Project title:	Improving weed control in hardy nursery stock
Project number:	HNS 198
Project leader:	John Atwood, ADAS UK Ltd.
Report:	Annual report, December 2016
Previous report:	N/A
Key staff:	John Atwood David Talbot Emma Worrall
Location of project:	Howard Nurseries Ltd., Wortham, Suffolk Whartons Nurseries Ltd., Diss, Norfolk J & A Growers Ltd., Wasperton, Warwick
Industry Representative:	Mark Cade, James Coles & Sons (Nurseries) Ltd., Leicester Bob Hollister, Country Garden Plant Sales Ltd., Wareham Hossein Arshadi, Hillier Nurseries Ltd., Romsey
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.

John Atwood

Principal horticultural consultant

ADAS UK Ltd.

Signature Date 17 November 2017

Report authorised by:

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Grower Summary

Headline

- HDC H43 proved safe and effective when used post planting in a tank mix with Stomp Aqua + Flexidor 500 on rose rootstocks. A post budding application in a tank mix with Flexidor 500 was also tolerated.
- HDC H25 found to be safe and effective at planting on field-grown herbaceous crops.

Background

Recent changes in legislation have meant that the ornamentals industry has been left with fewer herbicides for the control of problematic weeds. The control of annual weeds in field-grown production has become more difficult following the loss of active ingredients (e.g. oxadiazon) and restrictions placed on some of the remaining actives (e.g. metazachlor).

A number of small seeded tree species are known to be susceptible to residual herbicides used in the seedbed and will only tolerant low rates of Goltix 70 SC (metamitron). The concept of applying differential residual herbicide treatments as inter-row or in-row treatments was successfully developed in sensitive seed raised vegetable crops in the first SCEPTRE project. The objective of the work on band spray treatments for seed grown trees (in this case *Betula*) was to test five herbicide treatments normally considered unsafe on *Betula* applied only in the inter-row with metamitron (Goltix 70 SC) as a low rate pre-emergence herbicide over the crop row. The aim being to deliver better weed control than with Goltix 70 SC applied overall.

The key recommended products previously used on field-grown roses (Ronstar Liquid, Skirmish and Artist) have been withdrawn or have lost appropriate approvals. There is, therefore, an urgent need to test replacement products for rose production. Novel products tested include; HDC H42, Logo (foramsulfuron, iodosulfuron-methylsodium + isoxadifen-ethyl), HDC H43 and Samson Extra 6% (nicosulfuron). The aim for the budded rose herbicide trial in 2016 was to test the efficacy and crop safety of novel herbicide, either alone or in combination with standard herbicides, in programmes for field rose production.

The field-grown herbaceous nursery stock sector is very dependent on the use of Flexidor 500 (isoxaben) and Venzar Flowable (lenacil) which increases the risk of resistant weed populations. There is also concern that Venzar Flowable, used currently under the LTAEU, may not be granted an EAMU going forward. The aims of the herbaceous trials carried out in 2016 were to test the efficacy and crop safety of novel herbicides for use as a single application after planting on field-grown herbaceous nursery stock production and treatments applied as a follow-up.

Summary

Herbicide trials were carried out on *Betula pendula,* field-grown roses, and field-grown herbaceous HNS during 2016. **Table 1** lists the herbicides and rates used in each trial, along with the herbicides' approval status.

Table 1. Treatment list for hardy nursery stock trials carried out in 2016

			Rate kg/ha or L/ha				
Product	**Active**	**Approval status**	***Betula pendula***	**Budded rose**	**Aster & Geranium**	**Iris**	**Veronica**
Butisan S	500 g/L metazachlor	Label		1.5			
Butryflow	402 g/L bromoxynil	EAMU				1	
HDC H42		Not approved		1.5			
Flexidor 500	500 g/L isoxaben	Label[1]	0.5	0.5	0.25	0.25	
Gamit 36 CS	360 g/L clomazone	EAMU outdoor[3]	0.25				
Goltix 70 SC	700 g/L metamitron	EAMU[2]	1 2				
HDC H25	isoxaben 2.4% w/w + oryzalin 9.8% w/w	Not approved *			220	220	220
Logo	30% w/w foramsulfuron + 10% w/w iodosulfuron-methylsodium + 30% w/w isoxadifen-ethyl	EAMU outdoor		0.15			
Metobromuron	metobromuron 400 g/L	Not approved			3.75	3.75	3.75
Samson Extra 6%	60 g/L nicosulfuron	EAMU outdoor		0.75			
Sencorex Flow	600 g/L metribuzin	Not approved	1.15				

			Rate kg/ha or L/ha				
Product	**Active**	**Approval status**	***Betula pendula***	**Budded rose**	**Aster & Geranium**	**Iris**	**Veronica**
Springbok	200 g/L metazachlor + 200 g/L dimethenamid-p	EAMU outdoor	2.5	1.25		1.6	
Stomp Aqua	455 g/L pendimethalin	EAMU outdoor	2.9	2.9			
HDC H43		Not approved		2	2	2	2
Venzar Flowable	440 g/L lenacil	LTAEU Outdoor		3	1.5	1.5	1.5
Titus	25% w/w rimsulfuron	EAMU outdoor				0.05	0.05

[1]Label only covers use on outdoor trees and shrubs but other ornamentals may be treated outdoors at grower's risk.

[2]Pre-emergence only

[3]Pre-emergence and early post-emergence only

*Product known in other markets as Winshot

Betula trial

The aim was to test the use of precision band sprayers for use in herbicide sensitive field-grown crops where seedlings are grown in spaced rows. The trial was set up as a fully randomised block design with seven treatments, including a commercial standard and an untreated control. Goltix 70 SC was used as a row treatment (except in untreated controls); the residual herbicide treatments were applied as inter-row treatments. The treatments were applied on 20 May 2016, as residual pre-emergence treatments four days after *Betula pendula* (UK 403 provenance) was drilled.

There were subtle differences in weed control between treatments at the first assessment, carried out 2 WAT (weeks after treatment). Untreated controls had 0.75% weed cover. The best inter-row treatments for weed control were Flexidor 500 + Springbok and Stomp Aqua +

Sencorex Flow, both of which had no weed cover. The next best inter-row treatments in terms of weed control with 0.13% weed cover was Stomp Aqua + Springbok + Gamit 36 CS.

All inter-row treatments other than the Growers standard, Goltix 70 SC resulted in unacceptable phytotoxicity, expressed as a reduction in growth and the number of seedlings germinating. It is thought that application of the inter-row herbicides over the grit dressed bed surface resulted in more lateral movement of the herbicides than would have occurred on bare soil. The least damaging inter-row treatment (apart from the Goltix 70 SC standard) was Flexidor 500 + Goltix 50 SC raising the possibility that *Betula pendula* might tolerate a low rate of Flexidor 500 over the row.

Budded rose trial

The budded rose herbicide trial was set up in a field at Whartons Nurseries Ltd. in Pulham St Mary, near Diss, on newly planted rootstocks. The trial consisted of 10 herbicide programmes (**Table 2**). Applications were made to the rootstocks on two occasions: at planting (7 April 2016), after budding (21 July 2016) and a further treatment will be made post heading back (this application will be carried out in February 2017). The trial was set up as a fully randomised block design and treatments were replicated four times.

Table 2. Treatment list and timings for the budded rose herbicide trial, Pulham St Mary 2016

Trt. no.	Planting treatment (07.04.16)	Rate (Kg/ha or L/ha)	Budding treatment (21.07.16)	Rate (Kg/ha or L/ha)	Heading back treatment	Rate (Kg/ha or L/ha)
1	Untreated	N/A	Untreated	N/A	Untreated	N/A
2	Stomp Aqua + Flexidor 500 + Venzar Flowable	2.9 + 0.5 + 3.0	Flexidor 500 + Butisan S	0.5 + 1.5	Stomp Aqua + Flexidor 500 + Springbok	2.0 + 0.5 + 1.25
3	Stomp Aqua + Flexidor 500 + Venzar Flowable	2.9 + 0.5 + 3.0	Logo + Mero (adjuvant)	0.075 + 2.0	Stomp Aqua + Flexidor 500 + Springbok	2.0 + 0.5 + 1.25
4	Stomp Aqua + Flexidor 500 + HDC H43	2.9 + 0.5 +	Flexidor 500 + HDC H43	0.5 + 2.0	Stomp Aqua + Flexidor 500 + HDC H43	2.0 + 0.5 +
5	Stomp Aqua + Flexidor 500 + HDC H42	2.9 + 0.5 +	Flexidor 500 + Butisan S	0.5 + 1.5	Stomp Aqua + Flexidor 500 + HDC H42	2.0 + 0.5 +
6	Samson Extra 6%	0.75	Flexidor 500 + Butisan S	0.5 + 1.5	Samson Extra 6%	0.75
7	Flexidor 500 + Samson Extra 6%	0.5 + 0.75	Flexidor 500 Butisan S	0.5 + 1.5	Flexidor 500 Samson Extra 6%	0.5 + 0.75
8	Flexidor 500 + Samson Extra 6% + HDC H42	0.5 + 0.75 +	Flexidor 500 + Butisan S	0.5 + 1.5	Flexidor 500 + Samson Extra 6% + HDC H42	0.5 + 0.75 +
9	Logo + Mero (adjuvant)	0.15 + 2.0	Flexidor 500 + Butisan S	0.5 + 1.5	Logo + Mero (adjuvant)	0.15 + 2.0
10	Flexidor 500 + Logo	0.5 + 0.15	Flexidor 500 + Butisan S 1.5	0.5 + 1.5	Flexidor 500 + Logo	0.5 + 0.15

Phytotoxicity and weed assessments were carried out approximately 2, 6 and 12 WAT. Phytotoxicity was scored on a scale of 0 to 9 with 0 being dead, 9 being healthy and 7 being considered commercially acceptable. Weed cover was assessed as an overall percentage of the plot.

Out of the treatments applied at planting, Stomp Aqua + Flexidor 500 + HDC H43, Flexidor 500 + Samson Extra 6% + HDC H42 and Flexidor 500 + Logo all provided the best weed control in the trial, however the combination of Flexidor 500 + Logo was too phytotoxic to the rootstocks (**Figure 1**). The above treatments performed well in terms of weed control up to the assessment carried out 6 WAT, however by the 12 WAT assessment their weed control was beginning to break down (**Figure 2**). Logo, when used with only an adjuvant, was much safer than the combination with Flexidor 500 however in this case the weed control was inferior.

All of the post-budding treatments appeared to be safe to use on the rose rootstocks, however roses that were treated with Flexidor 500 + Logo at planting remained very stunted at budding and were scored down for phytotoxicity following the subsequent application of Flexidor 500 + Butisan S. However, this damage was thought to be the result of the application of Flexidor 500 + Logo at planting and not the Flexidor 500 + Butisan that was applied post-budding. Flexidor 500 + Butisan S also proved to be the best post budding treatment for weed control (**Figure 3**).

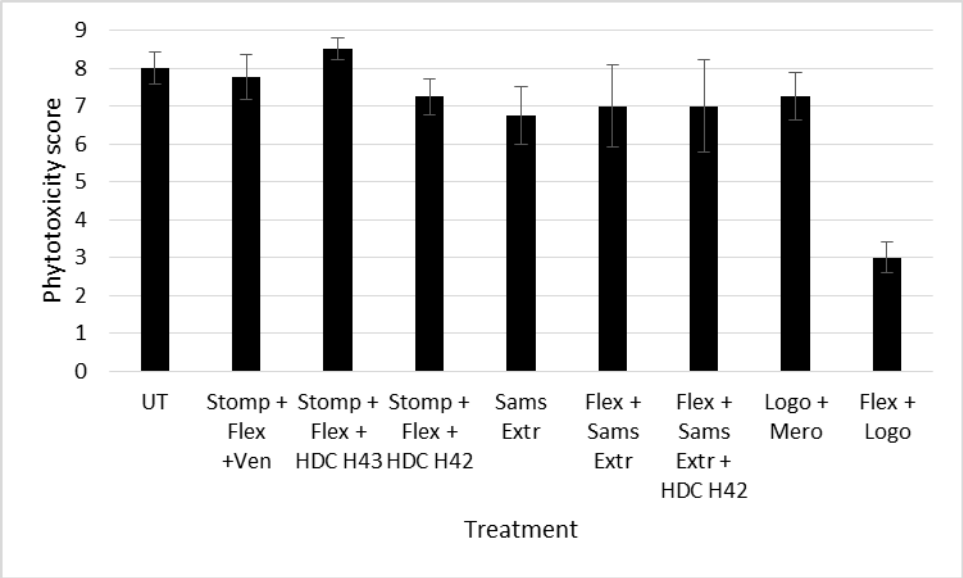

Figure 1. Phytotoxicity scores for budded rose trial 12 weeks after the treatments were applied at planting (p<0.001, l.s.d. 0.987) – Pulham St Mary, 22 June 2016 (scale of 0 – 9 where 9 is healthy, 0 is dead and 7 is commercially acceptable)

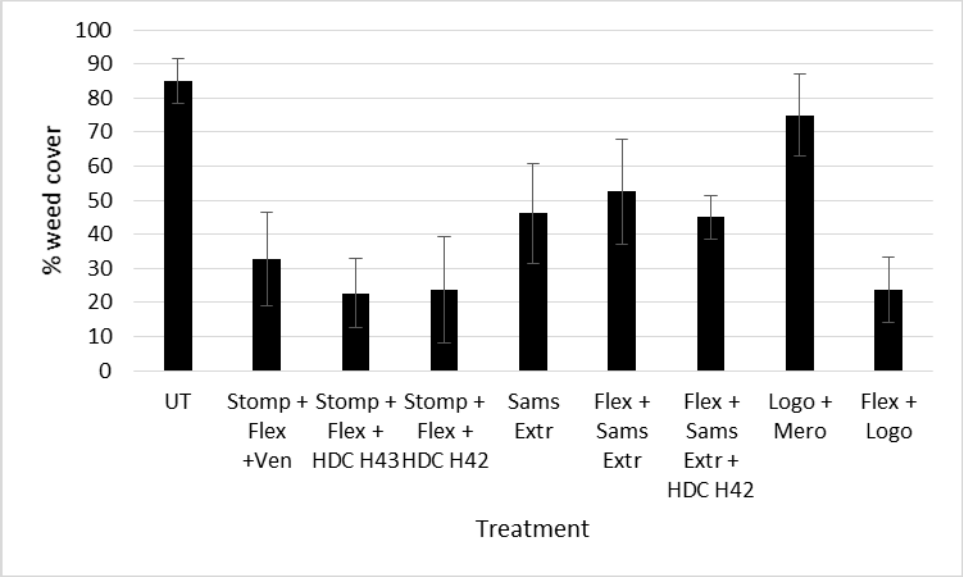

Figure 2. Percentage weed cover of budded rose plots 12 weeks after the planting treatments were applied (p<0.001, l.s.d. 9.04) - Pulham St Mary, 22 June 2016

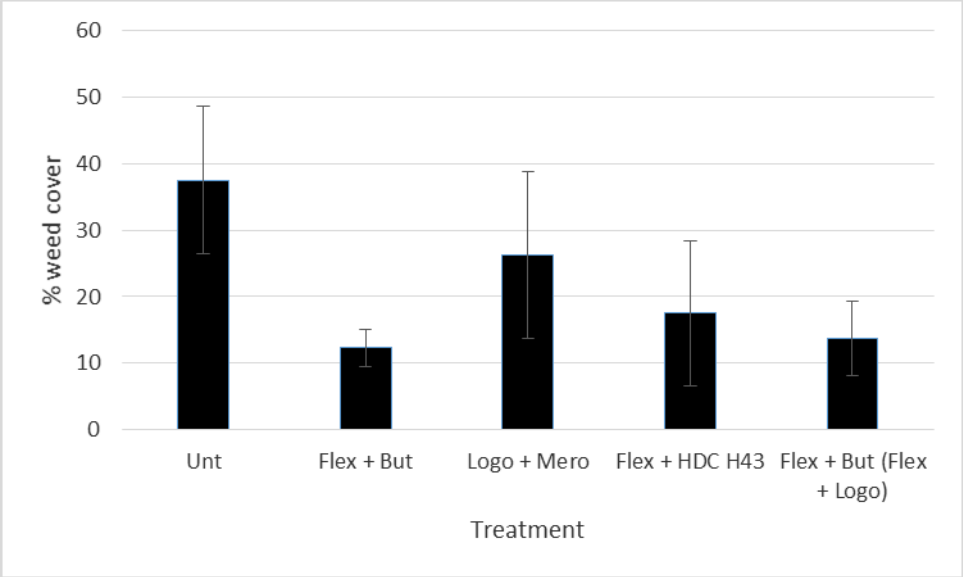

Figure 3. Percentage weed cover of budded rose trial 12 weeks after post-budding treatments were applied (p<0.001, l.s.d. 9.06) – Pulham St Mary, 5 October 2016

Herbaceous trials

The aster, geranium, iris and veronica trials were set up in fields at Howard Nurseries Ltd. in Wortham, near Diss. The aster and geranium trials both had the same five treatments (**Table 3**). Treatments were applied on two occasions for both trials; the first application was made on 4 May 2016 (at planting) and the second application was made on 9 August 2016. The iris trial consisted of seven treatment programmes. Treatments were applied on two occasions; at planting (14 April 2016) and as a follow up treatment, 10 weeks after the planting

application (22 June 2016) (**Table 4**). The veronica trial tested six herbicide treatment programmes (**Table 5**). The veronica treatments were applied on the same dates as the aster and geranium trials. Treatments were replicated four times in each of the herbaceous trials. Phytotoxicity and weed assessment were carried out approximately 2, 6 and 10 weeks after each treatment application was made. The assessments used the same methods as were used in the rose trial above.

