Project title:	Improving weed control in hardy nursery stock
Project number:	HNS 198
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Report:	Annual report, December 2019
Previous report:	Annual report, December 2019
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Date project commenced:	1 January 2016
Date project completed (or expected completion date):	31 December 2020

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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.

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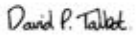
Signature  Date: 13 March 2020

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Headlines

- For budded tree production in the field, herbicide programmes of Sencorex Flow + Stomp Aqua + Venzar 500 SC + Sunfire after planting and after heading back proved safe and effective.
- HDC 42, HDC H43, HDC H44, HDC H46 and HDC H47 proved safe and effective on field-grown trees post budding when tank mixed with Sencorex Flow + Stomp Aqua + Venzar 500 SC.
- Sencorex Flow at 1.15 L/ha proved safe, applied as a post-planting and post heading back treatment to four tree species.
- Defy applied as a late winter treatment appears crop safe on the majority of species tested.
- Flexidor tank mixed with Centurion Max, Dual Gold and Sunfire was tolerated by 19 of the 20 hardy nursery stock species when applied after potting. A few species showed short-term phytotoxicity symptoms but plants grew away from the damage by 12 weeks after treatment.
- Flexidor at 0.5 L/ha (the maximum rate) proved safe (by 12 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 field-grown trees in the UK was completed in 2012 (CP 086), the key recommended products, Ronstar Liquid (oxadiazon) and Devrinol, have become unavailable for use. Although Devrinol has recently been issued an Extension of Authorisation for Minor Use (EAMU) for use in ornamentals, its restrictions prevent the product's use in many field-grown production systems. This combined with the restriction of one application of Flexidor per crop has resulted in a pressing need to test replacement products for tree production.

The herbicides selected for inclusion in the field tree trials are those for which appropriate EAMUs have recently been granted, e.g. Sencorex Flow (metribuzin) and Springbok (metazachlor + dimethenamid-p), alongside some newer products that are not yet

authorised. 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 trials was to build on the knowledge gained from the previous trials in roses, and to include new products alongside robust herbicides such as Sencorex Flow in other field-grown ornamentals.

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 hardy nursery stock. Flexidor 500 (isoxaben) – previously Flexidor 125 – has become the mainstay of weed control programmes in container hardy nursery stock 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 projects 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 hardy nursery stock treatments (though with limitations). Since then additional crop safety screening has been carried out within this project. Currently, relatively few new residual herbicides show potential for container hardy nursery stock 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, additional crop safety screening has continued to demonstrate their potential. Two new herbicide actives (both coded products) were also selected for inclusion in 2018 and 2019 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 hardy nursery stock. It was used as a post-emergence control of a range of annual grasses, in particular annual meadow grass. A safe and effective replacement, Centurion Max (clethodim) was selected as the most promising candidate and included in phytotoxicity screening on indicative nursery stock species. This was done alone and as a tank mix with Flexidor where it has proved its potential for use within the majority of species tested.

HDC H46 is a potential new active for the UK; it is approved in other countries and is used in hardy nursery stock production, and therefore was included in the 2018 and 2019 container screening tests and 2019 field trials. The UK formulation is likely to be different to the formulation used in hardy nursery stock production in other countries. It gives pre-emergence residual control of a range of annual grasses and broad-leaf 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 these are included to give growers crop safety information as EAMUs are issued.

Summary

During 2019 four herbicide trials were carried out, two trials each on container-grown nursery stock and field-grown trees. Phytotoxicity testing on 30 container-grown hardy nursery stock subjects was done in two other, 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 2019.

Product	Active	Approval status	2018 Field tree trial year two (L/ha)	2019 Field tree trial (L/ha)	HNS Container trial 2018 year two (L/ha)	HNS Container trial 2019 (L/ha)
Centurion Max	120 g/L clethodim	LTAEU				2.0
Defy	800 g/L prosulfocarb	EAMU[1]			5.0	
Dual Gold		EAMU				0.78
Flexidor 500	500 g/L isoxaben	Label		0.5		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	1.5	1.75		
HDC H46	Confidential	Not authorised	0.1	0.1	0.1	0.1
HDC H47	Confidential	Not authorised	3.75	3.75		
Laser[2]	Cycloxydim	EAMU	2.25			
Sencorex Flow	600 g/L metribuzin	EAMU	1.0 and 1.15	1.0 and 1.15		

Shark	60 g/L carfentrazone ethyl	EAMU		0.8		
Springbok	200 g/L metazachlor + 200 g/L dimethenamid-p	EAMU		2.5		1.66
Stomp Aqua	455 g/L pendimethalin	EAMU	2.9	2.9		
Sunfire	500 g/L flufenacet	EAMU		0.48		0.48
Venzar 500 SC	500 g/L lenacil	LTAEU now EAMU	0.4	0.4	0.4	0.4

[1] Pre-emergence only, [2]Toil was added at 5 ml per L of water.

*HDC H44 has been evaluated on wide range of horticultural crops in the SCEPTRE plus project. The active is authorised for use in potatoes and has a number of EAMUs and label extensions for other crops.

2018 Field Tree Trial year two

The 2018 field tree trial was set up on newly planted rootstocks at Frank P Matthews, Worcestershire in 2018 (see 2018 annual report for results from year one). The aim of the work carried out in year two (2019) of this study was to test the crop safety and efficacy of a number of residual herbicides as alternatives to Flexidor, post heading back (rootstocks cut back to just above the bud that was budded the previous season). There is 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 so that each plot contained four tree species (e.g. *Malus, Prunus, Quince* and *Sorbus)*. The trial consisted of eight herbicide treatments that were applied as residual pre-emergence treatments post heading back of rootstocks (Table 2). Phytotoxicity and weed assessments were carried out at 4, 6 and 12 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.

Sencorex was tested at the maximum rate (1.15 L/ha); a higher rate than previously used on the test species and it proved to be crop safe at this higher rate; experimental treatments also proved crop safe with no phytotoxicity recorded on any treatments or assessment dates.

Table 2. Treatment list and percentage weed cover, 4, 6 and 12 WAT (assessed 09/04/19, 24/04/19 and 05/06/19).

Trt. No.	**Post heading back **** 11/03/19	**Rate** (L/ha)	**Weed cover (%)** 4 weeks	**Weed cover (%)** 6 weeks	**Weed cover (%)** 12 weeks
1	Untreated	-	0	83.7	98.8
2	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H47	1 L/ha + 2.9 L/ha + 0.4 L/ha + 3.75 L/ha	0	0	0.75
3	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H44	1 L/ha + 2.9 L/ha + 0.4 L/ha + 1.5 L/ha	0.3	1	2.5
4	Sencorex Flow + Stomp Aqua + Venzar 500 SC +Sunfire	1 L/ha + 2.9 L/ha + 0.4 L/ha + 0.48 L/ha	0.3	0.75	2.8
5	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC 43	1 L/ha + 2.9 L/ha + 0.4 L/ha + 2.0 L/ha	0.5	2.5	8.5
6	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H46	1 L/ha + 2.9 L/ha + 0.4 L/ha + 0.1 L/ha	0.3	2	3
7	HDC H46	0.1 L/ha	0.3	1.8	8.3
8 and 9	Sencorex Flow + Stomp Aqua + Venzar 500 SC	1 L/ha + 2. 9L/ha + 0.4 L/ha	0	1.1	5.3
10	Sencorex Flow	1.15 L/ha	0	1	3.8

**Laser (EAMU) was applied at 2.25L/ha in 330 L/ha water with a 02F110 nozzle at medium spray quality with the adjuvant Toil a 5ml per litre of water.

The trials showed that both HDC 46 and Sencorex Flow have gaps in their weed control spectrums when applied alone, therefore they should be used with complimentary tank mix partners.

None of the treatments applied resulted in phytotoxic damage on any of the four species 2, 6 or 12 WAT. All of the post-heading back treatments were crop safe and effective and resulted in significantly improved weed control compared to untreated controls, see **Table 2, appendix 1** in the science section).

2019 Field Tree Trial

The 2019 field tree trial was set up on newly planted rootstocks at Frank P Matthews, Worcestershire in 2019. The aim of the work was to build on the results of the field tree trial carried out in 2018; continuing to test the crop safety and efficacy of a number of residual

herbicides as alternatives to Flexidor, whilst developing residual herbicide programmes for use post-planting.

The trial was set up with each plot containing four tree species (e.g. *Malus, Prunus, Quince* and *Sorbus)* and three replicate blocks. The trial consisted of nine herbicide treatments which were applied on 29/04/19 as residual pre-emergence treatments post heading back of rootstocks. Phytotoxicity and weed assessments were carried out at two, six and twelve weeks after treatment (WAT).

Sencorex was tested at the maximum rate (1.15L/ha); a higher rates than previously used on the rootstocks and proved to be crop safe at this higher rate. Coded experimental treatments (alone or included in tank mixes – treatments 2, 3, 5, 6, 7 & 8) also proved crop safe at 12 WAT with no commercially unacceptable damage recorded.

Table 3. Percentage weed cover, 2, 6 and 12 WAT (assessed 15/05/19, 12/06/19 and 26/07/19)

Trt. No.	**Treatment**	**Rate** (L/ha)	**Weed cover (%)** 2 weeks	**Weed cover (%)** 6 weeks	**Weed cover (%)** 12 weeks
1	Untreated	-	1	58.3	98.3
2	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H47	1 L/ha + 2.9 L/ha + 0.4 L/ha + 3.75 L/ha	0	5	8
3	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H44	1 L/ha + 2.9 L/ha + 0.4 L/ha + 1.75 L/ha	0	0.3	1.7
4	Sencorex Flow + Stomp Aqua + Venzar 500 SC +Sunfire	1 L/ha + 2.9 L/ha + 0.4 L/ha + 0.48 L/ha	0	1	2.3
5	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H43	1 L/ha + 2.9 L/ha + 0.4 L/ha + 2.0 L/ha	0	1	2.3
6	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H46	1 L/ha + 2.9 L/ha + 0.4 L/ha + 0.1 L/ha	0	0.3	1.3
7	HDC H46	0.1 L/ha	0	2	48.3
8	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H42	1 L/ha + 2.9 L/ha + 0.4 L/ha + 1.5 L/ha	0	0	0.3
9	Sencorex Flow + Stomp Aqua + Venzar 500 SC	1 L/ha + 2.9 L/ha + 0.4 L/ha	0	0.7	1.7
10	Sencorex Flow	1.15 L/ha	0	1.3	10

None of the herbicide treatments had more than 10% mean weed cover by 12 weeks after treatment. The untreated controls had a mean weed cover of over ninety eight percent by twelve weeks after treatment. The most effective treatment combinations are listed in **Table 4** below, see **Table 3** above for full results.

The least effective treatment was treatment 7 (HDC H46 applied alone) with 48.3% weed cover by 12 WAT however treatment 3 (HDC H46 applied as part of a tank mix) resulted in 1.3% weed cover 12 WAT. Treatment 10 (Sencorex Flow at the maximum rate) resulted in 10% weed cover which was higher than many of the tank mix combinations where Sencorex Flow was used at a lower rate. This suggests that both HDC 46 and Sencorex Flow have gaps in their weed control spectrums when applied alone without complimentary tank mix partners, as found in year two of the 2018 Field Tree Trial.

Table 4. Four most effective treatments for weed control (Percentage weed cover, 2, 6 and 12 WAT, assessed 15/05/19, 12/06/19 and 26/07/19).

Treatment number	Product (name)	Active ingredient	Rate (L/ha or kg/ha)	Percentage mean weed cover at 12 WAT*
8	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H42	metribuzin + pendimethalin + lenacil + Confidential	1 L/ha + 2.9 L/ha + 0.4 L/ha + 1.5 L/ha	0.3
6	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H46	metribuzin + pendimethalin + lenacil + Confidential	1 L/ha + 2.9 L/ha + 0.4 L/ha + 0.1 L/ha	1.3
3.	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H44	metribuzin + pendimethalin + lenacil + Confidential	1 L/ha + 2.9 L/ha + 0.4 L/ha + 1.5 L/ha	1.7
9	Sencorex Flow + Stomp Aqua + Venzar 500 SC	metribuzin + pendimethalin + lenacil	1 L/ha + 2.9 L/ha + 0.4 L/ha	1.7

* The four most effective treatments for weed control are listed in this table but there were no significant differences in weed control between treatments 2,3,4,5,6,8,9 and 10.

