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Project number:	HNS 198
Project leader:	David Talbot, ADAS UK Ltd.
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Key staff:	David Talbot Emily Lawrence Megan-Rose Beard
Location of project:	Whartons Nurseries Ltd., Diss, Norfolk Frank P Matthews, Tenbury, Worcestershire Wyevale Nurseries Ltd, Hereford. ADAS UK Ltd., Boxworth, Cambridge
Industry Representative:	Mark Cade, James Coles & Sons (Nurseries) Ltd., Leicester Bob Hollister, Country Garden Plant Sales Ltd., Wareham
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The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

David Talbot

Horticultural consultant

RSK ADAS Ltd.

Signature David P. Talbot Date: 14 December 2018

Report authorised by:

Signature Date: 01 May 2019

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Grower Summary

Headlines

- Sencorex Flow and HDC H43 proved safe and effective in a tank mix with Stomp Aqua + Flexidor 500 when used post-planting and post-heading back on rose rootstocks.
- HDC H43 proved safe and effective when used as a post-budding application in a tank mix with Flexidor 500 on roses.
- HDC H42 provided particularly effective weed control when applied with standard products Stomp Aqua and Flexidor 500, post-heading back on roses.
- Sencorex Flow at 1 L/ha proved safe, applied as a post planting treatment to four tree rootstock species.
- Sunfire and Centurion Max were tolerated by ten hardy nursery stock species when applied after potting. A few species showed short term phytotoxicity symptoms but plants grew away from the damage by six weeks.
- Sunfire and Defy applied as dormant season treatments appear crop safe.
- Flexidor at 0.5 L/ha (the maximum rate) proved safe (by 13 weeks after treatment) on the majority of species tested.

Background

A decreasing number of herbicides are available to the Hardy Nursery Stock (HNS) sector for efficient plant production and as a result effective weed control has become an urgent problem for the industry to solve.

Since the last herbicide trial on roses in the UK was completed in 2008 (HNS 132), the key recommended products Ronstar Liquid (oxadiazon), Skirmish (terbuthylazine + isoxaben) and Artist (flufenacet + metribuzin) have become unavailable for use. There is pressing need to test replacement products for rose production. The herbicides selected for inclusion are those for which appropriate Extension of Authorisation for Minor Use (EAMUs) have recently been granted, e.g. Logo (foramsulfuron + iodosulfuron-methyl-sodium), Sencorex Flow (metribuzin) and Springbok (metazachlor + dimethenamid-p). In 2016, this project looked at the efficacy and crop safety of two season herbicide programmes, including these new products for field rose production. The aim of the current trial was to build on the knowledge gained from the project's 2016 trials, and to include newly approved products such as Sencorex Flow.

The final use of Ronstar 2G (oxadiazon) in 2015 and restrictions on the use of Butisan S (metazachlor) have left gaps in the herbicides available to growers of container HNS. Flexidor 500 (isoxaben) – previously Flexidor 125 – has become the mainstay of weed control programmes in container HNS production, but it does not offer control of annual meadow grass, groundsel, willowherb, moss or liverwort, and now only one application is permitted per year. Research in the EMT/AHDB Horticulture/HTA Fellowship project CP 86 *'Weed control in ornamentals, fruit and vegetable crops – maintaining capability to devise suitable weed control strategies'* (Atwood, 2015) and HNS/PO 192 & 192a *'Herbicides screening for ornamental plant production (nursery stock, cut flowers and wallflowers)'* (Atwood 2015, 2016) have investigated promising new actives in screening trials, and reviewed cultural controls. As a result, Dual Gold (s-metolachlor) and Springbok were developed as container HNS treatments (though with limitations). Currently, relatively few new residual herbicides show potential for container HNS testing, but two were selected for 2017-18 trials; Sunfire (flufenacet) and Defy (prosulfocarb), both promising for efficacy on key weeds and safety on indicative nursery stock species. Two new herbicide actives (both coded products) were also selected for inclusion in 2018 trials; HDC H44 and HDC H46. The withdrawal of Aramo (tepraloxydim), a selective contact herbicide for grass control, has had an impact across both field and container grown HNS. It was used as a post-emergence control of a range of annual grasses, in particular annual meadow grass. A safe and effective replacement is urgently required. Centurion Max (clethodim) was selected as the most promising candidate and included phytotoxicity screening on indicative nursery stock species.

HDC H46 is an active that could be new to the UK; it is approved in other countries and is used in HNS production, and therefore was included in the 2018 container screening tests. The UK formulation is likely to be different to the formulation used in HNS production in other countries. It gives pre-emergence residual control of a range of annual grasses and broad leafed weeds including the following weed species: Hairy bittercress, Common chickweed, Mouse eared chickweed, Groundsel, Annual meadow Grass, Clovers and Italian Ryegrass.

Due to the delays in converting the Long Term Arrangements for Extensions of Use (LTAEU) to EAMUs a number of products are still available under the LTAEU. Some of which are included as this gives growers crop safety information as EAMUs are issued.

Summary

Over 2017-18, two herbicide trials were carried out on field-grown roses whilst one herbicide trial was carried out on field grown trees. Phytotoxicity testing on 10 container-grown HNS subjects was done in two separate trials. **Table 1** lists the herbicides and rates used in each trial, along with the herbicides' approval status.

Table 1. Herbicides, approval status and rates used in hardy nursery stock trials carried out in 2017/2018.

Product	**Active**	**Approval status**	**Budded rose** (L/ha)	**Budded rose – post heading back trial** (L/ha)	**Field Tree trial** (L/ha)	**HNS screen** (L/ha)	**Container trial 2018** (L/ha)

Betanal maxxPro	47 g/L desmedipham + 75 g/L ethofumesate + 27 g/L lenacil + 60 g/L phenmedipham	LTAEU	1.5				
Butisan S	500 g/L metazachlor	Label	1.5				
Centurion Max	120 g/L clethodim	LTAEU				2.0	2.0
Defy[2]	800 g/L prosulfocarb	EAMU[2]				5.0	
Flexidor 500	500 g/L isoxaben	Label	0.5	0.5	0.5	0.25	0.5
HDC H42	Confidential	Not authorised		1.5			
HDC H43	600 g/L pethoxamid	Not authorised	2.0	2.0			2.0
HDC H44*	Confidential	Not authorised			2.0		2.0
HDC H45	Confidential	Not authorised			1.5 2.5		
HDC H46	Confidential	Not authorised					Confidential
HDC H47	Confidential	Not authorised		3.75	3.75		
Logo[3]	30% w/w foramsulfuron + 10% w/w iodosulfuron-methyl-sodium	EAMU	0.075 kg/ha				
HDC H43	pethoxamid	Not authorised		2.0			2.0
Sencorex Flow	600 g/L metribuzin	EAMU	0.73[5]	0.44[4]	0.875 1.0		
Springbok	200 g/L metazachlor + 200 g/L dimethenamid-p	EAMU		1.25			1.6
Stomp Aqua	455 g/L pendimethalin	EAMU	2.9	2.0	2.9		
Sunfire	500 g/L flufenacet	EAMU		0.48			0.48
Venzar Flowable[1]	440 g/L lenacil	LTAEU[1]	3.0				
Venzar 500 SC	500 g/L lenacil	LTAEU			0.4		0.4

[1] Approval now expired, [2] Pre-emergence only, [3] Mero adjuvant was added at 2 L/ha, [4] Post heading back rate, [5] Post planting rate.
*HDC H44 has been evaluated on wide range of horticultural crops in the SCEPTRE plus project. A submission for use in potatoes has been submitted with potential for EAMUs and label extensions for other crops.

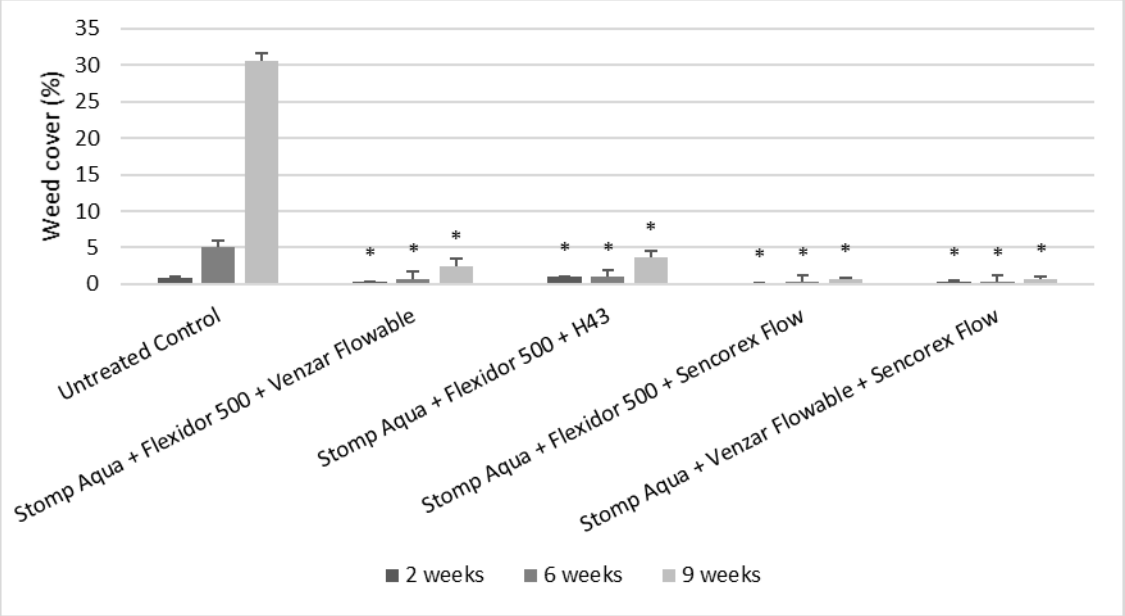
Budded rose trial

The budded rose herbicide trial was set up at Whartons Nurseries Ltd. in Pulham St Mary, on newly planted field-grown rootstocks. The trial consisted of nine herbicide programmes (**Table 2**). Applications were made to the rootstocks on four occasions; at planting (15/03/17), a follow-up (18/05/17) and after budding (30/06/17). The trial was set up as a fully randomised block design and treatments were replicated four times.

Table 2. Treatment list and timings for the budded rose herbicide trial, Pulham St Mary, 2017.

Trt. No.	Planting 15/03/2017	Follow up 18/05/2017	Budding 30/06/2017
1	Untreated	Untreated	Untreated
2	**Stomp Aqua** 2.9 L/ha + **Flexidor 500** 0.5 L/ha + **Venzar Flowable** 3.0 L/ha		**Flexidor 500** 0.5 L/ha + **Butisan S** 1.5 L/ha
3	**Stomp Aqua** 2.9 L/ha + **Flexidor 500** 0.5 L/ha + **HDC H43** 2.0 L/ha		**Flexidor 500** 0.5 L/ha + **HDC H43** 2.0 L/ha
4			**Flexidor 500** 0.5 L/ha + **Butisan S** 1.5 L/ha
5	**Stomp Aqua** 2.9 L/ha + **Flexidor 500** 0.5 L/ha + **Sencorex Flow** 0.73 L/ha		**Flexidor 500** 0.5 L/ha + **Butisan S** 1.5 L/ha
6	**Stomp Aqua** 2.9 L/ha + **Flexidor 500** 0.5 L/ha + **Sencorex Flow** 0.73 L/ha	**Logo** 0.075 kg/ha + **Mero** (adjuvant) 2.0 L/ha	**Flexidor 500** 0.5 L/ha + **Butisan S** 1.5 L/ha
7	**Stomp Aqua** 2.9 L/ha + **Flexidor 500** 0.5 L/ha + **Sencorex Flow** 0.73 L/ha	**Logo** 0.075 kg/ha + **Mero** (adjuvant) 2.0 L/ha + **Betanal maxxPro** 1.5 L/ha	**Flexidor 500** 0.5 L/ha + **Butisan S** 1.5 L/ha
8	**Stomp Aqua** 2.9 L/ha + **Flexidor 500** 0.5 L/ha + **Sencorex Flow** 0.73 L/ha	**Betanal maxxPro** 1.5 L/ha	**Flexidor 500** 0.5 L/ha + **Butisan S** 1.5 L/ha
9	**Stomp Aqua** 2.9 L/ha + **Venzar Flowable** 3.0 L/ha + **Sencorex Flow** 0.73 L/ha		**Flexidor 500** 0.5 L/ha + **Butisan S** 1.5 L/ha

Phytotoxicity and weed assessments were carried out at approximately two, six and ten weeks after treatment (WAT). Phytotoxicity was scored on a scale of 0-9; plants scoring 0 were considered dead, and 9 considered healthy, with plants scoring 7 or more considered to be of commercially acceptable quality. Weed cover was assessed as an overall



percentage of the plot. The same assessment criteria was used for all trials done in 2018. Of the post-planting treatments, the tank mixes which included Sencorex Flow appeared to offer the most effective weed control; the average weed cover in these treatments' plots was still <1% when assessed nine weeks after application (

Figure 1). The rose rootstocks showed no obvious symptoms of phytotoxicity after the application of these treatments.

Figure 1. Weed cover (%) of budded rose plots two, six and nine weeks after planting treatment * indicates significance at p value <0.001.

*Statistically significant

The follow-up treatments all offered good weed control, with weeds in untreated plots averaging 37% cover after two weeks, compared to an average of ≤0.5% weed cover in those treated with Logo and/or Betanal maxxPro. However, Logo appeared to cause yellowing and stunting to the rose stocks, whether applied alone or in combination with Betanal maxxPro. Betanal maxxPro alone had very little effect on the rose stocks. Post-budding, Butisan S and HDC H43 (pethoxamid) appear similarly effective as tank mix partners for Flexidor 500, both showing a significant improvement in weed control compared to the untreated plots (

Figure 2), and with no significant phytotoxic effects.

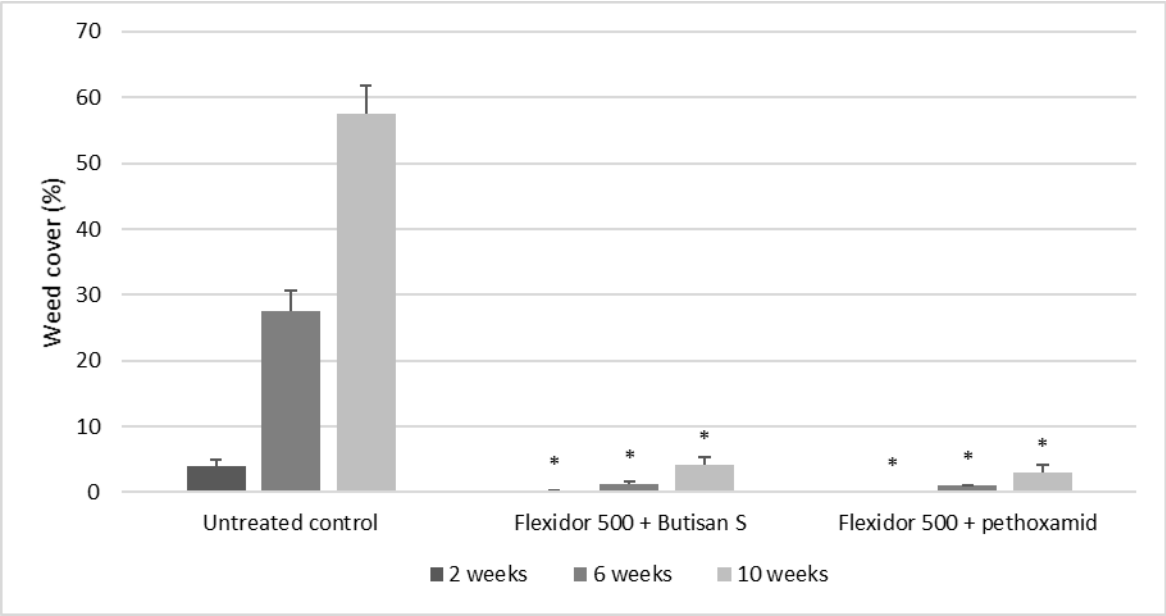


Figure 2. Weed cover (%) of budded rose plots two, six and ten weeks after budding treatment. Results for plots which had received the same post-budding treatment were combined. * indicates significance at p value <0.001.

Budded rose trial – post heading back trial

The budded rose herbicide trial was set up at Whartons Nurseries Ltd. in Pulham St Mary, on recently headed back (rootstocks cut back to just above the bud that was budded the previous season) field-grown rootstocks, which were budded the previous year. The trial consisted of six herbicide treatments (**Table 23**). Residual herbicides were applied to the rootstocks post-heading back (06/03/18). The trial was set up as a fully randomised block design and treatments were replicated four times.

