



Grower Summary

Improving weed control in hardy nursery stock

HNS 198

Final report

Project title: Improving weed control in hardy nursery stock

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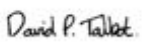
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The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because 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 31.03.2023

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Grower Summary

Headlines

- For budded tree production in the field, herbicide programmes of Sencorex Flow + Stomp Aqua + Venzar 500 SC + Sunfire after planting and Sencorex Flow + Stomp Aqua + Sunfire 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 or Sencorex Flow + Stomp Aqua + Sunfire.
- Sencorex Flow at the maximum rate of 1.15 L/ha proved safe, applied alone and as a component of tank mixes as a post-planting and post heading back treatment to four tree species.
- Sencorex Flow has not previously been widely used within container production and shows strong potential as a dormant season treatment.
- Sencorex Flow proved effective against eight weed species tested as a pre- and post-emergence treatment.
- HDC H43 and HDC H46 showed potential for use in container production if suitable EAMUs can be obtained.

Background

The decreasing number of herbicides available to the Hardy Nursery Stock (HNS) sector is an ongoing challenge with restrictions on the rates, timings, and number of applications of many of the available herbicides all impacting upon chemical weed control options.

Field grown nursery stock. Sencorex Flow performed well in previous trials on field grown nursery stock and has proven its suitability to form the basis of a residual herbicide programme post-planting and post-heading-back on field grown trees as an effective, crop safe alternative to Flexidor. The trials carried out under this programme of work have already assessed the suitability of this herbicide at higher rates than previously used on field grown trees. The final year of trials on field grown trees assessed Sencorex Flow at the maximum rate permitted on the EAMU alone and as a component of tank mixes. Although Devrinol has recently been issued an Extension of Authorisation for Minor Use (EAMU) for use in ornamentals, its restrictions prevent its 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.

Other herbicides selected for inclusion in the field tree trials are those for which appropriate EAMUs have recently been granted, e.g., Sunfire (flufenacet), alongside some newer products that are not yet authorised. In 2018, this project looked at the efficacy and crop safety of two-season herbicide programmes, including new products for field tree production. The aim of the current trials was to build on the knowledge gained from the previous trial, and to include new products alongside robust herbicides such as Sencorex Flow in other field-grown ornamentals.

Container grown nursery stock. Restrictions on the use of Butisan S (metazachlor) and Venzar 500 SC (under EAMU) have left gaps in the herbicides available to growers of container hardy nursery stock. Flexidor (isoxaben) has in recent years 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 projects CP 86 '*Weed control in ornamentals, fruit and vegetable crops – maintaining capability to devise suitable weed control strategies*' (Atwood, 2015), HNS/PO 192 & 192a '*Herbicides screening for ornamental plant production (nursery stock, cut flowers and wallflowers)*' (Atwood 2015, 2016), and HNS 198 '*Improving weed control in hardy nursery stock*' (Atwood & Talbot 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 (tepraloxymidim), 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. Centurion Max has recently been granted an EAMU for use in ornamentals.

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

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container screening tests, 2019 field trials and 2022 container pot screen. 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.

Sencorex Flow (metribuzin) showed potential in trials carried out in Ireland (personal communication, Flanagan, D., 2018) as a winter treatment applied to container grown hardy nursery stock. Given the lack of herbicide options Sencorex Flow was included in the 2019-year two herbicide screen and the 2022 container pot screen.

The Long Term Arrangements for Extensions of Use (LTAEU) have now ceased so only herbicides with either on label uses or EAMUs for use in ornamentals can legally be used.

The industry has become increasingly reliant on Flexidor in recent years, however the current label only permits one application per crop, so growers need to consider the alternative residual options assessed in this project.

Summary

Three herbicide trials were carried out on 1) field grown budded trees and 2) container-grown nursery stock and 3) crop safety of a range of herbicides on twenty container-grown HNS subjects. The herbicides included in these trials are listed in **Table 1**.

Table 1. Herbicides, approval status and rates used in HNS trials carried out in 2019 - 2022.