Phytotoxic yellowing associated with HDC H44 (as part of a tank mixture; Treatment 3) resulted in very similar results to those obtained in 2018 trials (see 2018 annual report) with some damage in all species 2 WAT (see **Figures 1 to 4** in results of Science section). By 12 WAT all species had grown away from this initial damage and were considered commercially acceptable.

HDC H42 (as part of a tank mixture, Treatment 8) was initially the most damaging treatment within the trial (see appendix 2 **Figures 1 - 4**); however by 12 WAT all species were considered commercially acceptable. This treatment delivered the best weed control.

HDC H46 alone did not provide persistent weed control beyond 6 WAT (see **Table 3**) whereas HDC H46 applied as a tank mix (with Sencorex Flow + Stomp Aqua + Venzar 500 SC) resulted in 1.3 percent weed cover 12 WAT.

All of treatments were crop safe and effective (12 WAT) and resulted in significantly improved weed control compared to untreated controls, see **Table 19** (Science section).

Table 5 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 5. Average phytotoxicity scores for *Malus, Prunus, Quince* and *Sorbus* assessed 12 WAT (assessed 26/07/19).

Trt. No.	Planting	Rate (Kg/ha or L/ha)	*Malus*	*Prunus*	*Quince*	*Sorbus*
1	Untreated	-	9	9	9	9
2	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H47	1 L/ha + 2.9 L/ha + 0.4 L/ha + 3.75 L/ha	9	9	9	9
3	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H44	1 L/ha + 2.9 L/ha + 0.4 L/ha + 1.75 L/ha	9	9	9	8.6
4	Sencorex Flow + Stomp Aqua + Venzar 500 SC +Sunfire	1 L/ha + 2.9 L/ha + 0.4 L/ha + 0.48 L/ha	9	9	9	9
5	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H43	1 L/ha + 2.9 L/ha + 0.4 L/ha + 2.0 L/ha	9	9	9	9
6	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H46	1 L/ha + 2.9 L/ha + 0.4 L/ha + 0.1 L/ha	9	9	9	9
7	HDC H46	0.1 L/ha	9	9	9	9
8	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H42	1 L/ha + 2.9 L/ha + 0.4 L/ha + 1.5 L/ha	9	8.3	8.3	8.3
9	Sencorex Flow + Stomp Aqua + Venzar 500 SC	1 L/ha + 2.9 L/ha + 0.4 L/ha	9	9	9	9
10	Sencorex Flow	1.15 L/ha	9	9	9	9

The post budding treatments Shark (applied as an inter-row spray), Flexidor, Springbok and Venzar 500SC (applied over the foliage) were crop safe with any treatment effects being

considered commercially acceptable (see **Table 7, appendix 2)**, no weed was present 2 WAT **(Table 6, appendix 2)**.

Hardy nursery stock container trial 2018 year two

The 2018 hardy nursery stock container trial was carried out at Wyevale nurseries, Hereford, on ten species of container-grown plants (**Table 6**). The trial consisted of six herbicide programmes, applied post-potting and as a top up treatment. The treatments applied in 2018 are detailed in the 2018 annual report. In the second year of the trial a further top up application of residual herbicides were applied in late winter (early March 2019). Treatments included an untreated control, a mulch (Sinclair pot topper applied post potting in 2018) and three herbicide products: Defy, Venzar 500 SC and the coded product HDC H46 (**Table 7**). Any weeds were removed before residual herbicides were applied.

Phytotoxicity was assessed at two, six, and twelve weeks after the herbicide treatments were applied on 08/03/19.

Table 6. Species and cultivars included in hardy nursery stock container trial 2018 year two.

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 7. Treatment list, active ingredients and timings for the hardy nursery stock container herbicide trial (2018 /2019).

Treatment		Active ingredient	Approval status	**Rate** (L/ha)	Timing
1	Untreated	-	-	-	-
2	Sinclair pot topper	Physical mulch	-	3 cm depth	June 2018 (post-potting)
3	Defy	Prosulfocarb 800g/L	EAMU	5.0	March 2019
4	Defy + HDC H46	Confidential	EAMU + Not approved	5.0 + 0.1	
5	HDC H46	Confidential	Not approved	0.1	

6	HDC H46 + Venzar 500 SC	Confidential	Not approved + LTAEU	0.1 + 0.4	
7	Defy + HDC H46 + Venzar 500 SC	Confidential	EAMU + Not approved + LTAEU	5.0 + 0.1 + 0.4	
8	Defy + Venzar 500 SC	Confidential	EAMU + LTAEU	5.0 + 0.4	

The new herbicide HDC H46 was safer as a late winter treatment than application timings tested in 2018 (see 2018 annual report). This treatment resulted on initial slight damage on *Cistus* and *Sambucus* however damage did not become apparent on *Buxus, Euonymus* and *Hydrangea* until 6 weeks after treatment (WAT). By 12 WAT all species (with the exception of *Cistus)* were considered commercially acceptable.

Defy caused some initial damage on *Buxus* which was considered commercially acceptable by 6WAT. All species tested (with the exception of *Buxus)* were considered commercially acceptable throughout the trial.

Defy tank mixed with Venzar - all of the ten species were considered commercially acceptable throughout the trial.

The combination of Defy tank mixed with HDC H46 resulted in damage on more species than either of these treatments did when applied alone. By 12 WAT all species with the exception of *Cistus* had grown away from phytotoxic damage and were considered commercially acceptable with a score of 7 or above. *Ceanothus* appear to be sensitive to this tank mixture however damage did not show until 12 WAT. By 12 WAT eight of the ten species were considered commercially acceptable.

Defy tank mixed with HDC H46 and Venzar 500 SC resulted in damage on various species. By 12 WAT severn species of the ten species were considered commercially acceptable; this treatment was too damaging and is not considered suitable for *Ceanothus, Cistus* or *Euonymus*.

Hardy nursery stock container trial 2019

This 2019 hardy nursery stock herbicide trial was set up at Darby Nursery Stock, Norfolk, in May 2019. The trial consisted of twenty container-grown hardy nursery stock species (**Table 8**). The trial consisted of six herbicide programmes, applied post-potting on 31/05/19 or as a top up treatment on 02/10/19, (**Table 9**).

Phytotoxicity was assessed at two, six, and twelve (May treatments) and again at two, six, and eleven (October treatments) weeks after the herbicide treatments were applied.

Table 8. Species and cultivars included in hardy nursery stock container trial 2019 (hereafter referred to by species).

Species	Cultivar
Berberis thunbergii f. atropurpurea	'Atropurpurea Nana'
Chaenomeles x superba	'Crimson and Gold'
Choisya ternata	
Convolvulus cneorum	
Cotoneaster dammeri	
Cytisus	'Lena'
Diervilla splendens	'Diva'
Escallonia	'Red Elf'
Hebe x franciscana	'Variegata'
Hypericum	'Hidcote'
Lavandula vera	
Lavateria Hybrida	'Barnsley'
Ligustrum ovifolium	'Aureum'
Pachysandra terminalis	'Green Sheen'
Photinia x fraseri	'Red Select'
Potentilla fruticosa	'Abbotswood'
Pyracantha	'Soleil d'Or'
Santolina chamaecyparissus	
Senecio compacta	'Drysdale'
Vinca minor	

Table 9. 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	HDC H46	Confidential	Not approved	0.1	May (post-potting)
3	Flexidor + HDC H43	isoxaben 500 g/L + pethoxamid	Label + Not approved	0.5+ 2.0	
4	Flexidor + Centurion Max	isoxaben 500 g/L + clethodim 120 g/L	Label + LTAEU	0.5 + 2.0	
5	Flexidor + Sunfire	isoxaben 500 g/L + flufenacet 500 g/L	Label + EAMU 1065/17	0.5 + 0.48	
6	Flexidor + Dual Gold	isoxaben 500 g/L + S-metolachlor	Label + EAMU 0501/12	0.5 + 0.78	
7	Flexidor	isoxaben 500 g/L	Label	0.5	
1	Untreated	-	-	-	-
2	Flexidor	isoxaben 500 g/L	Label	0.5	October top up
3	Springbok	dimethanid-p + metazachlor	EAMU 2108/15	1.6	

4	Springbok + HDC H43	dimethanid-p + metazachlor + pethoxamid	EAMU 2108/15 + Not approved	1.6 + 2	
5	Springbok + HDC H43 + Venzar 500 SC	dimethanid-p + metazachlor + pethoxamid + lenacil	EAMU 2108/15 + Not approved + LTAEU*	1.6 + 2 + 0.4	
6	HDC H43	pethoxamid	Not approved	2	
7	HDC H46	Confidential	Not approved	0.1	

* An EAMU for the use of Venzar 500 SC was granted in December 2019 however the EAMU restricts use to before the end of July.

Treatment application at potting, 31/05/19

At 2 weeks after treatment (WAT, Flexidor applied post-potting appeared to have caused some initial scorch. By 12 WAT all species were considered commercially acceptable.

The new herbicide HDC H46 caused more damage than Flexidor alone as it did in the trials carried out in 2018. Three species (*Cotoneaster, Lavandula* and *Photinia)* scored below 7.0 at twelve weeks after treatment and were not considered commercially acceptable; see **Table 10**.

Flexidor tank mixed with either Centurion Max, HDC H43, Sunfire or Dual Gold resulted in increased initial phytotoxicity on *Berberis* and *Lavandula* in all of the aforementioned treatments 2 WAT. By 12 WAT the majority of species were considered commercially acceptable. *Lavandula* was an exception with plants in all treatments still exhibiting phytotoxic symptoms (see **Table 10).** *Lavandula* treated with Flexidor alone was the only treatment on *Lavandula* where phytotoxic damage 12 WAT was considered commercially acceptable.

Table 10. Average phytotoxicity scores for hardy nursery species, twelve weeks after May treatment application (assessed 23/08/19).

Species	UTC	HDC H46	Flexidor + HDC H43	Flexidor + Centurion Max	Flexidor + Sunfire	Flexidor + Dual Gold	Flexidor
Berberis thunbergii f. atropurpurea	9	8.3	9	9	9	8.7	9
Chaenomeles x superba	9	8.7	8.7	8.3	9	9	8.7

Choisya ternata	9	9	9	9	8	9	9
Convolvulus cneorum	9	9	9	9	9	9	9
Cotoneaster dammeri	9	5.3	7.7	8	8.3	8.3	8.3
Cytisus	9	9	9	9	9	9	9
Diervilla splendens	9	8	9	9	9	9	8.3
Escallonia	9	9	9	9	8	9	9
Hebe x franciscana	9	7.6	9	9	9	9	9
Hypericum	9	8	7.7	7	7.3	9	8.3
Lavandula vera	9	6	6.3	5.7	6.3	6.7	7.7
Lavateria Hybrida	9	9	9	9	9	9	9
Ligustrum ovifolium	9	9	9	9	8	9	9
Pachysandra terminalis	9	8	9	9	9	9	9
Photinia x fraseri	9	5.7	8.7	8.7	8	9	9
Potentilla fruticosa	9	9	8.3	8.3	9	8	9
Pyracantha	9	8.7	9	9	9	9	9
Santolina chamaecyparissus	9	9	9	9	9	9	9
Senecio compacta	9	9	9	9	9	9	9
Vinca minor	9	8.7	8.3	9	9	9	9

Top up applications, 02/10/19

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 2, 6 and 12 WAT. Most plants were barely affected by the treatments at 2 WAT, with the exception of *Lavandula* where all treatments resulted in some phytotoxic damage and *Pachysandra* where all treatments other than Flexidor and Springbok alone resulted in phytotoxic damage that was not considered commercially acceptable. *Lavandula* treated with HDC H43 and HDC H46 scored below 7 at 12 WAT. HDC H46 and Springbok tank mixed with HDC H43 and Venzar 500 SC at 12 WAT resulted in *Pachysandra* scoring below 7 at 12 WAT, so was not considered a commercially acceptable treatment. . *Photinia* was initially slightly damaged by the tank mix of Springbok, HDC H43 and Venzar 500 SC but was considered commercially acceptable by 6 WAT. *Photinia* was also damaged by HDC H46, treated plants had not recovered sufficiently for the treatment to be considered

commercially acceptable scoring below 7 at 12 WAT. By 12 WAT the majority of species had recovered and any remaining damage was considered commercially acceptable.