Table 3. Treatment list for the post heading back rose herbicide trial, Pulham St Mary, 2018.

Treatment Number	**Heading back** 06/03/2018
1	Untreated
2	**Stomp Aqua** 2.0 L/ha + **Flexidor 500** 0.5 L/ha + **Springbok** 1.25 L/ha
3	**Stomp Aqua** 2.0 L/ha + **Flexidor 500** 0.5 L/ha + **HDC H43** 2.0 L/ha
4	**Stomp Aqua** 2.0 L/ha + **Flexidor 500** 0.5 L/ha + **HDC H42** 1.5 L/ha
5	**Stomp Aqua** 2.0 L/ha + **Flexidor 500** 0.5 L/ha + **Sencorex Flow** 0.44 L/ha
6	**Stomp Aqua** 2.0 L/ha + **HDC H47** 3.75 L/ha + **Sencorex Flow** 0.44 L/ha
7	**Stomp Aqua** 2.0 L/ha + **HDC H47** 3.75 L/ha + **Sencorex Flow** 0.44 L/ha **+ Sunfire** 0.48 L/ha

The post heading back treatments applied to the roses were all effective and safe; Stomp Aqua + Flexidor 500 + HDC H42 as a tank mix offered particularly good weed control.

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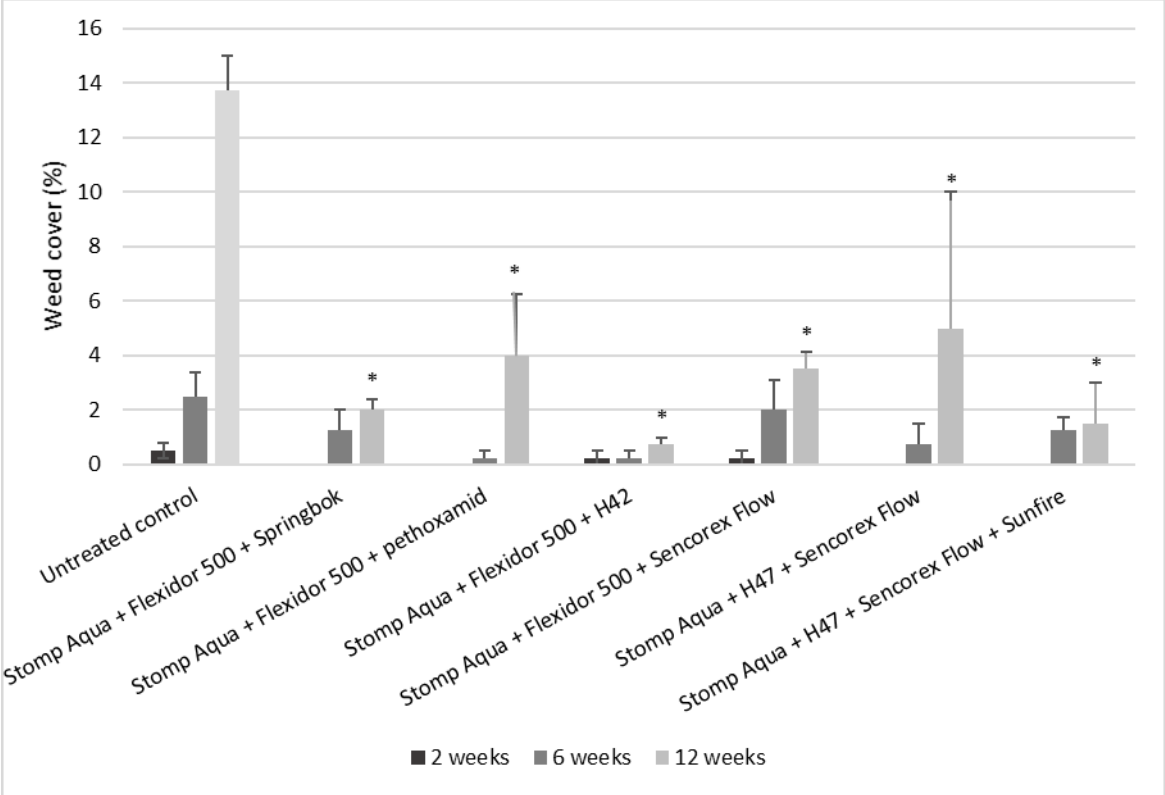

Figure 3. Weed cover (%) of budded rose plots at two, six and twelve weeks after post heading-back treatment (application made 06/03/18). * indicates significance at p value at 0.010.

2018 Field Tree Trial

The 2018 field tree trial was set up on newly planted rootstocks at Frank P Matthews, Worcestershire. The aim of this study was to test the crop safety of a number of residual herbicides as alternatives to Flexidor, post-planting. Recent losses of key herbicides and restrictions on remaining residual herbicides has resulted in an increased reliance on

Flexidor, however the new label only permits one application per crop, so growers need alternative residual options.

The trial was set up as a fully randomised block design with each plot containing four tree species (e.g. *Malus, Prunus, Quince* and *Sorbus)* and four replicate blocks. The trial consisted of seven herbicide treatments which were applied on 14/05/18 as residual pre-emergence treatments post planting of rootstocks. Phytotoxicity and weed assessments were carried out at two, six and twelve weeks after treatment (WAT). Phytotoxicity was scored on a scale of 0-9; plants scoring 0 were considered dead, and 9 considered healthy, with plants scoring 7 or more considered to be of commercially acceptable quality. Weed cover was assessed as an overall percentage of the plot (**Figure 4)**.

Sencorex was tested at higher rates than previously used on the test species and proved to be crop safe at these higher rates; experimental treatments also proved crop safe. Stomp Aqua was included for comparison as an industry standard treatment, it was also known to be crop safe so rootstocks would not be affected prior to the application of additional experimental treatments in 2019 post heading back (rootstocks cut back to just above the bud that was budded the previous season).

Table 4. Treatment list and timings

Trt. No.	**Planting** 14/05/2018	**Clean up contacts prior to post budding residuals** 13/09/18	**Post Budding** 24/09/18
1	Untreated	Untreated	Untreated
2	HDC H44 2.0 L/ha	Diquat 2 L/ha + Shark 0.8 L/ha	**Flexidor 500** 0.5 L/ha + **Venzar 500 SC 0.4** L/ha
3	HDC H45 1.5 kg/ha	Diquat 2 L/ha + Shark 0.8 L/ha	**Flexidor 500** 0.5 L/ha + **Venzar 500 SC 0.4** L/ha
4	HDC H45 2.5 kg/ha	Diquat 2 L/ha + Shark 0.8 L/ha	**Flexidor 500** 0.5 L/ha + **Venzar 500 SC 0.4** L/ha
5	HDC H47 3.75 L/ha	Diquat 2 L/ha + Shark 0.8 L/ha	**Flexidor 500** 0.5 L/ha + **Venzar 500 SC 0.4** L/ha
6	Sencorex Flow 0.875 L/ha	Diquat 2 L/ha + Shark 0.8 L/ha	**Flexidor 500** 0.5 L/ha + **Venzar 500 SC 0.4** L/ha
7	Sencorex Flow 1 L/ha	Diquat 2 L/ha + Shark 0.8 L/ha	**Flexidor 500** 0.5 L/ha + **Venzar 500 SC 0.4** L/ha
8 to 10	Stomp Aqua 2.9 L/ha	Diquat 2 L/ha + Shark 0.8 L/ha	**Flexidor 500** 0.5 L/ha + **Venzar 500 SC 0.4** L/ha

There were subtle differences in weed control between treatments at the first assessment, carried out 2 weeks after treatment (WAT). Untreated controls had 5% weed cover. The best treatment for weed control was HDC H44 with 1.2% weed cover followed by HDC H45 at the high rate with 1.25%. By the 6 WAT assessment Sencorex at the higher rate maintained the best weed control at 2% weed cover, followed by Sencorex at the lower rate with 2.5% weed cover. These two treatments continued to maintain the best weed control until the 12 WAT assessment. Both HDC H44 and HDC H45 at the low rate lacked persistence with weeds increasing between 6 and 12 WAT. Stomp Aqua did not control the weed spectrum present when applied alone without complimentary tank mix partners.

The only treatment that resulted in phytotoxic damage at the 2 WAT assessment (all four species in the trial were affected) was HDC H44. By 12 WAT, however, all genera had grown away from damage and were considered commercially acceptable although *Prunus* treated with HDC H44 and the high rate of Sencorex Flow were significantly different to untreated; p value at >.001 (27 df) L.S.D. 0.3746. Any large weeds were removed by hand after the 12 WAT assessment in line with grower practice prior to budding. Post budding any weeds were controlled with diquat and Shark to clean them up prior to the top up application of residual herbicides (Flexidor 0.5 L/ha and Venzar 500 SC 0.4 L/ha). The post-heading back treatments were crop safe and effective (mean weed cover in untreated plots was 19.5% compared to 2.89% in treated plots, see **Table 21.**).

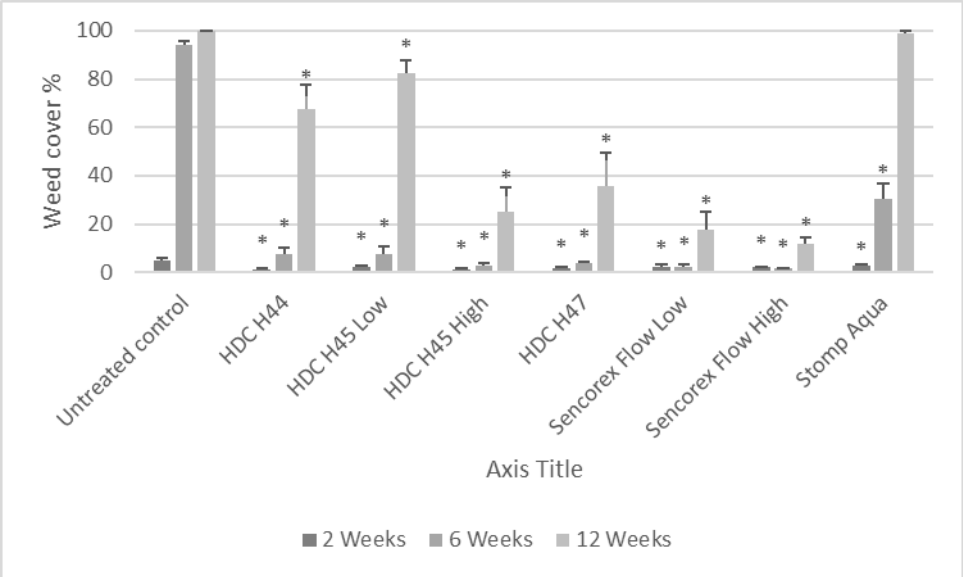

Figure 4: Weed cover (%) two, six and twelve weeks after planting treatment. Results for plots which had received the same post planting treatment were combined, ***** indicates significance at p value <.001.

Hardy nursery stock trial

The hardy nursery stock (HNS) trial was carried out at ADAS Boxworth on ten species of container grown plants (**Table 5**). The trial was set up as a fully randomised block design, with 5 plants per treatment and treatments replicated three times. The trial consisted of seven herbicide programmes, applied either post-potting or later, when the plants were dormant (**Table 5**). Applications of the post-potting treatments were made on 06/06/17, and dormant treatments were applied on 05/12/17.

Table 5. Species and cultivars included in hardy nursery stock trial.

Species	Cultivar
Azalea japonica	'Johanna'
Buddleja davidii	'Empire Blue'
Euonymus fortune	'Blondy R'
Hydrangea macrophylla	'Forever (R)'
Hypericum x *moserianum*	N/A
Lavandula stoechas	'Helmsdale'
Spiraea japonica	'Firelight'
Viburnum tinus	'Gwenllian'
Weigela florida	'Wine and Roses (R)'

Coreopsis verticillata	'Golden Gain'

Table 6. Treatment list and timings for the hardy nursery stock herbicide trial.

Treatment		**Active ingredient**	**Rate** (L/ha)	**Timing**
1	Untreated	-	-	-
2	Flexidor 500	isoxaben 500 g/L	0.25	June (post-potting)
3	Sunfire	flufenacet 500 g/L	0.48	
4	Centurion Max	clethodim 120 g/L	2.00	
5	Flexidor 500	isoxaben 500 g/L	0.25	December (over dormant crop)
6	Sunfire	flufenacet 500 g/L	0.48	
7	Defy	prosulfocarb 800 g/L	5.00	

None of the treatments applied after potting appeared to cause long-term phytotoxic effects (**Table 7**). Growers should note however, that Flexidor 500 may cause short-term scorch on *Hydrangea* and *Weigela*, and Sunfire could have a similar effect on *Buddleja*, *Hydrangea* and *Weigela*, as may Centurion Max on *Hydrangea* and *Spiraea*.

Table 7. Average phytotoxicity scores for hardy nursery species, thirteen weeks after June treatment application (assessed 04/09/17). *(NS = no significant differences)*

Species	**UTC**	**Flexidor 500**	**Sunfire**	**Centurion Max**
Azalea japonica	9.0	9.0	9.0	9.0
Buddleja davidii	9.0	9.0	9.0	9.0
Euonymus fortune	9.0	9.0	9.0	9.0
Hydrangea macrophylla	9.0	9.0	8.3	9.0
Hypericum x moserianum	9.0	9.0	8.7	9.0
Lavandula stoechas	9.0	9.0	9.0	9.0
Spiraea japonica	9.0	9.0	8.7	8.7
Viburnum tinus	9.0	8.7	9.0	9.0
Weigela florida	9.0	9.0	9.0	9.0
Coreopsis verticillata	9.0	9.0	9.0	9.0

Similarly, no significant phytotoxic effects were seen in hardy nursery stock plants treated while dormant – all treatments appeared crop safe on all species trialled (Table 7).

Table 8. Average phytotoxicity scores for hardy nursery species, nineteen weeks (due to prolonged dormancy as a result of a late spring) after December treatment application (assessed 17/04/18). *(NS = no significant differences)*

Species	UTC	Flexidor 500	Sunfire	Centurion Max
Azalea japonica	9.0	9.0	9.0	9.0
Buddleja davidii	9.0	8.7	9.0	9.0
Euonymus fortune	9.0	9.0	8.7	9.0
Hydrangea macrophylla	9.0	8.3	8.3	8.7
Hypericum x moserianum	9.0	9.0	9.0	9.0
Lavandula stoechas	9.0	9.0	9.0	9.0
Spiraea japonica	9.0	8.3	8.3	8.7
Viburnum tinus	9.0	8.7	8.7	8.7
Weigela florida	9.0	9.0	9.0	9.0
Coreopsis verticillata	9.0	9.0	9.0	9.0

HNS container trial 2018

The 2018 HNS container trial was carried out at Wyevale nurseries, Hereford, on ten species of container-grown plants (**Table 9**). The trial was set up as a fully randomised block design, with 5 plants per treatment, treatments were replicated three times. The trial consisted of six herbicide programmes, applied post-potting or as a top up treatment (**Table 10**). Applications of the post-potting treatments were made on 04/06/18,

Phytotoxicity was assessed at two, seven, and thirteen (June treatments) and again at three, six and twelve (October treatments) weeks after the herbicide treatments were applied on 16/10/18. Phytotoxicity was assessed by examining plants for any signs of herbicide damage (e.g. twisting, scorching, stunting), comparing treated plots to untreated, and scoring quality on a scale of 0-9; plants scoring 0 were considered dead, and 9 considered healthy, with plants scoring 7 or more considered to be of commercially acceptable quality

Flexidor was applied at the higher rate of 0.5 L/Ha (equivalent to 2 L/ha of the old Flexidor 125 formulation) to test crop safety at the maximum rate, as only one application can now be applied per crop.

Table 9. Species and cultivars included in hardy nursery stock container trial 2018.

Species	Cultivar
Buxus sempervirens	

Ceanothus thyrsiflorus	'Skylark'
Cistus x purpureus	
Cornus Alba	'Red Selection'
Euonymus japonicus	'Green Rocket'
Hydrangea paniculata	'Limelight'
Ilex aquifolium	
Olearia x haastii	
Perovskia atriplicifolia	'Blue Spire'
Sambucus nigra	'Black Lace'

Table 10. Treatment list and timings for the hardy nursery stock herbicide trial.

