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Project leader:	John Atwood, ADAS UK Ltd.
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Key staff:	John Atwood David Talbot Emma Worrall Emily Lawrence
Location of project:	Whartons Nurseries Ltd., Diss, Norfolk ADAS UK Ltd., Boxworth, Cambridge
Industry Representative:	Mark Cade, James Coles & Sons (Nurseries) Ltd., Leicester Bob Hollister, Country Garden Plant Sales Ltd., Wareham Hossein Arshadi, Hillier Nurseries Ltd., Romsey
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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 27 November 2017

Report authorised by:

Barry Mulholland

Head of horticulture

ADAS UK Ltd.

Signature ... ... Date .11 December 2017....

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Grower Summary

Headlines

- Sencorex Flow proved safe and effective in a tank mix with Stomp Aqua + Flexidor 500 or Venzar Flowable when used post planting and post-heading back on rose rootstocks
- 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 H42 provided particularly effective weed control when applied with standard products Stomp Aqua and Flexidor 500.
- Sunfire and Centurion Max were tolerated by 10 hardy nursery stock species when applied after potting. A few species showed short term symptoms but these were grown out of by 6 – 12 weeks.
- Sunfire and Centurion Max provided 100% control of annual meadow grass, pre-emergence and post-emergence respectively.
- Defy gave around 90% pre-emergence control of American willowherb and severe stunting post-emergence.

Background

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. Logo (foramsulfuron + iodosulfuron-methyl-sodium), Sencorex Flow (metribuzin) and 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, and HDC H43. The aim of the budded rose herbicide trial which commenced in 2016 was to test the efficacy and crop safety of herbicide programmes including these new products for field rose production. This trial continued into 2017 as a two year herbicide programme. In 2017 the second budded rose herbicide trial was set up. The

aim of this trial was to build on knowledge gained from the 2016 rose trial and to include newly approved products such as Sencorex Flow.

For HNS container growers, following the final use up of the herbicide product Ronstar 2G (oxadiazon) in 2015 and restrictions on the use of Butisan S (metazachlor), there has been a gap in herbicides available to growers. Flexidor 500 - previously Flexidor 125 (isoxaben) - has become the main stay of weed control programmes in container HNS production but it doesn't offer control of annual meadow grass, groundsel, willowherb, moss or liverwort and only one application is now permitted per year. Research in the EMT/AHDB Horticultural/ HTA Fellowship project CP 86 'Weed control in ornamentals, fruit and vegetable crops – maintaining capability to devise suitable weed control strategies' and HNS PO 192 and 192a 'Herbicides screening for ornamental plant production (nursery stock, cut flowers and wall flowers)' have investigated promising new actives in screening trials, and reviewed cultural controls and as a result Dual Gold (s-metolachlor) and Springbok were developed as a container HNS treatments (although with limitations) and data on HDC H43 is available should an EAMU be possible in the future. Currently there are relatively few new residual herbicides with potential for container HNS available for testing, but two; Sunfire (flufenacet) and Defy (prosulfocarb)) were selected for 2017 trials both for efficacy on key weeds and phytotoxicity on indicative nursery stock species. The withdrawal of the selective contact herbicide for grass control, Aramo (tepraloxydim) has had an impact across both field and container grown HNS. It has been widely used as a post-emergence control of a range of annual grasses, in particular annual meadow grass. A safe and effective replacement is urgently sought. Centurion Max (clethodim) was selected as the most promising candidate and included in the weed screening test (annual meadow grass only) and phytotoxicity screening on indicative nursery stock species

Summary

Herbicide trials were carried out on field-grown roses, phytotoxicity testing on 10 container-grown HNS subjects, and weed control screening on common weeds of container production during 2017. **Table 1** lists the herbicides and rates used in each trial, along with the herbicides' approval status.

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

Product	Active	Approval status	Budded rose (L/ha or kg/ha)	HNS phyto and weed screen (L/ha or Kg/ha)
Betanal Maxx Pro	desmedipham 47 g/L + ethofumesate 75 g/L + lenacil 27 g/L + phenmedipham 60 g/L	LTAEU	1.5	
Butisan S	metazachlor 500 g/L	Label	1.5	
Centurion Max	clethodim 120 g/L	LTAEU		2.0
Defy	prosulfocarb 800 g/L	EAMU[1]		5.0
Flexidor 500	500 g/L isoxaben	Label	0.5	0.25
HDC H42		Not authorised		
HDC H43		Not authorised		
Logo	30% w/w foramsulfuron + 10% w/w iodosulfuron-methylsodium	EAMU	0.075 kg/ha[2]	
Sencorex Flow	600 g/L metribuzin	EAMU	440 ml/ha[3] 730ml/ha[4]	
Springbok	200 g/L metazachlor + 200 g/L dimethenamid-p	EAMU	1.25	
Stomp Aqua	455 g/L pendimethalin	EAMU	2.9	
Sunfire	flufenacet 500 g/L	EAMU		0.48
Venzar Flowable[5]	lenacil 440 g/L	LTAEU	3.0	

[1]Pre-emergence only, [2]Mero adjuvant was added at 2 L/ha, [3]Post heading back, [4]Post planting, [5]Product no longer available.

Budded rose trial 2016-17

The budded rose herbicide trial was set up at Whartons Nurseries Ltd. In Pulham St Mary, near Diss, on newly planted field-grown rootstocks. The trial consisted of 10 herbicide programmes (**Table 2**). Applications were made to rootstocks on four occasions; at planting (7 April 2016), after budding (21 July 2016), post-heading back (15 March 2017) and follow up (18 May 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 2016-2017

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 (15.03.17)	Rate (Kg/ha or L/ha)	May treatment (18.05.17)	Rate (Kg/ha or L/ha)
1	Untreated	N/A	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	Untreated	N/A
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	Untreated	N/A
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 +	Untreated	N/A
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 +	Untreated	N/A
6	Samson Extra 6%	0.75	Flexidor 500 + Butisan S	0.5 + 1.5	Stomp Aqua + Venzar Flowable + Sencorex Flow	2.0 + 2.0 + 0.44	Untreated	N/A
7	Flexidor 500 + Samson Extra 6%	0.5 + 0.75	Flexidor 500 Butisan S	0.5 + 1.5	Stomp Aqua + Flexidor 500 + Sencorex Flow	2.0 + 0.5 + 0.44	Untreated	N/A
8	Flexidor 500 + Samson Extra 6% + HDC H42	0.5 + 0.75 +	Flexidor 500 + Butisan S	0.5 + 1.5	Stomp Aqua + HDC H42 + Sencorex Flow	2.0 + 1.5 + 0.44	Untreated	N/A
9	Logo + Mero (adjuvant)	0.15 + 2.0	Flexidor 500 + Butisan S	0.5 + 1.5	Stomp Aqua + Flexidor 500 + Springbok	2.0 + 0.5 + 1.25	Logo + Mero (adjuvant)	0.075 + 2.0
10	Flexidor 500 + Logo	0.5 + 0.15	Flexidor 500 + Butisan S 1.5	0.5 + 1.5	Stomp Aqua + Flexidor 500 + Springbok	2.0 + 0.5 + 1.25	Logo + Mero (adjuvant)	0.075 + 2.0

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

Of the treatments applied post-heading back, Stomp Aqua + Flexidor 500 + HDC H42 provided the best weed control in the trial, with zero weed cover when assessed at 6 WAT. Although HDC H42 proved safe in this trial, previous trials (HNS 132) have shown occasional phytotoxicity. All other treatments provided weed control better than the untreated control.