Table 11. Average phytotoxicity scores for hardy nursery species, eleven weeks after October treatment application (assessed 20/12/19).

Species	UTC	Flexidor	Springbok	Springbok + HDC H43	Springbok + HDC H43 + Venzar 500 SC	HDC H43	HDC H46
Berberis thunbergii f. atropurpurea	9	9	9	9	9	9	9
Chaenomeles x superba	9	9	9	9	9	9	9
Choisya ternata	9	9	9	9	9	9	9
Convolvulus cneorum	9	9	9	9	9	9	9
Cotoneaster dammeri	9	8.7	9	9	9	8	9
Cytisus	9	9	9	9	9	9	9
Diervilla splendens	9	9	9	9	9	9	9
Escallonia	9	9	9	9	9	9	9
Hebe x franciscana	9	8.3	9	7.3	8	9	7
Hypericum	9	9	9	8.3	8.7	8.7	8
Lavandula vera	8	7.3	8	7.7	7	6.3	5.7
Lavateria Hybrida	9	9	9	9	9	9	9
Ligustrum ovifolium	9	9	9	9	9	9	9
Pachysandra terminalis	9	8.3	9	7	6.3	7.7	5.3
Photinia x fraseri	9	8	9	7	7	7.7	6.7
Potentilla fruticosa	9	9	9	9	9	9	9
Pyracantha	9	9	9	9	9	9	9
Santolina chamaecyparissus	9	9	9	9	9	9	9
Senecio compacta	9	9	9	9	8.4	9	9
Vinca minor	9	9	9	9	8.7	8.7	9

Conclusions

- The EAMU for use of Sencorex Flow will allow the application of effective tank mix combinations after planting and heading back.
- Sencorex Flow could form the basis of residual herbicide programmes post-planting and post heading back at a higher rate than previously used on field-grown trees as an alternative to Flexidor to deliver crop safe, effective wed control.
- Dual Gold, Sunfire and Centurion Max have shown potential for use over hardy nursery stock foliage in tank mixes with Flexidor to broaden weed control spectrums. In terms of crop safety, whilst safe on most of the species tested by 12 WAT growers should be prepared for some varietal susceptibility.
- Defy applied as a late winter treatment 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 to help manage and prevent herbicide resistance. Growers should note that Devrinol will give superior control of groundsel than Defy.
- New coded herbicides all have potential to contribute to weed control in the production of hardy nursery stock providing that appropriate authorisations / EAMUs can be obtained.

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. 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 and experimental products with Sencorex Flowable appeared to provide improved weed control compared with Sencorex alone. The LTAEU in place for Venzar 500 SC when this trial commenced has been transferred to an EAMU, resulting in the unforeseen limitation of not being able to apply Venzar 500 SC after the end of July in the year of application. This prevents use at some of the timings detailed within this report, a loss which may slightly reduce the effectiveness of some treatments. The impact on weed control should not be particularly detrimental as the low rates used (0.4 L/ha) would have limited and fairly short persistence.

Centurion Max, Dual Gold, Springbok, Sunfire, Defy, Venzar 500 SC and HDC H46 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 tree production in the field, herbicide programmes of Sencorex Flow + Stomp Aqua + Venzar 500 SC + Sunfire after planting and after heading back are recommended.
- Tank mixes of Flexidor with the selective contact grass herbicide Centurion Max or residual herbicide Sunfire, appeared safe on container-grown hardy nursery stock.
- Tank mixes of Flexidor with Dual Gold appeared safe on the majority of species and can be applied in May.
- Springbok has potential as a top up treatment in both field and container production when foliage hardens later in the year.
- Applying 10 mm of irrigation, post-herbicide application, could be adopted by growers to help minimise crop damage associated with some of the treatments.

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 trees in the UK was completed in 2013 (CP 86), the key recommended products Ronstar Liquid (oxadiazon), Devrinol (napropamide) and Artist (flufenacet + metribuzin), became unavailable for use. Devrinol has recently been granted an EAMU for use in ornamentals but restrictions effectively rule the product out in the year of planting. Restrictions on remaining key herbicides such as Flexidor (isoxaben) limiting use to once per crop further compound the problem.

There is therefore a 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. 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 these current trials 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 hardy nursery stock. Flexidor (500 g/l isoxaben) – previously Flexidor 125 – has become the mainstay of weed control programmes in container hardy nursery stock 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 hardy nursery stock treatments (though with limitations). Currently, relatively few new residual herbicides show potential for container hardy nursery stock testing, but three were selected for 2018-19 trials; HDC H43 (pethoxamid), Defy (prosulfocarb), and a new active that is currently coded as HDC H46, all of which have promising 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 hardy nursery stock. 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 has been sought. Centurion Max (clethodim) was selected as the most promising candidate and included phytotoxicity screening on indicative nursery stock species as a tank mix partner for Flexidor (isoxaben) to add grass control to this herbicides weed control spectrum.

Coded actives that are promising may become available either through mutual recognition (if authorised in Europe) or EAMUs (Extension of Authorisation for Minor Use).

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

2018 Field Tree trial year two

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. Treatments applied in year one are detailed in the 2018 HNS 198 annual report. Post heading back, grass weeds were sprayed out with an inter-row spray of Laser (EAMU) prior to the application of residual herbicides. Phytotoxicity and weed assessments were carried out at four, six and twelve weeks after treatment (WAT) as the crop was still dormant two weeks after treatment. 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 nine novel herbicide treatments with potential to be used in future residual herbicide programmes as post-heading back alternatives to Flexidor **(Table 12)**, including an untreated control and Sencorex Flow at two rates (previously untested at the higher rate of 1.15L/ha) rates.

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 post heading back (whilst still dormant) on 11/03/19. The treatment list is shown below in **Table 12.**

Table 12: Post heading back treatments, 2018 Field tree trial year two.

Treatment number	Product (name)	Active ingredient	Rate (L/ha or kg/ha)
1.	Untreated	-	Untreated
2.	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H47	metribuzin + pendimethalin + lenacil + Confidential	1 L/ha + 2.9 L/ha + 0.4 L/ha + 3.75 L/ha
3.	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H44	metribuzin + pendimethalin + lenacil + Confidential	1 L/ha + 2.9 L/ha + 0.4 L/ha + 1.5 L/ha
4.	Sencorex Flow + Stomp Aqua + Venzar 500 SC +Sunfire	metribuzin + pendimethalin + lenacil + flufenacet	1 L/ha + 2.9 L/ha + 0.4 L/ha + 0.48 L/ha
5.	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC 43	metribuzin + pendimethalin + lenacil + pethoxamid	1 L/ha + 2.9 L/ha + 0.4 L/ha + 2.0 L/ha
6.	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H46	metribuzin + pendimethalin + lenacil + Confidential	1 L/ha + 2.9 L/ha + 0.4 L/ha + 0.1 L/ha
7.	HDC H46	Confidential	0.1 L/ha
8.	Sencorex Flow + Stomp Aqua + Venzar 500 SC	metribuzin + pendimethalin + lenacil	1 L/ha + 2.9 L/ha + 0.4 L/ha
9	Sencorex Flow	metribuzin	1.15 L/ha

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 Shark at 0.8 L/ha to clean them up prior to the top up application of residual herbicides (Flexidor 0.5 L/ha and Springbok 2.5 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

No phytotoxicity was recorded in any plants within the trial plots at four, six or twelve weeks after treatments were applied (see **Table 2, appendix 1)**. These herbicides and herbicide combinations are considered crop safe when applied to these species whilst dormant, post heading back.

All of the treatments had significantly less weed cover than untreated controls at six weeks after treatment (p value <.001, L.S.D. 4.495), this trend continued at 12 weeks after treatment when the trial finished (p value <.001, L.S.D. 4.464). None of the herbicide treatments had

more than nine percent mean weed cover by 12 weeks after treatment. The untreated controls had a mean weed cover of over ninety eight percent by twelve weeks after treatment. The most effective treatment combinations are listed in the table below, see **Table 1 appendix 1** for full results

Table 13: The most effective weed control treatments 12 WAT.

Treatment number	Product (name)	Active ingredient	Rate (L/ha or kg/ha)	*Percentage mean weed cover at 12 WAT
2.	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H47	metribuzin + pendimethalin + lenacil + Confidential	1L /ha + 2.9 L/ha + 0.4 L/ha + 3.75 L/ha	0.75
3.	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H44	metribuzin + pendimethalin + lenacil + Confidential	1 L/ha + 2.9 L/ha + 0.4 L/ha + 1.5 L/ha	2.5
4.	Sencorex Flow + Stomp Aqua + Venzar 500 SC +Sunfire	metribuzin + pendimethalin + lenacil + flufenacet	1 L/ha + 2.9 L/ha + 0.4 L/ha + 0.48 L/ha	2.8
6	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H46	metribuzin + pendimethalin + lenacil + Confidential	1 L/ha + 2.9 L/ha + 0.4 L/ha + 0.1 L/ha	3.0
p value				**<.001**
d.f.				**28**
L.S.D.				**4.464**

* Significantly different to untreated, the four most effective treatments for weed control are listed in this table but there were no significant differences in weed control between treatments 2,3,4,5,6,7,8 and 9.

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 1.15 L/ha rate had the potential to be one of the most damaging herbicides within the trial. It is worth noting 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 2019 was a relatively dry summer.

All treatments provided good weed control with 2.5 % weed cover or less at 6 WAT and with 8.5 % weed cover or less by 12 WAT. As expected, percentage weed cover was greatest on control plots by 12 WAT. Treatment 2 (Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H47) gave the best control (0.75 % mean wed cover), which persisted to 12 WAT. Other notable treatments include Treatment 3 (Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H44) which gave 2.5 % weed cover at 12 WAT and Sencorex Flow + Stomp Aqua + Venzar 500 SC + Sunfire which gave 2.8 % weed cover at 12 WAT. This has demonstrated these herbicides' suitability as highly effective alternatives to the traditional tank mix of Flexidor and Stomp Aqua post-planting. This will enable improved weed control with greater persistence to be achieved, providing alternative options to Flexidor post-planting.

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 hardy nursery stock. 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.

2019 Field Tree trial

Materials and methods

This budded tree herbicide trial was set up in 2019 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) on 11/03/19. For Phytotoxicity scoring criteria see methods section for the 2018 field tree trial year two.

The trial evaluated nine novel herbicide treatments (applied either as part of a tank mixture or alone) with potential to be used in future residual herbicide programmes as post-planting

alternatives to Flexidor **(Table 14)**. The same products were tested post – planting as in the post – heading back trial with the addition of HDC H42.

The trial was laid out in a fully randomised block design with 3-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 11/03/19. The treatment list is shown below in **Table 14.**

Table 14: Post-planting treatments, 2019 Field tree trial.

Trt. No.	**Product name**	**Active ingredient**	Rate (L/ha or kg/ha)
1.	Untreated	-	Untreated
2.	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H47	metribuzin + pendimethalin + lenacil + Confidential	1 L/ha + 2.9 L/ha + 0.4 L/ha + 3.75 L/ha
3.	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H44	metribuzin + pendimethalin + lenacil + Confidential	1 L/ha + 2.9 L/ha + 0.4 L/ha + 1.75 L/ha
4.	Sencorex Flow + Stomp Aqua + Venzar 500 SC +Sunfire	metribuzin + pendimethalin + lenacil + flufenacet	1 L/ha + 2.9 L/ha + 0.4 L/ha + 0.48 L/ha
5.	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H43	metribuzin + pendimethalin + lenacil + pethoxamid	1 L/ha + 2.9 L/ha + 0.4 L/ha + 2.0 L/ha
6.	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H46	metribuzin + pendimethalin + lenacil + Confidential	1 L/ha + 2.9 L/ha + 0.4 L/ha + 0.1L/ha
7.	HDC H46	Confidential	0.1 L/ha
8.	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H42	metribuzin + pendimethalin + lenacil + mesotrione	1 L/ha + 2.9 L/ha + 0.4 L/ha + 1.5 L/ha
9	Sencorex Flow + Stomp Aqua + Venzar 500 SC	metribuzin + pendimethalin + lenacil	1 L/ha + 2.9 L/ha + 0.4 L/ha
10.	Sencorex Flow	metribuzin	1.15 L/ha

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

Results

All of the treatments had significantly less weed cover than untreated controls at six weeks after treatment (p value <.001, L.S.D. 18.69), this trend continued at 12 weeks after treatment when the trial finished (p value <.001, L.S.D. 10.09). None of the herbicide treatments had more than nine percent mean weed cover by 12 weeks after treatment. The untreated

controls had a mean weed cover of over ninety eight percent by twelve weeks after treatment. The most effective treatment combinations are listed in the table below, see **Table 1, appendix 2** for full results.