Treatment		**Active ingredient**	**Rate** (L/ha)	**Timing**
1	Untreated	-	-	-
2	Sinclair pot topper	Physical mulch	3cm depth	June (post-potting)
3	HDC H46	Confidential	0.1	
4	HDC H44	Confidential	1.5	
5	Flexidor	isoxaben 500 g/L	0.5	
6	Flexidor + Centurion Max	isoxaben 500 g/L + clethodim 120 g/L	0.5 + 2.0	
7	Flexidor + HDC H43	isoxaben 500 g/L + pethoxamid	0.5+ 2.0	
8	Flexidor + Sunfire	isoxaben 500 g/L flufenacet 500 g/L	0.5 + 0.48	
1	Untreated	-	-	-
2	Untreated	-	-	-
3	Springbok + HDC H43	dimethanid-p + metazachlor + pethoxamid	1.6 + 2	October top up
4	Springbok + HDC H43	dimethanid-p + metazachlor + pethoxamid	1.6 + 2	
5	Springbok	dimethanid-p + metazachlor	1.6	
6	HDC H43	Pethoxamid	2	
7	Venzar 500 SC	Lenacil	0.4	
8	Springbok + H43 + Venzar 500 SC	dimethanid-p + metazachlor + pethoxamid + lenacil	1.6 + 2 + 0.4	

Following the June treatments, phytotoxicity assessments were carried out as before.

HDC H44 caused phytotoxic yellowing on a number of species (eight of the ten species treated) commercially unacceptable damage persisted to 13 WAT on five of the species tested (**Table 11**).

The new herbicide HDC H46 resulted in initial damage on a number of species however all species largely grew away from the damage with only slight damage by 13 WAT. Damage on four species was slightly more (scores between 6 and 6.3) than is considered commercially acceptable (a score of 7).

Flexidor at the 0.5 L rate damaged *Cornus* and *Perovskia* however *Cornus* grew away from the damage and plants were considered commercially acceptable by 13 WAT. *Perovskia* plants were not considered commercially acceptable by 13 WAT.

A tank mix of Flexidor and Centurion Max was slightly more damaging than Flexidor alone, however all species apart from *Perovskia* were considered commercially acceptable by 13 WAT. A tank mix of Flexidor and HDC H43 was also slightly more damaging than Flexidor alone however by 13 WAT only *Perovskia* and *Sambucus* were not considered commercially acceptable. Flexidor + Sunfire was also more damaging than Flexidor alone and *Ceanothus, Hydrangea*, *Perovskia* and *Sambucus* were not considered commercially acceptable by 13 WAT.

Table 11. Average phytotoxicity scores for hardy nursery species, thirteen weeks after June treatment application (assessed 04/09/18). *(NS = no significant differences)*

Species	UTC	Sinclair pot topper	HDC H46	HDC H44	Flexidor	Flexidor + Centurion Max	Flexidor + HDC H43	Flexidor + Sunfire	p value	L.S.D.
Buxus sempervirens	9	9	9	9	9	9	9	9	*(NS)*	
Ceanothus thyrsiflorus	9	9	6	4	7.3	8	**7**	6.3	*(NS)*	
Cistus x purpureus	9	9	9	6	9	9	9	9	*(NS)*	
Cornus alba	9	9	9	9	9	9	9	9	*(NS)*	
Euonymus japonicus	9	9	9	7	9	9	9	9	*(NS)*	
Hydrangea paniculata	9	9	6	7	8	8	8	6	*(NS)*	
Ilex aquifolium	9	9	9	6.3	9	9	9	9	*(NS)*	
Olearia x haastii	9	9	9	4	8	9	8	9	*(NS)*	
Perovskia atriplicifolia	9	9	6.3	6	6	6.3	6	5.3	*(NS)*	
Sambucus nigra	9	9	6	9	9	7	6	4.6	*(NS)*	

No significant phytotoxic effects were seen in hardy nursery stock top up treatments – all treatments appeared crop safe on all species trialled **(Tables 12 and 13)**.

Table 12. Average phytotoxicity scores for hardy nursery stock species, six weeks after October treatment application (assessed 20/11/18). *(NS = no significant differences)*

Species	UTC	Sinclair pot topper	Springbok + HDC H43	Springbok + HDC H43	Springbok	HDC H43	Venzar 500 SC	Springbok + HDC H43 + Venzar 500 SC	p value	L.S.D.
Buxus sempervirens	9	9	9	9	9	9	9	9	*(NS)*	-
Ceanothus thyrsiflorus	9	9	9	9	9	9	**9**	9	*(NS)*	-
Cistus x purpureus	9	9	9	9	9	9	9	9	*(NS)*	-
Cornus alba	9	9	9	9	9	9	9	9	*(NS)*	-
Euonymus japonicus	9	9	9	9	9	9	9	9	*(NS)*	-
Hydrangea paniculata	9	9	9	9	9	9	9	9	*(NS)*	-
Ilex aquifolium	9	9	9	8.3	9	9	9	8.6	*(NS)*	-
Olearia x haastii	9	9	8	8	8	8	9	8	*(NS)*	-
Perovskia atriplicifolia	9	9	9	9	9	9	9	9	*(NS)*	-
Sambucus nigra	9	9	9	9	9	9	9	9	*(NS)*	-

Table 13. Average phytotoxicity scores for hardy nursery stock species, twelve weeks after October treatment application (assessed 08/01/19). *(NS = no significant differences)*

Species	UTC	Sinclair pot topper	Springbok + HDC H43	Springbok + HDC H43	Springbok	HDC H43	Venzar 500 SC	Springbok + HDC H43 + Venzar 500 SC	p value	L.S.D.
Buxus	9	9	9	9	9	9	9	9	*(NS)*	-
Ceanothus thyrsiflorus	9	9	9	9	9	9	**9**	9	*(NS)*	-
Cistus x purpureus	9	9	9	9	9	9	9	9	*(NS)*	-
Cornus alba	9	9	9	9	9	9	9	9	*(NS)*	-
Euonymus japonicus	9	9	9	9	9	9	9	9	*(NS)*	-
Hydrangea paniculata	9	9	9	9	9	9	9	9	*(NS)*	-
Ilex aquifolium	9	9	9	9	9	9	9	9	*(NS)*	-

Olearia x haastii	9	9	8	8	8	8	9	8	*(NS)*	-
Perovskia atriplicifolia	9	9	9	9	9	9	9	9	*(NS)*	-
Sambucus nigra	9	9	9	9	9	9	9	9	*(NS)*	-

Discussion

Appearing safe and effective, a combination of Stomp Aqua + Flexidor 500 + Sencorex Flow can be recommended for weed control in roses after planting. HDC H43 also has potential as a tank mix partner with Stomp Aqua + Flexidor 500, if the appropriate EAMU is granted.

Tank mixes which included Venzar Flowable (440 g/L lenacil, applied at 3.0 L/ha) also offered good weed control and showed no obvious damage to the rose crop. However, this product has been replaced with a 500 g/L product, which is approved for use at the much lower rate of 0.4 L/ha. The LTAEU in place for Venzar Flowable when this trial commenced has since expired, however products containing lenacil such as Venzar 500 SC can be used under the LTAEU at 0.4 L/ha.

An EAMU was granted for use of Logo on roses (3437/16), but only for application from May to July. However, earlier trial work has shown that this product can be damaging when applied over rootstocks or rose maidens in May. Applying at a later timing, i.e. after budding, may be safer, but overall it is advisable to be cautious with this treatment. No notable damage was observed from the application of Betanal maxxPro; this product is a useful option as a follow-up treatment, it is currently authorised for use under the LTAEU; an EAMU should be requested to secure its longer term use in ornamentals.

Butisan S appeared effective and crop safe when applied *over* roses post-budding, however, the current label recommends that the product is applied as a plant base spray (to minimise any potential crop damage). Butisan S is not being marketed by the authorisation holder any more, although other products containing metazachlor with uses in ornamental plant production are still available.

While HDC H42 appeared crop safe on roses in this project, previous work has suggested that this product can cause temporary phytotoxicity (Burgess and Atwood, 2008). However, this may be more marked when used after planting. If EAMUs are granted, HDC H43 or HDC H42 show potential as tank mix partners for Stomp Aqua + Flexidor 500.

It is important to note that label use of Flexidor 500 permits only one application per year, i.e. the use of this product after planting and again post-budding would not be allowed. Application at the earlier spray timing is suggested – weed pressure will be greater at this point – with the product then omitted from subsequent spray mixes. HDC H47, an experimental product, appears to be a safe alternative to Flexidor 500 as a tank mix partner for treating roses post-heading back.

Sencorex Flow can be recommended for weed control in field trees post planting, although previous work has suggested that this product can cause tempory phytotoxicity when used on light soils and after heavy rainfall. Therefore when used on light soils the rate may need to be reduced, particularly if heavy rainfall is forecast. HDC H44 and HDC H47 also have potential as tank mix partners with Sencorex Flow and Stomp Aqua. None of the treatments tested on container hardy nursery stock appeared to cause long term damage to any of the ten species when applied after potting. However, growers should be aware of the possibility of short term scorch from Flexidor 500 on *Hydrangea* and *Weigela*; from Sunfire on *Buddleja*, *Hydrangea* and *Weigela*; and from Centurion Max on *Hydrangea* and *Spiraea*.

When applied over dormant container hardy nursery stock, none of the treatments assessed appeared to cause notable damage to any of the plant species.

Conclusions

- HDC H43 shows potential for safe use on roses in a tank mix after planting, budding and/or heading back, provided an EAMU can be granted.
- HDC H42 remains a possible treatment for post-heading back of roses, though this product has a history of occasional damage (foliar bleaching and stunting), particularly when used after planting. There may be varietal susceptibility which has not been fully explored.
- Logo applied as a follow-up treatment over rose rootstocks appeared to cause some crop damage. This product may be better employed as a directed-alleyway spray treatment in wider spaced field crops.
- The EAMU for use of Sencorex Flow will allow the application of effective tank mix combinations such as Stomp Aqua + Sencorex Flow after planting and heading back.
- Sencorex Flow could form the basis of residual herbicide programmes post planting at a higher rate than previously used on field grown trees as an alternative to Flexidor.
- New products Sunfire and Centurion Max have shown potential for use over HNS foliage. In terms of crop safety, growers should be prepared for some varietal susceptibility – further testing is needed before these products are adopted for wide scale use.
- Sunfire and Defy applied as dormant season treatments appear crop safe, and are recommended for taking forward to future trials work.
- Defy could be a partial alternative to Devrinol (napropamide) as a winter treatment for container-grown hardy nursery stock if an EAMU for the latter was not available. However, a renewal of the authorisation for Devrinol on ornamentals would be preferred – its control of groundsel is superior to that of Defy.

Financial Benefits

Hand weeding three times during the growing season is estimated to cost in the region of £30,000 per hectare for field crops, such as trees and roses. The effective use of residual herbicides – minimising the need for hand weeding or the application of direct contact herbicides – will help to reduce costs significantly, contributing to grower profitability. For example, herbicide mixtures of standard products with Sencorex Flowable appeared to provide improved weed control compared with the standard treatment Stomp Aqua + Flexidor 500 + Venzar Flowable. The LTAEU in place for Venzar Flowable when this trial commenced has since expired, resulting in a reduction in the rate of lenacil that can be applied, a loss which will reduce the effectiveness of the standard treatment. It is estimated that substitution with a product such as Sencorex Flow is likely to reduce the need for hand weeding compared with no substitution by around £10,000 per hectare.

New herbicides Sunfire, Defy and Centurion Max were evaluated for container-grown hardy nursery stock production. At present there is no financial benefit for Defy because an improved EAMU permitting use over the top of dormant crops would be required; current off-label approval for use of Defy in outdoor and protected ornamental plant production (EAMU 1431/13) only allows pre-emergence use.

Action Points

- For budded rose production in the field, a herbicide programme of Stomp Aqua + lenacil* + Sencorex Flow after planting, Butisan S after budding and Stomp Aqua + Flexidor 500 + Sencorex Flow after heading back can be recommended.

- Betanal maxxPro appears safe to use as a selective contact herbicide for removal of seedling weeds in rose stocks during May, it is currently authorised for use under the LTAEU.
- The selective contact grass herbicide Centurion Max or residual herbicide Sunfire, appeared safe on container grown HNS, some species tested.

*lenacil as Venzar 500 SC at the new LTAEU maximum rate of 0.4L/ha.

Science Section

Introduction

A decreasing number of herbicides are available to the Hardy Nursery Stock (HNS) sector for efficient plant production and as a result effective weed control has become an urgent problem for the industry to solve.

Since the last herbicide trial on roses in the UK was completed in 2008 (HNS 132), the key recommended products Ronstar Liquid (oxadiazon), Skirmish (terbuthylazine + isoxaben) and Artist (flufenacet + metribuzin) have become unavailable for use. Therefore there is pressing need to test replacement products. The herbicides selected for inclusion are those for which appropriate EAMUs could be obtained or have recently been granted, e.g. Logo (foramsulfuron + iodosulfuron-methyl-sodium), Sencorex Flow (metribuzin) and Springbok (metazachlor + dimethenamid-p). In 2016, this project looked at the efficacy and crop safety of two season herbicide programmes, including these new products for field rose production. The aim of the current trial was to build on the knowledge gained from the project's 2016 work, and to include newly approved products such as Sencorex Flow.

The final use of Ronstar 2G (oxadiazon) in 2015 and restrictions on the use of Butisan S (metazachlor) have left gaps in the herbicides available to growers of container HNS. Flexidor (500 g/l isoxaben) – previously Flexidor 125 – has become the mainstay of weed control programmes in container HNS production, but it doesn't offer control of annual meadow grass *(Poa annua)*, groundsel *(Senecio vulgaris)*, willowherb *(Epilobium* spp.), moss or liverwort, and now only one application is permitted per year. Research in the EMT/AHDB Horticulture/HTA Fellowship project CP 86 *'Weed control in ornamentals, fruit and vegetable crops – maintaining capability to devise suitable weed control strategies'* (Atwood, 2015) and HNS/PO 192 & 192a *'Herbicides screening for ornamental plant production (nursery stock, cut flowers and wallflowers)'* (Atwood 2015, 2016) investigated promising new actives in screening trials, and reviewed cultural controls. As a result, Dual Gold (s-metolachlor) and Springbok were developed as container HNS treatments (though with limitations). Currently, relatively few new residual herbicides show potential for container HNS testing, but two were selected for 2017-18 trials; Sunfire (flufenacet) and Defy (prosulfocarb), both promising for efficacy on key weeds and safety on indicative nursery stock species. The withdrawal of Aramo (tepraloxydim), a selective contact herbicide for grass control, has had an impact across both field and container grown HNS. It has been widely used as a post emergence control of a range of annual grasses, in particular annual meadow grass *(Poa annua)*. A safe and effective replacement is urgently sought. Centurion Max (clethodim) was selected as the most promising candidate and included phytotoxicity screening on indicative nursery stock species.

Budded rose

Materials and methods

This budded rose herbicide trial was set up in 2017 at Whartons Nurseries Ltd., Pulham St Mary, on rootstocks newly planted in a field of sandy clay loam. Planting spacing was 85 cm rows with in-row spacing of 16 cm. Plots measured 3.35 m x 3.5 m (four rows) and included 0.25 m discard at the end of each plot. The trial was set up as a fully randomised block design, and treatments were replicated four times.

The trial consisted of nine herbicide treatment programmes (**Table 34**). These included an untreated control, and the following herbicides in various tank mixes: Betanal maxxPro, Butisan S, Flexidor 500, HDC H43, Logo (+ Mero, an adjuvant), Sencorex Flow, Stomp Aqua, and Venzar Flowable. Tank mix combinations were selected on the basis of the known weed control spectrum of the individual products to give as wide a possible range of weed control. For example, a number of treatments used Stomp Aqua + Flexidor 500 as a

standard base, with an additional herbicide included to improve the weed control spectrum. The active ingredients of the treatment products can be found in

Table 45.

Table 34. Treatment list and timings for the budded rose herbicide trial, Pulham St Mary, 2017-18.