Product	Active	Approval status	2019 Field tree trial year two (L/ha)	HNS Container trial 2019 year two (L/ha)	2022 Container pot screen (L/ha)
Centurion Max	120 g/L clethodim	LTAEU			2.0
Devrinol	450 g/l napropamide	EAMU		7.0	
Dual Gold		EAMU			0.78
Flexidor	500 g/L isoxaben	Label			0.5
HDC H42	Confidential	Not authorised	1.5		
HDC H43	Confidential	Not authorised	2.0		1.0
HDC H44*	Confidential	Not authorised	1.75		

HDC H46	Confidential	Not authorised	0.1	0.1	0.1
HDC H47	Confidential	Not authorised	3.75		
Sencorex Flow	600 g/L metribuzin	EAMU	1.0 and 1.15	0.5 and 1.0	0.5 and 1.15
Springbok	200 g/L metazachlor + 200 g/L dimethenamid-p	EAMU		1.66	
Stomp Aqua	455 g/L pendimethalin	EAMU	2.9		
Sunfire	500 g/L flufenacet	EAMU	0.48		0.48
Venzar 500 SC	500 g/L lenacil	LTAEU, now EAMU			0.4

*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.

1. Field Tree Trial (2019). Year 2

The 2019 field tree trial was set up on newly planted rootstocks at Frank P Matthews, Worcestershire in 2019 (see 2018 annual report for results from year one). The aim of the work carried out in year two (2020) 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) as 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*) and three replicate blocks. 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) on the test species and was applied post heading back on 20/03/20. This was a higher rate of Sencorex Flow than previously used in tank mixes and it proved to be crop safe at this higher rate; experimental treatment 3 resulted in initial damage on *Prunus*, *Quince*, *Sorbus* that was considered commercially

unacceptable at 4 WAT. Experimental treatment 8 resulted in initial damage on *Prunus* that was considered commercially unacceptable at 4 WAT. However, all species grew away from the initial damage and were considered comparable with untreated control by 12 WAT in terms of crop safety.

Table 2. Treatment list and percentage weed cover, 4, 6 and 12 WAT (assessed 24/04/20, 07/05/20 and 20/06/20).

Trt. No.	Post heading back	Rate (L/ha)	Weed cover (%) 4 weeks	Weed cover (%) 6 weeks	Weed cover (%) 12 weeks
1	Untreated (10,16,25)	Untreated	81.8	88.3	98.3
2	Sencorex Flow + Sunfire + Stomp Aqua + HDC H47	1.15 L/ha + 0.48 L/ha + 2.9 L/ha + 3.75 L/ha	0.5	2.0	4.2
3	Sencorex Flow + Sunfire + Stomp Aqua + HDC H44	1.15 L/ha + 0.48 L/ha + 2.9 L/ha + 1.75 L/ha	0.0	0.2	1.0
4	Sencorex Flow + Sunfire + Stomp Aqua	1.15 L/ha + 0.48 L/ha + 2.9 L/ha	0.3	0.7	1.0
5	Sencorex Flow + Sunfire + Stomp Aqua + HDC H43	1.15 L/ha + 0.48 L/ha + 2.9 L/ha + 2.0	0.7	0.8	1.7
6	Sencorex Flow + Sunfire + Stomp Aqua + HDC H46	1.15 L/ha + 0.48 L/ha + 2.9 L/ha + 0.1 L/ha	0.5	0.5	0.7
7	HDC H46	0.1 L/ha	0.8	2.0	10.0
8	Sencorex Flow + Sunfire + Stomp Aqua + HDC H42	1.15 L/ha + 0.48 L/ha + 2.9 L/ha + 1.5 L/ha	0.2	0.3	1.0
9	Sencorex Flow	1.0 L/ha	0.8	1.3	6.7
10	Sencorex Flow	1.15 L/ha	0.7	0.8	1.8

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 lasting phytotoxic damage on any of the four species by 12 WAT. All the post-heading back treatments were crop safe and effective and resulted in significantly improved weed control compared to untreated control

2. Hardy nursery stock container trial (2019). Year 2

The 2019 hardy nursery stock trial (2019), year two was carried out as Darby Nursery Stock, Norfolk, using 20 container grown hardy nursery stock subjects (**Table 3**). It was a continuation of the trial reported in the previous annual report; the trial assessed four herbicide products as late winter treatments for crop safety assessed at the timings detailed in **Appendix 2**.