Table 15. Percentage weed cover, 2, 6 and 12 WAT (assessed 15/05/19, 12/06/19 and 26/07/19)

Treatment number	Product (name)	Active ingredient	Rate (L/ha or kg/ha)	Percentage mean weed cover at 12 WAT*
8	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H42	metribuzin + pendimethalin + lenacil + Confidential	1 L/ha + 2.9 L/ha + 0.4 L/ha + 1.5 L/ha	0.3
6	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H46	metribuzin + pendimethalin + lenacil + Confidential	1 L/ha + 2.9 L/ha + 0.4 L/ha + 0.1 L/ha	1.3
3.	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H44	metribuzin + pendimethalin + lenacil + Confidential	1 L/ha + 2.9 L/ha + 0.4 L/ha + 1.5 L/ha	1.7
9	Sencorex Flow + Stomp Aqua + Venzar 500 SC	metribuzin + pendimethalin + lenacil	1 L/ha + 2.9 L/ha + 0.4 L/ha	1.7
p value				**<.001**
d.f.				**18**
L.S.D.				**10.09**

* Significantly different to untreated. The four most effective treatments for weed control are listed in this table but there were no significant differences in weed control between treatments 2,3,4,5,6,8,9 and 10.

Phytotoxic yellowing associated with HDC H44 (as part of a tank mixture; Treatment 3) had very similar results to those obtained in 2018 trials (see 2018 annual report) with slight damage 2 WAT in *Malus, Quince* and *Sorbus* and very slight damage in *Prunus* (which was considered commercially acceptable. The herbicide damage was statistically significant in; *Malus* (score 6, p value <.001, L.S.D. 0.3132) and *Prunus* (score 7.6, p value <.001, L.S.D. 0.3132). Although not statistically significant, other species scored as follows: *Quince* (score 6) and *Sorbus* (score 6). A slight effect was recorded in *Malus* and Quince (both scored 8) and very slight damage in *Sorbus* at 6 WAT (score 7). By 12 WAT the plants had grown away from this initial damage and were all considered commercially acceptable.

Figure 1. Slight yellowing caused by HDC H44 as part of a tank mixture on *Malus* 2 WAT.

Figure 2. Slight yellowing caused by HDC H44 as part of a tank mixture on *Quince* 2 WAT.

Figure 3. Slight yellowing caused by HDC H44 as part of a tank mixture on *Sorbus* 2 WAT.

Figure 4. Slight yellowing caused by HDC H44 as part of a tank mixture on *Prunus* 2 WAT.

HDC H42 (as part of a tank mixture, Treatment 8) also resulted in yellowing which was considered damaging on all four species 2 WAT resulting in all four species receiving a score of 4 which was statistically different from untreated controls (*Malus*, p value <.001, L.S.D. 0.3132 and *Prunus* p value <.001, L.S.D. 0.3132). All four species had started to grow away from damage by 6 WAT when they were only slightly damaged with a score of 6; however they were still significantly different from untreated controls (*Malus*, p value <.001, L.S.D. 0.4304 and *Prunus* p value <.001, L.S.D. 0.3132, *Quince* p value <.001, L.S.D. 0.5323, *Sorbus* p value <.001, L.S.D. 0.5718). By 12 WAT all species were considered commercially

acceptable (Malus was comparable with the untreated control with a score of 9 and *Prunus, Quince* and *Sorbus* were barely affected with a score of 8.3.

The new herbicide HDC H46 was a little more damaging on *Malus* when applied as a tank mix (with Sencorex Flow + Stomp Aqua + Venzar 500 SC; Treatment 6) than when it was when applied alone (Treatment 7). When applied as part of a tank mixture it resulted in slight damage on *Malus* 2 WAT (a score of 6.7) that was significantly different to untreated controls (p value <.001, L.S.D. 0.3132). *Malus* recovered and were considered commercially acceptable by 6 WAT (score 8.3), all of the other three species were less susceptible throughout the trial. HDC H46 applied alone was crop safe, with treatment effects on all four of the species found to be crop safe and commercially acceptable throughout the trial. HDC H46 alone did not provide persistent weed control beyond 6 WAT (see **Table 1, appendix 1**) whereas HDC H46 applied as a tank mix (with Sencorex Flow + Stomp Aqua + Venzar 500 SC) resulted in 0.3 percent weed cover 12 WAT.

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 16 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 16: Mean results, 2019 Field tree trial 12 WAT.

Treatment	Percentage weed cover	Phytotoxicity score *Malus*	Phytotoxicity score *Prunus*	Phytotoxicity score *Quince*	Phytotoxicity score *Sorbus*
1	98.3	9	9	9	9
2	8*	9	9	9	9
3	1.7*	9	9	9	8.6
4	2.3*	9	9	9	9
5	2.3*	9	9	9	9
6	1.3*	9	9	9	9
7	48.3*	9	9	9	9
8	0.3*	9	8.3*	8.3*	8.3*
9	1.7*	9	9	9	9
10	10*	9	9	9	9
p value	**<.001**	*N/S*	0.006	*0.006*	*0.053*
(18 df) **L.S.D.**	**10.09**	-	0.3132	*0.3132*	*0.4304*

*Significantly different to untreated control.

The post budding treatments Shark (applied as an inter-row spray), Flexidor, Springbok and Venzar 500SC (applied over the foliage) were crop safe with any treatment effects being considered commercially acceptable (see **Table 6, appendix 2)**, no weed was present 2 WAT **(Table 7, appendix 2)**.

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 12 WAT. Sencorex Flow at the 1.15 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 2019 was a relatively dry year.

All treatments with the exception of HDC H46 (treatment 7) provided good weed control with less than 10 % weed cover on all plots 12 WAT. As expected, percentage weed cover was greatest on control plots by 12 WAT.

Treatment 8 gave the best weed control 12 WAT but there were no significant differences in weed control between treatments 2,3,4,5,6,8,9 and 10.

HDC H46 (treatment 7) and Sencorex Flow (treatment 10) at the high rate were both applied without tank mix partners to determine crop safety but gaps in these products weed control spectrums resulted in these treatments having the greatest percentage weed cover. These products and rates have demonstrated their crop safety, giving the potential to take the maximum rate of Sencorex Flow forward as post heading back treatments in 2020. This should result in improved weed control with greater persistence to continue to 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 Shark (carfentrazone-ethyl) as a direct treatment.

A standard herbicide treatment of Venzar 500 SC (0.4 L/Ha) + Flexidor (0.5 L/Ha) + Springbok (2.5 L/ha) was applied over the top of the crop to all treatment plots on 02/10/19 (plots 2-10). A phytotoxicity assessment was carried out 2 weeks later and no commercially unacceptable crop damage was noted.

Conclusions

Most residual herbicides are generally much safer when applied over the top of dormant crops, 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 species tested, are effective against common weeds of field production of hardy nursery stock and thus have potential for use in the production of field-grown hardy nursery stock. 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.

Hardy nursery stock container trial 2018 year two

Materials and methods

The hardy nursery stock herbicide trial was set up at Wyevale nurseries, Herefordshire, in June 2018. The trial consisted of ten representative hardy nursery stock species (**Table 17**), 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 treatments applied in 2018 are detailed in the 2018 annual report. In the second year of the trial a further top up application of residual herbicides were applied in late winter (early March 2019). Treatments included an untreated control, a mulch (Sinclair pot topper applied post potting in 2018) and three herbicide products (**Table 18**). Any weeds were removed before residual herbicides were applied.

The trial was set up as a fully 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 treatments to maintain weed control were applied on 08/03/19.

Phytotoxicity was assessed at two, six, and twelve 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.

Table 17. 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 18. 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 2018 (post-potting)
3	Defy	Prosulfocarb 800g/L	EAMU	5.0	March 2019
4	Defy + HDC H46	Confidential	EAMU + Not approved	5.0 + 0.1	
5	HDC H46	Confidential	Not approved	0.1	
6	HDC H46 + Venzar 500 SC	Confidential	Not approved + LTAEU	0.1 + 0.4	
7	Defy + HDC H46 + Venzar 500 SC	Confidential	EAMU + Not approved + LTAEU	5.0 + 0.1 + 0.4	
8	Defy + Venzar 500 SC	Confidential	EAMU + LTAEU	5.0 + 0.4	

Results

Table 19: Average phytotoxicity scores for hardy nursery species, two weeks after March treatment application (assessed 22/03/19). *(NS = no significant differences)*

Species	UTC	Sinclair pot topper	Defy	Defy + HDC H46	HDC H46	HDC H46 + Venzar 500 SC	Defy + HDC H46 + Venzar 500 SC	Defy + Venzar 500 SC	p value	L.S.D.
*Buxus sempervirens***	9	9	3*	6*	9	7*	6*	9	-	-
Ceanothus thyrsiflorus	9	9	9	9	9	9	9	9	*(NS)*	-
Cistus x purpureus	9	9	9	6	6	7	7.3	9	*<.001*	0.7149
Cornus alba	9	9	9	6*	9	8.7	7.3*	9	*<.001*	0.974
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	9	9	9	9	9	9	*(NS)*	-
Perovskia atriplicifolia	9	9	9	9	9	9	9	9	*(NS)*	-
Sambucus nigra	9	9	9	6*	6*	7*	6*	9	*<.001*	*1.072*

* Significantly different to untreated.

**** Within a treatment all values were the same therefore it was not possible to carry out an Analysis of Variance on this data.

<u>Treatment application late winter, 08/03/19</u>

The new herbicide HDC H46 was safer at this time of year than application timings tested in 2018 (see 2018 annual report). *Cistus* was slightly damaged and damage persisted until 12 weeks after treatment (WAT). *Sambucus* was also slightly damaged which was significant (p value <.001, L.S.D. 1.072) 2 WAT. By 6 WAT *Sambucus* was starting to grow away from the damage that was still statistically significant, however the plants were not quite commercially acceptable (**Table 2, appendix 3)**. Slight, but significant, damage was also present on *Euonymus* 6 WAT however they had made a full recovery by 12 WAT and were comparable with untreated controls. *Sambucus* had grown away from damage by 12 WAT and were considered commercially acceptable with an average score of 9. By 12 WAT all of the species within the trial were considered commercially acceptable with the exception of *Cistus*.

At 2 WAT, Defy appeared to have scorched *Buxus*, causing a significant reduction in the quality with an average phytotoxicity score of 3 (**Table 19**). Defy 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 6 WAT *Buxus* had recovered and were considered commercially acceptable with a phytotoxicity score of 7. All species tested were considered commercially acceptable by 2 WAT and remained so throughout the trial, last assessed 12 WAT.

Defy tank mixed with Venzar 500 SC had a slight effect on *Hydrangea* and *Sambucus* 6 WAT but were still commercially acceptable (**Table 2, appendix 3)**. *Hydrangea* was comparable with untreated controls by 12 WAT and *Sambucus* was recovering (**Table 3, appendix 3)**. By 12 WAT all of the ten species were considered commercially acceptable.

Defy tank mixed with HDC H46 resulted in damage on more species than either treatment applied alone; at 2 WAT slight damage was significant on *Buxus, Cistus, Cornus* and *Sambucus* (**Table 19)**. By 6 WAT *Sambucus* had recovered and were considered commercially acceptable whereas *Buxus, Cistus, Cornus* had not started to grow away from phytotoxic damage (**Table 2, appendix 3)**. Slight damage that was significant was also present on *Euonymus* 6 WAT. By 12 WAT all of the aforementioned species with the exception of *Cistus* had grown away from phytotoxic damage and were considered commercially acceptable with a score of 7 or above. *Ceanothus* appear to be sensitive to this tank mixture, however significant damage was not visible until 12 WAT (p value <.001, L.S.D. 0.7149). By 12 WAT, eight of the ten species were considered commercially acceptable.