Trt. No.	Planting 15/03/2017	Follow up 18/05/2017	Budding 30/06/2017
1	Untreated	Untreated	Untreated
2	**Stomp Aqua** 2.9 L/ha + **Flexidor 500** 0.5 L/ha + **Venzar Flowable** 3.0 L/ha		**Flexidor 500** 0.5 L/ha + **Butisan S** 1.5 L/ha
3	**Stomp Aqua** 2.9 L/ha + **Flexidor 500** 0.5 L/ha + **HDC H43** 2.0 L/ha		**Flexidor 500** 0.5 L/ha + **HDC H43** 2.0 L/ha
4			**Flexidor 500** 0.5 L/ha + **Butisan S** 1.5 L/ha
5	**Stomp Aqua** 2.9 L/ha + **Flexidor 500** 0.5 L/ha + **Sencorex Flow** 0.73 L/ha		**Flexidor 500** 0.5 L/ha + **Butisan S** 1.5 L/ha
6	**Stomp Aqua** 2.9 L/ha + **Flexidor 500** 0.5 L/ha + **Sencorex Flow** 0.73 L/ha	**Logo** 0.075 kg/ha + **Mero** (adjuvant) 2.0 L/ha	**Flexidor 500** 0.5 L/ha + **Butisan S** 1.5 L/ha
7	**Stomp Aqua** 2.9 L/ha + **Flexidor 500** 0.5 L/ha + **Sencorex Flow** 0.73 L/ha	**Logo** 0.075 kg/ha + **Mero** (adjuvant) 2.0 L/ha + **Betanal maxxPro** 1.5 L/ha	**Flexidor 500** 0.5 L/ha + **Butisan S** 1.5 L/ha
8	**Stomp Aqua** 2.9 L/ha + **Flexidor 500** 0.5 L/ha + **Sencorex Flow** 0.73 L/ha	**Betanal maxxPro** 1.5 L/ha	**Flexidor 500** 0.5 L/ha + **Butisan S** 1.5 L/ha
9	**Stomp Aqua** 2.9 L/ha + **Venzar Flowable** 3.0 L/ha + **Sencorex Flow** 0.73 L/ha		**Flexidor 500** 0.5 L/ha + **Butisan S** 1.5 L/ha

Table 45. Active ingredients used in budded rose herbicide trials.

Product	Active ingredient	Approval status
Betanal maxxPro	47 g/L desmedipham + 75 g/L ethofumesate + 27 g/L lenacil + 60 g/L phenmedipham	LTEAU[1]
Butisan S	500 g/L metazachlor	Label
Flexidor 500	500 g/L isoxaben	Label
HDC H43	600 g/L pethoxamid	Not authorised
Logo	30% w/w foramsulfuron + 10% w/w iodosulfuron-methyl-sodium + 30% w/w isoxadifen-ethyl	EAMU 3437/16
Mero	81.4% w/w oil (rapeseed fatty acid esters)	Label
Sencorex Flo	600 g/L metribuzin	EAMU 1732/17
Stomp Aqua	455 g/L pendimethalin	EAMU 2919/09
Venzar Flowable	440 g/L lenacil	LTEAU[1]

[1] Approval now expired

Treatments were applied to plots using an OPS knapsack sprayer at a medium spray pressure, with 02F110 nozzles applying water at a rate of 300 L/ha. Applications were made to the rootstocks on four occasions: at planting (15/03/17), a follow up treatment (18/05/17) and after budding (30/06/17).

Phytotoxicity and weed assessments were carried out at approximately two, six and ten weeks after treatment. Phytotoxicity was assessed by examining the plants for any signs of herbicide damage (e.g. twisting, scorching, stunting), and was scored on a scale of 0-9;

plants scoring 0 were considered dead, and 9 considered healthy, with those scoring 7 or more considered to be of commercially acceptable quality. Weed cover was assessed as an overall percentage of the plot area, and key weed species present in the trial area were recorded. The methods for the phytotoxicity and weed assessments were the same for all of the trials.

Data was analysed by Analysis of variance (ANOVA) using the Least Squares Difference (LSD) to test for differences to the control. (Genstat 18.4).

Results

Treatment application after planting, 15/03/17

There were no visible signs of phytotoxicity from any of the treatments at the two week (30/03/2017), six week (26/04/2017) or nine week (18/05/2017) after treatment assessments, and no significant differences between the treatments' plant quality scores; all were similar to the untreated.

All treatments maintained weed control below 1% cover for the first six weeks of assessment; the untreated plots reached an average of 5% weed cover in this time (**Figure 5**). By nine weeks after the treatment application date, the average weed cover in untreated plots was at 30%, while none of the treatments showed an average weed cover greater than 4%. At the six weeks after treatment assessment, six weed species were found throughout the trial. The control plots contained all six species; grass *(Poa annua)*, annual nettles *(Urtica urens)*, common chickweed *(Stellaria media)*, field pansy *(Viola arvensis)*, fat hen *(Chenopodium album)*, groundsel *(Senecio vulgaris)*. Annual meadow grass and annual nettles were most common.
The tank mixes, which included Sencorex Flow, appeared to offer the most effective weed control, with the average weed cover in these treatments' plots still <1% when assessed nine weeks after application.

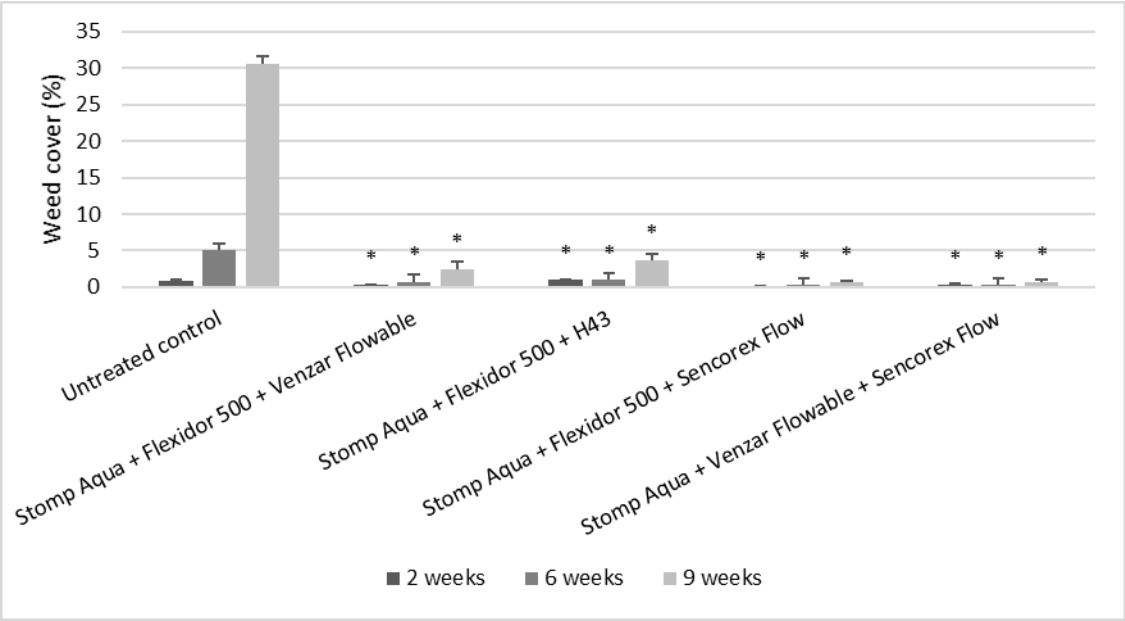

Figure 5. Weed cover (%) of budded rose plots two, six and nine weeks after planting treatment (*for tabulated results, see appendix 1;* **Table1**), * indicates significance at p value at <0.001.

Follow up treatment application, 18/05/17

Logo cause yellowing and stunting to the rose stocks, whether applied alone (score of 5.50, p value 0.002, L.S.D. 1.560) or in combination with Betanal maxxPro (score of 6.75, p value 0.002, L.S.D. 1.560) (**Figure 6**, **Table 56**). Damage was statistically significant compared to the untreated control at two weeks after treatment however damage was not significant by 6 weeks after treatment as the rose stocks were growing away from the initial damage. Logo applied alone had a score of 6 that was not considered commercially acceptable by 6 weeks after treatment. Surprisingly, the damage was less marked where Logo was tank mixed with Betanal maxxPro. Betanal maxxPro alone had very little phytotoxic effect on the rose stocks (**Figure7**).

Figure 6. Rose stocks treated with Logo + Mero (left), and Logo + Mero + Betanal maxxPro (right) (pictured on 31/05/17, 2 weeks after treatment).

Table 56. Plant quality scores* for the budded rose trial two and six weeks after follow-up treatment. *(NS = no significant differences)*

Trt. No.	Planting	Rate (Kg/ha or L/ha)	Quality score 2 weeks	Quality score 6 weeks
1	Untreated	N/A	9.00	7.00
6	Logo + Mero (adjuvant)	0.075 + 2.0	****5.50**	6.00
7	Logo + Mero (adjuvant) + Betanal maxxPro	0.075 + 2.0 + 1.5	****6.75**	7.25
8	Betanal maxxPro	1.5	8.50	8.25
		p value	0.002	*(NS)* 0.239
		(9df) **L.S.D.**	1.560	2.278

* *phytotoxicity scale of 0-9; plants scoring 0 considered dead, and 9 considered healthy, with those scoring 7or more considered to be of commercially acceptable quality.*

** *Significantly different to untreated.*

Figure 7. Rose stocks treated with Betanal maxxPro (only) treatment (31/05/17, 2 weeks after treatment).

Percentage weed cover of plots was assessed two weeks after follow up treatments were applied. Each of these treatments appeared to offer good weed control, with weeds in untreated plots averaging 37% cover, compared to an average of ≤0.5% cover in those treated with Logo and/or Betanal maxxPro.

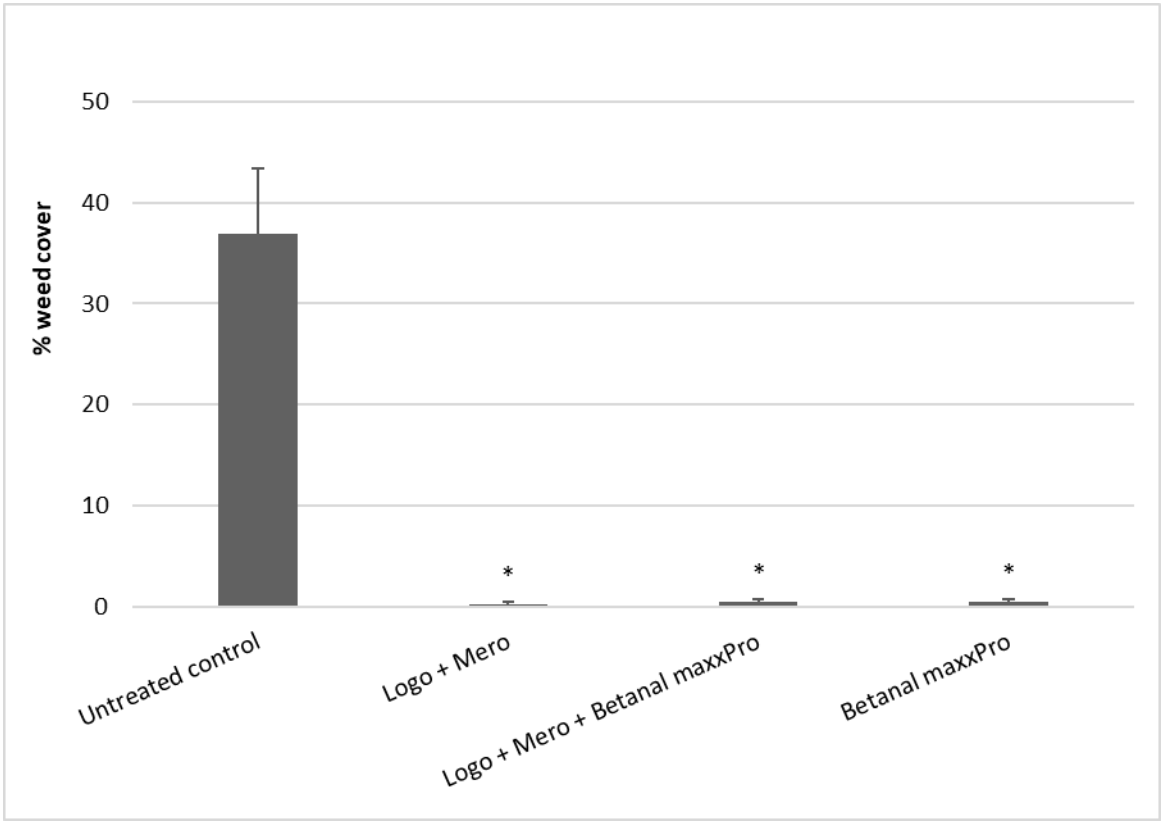

Figure 8. Weed cover (%) of budded rose plots two weeks after follow up treatment (*for tabulated results, see appendix 1;* **Table 2,** * indicates significance at p value at <0.001.

Post-budding application, 30/06/17

Post budding, plots received Flexidor 500 in a tank mix with either Butisan S or HDC H43. There was no phytotoxicity seen from either treatment; both scored similarly to the untreated for plant quality.

At the six week after treatment assessment, nine weed species were found throughout the trial, with annual meadow grass *(Poa annua)* and annual nettles *(Urtica urens)* the most common. This assessment showed that the control plots contained the most weed species (fat hen *(Chenopodium album),* annual nettle *(Urtica urens)*, creeping thistle *(Cirsium arvense)*, groundsel *(Senecio vulgaris)*, annual meadow grass *(Poa annua)*, common chickweed *(Stellaria media)*, nightshade, black *(Solanum nigrum)* and bittercress, hairy *(Cardamine hirsuta)*. The weed species most common in the treated plots were annual nettles, with some groundsel and crane's-bill, dove's-foot *(Geranium molle).*

By nine weeks after treatment, the average weed cover in treated plots did not exceed 5%, compared to an average of 57.5% for untreated plots (

Figure9). Butisan S and HDC H43 appeared similarly effective as tank mix partners for Flexidor 500.

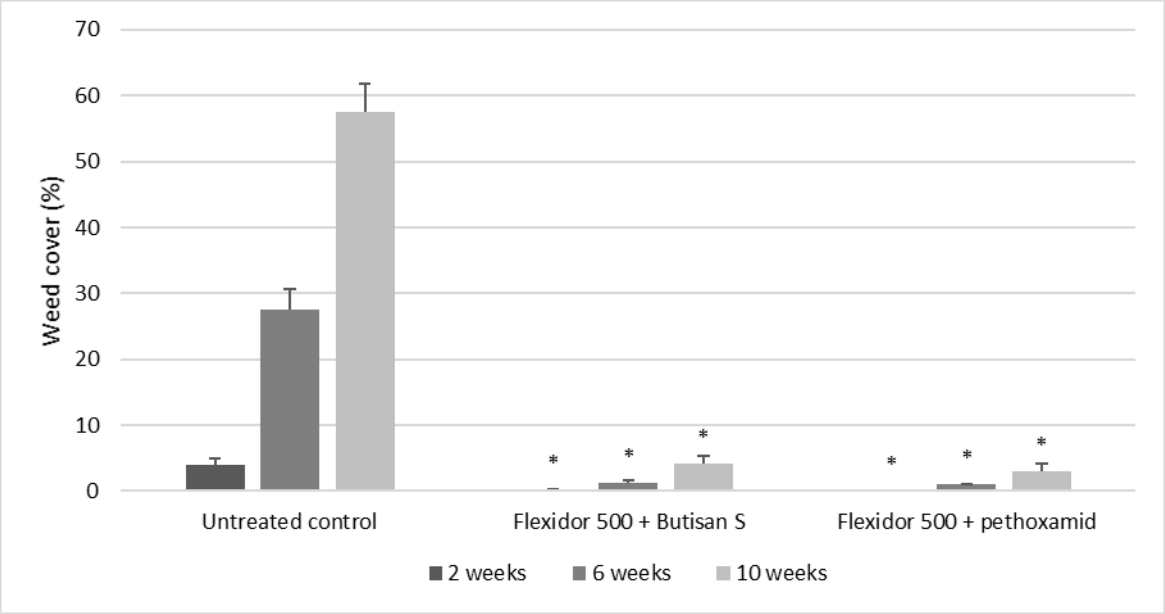

Figure 9. Weed cover (%) of budded rose plots two, six and ten weeks after budding treatment (*for tabulated results, see appendix 1;* **Table3**). Results for plots which had received the same post-budding treatment were combined, * indicates significance at p value at <0.001.

Discussion

Of the post-planting treatments, the tank mixes which included Sencorex Flow appeared to offer the most effective weed control; the average weed cover in these treatments' plots was still <1% when assessed nine weeks after application. The rose rootstocks showed no obvious symptoms of phytotoxicity after the application of these treatments, hence a combination of Stomp Aqua + Flexidor 500 + Sencorex Flow can be recommended after planting. HDC H43 also has potential as a tank mix partner with Stomp Aqua + Flexidor 500, if the appropriate EAMU is granted.