The rose maidens that received Logo + Mero at the follow up treatment applications showed severe phytotoxic symptoms, which persisted through to the 12 WAT assessment. Post-application assessments found no significant differences in percentage weed cover between the follow up treatments.

Budded rose trial 2017-18

The budded rose herbicide trial was set up at Whartons Nurseries Ltd. in Pulham St Mary, near Diss, on newly planted field-grown rootstocks. The trial consisted of 9 herbicide programmes (**Table 3**). Applications were made to the rootstocks on three occasions; at planting (15 March 2017), a follow-up (18 May 2017) and after budding (30 June 2017). A further treatment will be applied post-heading back (this application will carried out in February 2018). The trial was set up as a fully randomized block design and treatments were replicated four times.

Table 3. Treatment list and timings for the budded rose herbicide trial, Pulham St Mary, 2017

Trt. No.	Planting 15/03/2017	Rate (L/ha, ml/ha*)	Follow up 18/05/2017	Rate (L/ha)	Budding 30/06/2017	Rate (L/ha)
1	Untreated				Untreated	
2	Stomp Aqua + Flexidor 500 + Venzar Flo	2.9 + 0.5 + 3.0			Flexidor 500 + Butisan S	0.5 + 1.5
3	Stomp Aqua + Flexidor 500 + HDC H43	2.9 + 0.5 + 2.0			Flexidor 500 + HDC H43	0.5 + 2.0
4	Untreated				Flexidor 500 + Butisan S	0.5 + 1.5
5	Stomp Aqua + Flexidor 500 + Sencorex Flo	2.9 + 0.5 + 730*			Flexidor 500 + Butisan S	0.5 + 1.5

Trt. No.	Planting 15/03/2017	Rate (L/ha, ml/ha*)	Follow up 18/05/2017	Rate (L/ha)	Budding 30/06/2017	Rate (L/ha)
6	Stomp Aqua + Flexidor 500 + Sencorex Flo	2.9 + 0.5 + 730*	Logo + Mero (adjuvant)	0.075 + 2.0	Flexidor 500 + Butisan S	0.5 + 1.5
7	Stomp Aqua + Flexidor 500 + Sencorex Flo	2.9 + 0.5 + 730*	Logo + Mero (adjuvant) + Betanal Maxx Pro	0.075 + 2.0 + 1.5	Flexidor 500 + Butisan S	0.5 + 1.5
8	Stomp Aqua + Flexidor 500 + Sencorex Flo	2.9 + 0.5 + 730*	Betanal Maxx Pro	1.5	Flexidor 500 + Butisan S	0.5 + 1.5
9	Stomp Aqua + Venzar Flo + Sencorex Flo	2.9 + 3.0 + 730*			Flexidor 500 + Butisan S	0.5 + 1.5

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

Of the treatments applied post-planting, the mixtures including Sencorex Flow provided the most effective weed control (Stomp Aqua + Venzar Flowable + Sencorex Flow, Stomp Aqua + Flexidor 500 + Sencorex Flow). Assessments following the post-budding herbicide application showed both treatments to be equally effective in weed control, with significantly lower weed cover compared to untreated plots.

None of the post-planting treatments caused visible phytotoxic effects, with no significant differences in plant quality observed between treated and untreated plots at any stage of assessment. However, rootstocks treated with Logo in the follow up treatment – applied both alone and in a mixture – were yellowed and stunted, phytotoxic symptoms which persisted through assessments for this treatment. Assessments following the post-budding herbicide application showed no phytotoxic effects from either treatment, with similar plant quality scores recorded for both treated and untreated plots.

Hardy nursery stock trial

The hardy nursery stock trial was carried out at ADAS Boxworth on container grown plants. The trial consisted of 7 herbicide programmes (**Table 4**). Applications of post-potting treatments were made on 6 June 2017, and dormant treatments will be applied in December 2017. The trial was set up as a fully randomised block design and treatments were replicated three times.

Table 4. Treatment list and timings for the hardy nursery stock herbicide trial, ADAS Boxworth, 2017

Treatment		Active ingredient	Rate (L/ha)	Timing
1	Untreated	N/A	N/A	N/A
2	Flexidor 500	Isoxaben 500 g/L	0.25	June
3	Sunfire	flufenacet 500 g/L	0.48	June
4	Centurion Max	Clethodim 120 g/L	2.0	June
5	Flexidor 500	Isoxaben 500 g/L	0.25	December*
6	Sunfire	flufenacet 500 g/L	0.48	December*
7	Defy	Prosulfocarb 800 g/L	5.0	December*

*not yet applied at time of reporting

Phytotoxicity assessments were carried out at approximately 2, 6 and 12 weeks after treatment (WAT). Phytotoxicity was scored on a scale of 0 to 9, with 0 considered dead, 9 considered healthy, and 7 considered commercially acceptable.

None of the treatments applied after potting caused long term phytotoxic effects (**Figure 1**). However, growers should note that Flexidor 500 may cause short term scorch on *Hydrangea macropylla* 'Forever (R)' and *Weigela florida* 'Wine and Roses (R)'. Sunfire may have such an effect on on *Buddleja davidii* 'Empire Blue', *Hydrangea macropylla* 'Forever (R)' and *Weigela florida* 'Wine and Roses', as may Centurion Max on *Hydrangea macropylla* 'Forever (R)' and *Spiraea japonica* 'Firelight'.

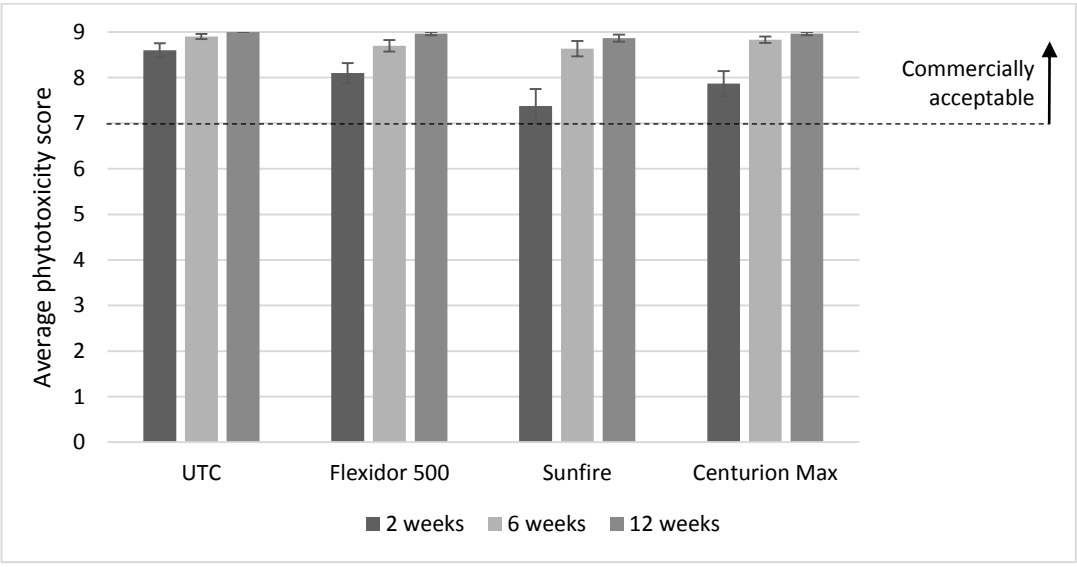

Figure 1. Hardy nursery stock plant quality scores, 2, 6 and 12 weeks after treatment (WAT) (scale of 0 - 9 where 9 is healthy, 0 is dead, 7 is commercially acceptable) – ADAS Boxworth, 2017

Weed screening trial

The weed herbicide screens were carried out at ADAS Boxworth on container grown seedlings. The trial consisted of 4 herbicide programmes (5 for annual meadow grass) (**Table 5**). Applications were made on 4 occasions; pre-emergence, growth stage (GS) 11-12, GS 13-14 and GS1, 10. The trial was set up as a fully randomised block design and treatments were replicated four times.