Defy tank mixed with HDC H46 and Venzar 500 SC resulted in damage that was significant on *Buxus* and *Sambucus* 2 WAT (**Table 19)**. *Buxus* had grown away from this damage by 6 WAT and were considered commercially acceptable with a score of 8. By 6 WAT *Sambucus* were also starting to grow away from the damage that was significant but were not quite commercially acceptable (**Table 2, appendix 3)**. Slight damage that was significant was also present on *Euonymus* 6 WAT which persisted until 12 WAT. *Sambucus* had grown away from damage by 12 WAT and were considered commercially acceptable with a score of 8.3. There was very slight damage on *Cistus* at 6 WAT that was still commercially acceptable, but by 12 WAT had progressed to significant (although still slight) damage that was below the threshold of commercial acceptability; below a score of 7 (**Table 3, appendix 3)**. *Ceanothus* appeared to be sensitive to this tank mixture, however significant damage was not visible until 12 WAT (p value <.001, L.S.D. 0.7149). By 12 WAT seven species were considered commercially acceptable.

Discussion

Crop safety of residual herbicides typically relates to plant species; this trial has developed options for some hardy nursery stock 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 as a late winter treatment on species including *Buxus sempervirens, Ceanothus thyrsiflorus, Cornus alba, Euonymus japonicus, Hydrangea paniculata, Ilex aquifolium, Olearia haastii, Perovskia atriplicifolia* and *Sambucus nigra,* giving 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.*

It is worth noting that HDC H46 was considered commercially acceptable on *Cistus* when applied at other times of year (refer to 2018 annual report). However, when applied at other times of year in 2018, HDC H46 was not crop safe on the following species: *Hydrangea paniculata, Perovskia atriplicifolia* and *Sambucus nigra.* Application timing does have an influence on the crop safety of residual herbicides; where crop safety is an issue with a particular species, winter treatments may well be safer.

Defy applied as a late winter treatments appears crop safe, with all 10 species within the trial being commercially acceptable by 12 WAT, however an improved EAMU is required to facilitate its use post crop emergence. When Defy was applied as a tank mix with other residual herbicides it was crop safe on the majority of species tested (see **Table 3, appendix 3)**

Conclusions

The new herbicide HDC H46 has potential for use either alone or in a tank mixture with other products such as Defy and Venzar 500 SC assuming it either gains authorisation for use in ornamental plant production or is granted an EAMU for use in ornamental plant production. Unfortunately, the recently issued EAMU for Venzar 500 SC in ornamentals precludes the products use after the end of July within a calendar year. Venzar 500 SC is safe on a range of species in late winter and in July when foliage starts to harden. Due to restrictions on the maximum rate of Venzar 500 SC and its short persistence, this herbicide is most suited to use in tank mixes to either broaden other residual herbicides' weed control spectrums or as a resistance management tool.

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. Devrinol is in Herbicide Resistance Action Committee (HRAC) resistance code K3; other herbicides used in ornamentals (including Dual Gold and Sunfire) or for possible use in ornamentals (pethoxamid) are within the same HRAC resistance code. Defy is coded as follows by the HRAC: N, so has the potential to be a useful tool to prevent the onset of resistance in key weed species (a known problem with Groundsel).

Hardy nursery stock container trial 2019

Materials and methods

The hardy nursery stock herbicide trial was set up at Darby Nursery Stock, Norfolk, in May 2019. The trial consisted of twenty container-grown hardy nursery stock species (**Table 20**), potted up into 2 or 3 L pots with ICL peat based growing media (including 5 kg/m³ Osmocote Exact Standard 12 - 14 month). The trial included an untreated control and eight herbicide products: (**Table 21**). The treatments were tested at one or two timings, either in May 2019 (after potting), or October 2019 (as a top up application). Any weeds were removed before residual herbicides were applied.

The trial was set up as a fully randomised split block design with three replicates. Each plot contained 100 plants – five plants from each of twenty species. Treatments were applied in the same way as described in the methods section of the previous trial (hardy nursery stock container trial 2018 year two). The May treatments were applied after potting, on 31/05/19, and later treatments applied as top up applications to maintain weed control, on 02/10/19.

Phytotoxicity was assessed at two, six, and twelve (May treatments) and again at two, six, and eleven (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.

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

Table 20. Species and cultivars included in hardy nursery stock container trial 2019 (hereafter referred to by species).

Species	Cultivar
Berberis thunbergii f. atropurpurea	'Atropurpurea Nana'
Chaenomeles x superba	'Crimson and Gold'
Choisya ternata	
Convolvulus cneorum	
Cotoneaster dammeri	
Cytisus	'Lena'
Diervilla splendens	'Diva'
Escallonia	'Red Elf'
Hebe x franciscana	'Variegata'
Hypericum	'Hidcote'
Lavandula vera	
Lavateria Hybrida	'Barnsley'
Ligustrum ovifolium	'Aureum'
Pachysandra terminalis	'Green Sheen'
Photinia x fraseri	'Red Select'
Potentilla fruticosa	'Abbotswood'
Pyracantha	'Soleil d'Or'
Santolina chamaecyparissus	
Senecio compacta	'Drysdale'
Vinca minor	

Table 21. 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	HDC H46	Confidential	Not approved	0.1	May (post-potting)
3	Flexidor + HDC H43	isoxaben 500 g/L + pethoxamid	Label + Not approved	0.5+ 2.0	
4	Flexidor + Centurion Max	isoxaben 500 g/L + clethodim 120 g/L	Label + LTAEU	0.5 + 2.0	
5	Flexidor + Sunfire	isoxaben 500 g/L + flufenacet 500 g/L	Label + EAMU 1065/17	0.5 + 0.48	
6	Flexidor + Dual Gold	isoxaben 500 g/L + S-metolachlor	Label + EAMU 0501/12	0.5 + 0.78	
7	Flexidor	isoxaben 500 g/L	Label	0.5	
1	Untreated	-	-	-	-
2	Flexidor	isoxaben 500 g/L	Label	0.5	October top up
3	Springbok	dimethanid-p + metazachlor	EAMU 2108/15	1.6	

4	Springbok + HDC H43	dimethanid-p + metazachlor + pethoxamid	EAMU 2108/15 + Not approved	1.6 + 2	
5	Springbok + HDC H43 + Venzar 500 SC	dimethanid-p + metazachlor + pethoxamid + lenacil	EAMU 2108/15 + Not approved + LTAEU*	1.6 + 2 + 0.4	
6	HDC H43	pethoxamid	Not approved	2	
7	HDC H46	Confidential	Not approved	0.1	

* An EAMU for the use of Venzar 500 SC was granted in December 2019 however the EAMU restricts use to before the end of July.

Results

Table 22. Average phytotoxicity scores for hardy nursery species, two weeks after May treatment application (assessed 14/06/19). *(NS = no significant differences)*

Species	UTC	HDC H46	Flexidor + HDC H43	Flexidor + Centurion Max	Flexidor + Sunfire	Flexidor + Dual Gold	Flexidor	p value	L.S.D.
Berberis thunbergii f. atropurpurea	9	4.7*	5.3*	6*	5*	4.7*	6*	*<.001*	*1.248*
Chaenomeles x superba	9	7*	7.7*	7.7*	8.3	8*	9	*<.001*	*0.7088*
Choisya ternata	9	8.3	9	8.3	8*	8*	8.3	*0.026*	*0.6724*
Convolvulus cneorum	9	9	9	9	9	9	9	*(NS)*	-
Cotoneaster dammeri	9	5.7*	7.7*	7.7*	7*	6*	8.3	*<.001*	*1.063*
Cytisus	9	9	9	9	8.7	8.7	9	*0.468*	*0.5012*
Diervilla splendens	9	6.3*	8.3	7*	8*	8.3	8.7	*<.001*	*0.7263*
Escallonia	9	9	8.7	8*	8*	8*	8.7	*0.003*	*0.5714*
Hebe x franciscana	9	6	9	9	9	9	9	*0.003*	*1.345*
Hypericum	9	7	6*	6.7	8	7.7	7	*0.248*	*2.536*
Lavandula vera	9	6*	6*	6*	5.3*	5.7*	8.3	*<.001*	*1.121*

Lavateria Hybrida	9	4*	8*	9	8.7	9	9	*<.001*	*0.7263*
Ligustrum ovifolium	9	8*	8*	8*	7.7*	7.3*	8*	*0.002*	*0.5930*
Pachysandra terminalis	9	8.3*	9	8.3*	8.7*	8.7	9	*0.184*	*0.6908*
Photinia x fraseri	9	5*	8	6.7*	8	7.7	8	*0.004*	*1.632*
Potentilla fruticosa	9	8	9	8.3	7	8.3	7	*0.204*	*1.967*
Pyracantha	9	8	8	7.3	8	9	8.3	*<.001*	*0.5714*
Santolina chamaecyparissus	9	9	9	9	9	8.7	9	*0.468*	*0.3882*
Senecio compacta	9	8.3	8.3	9	8*	8.7	9	*0.045*	*0.7088*
Vinca minor	9	8	8	8	8	7.7	7.7	*0.111*	*0.924*

* Significantly different to untreated.

Treatment application at potting, 31/05/19

At 2 weeks after treatment (WAT), Flexidor applied post-potting appeared to have scorched *Berberis,* resulting in an average phytotoxicity score of 6 (p value <.001, L.S.D. 1.248) (**Table 22).** 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 6 WAT *Berberis* had fully recovered and were comparable with untreated controls with a scores of 9.

The new herbicide HDC H46 caused more damage than Flexidor, as it did in 2018 trials; damage in 2019 was recorded on 16 out of the 20 species tested at the first assessment 2 WAT. Of these 16 species only six scored below 7 at 2 WAT (all of these six were significantly different from the untreated control – see **Table 22)** and three (*Cotoneaster, Lavandula* and *Photinia*) scored below 7 at 12 WAT (all three were significantly different from the untreated control; see **Table 23)**

Flexidor tank mixed with either Centurion Max, HDC H43, Sunfire or Dual Gold resulted in increased, significant phytotoxicity on *Berberis* and *Lavandula* in all of the aforementioned treatments 2 WAT. In addition to these species, Flexidor tank mixed with HDC H43 and Flexidor tank mixed with Centurion Max resulted in slight, but significant, damage/reduced growth on *Hypericum* (p value 0.284, L.S.D. 2.536). Flexidor tank mixed with Dual Gold also resulted in slight, but significant, damage/reduced growth on *Cotoneaster* (p value <.001, L.S.D. 1.063). By 6 WAT the majority of species treated with these tank mixes had started to recover and by 12 WAT (**Table 23**) the majority of species were considered commercially acceptable. *Lavandula* was an exception with plants in all treatments still exhibiting

phytotoxic symptoms that were significantly different to untreated controls (see **Table 23** for individual p values and L.S.D.**).** *Lavandula* treated with Flexidor alone was the only treatment on *Lavandula* where the phytotoxic damage 12 WAT was considered commercially acceptable.

Table 23. Average phytotoxicity scores for hardy nursery species, twelve weeks after May treatment application (assessed 23/08/19). *(NS = no significant differences)*

Species	UTC	HDC H46	Flexidor + HDC H43	Flexidor + Centurion Max	Flexidor + Sunfire	Flexidor + Dual Gold	Flexidor	p value	L.S.D.
Berberis thunbergii f. atropurpurea	9	8.3	9	9	9	8.7	9	*0.170*	0.5930
Chaenomeles x superba	9	8.7	8.7	8.3	9	9	8.7	*0.532*	0.824
Choisya ternata	9	9	9	9	8	9	9	*0.468*	1.165
Convolvulus cneorum	9	9	9	9	9	9	9	*(NS)*	-
Cotoneaster dammeri	9	5.3*	7.7*	8	8.3	8.3	8.3	*<.001*	1.051
Cytisus	9	9	9	9	9	9	9	*(NS)*	-
Diervilla splendens	9	8	9	9	9	9	8.3	*0.175*	0.951
Escallonia	9	9	9	9	8	9	9	*0.468*	*1.165*
Hebe x franciscana	9	7.6*	9	9	9	9	9	*0.020*	0.7764
Hypericum	9	8	7.7	7	7.3	9	8.3	*0.098*	*1.569*
Lavandula vera	9	6*	6.3*	5.7*	6.3*	6.7*	7.7*	*0.001*	*1.238*
Lavateria Hybrida	9	9	9	9	9	9	9	*(NS)*	-
Ligustrum ovifolium	9	9	9	9	8	9	9	*0.552*	*1.258*
Pachysandra terminalis	9	8*	9	9	9	9	9	*0.050*	*0.6724*
Photinia x fraseri	9	5.7*	8.7	8.7	8	9	9	*0.034*	*2.017*
Potentilla fruticosa	9	9	8.3	8.3	9	8	9	*0.683*	*1.632*

Pyracantha	9	8.7	9	9	9	9	9	*0.486*	*0.3882*
Santolina chamaecyparissus	9	9	9	9	9	9	9	*(NS)*	-
Senecio compacta	9	9	9	9	9	9	9	*(NS)*	-
Vinca minor	9	8.7	8.3	9	9	9	9	*0.580*	*0.897*

* Significantly different to untreated.