The mixes which included Venzar Flowable (440 g/L lenacil, applied at 3.0 L/ha) also offered good weed control and showed no obvious damage to the crop. However, this product has been replaced with a 500 g/L product, which is approved for use at the much lower rate of 0.4 L/ha. The LTAEU in place for Venzar Flowable when this trial commenced has since expired, however products containing lenacil such as Venzar 500 SC can be used under the LTAEU at 0.4 L/ha.

The follow-up treatments all offered good weed control, though Logo appeared to cause some damage to the crop. An EAMU was granted for use of Logo on roses (3437/16), but only for application from May to July. However, earlier trial work has shown this that this product can be damaging when applied over rootstocks or rose maidens in May. Applying at a later timing, i.e. after budding, may be safer. With no notable damage observed from its application, Betanal maxxPro which can be used under the LTAEU looks to be a useful option as a follow-up treatment.

Post-budding, Butisan S and HDC H43 appear similarly effective as tank mix partners for Flexidor 500, both showing a significant improvement in weed control compared to the untreated plots, and no significant phytotoxic effects. However, while Butisan S appeared safe when applied over roses, the current label approval for this product recommends use on ornamentals as a plant base spray only.

It is important to note that label use of Flexidor 500 permits only one application per year, i.e. the use of this product after planting, post-budding and post heading back is no longer legal. Application at the earlier spray timing is suggested – weed pressure will be greater at this point – with the product then omitted from the post-budding mix with Butisan S.

Conclusions

- HDC H43 shows potential for safe use on roses in a tank mix after planting or budding, provided an EAMU can be granted.
- Logo applied as a follow-up treatment appeared to cause some crop damage. This product may be better employed as a directed-alleyway spray treatment in wider spaced field crops.

Budded rose trial – post heading back trial

Materials and methods

The post heading back rose herbicide trial was set up at Whartons Nurseries Ltd. in Pulham St Mary in 2018, on recently headed back field-grown rootstocks, which were planted in a field of sandy clay loam. Planting spacing was 85 cm rows with in-row spacing of 16 cm. Plots measured 3.35 m x 3.5 m (four rows) and included 0.25 m discard at the end of each plot. The trial was set up as a fully randomised block design, and treatments were replicated four times. Roses were budded the previous year.

The trial consisted of six herbicide treatments (**Table 37**). These included an untreated control, and the following herbicides in various tank mixes: Flexidor 500, HDC H47, HDC H42, HDC H43, Sencorex Flow, Springbok, Stomp Aqua and Sunfire. Tank mix combinations were selected on the basis of the known weed control spectrum of the individual products to give as wide a possible range of weed control. For example, a number of treatments used Stomp Aqua + Flexidor 500 as a standard base, with an additional herbicide included to improve the weed control spectrum. The active ingredients of the treatment products can be found in

Table 48.

Table 67. Treatment list and timings for the budded rose herbicide trial, Pulham St Mary, 2017-18.

Trt. No.	**Heading back** 06/03/2018
1	Untreated
2	**Stomp Aqua** 2.0 L/ha + **Flexidor 500** 0.5 L/ha + **Springbok** 1.25 L/ha
3	**Stomp Aqua** 2.0 L/ha + **Flexidor 500** 0.5 L/ha + **HDC H43** 2.0 L/ha
4	**Stomp Aqua** 2.0 L/ha + **Flexidor 500** 0.5 L/ha + **HDC H42** 1.5 L/ha
5	**Stomp Aqua** 2.0 L/ha + **Flexidor 500** 0.5 L/ha + **Sencorex Flow** 0.44 L/ha
6	**Stomp Aqua** 2.0 L/ha + **HDC H47** 3.75 L/ha + **Sencorex Flow** 0.44 L/ha
7	**Stomp Aqua** 2.0 L/ha + **HDC H47** 3.75 L/ha + **Sencorex Flow** 0.44 L/ha + **Sunfire** 0.48 L/ha

Table 78. Active ingredients used in the post heading back rose herbicide trials.

Product	Active ingredient	Approval status
Flexidor 500	500 g/L isoxaben	Label
HDC H47	Confidential	Not authorised
HDC H42	Confidential	Not authorised
HDC H43	600 g/L pethoxamid	Not authorised
Sencorex Flow	600 g/L metribuzin	EAMU 1732/17
Springbok	200 g/L metazachlor + 200 g/L dimethenamid-p	EAMU 3006/14
Stomp Aqua	455 g/L pendimethalin	EAMU 2919/09
Sunfire	500 g/L flufenacet	EAMU 1056/17

Treatments were applied to plots using an OPS knapsack sprayer at a medium spray pressure, with 02F110 nozzles applying water at a rate of 300 L/ha. Herbicides were applied post heading back (06/03/18).

Phytotoxicity and weed assessments were carried out at approximately two, six and ten weeks after treatment. Phytotoxicity was assessed by examining the plants for any signs of herbicide damage (e.g. twisting, scorching, stunting), and was scored on a scale of 0-9; plants scoring 0 were considered dead, and 9 considered healthy, with those scoring 7 or more considered to be of commercially acceptable quality. Weed cover was assessed as an overall percentage of the plot area, and key weed species present in the trial area were recorded. The methods for the phytotoxicity and weed assessments were the same for all of the trials.

Data was analysed by Analysis of variance using the LSD to test for differences to the control. (Genstat 18.4).

Results

Treatment application post-heading back, 06/03/18

There were no visible signs of phytotoxicity from any of the treatments at the two week (21/03/2018), six week (16/04/2018) or twelve week (28/05/2018) after treatment assessments, and no significant differences in the plant quality scores, all being similar to the untreated.

Five species of weed emerged in the trial area during the assessment period – most common were creeping thistles *(Cirsium arvense),* annual nettles *(Urtica urens)* and Common ragwort *(Senecio jacobaea)*; broad leaved dock *(Rumex obtusifolius)* and common chickweed *(Stellaria media)* were also present. All treatments maintained weed control below 2% cover for six weeks, with weed cover in the untreated plots only reaching 2.5% in the same period (**Error! Reference source not found.10**). However, weed cover in the untreated plots reached 13.75% by twelve weeks after treatment, and all treated plots showed significantly lower weed cover than the untreated (*see appendix 2*,

Appendix 2 – Budded rose trial – post heading back trial

Table1).

Application of Stomp Aqua 2.0 L/ha + Flexidor 500 0.5 L/ha + HDC H42 1.5 L/ha appeared the most effective post-heading back treatment, with the average weed cover in these plots <1% when assessed twelve weeks after treatment application.

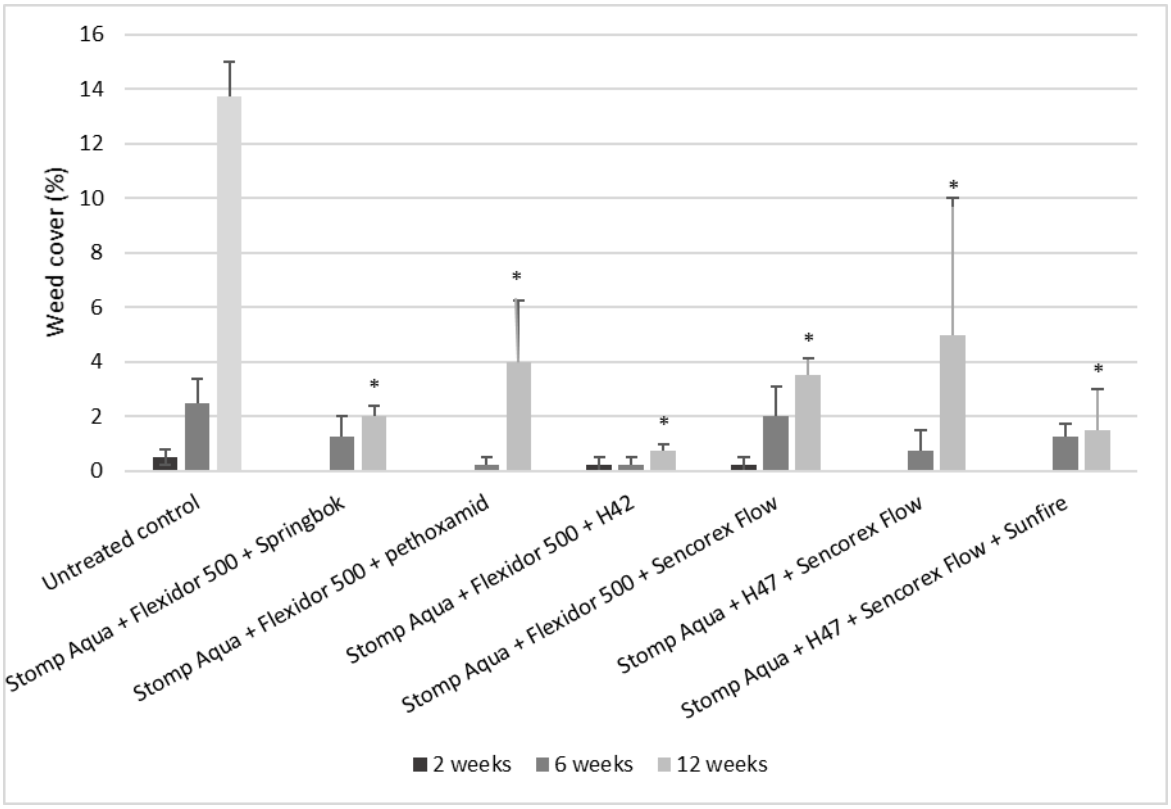

Figure 10. Weed cover (%) of budded rose plots at two, six and twelve weeks post 'heading-back' treatment (application made 06/03/18), * indicates significance at p value at 0.010.

Discussion

The post heading back treatments applied to the rose rootstocks were all effective and safe. The combination Stomp Aqua + Flexidor 500 + HDC H42 offered very good weed control in this trial, though previous work has suggested that HDC H42 can cause temporary phytotoxicity (Burgess and Atwood, 2008). However, this may be more marked when used after planting. If EAMUs are granted, HDC H43 or HDC H42 show potential as tank mix partners for Stomp Aqua + Flexidor 500.

It is important to note that label use of Flexidor 500 permits only one application per year, i.e. the use of this product after planting, post-budding and post heading back is no longer legal. Application at the earlier spray timing is suggested – weed pressure will be greater at this point – with the product then omitted from the post-budding mix with Butisan S. HDC

H47, an experimental product, appears to be a safe alternative to Flexidor 500 as a tank mix partner for rose treatment post-heading back.

Conclusions

- HDC H43 shows potential for safe use on roses in a tank mix after heading back, provided an EAMU can be granted.
- HDC H42 remains a possible treatment for post-heading back, though this product has a history of occasional damage (foliar bleaching and stunting), particularly when used after planting. There may be varietal susceptibility which has not been fully explored.

2018 Field Tree trial

Materials and methods

This budded tree herbicide trial was set up in 2018 at Frank P Matthews, Tenbury, Worcestershire, on rootstocks planted in a field of medium loam. Phytotoxicity and weed assessments were carried out at two, six and twelve weeks after treatment (WAT). Phytotoxicity was scored on a scale of 0-9; plants scoring 0 were considered dead, and 9 considered healthy, with plants scoring 7 or more considered to be of commercially acceptable quality. Weed cover was assessed as an overall percentage of the plot.

The trial evaluated six novel herbicide treatments with potential to be used in future residual herbicide programmes as post-planting alternatives to Flexidor **(Table 19)**. These included an untreated control and the following herbicides: HDC H44, HDC 45 at two rates, H47 and Sencorex Flow at two previously untested rates.

Coded actives that are promising may become available either through mutual recognition (if authorised in Europe) or EAMUs (Extension of Authorisation for Minor Use). The trial was laid out in a fully randomised block design with 4 fold replication. Each plot was 3.5 m wide and 2.4 m long and contained four species of rootstock, planted in rows spanning all plots within the trial. The species of rootstock were *Malus mm106, Prunus colt, Quince A* and *Sorbus aucuparia.* Standard and novel herbicides were applied to the respective plots using a 3.5 m boom sprayer in 400 L/ha over the top of the trees (whilst still dormant) on 14/05/18. The treatment list is shown below in **Table 19.**

Table 19: Post planting treatments, 2018 Field tree trial.

Trt. No.	**Product name**	**Active ingredient**	Rate (L/ha or kg/ha)
1	Untreated	Untreated	Untreated
2	HDC H44	Confidential	2.0 L
3	HDC H45 Low	Confidential	1.5 kg
4	HDC H45 High	Confidential	2.5 kg
5	HDC H47	Confidential	3.75 L
6	Sencorex Flow Low	metribuzin	0.875 L
7	Sencorex Flow High	metribuzin	1 L
8 to 10	Stomp Aqua	pendimethalin	2.9 L

Any large weeds were removed by hand after the 12 WAT assessment in line with grower practice prior to budding. Post budding any weeds were controlled with Diquat and Shark to clean them up prior to the top up application of residual herbicides (Flexidor 0.5 L/ha and Venzar 500 SC 0.4 L/ha).

Data was analysed by ANOVA using Genstat 18.2; significant differences from the untreated control were determined by using the LSD.

Results

Phytotoxic yellowing associated with HDC H44 resulted in slight damage 2 WAT in all species which was statistically significant; *Prunus* (score 7, p value <.001, L.S.D. 0.2294), *Malus* (score 6), *Quince* (score 7) and *Sorbus* (score 7, p value <.001, L.S.D.1.252). A slight effect was recorded in *Malus* (score 8) and very slight damage in *Sorbus* at 6 WAT (score 7, p value <.001, L.S.D.0.6882). By 12 WAT the plants had grown away from this initial damage and were all considered commercially acceptable.

Figure 11. Slight yellowing caused by HDC H44 on *Quince* 2 WAT.

Figure 12. Slight yellowing caused by HDC H44 on *Sorbus* 2 WAT.

Sencorex Flow at 1 L/ha resulted in slightly reduced growth that was statistically significant in *Prunus* 2 WAT (score 6.7, p value <.001), but by 12 WAT the growth had caught up with untreated controls and was comparable.

Sorbus treated with HDC H45 at the higher rate was slightly affected but were considered commercially acceptable throughout the trial.

At 2 weeks after treatment mean percentage weed cover in treated plots was 3.5% or less whilst weed cover in the untreated controls was 5%. All treatments resulted in significantly less weeds compared to untreated controls with the exception of Stomp Aqua at 12 WAT(p value <.001, L.S.D. 1.252)

Table 20 below shows that all of the treatments have potential for use in the production of field grown trees. All scores were above 8 and the test species were considered tolerant to the herbicides.

Table 20: Mean results 12 WAT.

Treatment	Percentage weed cover	Phytotoxicity score *Malus*	Phytotoxicity score *Prunus*	Phytotoxicity score *Quince*	Phytotoxicity score *Sorbus*
1	100	9	9	9	9

2	67.5*	9	7*	9	8.75
3	82.5*	9	9	9	9
4	25*	9	9	9	9
5	35.5*	9	9	9	8.25
6	17.8*	9	9	9	9
7	11.8*	9	7*	9	9
8	98.8	9	9	9	9
9	97.5	9	9	9	9
10	100	9	9	9	9
p value	<.001	*N/S*	<.001	*N/S*	*N/S* 0464
(27 df) **L.S.D.**	21.19	-**	0.3746	-**	0.7008

*Significantly different to untreated control.

**Within a treatment all values were the same, therefore it was not possible to carry out analysis of variance on this data.

The post budding treatments Diquat and Shark were crop safe and effective (mean weed cover in untreated plots was 19.5% compared to 2.89% in treated **(Table 21)**.

Table 21: Post budding treatments.

Trt. No.	**Treatment**	**Rate** (L/ha)	**Weed cover (%)** 4 weeks
1	Untreated	-	19.5
2 - 10	Flexidor + Venzar 500 SC	2L/ha + 0.4 L/ha	2.89*
p value			**<.001**
d.f.			**27**
L.S.D.			**2.516**

* Significantly different to untreated.

Discussion

None of the herbicide treatments in this trial showed significant or lasting signs of crop damage and all treatments were considered commercially acceptable by 6 WAT. Sencorex Flow at the 1 L/ha rate had the potential to be one of the most damaging herbicides within the trial. Growers should note that metribuzin can leach and cause damage by root uptake on some species especially on light soils after heavy rainfall so when interpreting these results, it should be borne in mind that as 2018 was a very dry year.

All treatments with the exception of Stomp Aqua provided good weed control with less than 8% weed cover on all plots 6 WAT. As expected, percentage weed cover was greatest on control plots by 12 WAT. Sencorex Flow at the high rate gave the best control which persisted to 12 WAT; other treatments lacked persistence but have demonstrated their crop safety and potential to contribute to weed control in field grown HNS. Many of the treatments tested have the potential to be taken forward into next year's trials in tank mixes with products such as Sencorex Flow (as an alternative to Flexidor) and Stomp Aqua. This will result in improved weed control with greater persistence, providing alternative options to Flexidor post-planting.

