is already authorised for use in narcissus, and was safe and effective to use in a number of tank-mix combinations. Coded products AHDB 9987, AHDB 9994, AHDB 9900 and AHDB 9982 are not yet authorised for use on outdoor ornamentals, but they have shown promise to improve weed control in narcissus. These products showed lasting efficacy without any persistent phytotoxic effects and would be a valuable addition to growers weed control options. In addition, AHDB 9982 controls volunteer potatoes.

Conclusions

- All treatments significantly reduced the overall weed cover in every assessment ($p > 0.05$); annual meadow grass, shepherds purse and small nettle were significantly reduced ($p > 0.05$) on all assessment dates after the final treatment application.
- All treatments had no significant effect on mean leaf height, number of buds per meter, or flower quality and size.
 - The only crop effect seen was from Hurricane SC, which significantly reduced the number of emerged leaves per metre at the assessment on 30th January.
- Metobromuron is a useful and safe alternative to linuron when tank-mixed with Sencorex Flow and/or Stomp Aqua.
- Hurricane SC and Wing-P in tank mix with AHDB 9994 provided the best control eliminating weed cover at the final assessment.
- Nirvana was safe in this trial, and could be a useful alternative to include in programmes, but has not yet been tested in tank-mixes.
- AHDB 9987 would fill weed control gaps in shepherds purse, mayweeds and groundsel when authorised.
- AHDB 9994 would be a useful addition for shepherds purse, annual meadow grass and small nettle control.
- AHDB 9900 significantly reduced percentage weed cover and was safer at the dormant timing rather than post-cropping.

Acknowledgements

AHDB for funding the work, and also the crop protection companies for their financial contributions as well as providing samples for the trials. Thanks should also be given to O.A. Taylor and sons and Richard Daubney who provided sites and crops for the trials as well as technical input, and Victoria Collins of ADAS for management of the trial applications and assessments.

Appendix

a. Crop diary – events related to growing crop

Crop	Cultivar	Planting date	Row width (m)
Narcissus	Fortune	Autumn 2019	1 m

Previous cropping

Year	Crop
2018/19	Winter wheat
2017	N/K
2016	N/K

Cultivations

Date	Description
	None as the crop is perennial and not cultivated once ridged

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

Date	Product	Rate (kg/ha)
Pre-planting	N:P:K	308 kg N/ha 56 kg P ₂ O ₅ /ha 200 kg K ₂ O/ha

Pesticides applied to trial area

Date	Product	Rate (L/ha)
	None applied through trial	

b. Trial diary

Date	Event
20/11/2019	Trial area marked out.
21/11/2019	Baseline weed count assessment completed.
05/12/2019	Assessment, two weeks after treatment (% weed cover and % weed species). No phyto as narcissus yet to emerge.
19/12/2019	Assessment, four weeks after treatment (% weed cover and % weed species). No phyto as narcissus yet to emerge.
02/01/2020	Assessment, six weeks after treatment (% weed cover and % weed species). No phyto yet as narcissus only just emerging in a few plots.
15/01/2020	Assessment, eight weeks after treatment (Phyto, leaf height and leaf emergence).
28/01/2020	Assessment, ten weeks after treatment (% weed cover and % weed species).

Date	Event
30/01/2020	Assessment, ten weeks after treatment (Phyto, leaf height and leaf emergence).
07/02/2020	Assessment, eleven weeks after treatment (Phyto, bud numbers).
20/02/2020	Assessment, fourteen weeks after treatment (Phyto, bud numbers).
02/03/2020	Assessment, sixteen weeks after treatment (Phyto, flower quality and diameter, % weed cover and % weed species).