Table 3. Treatment list and timings for the aster and geranium trials, Wortham 2016

Trt. no.	Planting treatment (04.05.16)	Rate (Kg/ha or L/ha)	Follow up treatment (09.08.16)	Rate (Kg/ha or L/ha)
1.	Untreated	N/A	Untreated	N/A
2.	HDC H25	220.0	Untreated	N/A
3.	Flexidor 500 + Venzar Flowable	0.25 + 1.5	Flexidor 500 + Venzar Flowable	0.25 + 1.5
4.	Flexidor 500 + HDC H43	0.25 +	Flexidor 500 + HDC H43	0.25 +
5.	Flexidor 500 + Metobromuron	0.25 + 3.75	Flexidor 500 + Metobromuron	0.25 + 3.75

Table 4. Treatment list and timings for the field-grown iris herbicide trial, Wortham 2016

Trt. no.	Planting treatment	Rate (Kg/ha or L/ha)	Follow up treatment (22.06.16)	Rate (Kg/ha or L/ha)
1.	Untreated	N/A	Untreated	N/A
2.	HDC H25	220.0	Untreated	N/A
3.	Flexidor 500 + Venzar Flowable	0.25 + 1.5	Flexidor 500 + Springbok	0.25 + 1.6
4.	Flexidor 500 + Venzar Flowable	0.25 + 1.5	Butryflow	1.0
5.	Flexidor 500 Venzar Flowable	0.25 + 1.5	Titus	0.05
6.	Flexidor 500 + HDC H43	0.25 +	Flexidor 500 + HDC H43	0.25 +
7.	Flexidor 500 + Metobromuron	0.25 + 3.75	Flexidor 500 + Metobromuron	0.25 + 3.75

Table 5. Treatment list and timings for the veronica herbicide trial, Wortham 2016

Trt. no.	Planting treatment (04.05.16)	Rate (Kg/ha or L/ha)	Follow up treatment (09.08.16)	Rate (Kg/ha or L/ha)
1.	Untreated	N/A	Untreated	N/A
2.	HDC H25	220.0	Untreated	N/A
3.	Venzar Flowable	1.5	HDC H43	
4.	Venzar Flowable	1.5	Titus	0.05
5.	HDC H43		Venzar Flowable	1.5
6.	Metobromuron	3.75	Metobromuron	3.75

Aster

All of the treatments that were applied to the asters at planting proved to be safe on the plants with no obvious signs of phytotoxicity seen throughout the trial. HDC H25 was found to be the most effective herbicide at controlling weeds (**Figure 4**).

All of the follow-up treatments that were applied proved to be safe on the asters. The plots that had received the treatment HDC H25 at planting even though it received no further follow up treatment, had the lowest levels of weeds throughout the trial period (**Figure 5**).

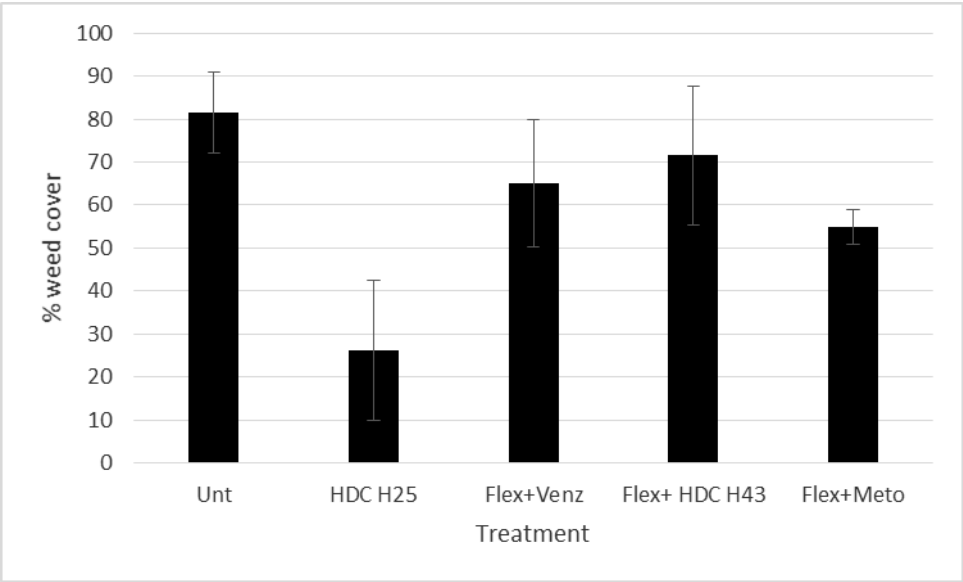

Figure 4. Percentage weed cover of plots 10 weeks after the planting treatments were applied to the aster trial (p<0.001, l.s.d. 20.55) – Wortham, 4 August 2016

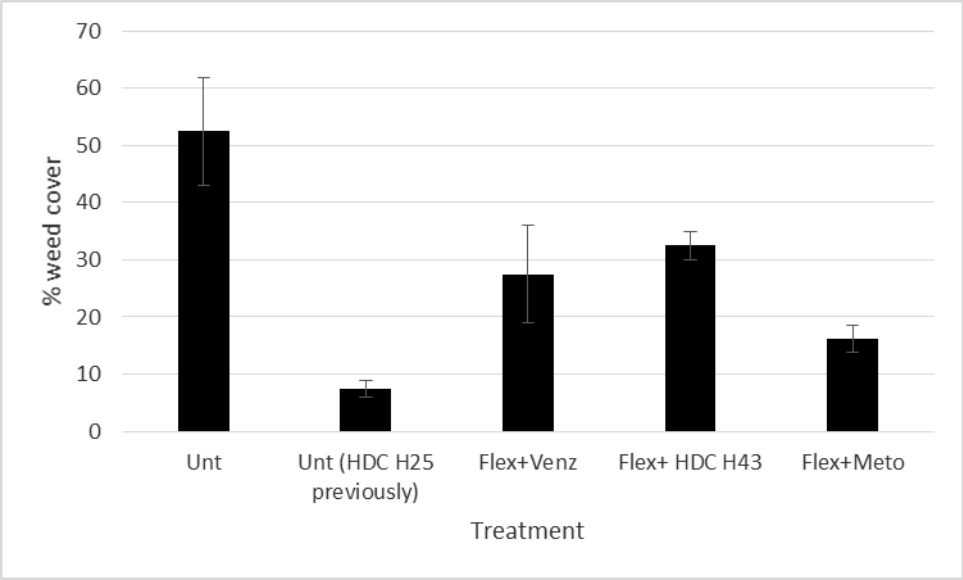

Figure 5. Percentage weed cover of plots 10 weeks after the second treatments were applied to the aster trial (p=0.004, l.s.d. 20.16) – Wortham, 26 October 2016

Geranium

None of the planting treatments used in the geranium trial caused any serious damage to the geraniums. At the 6 WAT assessment, all of the treatments applied at planting had the same percentage weed cover, including the untreated plots (**Figure 6)**. Weed assessments were difficult to carry out throughout the trial due to the crop becoming very dense and so the next assessment was postponed until the final assessment after the follow-up treatments had been applied. At the final assessment carried out after the follow-up treatments had been applied, the geraniums had started to die back, making it easier to assess the weed level. Plots that were treated with HDC H25 had the lowest level of weeds and were closely followed by plots that had been treated with Flexidor 500 + metobromuron (**Figure 7**). All of the follow-up treatments applied were considered safe to the geraniums.

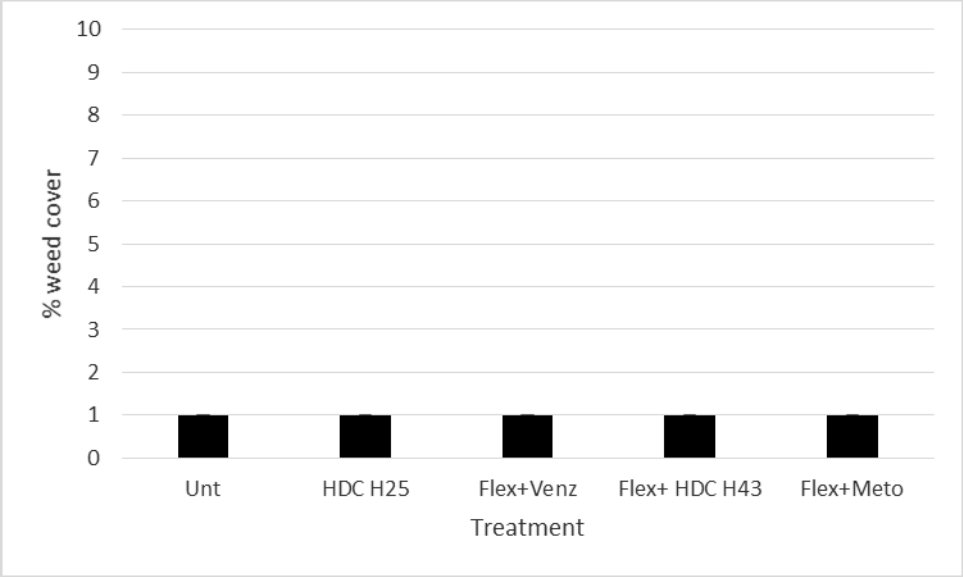

Figure 6. Percentage weed cover of plots 6 weeks after the planting treatments were applied to the geranium trial – Wortham, 16 June 2016

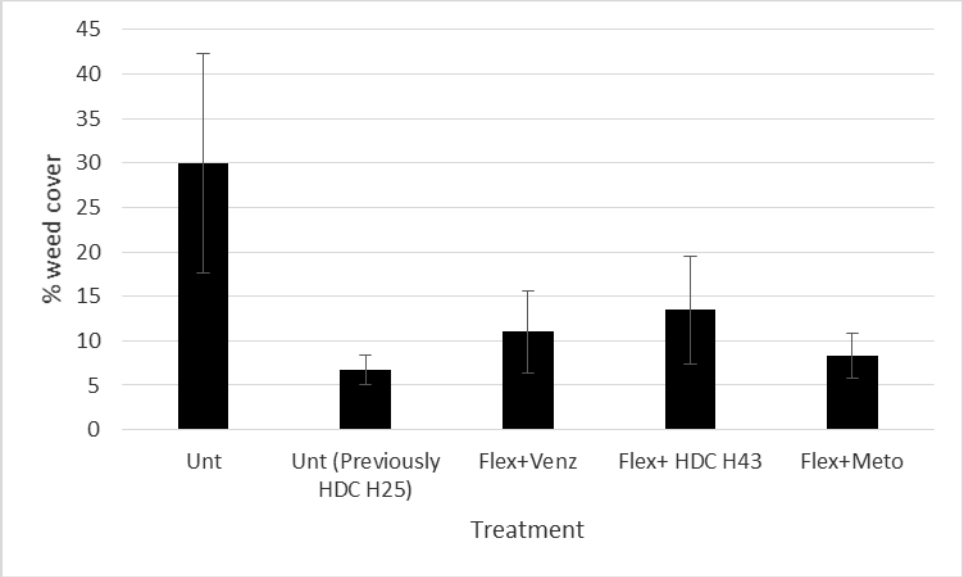

Figure 7. Percentage weed cover 10 weeks after the second treatments were applied to the geranium trial – Wortham, 26 October 2016

Iris

None of the treatments applied at planting in the iris trial caused any lasting herbicide damage to the crop. HDC H25 provided the best weed control and Flexidor 500 + HDC H43, Flexidor 500 + Venzar Flowable and Flexidor 500 + metobromuron all provided good weed control in the trial when applied at planting (**Figure 8**). No significant phytotoxicity was seen from any of the follow-up treatments that were applied to the iris trial. Out of the follow-up treatments,

the only plots where effective weed control was seen were the plots that had received an application of HDC H25 at planting and received no further follow-up treatment (**Figure 9**).

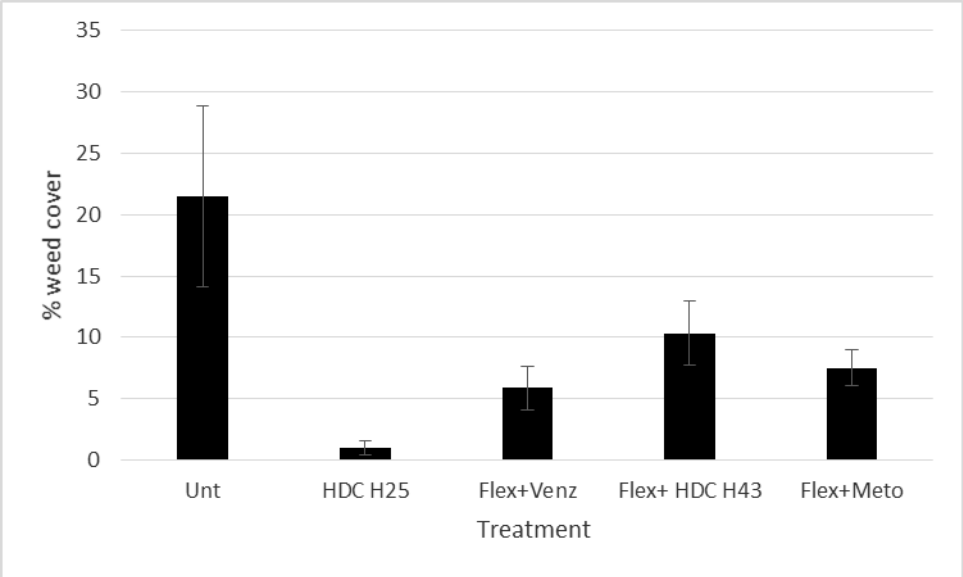

Figure 8. Percentage weed cover of plots 6 weeks after the first treatments were applied to the iris trial – Wortham, 26 May 2016

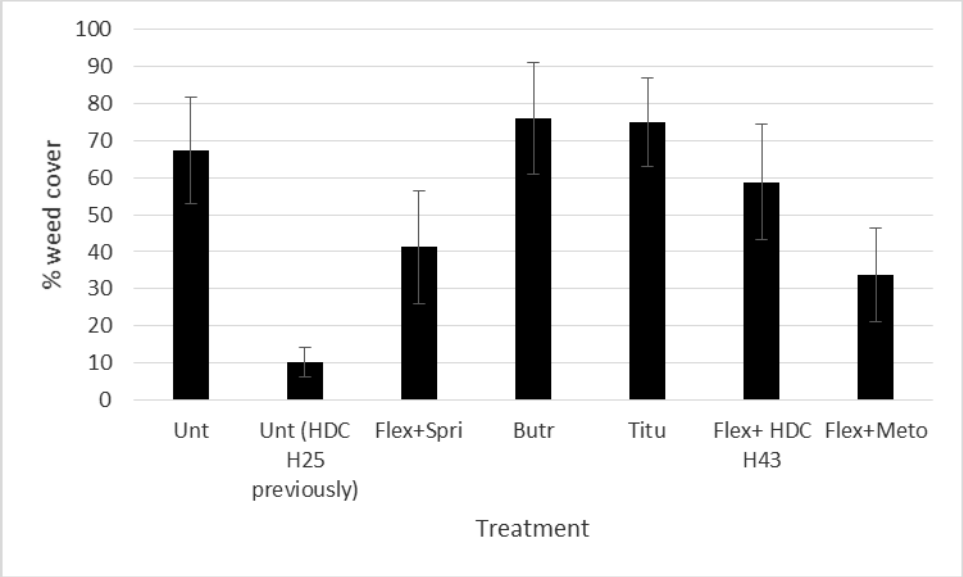

Figure 9. Percentage weed cover of plots 10 weeks after the second treatments were applied to the iris trial – Wortham, 2016

Veronica

The veronica were very slow to establish due to the dry conditions that were experienced at the time of planting. Despite the plants being slow to establish, no phytotoxic symptoms were seen in any of the different treated plots throughout the trial. HDC H25 performed the best in terms of weed control, however weed control with this treatment was not as good as was experienced from the other herbicide trials in this project where it was tested, even at the 6 WAT assessment (**Figure 10**). This was probably because the veronicas did not compete with the weeds as well as the species in the other trials did. None of the follow-up treatments applied to the veronica caused any phytotoxic damage. The plots with the lowest level of weeds after the follow-up treatments were applied were the HDC H25 treated plots 10 WAT, however weed levels in these plots were still high (**Figure 11**).