Table 5. Treatment list and timings for the weed herbicide screens, ADAS Boxworth, 2017

Treatment		**Active ingredient**	**Rate l/ha**	**Treatment timing**			
				Pre-emergence	GS11-12 1-2 true leaves	GS13-14 3-4 true leaves	GS1,10 10 true leaves*
1	Untreated	Untreated	N/A	✓	✓	✓	✓
2	Flexidor 500	isoxaben 500 g/L	0.5	✓	✓	✓	✓
3	Sunfire	flufenacet 500 g/L	0.48	✓	✓	✓	✓
4	Defy	Prosulfocarb 800 g/L	5.0	✓	✓	✓	✓
5	Centurion Max*	clethodim 120 g/L	2.0	Not applied	✓	✓	✓

*only applied to annual meadow grass

Phytotoxicity assessments and seedling counts were carried out at approximately 2, 4 and 6 WAT. Phytotoxicity was scored for plant health on a scale of 0 to 9, with 0 considered dead, and 9 considered healthy, comparable to the untreated.

Annual meadow grass

Of the treatments applied pre-emergence, Sunfire and Defy reduced the emergence rate of annual meadow grass seedlings. Centurion Max applied to seedlings with 1-2 true leaves reduced their numbers to zero by 4 WAT. Sunfire applied at this growth stage also slightly reduced the number of seedlings, from the 4 WAT assessment onwards. At 3-4 true leaves, the application of Centurion Max or Defy treatments significantly reduced the number of annual meadow grass seedlings. The application of Centurion Max at 10 true leaves also reduced the number of seedlings.

Defy applied pre-emergence caused significant scorching to those annual meadow grass seedlings that did emerge. Of the treatments applied at 1-2 true leaves, only Centurion Max caused significant phytotoxic symptoms, scorching seedlings. When applied at 3-4 true

leaves, Centurion Max again caused severe scorching to seedlings, as did Defy. Applied at 10 true leaves, Centurion Max scorched seedlings, though it effects weren't observed until 4 WAT.

Wavy bittercress

Applied pre-emergence, Flexidor 500 gave superior control, with no wavy bittercress seedling emergence. Flexidor 500 applied at 1-2 true leaves was also the only treatment to reduce the number of seedlings. None of the treatments applied at 3-4 true leaves significantly reduced the number of seedlings.

Of the treatments applied pre-emergence, only Flexidor 500 had a phytotoxic effect with persistent symptoms – any seedlings that did germinate were severely scorched, and by 6 WAT were dead. Flexidor 500 also significantly scorched seedlings when applied at 1-2 true leaves. Of the treatments applied to wavy bittercress at 3-4 true leaves, Flexidor and Sunfire caused scorching by 2 WAT, though the condition of seedlings had begun to improve by the 6 WAT assessment.

New Zealand bittercress

Flexidor 500 was the only pre-emergence treatment to reduce the emergence of New Zealand bittercress. None of the treatments (Flexidor 500, Sunfire or Defy) applied at subsequent applications (1-2 or 3-4 true leaves) caused any significant reduction in the number of seedlings.

As a pre-emergence treatment, Flexidor 500 caused severe scorching for the few New Zealand bittercress seedlings that had emerged 2 WAT. Flexidor 500 applied at 3-4 true leaves also caused scorching, and Defy applied at this growth stage had a growth-slowing phytotoxic effect on seedlings.

Common mouse ear chickweed

Of the treatments applied pre-emergence, only Flexidor 500 significantly reduced the number of common mouse ear chickweed seedlings that emerged. None of the treatments (Flexidor 500, Sunfire or Defy) applied at subsequent applications (1-2 or 3-4 true leaves) caused any significant reduction in the number of seedlings.

Despite Flexidor 500's impact on seedling emergence, it did not cause any significant phytotoxic effects to the seedling that did emerge. None of the treatments (Flexidor 500, Sunfire or Defy) applied at subsequent applications (1-2 or 3-4 true leaves) caused any significant phytotoxic effects.

American willowherb

Applied pre-emergence, Defy was the only treatment that significantly reduced the number of willowherb seedlings that emerged in the trial. None of the treatments (Flexidor 500, Sunfire or Defy) applied at subsequent applications (1-2 or 3-4 true leaves) caused any significant reduction in the number of seedlings.

Significant phytotoxic effects were caused by the pre-emergence Sunfire and Defy treatments, with both resulting in severe stunting and Sunfire shrivelling leaves. At 6 WAT, phytotoxic symptoms of Defy treatment persisted. Of the treatments applied at 1-2 true leaves, both Defy and Sunfire caused initial phytotoxic effects, though only symptoms caused by Defy persisted through to 6 WAT. All treatments (Flexidor 500, Sunfire, Defy) applied at 3-4 true leaves caused significant phytotoxic effects; symptoms persisted to 6WAT for both Sunfire and Defy treatments, with growth distortion and foliar discoloration.

Common chickweed

Flexidor 500 was the only treatment that had a significant effect on chickweed seedling numbers. This was the case whether applied pre-emergence or at 1-2 true leaves. None of the treatments applied at 3-4 true leaves caused a notable reduction in the number of chickweed seedlings.

None of the pre-emergence treatments produced phytotoxic symptoms in the emergent seedlings. Of the treatments applied at 1-2 true leaves, Flexidor significantly stunted the seedlings, though symptoms did not persist to 6 WAT. Applied at 3-4 true leaves, both Flexidor and Defy reduced seedling quality, with effects still seen at 6 WAT.

Groundsel

When applied pre-emergence, none of the treatments reduced the number of groundsel seedlings that emerged or caused significant phytotoxicity.

None of the treatments reduced the number of groundsel seedlings or caused significant phytotoxicity when applied at the 1-2 or 3-4 true leaf stage.

Procumbent pearlwort

The only significant reduction in pearlwort seedling numbers was seen with pre-emergence application of Flexidor or Sunfire – treatments applied at 1-2 or 3-4 true leaf stages did not significantly reduce the seedling count.

With regards to the phytotoxic effect of the treatments, no treatments applied pre-emergence caused any significant phytotoxic effects. Applications of Flexidor or Defy at 1-2 true leaves

caused persistent phytotoxic effects, with reduced plant quality observed at 6 WAT. The same was true for the Flexidor and Defy treatments when applied at the 3-4 true leaf stage.