Prior to budding, any large weeds were removed by hand, after budding and after the 12 WAT assessment weeds were treated with Diquat and Shark (carfentrazone-ethyl) as a direct treatment. A standard herbicide treatment of Venzar 500 SC (0.4 L/Ha) + Flexidor (0.5 L/Ha) were applied over the top of the crop to all treatment plots (2-10). A phytotoxicity assessment was carried out a month later and no crop damage was noted.

Conclusions

Most residual herbicides are generally much safer when applied over the top of dormant trees, particularly deciduous crops. Residual herbicides bind to soil particles and are not generally taken up by plant roots. All of the products tested within this trial appear to be safe on the crops tested, and have potential for use in the production of field-grown HNS. Past experience has shown that some residual herbicides can leach through the soil profile. This highlights the importance of carrying out trials in different seasons, over a number of years, in order to get the best results. Slight reductions in the growth and girth of rootstocks prior to budding are not likely to be an issue for many growers. More caution with rates of herbicides may be needed post-heading back where there is potential to reduce the crops growth, as there is a risk of some herbicides being taken up by the crop during periods of wet weather and rapid growth, which in severe cases could impact negatively on crop value.

Hardy nursery stock herbicide screen

Materials and methods

The hardy nursery stock (HNS) herbicide trial was set up at ADAS Boxworth, Cambridgeshire, in June 2017. The trial consisted of ten representative hardy nursery stock species (

Table 22), potted up into 3 L pots with Klasman M96 peat based growing media (including 1.5 kg Osmocote Exact 5 – 6 month and 4 kg Osmocote Exact 12 – 14 month). The trial included an untreated control and four herbicide products; Flexidor 500, Sunfire, Centurion Max and Defy (**Table 23**). The treatments were tested at one or two timings, either in June 2017 (after potting), or December 2017 (when plants were dormant). Two treatments – Centurion Max and Defy – were each applied at one timing only, reflecting their likely season of use (summer and winter respectively).

The trial was set up as a randomised split block design with three replicates. Each plot contained 50 plants – five plants from each of ten species. Treatments were applied to plots using an OPS knapsack sprayer and 1 m boom at a medium spray pressure, with 02F110 nozzles applying water at a rate of 1000 L/ha. No attempt was made to wash any treatments from the foliage after application. The June treatments were applied after potting, on 06/06/17, and later treatments applied over the dormant plants, on 5th December 2017.

Data was analysed by Analysis of variance using the LSD to test for differences to the control. (Genstat 18.4).

Table 22. Species and cultivar included in hardy nursery stock trial (hereafter referred to by species).

Species	Cultivar
Azalea japonica	'Johanna'
Buddleja davidii	'Empire Blue'
Euonymus fortune	'Blondy R'
Hydrangea macrophylla	'Forever (R)'
Hypericum x moserianum	N/A
Lavandula stoechas	'Helmsdale'
Spiraea japonica	'Firelight'
Viburnum tinus	'Gwenllian'
Weigela florida	'Wine and Roses (R)'
Coreopsis verticillata	'Golden Gain'

Table 23. Treatment products and actives for hardy nursery stock trial.

Treatment		Active ingredient	Approval status	Rate (L/ha)	Timing
1	Untreated	-	-	-	-
2	Flexidor 500	500 g/L isoxaben	Label	0.25	June (post-potting)
3	Sunfire	500 g/L flufenacet	EAMU 1065/17	0.48	
4	Centurion Max	120 g/L clethodim	LTAEU	2.00	
5	Flexidor 500	500 g/L isoxaben	Label	0.25	December (over dormant crop)
6	Sunfire	500 g/L flufenacet	EAMU 1065/17	0.48	
7	Defy	800 g/L prosulfocarb	EAMU 1431/13[1]	5.00	

[1] Pre-emergence only

Results

Treatment application at potting, 06/06/17

At 2 WAT, Sunfire was the most damaging treatment, significantly affecting the following species: *Buddleja davidii* (Score 5.5, p value <0.001, L.S.D. (5df) 0.5748), *Hydrangea macrophylla* (Score 4.3, p value 0.039, L.S.D. (6df) 1.489 and *Weigelia florida* (Score 4.7, p value 0.010, L.S.D. (6df) 1.290).

Damage was in the form of curled and twisted leaves on *Buddleja*, and both *Hydrangea* and *Weigela* had scorched leaves (**Figure 3**). By 6 WAT, the quality of all species was considered commercially acceptable, with none scoring below 7.0 for phytotoxicity. The same was true for the assessment thirteen weeks after treatment.

Flexidor 500 applied at potting appeared to have scorched *Hydrangea* and *Weigela*, with average phytotoxicity scores for these treatments at 6.0 and 6.7 respectively (

Table 24). However, these scores were not significantly different to the untreated plots. These 'low' scores for the untreated plots are attributed to drought stress; the weather after potting was exceptionally hot. Flexidor 500 was found to be safe on all of the other species it was trialled on at this treatment timing, with none scoring below the commercially acceptable phytotoxicity score of 7.

After six weeks, *Hydrangea* and *Weigela* had recovered from initial scorching, with new respective scores of 8.0 and 9.0 for quality. All species that had been treated with Flexidor 500 in June 2017 appeared healthy at thirteen weeks after treatment.

Figure 13. Sunfire damage to *Hydrangea* foliage (21/07/17, 7 WAT).

Centurion Max applied at potting appeared to cause some initial scorching to *Hydrangea* and *Spiraea* (**Figure 44**), with average phytotoxicity scores of 5.3 and 6.7 respectively, 2 WAT, however it was not significant on any other species at this assessment. By 6 WAT, assessment showed all species to be of commercially acceptable quality, and both *Hydrangea* and *Spiraea* had recovered from any initial scorching.

Figure 44. Centurion Max damage to *Spiraea* foliage (pictured on 07/07/17, 5 WAT).

Table 24. Average phytotoxicity scores** for hardy nursery species, two weeks after June treatment application (assessed 21/06/17). *(NS = no significant differences)*

Species	UTC	Flexidor 500	Sunfire	Centurion Max	p value	L.S.D.
Azalea japonica	9.0	8.3	8.0	7.3	*NS*	-
Buddleja davidii	9.0	8.0	5.5*	9.0	<0.001	(5df) 0.5748
Euonymus fortune	9.0	8.3	8.7	8.3	*NS*	-
Hydrangea macrophylla	6.7	6.0	4.3*	5.3	0.039	(6df) 1.489
Hypericum x moserianum	9.0	8.7	8.0	8.3	*NS*	-
Lavandula stoechas	9.0	9.0	9.0	9.0	*NS*	-
Spiraea japonica	9.0	9.0	7.0	6.7	*NS*	-
Viburnum tinus	9.0	8.0	9.0	9.0	*NS*	-
Weigela florida	7.3	6.7	4.7*	6.7	0.010	(6df) 1.290
Coreopsis verticillata	9.0	9.0	9.0	9.0	*NS*	-

** *phytotoxicity scale of zero to nine; plants scoring zero considered dead, and nine considered healthy, with those scoring seven or more considered to be of commercially acceptable quality.*

* *Significantly different to untreated.*

Treatment application over dormant plants, 05/12/17

The trial was assessed for phytotoxicity damage at 2, 6 and 19 WAT (due to prolonged dormancy due to a late spring) application. None of the treated plants differed significantly in terms of crop quality from the untreated plants – no notable damage was observed, and all treatments appear crop safe (*see Appendix, section 4.2 – December treatment results*).

Discussion

None of the treatments tested caused long-term damage to any of the ten species when applied after potting. However, growers should be aware of the possibility of short-term scorch from Flexidor 500 on *Hydrangea* and *Weigela*; from Sunfire on *Buddleja*, *Hydrangea* and *Weigela*; and from Centurion Max on *Hydrangea* and *Spiraea*.

When applied over dormant plants, none of the treatments appeared to cause notable damage to any of the plant species.

Conclusions

New products Sunfire and Centurion Max show potential for use over foliage on a range of ten representative HNS subjects. Slight initial scorch on a few subjects suggests that growers should be prepared for some varietal susceptibility and there is a need for further testing before these products are adopted for wide scale use. Also, a renewal of off-label approval for Centurion Max would be required before further use in HNS.

Similarly, products Sunfire and Defy applied as dormant season treatments appear crop safe, and are recommended for taking forward to future trials work.

Hardy nursery stock container trial 2018

Materials and methods

The HNS herbicide trial was set up at Wyevale nurseries, Herefordshire, in June 2018. The trial consisted of ten representative hardy nursery stock species (

Table 25), potted up into 2 or 3 L pots with Klasman M96 peat based growing media (including 1.5 kg Osmocote Exact 5 – 6 month and 4 kg Osmocote Exact 12 – 14 month). The trial included an untreated control, a mulch (Sinclair pot topper) and eight herbicide products: Centurion Max, Flexidor 500, Sunfire, Venzar 500 SC, Springbok and three coded products (HDC H43, HDC H44 & HDC H46) (**Table 6**). The treatments were tested at one or two timings, either in June 2018 (after potting), or October 2018 (as a top up application). Any weeds were removed before residual herbicides were applied.

The trial was set up as a randomised split block design with three replicates. Each plot contained 50 plants – five plants from each of ten species. Treatments were applied to plots using an OPS knapsack sprayer and 1m boom at a medium spray pressure, with 02F110 nozzles applying water at a rate of 1000 L/ha. No attempt was made to wash any treatments from the foliage after application. The June treatments were applied after potting, on 04/06/18, and later treatments applied as top up applications to maintain weed control, on 16/10/18.

Phytotoxicity was assessed at two, seven, and thirteen (June treatments) and again at three, six and twelve (October treatments) weeks after the herbicide treatments were applied. Phytotoxicity was assessed by examining plants for any signs of herbicide damage (e.g. twisting, scorching, stunting), comparing treated plots to untreated, and scoring quality on a scale of zero to nine; plants scoring zero were considered dead, and nine considered healthy, with those scoring seven or more considered to be of commercially acceptable quality.

Data was analysed by ANOVA using Genstat 18.2; significant differences from the untreated control were determined by using the LSD.

Table 25. Species and cultivars included in hardy nursery stock container trial 2018 (hereafter referred to by species).

Species	Cultivar
Buxus sempervirens	
Ceanothus thyrsiflorus	'Skylark'
Cistus x purpureus	
Cornus Alba	'Red Selection'

Euonymus japonicus	'Green Rocket'
Hydrangea paniculata	'Limelight'
Ilex aquifolium	
Olearia x haastii	
Perovskia atriplicifolia	'Blue Spire'
Sambucus nigra	'Black Lace'

Table 26. Treatment list, active ingredients and timings for the hardy nursery stock container herbicide trial.

Treatment		**Active ingredient**	**Approval status**	**Rate** (L/ha)	**Timing**
1	Untreated	-	-	-	-
2	Sinclair pot topper	Physical mulch	-	3 cm depth	June (post-potting)
3	HDC H46	Confidential	Not approved	0.1	
4	HDC H44	Confidential	Not approved	1.5	
5	Flexidor	isoxaben 500 g/L	Label	0.5	
6	Flexidor + Centurion Max	isoxaben 500 g/L + clethodim 120 g/L	Label + LTAEU	0.5 + 2.0	
7	Flexidor + HDC H43	isoxaben 500 g/L + pethoxamid	Label + Not approved	0.5+ 2.0	
8	Flexidor + Sunfire	isoxaben 500 g/L flufenacet 500 g/L	Label + EAMU 1065/17	0.5 + 0.48	
1	Untreated	-	-	-	-
2	Untreated	-	-	-	October top up
3	Springbok + HDC H43	dimethanid-p + metazachlor + pethoxamid	EAMU 2108/15 + Not approved	1.6 + 2	
4	Springbok + HDC H43	dimethanid-p + metazachlor + pethoxamid	EAMU 2108/15 + Not approved	1.6 + 2	
5	Springbok	dimethanid-p + metazachlor	EAMU 2108/15	1.6	
6	HDC H43	pethoxamid	Not approved	2	
7	Venzar 500 SC	Lenacil	EAMU	0.4	
8	Springbok + HDC H43 + Venzar 500 SC	dimethanid-p + metazachlor + pethoxamid + lenacil	EAMU 2108/15 + Not approved +	1.6 + 2 + 0.4	

			EAMU		

Results

Table 27: Average phytotoxicity scores* for hardy nursery species, two weeks after June treatment application (assessed 21/06/18). *(NS = no significant differences)*

Species	UTC	Sinclair pot topper	HDC H46	HDC H44	Flexidor	Flexidor + Centurion Max	Flexidor + HDC H43	Flexidor + Sunfire	p value	L.S.D.
Buxus sempervirens	9	9	9	9	9	9	9	9	*(NS)*	-
Ceanothus thyrsiflorus	9	9	4	2	9	5	6	6	*(NS)*	-
Cistus x purpureus	9	9	6	6	9	9	9	9	*(NS)*	-
Cornus alba	9	9	4	4	5	4	6	6	*(NS)*	-
Euonymus japonicus	9	9	4*	6*	9	9	9	5*	*<.001*	0.6191
Hydrangea paniculata	9	9	4	4	7	6	6	6	*(NS)*	-
Ilex aquifolium	9	9	6	9	9	9	9	9	*(NS)*	-
Olearia x haastii	9	9	9	7	9	9	7	9	*(NS)*	-
Perovskia atriplicifolia	9	9	4*	5.3*	7*	7*	4*	4*	*<.001*	0.7149
Sambucus nigra	9	9	6	9	6	6	6	6	*(NS)*	-

* Significantly different to untreated.

Treatment application at potting, 04/06/18

At 2 WAT, Flexidor applied post-potting appeared to have scorched *Cornus* and *Sambucus*, with average phytotoxicity scores for these treatments at 5.0 and 6.0 respectively (

Appendix 2 – Budded rose trial – post heading back trial

Table27). Flexidor caused a significant reduction in the quality of *Perovskia* which had a score of 7 (p value <.001, L.S.D. 0.7149). Flexidor was found to be safe on all of the other species tested at this treatment timing, with none scoring below the commercially acceptable phytotoxicity score of 7.

By 7 WAT, *Cornus* and *Sambucus* had recovered from the initial scorching, with new respective scores of 7.0 and 9.0 (

Appendix 2 – Budded rose trial – post heading back trial

Table28). *Cornus* had fully recovered by 13 WAT. *Perovskia* did not grow away from the damage recorded 7 WAT and were still slightly damaged by Flexidor 13 WAT and were not considered to be commercially acceptable. Damage on *Ceanothus* caused by Flexidor also took a long time to show, although the plants were commercially acceptable throughout the trial. Nine of the ten species that had been treated with Flexidor in June 2018 were considered commercially acceptable at 13 weeks after treatment.

The new herbicide HDC H46 was more damaging than Flexidor; all of the species except *Buxus* and *Olearia* were damaged and scored below 7.0 at 2 WAT, interestingly both *Buxus* and *Olearia* were tolerant of HDC H46 and were comparable with untreated controls. By the second assessment (7 WAT) all species were growing away from initial damage caused by HDC H46 and two of the ten species treated were considered commercially acceptable (**Table 28**). By 13 WAT six of the ten species treated were considered commercially acceptable (**Table 29)**.

Figure 15. *Perovskia* 2 WAT with HDC H46

Figure 16. Distortion on *Cistus* 2 WAT with HDC H46

Figure 17. Scorch on *Hydrangea* 2 WAT with HDC H46

Figure 18. Yellowing on *Euonymus* 2 WAT with HDC H46

The new herbicide HDC H44 resulted in initial phytotoxic yellowing that was commercially unacceptable on six of the ten test species when assessed 2 WAT (see **Table 27)**. Of the six species that were commercially unacceptable two of these (*Euonymus japonicus* and *Perovskia* atriplicifolia) were statistically significant (see **Table 27**) for p values and L.S.D. Damage did not show on *Ilex* until after the 13 WAT assessment and initial damage on *Olearia* got significantly worse by the 7 WAT assessment (p value <.001, L.S.D. 1.072) and did not recover by the 13 WAT assessment (see **Table 29**). Significant damage was recorded on *Ceanothus, Hydrangea* and *Perovskia* 7 WAT (see **Table 28 for** p value and L.S.D**.).** By 13 WAT damage was still considered unacceptable on half of the plant species tested.