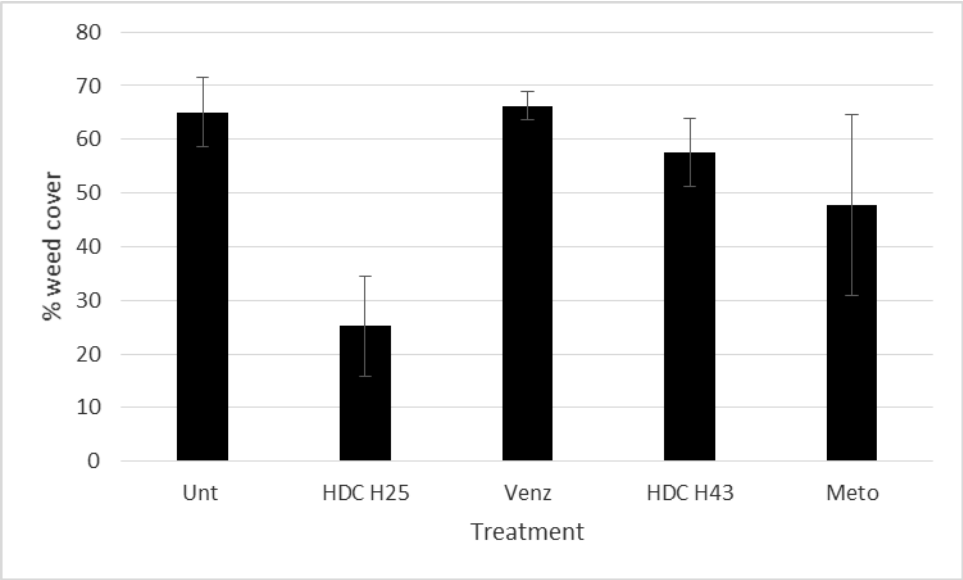

Figure 10. Percentage weed cover of plots 6 weeks after the planting treatments were applied to the veronica trial – Wortham, 16 June 2016

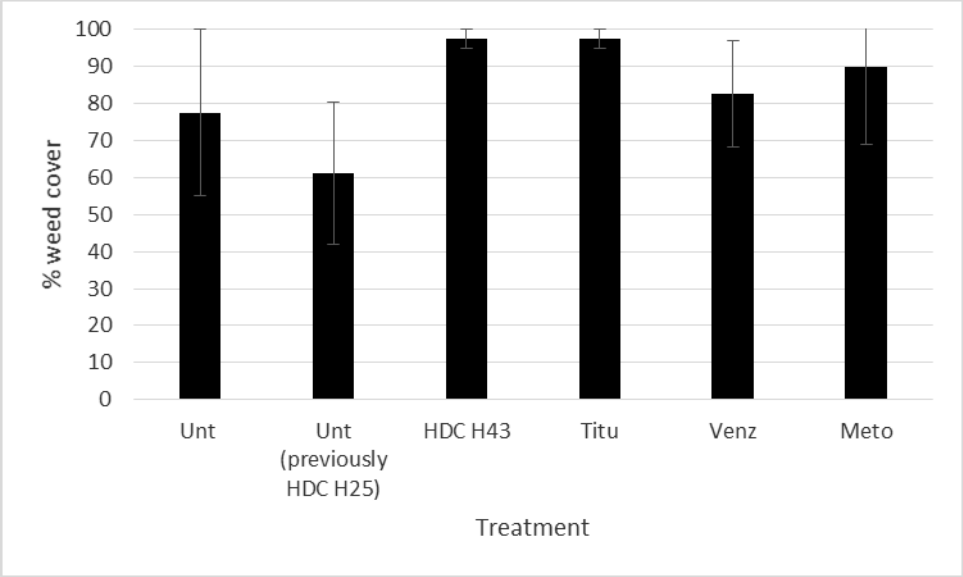

Figure 11. Percentage weed cover of plots 10 weeks after second treatments were applied to the veronica trial – Wortham, 26 October 2016

Review of herbicide authorisations for hardy nursery stock production in selected European countries

A review of herbicide authorisations was undertaken to identify treatments that are available in other European countries for nursery stock production but are not currently available in the UK or are available only with restrictions that do not apply elsewhere. In fact there are relatively few new active ingredients available in other European countries that would be useful for UK nursery stock production. Of particular interest are oxyfluorfen and oryzalin however we are unlikely to see availability in the UK for these actives. There are several products based on iodosulfuron-methyl-sodium either co-formulated with foramsulfuron or diflufenican. The former combination is already proposed for an EAMU in the UK.

Although there are few actives being used that are completely new to hardy nursery stock in the UK there are many examples of products available in other European countries but which in the UK have very much lower rates of use (e.g flumioxazin, s-metolachlor), restrictions to pre-emergence use only (before crop emergence) (e.g. prosulfocarb, dimethenamid-p + pendimethalin, metribuzin, metamitron) or other crop restrictions (e.g. propyzamide). It is proposed that improvements to the EAMUs for prosulfocarb and metribuzin be sought to allow use over dormant crops as is permitted in other European countries.

Financial Benefits

Hand weeding field-grown crops three times during the growing season is estimated to cost in the region of £30,000 per hectare. Any reduction in hand weeding or reduction in direct contact herbicide applications that can be achieved with residual herbicides will help to reduce this cost significantly, contributing to grower profitability. For example Veronica is not normally treated with herbicides but treatment HDC H25 was safe and reduced weed cover by more than 50% of the untreated for 5 months. Although some hand weed weeding would still be required the saving in labour cost could be in the region of £15,000 per hectare.

Action Points

- Flexidor 500 and Goltix 70SC showed the best potential as an inter-row treatment on *Betula* although further work is required with lower rates of both herbicides.
- New herbicide HDC H25 has good potential for use at planting for herbaceous nursery stock species grown in the soil and it has a very good weed control spectrum. It had been hoped that HDC H25 would be available as a commercial product with a label approval for outdoor ornamental plant production during 2017, but regulatory hurdles are currently preventing this from happening in the short term.
- HDC H43 is now authorised on Maize in the UK and could be a useful additional herbicide for growers of a range of field-grown nursery stock providing an EAMU can be obtained.
- Butryflow and Titus are already approved for ornamental plant production and could be safely used for selective post-emergence weed control in herbaceous nursery stock crops of Iris. Initial results suggest that Titus may also be safe for use in Veronica.

Science Section

Introduction

With a decreasing number of herbicides available to the Hardy Nursery Stock (HNS) sector, weed control has become critical as the sector has become over-dependent on few herbicides.

Since the last herbicide trial on roses in the UK was completed in 2008 (HNS 132), the key recommended products Ronstar Liquid (oxadiazon), Skirmish (terbuthylazine + isoxaben) and Artist (flufenacet + metribuzin) have been withdrawn or lost appropriate approvals. There is therefore an urgent need to test replacement products for rose production. The herbicides selected for inclusion are those for which appropriate EAMUs have recently been granted e.g. Springbok (metazachlor + dimethenamid-p), those where EAMUs exist but the products are of uncertain safety e.g. Samson Extra 6% (nicosulfuron) and those where new EAMUs could be sought e.g. HDC H42, Logo (foramsulfuron, iodosulfuron-methylsodium + isoxadifen-ethyl) and HDC H43. The aim of the budded rose herbicide trial in 2016 was to test the efficacy and crop safety of herbicide programmes including these new products for field rose production.

No recent work has been carried out on field-grown herbaceous nursery stock. This sector is very dependent on the use of Flexidor (isoxaben) and Venzar Flowable (lenacil) and this can give rise to resistant weed problems, in particular groundsel and field pansy. Venzar Flowable is used under the LTAEU and there is concern that it will not be possible to convert the LTAEU to an EAMU going forward. There are potential candidates for use as residual herbicides after planting e.g. HDC H43, metobromuron and HDC H25. Projects CP 86 and HNS PO 192 and 192a identified HDC H25 as a highly promising granular herbicide with good crop safety and efficacy on both shrub and herbaceous species. Products such as Butryflow and Titus were shown to have potential for selective contact use in *Hemerocallus* in HNS 70a and Lily in HNS PO 192 but require further testing on a wider range of species. The aim of the herbaceous trials carried out in 2016 was to test the efficacy and crop safety of novel herbicides for use as a single application after planting on field-grown herbaceous nursery stock production.

A comprehensive range of treatments were screened in tree seedbeds in project HNS 155 completed in 2015. From this work the main addition to standard treatments was Gamit 36 CS (clomazone) on selected crops such as *Crataegus*. It is recognised however, that for some sensitive small seeded subjects, the current range of low rate treatments are not fully effective. It is, therefore, proposed to test the band sprayer technology developed in SCEPTRE project CP 77 for herbicide-sensitive drilled vegetables, on tree seedbeds. The

principal is very simple but requires the use of GPS equipped tractors in order to line up the sprayer correctly over the drilled rows. There now exist band sprayers capable of applying differential bands of herbicides (e.g. Garford Farm Machinery Ltd.). Typically a weaker crop safe herbicide is applied in a 10 cm band over the drilled row, at the same time a mixture of stronger (but approved) herbicides are applied to the interrow strip between rows. Project CP 77 showed that with most of the herbicides tested there was not sufficient lateral movement to cause damage to drilled vegetables in a row but this requires further testing in tree seedbeds. If successful, this technology could also have application in drilled cut flowers and field-grown herbaceous crops. The aim in 2016 is to test the use of precision band sprayers for use in herbicide sensitive field-grown crops where seedlings are grown in spaced rows.

Betula

Materials and methods

The band spray treatments for seed grown trees was set up on a commercial nursery; J&A Growers Ltd., Warwick. The test species was a seedling crop of *Betula pendula* (UK 403 provenance) that was sown into a pre-formed bed on 16 May 2016, the soil type being a medium sandy loam**.** The seed rate was worked out on seed viability; seed was sown at a rate of 7.2 grams per metre. After sowing, 25B horticultural grit (2 to 5 mm) was applied at a target depth of 3 mm. The pre-formed bed was treated with Basamid at 500 kg/ha on 02/10/15.

A fully randomised block design spanning seven beds with four treatments per bed, including an untreated control, replicated four times, giving a total of 28 plots. Within each bed, plots were 1.4 m wide and 4.5 m long.

The herbicide treatments (seven treatments including an untreated control) consisted of six different herbicides; Goltix 70 SC (metamitron), Flexidor 500 (isoxaben), Springbok (dimethenamid-p + metazachlor), Stomp Aqua (pendimethalin), Gamit 36 CS (clomazone) and Sencorex Flow (metribuzin); all of these herbicides were either used alone or in combination **(Table 6).** Treatment programmes also included an untreated control for comparison. Additional information for each treatment can be found in **Table 7.**

The treatments were applied to the plots in 300 L/ha water using a band spray test rig, developed by the Allium and Brassica Centre. The sprayer has tandem booms which are simultaneously applied over both the crop row and inter-row. Plots consisted of five rows of 0.1 m and six inter-row at 0.15 m wide. The areas sprayed were as follows; crop rows (0.1 m x 4.5 m) x 5 = 2.25 m² and inter-row (0.15 x 4.5) x 6 = 4.05 m². Residual herbicides were applied on 20 May 2016.

Phytotoxicity was assessed at two, six and 12 weeks after treatment (WAT). Phytotoxicity assessments involved comparing the treated plots to the untreated controls and awarding scores on a scale of 0 to 9 where 0 is dead, 7 is commercially acceptable and 9 is healthy and comparable with an untreated control. A weed cover assessment was carried out at two WAT and a percentage score was recorded for weeds found in each plot. The weed species present were recorded along with their location within plots (within crop rows or inter-row).

Table 6. Details of the residual herbicides used for the band spray treatments for seed grown trees (*Betula*). All row treatments were Goltix 70 SC, rate 1 l/ha.

Treatment No.	**Product number**	**Rate (kg/L/ha)**
1	Untreated control	N/A
2	Goltix 70 SC	1.0
3	Flexidor 500 + Goltix 70 SC	0.5 + 2.0
4	Flexidor 500 + Springbok	0.5 + 2.5
5	Stomp Aqua + Springbok	2.9 + 2.5
6.	Stomp Aqua + Springbok + Gamit 36 CS	2.9 + 2.5 + 0.25
7.	Stomp Aqua + Sencorex Flow	2.9 + 1.15

Table 7. Details of the residual herbicides active ingredients for the band spray treatments for seed grown trees (*Betula*). All row treatments were Goltix 70 SC, rate 1 l/ha.

Treatment	Active ingredient
Untreated control	N/A
Goltix 70 SC	700 g/L metamitron
Flexidor 500	500 g/L isoxaben
Springbok	200 g/L metazachlor + 200 g/L dimethenamid-p
Stomp Aqua	455 g/L pendimethalin
Gamit 36 CS	360 g/L clomazone
Sencorex Flow	600 g/L metribuzin

Results

All treatments except the host grower's standard residual herbicide treatment for *Betula* (Goltix 70 SC) resulted in phytotoxic damage which resulted in a severe reduction in germination and vigour. None of the treatments other than Goltix 70 SC were considered commercially acceptable as inter-row treatments in *Betula* seedbeds (**Table 8**).

Weed percentage cover, 2 WAT was assessed for both the row and inter-row sections of individual plots. This was done because the percentage cover was so low. The weed species present were recorded along with their location within plots (within crop rows or inter-row, see **Table 9)**.

Table 8. Mean phytotoxicity scores for the inter-row band spray treatments for seed grown trees, two, six and twelve weeks after treatment (WAT) (Scale of 0-9 where 0 is dead and 7 is commercially acceptable). All row treatments were Goltix 70 SC

Assessment	**Trt 1 Untreated control**	**2 Goltix 70 SC**	**3 Flexidor 500 + Goltix 70 SC**	**4 Flexidor 500 + Springbok**	**5 Stomp Aqua + Springbok**	**6 Stomp Aqua + Springbok + Gamit 36 CS**	**7 Stomp Aqua + Sencorex Flow**
2 WAT	9.0	8.0	6.0	1.8	2.0	2.0	1.0
6 WAT	9.0	8.0	3.0	1.3	1.8	2.0	0.3
12 WAT	9.0	8.0	5.0	1.3	1.5	1.8	1.0

Scores were similar between treatment replications therefore no statistical analysis was required.

Table 9. Details of percentage weed cover, assessed 2 weeks after treatment (WAT)

Trt. No.	**% weed cover 2 WAT**	**Weed species within crop rows**	**Weed species inter-rows**
1 Untreated control	0.75	*Geranium molle, Capsella bursa – pastoris, Chenopodium album, Poa annua, Solanum nigrum, Trifolium repens, Urtica urens.*	
2 Goltix 70 SC	0.25	*Sonchus oleraceus, Urtica urens, Viola arvensis.*	
3 Flexidor 500 + Goltix 70 SC	0.38	*Geranium molle Chenopodium album, Urtica urens,*	*Geranium molle,* Volunteer cereal.
4 Flexidor 500 + Springbok	0.00	-	-
5 Stomp Aqua + Springbok	0.25	*Urtica urens,* Volunteer cereal.	*Polygonum aviculare*
6 Stomp Aqua + Springbok + Gamit 36 CS	0.00	*Urtica urens.*	-
7 Stomp Aqua + Sencorex Flow	0.00	-	-

Figure 12. Untreated 12 weeks after treatments were applied (left), grower standard treatment; Goltix 70 SC 1.0 l/ha (middle) and Flexidor 500 0.5 l/ha + Goltix 70 SC 2.0 l/ha (right) – Wasperton, Warwick, 12 August 2016.

Discussion

All of the experimental treatments resulted in unacceptable crop damage and were not considered commercially acceptable treatments. This is thought to be because the residual herbicides were unable to bind to the horticultural grit that is used to cover seed after sowing. It is suspected that lateral movement of the residual herbicides (in rain and irrigation water) from the inter-row treatments moved herbicides into the crop rows, resulting in damage.

Although Flexidor 500 + Goltix 70 SC as an inter-row treatment resulted in damaged and reduced growth, this treatment was the least damaging after Goltix 70 SC. Reducing the rates of these two residual herbicides may result in commercially acceptable treatments with improved weed control.

It is industry practice to cover small seed such as *Betula* with either grit or sand in order to optimise germination. Residual herbicides are likely to bind to soil or sand better than they do to grit, so less damage may be expected where band treatments of residual herbicides are applied to crops that are not covered in grit. Soil type can have an influence on the crop selectivity and efficacy of residual herbicides; lower rates are typically recommended on light soils. Using lower rates of herbicides as inter-row treatments in herbicide sensitive field-grown crops may help to minimise phytotoxic damage to an acceptable level. Utilising sand rather than grit to cover seeds may help to reduce lateral movement of residual herbicides within crop rows.

Budded rose

Materials and methods

The budded rose herbicide trial was set up in a field at Whartons Nurseries Ltd. in Pulham St Mary, near Diss, on newly planted rootstocks. Planting spacing was 85 cm rows with in-row spacing 16 cm. The trial consisted of 10 herbicide programmes (**Table 10**). The treatment programmes included an untreated control, Stomp Aqua (pendimethalin), Flexidor 500 (isoxaben), Venzar Flowable (lenacil), HDC H43, HDC H42, Samson Extra 6% (nicosulfuron), Logo (foramsulfuron, iodosulfuron-methylsodium and isoxadifen-ethyl), Mero (adjuvant, rapeseed fatty acid esters), Butisan S (metazachlor) and Springbok (metazachlor and dimethenamid-p); these herbicides were either used alone or in combination in the trials. Active ingredients of the treatment applications can be found in **Table 11**. Applications were made to the rootstocks on three occasions: at planting (7 April 2016), after budding (21 July 2016) and post heading back (this application will be carried out in February 2017). Treatments were applied to plots using an OPS knapsack sprayer at a medium spray pressure in 300 L water per ha, using 02F110 nozzles. The trial was set up as a fully randomised block design and treatments were replicated four times. Data were analysed using ANOVA..Plots measured 3.35 m x 3.5 m (four rows) and included 0.25 m discard at the end of each plot.