Sencorex Flow had mostly been used in field grown crops prior to this work which demonstrated the product's potential for use as an alternative residual herbicide in container

production of hardy nursery stock when applied as a dormant season treatment. Where the higher rate treatment of 1 L/ha appeared to be too damaging (*Pachysandra* and *Vinca*), the lower rate of 0.5 L/ha appeared to be relatively crop safe with only slight damage recorded at the 12 weeks after treatment assessment that was deemed to be commercially acceptable. Sencorex Flow is not suitable for use on *Hebe x franciscana* however it has potential on the other 19 species within this trial.

Devrinol tank mixed with Springbok showed potential as tank mix partners where Springbok has not previously been applied to a crop. This tank mix appeared to be relatively safe when applied as a dormant season treatment. Where Springbok has already been applied Devrinol proved to be a safe stand-alone treatment on the species tested.

If authorised for use in ornamentals, the coded product HDC H46 has potential as a residual herbicide in programmes with Flexidor and as a tank mix with Devrinol. HDC H46 should provide residual control of most of the main 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 the herbicide treatments within the trial contributed significantly to weed control. Where crop safety has not been proven either conduct your own in house trials or use alternative cultural methods of weed control such as mulches or pot toppers.

Table 3. Average phytotoxicity scores for hardy nursery species, twelve weeks after early March treatment application (assessed 29/05/20). (NS = no significant differences)

Species	UTC	Sencorex Flow 1.0 L	HDC H46	HDC H46 + Devrinol	Devrinol	Sencorex Flow 0.5 L	Devrinol + Springbok	p value	L.S.D.
<i>Berberis thunbergii</i> f. <i>atropurpurea</i>	9.0	9.0	9.0	9.0	9.0	9.0	9.0	(NS)	-
<i>Chaenomeles</i> x <i>superba</i>	9.0	9.0	7.3*	8.3	8.0	9.0	8.7	0.020	0.977
<i>Choisya ternata</i>	9.0	8.0	9.0	8.7	9.0	9.0	9.0	(NS)	-
<i>Convolvulus cneorum</i>	9.0	9.0	9.0	9.0	9.0	9.0	9.0	(NS)	-
<i>Cotoneaster dammeri</i>	9.0	9.0	9.0	9.0	8.7	8.7	9.0	(NS)	-
<i>Cytisus</i>	9.0	9.0	9.0	9.0	9.0	9.0	9.0	(NS)	-
<i>Diervilla splendens</i>	9.0	8.7*	7.7*	8.0*	7.7*	7.3*	9.0	0.003	0.824
<i>Escallonia</i>	9.0	9.0	9.0	8.7	9.0	9.0	9.0	(NS)	-
<i>Hebe</i> x <i>franciscana</i>	9.0	6.3*	4.7*	4.7*	8.3	4.7*	7.3*	<.001	1.821
<i>Hypericum</i>	9.0	9.0	7.3	8.7	8.7	9.0	8.7	(NS)	-
<i>Lavandula vera</i>	9.0	9.0	9.0	8.0	9.0	7.0	8.0	(NS)	-
<i>Lavatera Hybrida</i>	9.0	9.0	7.3*	8.0*	8.7*	9.0	9.0	0.002	0.7601
<i>Ligustrum ovifolium</i>	9.0	8.7	8.0	8.3	8.3	9.0	9.0	(NS)	-
<i>Pachysandra terminalis</i>	9.0	6.3*	7.7*	6.3*	8.3	7.0*	9.0	<.001	1.098
<i>Photinia</i> x <i>fraseri</i>	9.0	7.3*	6.0*	7.0*	7.0*	7.7	9.0	0.004	1.363
<i>Potentilla fruticosa</i>	9.0	9.0	9.0	9.0	8.7	8.0	8.3	(NS)	-
<i>Pyracantha</i>	9.0	9.0	9.0	8.0	9.0	9.0	9.0	0.050	0.6724
<i>Santolina chamaecyparissus</i>	9.0	9.0	9.0	9.0	9.0	9.0	9.0	(NS)	-
<i>Senecio compacta</i>	9.0	9.0	9.0	7.7	9.0	9.0	9.0	(NS)	-
<i>Vinca minor</i>	9.0	6.7*	7.7*	7.7*	8.7	8.3	8.3	0.003	0.938