Figure 19. Yellowing on *Ceanothus* 2WAT with HDC H44

Figure 20. Yellowing on *Hydrangea* 2WAT with HDC H44

Figure 21. Yellowing on *Cornus* 2 WAT with HDC H44

Figure 22. Yellowing on *Euonymus* 2 WAT with HDC H44

Figure 23. Yellowing on *Olearia* 13 WAT with HDC H44

Figure 24. Yellowing on *Ilex* 13 WAT with HDC H44

Flexidor tank mixed with either Centurion Max, HDC H43 or Sunfire resulted in increased phytotoxicity 2 WAT on *Ceanothus* and *Hydrangea*, compared to Flexidor alone but this was not significant. The tank mix of Flexidor and Centurion Max also resulted in slightly more damage on *Cornus* 2 WAT, however this was not significant. Flexidor tank mixed with HDC H43 or Sunfire resulted in increased damage on *Perovskia* compared to Flexidor alone at 2 WAT. All herbicides applied to *Perovskia* in June resulted in significant damage that persisted until 13 WAT (see **Table 29** for individual p values and L.S.D.). By 7 WAT the majority of species treated with these tank mixes had started to recover and by 13 WAT (**Table 29**) the majority of species were considered commercially acceptable.

Table 28. Average phytotoxicity scores for hardy nursery species, seven weeks after June treatment application (assessed). *(NS = no significant differences)*

Species	UTC	Sinclair pot topper	HDC H46	HDC H44	Flexidor	Flexidor + Centurion Max	Flexidor + HDC H43	Flexidor + Sunfire	p value	L.S.D.
Buxus sempervirens	9	9	9	9	9	9	9	9	*(NS)*	-
Ceanothus thyrsiflorus	9	9	4*	2*	9	5*	6*****	6*	*<.001*	1.787
Cistus x purpureus	9	9	6*	9	9	9	9	9	*<.001*	0.3575
Cornus alba	9	9	4	4	5	4	6	6	*(NS)*	-
Euonymus japonicus	9	9	4	6	9	9	9	5	*(NS)*	-
Hydrangea paniculata	9	9	4*	4*	7*	6*	6*	6*	*<.001*	0.3575
Ilex aquifolium	9	9	6*	9	9	9	9	9	*<.001*	1.430
Olearia x haastii	9	9	9	7*	9	9	7*	9	*<.001*	1.072
Perovskia atriplicifolia	9	9	4*	5.3*	7*	7*	4*	4*	*<.001*	0.7761

Perovskia was an exception where damage would have rendered *Perovskia* unsaleable*.* The tank mix of Flexidor + Sunfire was the most damaging compared to Flexidor as four (*Ceanothus, Hydrangea, Perovskia* and *Sambucus)* of the ten species were considered commercially unacceptable 13 WAT. Of these four *Ceanothus, Perovskia* and *Sambucus* were significantly different to untreated controls (see **Table 29** for individual p values and L.S.D.)

The Sinclair pot topper was included as a mulch for comparison and delivered good persistent weed control; it was applied in line with the supplier's recommendation to apply the mulch to a depth of 3 cm. Low levels of liverwort *Marchantia polymorpha)* were present at 13 weeks after treatment along with the odd willow *(Salix caprea)* and bittercress *(Cardamine hirsuta)* seedlings*.*

Table 29. Average phytotoxicity scores for HNS species, 13 WAT application (assessed 04/09/18). *(NS = no significant differences)*

Species	UTC	Sinclair pot topper	HDC H46	HDC H44	Flexidor	Flexidor + Centurion Max	Flexidor + HDC H43	Flexidor + Sunfire	p value	L.S.D.
Buxus sempervirens	9	9	9	9	9	9	9	9	*(NS)*	-
Ceanothus thyrsiflorus	9	9	6*	4*	7.3	8	7*	6.3*	*<.001*	1.813
Cistus x purpureus	9	9	9	6*	9	9	9	9	*0.006*	1.430
Cornus alba	9	9	9	9	9	9	9	9	*(NS)*	-
Euonymus japonicus	9	9	9	7	9	9	9	9	*(NS)*	-
Hydrangea paniculata	9	9	6	7	8	8	8	6	*(NS)*	-
Ilex aquifolium	9	9	9	6.3*	9	9	9	9	*0.025*	1.558
Olearia x haastii	9	9	9	4*	8	9	8	9	*<.001*	1.072
Perovskia atriplicifolia	9	9	6.3*	6*	6*	6.3*	6*	5.3*	*<.001*	0.6619
Sambucus nigra	9	9	6*	9	9	7*	6*	4.6*	*<.001*	0.7149

* Significantly different to untreated.

Top up applications, October 2018

Any weeds were removed from the pots by hand before top up applications were applied, in line with standard nursery practice. Post-treatment the trial was assessed for phytotoxicity damage at 3, 6 and 12 WAT. Plants were barely affected by the treatments, all of which were considered commercially acceptable at 3 WAT, with the exception of *Ilex* 3 WAT treated with Springbok + H43 + Venzar 500 SC (see *Appendix 5.2*, **Table 1**, October treatments.).

Discussion

Crop safety of residual herbicides typically relates to plant species; this trial has developed options for some HNS species that should improve the robustness of weed control with residual herbicides. The foliage of treated plants was dry at the point of application and herbicides were not washed off the foliage with overhead irrigation, this technique (10 mm of irrigation post application) could be adopted by growers to help minimise crop damage associated with some of the treatments.

The new herbicide HDC H46 has potential for use on species including *Buxus sempervirens, Cistus x purpureus, Cornus alba, Euonymus japonicus, Ilex aquifolium, Olearia haastii* and gives control of a useful range of common weeds of container nurseries. Short term scorch may be a problem on some species such as *Euonymus japonicus.*

Where Flexidor alone at 0.5 L/ha was too damaging it may still have potential to be crop safe at 0.25 L/Ha, this is known to be the case for *Ceanothus.*

Sinclair pot topper delivered good weed control throughout the trial compared to the untreated controls and was comparable to the herbicide programmes. Although liverwort was present 13 WAT, this was on pots of plant species with a lower water demand such as *Buxus sempervirens;* due to the hot, dry summer, high levels of irrigation had been applied. As a result some of the plants with a lower irrigation demand were on the wet side at times, favouring liverwort growth. For further information on liverwort control refer to HNS 93 which looked at lenacil for control of liverwort in containers.

Growers should be aware of the possibility of short term scorch from Flexidor 500 + Centurion Max on *Ceanothus, Hydrangea* and *Sambucus;* from Flexidor + HDC H43 on *Hydrangea* and Flexidor + Sunfire on *Euonymus*.

When top up treatments were applied in October, none of the treatments with the exception of Springbok + HDC H43 + Venzar 500 SC (*Ilex* not commercially acceptable) caused notable damage to any of the plant species.

Conclusions

Sensitive species such as *Perovskia* should only be treated with herbicides where crop safety has been proven, alternatively cultural methods and pot toppers are likely to deliver crop safe weed control on such species.

New products Sunfire and Centurion Max have shown potential for use either alone or in a tank mixture with Flexidor over foliage on some of the species tested. Sunfire is a useful tank mix partner for Flexidor where annual meadow grass *(Poa annua)* and pearlwort *(Sagina procumbens) a*re a problem (as a pre-emergence treatment). Centurion Max is a useful addition to Flexidor or as a standalone treatment for post emergence control of annual meadow grass *(Poa annua)*. Some scorch on a few subjects suggests that growers should be prepared for some varietal susceptibility and there is a need for further testing before these products are adopted for wide scale use.

Another potential tank mix partner for Flexidor is HDC H43 (for residual control of Groundsel) which has potential as a tank mix partner with Flexidor however an EAMU is required for HDC H43 to be used in ornamental plant production.

If authorised for use in ornamentals, HDC H46 has potential as a residual herbicide in programmes with Flexidor. HDC H46 should provide residual control of the majority of the main weeds of container nurseries, although there is a need for more work to continue to build information relating to the crop safety of this herbicide within container HNS production.

Whilst HDC H44 is effective against annual meadow grass *(Poa annua)* and groundsel *Senecio vulgaris),* caution is required as phytotoxic damage can take a long time to show on evergreens and seems to persist for a long time on some crops. Therefore HDC H44 may be of limited use whilst safer alternatives for annual meadow grass control are available. Springbok, HDC H43 and Venzar 500 SC applied as top up treatments when the foliage has hardened appear crop safe on the species tested.

If an improved EAMU can be obtained, Defy could be a partial alternative to Devrinol (napropamide) as a winter treatment for container grown hardy nursery stock.

References

Atwood, J. (2015). Herbicide screening for ornamental plant production (nursery stock, cut flowers and wallflowers). Horticultural Development Company Final report for project HNS/PO 192.

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Atwood, J. (2016). Herbicide screening for ornamental plant production (nursery stock, cut flowers and wallflowers). Horticultural Development Company Final report for project HNS/PO 192a.

Burgess, C. M and Atwood, J. (2008). Triazine-free herbicide programmes. Horticultural Development Company report for project HNS 132

Appendices

Appendix 1 – Budded rose trial

Table 1. Percentage weed cover of budded rose plots two (30/03/2017), six (26/04/17) and nine weeks (18/05/17) after planting treatment application

Trt. No.	Treatment	Rate (L/ha)	Weed cover (%) 2 weeks	Weed cover (%) 6 weeks	Weed cover (%) 9 weeks
1, 4	Untreated	N/A	0.88	5.00	30.63
2	Stomp Aqua + Flexidor 500 + Venzar Flowable	2.9 + 0.5 + 3.0	*0.25	*0.75	*2.50
3	Stomp Aqua + Flexidor 500 + HDC H43	2.9 + 0.5 + 2.0	1.00	*1.00	*3.75
5 – 8	Stomp Aqua + Flexidor 500 + Sencorex Flow	2.9 + 0.5 + 0.73	*0.16	*0.25	*0.69
9	Stomp Aqua + Venzar Flowable + Sencorex Flow	2.9 + 3.0 + 0.73	*0.25	*0.25	*0.75
p value			**<0.001**	**<0.001**	**<0.001**
d.f.			**28**	**28**	**28**
L.S.D.			**0.4229**	**0.4358**	**4.818**

* Significantly different to untreated.

Table 2. Percentage weed cover of budded rose plots two weeks after follow-up treatment application (31/05/17).

Trt. No.	Treatment	Rate (L or kg/ha)	Weed cover (%)
1-5, 9	Untreated	N/A	36.88
6	Logo + Mero (adjuvant)	0.075 + 2.0	*0.25
7	Logo + Mero (adjuvant) + Betanal maxxPro	0.075 + 2.0 + 1.5	*0.50
8	Betanal maxxPro	1.5	*0.50
p value			**<0.001**
d.f.			**13**
L.S.D.			**17.30**

* Significantly different to untreated.

Table 3. Percentage weed cover of budded rose plots 2, 6 and 10 weeks after budding treatment application.

Trt. No.	**Treatment**	**Rate** (L/ha)	**Weed cover (%)** 2 WAT (14/07/17)	**Weed cover (%)** 6 WAT (10/08/17)	**Weed cover (%)** 10 WAT (08/09/2017)
1	Untreated	N/A	4.00	27.50	57.50
2, 4 – 9	Flexidor 500 + Butisan S	0.5 + 1.5	*0.25	*1.29	*4.30
3	Flexidor 500 + HDC H43	0.5 + 2.0	*0.00	*1.00	*3.00
p value			**<0.001**	**<0.001**	**<0.001**
d.f.			**30**	**30**	**30**
L.S.D.			**0.770**	**2.595**	**6.64**

Appendix 2 – Budded rose trial – post heading back trial

Table 1. Percentage weed cover of budded rose plots 2, 6 and 12 weeks after post-heading-back treatment application. *(NS = not significant)*

Trt. No.	**Treatment**	**Rate** (L/ha)	**Weed cover (%)** 2 WAT (21/03/18)	**Weed cover (%)** 6 WAT (16/04/18)	**Weed cover (%)** 12 WAT (28/05/18)
1	Untreated	N/A	0.50	2.50	13.75
2	Stomp Aqua + Flexidor 500 + Springbok	2.0 + 0.5 + 1.25	0.00	1.25	*2.00
3	Stomp Aqua + Flexidor 500 + HDC H43	2.0 + 0.5 + 2.0	0.00	0.25	*4.00
4	Stomp Aqua + Flexidor 500 + HDC H42	2.0 + 0.5 + 1.5	0.25	0.25	*0.75
5	Stomp Aqua + Flexidor 500 + Sencorex Flow	2.0 + 0.5 + 0.44	0.25	2.00	*3.50
6	Stomp Aqua + HDC H47 + Sencorex Flow	2.0 + 3.75 + 0.44	0.00	0.75	*5.00
7	Stomp Aqua + HDC H47 + Sencorex Flow + Sunfire	2.0 + 3.75 + 0.44 + 0.48	0.00	1.25	*1.50
p value			*(NS)* **0.179**	*(NS)* **0.261**	**0.010**
d.f.			**18**	**18**	**18**
L.S.D.			**0.4488**	**2.120**	**6.507**

* Significantly different to untreated.

Appendix 3 – 2018 Field Tree trial

Table 1. Percentage weed cover, 2, 6 and 12 WAT

Trt. No.	Treatment	Rate (L/ha)	Weed cover (%) 2 weeks	Weed cover (%) 6 weeks	Weed cover (%) 12weeks
1	Untreated	-	5	94.2	100
2	HDC H44	2.0 L/ha	1.25*	7.8*	67.5*
3	HDC H45	1.5 kg/ha	2.5*	7.8*	82.5*
4	HDC H45	2.5 kg/ha	1.25*	2.8*	25*
5	HDC H47	3.75 L/ha	1.5*	3.8*	35.5*
6	Sencorex Flow	0.875 L/ha	2.5*	2.5*	17.8*
7	Sencorex Flow	1 L/ha	2*	1.5*	11.8*
8	Stomp Aqua	2.9 L/ha	2.5*	28.2*	98.8
9	Stomp Aqua	2.9 L/ha	3*	30*	97.5
10	Stomp Aqua	2.9 L/ha	3.5*	32.5*	100
p value			**<.001**	**<.001**	**<.001**
d.f.			**27**	**27**	**27**
L.S.D.			**1.252**	**10.22**	**21.19**

* Significantly different to untreated.

Table 2. Average phytotoxicity scores for *Malus*, assessed 2, 6 and 12 WAT. *(NS = no significant differences)*

Trt. No.	Planting	Rate (Kg/ha or L/ha)	Phytotoxicity score 2 weeks	Phytotoxicity score 6 weeks	Phytotoxicity score 12 weeks
1	Untreated	-	9	9	9
2	HDC H44	2.0 L/ha	6*	8*	9
3	HDC H45	1.5 kg/ha	9	9	9
4	HDC H45	2.5 kg/ha	9	9	9
5	HDC H47	3.75 L/ha	9	9	9
6	Sencorex Flow	0.875 L/ha	9	9	9
7	Sencorex Flow	1 L/ha	9	9	9
8	Stomp Aqua	2.9 L/ha	9	9	9
9	Stomp Aqua	2.9 L/ha	9	9	9
10	Stomp Aqua	2.9 L/ha	9	9	9

*Within a treatment all values were the same therefore it was not possible to carry out analysis of variance on this data. Treatment 2 (HDC 44) was significantly different from all other treatments at 2 & 6 WAT.

Table 3. Average phytotoxicity scores for *Prunus*, assessed 2, 6 & 12 WAT. *(NS = no significant differences)*

Trt. No.	Planting	Rate (Kg/ha or L/ha)	Phytotoxicity score 2 weeks	Phytotoxicity score 6 weeks	Phytotoxicity score 12 weeks
1	Untreated	-	9	9	9
2	HDC H44	2.0 L/ha	7*	9	7*
3	HDC H45	1.5 kg/ha	9	9	9
4	HDC H45	2.5 kg/ha	9	9	9
5	HDC H47	3.75 L/ha	9	9	9
6	Sencorex Flow	0.875 L/ha	9	9	9
7	Sencorex Flow	1 L/ha	6.7*	8.25*	7*
8	Stomp Aqua	2.9 L/ha	9	9	9
9	Stomp Aqua	2.9 L/ha	9	9	9
10	Stomp Aqua	2.9 L/ha	9	9	9
		p value	<.001	0.034	<.001
		(27 df) **L.S.D.**	0.2294	0.4393	0.3746

* Significantly different to untreated.