Discussion

Results confirmed that the standard, Flexidor 500, continues to give good pre-emergence control of the majority of weeds of container grown nursery stock. The exceptions are annual meadow grass and American willowherb, confirming earlier findings (Atwood 2009). It is interesting that Flexidor 500 gave good control of early post-emergence (1-2 true leaf) and some stunting of 3-4 true leaf of wavy bittercress but no significant post-emergence control of New Zealand bittercress.

The new residual herbicides Sunfire and Defy only offered control of two of the key weeds tested. Both gave good pre-emergence control of annual meadow grass. Sunfire gave some suppression of emerged annual meadow grass at the 1-2 true leaf stage. Defy gave good suppression at the 3-4 true leaf stage but not at the earlier stage. Sunfire gave some pre-emergence control of pearlwort but inferior to Flexidor 500. Defy gave good control of American willowherb pre-emergence and marked stunting of emerged seedlings. However once emerged the seedlings were not completely eliminated so in practice weeding would still be required. Sunfire did not control American willowherb pre-emergence but caused some stunting to emerge seedlings, although less severe than with Defy and again, weeding would be required in practice.

The selective, contact grass herbicide Centurion Max performed well on emerged annual meadow grass, giving superior control to the other treatments and gave significant control up to the 10 true-leaf stage

Conclusions

- Flexidor 500 was confirmed as giving good pre-emergence control of wavy bittercress, New Zealand bittercress, mouse ear chickweed, common chickweed and pearlwort. Annual meadow grass, groundsel and American willowherb were resistant.
- Defy gave good pre-emergence control of annual meadow grass and American willowherb and so could supplement Flexidor 500, but is only likely to be safe as a dormant season treatment.
- Defy could be a partial alternative to Devrinol (napropamide) as a winter treatment for container-grown hardy nursery stock if an EAMU for the latter was not available, but if an authorisation for Devrinol on ornamentals was restored this would be preferred to Defy because of groundsel control.

- Sunfire gave good control of annual meadow grass and some control of pearlwort. Control of other weeds was disappointing. It may be useful as a supplement to Flexidor 500 but only where annual meadow grass and pearlwort is a problem.
- Centurion Max gave good control of emerged annual meadow grass including larger seedlings.

Financial Benefits

Hand weeding field-grown crops such as roses 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 herbicide mixtures of standard products with Sencorex Flowable or HDC H43 gave slightly improved weed control compared to the standard treatment Stomp Aqua + Flexidor 500 + Venzar Flowable. However Venzar Flowable is now only be available at a much reduced rate. The loss of this component is likely to reduce the effectiveness of the standard treatment and it is estimated that substitution with Sencorex Flow or HDC H43 is likely to reduce the need for hand weeding, compared with no substitution, by around £10,000 per hectare.

New herbicides Sunfire, Defy and Centurion Max were evaluated for container-grown hardy nursery stock production. At present there is no financial benefit for Defy because an improved EAMU permitting use over wood and foliage of dormant crops would be required.

The financial benefit of Sunfire and Centurion Max arise largely from improved control of annual meadow grass, pre-emergence and post-emergence respectively. These products can already be used by growers though EAMU and LTAEU authorisations respectively. Although annual meadow grass is not a predominant weed it can be occasionally troublesome and the availability of pre and post-emergence treatments is estimated to reduce hand-weeding requirements for container-grown hardy nursery stock by £1000 per ha on average.

Action Points

- For budded rose production in the field, a herbicide programme of Stomp Aqua + Flexidor 500 + Sencorex Flow after planting, Butisan S after budding and Stomp Aqua + Flexidor 500 + Sencorex Flow after heading back can be recommended.
- Betanal Maxx Pro is adequately safe to use as a selective contact herbicide to remove seedling weeds in rose stocks during May

- When an EAMU is available, HDC H43 can be used to supplement herbicide programmes in roses either post planting, post-budding or post heading back.
- If an EAMU can be obtained HDC H42 can be used to supplement herbicide programmes in roses either post planting, or post heading back. There may be some risk of temporary phytotoxicity with this product.
- The selective contact grass herbicide Centurion Max is effective for control of emerged annual meadow grass. Where used on container grown hardy nursery stock some species may show temporary scorch symptoms but these usually grow out.
- The residual herbicide Sunfire can be used for pre-emergence annual meadow grass control. Where used on container grown hardy nursery stock some species may show temporary scorch symptoms but these usually grow out.
- If an improved EAMU can be obtained Defy could be a partial alternative to Devrinol (napropamide) as a winter treatment for container-grown hardy nursery stock if an EAMU for the latter was not available, but if an authorisation for Devrinol on ornamentals was restored this would be preferred to Defy because of groundsel control.

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. Logo (foramsulfuron + iodosulfuron-methyl-sodium), Sencorex Flow (metribuzin) and 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, and HDC H43. The aim of the budded rose herbicide trial which commenced in 2016 was to test the efficacy and crop safety of two season herbicide programmes including these new products for field rose production. This trial continued into 2017 for the rose maiden crop. In 2017 the second budded rose herbicide trial was set up. The aim of this trial was to build on knowledge gained from the 2016 rose trial and to include newly approved products such as Sencorex Flow.

For HNS container growers, following the final use up of the herbicide product Ronstar 2G (oxadiazon) in 2015 and restrictions on the use of Butisan S (metazachlor), there has been a gap in herbicides available to growers. Flexidor 500 - previously Flexidor 125 (isoxaben) - has become the main stay of weed control programmes in container HNS production but it doesn't offer control of annual meadow grass, groundsel, willowherb, moss or liverwort and only one application is now permitted per year. Research in the EMT/AHDB Horticultural/ HTA Fellowship project CP 86 'Weed control in ornamentals, fruit and vegetable crops – maintaining capability to devise suitable weed control strategies' and HNS PO 192 and 192a 'Herbicides screening for ornamental plant production (nursery stock, cut flowers and wall flowers)' have investigated promising new actives in screening trials, and reviewed cultural controls. As a result, Dual Gold (s-metolachlor) and Springbok were developed as a container HNS treatments (although with limitations) and data on HDC H43 is available should an EAMU be possible in the future. Currently there are relatively few new residual herbicides with potential for container HNS available for testing but two; Sunfire (flufenacet) and Defy (prosulfocarb)) were selected for 2017 trials both for efficacy on key weeds and phytotoxicity on indicative nursery stock species. The withdrawal of the selective contact herbicide for

grass control, Aramo (tepraloxydim) has had an impact across both field and container grown HNS. It has been widely used as a post-emergence control of a range of annual grasses, in particular annual meadow grass. A safe and effective replacement is urgently sought. Centurion Max (clethodim) was selected as the most promising candidate and included in the weed screening test (annual meadow grass only) and phytotoxicity screening on indicative nursery stock species.