* Significantly different to untreated

3. Container pot screen (2022)

The 2022 container pot screen was carried out as ADAS Boxworth, Cambridgeshire, using eight common annual weeds (**Table 4**) that frequently occur and cause problems on nurseries producing container grown hardy nursery stock. The trial assessed seven residual herbicides applied pre-emergence of weeds (T0), at two to four true leaves (T1) and at six to ten true leaves (T2) (**Table 5**).

Phytotoxicity was assessed at three growth stages (pre emergence, post emergence at 2-4 true leaves and post emergence at 6 – 10 true leaves) after the herbicide treatments were applied.

Table 4 Weed species used in the pot screen

	Weed species
1	Annual meadow grass (<i>Poa annua</i>)
2	Hairy bittercress (<i>Cardamine hirsute</i>)
3	Common mouse eared chickweed (<i>Cerastium fontanum</i>)
4	Common Chickweed (<i>Stellaria media</i>)
5	American Willowherb (<i>Epilobium ciliatum</i>)
6	Groundsel (<i>Senecio vulgaris</i>)
7	Sow thistle (<i>Sonchus oleraceus</i>)
8	Procumbent pearlwort (<i>Sagina procumbens</i>)

Table 5. Treatment list, active ingredients and timings for the 2022 container pot screen

Treatment	Active ingredient	Approval status	Rate (L/ha)	Timing
1 Untreated	-	-	-	T0, T1, T2
2 Flexidor	isoxaben 500 g/L	Label	0.5	T0, T1, T2
3 Dual Gold	S-metolachlor 960 g/L	EAMU	0.78	T0, T1, T2
4 Sencorex Flow	metribuzin 600 g/L	EAMU	1.15	T0, T1, T2
5 Sencorex Flow	metribuzin 600 g/L	EAMU	0.5	T0, T1, T2

6	Sunfire	flufenacet 500 g/L	EAMU	0.48	T0, T1, T2
7	HDC H43	Confidential	Experimental	1.0	T0, T1, T2
8	Venzar 500 SC	lenacil 500 g/L	EAMU	0.4	T0, T1, T2

* The EAMU for Venzar 500 SC states use before the end of July, therefore Venzar 500 SC was used under an experimental permit in this trial.

This trial has found effective, alternative solutions to weed control that will help to reduce costs associated with hand weeding. The species listed by treatment and timing resulting in 75% or more weed control were considered effective treatments and are listed in **Table 6**. Where less than 75% weed control was achieved weed species are not listed in the table below.

Table 6. Treatments and timings that resulted in 75% or more control by weed species.

Treatment		T0 21 days	T0 42 days	T1 7 days	T1 14 days	T1 42 days	T2 7 days	T2 14 days	T2 42 days
Flexidor	Hairy bittercress	✓	✓		✓	✓			
	Common mouse eared chickweed	✓	✓						
	Common chickweed	✓	✓						
	Groundsel	✓							
	Sow thistle	✓	✓						
	Pearlwort	✓	✓						
Dual Gold	Common chickweed	✓			✓				
	American willowherb		✓						
	Sow thistle	✓	✓						✓
Sencorex Flow 1.15 L/Ha	Annual meadow grass,	✓	✓		✓	✓	✓	✓	✓
	Hairy bittercress		✓	✓	✓	✓	✓	✓	✓