Phytotoxicity and weed assessments were carried out approximately 2, 6 and 12 WAT. Phytotoxicity was assessed by examining the plants for any signs of herbicide damage (e.g. twisting, scorching, stunting) and was scored on a scale of 0 to 9 with 0 being dead, 9 being healthy and 7 being considered commercially acceptable. Weed cover was assessed as an overall percentage of the plot and also as a percentage of quadrat cover by using two 1 m^2 quadrats in each plot. Key weed species present in the quadrats were recorded.

Table 10. Treatment list and timings for the budded rose herbicide trial, Pulham St Mary 2016

Trt. no.	Planting treatment (07.04.16)	Rate (Kg/ha or L/ha)	Budding treatment (21.07.16)	Rate (Kg/ha or L/ha)	Heading back treatment	Rate (Kg/ha or L/ha)
1	Untreated	N/A	Untreated	N/A	Untreated	N/A
2	Stomp Aqua + Flexidor 500 + Venzar Flowable	2.9 + 0.5 + 3.0	Flexidor 500 + Butisan S	0.5 + 1.5	Stomp Aqua + Flexidor 500 + Springbok	2.0 + 0.5 + 1.25
3	Stomp Aqua + Flexidor 500 + Venzar Flowable	2.9 + 0.5 + 3.0	Logo + Mero (adjuvant)	0.075 + 2.0	Stomp Aqua + Flexidor 500 + Springbok	2.0 + 0.5 + 1.25
4	Stomp Aqua + Flexidor 500 + HDC H43	2.9 + 0.5 +	Flexidor 500 + HDC H43	0.5 +	Stomp Aqua + Flexidor 500 + HDC H43	2.0 + 0.5 +
5	Stomp Aqua + Flexidor 500 + HDC H42	2.9 + 0.5 +	Flexidor 500 + Butisan S	0.5 + 1.5	Stomp Aqua + Flexidor 500 + HDC H42	2.0 + 0.5 +
6	Samson Extra 6%	0.75	Flexidor 500 + Butisan S	0.5 + 1.5	Samson Extra 6%	0.75
7	Flexidor 500 + Samson Extra 6%	0.5 + 0.75	Flexidor 500 Butisan S	0.5 + 1.5	Flexidor 500 Samson Extra 6%	0.5 + 0.75
8	Flexidor 500 + Samson Extra 6% + HDC H42	0.5 + 0.75 +	Flexidor 500 + Butisan S	0.5 + 1.5	Flexidor 500 + Samson Extra 6% + HDC H42	0.5 + 0.75 +
9	Logo + Mero (adjuvant)	0.15 + 2.0	Flexidor 500 + Butisan S	0.5 + 1.5	Logo + Mero (adjuvant)	0.15 + 2.0
10	Flexidor 500 + Logo	0.5 + 0.15	Flexidor 500 + Butisan S 1.5	0.5 + 1.5	Flexidor 500 + Logo	0.5 + 0.15

Table 11. List of active ingredients for the budded rose herbicide trial, Pulham St Mary 2016

Product	**Active ingredient**	**Approval status**
Stomp Aqua	455 g/L pendimethalin	EAMU 2919/09
Flexidor 500	500 g/L isoxaben	Label
Venzar Flowable	440 g/L lenacil	LTEAU
HDC H43		Not approved
HDC H42		Not approved
Samson Extra 6%	60 g/L nicosulfuron	EAMU 1054/14
Logo	30% w/w foramsulfuron + 10% w/w iodosulfuron-methylsodium + 30% w/w isoxadifen-ethyl	EAMU 3437/16
Mero	rapeseed fatty acid esters	Not approved
Butisan S	500 g/L metazachlor	Label
Springbok	200 g/L metazachlor + 200 g/L dimethenamid-p	EAMU 3006/14

Results

Treatment application at planting, 7 April 2016

At 2 WAT there were no obvious signs of any phytotoxicity caused by the treatments that were applied at planting to the rose rootstocks (**Table 12**). At 6 WAT Stomp Aqua + Flexidor 500 + HDC H42 (T4), Flexidor 500 + Samson Extra 6% + HDC H42 (T7) and Flexidor 500 + Logo (T9) all caused phytotoxic damage to the crop; scoring 5.5, 6 and 6.5 respectively, all below the commercially acceptable phytotoxicity score of 7. Stomp Aqua + Flexidor 500 + HDC H42 (T4) scorched the leaves of the roses and resulted in much paler leaves than the untreated roses (**Figure 13)**. The Flexidor 500 + Logo (T9) combination caused stunting and defoliation of leaves. By 12 WAT scorched leaves and stunted plants could be seen in plots that had received an application of Samson Extra 6% (T5), which had not been noticeable previously, with plants scoring a mean phytotoxicity score of 6.8. At this assessment roses that had been treated with Flexidor 500 + Logo (T9) had not recovered, scoring a mean phytotoxicity score of 3 as the roses were severely stunted (**Figure 14**). Roses that had previously been scored down in plots treated with either Stomp Aqua + Flexidor 500 + HDC H42 (T4) or Flexidor 500 + Samson Extra 6% + HDC H42 had recovered since the last assessment at 6 WAT and were considered commercially acceptable (**Figure 15**). Logo when used with only the adjuvant (Mero) was much safer than the combination with Flexidor 500, however in this case the weed control was inferior.

Table 12. Phytotoxicity scores for the budded rose trial 2, 6 and 12 weeks after treatment (WAT) (scale of 0 - 9 where 9 is healthy, 0 is dead and 7 is commercially acceptable) – Pulham St Mary, 2016

Trt. no.	**Planting treatment**	**Rate (Kg/ha or L/ha)**	**Phytotoxicity score 2 WAT (21.04.16)**	**Phytotoxicity score 6 WAT (17.05.16)**	**Phytotoxicity score 12 WAT (22.06.16)**
1	Untreated	N/A	9.0	8.8	8.0
2	Stomp Aqua + Flexidor 500 + Venzar Flowable	2.9 + 0.5 + 3.0	7.5	7.3	7.8
3	Stomp Aqua + Flexidor 500 + HDC H43	2.9 + 0.5 +	8.3	7.5	8.5
4	Stomp Aqua + Flexidor 500 + HDC H42	2.9 + 0.5 +	7.8	5.5	7.3
5	Samson Extra 6%	0.75	7.3	7.8	6.8
6	Flexidor 500 + Samson Extra 6%	0.5 + 0.75	8.3	7.3	7.0
7	Flexidor 500 + Samson Extra 6% + HDC H42	0.5 + 0.75 +	7.0	6.0	7.0
8	Logo + Mero (adjuvant)	0.15 + 2.0	8.0	8.5	7.3
9	Flexidor 500 + Logo	0.5 + 0.15	8.8	6.5	3.0
P value			NS	<0.001	<0.001
L.S.D.			NS	0.796	0.987

NS (not significant)

Figure 13. Scorched and pale leaves of rose rootstocks 6 weeks after Stomp + Flexidor + HDC H42 was applied (left) and untreated (right) – Pulham St Mary, 17 May 2016

Figure 14. Samson Extra 6% 12 weeks after treatments were applied (left) and untreated (right) – Pulham St Mary, 22 June 2016

Figure 15. Roses 12 weeks after being treated with Stomp Aqua + Flexidor 500 + HDC H42 – Pulham St Mary, 22 June 2016

At the assessment carried out 6 WAT, Stomp Aqua + Flexidor 500 + HDC H43 (T3), Flexidor 500 + Samson Extra 6% + HDC H42 (T4) and Flexidor 500 + Logo (T9) provided the best weed control with 6.8%, 5% and 5.5% average weed cover of plots respectively ($p<0.001$, l.s.d. 9.04, **Figure 16**). At this assessment the untreated plots had the highest weed cover with a mean plot cover of 70%. After 10 weeks the lowest percentage weed cover of plots were plots that had been treated with either Stomp Aqua + Flexidor 500 + HDC H43 (T3), Stomp Aqua + Flexidor 500 + HDC H42 (T4) or Flexidor 500 + Logo (T9); with 22.8%, 23.8% and 23.8% plot cover respectively ($p<0.001$, l.s.d. 14.71, **Figure 17**).

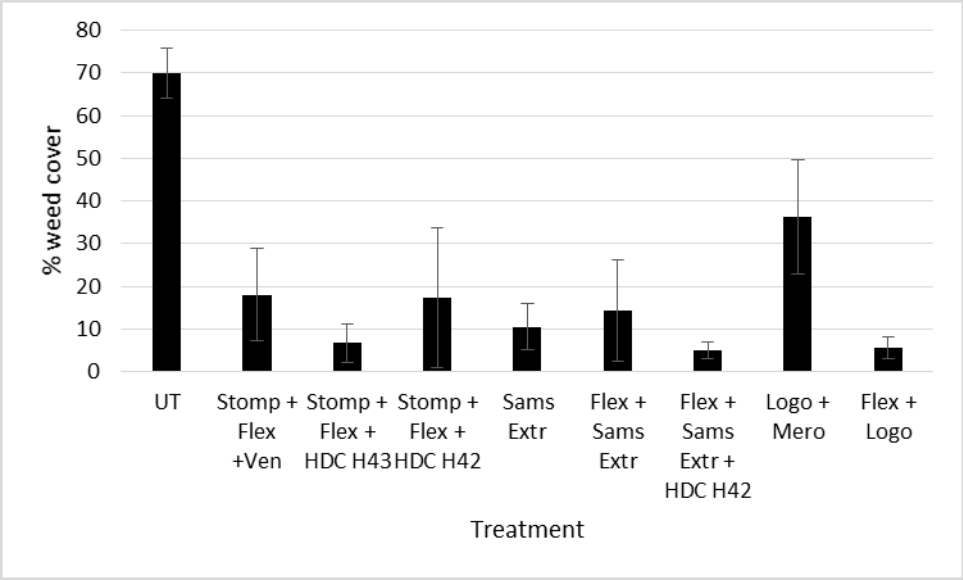

Figure 16. Percentage weed cover of the budded rose plots 6 weeks after the planting treatments were applied – Pulham St Mary, 17 May 2016

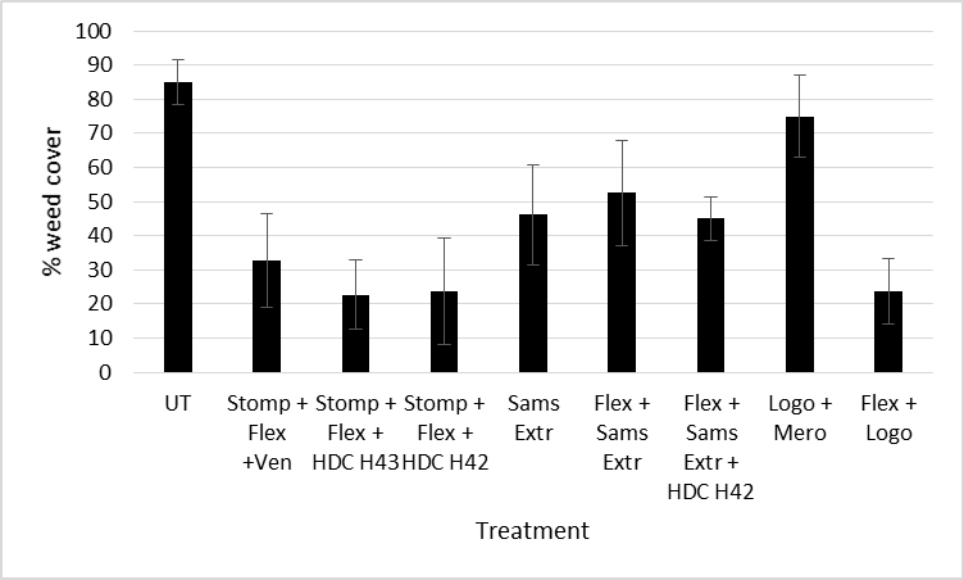

Figure 17. Percentage weed cover of budded rose plots 12 weeks after the planting treatments were applied – Pulham St Mary, 22 June 2016

Treatment application post-budding, 21 July 2016

At the assessment carried out 6 WAT post-budding herbicides, the only plots where significant phytotoxic damage to the roses was noted was where Flexidor 500 + Logo (T9) had been applied at planting and the plants had never fully recovered when they were re-treated with Flexidor 500 + Butisan S (T10) (**Table 13**). At 12 WAT all treatments applied post-budding were considered safe apart from Flexidor 500 + Butisan S (T10) that had been applied to plots following treatment of Flexidor 500 + Logo at planting.

Table 13. Phytotoxicity scores for the budded rose trial 6 weeks after post-budding treatments were applied (WAT) and 10 WAT (scale of 0 - 9 where 9 is healthy, 0 is dead and 7 is commercially acceptable) – Pulham St Mary, 2016

Trt. no.	**Budding treatment**	**Rate (Kg/ha or L/ha)**	**Phytotoxicity score 6 WAT (01.09.16)**	**Phytotoxicity score 12 WAT (05.10.16)**
1	Untreated	N/A	8.0	8.5
2, 5, 6, 7, 8, 9	Flexidor 500 + Butisan S	0.5 + 1.5	7.9	7.8
3	Logo + Mero (adjuvant)	0.075 + 2.0	8.5	8.5
4	Flexidor 500 + HDC H43	0.5 + 2.0	8.0	8.3
10	Flexidor 500 + Butisan S (following Flexidor 500 + Logo at planting)	0.5 + 1.5	5.3	6.7
P value			<0.001	<0.001
L.S.D			0.967	0.712

At the 6 WAT assessment all herbicides provided significantly better weed control than the untreated plots (p<0.001, l.s.d. 1.302, **Figure 18**). At this assessment Flexidor 500 + Butisan S (T2) and Logo + Mero (T3), Flexidor 500 + HDC H43 (T4) and Flexidor 500 + Butisan S (T10) all provided the best weed control with 1.7%, 1.8%, 2.8% and 2% weed cover of plots respectively . At 12 WAT (p<0.001, l.s.d. 9.06, **Figure 19**) all treatments provided better weed control than the untreated control, however Flexidor 500 + Butisan S (T2 and T10) had the lowest weed cover in plots with 12.3% and 13.8% weed cover respectively.

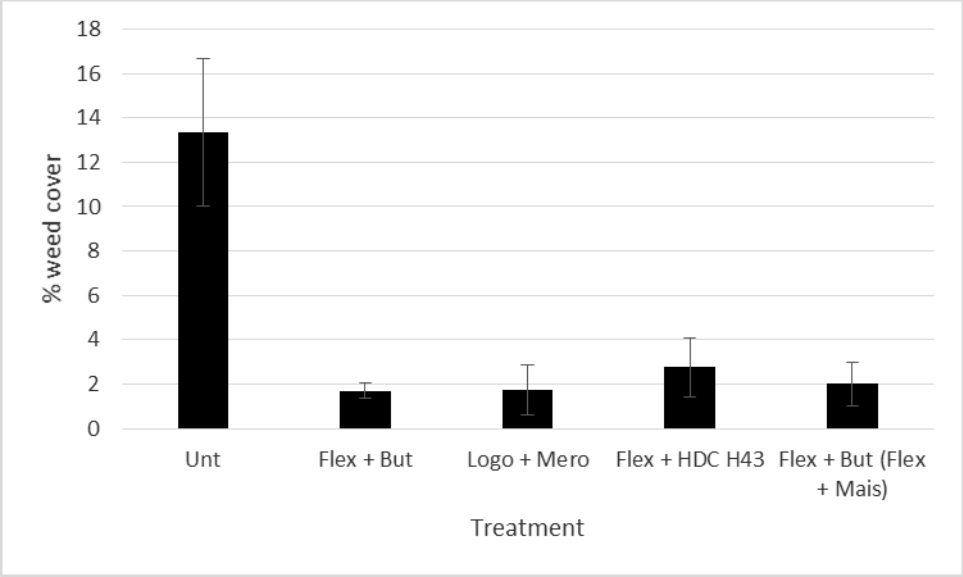

Figure 18. Percentage weed cover of budded rose trial 6 weeks after the post-budding treatments were applied – Pulham St Mary, 1 September 2016

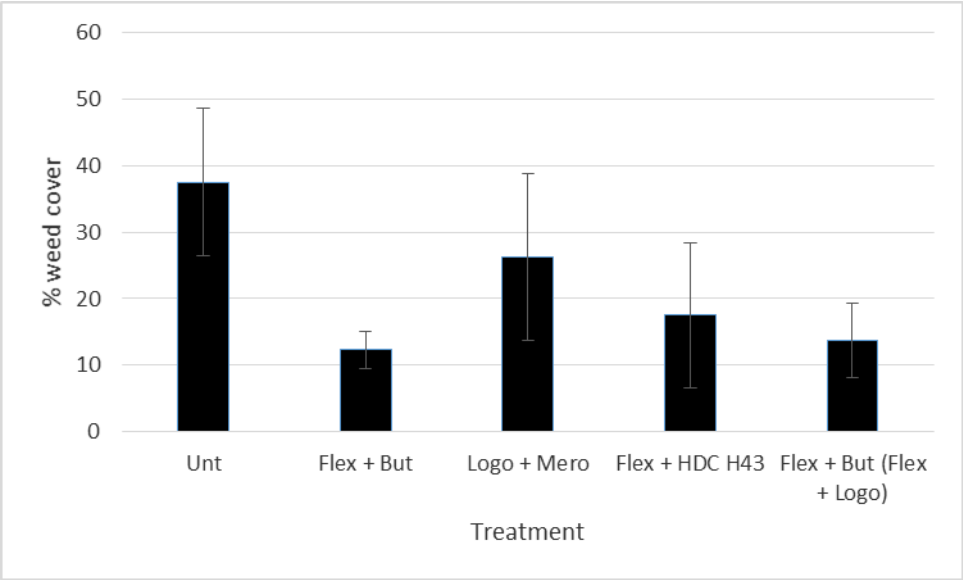

Figure 19. Percentage weed cover of budded rose trial 12 weeks after post-budding treatments were applied – Pulham St Mary, 5 October 2016

Discussion

Phytotoxic symptoms were not obvious on the rose rootstocks until 6 weeks after the planting treatments were applied. At this stage Stomp Aqua + Flexidor 500 + HDC H42, Flexidor 500 + Samson Extra + HDC H42 and Flexidor 500 + Logo appeared to be too damaging to use at planting on the rose rootstocks. However by the final assessment, 12 WAT, roses that had received treatments containing HDC H42 had fully recovered. At the 12 WAT assessment the roses that had been scorched from the Flexidor 500 + Logo treatment had not recovered and

so this treatment would not be recommended. At this assessment, new damage was apparent from roses that had received an application of Samson Extra 6% at the planting application, meaning that this treatment was not considered to be safe.