Budded rose (2016–2017 and 2017-2018)

Materials and methods

The first budded rose herbicide trial was set up at Whartons Nurseries Ltd., Pulham St Mary, near Diss, on newly planted rootstocks in 2016. Planting spacing was 85 cm rows with in-row spacing 16 cm. Soil type was a sandy clay loam. The trial consisted of 10 herbicide programmes (**Table 6**). The treatment programmes included an untreated control, Stomp Aqua (pendimethalin), Flexidor 500 (isoxaben), Venzar Flowable (lenacil), HDC H43, HDC H42, Samson Extra 6%, Logo, Butisan S and Springbok; these herbicides were either used alone or in combination in the trials. Where tank mix combinations were used, these were selected on the basis of the known weed control spectrum of the individual products to give as wide a possible range of weed control. For example, a number of treatments used Stomp Aqua + Flexidor 500 as a standard base with an additional herbicide applied to improve the weed control spectrum.

Active ingredients of the treatment applications can be found in **Table 8**, in the grower summary. Applications were made to the rootstocks on four occasions: at planting (7 April 2016), after budding (21 July 2016), post heading back (15 March 2017) and follow up treatments were applied on 18 May 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.

The second budded rose herbicide trial was also set up at Whartons Nurseries Ltd., Pulham St Mary, near Diss, on newly planted rootstocks in 2017. Planting spacing was as for the first trial. Soil type was a sandy clay loam but lighter texture than the first trial. The trial consisted of 9 herbicide programmes (**Table 7**). The treatment programmes included an untreated control, Stomp Aqua, Flexidor 500, Venzar Flowable, HDC H43, HDC H42, Samson Extra 6%, Logo, Butisan S and Springbok; these herbicides were either used alone or in combination in the trials. As with the first trial combinations were selected on the basis of the

known weed control spectrum of the individual products to give as wide a possible range of weed control. Active ingredients of the treatment applications can be found in **Table 8**. Applications were made to the rootstocks on four occasions: at planting (15 March 2017), as follow up treatments on 18 May 2017, after budding (30 June 2017) and with treatments due to be applied post heading back March 2018. Plot size and treatment application were similar to the first trial.

Phytotoxicity and weed assessments for both trials 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 as plant quality 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 m² quadrats in each plot. Key weed species present in the quadrats were recorded.

Table 6. Treatment list and timings for the budded rose herbicide trial, Pulham St Mary 2016-2017

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 (15.03.17)**	**Rate (Kg/ha or L/ha)**	**May treatment (18.05.17)**	**Rate (Kg/ha or L/ha)**
1	Untreated	N/A	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	Untreated	N/A
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	Untreated	N/A
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 +	Untreated	N/A
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 +	Untreated	N/A

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 (15.03.17)	Rate (Kg/ha or L/ha)	May treatment (18.05.17)	Rate (Kg/ha or L/ha)
6	Samson Extra 6%	0.75	Flexidor 500 + Butisan S	0.5 + 1.5	Stomp Aqua + Venzar Flowable + Sencorex Flow	2.0 + 2.0 + 0.44	Untreated	N/A
7	Flexidor 500 + Samson Extra 6%	0.5 + 0.75	Flexidor 500 Butisan S	0.5 + 1.5	Stomp Aqua + Flexidor 500 + Sencorex Flow	2.0 + 0.5 + 0.44	Untreated	N/A
8	Flexidor 500 + Samson Extra 6% + HDC H42	0.5 + 0.75 +	Flexidor 500 + Butisan S	0.5 + 1.5	Stomp Aqua + HDC H42 + Sencorex Flow	2.0 + 1.5 + 0.44	Untreated	N/A
9	Logo + Mero (adjuvant)	0.15 + 2.0	Flexidor 500 + Butisan S	0.5 + 1.5	Stomp Aqua + Flexidor 500 + Springbok	2.0 + 0.5 + 1.25	Logo + Mero (adjuvant)	0.075 + 2.0
10	Flexidor 500 + Logo	0.5 + 0.15	Flexidor 500 + Butisan S 1.5	0.5 + 1.5	Stomp Aqua + Flexidor 500 + Springbok	2.0 + 0.5 + 1.25	Logo + Mero (adjuvant)	0.075 + 2.0

Note – rates are not disclosed for coded products.

Table 7. Treatment list and timings for the budded rose herbicide trial, Pulham St Mary 2017-2018

Trt. no.	Planting treatment (15.03.17)	Rate (Kg/ha or L/ha)	May treatment (18.05.17)	Rate (Kg/ha or L/ha)	Budding treatment (30.06.17)	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
3	Stomp Aqua + Flexidor 500 + HDC H43	2.9 + 0.5 +			Flexidor 500 + HDC H43	0.5 +
4	Untreated				Flexidor 500 + Butisan S	0.5 + 1.5
5	Stomp Aqua + Flexidor 500 + Sencorex Flow	2.9 + 0.5 + 0.73			Flexidor 500 + Butisan S	0.5 + 1.5
6	Stomp Aqua + Flexidor 500 + Sencorex Flow	2.9 + 0.5 + 0.73	Logo + Mero (adjuvant)	0.075 + 2.0	Flexidor 500 + Butisan S	0.5 + 1.5

Trt. no.	Planting treatment (15.03.17)	Rate (Kg/ha or L/ha)	May treatment (18.05.17)	Rate (Kg/ha or L/ha)	Budding treatment (30.06.17)	Rate (Kg/ha or L/ha)
7	Stomp Aqua + Flexidor 500 + Sencorex Flow	2.9 + 0.5 + 0.73	Logo + Mero (adjuvant) + Betanal Maxx Pro	0.075 + 2.0 + 1.5	Flexidor 500 + Butisan S	0.5 + 1.5
8	Stomp Aqua + Flexidor 500 + Sencorex Flow	2.9 + 0.5 + 0.73	Betanal Maxx Pro	1.5	Flexidor 500 + Butisan S	0.5 + 1.5
9	Stomp Aqua + Venzar Flowable Sencorex Flow	2.9 + 3.0 + 0.73			Flexidor 500 + Butisan S	0.5 + 1.5

Table 8. List of active ingredients for the budded rose herbicide trials, Pulham St Mary

Product	Active ingredient	Approval status
Betanal Maxx Pro	47 g/L desmedipham + 75 g/L ethofumesate + 27 g/L lenacil + 60 g/L phenmedipham	LTEAU
Butisan S	500 g/L metazachlor	Label
Flexidor 500	500 g/L isoxaben	Label
HDC H42	Not disclosed	Not approved
HDC H43	Not disclosed	Not approved
Logo	30% w/w foramsulfuron + 10% w/w iodosulfuron-methylsodium + 30% w/w isoxadifen-ethyl	EAMU 3437/16
Mero	rapeseed fatty acid esters	Approved adjuvant
Samson Extra 6%	60 g/L nicosulfuron	EAMU 1054/14
Sencorex Flo	600 g/L metribuzin	EAMU 1732/17
Stomp Aqua	455 g/L pendimethalin	EAMU 2919/09
Springbok	200 g/L metazachlor + 200 g/L dimethenamid-p	EAMU 3006/14
Venzar Flowable	440 g/L lenacil	LTEAU

Results 2016-17 trial

Effect of treatment applications 2016

Apart from some stunting on roses that had received Flexidor + Logo at planting 2016, all other treatments ended the season with acceptable quality scores.