	Common mouse eared chickweed	✓	✓		✓	✓	✓	✓	✓
	Common chickweed	✓	✓	✓	✓	✓	✓	✓	✓
	American willowherb	✓	✓	✓	✓	✓	✓	✓	✓
	Groundsel	✓	✓	✓	✓	✓	✓	✓	✓
	Sow thistle	✓	✓	✓	✓	✓	✓	✓	✓
	Pearlwort		✓			✓			✓
Sencorex Flow 0.5 L/Ha	Annual meadow grass	✓	✓		✓	✓	✓	✓	✓
	Hairy bittercress		✓	✓	✓	✓	✓	✓	✓
	Common mouse eared chickweed	✓	✓		✓	✓	✓	✓	✓
	Common chickweed	✓	✓	✓	✓	✓	✓	✓	✓
	American willowherb	✓	✓	✓	✓	✓	✓	✓	✓
	Groundsel	✓	✓	✓	✓	✓	✓	✓	✓
	Sow thistle	✓	✓	✓	✓	✓	✓	✓	✓
	Pearlwort					✓			✓
Sunfire	Annual meadow grass		✓						
	Hairy bittercress		✓				✓	✓	
	American willowherb		✓		✓	✓			✓
	Groundsel	✓							
	Sow thistle	✓	✓						
	Pearlwort		✓			✓			
HDC H43	Annual meadow grass	✓	✓						

	Common chickweed	✓			✓				
	American willowherb		✓						
	Sow thistle	✓	✓						
	Pearlwort		✓						
Venzar 500 SC	Sow thistle							✓	✓

Conclusions

1. Field trial (2019), Year 2.

All of the products tested were safe on the species tested (grown on a medium loam). A tank mix of Sencorex Flow, Sunfire and Stomp Aqua is a safe and effective treatment that growers can implement. Coded products also showed potential as tank mix partners and may become available through on label / EAMU authorisations.

2. Hardy Nursery stock container trial (2019), Year 2.

Sencorex Flow showed potential as a dormant season herbicide on 19 of the 20 species tested. Springbok showed potential as an alternative tank mix to Flexidor for Devrinol as a dormant season treatment where Springbok has not previously been applied. The coded product HDC H46 also showed potential as an alternative tank mix partner to Flexidor to be used in conjunction with Devrinol if it is granted either an on label or off label authorisation for use in the production of hardy nursery stock.

3. Container pot screen (2022)

Sencorex Flow proved to be effective against all the weed species tested (depending on growth stage) when used as a pre / post emergence treatment. Sunfire contributed to the control of broad-leafed weed species including Groundsel, Hairy bittercress, American Willowherb and Pearlwort. Although the coded product HDC H43 had little post emergence activity it has useful pre – emergence activity against Common Chickweed, American Willowherb, Sow Thistle and Pearlwort if it is granted either an on label or off label authorisation for use in the production of hardy nursery stock.

Financial Benefits

Hand weeding three times during the growing season is estimated to cost in the region of £33,000 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. It is estimated that substitution with a product such as Sencorex Flow is likely to reduce the need for hand weeding compared with no substitution by around £11,000 per hectare.

The LTAEU in place for Venzar 500 SC when this trial commenced has been transferred to an EAMU, resulting in the 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 been limited and with short persistence.

Centurion Max, Devrinol, Dual Gold, Flexidor, Sencorex Flow, Springbok, Sunfire, Venzar 500 SC and HDC H43 and HDC H46 were evaluated for container-grown hardy nursery stock production. Hand weeding is estimated to cost up to £47,000 per hectare per year in container production, which includes three weeding sessions and a clean-up when it comes to dispatch. Any reduction in hand weeding that can be achieved via chemicals will help reduce this cost. An effective herbicide programme could mean that less time is spent on hand weeding sessions which would significantly reduce this cost for all container hardy nursery stock growers. It is estimated that an effective herbicide programme, supported by hand weeding to prevent any weeds that do germinate from setting seed within the crop, to reduce the cost of hand weeding by around 30 percent / £14,000 per hectare.

Action Points

- For budded tree production in the field, herbicide programmes of Sencorex Flow + Stomp Aqua + Venzar 500 SC + Sunfire after planting and Sencorex Flow + Stomp Aqua + Sunfire after heading back are recommended.
- Evaluate whether Sencorex Flow could play a role in weed control in container product as a dormant season treatment which has both pre and post emergence activity on common weeds of container nurseries.
- Review if experimental products receive new EAMUs to facilitate a wider range of herbicides.
- Consider applying 10 mm of irrigation post herbicide application to help minimise the crop damage associated with some of the treatments.

- Note that no attempt was made to wash products off in this trial as this may have minimised the risk of potential damage and determining crop safety was an important aspect of this work.