Table 4. Average phytotoxicity scores for Quince, assessed 2, 6 & 12 WAT. *(NS = no significant differences)*

Trt. No.	Planting	Rate (Kg/ha or L/ha)	Phytotoxicity score 2 weeks	Phytotoxicity score 6 weeks	Phytotoxicity score 12 weeks
1	Untreated	-	9	9	9
2	HDC H44	2.0 L/ha	7*	9	9
3	HDC H45	1.5 kg/ha	9	9	9
4	HDC H45	2.5 kg/ha	9	9	9
5	HDC H47	3.75 L/ha	9	9	9
6	Sencorex Flow	0.875 L/ha	9	9	9
7	Sencorex Flow	1 L/ha	9	9	9
8	Stomp Aqua	2.9 L/ha	9	9	9
9	Stomp Aqua	2.9 L/ha	9	9	9
10	Stomp Aqua	2.9 L/ha	9	9	9

***** Within a treatment all values were the same therefore it was not possible to carry out an analysis of variance on this data. Treatment 2 (HDC H44) was significantly different from all other treatments at 2WAT.

Table 5. Average phytotoxicity scores for Sorbus, assessed 2, 6 & 12 WAT. *(NS = no significant differences)*

Trt. No.	**Planting**	**Rate** (Kg/ha or L/ha)	**Phytotoxicity score** 2 weeks	**Phytotoxicity score** 6 weeks	**Phytotoxicity score** 12 weeks
1	Untreated	-	9	9	9
2	HDC H44	2.0 L/ha	7*	7*	8.75
3	HDC H45	1.5 kg/ha	9	9	9
4	HDC H45	2.5 kg/ha	9	9	9
5	HDC H47	3.75 L/ha	8.25	8.25	8.25
6	Sencorex Flow	0.875 L/ha	9	9	9
7	Sencorex Flow	1 L/ha	9	9	9
8	Stomp Aqua	2.9 L/ha	9	9	9
9	Stomp Aqua	2.9 L/ha	9	9	9
10	Stomp Aqua	2.9 L/ha	9	9	9
		p value	<.001	<.001	*(NS)* 0.464
		(27 df) **L.S.D.**	1.252	0.6882	0.7008

* Significantly different to untreated.

Table 6. Top up treatments applied post budding

Trt. No.	**Treatment**	**Rate** (L/ha)	**Weed cover (%)** 4 weeks
1	Untreated	-	19.5
2 - 10	Flexidor + Venzar 500 SC	2L/ha + 0.4 L/ha	2.89*
p value			**<.001**
d.f.			**27**
L.S.D.			**2.516**

* Significantly different to untreated.

Table 7. Average phytotoxicity scores for *Malus, Prunus, Quince* and *Sorbus*, 4 WAT top up application. *(NS = no significant differences)*

Trt. No.	**Planting**	**Rate** (Kg/ha or L/ha)	**Phytotoxicity score** 2 weeks	**Phytotoxicity score** 6 weeks	**Phytotoxicity score** 12 weeks

1	Untreated	-	9	9	9
2	HDC H44	2.0 L/ha	9	9	9
3	HDC H45	1.5 kg/ha	9	9	9
4	HDC H45	2.5 kg/ha	9	9	9
5	HDC H47	3.75 L/ha	9	9	9
6	Sencorex Flow	0.875 L/ha	9	9	9
7	Sencorex Flow	1 L/ha	9	9	9
8	Stomp Aqua	2.9 L/ha	9	9	9
9	Stomp Aqua	2.9 L/ha	9	9	9
10	Stomp Aqua	2.9 L/ha	9	9	9
		p value	*(NS)*	*(NS)*	*(NS)*
		(27df) **L.S.D.**	-	-	-

Appendix 4 – nursery herbicide screen

4.1 – June treatment results

** Phytotoxicity scale of zero to nine; plants scoring zero considered dead, and nine considered healthy, with those scoring seven or more considered to be of commercially acceptable quality.*

Table 1. Average phytotoxicity scores* for hardy nursery species, six weeks after June treatment application (assessed 21/07/17). *(NS = no significant differences)*

Species	UTC	Flexidor 500	Sunfire	Centurion Max	p value	L.S.D.
Azalea japonica	9.0	9.0	9.0	9.0	*NS*	-
Buddleja davidii	9.0	9.0	8.7	9.0	*NS*	-
Euonymus fortune	9.0	9.0	9.0	9.0	*NS*	-
Hydrangea macrophylla	8.0	8.0	7.0	8.0	*NS*	-
Hypericum x moserianum	9.0	9.0	9.0	9.0	*NS*	-
Lavandula stoechas	9.0	8.7	9.0	9.0	*NS*	-
Spiraea japonica	9.0	8.3	7.7	8.7	*NS*	-
Viburnum tinus	9.0	8.0	9.0	8.7	*NS*	-
Weigela florida	9.0	9.0	9.0	9.0	*NS*	-
Coreopsis verticillata	9.0	9.0	9.0	9.0	*NS*	-

Table 2. Average phytotoxicity scores* for hardy nursery species, thirteen weeks after June treatment application (assessed 04/09/17). *(NS = no significant differences)*

Species	UTC	Flexidor 500	Sunfire	Centurion Max	p value	L.S.D.

Azalea japonica	9.0	9.0	9.0	9.0	*NS*	-
Buddleja davidii	9.0	9.0	9.0	9.0	*NS*	-
Euonymus fortune	9.0	9.0	9.0	9.0	*NS*	-
Hydrangea macrophylla	9.0	9.0	8.3	9.0	*NS*	-
Hypericum x moserianum	9.0	9.0	8.7	9.0	*NS*	-
Lavandula stoechas	9.0	9.0	9.0	9.0	*NS*	-
Spiraea japonica	9.0	9.0	8.7	8.7	*NS*	-
Viburnum tinus	9.0	8.7	9.0	9.0	*NS*	-
Weigela florida	9.0	9.0	9.0	9.0	*NS*	-
Coreopsis verticillata	9.0	9.0	9.0	9.0	*NS*	-

4.2 – December treatment results

Table 1. Average phytotoxicity scores* for hardy nursery species, two weeks after December treatment application (assessed 18/01/2017). *(NS = no significant differences)*

Species	UTC	Flexidor 500	Sunfire	Defy	p value	L.S.D.
Azalea japonica	8.3	8.3	8.3	7.7	*NS*	-
Buddleja davidii	8.3	8.7	8.0	8.0	*NS*	-
Euonymus fortune	8.7	9.0	8.7	9.0	*NS*	-
Hydrangea macrophylla	8.0	7.3	8.3	6.3	*NS*	-
Hypericum x moserianum	8.7	8.0	8.3	8.3	*NS*	-
Lavandula stoechas	9.0	8.0	9.0	8.7	*NS*	-
Spiraea japonica	9.0	8.7	8.7	9.0	*NS*	-
Viburnum tinus	9.0	9.0	9.0	9.0	*NS*	-
Weigela florida	9.0	9.0	9.0	9.0	*NS*	-
Coreopsis verticillata	9.0	9.0	9.0	9.0	*NS*	-

Table 2. Average phytotoxicity scores** for hardy nursery species, six weeks after December treatment application (assessed 15/01/18). *(NS = no significant differences)*

Species	UTC	Flexidor 500	Sunfire	Defy	p value	L.S.D.

Azalea japonica	9.0	9.0	8.7	8.7	*NS*	-
Buddleja davidii	8.3	8.0	7.7	8.0	*NS*	-
Euonymus fortune	9.0	8.3	8.7	8.3	*NS*	-
Hydrangea macrophylla	9.0	9.0	9.0	9.0	*NS*	-
Hypericum x moserianum	8.3	8.3	8.7	8.7	*NS*	-
Lavandula stoechas	9.0	7.7	8.0	7.7	*NS*	-
Spiraea japonica	9.0	9.0	9.0	9.0	*NS*	-
Viburnum tinus	9.0	8.7	7.7	8.3	*NS*	-
Weigela florida	9.0	9.0	9.0	9.0	*NS*	-
Coreopsis verticillata	9.0	9.0	9.0	9.0	*NS*	-

Table 3. Average phytotoxicity scores** for hardy nursery species, nineteen weeks after December treatment application (assessed 17/04/18). *(NS = no significant differences)*

Species	UTC	Flexidor 500	Sunfire	Defy	p value	L.S.D.
Azalea japonica	9.0	9.0	9.0	9.0	*NS*	-
Buddleja davidii	9.0	8.7	9.0	9.0	*NS*	-
Euonymus fortune	9.0	9.0	8.7	9.0	*NS*	-
Hydrangea macrophylla	9.0	8.3	8.3	8.7	*NS*	-
Hypericum x moserianum	9.0	9.0	9.0	9.0	*NS*	-
Lavandula stoechas	9.0	9.0	9.0	9.0	*NS*	-
Spiraea japonica	9.0	8.3	8.3	8.7	*NS*	-
Viburnum tinus	9.0	8.7	8.7	8.7	*NS*	-
Weigela florida	9.0	9.0	9.0	9.0	*NS*	-
Coreopsis verticillata	9.0	9.0	9.0	9.0	*NS*	-

Appendix 5 – Hardy nursery stock container trial 2018

5.1 – June treatment results

** Phytotoxicity scale of zero to nine; plants scoring zero considered dead, and nine considered healthy, with those scoring seven or more considered to be of commercially acceptable quality.*

Table 1. Average phytotoxicity scores for hardy nursery species, two weeks after June treatment application (assesse). *(NS = no significant differences)*

Species	UTC	Sinclair pot topper	HDC H46	HDC H44	Flexidor	Flexidor + Centurion Max	Flexidor + HDC H43	Flexidor + Sunfire	p value	L.S.D.
Buxus sempervirens	9	9	9	9	9	9	9	9	*(NS)*	-
Ceanothus thyrsiflorus	9	9	4	2	9	5	6	6	*(NS)*	-
Cistus x purpureus	9	9	6	6	9	9	9	9	*(NS)*	-
Cornus alba	9	9	4	4	5	4	6	6	*(NS)*	-
Euonymus japonicus	9	9	4*	6*	9	9	9	5*	*<.001*	0.6191
Hydrangea paniculata	9	9	4	4	7	6	6	6	*(NS)*	-
Ilex aquifolium	9	9	6	9	9	9	9	9	*(NS)*	-
Olearia x haastii	9	9	9	7	9	9	7	9	*(NS)*	-
Perovskia atriplicifolia	9	9	4*	5.3*	7*	7*	4*	4*	*<.001*	0.7149
Sambucus nigra	9	9	6	9	6	6	6	6	*(NS)*	-

* Significantly different to untreated.

Table 2. Average phytotoxicity scores for hardy nursery species, seven weeks after June treatment application (assessed). *(NS = no significant differences)*

Species	UTC	Sinclair pot topper	HDC H46	HDC H44	Flexidor	Flexidor + Centurion Max	Flexidor + HDC H43	Flexidor + Sunfire	p value	L.S.D.
Buxus sempervirens	9	9	9	9	9	9	9	9	*(NS)*	-
Ceanothus thyrsiflorus	9	9	4*	2*	9	5*	6*	6*	*<.001*	1.787
Cistus x purpureus	9	9	6*	9	9	9	9	9	*<.001*	0.3575
Cornus alba	9	9	4	4	5	4	6	6	*(NS)*	-
Euonymus japonicus	9	9	4	6	9	9	9	5	*(NS)*	-
Hydrangea paniculata	9	9	4*	4*	7*	6*	6*	6*	*<.001*	0.3575
Ilex aquifolium	9	9	6*	9	9	9	9	9	*<.001*	1.430
Olearia x haastii	9	9	9	7*	9	9	7*	9	*<.001*	1.072
Perovskia atriplicifolia	9	9	4*	5.3*	7*	7*	4*	4*	*<.001*	0.7761
Sambucus nigra	9	9	6*	9	9	6*	6*	6*	*<.001*	0.4680

* Significantly different to untreated.

Table 3: Average phytotoxicity scores for hardy nursery species, thirteen weeks after June treatment application (assessed 04/09/18). *(NS = no significant differences)*

Species	UTC	Sinclair pot topper	HDC H46	HDC H44	Flexidor	Flexidor + Centurion Max	Flexidor + HDC H43	Flexidor + Sunfire	p value	L.S.D.
Buxus sempervirens	9	9	9	9	9	9	9	9		
Ceanothus thyrsiflorus	9	9	6	4	7.3	8	**7**	6.3		
Cistus x purpureus	9	9	9	6	9	9	9	9		
Cornus alba	9	9	9	9	9	9	9	9		
Euonymus japonicus	9	9	9	7	9	9	9	9		
Hydrangea paniculata	9	9	6	7	8	8	8	6		
Ilex aquifolium	9	9	9	6.3	9	9	9	9		
Olearia x haastii	9	9	9	4	8	9	8	9		
Perovskia atriplicifolia	9	9	6.3	6	6	6.3	6	5.3		
Sambucus nigra	9	9	6	9	9	7	6	4.6		

5.2 – October treatment results

Table 1. Average phytotoxicity scores for hardy nursery species, three weeks after October treatment application (assessed). *(NS = no significant differences)*

Species	UTC	UTC	Springbok + HDC H43	Springbok + HDC H43	Springbok	HDC H43	Venzar 500 SC	Springbok + HDC H43 + Venzar 500 SC	p value	L.S.D.
Buxus sempervirens	9	9	9	9	9	9	9	9	*(NS)*	-
Ceanothus thyrsiflorus	9	9	9	9	9	9	9	9	*(NS)*	-
Cistus x purpureus	9	9	9	9	9	9	9	9	*(NS)*	-
Cornus alba	9	9	8	8	8	8	8	8	*(NS)*	-
Euonymus japonicus	9	9	9	9	9	9	9	9	*(NS)*	-
Hydrangea paniculata	9	9	9	9	9	9	9	9	*(NS)*	-
Ilex aquifolium	9	9	9	8.3*	8.6	8.6	9	6*	*<.001*	0.6480
Olearia x haastii	9	9	8	8	8	8	9	8	*(NS)*	-
Perovskia atriplicifolia	9	9	9	9	9	9	9	9	*(NS)*	-
Sambucus nigra	9	9	9	9	9	9	9	9	*(NS)*	-

* Significantly different to untreated.

Table 2. Average phytotoxicity scores for hardy nursery species, six weeks after October treatment application (assessed). *(NS = no significant differences)*

Species	UTC	UTC	Springbok	Springbok	Springbok	HDC H43	Venzar 500 SC	Springbok + HDC	p value	L.S.D.

			+ HDC H43	+ HDC H43				H43 + Venzar 500 SC		
Buxus sempervirens	9	9	9	9	9	9	9	9	*(NS)*	-
Ceanothus thyrsiflorus	9	9	9	9	9	9	9	9	*(NS)*	-
Cistus x purpureus	9	9	9	9	9	9	9	9	*(NS)*	-
Cornus alba	9	9	9	9	9	9	9	9	*(NS)*	-
Euonymus japonicus	9	9	9	9	9	9	9	9	*(NS)*	-
Hydrangea paniculata	9	9	9	9	9	9	9	9	*(NS)*	-
Ilex aquifolium	9	9	9	8.3	9	9	9	8.6	*(NS)*	-
Olearia x haastii	9	9	8	8	8	8	9	8	*(NS)*	-
Perovskia atriplicifolia	9	9	9	9	9	9	9	9	*(NS)*	-
Sambucus nigra	9	9	9	9	9	9	9	9	*(NS)*	-

Table 3. Average phytotoxicity scores for hardy nursery species, twelve weeks after October treatment application (assessed). *(NS = no significant differences)*

Species	**UTC**	**UTC**	**Springbok**	**Springbok**	**Springbok**	**HDC H43**	**Venzar 500 SC**	**Springbok + HDC**	**p value**	**L.S.D.**

			+ HDC H43	+ HDC H43				H43 + Venzar 500 SC		
Buxus sempervirens	9	9	9	9	9	9	9	9	*(NS)*	-
Ceanothus thyrsiflorus	9	9	9	9	9	9	9	9	*(NS)*	-
Cistus x purpureus	9	9	9	9	9	9	9	9	*(NS)*	-
Cornus alba	9	9	9	9	9	9	9	9	*(NS)*	-
Euonymus japonicus	9	9	9	9	9	9	9	9	*(NS)*	-
Hydrangea paniculata	9	9	9	9	9	9	9	9	*(NS)*	-
Ilex aquifolium	9	9	9	9	9	9	9	9	*(NS)*	-
Olearia x haastii	9	9	8	8	8	8	9	8	*(NS)*	-
Perovskia atriplicifolia	9	9	9	9	9	9	9	9	*(NS)*	-
Sambucus nigra	9	9	9	9	9	9	9	9	*(NS)*	-