c. Photograph of trial area 29/01/2020



d. Climatological data during study period

Date	Min Temp (°C)	Max temp (°C)	Av. Relative humidity (%)
5-12-19	2	8.5	88.92857
6-12-19	7.5	13	92.20833
7-12-19	6.5	10	89.64583
8-12-19	5	11	85.14583
9-12-19	0.5	7.5	83.33333
10-12-19	0	11	93.8125
11-12-19	1	7.5	92.85417
12-12-19	0	7.5	99.47917
13-12-19	4	8.5	91.58333
14-12-19	3	6.5	86.77083
15-12-19	3.5	8	89.02083
16-12-19	3	6	97.02083
17-12-19	1	5	102.125
18-12-19	1.5	8.5	100.0833
19-12-19	8.5	12	96.85417

Date	Min Temp (°C)	Max temp (°C)	Av. Relative humidity (%)
20-12-19	4.5	10	100.08
21-12-19	3.5	9.5	99.43
22-12-19	5.5	8.5	98.62
23-12-19	4	9.5	93.54
24-12-19	5	10.5	96.85
25-12-19	-1	8	95.97
26-12-19	0	6.5	101.31
27-12-19	5.5	7.5	100.33
28-12-19	6	9	100.43
29-12-19	4.5	8.5	96.79
30-12-19	2	9.5	96.60
31-12-19	1.5	9.5	98.43
1-01-20	4.5	5.5	96.14
2-01-20	5	9.5	93.31
3-01-20	4	10	90.81
4-01-20	3	8	89.25
5-01-20	5.5	8.5	91.37
6-01-20	5.5	8	89.45
7-01-20	2.5	13	92.62
8-01-20	6.5	13	85.81
9-01-20	5	11.5	89.10
10-01-20	3	8.5	88.75
11-01-20	4	10.5	86.18
12-01-20	4	10.5	89.83
13-01-20	3.5	9	91.04
14-01-20	5	13.5	88.70
15-01-20	5	10	87.85
16-01-20	4	11	88.75
17-01-20	3	10	89.47
18-01-20	1.5	7.5	86.50
19-01-20	0	8	86.39
20-01-20	-1	8.5	90.33
21-01-20	-2	8	92.79
22-01-20	3	7.5	96.79
23-01-20	5	7.5	95.85
24-01-20	5.5	8	94.97
25-01-20	5	6.5	90.85
26-01-20	4.5	9.5	93.68
27-01-20	3.5	8	92.68
28-01-20	2	7.5	85.68
29-01-20	2	8	82.20
30-01-20	5.5	11	88.68
31-01-20	6	12	89.29
1-02-20	6	11.5	77.16
2-02-20	5.5	12	88.18
3-02-20	4	10.5	76.89
4-02-20	3	8.5	78.85
5-02-20	-3	9.5	87.75
6-02-20	-3.5	10	88.41

Date	Min Temp (°C)	Max temp (°C)	Av. Relative humidity (%)
7-02-20	-2	9.5	87.89
8-02-20	6	10.5	81.60
9-02-20	7	13	81.39
10-02-20	0.5	8	80.22
11-02-20	2	6.5	71.89
12-02-20	1	8	75.27
13-02-20	2	9.5	87.06
14-02-20	0	10	87.33
15-02-20	8.5	13.5	89.02
16-02-20	5	13	86.08
17-02-20	4	11.5	77.08
18-02-20	2.5	9.5	81.70
19-02-20	1	8	86.62
20-02-20	3	11	85.08
21-02-20	2.5	9.5	81.06
22-02-20	6.5	11.5	75.02
23-02-20	4	12	80.89
24-02-20	2	13.5	84.18
25-02-20	2.5	8.5	80.31
26-02-20	-1	8	85.04
27-02-20	0.5	8	84.56
28-02-20	-1	10	92.64
29-02-20	4	10	81.97
1-03-20	2	10	77.77
2-03-20	-1.5	10.5	82.29
3-03-20	-1	9	83.72
4-03-20	-0.5	10	86.33
5-03-20	2.5	6.5	91.64
6-03-20	-0.5	11	82.95
7-03-20	-1	13.5	86.12
8-03-20	5.5	13	78.83
9-03-20	3.5	11	83.70
10-03-20	8.5	15.5	82.58
11-03-20	4.5	14.5	79.56
12-03-20	2	11	74.39
13-03-20	3.5	12.5	79.50
14-03-20	4	12	88.75
15-03-20	4	11	87.93
16-03-20	1.5	19	93.12