Out of the treatments applied at planting, Stomp Aqua + Flexidor 500 + HDC H43, Flexidor 500 + Samson Extra 6% + HDC H42 and Flexidor 500 + Logo all provided the best weed control in the trial, however Flexidor 500 + Logo was too phytotoxic to the rootstocks. The above treatments performed well in terms of weed control up to the assessment carried out 6 WAT, however by the 12 WAT assessment their weed control was beginning to break down. The dominant weed species present in the trial area was fat hen. The best control of fat hen was seen from Stomp Aqua + Flexidor 500 + Venzar Flowable and Stomp Aqua + Flexidor 500 + HDC H42.

All of the post-budding treatments including the contact herbicide Logo appeared to be safe to use on the rose rootstocks, however roses that had been treated with Flexidor 500 + Logo at planting remained very stunted and scorched.

At 6 weeks after the post-budding treatments were applied, Flexidor 500 + Butisan S, Logo + Mero and Flexidor 500 + HDC H43 provided the best weed control, however by 12 WAT the most effective treatment was Flexidor 500 + Butisan S, with all the other treatments starting to break down in terms of weed control. Although Logo does not have good persistence it could prove useful as a selective contact herbicide in rose rootstocks.

Herbaceous trials

Materials and methods

The aster, geranium, iris and veronica trials were set up in fields at Howard Nurseries Ltd. in Wortham, near Diss. All crops were planted in 1.7m beds with 5 rows per bed. The aster and geranium trials both had five treatments; including an untreated control, HDC H25, Flexidor 500, Venzar Flowable, HDC H43 and metobromuron (**Table 14**). The aster and veronica plots measured 1.7 m x 2.5 m and the geranium and iris plots measured 1.7 m x 3.5 m, plant spacing in the bed was approximately 20 cm. Treatments were applied on two occasions for both trials; the first application was made on 4 May 2016 (at planting) and the second application was made on 9 August 2016. The aster varieties used were: Chequers, Jenny, Kristina, Little pink beauty, Marie Ballard, Patricia Ballard and Snowsprite. The geranium variety used was Blue cloud.

The iris trial consisted of seven treatment programmes with treatments including: an untreated control, HDC H25, Flexidor 500, Venzar Flowable, HDC H43, metobromuron,

Springbok, Butryflow and Titus (**Table 15**). Treatments were applied on two occasions; at planting (14 April 2016) and as a follow up treatment, 10 weeks after the planting application (22 June 2016).

The veronica trial tested six herbicide treatment programmes that included: an untreated control, HDC H25, Venzar Flowable, HDC H43, metobromuron and Titus (**Table 16**). The veronica treatments were applied at planting (4 May 2016) and as a follow up treatment on 9 August 2016.

Treatments were applied by an OPS knapsack sprayer at a water volume of 300 L/ha at a medium spray pressure using 02F110 nozzles, apart from HDC H25 which is a granular herbicide and was applied using a pepper pot shaker. All trials were set up as a fully randomised block design and with the treatments replicated four times. Data were analysed using ANOVA.

A list of the active ingredients for all of the herbaceous trials can be found in **Table 17**.

Table 14. Treatment list and timings for the aster and geranium trials, Wortham 2016

Trt. no.	**Planting treatment (04.05.16)**	**Rate (Kg/ha or L/ha)**	**Follow up treatment (09.08.16)**	**Rate (Kg/ha or L/ha)**
1.	Untreated	N/A	Untreated	N/A
2.	HDC H25 *	220.0	Untreated	N/A
3.	Flexidor 500 + Venzar Flowable	0.25 + 1.5	Flexidor 500 + Venzar Flowable	0.25 + 1.5
4.	Flexidor 500 + HDC H43	0.25 +	Flexidor 500 + HDC H43	0.25 +
5.	Flexidor 500 + Metobromuron	0.25 + 3.75	Flexidor 500 + Metobromuron	0.25 + 3.75

*known in other markets as Winshot

Table 15. Treatment list and timings for the field-grown iris herbicide trial, Wortham 2016

Trt. no.	Planting treatment	Rate (Kg/ha or L/ha)	Follow up treatment (22.06.16)	Rate (Kg/ha or L/ha)
1.	Untreated	N/A	Untreated	N/A
2.	HDC H25*	220.0	Untreated	N/A
3.	Flexidor 500 + Venzar Flowable	0.25 + 1.5	Flexidor 500 + Springbok	0.25 + 1.6
4.	Flexidor 500 + Venzar Flowable	0.25 + 1.5	Butryflow	1.0
5.	Flexidor 500 Venzar Flowable	0.25 + 1.5	Titus	0.05
6.	Flexidor 500 + HDC H43	0.25 +	Flexidor 500 + HDC H43	0.25 +
7.	Flexidor 500 + Metobromuron	0.25 + 3.75	Flexidor 500 + Metobromuron	0.25 + 3.75

*Known in other markets as Winshot

Table 16. Treatment list and timings for the veronica herbicide trial, Wortham 2016

Trt. no.	Planting treatment (04.05.16)	Rate (Kg/ha or L/ha)	Follow up treatment (09.08.16)	Rate (Kg/ha or L/ha)
1.	Untreated	N/A	Untreated	N/A
2.	HDC H25 *	220.0	Untreated	N/A
3.	Venzar Flowable	1.5	HDC H43	2.0
4.	Venzar Flowable	1.5	Titus	0.05
5.	HDC H43		Venzar Flowable	1.5
6.	Metobromuron	3.75	Metobromuron	3.75

*Known in other markets as Winshot

Table 17. Active ingredients and approval status of herbicides used in the herbaceous trials – Diss 2016

Product	Active ingredient	Approval
HDC H25*	isoxaben 2.4% w/w + oryzalin 9.8% w/w	Not approved
Flexidor 500	500 g/L isoxaben	Label
Venzar Flowable	440 g/L lenacil	LTAEU
HDC H43		Not approved
Metobromuron	400 g/L metobromuron	Not approved
Springbok	200 g/L metazachlor + 200 g/L dimethenamid-p	EAMU 2108/15
Butryflow	402 g/L bromoxynil	EAMU 0561/14
Titus	25% w/w rimsulfuron	EAMU 1912/14

*Known in other markets as Winshot

Results

Aster

After the first application of treatments were made at planting, no phytotoxic symptoms were observed at the 6 WAT assessment (**Table 18**). At the assessment carried out 10 WAT, the lowest scoring plots in terms of phytotoxicity were plots that had been treated with Flexidor 500 + HDC H43 (T4) (**Table 19**). Asters treated with Flexidor 500 + HDC H43 scored 7.5 on the phytotoxic scale which is still above the commercially acceptable score of 7. The second application of treatments to the asters caused no serious damage to the asters with none of the plots scoring below a commercially acceptable score of 7.

Table 18. Phytotoxicity scores for the aster trial after the planting treatments were applied, six weeks after treatment (WAT) and 10 WAT – Wortham, 2016 (scale of 0 - 9 where 9 is healthy, 0 is dead and 7 is commercially acceptable)

Trt. no.	**Planting treatment (04.05.16)**	**Rate (Kg/ha or L/ha)**	**Phytotoxicity score 6 WAT (16.06.16)**	**Phytotoxicity score 12 WAT (04.08.16)**
1.	Untreated	N/A	9.0	9.0
2.	HDC H25*	220.0	9.0	8.5
3.	Flexidor 500 + Venzar Flowable	0.25 + 1.5	9.0	9.0
4.	Flexidor 500 + HDC H43	0.25 +	8.8	7.5
5.	Flexidor 500 Metobromuron	0.25 + 3.75	9.0	9.0
P value			NS	<0.001
L.S.D			NS	0.731

*Known as Winshot in other markets

NS (not significant)

Table 19. Phytotoxicity scores for the aster trial after the follow up treatments were applied, six weeks after treatment (WAT) and 10 WAT – Wortham, 2016 (scale of 0 - 9 where 9 is healthy, 0 is dead and 7 is commercially acceptable)

Trt. no.	**Follow up treatment (09.08.16)**	**Rate (Kg/ha or L/ha)**	**Phytotoxicity score 6 WAT (05.10.16)**	**Phytotoxicity score 10 WAT (26.10.16)**
1.	Untreated	N/A	8.3	9.0
2.	Untreated	N/A	9.0	9.0
3.	Flexidor 500 + Venzar Flowable	0.25 + 1.5	8.3	9.0
4.	Flexidor 500 + HDC H43	0.25 +	9.0	9.0
5.	Flexidor 500 + Metobromuron	0.25 + 3.75	9.0	9.0
P value			NS	NS
L.S.D.			NS	NS

NS (Not significant)

At the assessment carried out 6 WAT, the best treatments for weed control were HDC H25 (T2) and Flexidor 500 + metobromuron (T5) ($p<0.001$, l.s.d. 8.17, **Figure 20**). At this assessment plots treated with HDC H25 or Flexidor 500 + metobromuron had means of 10.3% weed cover of plots (**Figure 21**). At 10 WAT the treatment providing the best weed control was HDC H25 with an average of 26.3% weed cover of plots ($p<0.001$, l.s.d. 20.55, **Figure 22**). Flexidor 500 + metobromuron no longer provided good control with a mean weed cover percentage of plots of 55%. During the trial Flexidor 500 + Venzar Flowable and Flexidor 500 + metobromuron provided the best control of mayweed. HDC H25 was the best herbicide out of the treatments for scarlet, although it didn't give much control of knotgrass, a weed that was very common over the trial area.

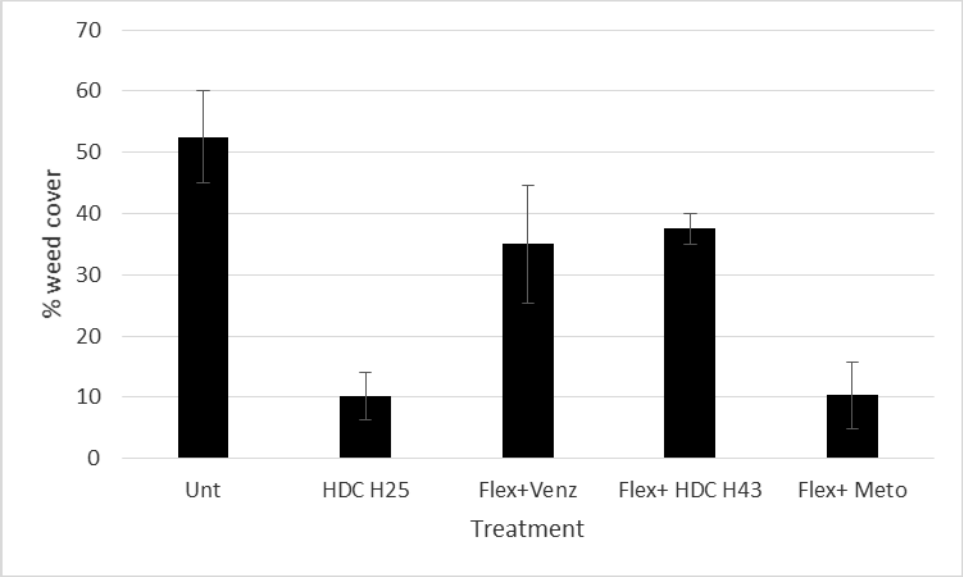

Figure 20. Percentage weed cover of plots 6 weeks after the planting treatments were applied to the aster trial – Wortham, 16 June 2016

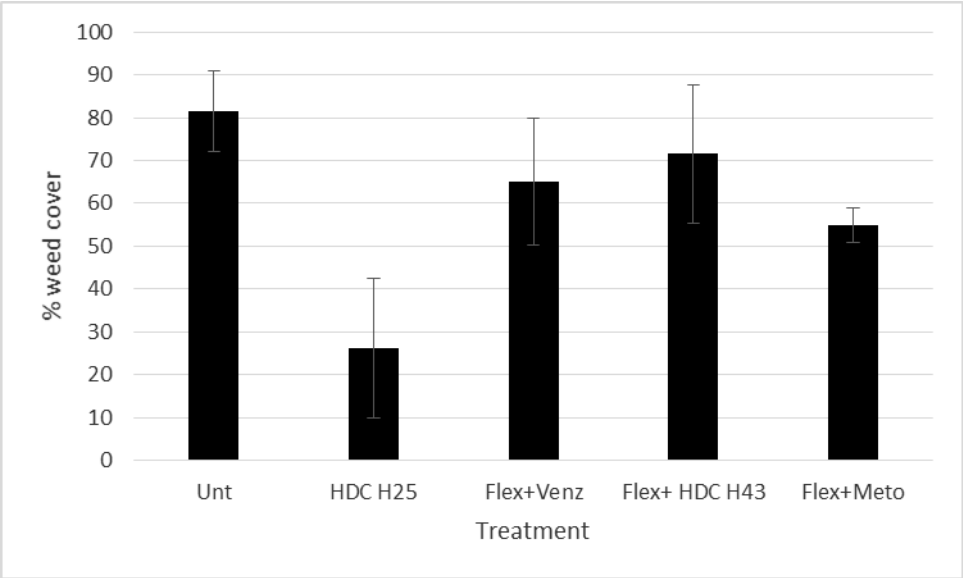

Figure 21. Percentage weed cover of plots 10 weeks after the planting treatments were applied to the aster trial – Wortham, 4 August 2016

Figure 22. Untreated (left) and HDC H25 treated plots (right) 6 weeks after planting treatments were applied – Wortham, 16 June 2016

After the second round of treatments had been applied to the asters, the plots treated with HDC H25 when the planting treatments were applied, but received no treatment when the second round of treatments were applied (T2), remained the best treatment with an average weed cover of plots of 7.5% ($p<0.001$, l.s.d. 11.86, **Figure 23**). At the 6 WAT assessment all other treatments (Flexidor 500 + Venzar Flowable, Flexidor 500 + HDC H43 and Flexidor 500 + metobromuron) all provided significantly better weed control than the untreated control. At the assessment carried out 10 weeks after treatment, HDC H25 remained the best treatment in terms of weed control ($p=0.004$, l.s.d. 20.16, **Figure 24**).

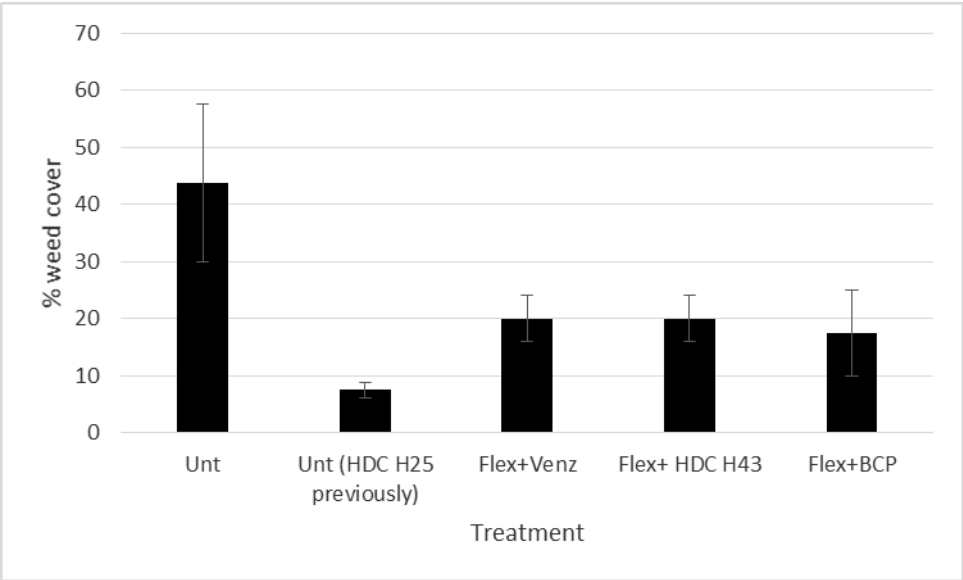

Figure 23. Percentage weed cover of plots 6 weeks after the second treatments were applied to the aster trial – Wortham, 5 October 2016

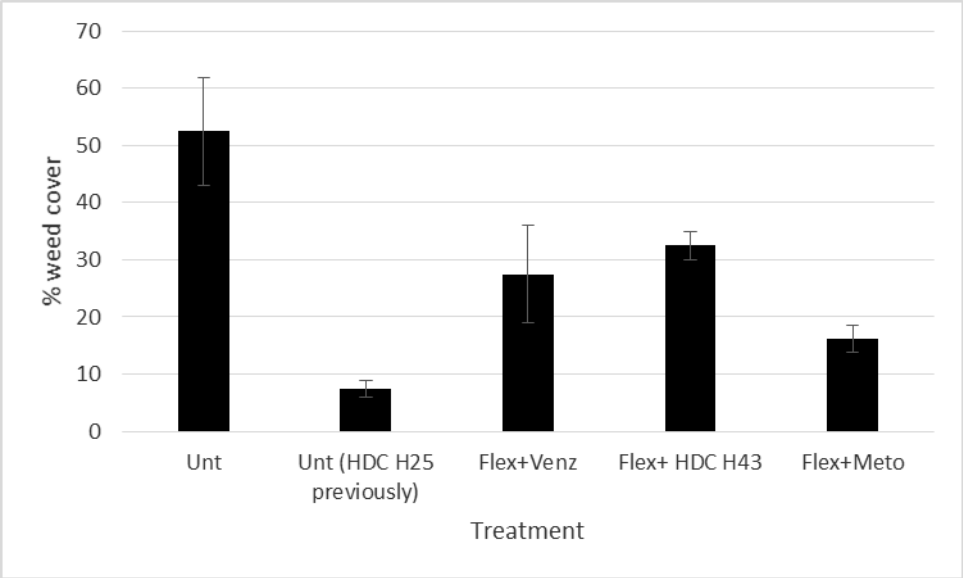

Figure 24. Percentage weed cover of plots 10 weeks after the second treatments were applied to the aster trial – Wortham, 26 October 2016

Geraniums

After the first round of treatments had been applied to the geranium trial at planting, no herbicide damage could be seen from any of the treatments at the assessment carried out 6 WAT (**Table 20**). At 10 WAT all treatments were considered commercially acceptable on the geraniums. **Figure 25** shows an HDC H25 treated plot 6 WAT. After the second round of treatments were applied to the geranium trial, no damage was observed to the geraniums from any of the treatments when the trial was assessed 6 WAT and 10 WAT (**Table 21**).