Top up applications, 02/10/19

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 2, 6 and 12 WAT. Most plants were barely affected by the treatments at 2 WAT, with the exception of *Lavandula* where all treatments had a significant phytotoxic effect (p value 0.0001, L.S.D. 1.391) and *Pachysandra* where all treatments other than Springbok alone had a significant effect (p value <.001, L.S.D. 1.487). *Photinia* was damaged by HDC H46 and was slightly but significantly damaged by the tank mix of Springbok, HDC H43 and Venzar 500 SC (p value <.001, L.S.D. 1.545). By 12 WAT the majority of species had recovered and any remaining damage was considered commercially acceptable. *Lavandula* treated with HDC H43 and HDC H46 scored below 7 at 12 WAT. HDC H46 at 12 WAT also resulted in *Photinia* and *Pachysandra* scoring below 7. *Pachysandra* was significant (p value 0.126, L.S.D. 2.931). Pachysandra treated with Springbok tank mixed with HDC H43 and Venzar 500 SC also scored below 7 at 12 WAT, so was not considered a commercially acceptable treatment.

For percentage weed cover see **Table 4, appendix 4.1 and Table 4, appendix 4.2** shows that all treatments had significantly less weed cover than untreated controls.

Discussion

Crop safety of residual herbicides depends on plant species; this trial has developed options other than Flexidor for some hardy nursery stock 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 *Berberis thunbergii f. atropurpurea, Chaenomeles x superba, Choisya ternata, Convolvulus cneorum, Cytisus,*

Diervilla splendens, Escallonia, Hebe x franciscana, Hypericum, Ligustrum ovifolium, Potentilla fruticosa, Pyracantha, Santolina chamaecyparissus, Senecio compacta Vinca minor and gives control of a useful range of common weeds of container nurseries. Short-term scorch may be a problem on some species.

Where Flexidor alone at 0.5 L/ha was too damaging, it may still have potential to be crop safe at the lower rate of 0.25 L/Ha.

Growers should be aware of the possibility of short-term scorch from Flexidor 500 + Centurion Max on *Berberis, Hypericum* and *Photinia;* from Flexidor + Dual Gold on *Berberis* and *Cotoneaster;* from Flexidor + HDC H43 on *Berberis* and *Hypericum*; from Flexidor + Sunfire on *Berberis* and *Lavandula.*

When top up treatments were applied in October, none of the treatments caused notable damage to any of the plant species, with the exception of Springbok + HDC H43 + Venzar 500 SC (*Pachysandra* not commercially acceptable), HDC H43 (*Lavandula* not commercially acceptable), HDC H46 (*Lavandula, Pachysandra* and *Photinia* not commercially acceptable).

Conclusions

Sensitive species such as *Lavandula* 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. Interestingly *Pachysandra* were much more sensitive to autumn applications of residual herbicides when most treatments resulted in initial damage. The applications in May were much safer to the crop. However, with the exception of HDC H46 damage on *Pachysandra,* the various treatments and treatment combinations were considered commercially acceptable by 12 WAT. Therefore such damage would only pose a problem for growers marketing this crop at this time of year.

Dual Gold has demonstrated its potential for use as a summer treatment post potting in combination with Flexidor although the EAMU for Dual Gold restricts use to during May. This tank mixture will give improved control of grass weeds, groundsel and willowherb compared to Flexidor alone and helps to achieve weed control.

New products Sunfire and Centurion Max have shown potential for use in a tank mixture with Flexidor over foliage on most 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)*. Initial scorch on a few subjects was generally temporary with most species growing away from any initial damage, which suggests that growers should be prepared for some varietal susceptibility and there is a need for further testing before these products are adopted for wider 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 carry out weed screening of this herbicides efficacy against the key weeds of container nurseries. Additional work to continue to build information relating to the crop safety of this herbicide within container hardy nursery stock production would be useful, particularly if the active gained an authorisation / EAMU for use in ornamental production.

All of the herbicide treatments with the trial contributed significantly to weed control.

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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Appendices

Appendix 1 2018 Field Tree trial year two

Table 1. Percentage weed cover, 4, 6 and 12 WAT (assessed 09/04/19, 24/04/19, 05/06/19).

Trt. No.	**Treatment**	**Rate** (L/ha)	**Weed cover (%)** 4 weeks	**Weed cover (%)** 6 weeks	**Weed cover (%)** 12 weeks
1	Untreated	-	0	83.7	98.8
2	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H47	1 L/ha + 2.9 L/ha + 0.4 L/ha + 3.75 L/ha	0	0*	0.75*
3	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H44	1 L/ha + 2.9 L/ha + 0.4 L/ha + 1.5 L/ha	0.3	1*	2.5*
4	Sencorex Flow + Stomp Aqua + Venzar 500 SC +Sunfire	1 L/ha + 2.9 L/ha + 0.4 L/ha + 0.48 L/ha	0.3	0.75*	2.8*
5	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC 43	1 L/ha + 2.9 L/ha + 0.4 L/ha + 2.0 L/ha	0.5	2.5*	8.5*
6	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H46	1 L/ha + 2.9 L/ha + 0.4 L/ha + 0.1 L/ha	0.3	2*	3*
7	HDC H46	0.1 L/ha	0.3	1.8*	8.3*
8 and 9	Sencorex Flow + Stomp Aqua + Venzar 500 SC	1 L/ha + 2.9 L/ha + 0.4 L/ha	0	1.1*	5.3*
10	Sencorex Flow	1.15 L/ha	0	1*	3.8*
p value			***0.619***	**<.001**	**<.001**
d.f.			**28**	**28**	**28**
L.S.D.			**0.5247**	**4.495**	**4.464**

* Significantly different to untreated.

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 2. Average phytotoxicity scores for *Malus*, *Prunus, Quince* and *Sorbus* (assessed 4, 6 and 12 WAT; 09/04/19, 24/04/19, 05/06/19). *(NS = no significant differences).* No phytotoxicity was recorded on any species on any of the assessment dates.

Trt. No.	**Planting**	**Rate** (Kg/ha or L/ha)	**Phytotoxicity score** 4 weeks	**Phytotoxicity score** 6 weeks	**Phytotoxicity score** 12 weeks
1	Untreated	-	9	9	9
2	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H47	1 L/ha + 2.9 L/ha + 0.4 L/ha + 3.75 L/ha	9	9	9
3	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H44	1 L/ha + 2.9 L/ha + 0.4 L/ha + 1.5 L/ha	9	9	9
4	Sencorex Flow + Stomp Aqua + Venzar 500 SC +Sunfire	1 L/ha + 2.9 L/ha + 0.4 L/ha + 0.48 L/ha	9	9	9
5	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC 43	1 L/ha + 2.9 L/ha + 0.4 L/ha + 2.0 L/ha	9	9	9
6	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H46	1 L/ha + 2.9 L/ha + 0.4 L/ha + 0.1 L/ha	9	9	9
7	HDC H46	0.1 L/ha	9	9	9
8 and 9	Sencorex Flow + Stomp Aqua + Venzar 500 SC	1 L/ha + 2.9 L/ha + 0.4 L/ha	9	9	9
10	Sencorex Flow	1.15 L/ha	9	9	9
		p value	*N/S*	*N/S*	*N/S*
		L.S.D.	-	-	-

Appendix 2 – 2019 Field Tree trial

Table 1. Percentage weed cover, 2, 6 and 12 WAT (assessed 15/05/19, 12/06/19 and 26/07/19)

Trt. No.	**Treatment**	**Rate** (L/ha)	**Weed cover (%)** 2 weeks	**Weed cover (%)** 6 weeks	**Weed cover (%)** 12 weeks
1	Untreated	-	1	58.3	98.3
2	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H47	1 L/ha + 2.9 L/ha + 0.4 L/ha + 3.75 L/ha	0	5*	8*
3	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H44	1 L/ha + 2.9 L/ha + 0.4 L/ha + 1.75 L/ha	0	0.3*	1.7*
4	Sencorex Flow + Stomp Aqua + Venzar 500 SC +Sunfire	1 L/ha + 2.9 L/ha + 0.4 L/ha + 0.48 L/ha	0	1*	2.3*
5	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H43	1 L/ha + 2.9 L/ha + 0.4 L/ha + 2.0 L/ha	0	1*	2.3*
6	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H46	1 L/ha + 2.9 L/ha + 0.4 L/ha + 0.1 L/ha	0	0.3*	1.3*
7	HDC H46	0.1 L/ha	0	2*	48.3*
8	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H42	1 L/ha + 2.9 L/ha + 0.4 L/ha + 1.5 L/ha	0	0*	0.3*
9	Sencorex Flow + Stomp Aqua + Venzar 500 SC	1 L/ha + 2.9 L/ha + 0.4 L/ha	0	0.7*	1.7*
10	Sencorex Flow	1.15 L/ha	0	1.3*	10*
p value			***N/S***	**<.001**	**<.001**
d.f.			**-**	**18**	**18**
L.S.D.			**-**	**18.69**	**10.09**

* Significantly different to untreated.

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 2. Average phytotoxicity scores for *Malus*, assessed 2, 6 and 12 WAT (assessed 15/05/19, 12/06/19 and 26/07/19). *(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	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H47	1 L/ha + 2.9 L/ha + 0.4 L/ha + 3.75 L/ha	8*	9	9
3	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H44	1 L/ha + 2.9 L/ha + 0.4 L/ha + 1.75 L/ha	6*	8*	9
4	Sencorex Flow + Stomp Aqua + Venzar 500 SC +Sunfire	1 L/ha + 2.9 L/ha + 0.4 L/ha + 0.48 L/ha	8*	8.7	9
5	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H43	1 L/ha + 2.9 L/ha + 0.4 L/ha + 2.0 L/ha	8*	9	9
6	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H46	1 L/ha + 2.9 L/ha + 0.4 L/ha + 0.1 L/ha	6.7*	8.3*	9
7	HDC H46	0.1 L/ha	8*	9	9
8	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H42	1 L/ha + 2.9 L/ha + 0.4 L/ha + 1.5 L/ha	4*	6*	9
9	Sencorex Flow + Stomp Aqua + Venzar 500 SC	1 L/ha + 2.9 L/ha + 0.4 L/ha	8*	9	9
10	Sencorex Flow	1.15 L/ha	8*	9	9
		p value	*<.001*	*<.001*	*N/S*
		(18 df) **L.S.D.**	*0.3132*	*0.4304*	-

* Significantly different to untreated.

Table 3. Average phytotoxicity scores for *Prunus*, assessed 2, 6 & 12 WAT (assessed 15/05/19, 12/06/19 and 26/07/19). *(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	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H47	1 L/ha + 2.9 L/ha + 0.4 L/ha + 3.75 L/ha	8*	9	9
3	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H44	1 L/ha + 2.9 L/ha + 0.4 L/ha + 1.75 L/ha	7.6*	9	9
4	Sencorex Flow + Stomp Aqua + Venzar 500 SC +Sunfire	1 L/ha + 2.9 L/ha + 0.4 L/ha + 0.48 L/ha	8*	9	9
5	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H43	1 L/ha + 2.9 L/ha + 0.4 L/ha + 2.0 L/ha	8*	9	9
6	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H46	1 L/ha + 2.9 L/ha + 0.4 L/ha + 0.1 L/ha	8*	8.6*	9
7	HDC H46	0.1 L/ha	8*	9	9
8	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H42	1 L/ha + 2.9 L/ha + 0.4 L/ha + 1.5 L/ha	4*	6*	8.3*
9	Sencorex Flow + Stomp Aqua + Venzar 500 SC	1 L/ha + 2.9 L/ha + 0.4 L/ha	8*	9	9
10	Sencorex Flow	1.15 L/ha	8*	9	9
		p value	<.001	<.001	0.006
		(18 df) **L.S.D.**	0.3132	0.3132	0.3132

* Significantly different to untreated.