Treatment application post-heading back, 15 March 2017

At 2 WAT the roses were still only at the extended bud stage and no damage to the bud was visible from any of the treatments applied post-heading back. Between the 2 and 6 WAT assessments some slight bleaching of the leaf edges was noted in plots which had received HDC H42 but this was only a slight effect. At 6 WAT there was some variability in growth most likely due to soil conditions, but no consistent treatment effects from the post-heading back treatments; all being of commercially acceptable quality.

At 6 WAT, Stomp Aqua + Flexidor 500 + HDC H42 provided the best weed control with zero weed cover recorded in plots that had received these treatments (**Figure 2**). However all treatments, including the untreated, had below 0.9 % weed cover per plot.

At the 6 WAT assessment, 11 weed species were found throughout the trial, with mayweed and fat hen most common. The Stomp Aqua + Flexidor 500 + Springbok plots contained the most weed species (10 species, including mayweed, fat hen, groundsel and penny cress). Stomp Aqua + Flexidor 500 + Sencorex Flo plots contained four weed species; plantain, mayweed, fat hen and penny cress. The weeds in the control plots were less diverse, but larger.

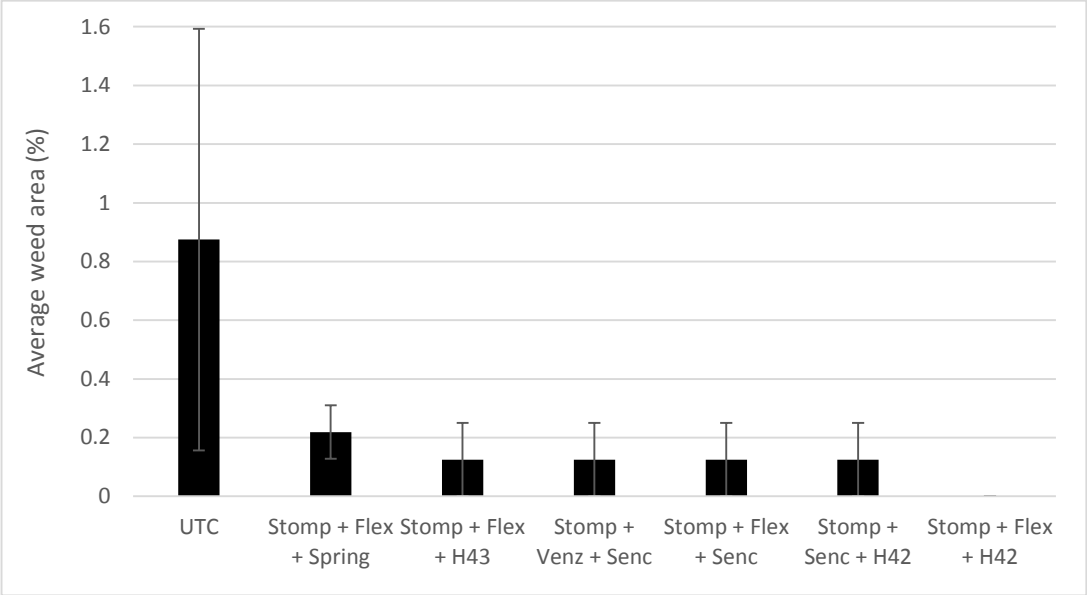

Figure 2. Percentage weed cover of budded rose plots 6 weeks after heading back treatments were applied – Pulham St Mary, 26 April 2017 ($p < 0.001$, 25df, L.S.D. 0.3081)

Follow up treatment application, 18 May 2017

At the assessment carried out 2 WAT, phytotoxic effects could be seen in plots that had received the follow up treatment of Logo + Mero (T2) in May (**Figure 3**, **Table 9**)**.** Results were combined for plots that were untreated or treated at this stage. Roses that had received the Logo + Mero in May were very scorched and scored 5.4 for plant quality (**Figure 3**). These symptoms persisted at the 6 WAT assessment and by the final assessment carried out 12 WAT the roses that had received the treatment of Logo + Mero had not recovered, scoring 5.4 (**Figure 3**).

Figure 3. Phytotoxic effects on foliage following Logo + Mero application (2 WAT)

Table 9. Plant quality 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, 2016-17

Trt. nos.	**Follow up treatment application May**	**Rate (Kg/ha or L/ha)**	**Quality score 2 WAT (31.05.17)**	**Quality score 6 WAT (30.06.17)**	**Quality score 12 WAT (10.08.17)**
1-8	Untreated	N/A	7.5	8.6	7.5
9/10	Logo + Mero (adjuvant)	0.075 + 2.0	5.4	4.6	5.4
P value			<.001	<.001	<.001
L.S.D. (32df)			0.2714	0.3856	0.2714

No significant differences were seen between treatments in terms of weed levels six weeks after the follow up treatments were applied (**Figure 4**). It was decided that the trial should be weeded after the six week assessment was carried out as some of the plots were getting weedy.

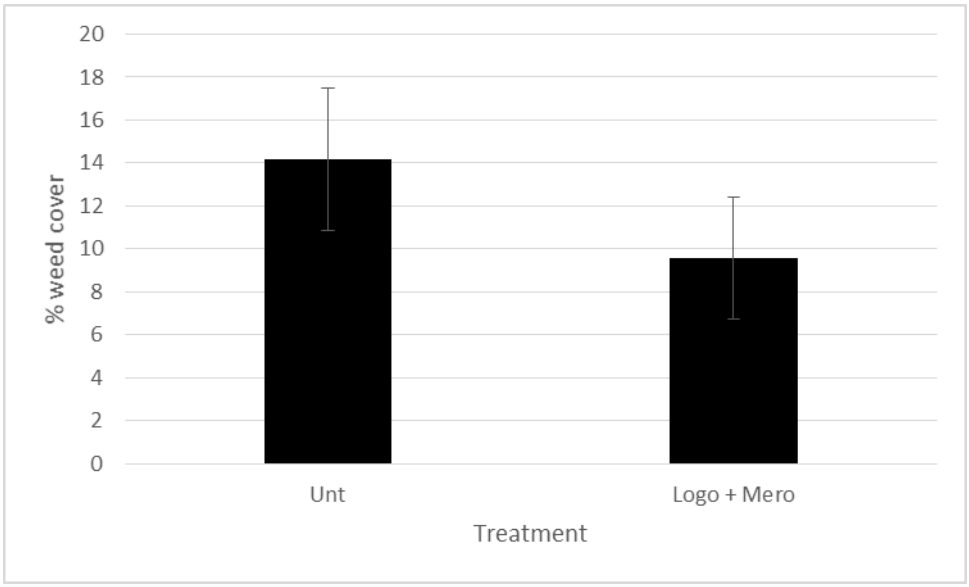

Figure 4. Percentage weed cover of budded rose plots 6 weeks after the follow up treatments were applied – Pulham St Mary, 30 June 2017 (p=0.079, 33df, L.S.D. 6.71)

Results 2017-18 trial

Treatment application after planting, 15 March 2017

Results for plots which had received the same treatment after planting were combined. There were no visible signs of phytotoxicity from any of the treatments at the 2 WAT (30.03.17), 6 WAT (26.04.17) or the 9 WAT (18.05.17) assessments and no significant differences in the plant quality scores, all being similar to the untreated.