Table 20. Phytotoxicity scores for the geranium trial after the planting treatments were applied, six weeks after treatment (WAT) and 12 WAT – Wortham, 2016 (scale of 0 - 9 where 9 is healthy, 0 is dead and 7 is commercially acceptable) –

Trt. no.	Planting treatment (04.05.16)	Rate (Kg/ha or L/ha)	Phytotoxicity score 6 WAT (16.06.16)	Phytotoxicity score 12 WAT (04.08.16)
1.	Untreated	N/A	9.0	8.3
2.	HDC H25	220.0	9.0	8.3
3.	Flexidor 500 + Venzar Flowable	0.25 + 1.5	9.0	8.3
4.	Flexidor 500 +	0.25 +	9.0	8.5

Trt. no.	Planting treatment (04.05.16)	Rate (Kg/ha or L/ha)	Phytotoxicity score 6 WAT (16.06.16)	Phytotoxicity score 12 WAT (04.08.16)
	HDC H43			
5.	Flexidor 500 + Metobromuron	0.25 + 3.75	9.0	8.5
P Value			NS	NS
L.S.D			NS	NS

NS (not significant)

Figure 25. HDC H25 treated geranium plot 6 weeks after treatments were applied – Wortham, 16 June 2016

Table 21. Phytotoxicity scores for the geranium trial after second treatments were applied, six weeks after treatment (WAT) and 10 WAT – Wortham, 2016 (scale of 0 - 9 where 9 is healthy, 0 is dead and 7 is commercially acceptable)

Trt. no.	Follow up treatment (09.08.16)	Rate (Kg/ha or L/ha)	Phytotoxicity score 6 WAT (05.10.16)	Phytotoxicity score 10 WAT (26.10.16)
1	Untreated	N/A	9.0	9.0
2	Untreated	N/A	9.0	9.0
3	Flexidor 500 + Venzar Flowable	0.25 + 1.5	9.0	9.0
4	Flexidor 500 + HDC H43	0.25 +	9.0	9.0
5	Flexidor 500 + Metobromuron	0.25 + 3.75	9.0	9.0
P Value			NS	NS
L.S.D.			NS	NS

NS (Not significant)

Very few weeds were observed in any of the geranium plots, including the untreated plots, 6 weeks after the planting treatments had been applied to plots, with all plots having less than 1% weed cover (**Figure 26**). At the 12 WAT assessment the geraniums had outcompeted the weeds making it impossible to carry out a weed assessment. At the final assessment carried out 10 weeks after the second treatments had been applied, the geraniums had started to die back, making it possible to carry out the final weed assessment. At the 10 WAT assessment carried out after the second treatments had been applied, the best treatment for controlling weeds was the HDC H25 treatment that had been applied at the first treatment application and remained untreated at the second treatment application (T2) (**Figure 27**). At this assessment HDC H25 plots had an average of 6.7% weed cover in a quadrat. At the same assessment, plots that had received a treatment of Flexidor 500 + metobromuron (T5) were the second best plots with an average quadrat weed cover of 8.3%.

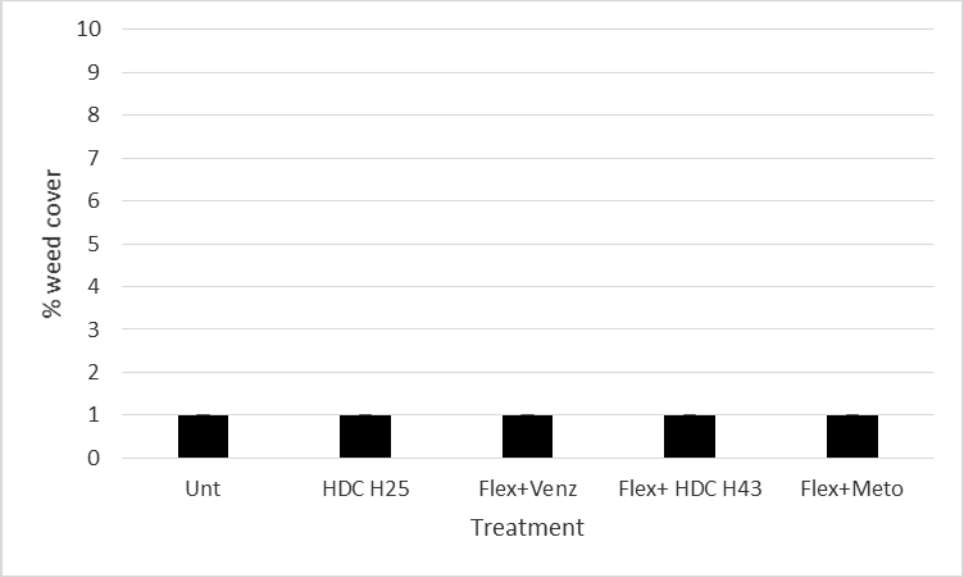

Figure 26. Percentage weed cover of plots 6 weeks after the planting treatments were applied to the geranium trial – Wortham, 16 June 2016

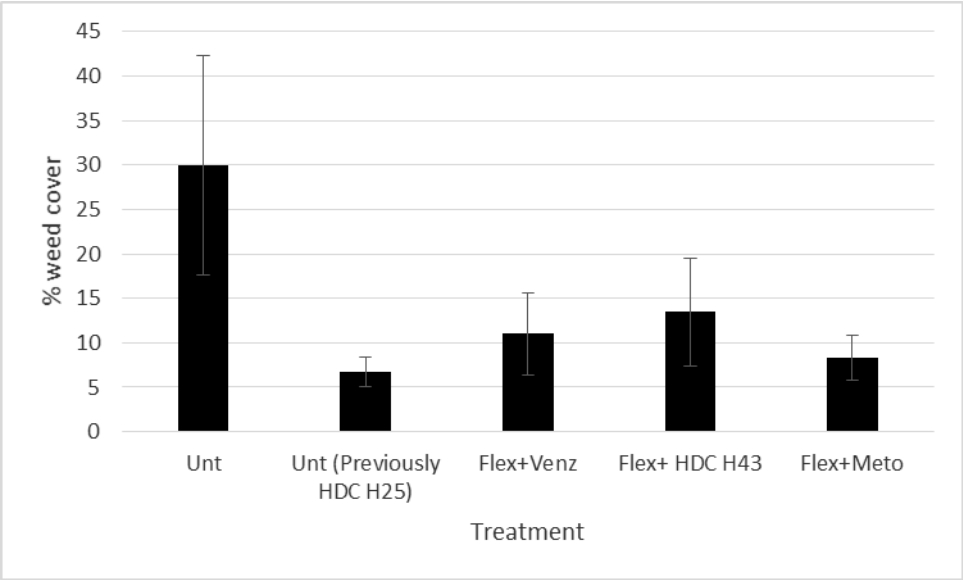

Figure 27. Percentage weed cover 10 weeks after the second treatments were applied to the geranium trial – Wortham, 26 October 2016

Iris

There were no significant phytotoxic effects seen at either 2 or 6 weeks after the first treatment application was made to the iris trial from any of the treatments that were tested (**Table 22**). **Figure 28** shows an untreated plot of irises, a plot treated with HDC H25 and a plot treated with Flexidor 500 + metobromuron, all two weeks after treatments were applied. At the assessment carried out 10 weeks after the second treatment application was made, all

treatments were found to be acceptably safe when applied over the crop of irises. A couple of the plots that were treated with Titus were scored slightly down due to a couple of the irises having slightly yellow leaves compared to the untreated plots. Although there were significant differences, all treatments were above the commercially acceptable score of 7. (**Table 23**).

Table 22. Phytotoxicity scores for the iris trial after the first treatments were applied, 6 weeks after treatment (WAT) and 10 WAT – Wortham, 2016 (scale of 0 - 9 where 9 is healthy, 0 is dead and 7 is commercially acceptable)

Trt. no.	**Planting treatment (14.04.16)**	**Rate (Kg/ha or L/ha)**	**Phytotoxicity 2 WAT (28.04.16)**	**Phytotoxicity 6 WAT (26.05.16)**	**Phytotoxicity 10 WAT (22.06.16)**
1.	Untreated	N/A	8.0	7.4	8.0
2.	HDC H25	220.0	8.5	7.5	8.5
3.	Flexidor 500 + Venzar Flowable	0.25 + 1.5	8.0	7.4	8.8
4.	Flexidor 500 + HDC H43	0.25 +	8.3	7.7	8.8
5.	Flexidor 500 + Metobromuron	0.25 + 3.75	8.3	7.1	8.5
P value			NS	0.843	8.25
L.S.D			NS	NS	7.5

NS (not significant)

Figure 28. Untreated (left), HDC H25 (middle) and Flexidor 500 + metobromuron (right) 2 weeks after treatment, Wortham, 28 April, 2016

Table 23. Phytotoxicity scores for the iris trial after the second treatments were applied, 10 weeks after treatment (WAT) – Wortham, 2016 (scale of 0 - 9 where 9 is healthy, 0 is dead and 7 is commercially acceptable)

Trt. no.	**Follow up treatment (22.06.16)**	**Rate (Kg/ha or L/ha)**	**Phytotoxicity 10 WAT**
1	Untreated	N/A	8.5
2	Untreated	N/A	8.5
3	Flexidor 500 + Springbok	0.25 + 1.6	9.0
4	Butryflow	1.0	8.3
5	Titus	0.05	7.8
6	Flexidor 500 + HDC H43	0.25 +	9.0
7	Flexidor 500 + Metobromuron	0.25 + 3.75	8.5
P value			0.002
L.S.D			0.5847

At the assessment carried out 6 weeks after the first treatment application was made all treatments provided significantly better weed control than the untreated control (p<0.001, l.s.d. 10.34, **Figure 29**). At the 6 WAT assessment HDC H25 (T2) was the best treatment in terms of weed control with an average plot cover of 1%. Flexidor 500 + Venzar Flowable (T3) had an average weed plot cover of 6%, Flexidor 500 + HDC H43 (T4) had an average of 10% and Flexidor 500 + metobromuron had an average plot cover of 8% weed cover. At the assessment 10 WAT, HDC H25 was the best performing herbicide with an average plot cover of 5% weeds (p<0.001, l.s.d. 12.67, **Figure 30**).

After the second treatment application, 6 WAT, plots that had been treated with HDC H25 previously but were left untreated at the second treatment application (T2) were the best for weed control (p<0.001, l.s.d. 18.63, **Figure 31**). This treatment remained the most effective treatment in terms of weed control 10 WAT at the final assessment (p<0.001, l.s.d. 21.83, **Figure 32**). The Titus and Butryflow treatments were less effective as although they scorched existing weed it was too advanced to be fully controlled and, having no residual action, they did not prevent further germination.

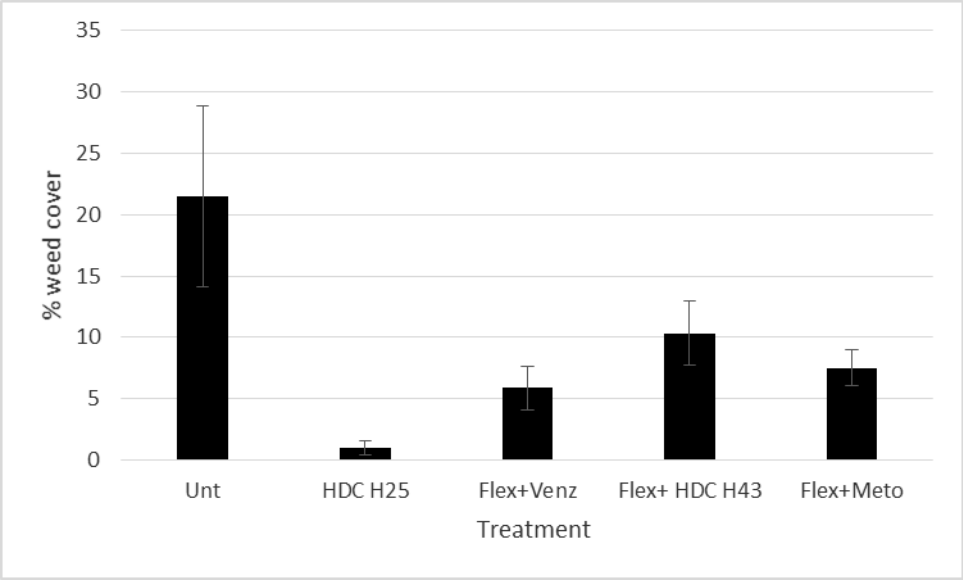

Figure 30. Percentage weed cover of plots 6 weeks after the first treatments were applied to the iris trial – Wortham, 26 May 2016

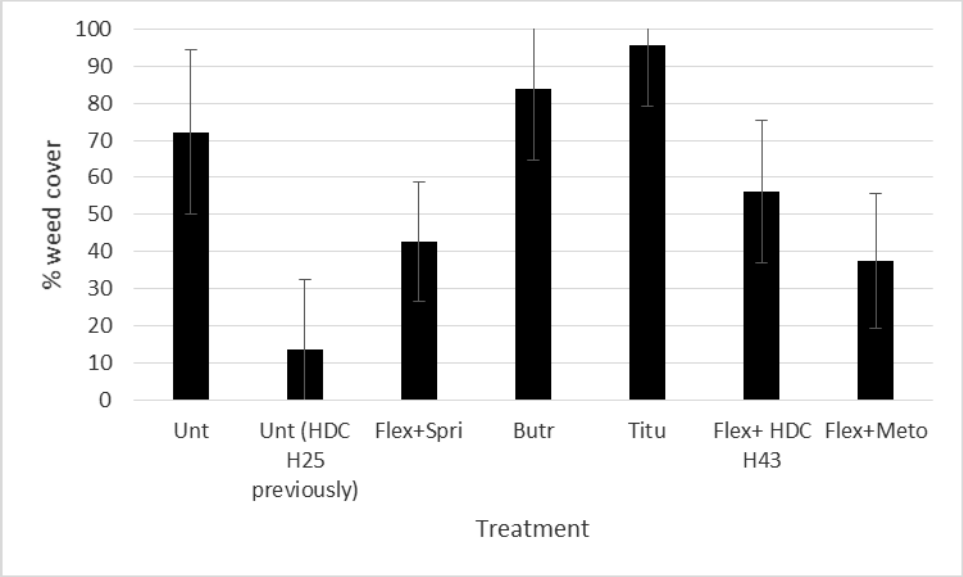

Figure 31. Percentage weed cover of plots 6 weeks after the second treatments were applied to the iris trial – Wortham, 4 August 2016

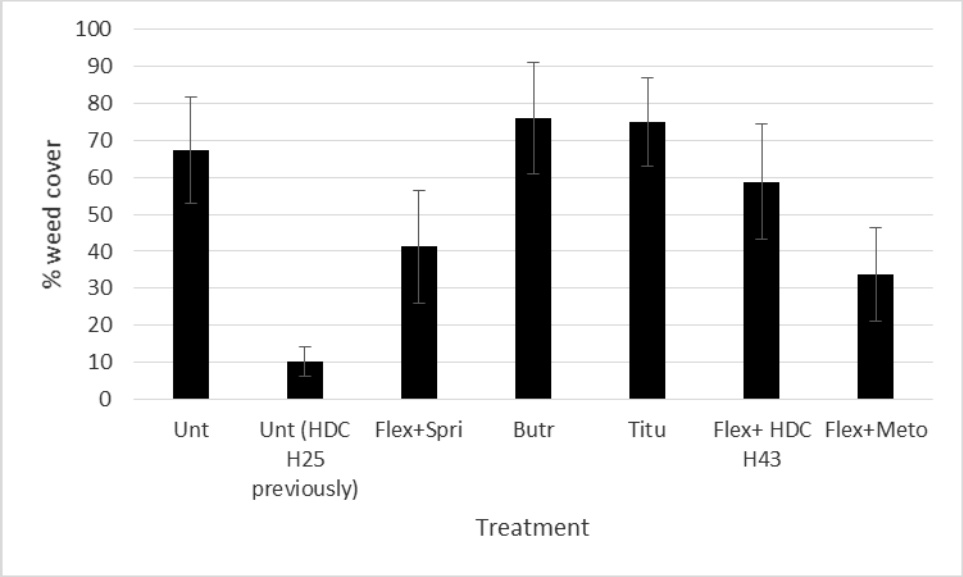

Figure 32. Percentage weed cover of plots 10 weeks after the second treatments were applied to the iris trial – Wortham, 2016

Veronica

The veronica trial took a long time to establish due to the ground being very dry at planting. No significant phytotoxic damage was seen in any of the treated plots 6 weeks after the planting treatments had been applied or at the assessment carried out 12 WAT (**Table 24**). None of the treatments applied at the second application caused any damage to the veronica that could be seen at the 6 WAT and 10 WAT assessment (**Table 25**).