Table 4. Average phytotoxicity scores for Quince, assessed 2, 6 & 12 WAT (assessed 15/05/19, 12/06/19 and 26/07/19). *(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	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H47	1 L/ha + 2.9 L/ha + 0.4 L/ha + 3.75 L/ha	8	8*	9
3	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H44	1 L/ha + 2.9 L/ha + 0.4 L/ha + 1.75 L/ha	6	8*	9
4	Sencorex Flow + Stomp Aqua + Venzar 500 SC +Sunfire	1 L/ha + 2.9 L/ha + 0.4 L/ha + 0.48 L/ha	8	9	9
5	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H43	1 L/ha + 2.9 L/ha + 0.4 L/ha + 2.0 L/ha	8	8.7	9
6	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H46	1 L/ha + 2.9 L/ha + 0.4 L/ha + 0.1 L/ha	8	8.3	9
7	HDC H46	0.1 L/ha	8	9	9
8	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H42	1 L/ha + 2.9 L/ha + 0.4 L/ha + 1.5 L/ha	4	6*	8.3*
9	Sencorex Flow + Stomp Aqua + Venzar 500 SC	1 L/ha + 2.9 L/ha + 0.4 L/ha	8	8.7	9
10	Sencorex Flow	1.15 L/ha	8	9	9
		p value	*N/S*	*<.001*	*0.006*
		(18 df) **L.S.D.**	-	*0.5323*	*0.3132*

*** ***Within a treatment all values were the same therefore it was not possible to carry out an analysis of variance on this data. All treatments were significantly different from untreated controls at 2 WAT.

Table 5. Average phytotoxicity scores for Sorbus, assessed 2, 6 & 12 WAT (assessed 15/05/19, 12/06/19 and 26/07/19). *(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	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H47	1 L/ha + 2.9 L/ha + 0.4 L/ha + 3.75 L/ha	8	8.3*	9
3	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H44	1 L/ha + 2.9 L/ha + 0.4 L/ha + 1.75 L/ha	6	7*	8.6
4	Sencorex Flow + Stomp Aqua + Venzar 500 SC +Sunfire	1 L/ha + 2.9 L/ha + 0.4 L/ha + 0.48 L/ha	7	9	9
5	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H43	1 L/ha + 2.9 L/ha + 0.4 L/ha + 2.0 L/ha	7	8.3*	9
6	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H46	1 L/ha + 2.9 L/ha + 0.4 L/ha + 0.1 L/ha	8	8*	9
7	HDC H46	0.1 L/ha	8	8*	9
8	Sencorex Flow + Stomp Aqua + Venzar 500 SC + HDC H42	1 L/ha + 2.9 L/ha + 0.4 L/ha + 1.5 L/ha	4	6*	8.3*
9	Sencorex Flow + Stomp Aqua + Venzar 500 SC	1 L/ha + 2.9 L/ha + 0.4 L/ha	8	8*	9
10	Sencorex Flow	1.15 L/ha	8	8.3*	9
		p value	*N/S*	*<.001*	*0.053*
		(18 df) **L.S.D.**	-	*0.5718*	*0.4304*

* Significantly different to untreated.

*** ***Within a treatment all values were the same therefore it was not possible to carry out an analysis of variance on this data. All treatments were significantly different to the untreated control at 2 WAT.

Figures 1 – 4 Initial damage caused by HDC H42 in tank mixtures 2 WAT.

Figure 1. Damaged / reduced growth caused by tank mixture containing HDC H42 on *Malus* 2 WAT.

Figure 2. Damaged / reduced growth caused by tank mixture containing HDC H42 on *Quince* 2 WAT.

Figure 3. Damaged / reduced growth caused by tank mixture containing HDC H42 on *Sorbus* 2 WAT.

Figure 4. Damaged / reduced growth caused by tank mixture containing HDC H42 on *Prunus* 2 WAT.

Table 6. Top up treatments applied post budding.

Trt. No.	Treatment	**Rate** (L/ha)	**Weed cover (%)** 2 weeks
1	Untreated	-	0
2 – 10	Shark* + Flexidor + Springbok + Venzar 500 SC	0.8L/ha + 0.5 L/ha + 2.5 L/Ha + 0.4 L/ha	0
p value			***N/S***
d.f.			**-**
L.S.D.			**-**

* Applied separately, prior to residual herbicides.

Table 7. Average phytotoxicity scores for *Malus, Prunus, Quince* and *Sorbus*, 2 WAT top up application (assessed 17/10/19). *(NS = no significant differences)*

Treatment	Percentage weed cover	Phytotoxicity score *Malus*	Phytotoxicity score *Prunus*	Phytotoxicity score *Quince*	Phytotoxicity score *Sorbus*
1	98.3	9	9	9	9
2	8*	9	9	8*	9
3	1.7*	9	9	8*	9
4	2.3*	9	9	8*	9
5	2.3*	9	9	8*	9
6	1.3*	9	9	8*	9
7	48.3*	9	9	8*	9
8	0.3*	9	9	8*	9
9	1.7*	9	9	8*	9
10	10*	9	9	8*	9
p value	**<.001**	*N/S*	*N/S*	*0.093*	*N/S*
(18 df) **L.S.D.**	**10.09**	-	-	*0.4669*	-

* Significantly different

Appendix 3 – Hardy nursery stock container trial 2018 year two

March 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 March treatment application (assessed 22/03/19). *(NS = no significant differences)*

Species	UTC	Sinclair pot topper	Defy	Defy + HDC H46	HDC H46	HDC H46 + Venzar 500 SC	Defy + HDC H46 + Venzar 500 SC	Defy + Venzar 500 SC	p value	L.S.D.
*Buxus sempervirens***	9	9	3*	6*	9	7*	6*	9	-	-
Ceanothus thyrsiflorus	9	9	9	9	9	9	9	9	*(NS)*	-
Cistus x purpureus	9	9	9	6	6	7	7.3	9	*<.001*	0.7149
Cornus alba	9	9	9	6*	9	8.7	7.3*	9	*<.001*	0.974
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	9	9	9	9	9	9	*(NS)*	-
Perovskia atriplicifolia	9	9	9	9	9	9	9	9	*(NS)*	-
Sambucus nigra	9	9	9	6*	6*	7*	6*	9	*<.001*	*1.072*

* Significantly different to untreated.

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

Table 2. Average phytotoxicity scores for hardy nursery species, six weeks after March treatment application (assessed 17/04/19). *(NS = no significant differences)*

Species	UTC	Sinclair pot topper	Defy	Defy + HDC H46	HDC H46	HDC H46 + Venzar 500 SC	Defy + HDC H46 + Venzar 500 SC	Defy + Venzar 500 SC	p value	L.S.D.
*Buxus sempervirens***	9	9	9	6*	8*	8*	8*	9	-	-
Ceanothus thyrsiflorus	9	9	9	9	9	9	9	9	*(NS)*	-
Cistus x purpureus	9	9	9	6*	*6	7*	7.3*	9	*<.001*	*0.7149*
Cornus alba	9	9	9	6*	9	8.7	7.3*	9	*<.001*	*0.974*

Euonymus japonicus	9	9	9	6*	6.3*	6*	6*	9	*<.001*	*0.3575*
Hydrangea paniculata	9	9	8*	8.3*	8.3*	8*	8*	8*	*0.002*	*0.5233*
Ilex aquifolium	9	9	9	9	9	9	9	9	*(NS)*	-
Olearia x haastii	9	9	9	9	9	9	9	9	*(NS)*	-
Perovskia atriplicifolia	9	9	9	8*	9	8	8	9	*<.001*	*0.7149*
Sambucus nigra	9	9	8*	7*	6.7*	7*	6.7*	7.3*	*<.001*	*0.6480*

* Significantly different to untreated.

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

Table 3: Average phytotoxicity scores for hardy nursery species, twelve weeks after March treatment application (assessed 31/05/19). *(NS = no significant differences)*

Species	**UTC**	**Sinclair pot topper**	**Defy**	**Defy + HDC H46**	**HDC H46**	**HDC H46 + Venzar 500 SC**	**Defy + HDC H46 + Venzar 500 SC**	**Defy + Venzar 500 SC**	**p value**	**L.S.D.**
Buxus sempervirens	9	9	9	9	9	9	9	9	*(NS)*	-
Ceanothus thyrsiflorus	9	9	9	4*	9	9	5.3*	9	*<.001*	*0.7149*
Cistus x purpureus	9	9	9	6*	6*	7*	6*	9	*(NS)*	-
Cornus alba	9	9	9	9	9	9	9	9	*(NS)*	-
*Euonymus japonicus***	9	9	9	9	9	7*	6*	9	-	-
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	9	9	9	9	9	9	*(NS)*	-
Perovskia atriplicifolia	9	9	9	9	9	9	9	9	*(NS)*	-
Sambucus nigra	9	9	9	9	9	9	9	8.3*	*0.013*	*0.3575*

***** Significantly different to untreated.

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

Appendix 4 – Hardy nursery stock container trial 2019

4.1 – May 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 May treatment application (assessed 14/06/19). *(NS = no significant differences)*

Species	UTC	HDC H46	Flexidor + HDC H43	Flexidor + Centurion Max	Flexidor + Sunfire	Flexidor + Dual Gold	Flexidor	p value	L.S.D.
Berberis thunbergii f. atropurpurea	9	4.7*	5.3*	6*	5*	4.7*	6*	*<.001*	*1.248*
Chaenomeles x superba	9	7*	7.7*	7.7*	8.3	8*	9	*<.001*	*0.7088*
Choisya ternata	9	8.3	9	8.3	8*	8*	8.3	*0.026*	*0.6724*
Convolvulus cneorum	9	9	9	9	9	9	9	*(NS)*	-
Cotoneaster dammeri	9	5.7*	7.7*	7.7*	7*	6*	8.3	*<.001*	*1.063*
Cytisus	9	9	9	9	8.7	8.7	9	*0.468*	*0.5012*
Diervilla splendens	9	6.3*	8.3	7*	8*	8.3	8.7	*<.001*	*0.7263*
Escallonia	9	9	8.7	8*	8*	8*	8.7	*0.003*	*0.5714*
Hebe x franciscana	9	6	9	9	9	9	9	*0.003*	*1.345*
Hypericum	9	7	6*	6.7	8	7.7	7	*0.248*	*2.536*
Lavandula vera	9	6*	6*	6*	5.3*	5.7*	8.3	*<.001*	*1.121*
Lavateria Hybrida	9	4*	8*	9	8.7	9	9	*<.001*	*0.7263*
Ligustrum ovifolium	9	8*	8*	8*	7.7*	7.3*	8*	*0.002*	*0.5930*
Pachysandra terminalis	9	8.3*	9	8.3*	8.7*	8.7	9	*0.184*	*0.6908*
Photinia x fraseri	9	5*	8	6.7*	8	7.7	8	*0.004*	*1.632*
Potentilla fruticosa	9	8	9	8.3	7	8.3	7	*0.204*	*1.967*
Pyracantha	9	8	8	7.3	8	9	8.3	*<.001*	*0.5714*

Santolina chamaecyparissus	9	9	9	9	9	8.7	9	*0.468*	*0.3882*
Senecio compacta	9	8.3	8.3	9	8*	8.7	9	*0.045*	*0.7088*
Vinca minor	9	8	8	8	8	7.7	7.7	*0.111*	*0.924*

* Significantly different to untreated.