All treatments maintained weed control below 1% cover for six weeks compared with the untreated at 5% (**Figure 5**) and below 4% cover for 9 weeks compared with the untreated at 30% (**Figure 6)**. At the 6 WAT assessment, 6 weed species were found throughout the trial, with grass and nettles most common. The control plots contained the most weed species (all 6 species; grass, nettles, chickweed, field pansy, fat hen, groundsel).

The most effective treatments were the combinations that included Sencorex Flow with no difference between the mixture with Stomp Aqua and Venzar Flowable or Stomp Aqua and Flexidor 500.

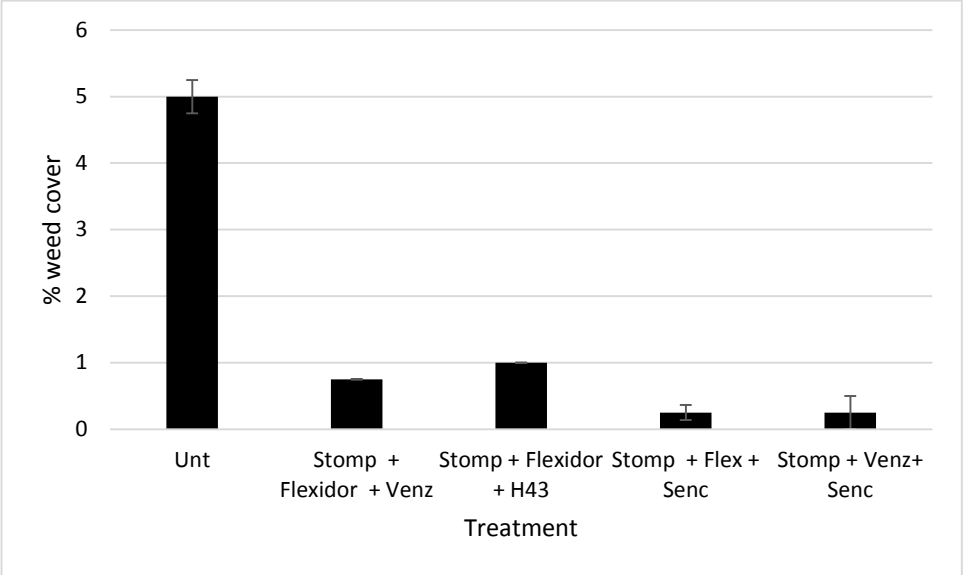

Figure 5. Percentage weed cover of budded rose plots 6 weeks after the planting treatments were applied – Pulham St Mary, 26 April 2017 ($p < 0.001$, 28df, L.S.D. 0.4358)

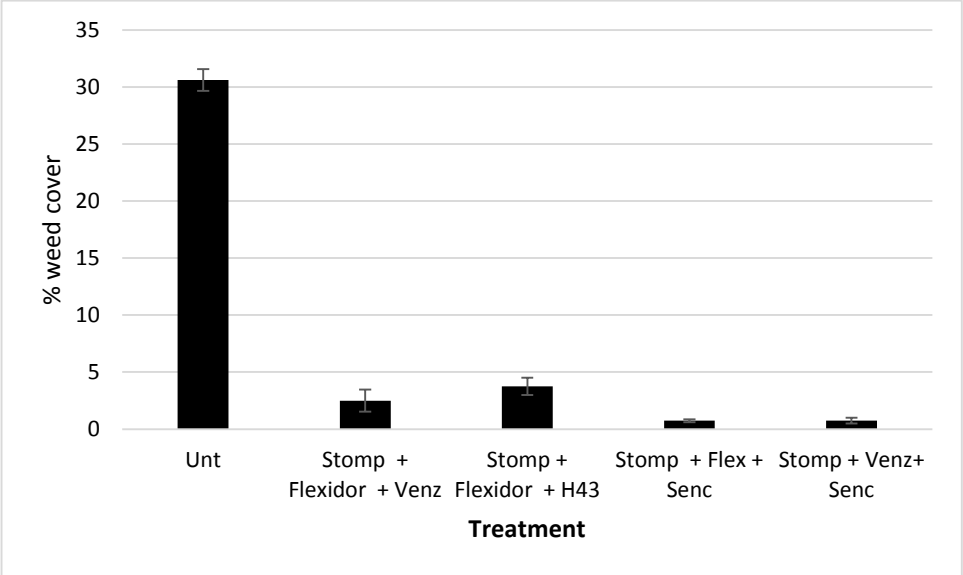

Figure 6. Percentage weed cover of budded rose plots 9 weeks after the planting treatments were applied – Pulham St Mary, 18 May 2017 ($p < 0.001$, 27df, L.S.D. 4.914)

Follow up treatment application, 18 May 2017

Results for plots which did not receive a follow up treatment were combined. Logo caused yellowing and stunting to the rose stocks whether applied alone or in combination with Betanal Maxx Pro (**Figure 7**, **Table 10)**. Surprisingly, the damage was less marked where mixed with

Betanal Maxx Pro. Betanal Maxx Pro alone had very little effect on the rose stocks (**Figure 8**).

Figure 7. Logo + Mero (left), Logo + Mero + Betanal Maxx Pro (right)

Table 10. Plant quality scores for the budded rose trial 2 and 6 weeks after treatment (WAT) (scale of 0 - 9 where 9 is healthy, 0 is dead and 7 is commercially acceptable) – Pulham St Mary, 2017-18

Trt. no.	**Planting**	**Rate (Kg/ha or L/ha)**	**Quality score 2 WAT (31.05.17)**	**Quality score 6 WAT (30.06.17)**
1-5/9	Untreated	N/A	9.0	8.4
6	Logo + Mero (adjuvant)	0.075 + 2.0	5.5	6.0
7	Logo + Mero (adjuvant) + Betanal Maxx Pro	0.075 + 2.0 + 1.5	6.8	7.3
8	Betanal Maxx	1.5	8.5	8.3
P value			<.001	0.003
L.S.D. (29df)			0.832	1.242

Figure 8. Rose stocks following Betanal Maxx Pro (only) treatment (2 WAT)

Percentage weed cover of plots was assessed 2 weeks after follow up treatments were applied. All treatments significantly reduced weed cover compared to the untreated control ($p < 0.001$).

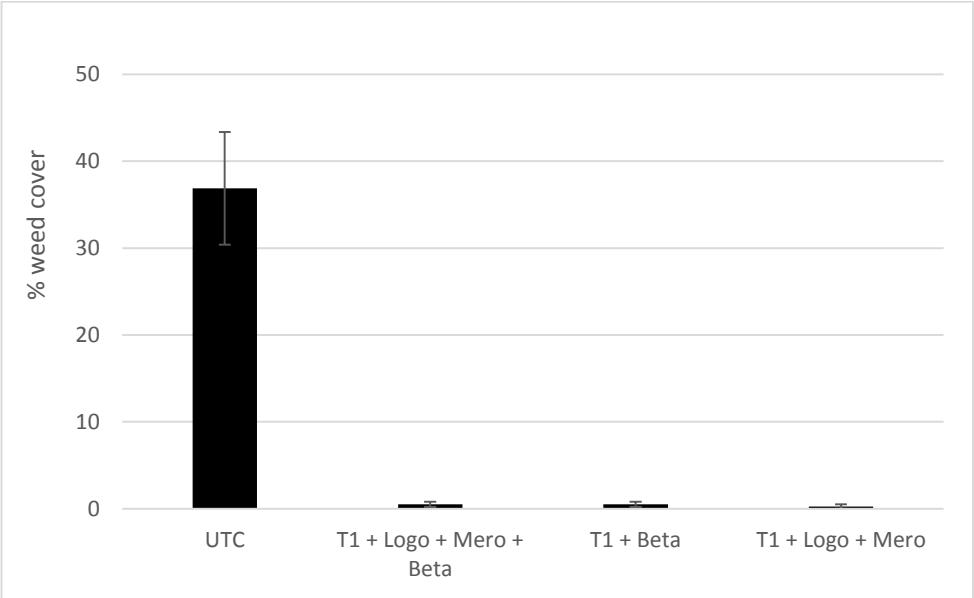

Figure 9. Percentage weed cover of budded rose plots 2 weeks after the follow up treatments were applied – Pulham St Mary, 31 May 2017 ($p < 0.001$, 13df, L.S.D. 17.3)