Table 24. Phytotoxicity scores for veronica trial after first treatments were applied, 6 weeks after treatment (WAT) and 12 WAT – Wortham, 2016 (scale of 0 - 9 where 9 is healthy, 0 is dead and 7 is commercially acceptable) –

Trt. no.	**Planting (04.05.16)**	**Rate (Kg/ha or L/ha)**	**Phytotoxicity score 6 WAT (16.06.16)**	**Phytotoxicity score 10 WAT (05.08.16)**
1.	Untreated	N/A	8.8	7.5
2.	HDC H25*	220.0	7.8	8.0
3	Venzar Flowable	1.5	8.9	8.0
4	HDC H43		8.3	8.0
5	Metobromuron	3.75	8.3	8.3
P value			0.002	0.015
L.S.D.			0.5489	11.15

*Known as Winshot in other markets

Table 25. Phytotoxicity scores for the veronica trial after second treatments were applied, 6 weeks after treatment (WAT) and 10 WAT – Wortham, 2016 (scale of 0 - 9 where 9 is healthy, 0 is dead and 7 is commercially acceptable)

Trt. no.	**Follow up trt. (09.08.16)**	**Rate (Kg/ha or L/ha)**	**Phytotoxicity score 6 WAT (05.10.16)**	**Phytotoxicity score 10 WAT (26.10.16)**
1	Untreated	N/A	8.0	8.8
2	Untreated	N/A	8.0	9.0
3	HDC H43		8.0	8.8
4	Titus	0.05	8.5	9.0
5	Venzar Flowable	1.5	8.0	8.3
6	Metobromuron	3.75	8.3	8.0
P Value			0.043	0.002
L.S.D.			0.6914	14.19

At the assessment carried out 6 weeks after the first treatments had been applied to the veronica trial at planting, HDC H25 (T2) provided the best control of weeds ($p<0.001$, l.s.d. 13.42, **Figure 33**). The average percentage weed cover of plots treated with HDC H25 was 25.3%. At the assessment carried out 10 WAT, HDC H25 remained the most effective treatment, however the average weed cover of a plot was 42.5% ($p<0.001$, l.s.d. 8.44, **Figure 34**).

After the second round of treatments were applied, at the 6 WAT assessment plots that had received an application of HDC H25 when the first round of treatments had been applied and had been left untreated at the second round (T2), provided the best weed control ($p<0.001$, l.s.d. 8.44, **Figure 36**). The average percentage weed cover per plot for HDC H25 treated plots was however quite high at 42.5%. At the 10 WAT assessment, HDC H25 (T2) remained the best treatment in terms of weed control, however weed cover had increased to an average of 61.3% per plot ($p<0.009$, l.s.d. 23.46, **Figure 36**).

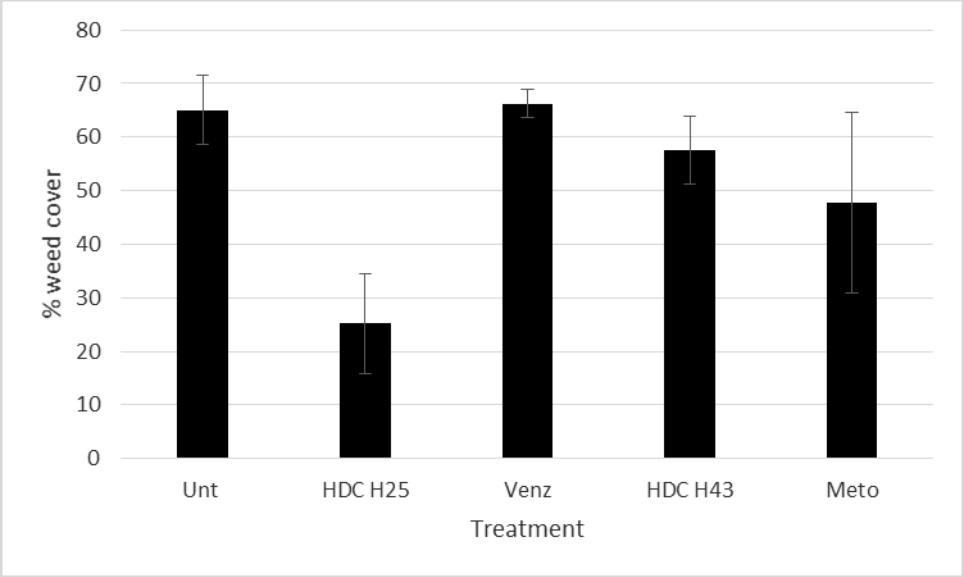

Figure 33. Percentage weed cover of plots 6 weeks after the planting treatments were applied to the veronica trial – Wortham, 16 June 2016

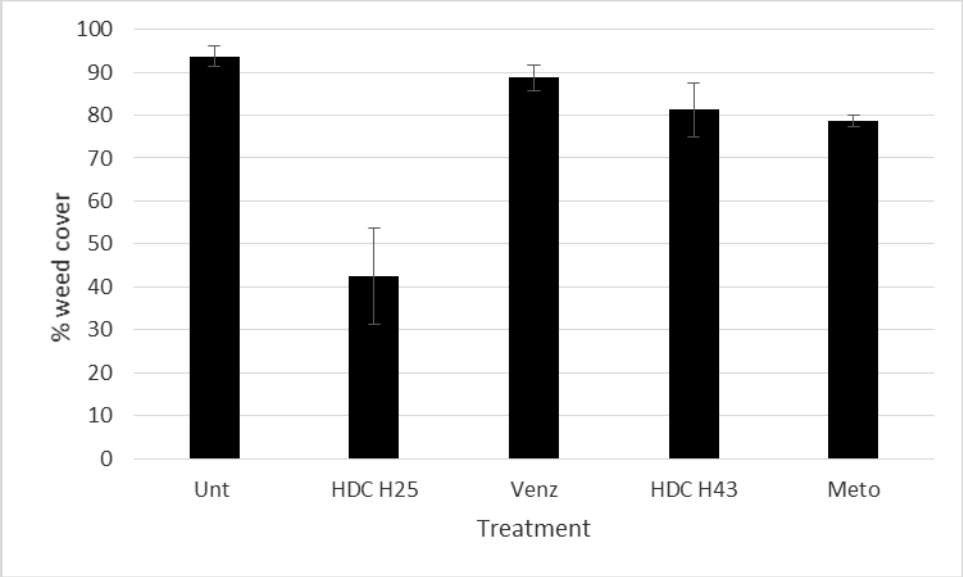

Figure 34. Percentage weed cover of plots 12 weeks after first treatments were applied to the veronica trial – Wortham, 2016

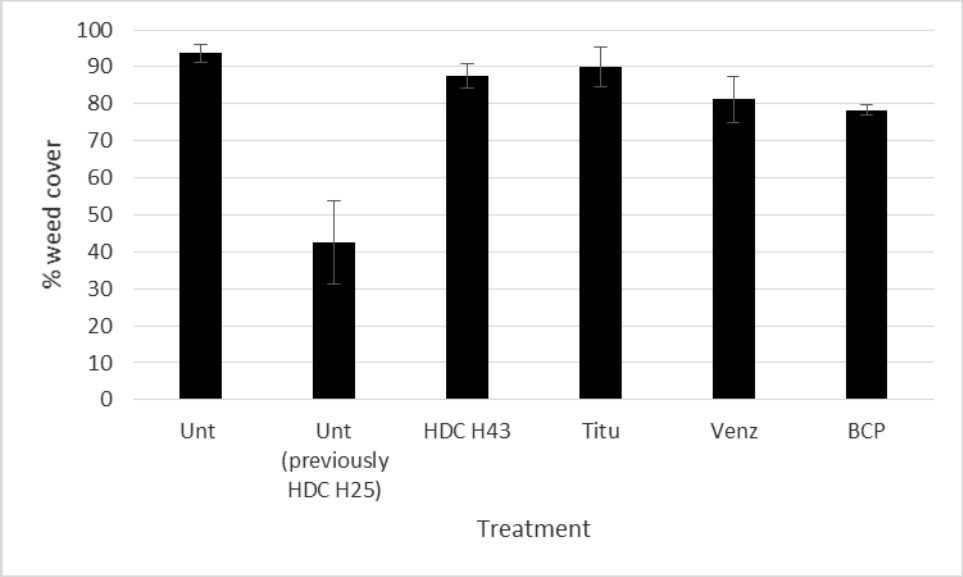

Figure 35. Percentage weed cover of plots 6 weeks after the second treatments were applied to the veronica trial – Wortham, 5 October 2016

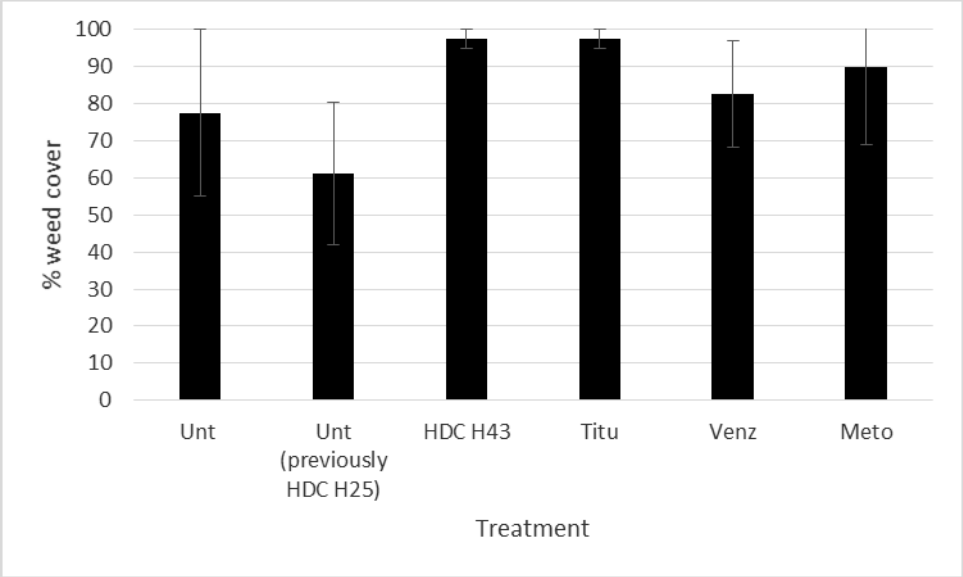

Figure 36. Percentage weed cover of plots 10 weeks after second treatments were applied to the veronica trial – Wortham, 26 October 2016

Discussion

Aster

All of the treatments that were applied to the asters at planting proved to be safe on the plants with no obvious signs of phytotoxicity seen throughout the trial. HDC H25 and Flexidor 500 + metobromuron were the best of the treatments in terms of weed control at the 6 WAT

assessment. However, by the final assessment, 10 WAT, Flexidor 500 + metobromuron was no longer as effective as HDC H25 at controlling weeds.

All of the treatments that were applied to the asters at the follow up treatment to the post-planting treatment proved to be safe to the asters. The plots that had received the treatment HDC H25 at planting but received no further application at the second treatment application had the lowest levels of weeds 6 WAT. At this stage all other herbicides provided better weed control compared to the untreated control but were not as good as HDC H25. HDC H25 remained the best treatment at the 10 WAT assessment but it was starting to break down in terms of weed control.

Geranium

No significant phytotoxic damage was caused by any of the treatments applied to the geraniums at planting, and so all of these treatments would be considered safe to use on this crop type. At the assessment that was carried out 6 WAT, very few weeds were present in any of the plots, even in the untreated plots. By 10 WAT the geraniums were very dense, making it hard to assess the weed level of plots.

All of the treatments applied over the geraniums at the follow up treatment to the planting treatment were safe and caused no significant damage to the geraniums. It was not possible to assess the weed level of the plots until the final assessment carried out 10 weeks after the second round of treatments had been applied. At this final assessment the geraniums had started to die back making it easier to assess the weed level. Plots that were treated with HDC H25 had the lowest level of weeds and were closely followed by plots treated with Flexidor 500 + metobromuron.

Iris

All of the treatments applied shortly after planting proved to be safe to spray over the irises. At the assessment carried out 6 WAT, HDC H25 provided the best weed control and proved to be the best treatment for controlling scarlet, black bindweed and mayweed. Flexidor 500 + HDC H43, Flexidor 500 + Venzar Flowable and Flexidor 500 + metobromuron all provided good weed control.

None of the treatments applied to the irises at the follow up treatment application were found to cause any damage to the crop. HDC H25 provided the best weed control at the assessment carried out 6 WAT and remained the best out of the treatments at 10 WAT.

Veronica

The veronica were very slow to establish due to the dry conditions that were experienced at the time of planting. Despite the plants being slow to establish, no phytotoxic symptoms were seen in any of the different treated plots after the first application of herbicides were made at the time of planting. Out of the planting treatments HDC H25 performed the best in terms of weed control, however weed control with this treatment was not as good as was experienced from the other herbicide trials in this project where it was tested, even at the 6 WAT assessment. This was probably because the crops did not compete as well with the weeds.

All of the treatments applied to the veronica 10 weeks after planting were safe and caused no significant phytotoxic effects. At the assessments made after these treatments were applied, plots that had received an application of HDC H25 at planting and no other treatment at the 10 WAT application still remained the best in terms of weed control.

Conclusions

The safest residual herbicide to apply to *Betula* seedbeds was the grower standard Goltix 70 SC, post sowing. It was noted from the *Betula* trial that covering the beds in grit resulted in greater than anticipated lateral movement of the inter-row herbicide treatment. In conclusion band treatments of row and inter-row residual herbicides may have more potential when applied where seeds are not covered in sand or grit. However, the smaller seeded tree species (which are routinely covered in sand or grit) are generally the most sensitive to residual herbicides. There is a need to do more work, looking at lower rate inter-row residual herbicide treatments, where small seeded species are covered with sand rather than grit. There was an indication that *Betula* may be tolerant of a low rate of Flexidor 500.

The rose herbicide trial highlighted a promising herbicide treatment for use at planting: Stomp Aqua + Flexidor 500 + HDC H43. It was confirmed that Flexidor 500 + Butisan S was an effective treatment post budding and that Logo (plus Mero adjuvant) has potential for use over the foliage of the rose stocks for selective post-emergence weed control. The use of HDC H42 after planting gave growth suppression and yellowing from which the rose stocks eventually recovered but it would be regarded as a risky treatment in comparison with other equally effective treatments. Samson Extra 6% also gave rise to some initial suppression and it has now been clarified that applications are only authorised in May and June, ruling out use immediately post-planting on dormant stock. The final application to the 2016 trial will be applied post-heading back in February 2017. Some modifications to the planned treatments will be made following this year's results and further information on authorisation. In 2017 there will also be a second herbicide trial carried out on budded roses to refine treatments.

HDC H25 was the stand out treatment in all the herbaceous trials proving to be safe on aster, geranium, iris and veronica. Not only was this treatment safe, but it also provided the best weed control in all of the herbaceous trials.

Review of herbicide authorisations for hardy nursery stock production in selected European countries

A review of herbicide authorisations was undertaken to identify treatments that are available in other European countries for nursery stock production but are not currently available in the UK or are available in the UK only with restrictions that do not apply elsewhere. The review focused on countries that have significant nursery stock production and / or a good range of herbicide authorisations (**Table 26**).