e. Trial design

		DISCARD (10m)									
Treatment	DISCARD	DISCARD	Trt 4	Trt 1	Trt 5	Trt 7	Trt 6	DISCARD	DISCARD		
Block			3	3	3	3	3				
Plot			Plot 316	Plot 317	Plot 318	Plot 319	Plot 320				
Treatment	DISCARD	DISCARD	Trt 15	Trt 10	Trt 19	Trt 17	Trt 8	DISCARD	DISCARD		
Block			3	3	3	3	3				
Plot			Plot 311	Plot 312	Plot 313	Plot 314	Plot 315				
Treatment	DISCARD	DISCARD	Trt 16	Trt 9	Trt 14	Trt 3	Trt 2	DISCARD	DISCARD		
Block			3	3	3	3	3				
Plot			Plot 306	Plot 307	Plot 308	Plot 309	Plot 310				
Treatment	DISCARD	DISCARD	Trt 13	Trt 18	Trt 12	Trt 11	Trt 20	DISCARD	DISCARD		
Block			3	3	3	3	3				
Plot			Plot 301	Plot 302	Plot 303	Plot 304	Plot 305				
Treatment	DISCARD	DISCARD	Trt 8	Trt 14	Trt 6	Trt 17	Trt 10	DISCARD	DISCARD		
Block			2	2	2	2	2				
Plot			Plot 216	Plot 217	Plot 218	Plot 219	Plot 220				
Treatment	DISCARD	DISCARD	Trt 9	Trt 7	Trt 15	Trt 5	Trt 12	DISCARD	DISCARD		
Block			2	2	2	2	2				
Plot			Plot 211	Plot 212	Plot 213	Plot 214	Plot 215				
Treatment	DISCARD	DISCARD	Trt 1	Trt 2	Trt 11	Trt 4	Trt 20	DISCARD	DISCARD		
Block			2	2	2	2	2				
Plot			Plot 206	Plot 207	Plot 208	Plot 209	Plot 210				
Treatment	DISCARD	DISCARD	Trt 16	Trt 18	Trt 13	Trt 3	Trt 19	DISCARD	DISCARD		
Block			2	2	2	2	2				
Plot			Plot 201	Plot 202	Plot 203	Plot 204	Plot 205				
Treatment	DISCARD	DISCARD	Trt 20	Trt 15	Trt 14	Trt 3	Trt 9	DISCARD	DISCARD		
Block			1	1	1	1	1				
Plot			Plot 116	Plot 117	Plot 118	Plot 119	Plot 120				
Treatment	DISCARD	DISCARD	Trt 8	Trt 19	Trt 12	Trt 2	Trt 17	DISCARD	DISCARD		
Block			1	1	1	1	1				
Plot			Plot 111	Plot 112	Plot 113	Plot 114	Plot 115				
Treatment	DISCARD	DISCARD	Trt 7	Trt 10	Trt 6	Trt 13	Trt 1	DISCARD	DISCARD		
Block			1	1	1	1	1				
Plot			Plot 106	Plot 107	Plot 108	Plot 109	Plot 110				
Treatment	DISCARD	DISCARD	Trt 16	Trt 4	Trt 11	Trt 18	Trt 5	DISCARD	DISCARD		
Block			1	1	1	1	1				
Plot			Plot 101	Plot 102	Plot 103	Plot 104	Plot 105				
		DISCARD (10m)									

f. ORETO certificate.



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

This certifies that
RSK ADAS Ltd
complies with the minimum standards laid down in
Regulation (EC) 1107/2009 for efficacy testing.
The above Facility/Organisation has been officially
recognised as being competent to carry out efficacy trials/tests
in the United Kingdom in the following categories:

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

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

Signature 
Authorised signatory

Certification Number
ORETO 409


Chemicals Regulation Division

 Department of
Agriculture and
Rural Development