Table 2. Average phytotoxicity scores for hardy nursery species, six weeks after May treatment application (assessed 12/07/19). *(NS = no significant differences)*

Species	UTC	HDC H46	Flexidor + HDC H43	Flexidor + Centurion Max	Flexidor + Sunfire	Flexidor + Dual Gold	Flexidor	p value	L.S.D.
Berberis thunbergii f. atropurpurea	9	7.7*	9	8.7	9	8.3	9	*0.009*	*0.7008*
Chaenomeles x superba	9	8.3	8.7	8.7	9	9	8.7	*(NS)*	-
Choisya ternate	9	9	9	8.7	8.7	9	9	*0.608*	*0.5714*
Convolvulus cneorum	9	9	9	9	9	9	9	*(NS)*	-
Cotoneaster dammeri	9	4.3	5.7	7.7	6.7	6.7	9	*<.001*	*1.363*
Cytisus	9	9	9	9	9	9	9	*(NS)*	-
Diervilla splendens	9	6.3*	8.67	8.67	9	9	9	*0.026*	*1.569*
Escallonia	9	9	9	9	9	9	9	*(NS)*	-
Hebe x franciscana	9	7	9	9	9	9	9	*0.020*	*1.165*
Hypericum	9	8.3	8.3	8.3	9	9	9	*(NS)*	-
Lavandula vera	9	6.3	6.7*	7	6	6.7	8	*0.002*	*1.186*
Lavateria Hybrida	9	6.7	9	9	9	9	9	*0.024*	*1.400*
Ligustrum ovifolium	9	9	9	9	9	9	9	*(NS)*	-
Pachysandra terminalis	9	4	9	9	9	8.7	9	*<.001*	*1.197*
Photinia x fraseri	9	4*	8.67	8.67	9	9	9	*<.001*	*0.882*

Potentilla fruticosa	9	8.3	9	9	9	9	9	*0.020*	*03882*
Pyracantha	9	8.7	9	9	9	9	9	*0.468*	*0.3882*
Santolina chamaecyparissus	9	9	9	9	9	9	9	*(NS)*	-
Senecio compacta	9	9	9	9	9	9	9	*(NS)*	-
Vinca minor	9	9	9	9	9	9	9	*(NS)*	-

* Significantly different to untreated.

Table 3. Average phytotoxicity scores for hardy nursery species, twelve weeks after May treatment application (assessed 23/08/19). *(NS = no significant differences)*

Species	UTC	HDC H46	Flexidor + HDC H43	Flexidor + Centurion Max	Flexidor + Sunfire	Flexidor + Dual Gold	Flexidor	p value	L.S.D.
Berberis thunbergii f. atropurpurea	9	8.3	9	9	9	8.7	9	*0.170*	0.5930
Chaenomeles x superba	9	8.7	8.7	8.3	9	9	8.7	*0.532*	0.824
Choisya ternate	9	9	9	9	8	9	9	*0.468*	1.165
Convolvulus cneorum	9	9	9	9	9	9	9	*(NS)*	-
Cotoneaster dammeri	9	5.3*	7.7*	8	8.3	8.3	8.3	*<.001*	1.051
Cytisus	9	9	9	9	9	9	9	*(NS)*	-
Diervilla splendens	9	8	9	9	9	9	8.3	*0.175*	0.951
Escallonia	9	9	9	9	8	9	9	*0.468*	*1.165*
Hebe x franciscana	9	7.6*	9	9	9	9	9	*0.020*	0.7764
Hypericum	9	8	7.7	7	7.3	9	8.3	*0.098*	*1.569*
Lavandula vera	9	6*	6.3*	5.7*	6.3*	6.7*	7.7*	*0.001*	*1.238*
Lavateria Hybrida	9	9	9	9	9	9	9	*(NS)*	-

Ligustrum ovifolium	9	9	9	9	8	9	9	*0.552*	*1.258*
Pachysandra terminalis	9	8*	9	9	9	9	9	*0.050*	*0.6724*
Photinia x fraseri	9	5.7*	8.7	8.7	8	9	9	*0.034*	*2.017*
Potentilla fruticosa	9	9	8.3	8.3	9	8	9	*0.683*	*1.632*
Pyracantha	9	8.7	9	9	9	9	9	*0.486*	*0.3882*
Santolina chamaecyparissus	9	9	9	9	9	9	9	*(NS)*	-
Senecio compacta	9	9	9	9	9	9	9	*(NS)*	-
Vinca minor	9	8.7	8.3	9	9	9	9	*0.580*	*0.897*

* Significantly different to untreated.

Table 4. Average mean percentage weed cover by treatment and assessment date after May treatment application (assessed 14/06/19, 12/07/19, 23/08/19). *(NS = no significant differences)*

Assessment date	UTC	HDC H46	Flexidor + HDC H43	Flexidor + Centurion Max	Flexidor + Sunfire	Flexidor + Dual Gold	Flexidor	p value	L.S.D.
2 WAT	0	0	0	0	0	0	0	*(NS)*	-
6 WAT	0.3	0.1	0.1	0.1	0.1	0.1	0.1	*0.101*	0.1528
12 WAT	30	5.7*	9*	8*	7.3*	9*	9*	*<.001*	7.571

* Significantly different to untreated.

4.2 – October treatment results

Table 1. Average phytotoxicity scores* for hardy nursery species, two weeks after October treatment application (assessed 17/10/19). *(NS = no significant differences)*

Species	UTC	Flexidor	Springbok	Springbok + HDC H43	Springbok + HDC H43 + Venzar 500 SC	HDC H43	HDC H46	p value	L.S.D.
Berberis thunbergii f. atropurpurea	9	9	9	9	9	9	9	*(NS)*	-

Chaenomeles x superba	9	9	9	8.7	9	8.7	8.7	*0.679*	*0.6724*
Choisya ternata	9	9	9	9	9	9	9	*(NS)*	-
Convolvulus cneorum	9	9	9	9	9	9	7.7*	*0.020*	*0.7764*
Cotoneaster dammeri	9	7*	9	9	8.7	9	8	*0.030*	*1.258*
Cytisus	9	9	9	9	9	8.7	9	*0.468*	*0.3882*
Diervilla splendens	9	8.3	9	8.7	9	8.7	8	*0.230*	*0.938*
Escallonia	9	9	9	9	9	9	9	*(NS)*	-
Hebe x franciscana	9	8	9	8.7	9	8.7	6*	*0.002*	*1.268*
Hypericum	9	8.7	9	7.7	8.3	8.7	8	*0.105*	*1.027*
Lavandula vera	9	6*	7*	6.7*	5.7*	6.3*	5*	*0.001*	*1.391*
Lavateria Hybrida	9	8.7	9	9	9	9	9	*0.468*	*0.3882*
Ligustrum ovifolium	9	9	9	9	8.7	9	8.7	*0.468*	*0.5012*
Pachysandra terminalis	9	.3*	8.3	6.3*	5*	5.3*	6.3*	*<.001*	*1.487*
Photinia x fraseri	9	7.7	8.7	8	6.7*	8.7	3.3*	*<.001*	*1.545*
Potentilla fruticosa	9	8.7	9	9	9	8.3	9	*0.580*	*0.897*
Pyracantha	9	9	9	9	9	8.7	9	*0.468*	*0.3882*
Santolina chamaecyparissus	9	8.3*	9	9	9	9	9	*0.020*	*0.3882*
Senecio compacta	9	9	8.3	8.3	9	8.7	9	*0.615*	*1.121*
Vinca minor	9	8*	8.7	9	9	9	9	*<.001*	*0.3882*

* Significantly different to untreated.

Table 2. Average phytotoxicity scores** for hardy nursery species, six weeks after October treatment application (assessed 14/11/19). *(NS = no significant differences)*

Species	UTC	Flexidor	Springbok	Springbok + HDC H43	Springbok + HDC H43 + Venzar 500 SC	HDC H43	HDC H46	p value	L.S.D.
Berberis thunbergii f. atropurpurea	9	9	9	9	9	9	9	*(NS)*	-
Chaenomeles x superba	9	7.3	9	8.7	9	8.7	9	*0.573*	*2.066*
Choisya ternata	9	9	9	9	9	9	9	*(NS)*	-
Convolvulus cneorum	9	9	9	9	9	9	8.3	*0.468*	*0.7764*
Cotoneaster dammeri	9	8	9	9	8.7	8.3	8	*0.771*	*1.935*
Cytisus	9	9	9	9	9	9	9	*(NS)*	-
Diervilla splendens	9	7	8.3	8.3	8	8.7	7.3	*0.376*	*2.017*
Escallonia	9	9	9	9	9	9	9	*(NS)*	-
Hebe x franciscana	9	7.3	9	8	9	7.7	5.7 *	*0.006*	*1.593*
Hypericum	9	8.7	8	8	8.3	8.7	7.7	*0.630*	*1.692*
Lavandula vera	9*	4.7*	7*	6.7*	6*	7*	6*	*0.008*	*1.807*
Lavateria Hybrida	9	9	9	9	9	9	9	*(NS)*	-
Ligustrum ovifolium	9	9	9	9	9	8	9	*0.468*	*1.165*
Pachysandra terminalis	9	6*	8	8	7	9	3.3 *	*<.001*	*2.072*
Photinia x fraseri	9	7.7*	8.7	8.7	7.7*	8.7	3.7 *	*<.001*	*0.910*
Potentilla fruticosa	9	9	9	9	9	9	9	*(NS)*	-
Pyracantha	9	9	9	9	9	9	9	*(NS)*	-
Santolina chamaecyparissus	9	9	9	9	9	9	8.3	*0.468*	*0.7764*

Senecio compacta	9	9	8.3	9	9	8.7	9	*0.580*	*0.897*
Vinca minor	9	9	8.7	9	9	9	8.3	*0.580*	*0.897*

* Significantly different to untreated.

Table 3. Average phytotoxicity scores** for hardy nursery species, eleven weeks after October treatment application (assessed 20/12/19). *(NS = no significant differences)*

Species	UTC	Flexidor	Springbok	Springbok + HDC H43	Springbok + HDC H43 + Venzar 500 SC	HDC H43	HDC H46	p value	L.S.D.
Berberis thunbergii f. atropurpurea	9	9	9	9	9	9	9	*(NS)*	-
Chaenomeles x superba	9	9	9	9	9	9	9	*(NS)*	-
Choisya ternata	9	9	9	9	9	9	9	*(NS)*	-
Convolvulus cneorum	9	9	9	9	9	9	9	*(NS)*	-
Cotoneaster dammeri	9	8.7	9	9	9	8	9	*0.552*	*1.258*
Cytisus	9	9	9	9	9	9	9	*(NS)*	-
Diervilla splendens	9	9	9	9	9	9	9	*(NS)*	-
Escallonia	9	9	9	9	9	9	9	*(NS)*	-
Hebe x franciscana	9	8.3	9	7.3	8	9	7	*0.416*	*2.445*
Hypericum	9	9	9	8.3	8.7	8.7	8	*0.549*	*1.278*
Lavandula vera	8	7.3	8	7.7	7	6.3	5.7	*0.599*	*3.061*
Lavateria Hybrida	9	9	9	9	9	9	9	*(NS)*	-
Ligustrum ovifolium	9	9	9	9	9	9	9	*(NS)*	-
Pachysandra terminalis	9	8.3	9	7	6.3	7.7	5.3 *	*0.126*	*2.931*
Photinia x fraseri	9	8	9	7	7	7.7	6.7	*0.518*	*3.085*
Potentilla fruticosa	9	9	9	9	9	9	9	*(NS)*	-
Pyracantha	9	9	9	9	9	9	9	*(NS)*	-
Santolina chamaecyparissus	9	9	9	9	9	9	9	*(NS)*	-

Senecio compacta	9	9	9	9	8.4	9	9	*0.608*	*0.5714*
Vinca minor	9	9	9	9	8.7	8.7	9	*0.608*	*0.5714*

* Significantly different to untreated.

Table 4. Average mean percentage weed cover by treatment and assessment date after October treatment application (assessed 17/10/19, 14/11/19, 20/12/19). *(NS = no significant differences)*

Assessment date	**UTC**	**HDC H46**	**Flexidor + HDC H43**	**Flexidor + Centurion Max**	**Flexidor + Sunfire**	**Flexidor + Dual Gold**	**Flexidor**	**p value**	**L.S.D.**
2 WAT	6.7	1.2*	1.7*	1.8*	0.5*	1*	0.5*	*<.001*	1.699
6 WAT	10	1*	1*	3*	1.2*	2*	0.7*	*<.001*	2.052
12 WAT	15	1.2*	2.7*	3*	1.7*	1.7*	0.6*	*<.001*	3.487

* Significantly different to untreated.