Table 26. Herbicide authorisations for hardy nursery stock production in selected European countries that differ from those in the UK

Active ingredient	Belgium	Denmark	Eire	France	Germany	Italy	Netherlands	Poland	Spain	Switzerland
Amidosulfuron (10.23% w/w) + iodosulfuron (1.16% w/w), Hoestar Super					0.2 kg/ha, Xmas trees only.					
Amidosulfuron (75% w/w), Eagle			40 g/ha, ornamentals							
Clethodim (120-240 g/L), Select 240EC, Select Prim, Centurion Max	2.5 L/ha, Xmas trees only				Proposed EAMU, ornamentals			1.5 L/ha, ornamentals		
Clomazone (360 g/L), Centium, Gamit		0.25 L/ha, nursery stock, before bud burst								
Dimethenamid-p (212.5 g/L)+ pendimethalin (250 g/L), Wing-p			4 L/ha, ornamentals, 20wk witholding				4 L/ha various perennials, tree seedbeds			
Dimethenamid-p (200 g/L) + metazachlor (200 g/L), Springbok, Butisan Kombi					2.5 L/ha, ornamentals					
Dimethenamid-p (720 g/L), Spectrum, Frontier Elite	1 L/ha, ornamentals			In trials for EAMU	1.2 L/ha, ornamentals					

Active ingredient	Belgium	Denmark	Eire	France	Germany	Italy	Netherlands	Poland	Spain	Switzerland
Flazasulfuron (25% w/w), Chikara, Katana	200 g/ha, conifers; Abies, Picea, Taxus, Thuja incl protected		150 g/ha, ornamentals		200 g/ha, conifers					
Flumioxazin (50% w/w), Vorox F, Toki, Sumimax	300 g/ha, ornamentals, pre-bud burst, incl use under protection				300 g/ha, ornamentals, pre-bud burst, due for re-registration					
Foramsulfuron (0.3% w/w) + iodosulfuron-methyl-sodiumn(0.01% w/w), Maister, Logo		150 g/ha, Nordman fir, various trees in nursery			150 g/ha, ornamentals before bud burst but no longer available					
Foramsulfuron (22.5% w/w, Monsoon)					Proposed EAMU, Xmas trees					
Haloxyfop-p (104 g/L), Gallant Super, Eloge	0.5 L/ha, ornamentals				1 L/ha, ornamentals					
iodosulfuron-methyl-sodiumn(1% w/w) + diflufenican (360 g/L), Ronstar Expert		0.33 kg/ha nursery stock, ornamentals, shielded spray, April-July		0.33 kg/ha nursery stock, ornamentals, shielded spray, Mar-Jun or overall Dec-Feb					0.33 kg/ha nursery stock, ornamentals, shielded spray, Mar-Jun or overall Dec-Feb	

Active ingredient	Belgium	Denmark	Eire	France	Germany	Italy	Netherlands	Poland	Spain	Switzerland
Isoxadifen (10% w/w + tembotrione (20% w/w), Laudis WG					Proposed EAMU, conifers only					
Mesotrione (100 g/L), Callisto		1 L/ha, nursery stock, pre bud burst only					0.1-0.25 L/ha, flower seed crops only, post-emergence, up to 4 treatments			
Metamitron (70% w/w), Goltix 70 SC							3 kg/ha pre-em, 0.5 kg/ha post em, selected herbaceous perennials			
Metazachlor (500 g/L), Butisan S					1.5 L/ha ornamentals container crops excl from annual limit					
Metribuzin (70% w/w), Sencor, Sencorex					0.75 kg/ha, ornamentals					
Oryzalin (429 g/L) + isoxaben 107 g/L), Winch, Fleuron				5 L/ha. Trees, shrubs, open ground and containers, dormant only						
Oryzalin (480 g/L), Surflan										6 L/ha, forest nurseries

Active ingredient	Belgium	Denmark	Eire	France	Germany	Italy	Netherlands	Poland	Spain	Switzerland
Oxyfluorfen (0.45% w/w), pendimethalin (2.3% w/w), Stratage B, Gran'herb G, Boul'herb GR, Gran'herb J granules				110 kg/ha, trees, shrubs, nursery stock, in filed no more than 33% of area to be treated						
Oxyfluorfen (240 g/L), Febo									2-4L/ha, forest nurseries, conifers	
Oxyfluorfen (70 g/L), pendimethalin (350 g/L), Stratege L				5 L/ha. trees, shrubs, nursery stock						
Pendimethalin (2% w/w), Granamide select granules				120 kg/ha. Trees, shrubs, open ground and containers, dormant only						
Propaquizafop (100 g/L), Shogun									0.5-1 L/ha, Nurseries	
Propyzamide (400 g/L), Kerb Flo 400, Carcea	2.5 L/ha, ornamentals	0.875-1 L/ha nursery stock seedbeds		3.75 L/ha, ornamentals, only 50% of area to be treated	6.25 L/ha, ornamentals				3 L/ha, ornamental trees, forest nurseries	4.0 L/ha, ornamentals

Active ingredient	Belgium	Denmark	Eire	France	Germany	Italy	Netherlands	Poland	Spain	Switzerland
Prosulfocarb (800 g/L), Defy, Boxer	5 L/ha tree, nurseries, dormant season	4 L/ha, nursery crops, selected herbaceous, nordman fir, pre bud burst	5 L/ha, ornamentals	5 L/ha, trees, shrubs incl containers, dormant season	5 L/ha ornamentals		4 L/ha, flowers, before emergence	5 L/ha ornamentals		
Pryraflufen-ethyl (26.5 g/L), Quickdown, Gizmo							0.8 L/ha, flower crops, herbaceous perennials, guarded spray only, 2 apps			
Pyridate)45% w/w), Lentagran WG	2 kg/ha Tree nurseries, interrow only.									
Quinoclamine (25% w/w), Mogeton		15 kg/ha in 1000 L/ha outdoor and protected	15 kg/ha in 1000 L/ha protected	15 kg/ha in 1000 L/ha outdoor and protected	15 kg/ha in 1000 L/ha outdoor and protected					
Quisalofop-p-ethyl (120 g/L), Coursier				1.25 L/ha. Ornamental trees and shrubs						
S-metolachlor (960 g/L), Dual Gold	0.5 L/ha, Begonia, 1.5 L/ha annual flowering plants pre-emergence						1.5 L/ha, herbaceous perennials, fruit tree nursery,			

There are relatively few new active ingredients available in other European countries that would be useful to introduce into the UK for nursery stock production. Of particular interest is oxyfluorfen which is available in Spain as a liquid formulation and as a granular in France. However it is thought that the future for oxyfluorfen in Europe is limited and there is already concern about finding replacements for granular oxyfluorfen/pendimethalin products on the French market. Another active is oryzalin which is only available in France as a liquid co-formulated with pendimethalin and as a straight in Switzerland. This is a useful product but the UK is likely to be limited to one granular product, HDC H25. There is little prospect of the straight liquid being made available. There are several products based on iodosulfuron-methyl-sodium either co-formulated with foramsulfuron or diflufenican. The former combination is already proposed for an EAMU in the UK. The combination with diflufenican (Ronstar Expert) available in France, Spain and Denmark may be less useful as diflufenican can be phytotoxic to many crops.

Apart from actives completely new to hardy nursery stock in the UK there are many examples of products available with EAMUs in the UK but which have very much lower rates of use (e.g flumioxazin, s-metolachlor), restrictions to pre-emergence use only (before crop emergence) (e.g. prosulfocarb, dimethenamid-p + pendimethalin, metribuzin, metamitron) or other crop restrictions (e.g. propyzamide). Some actives, e.g. dimethenamid-p are not available as a straight product in the UK, the alternative co formulated products (e.g. Springbok, Wing-P), whilst useful have stringent limitations with their UK authorisations that do not apply to the straight product authorisations in other European countries.

The following actives/products should be pursued for new or more flexible EAMUs.

Foramsulfuron + iodosulfuron-methyl-sodium (Logo)	**New EAMU**
Prosulfocarb (Defy)	EAMU extended to include use over dormant stock including under protection
Metribuzin (Sencorex)	EAMU extended to include use over dormant stock including under protection
Clethodim (Centurion Max)	EAMU to replace LTAEU
Pyraflufen-ethyl (Quickdown)	New EAMU

Knowledge and Technology Transfer

AHDB Horticulture weed control workshop, Coles Nurseries, Leicester. 29 June 2016.

AHDB Horticulture weed control workshop, Hillier Nurseries, Romsey. 30 June 2016.

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Appendices

Appendix 1 – Betula trial

Table 27. Phytotoxicity scores and percentage weed cover for the Betula trial 2 weeks after treatment (WAT) (scale of 0 - 9 where 9 is healthy, 0 is dead and 7 is commercially acceptable) – Wasperton, Warwick, 3 June 2016

Trt no.	Inter-row treatment.	Rate (kg/L/ha)	Phytotoxicity score 2 WAT	% weed cover 2 WAT
1	Untreated control	N/A	9.0	0.75
2	Goltix 70 SC	1.0	8.0	0.25
3	Flexidor 500 + Goltix 70 SC	0.5 + 2.0	6.0	0.38
4	Flexidor 500 + Springbok	0.5 + 2.5	1.8	0.00
5	Stomp Aqua + Springbok	2.9 + 2.5	2.0	0.25
6	Stomp Aqua + Springbok + Gamit 36 CS	2.9 + 2.5 + 0.25	2.0	0.00
7	Stomp Aqua + Sencorex Flow	2.9 + 1.15	1.0	0.00

Scores were consistant between treatment replications therefore differences between treatments were considered to be definitive and no further no statistical analysis was required.

Appendix 2 – Budded rose trial

Table 28 - Percentage weed cover for the budded rose trial 2 weeks after treatment (WAT) at planting – Pulham St Mary, 21 April 2016

Trt. no.	Planting treatment	Rate (Kg/ha or L/ha)	% weed cover 2 WAT (21.04.16)
1	Untreated	N/A	1.00
2	Stomp Aqua + Flexidor 500 + Venzar Flowable	2.9 + 0.5 + 3.0	1.00
3	Stomp Aqua + Flexidor 500 + HDC H43	2.9 + 0.5 +	1.00
4	Stomp Aqua + Flexidor 500 + HDC H42	2.9 + 0.5 +	1.75
5	Samson Extra 6%	0.75	1.00
6	Flexidor 500 + Samson Extra 6%	0.5 + 0.75	1.00
7	Flexidor 500 + Samson Extra 6% + HDC H42	0.5 + 0.75 +	2.00
8	Logo + Mero (adjuvant)	0.15 + 2.0	2.00
9	Flexidor 500 + Logo	0.5 + 0.15	1.00
P value			0.029
L.S.D.			0.8257

Table 29 - Phytotoxicity scores and percentage weed cover for the budded rose trial 2 weeks after treatment (WAT) at at budding (scale of 0 - 9 where 9 is healthy, 0 is dead and 7 is commercially acceptable) – Pulham St Mary, 4 August 2016

Trt. no.	Budding treatment	Rate (Kg/ha or L/ha)	Phytotoxicity score 2 WAT	% weed cover 2 WAT
1	Untreated	N/A	6.5	17.0
2, 5, 6, 7, 8, 9	Flexidor 500 + Butisan S	0.5 + 1.5	6.7	2.3
3	Logo +	0.075 + 2.0	6.8	5.0

Trt. no.	Budding treatment	Rate (Kg/ha or L/ha)	Phytotoxicity score 2 WAT	% weed cover 2 WAT
	Mero (adjuvant)			
4	Flexidor 500 + HDC H43	0.5 +	6.8	1.5
10	Flexidor 500 + Butisan S (following Flexidor 500 + Logo at planting)	0.5 + 1.5	6.0	1.3
P value			0.003	<.001
L.S.D			0.3212	2.109

Appendix 3 – Herbaceous trials

Appendix 3.1 – Aster

Table 30. Phytotoxicity score and percentage weed cover for the aster trial after the planting treatments were applied, 2 weeks after treatment (WAT)– Wortham, 2016 (scale of 0 - 9 where 9 is healthy, 0 is dead and 7 is commercially acceptable)

Trt. no.	**Planting treatment (04.05.16)**	**Rate (Kg/ha or L/ha)**	**Phytotoxicity score 2 WAT (17.05.16)**	**% weed cover 2 WAT (17.05.16)**
1.	Untreated	N/A	9.0	1.0
2.	HDC H25*	220.0	8.0	1.0
3.	Flexidor 500 + Venzar Flowable	0.25 + 1.5	7.8	1.0
4.	Flexidor 500 + HDC H43	0.25 +	8.8	1.0
5.	Flexidor 500 Metobromuron	0.25 + 3.75	7.5	1.0
P value			0.009	NS
L.S.D			0.847	NS

NS (not significant)

Table 31. Phytotoxicity score and percentage weed cover for the aster trial after the follow-up treatments were applied, 2 weeks after treatment (WAT)– Wortham, 2016 (scale of 0 - 9 where 9 is healthy, 0 is dead and 7 is commercially acceptable)

Trt. no.	**Follow up treatment (09.08.16)**	**Rate (Kg/ha or L/ha)**	**Phytotoxicity score 2 WAT (01.09.16)**	**% weed cover 2 WAT (01.09.16)**
1.	Untreated	N/A	9.0	16.7
2.	Untreated	N/A	8.5	5.2
3.	Flexidor 500 + Venzar Flowable	0.25 + 1.5	8.0	45.0
4.	Flexidor 500 + HDC H43	0.25 +	9.0	27.0
5.	Flexidor 500 + Metobromuron	0.25 + 3.75	9.0	17.5
P value			0.002	0.021
L.S.D.			0.4872	22.32

Appendix 3.2 – Geranium

Table 32. Phytotoxicity score and percentage weed cover for the geranium trial after the planting treatments were applied, 2 weeks after treatment (WAT)– Wortham, 2016 (scale of 0 - 9 where 9 is healthy, 0 is dead and 7 is commercially acceptable)

Trt. no.	**Planting treatment (04.05.16)**	**Rate (Kg/ha or L/ha)**	**Phytotoxicity score 2 WAT (17.05.16)**	**% weed cover 2 WAT (17.05.16)**
1.	Untreated	N/A	8.8	1.0
2.	HDC H25	220.0	7.5	1.0
3.	Flexidor 500 + Venzar Flowable	0.25 + 1.5	8.3	1.0
4.	Flexidor 500 + HDC H43	0.25 +	7.0	1.0
5.	Flexidor 500 + Metobromuron	0.25 + 3.75	5.0	1.0
P Value			<.001	NS
L.S.D			0.754	NS

NS (not significant)

Table 33. Phytotoxicity scores for the geranium trial after the follow-up treatments were applied, 2 weeks after treatment (WAT)– Wortham, 2016 (scale of 0 - 9 where 9 is healthy, 0 is dead and 7 is commercially acceptable)

trt. no.	Follow up treatment (09.08.16)	Rate (Kg/ha or L/ha)	Phytotoxicity score 2 WAT (01.09.16)
1.	Untreated	N/A	7.7
2.	Untreated	N/A	7.0
3.	Flexidor 500 + Venzar Flowable	0.25 + 1.5	8.3
4.	Flexidor 500 + HDC H43	0.25 +	7.3
5.	Flexidor 500 + Metobromuron	0.25 + 3.75	8.3
P value			0.020
L.S.D.			0.824

Appendix 3.3 – Iris

Table 34. Percentage weed cover of plots 2 weeks after the first treatments were applied to the iris trial (WAT) and 10 WAT – Wortham, 2016

Trt. no.	Planting treatment (14.04.16)	Rate (Kg/ha or L/ha)	% weed cover 2 WAT (28.04.16)	% weed cover 10 WAT (22.06.16)
1.	Untreated	N/A	1.0	67.5
2.	HDC H25	220.0	1.0	5.0
3.	Flexidor 500 + Venzar Flowable	0.25 + 1.5	1.1	20.3
4.	Flexidor 500 + HDC H43	0.25 +	2.0	47.5
5.	Flexidor 500 + Metobromuron	0.25 + 3.75	1.8	40.0
P value			0.699	<0.001
L.S.D			1.967	10.34

Table 35. Percentage weed cover for the iris trial after the second treatments were applied, 6 weeks after treatment (WAT) – Wortham, 2016 (scale of 0 - 9 where 9 is healthy, 0 is dead and 7 is commercially acceptable)

Trt. no.	**Follow up treatment (22.06.16)**	**Rate (Kg/ha or L/ha)**	**% weed cover 2 WAT**
1	Untreated	N/A	72.3
2	Untreated	N/A	13.8
3	Flexidor 500 + Springbok	0.25 + 1.6	42.8
4	Butryflow	1.0	83.8
5	Titus	0.05	95.8
6	Flexidor 500 + HDC H43	0.25 +	56.3
7	Flexidor 500 + Metobromuron	0.25 + 3.75	37.5
P value			<0.001
L.S.D			18.63

Appendix 3.4 – Veronica

Table 36. Phytotoxicity score and percentage weed cover of plots 2 weeks after the first treatments were applied to the veronica trial (WAT)– Wortham, 2016

Trt. no.	**Planting (04.05.16)**	**Rate (Kg/ha or L/ha)**	**Phytotoxicity score 2 WAT**	**% weed cover 2 WAT**
1.	Untreated	N/A	9.0	2.0
2.	HDC H25	220.0	8.5	1.0
3	Venzar Flowable	1.5	9.0	1.5
4	HDC H43		9.0	1.0
5	Metobromuron	3.75	9.0	1.0
P value			0.017	0.046
L.S.D.			0.3076	0.899

Table 37. Percentage weed cover of plots 6 weeks after the follow-up treatments were applied to the veronica trial (WAT) – Wortham, 2016

Trt. no.	**Follow up trt. (09.08.16)**	**Rate (Kg/ha or L/ha)**	**% weed cover 6 WAT**
1	Untreated	N/A	93.8
2	Untreated*	N/A	42.5
3	HDC H43		87.5
4	Titus	0.05	90.0
5	Venzar Flowable	1.5	81.3
6	Metobromuron	3.75	78.3
P Value			<0.001
L.S.D.			21.23

*previously treated with HDC H25