Post-budding application, 30 June 2017

Results for plots which had received the same post-budding treatment were combined. Post-budding, plots received either Flexidor 500 + Butisan S or + HDC H43. There was no phytotoxicity seen from either treatment, both scored similarly to the untreated for plant quality.

Weed control in treated plots remained significantly lower ($p < 0.001$), below 2%, compared to the 27% average weed cover of the untreated plots. Butisan S and HDC 43 were equally effective as tank mix partners for Flexidor 500 at this stage (**Figure 10**).

At the 6 WAT assessment, 9 weed species were found throughout the trial, with grass and nettles most common. The 6 WAT assessment showed that the control plots contained the most weed species (8 species; fat hen, nettle, creeping thistle, groundsel, annual meadow grass, chickweed, nightshade, bittercress). The weed species most common in the treated plots was nettles, with some groundsel and cranesbill also.

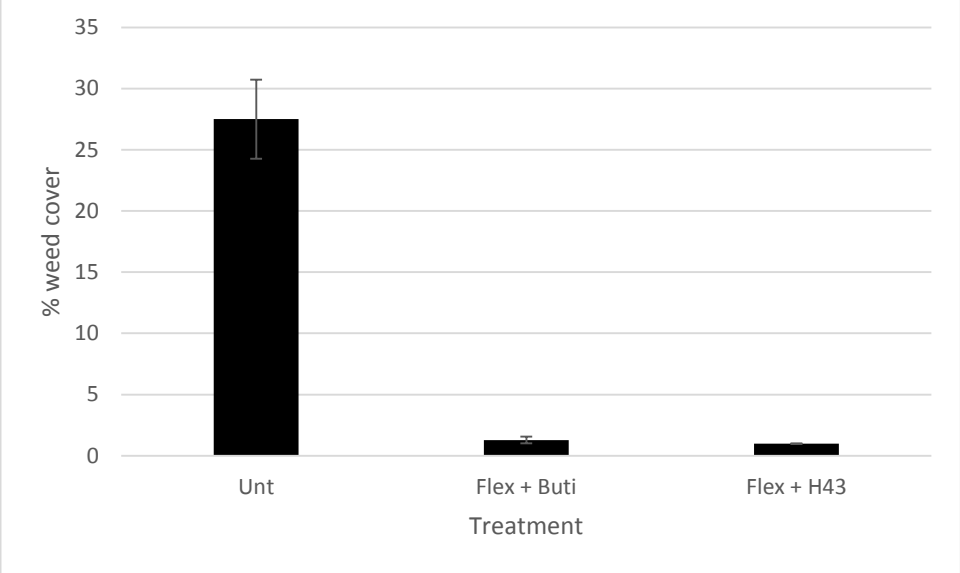

Figure 10. Percentage weed cover of budded rose plots 6 weeks after the budding treatments were applied – Pulham St Mary, 10 August 2017 ($p < 0.001$, 30df, L.S.D. 2.595)

Discussion

The post heading back treatments applied to the 2016 planted rose stocks were equally effective and safe, only slight foliar effects being noted from HDC H42. Therefore combinations such as Stomp Aqua + Flexidor 500 + Sencorex Flow can be recommended. HDC H43 or HDC H42 also have potential as a tank mix partners with Stomp Aqua + Flexidor 500 if they gain an EAMU. However previous results have shown that HDC H42 can cause temporary phytotoxicity (Burgess and Atwood 2008) although this may be more marked when used after planting than post-budding. A follow up treatment of Logo applied to the maiden roses in May however, was too damaging.

Unlike the 2016 trial no phytotoxicity symptoms were obvious on the rose rootstocks after planting and all treatments were crop safe. Therefore combinations such as Stomp Aqua + Flexidor 500 + Sencorex Flow can be recommended after planting. HDC H43 also has potential as a tank mix partner with Stomp Aqua + Flexidor 500 if it gains an EAMU. Unlike in

2016, applications of HDC H42 after planting did not give rise to any symptoms on the rootstocks. Out of the treatments applied at planting, combinations with Sencorex Flow, such as Stomp Aqua + Flexidor 500 + Sencorex Flow, provided slightly better weed control compared to other treatments. A follow up treatment of Logo applied to the rose rootstocks in May was too damaging but Betanal Maxx Pro was tolerated well.

The two post-budding treatments Butisan S + Flexidor 500 or Butisan S + HDC H43 were safe and effective. Initial results in 2016 suggested that Logo could be applied safely after budding but because of poor residual action there was no advantage to be gained over using residual herbicides such as Butisan S + Flexidor 500.

During the course of the trial, numerous changes to authorisations for herbicide use on ornamentals were noted and the planned treatments had to be changed in order to accommodate these changes.

It was clarified that Samson 6% extra can only be applied in May to June. The product has a strong contact action so it is unsuitable for application over foliage effectively ruling this treatment out for rose crops.

An EAMU was granted for Logo but only for use between May to July. Logo proved to be too damaging to be used in May, either over rootstocks or over the rose maidens. Initial results in 2016 suggested that it could be applied safely after budding but following damage from applications in 2017 albeit at an earlier (May) timing it seems advisable to be cautious about this treatment.

Old product Venzar Flowable (lenacil 440 g/L) was used in some treatments, however it has been replaced with a 500 g/L product which is approved for use at a much lower rate 0.4 L/ha, although it can still be used under LTAEU.

Flexidor 500 is still available but the new label only permits one application per year. Therefore it would not be possible to apply Flexidor 500 after planting and again after budding. The preferable alternative would be to retain the Flexidor 500 application for use after planting where there is greater weed pressure and omit it from the post-budding mix with Butisan S or replace it with Venzar Flowable 0.4 L/ha.

Conclusions

- The new EAMU for Sencorex Flow will enable the use of effective tank mix combinations such as Stomp Aqua + Flexidor 500 + Sencorex Flow to be used after planting and after heading back.
- HDC H43 has potential for use in tank mix combinations after planting, after budding and/or after heading back, provided an EAMU can be granted.

- HDC H42 remains a possible treatment for roses either after planting or after heading back, but this product has a history of occasional damage with foliar beaching and stunting particularly when used after planting. There may be varietal susceptibility which has not been fully explored
- Logo was damaging when applied to either rose rootstocks or the rose maiden crop in May. It may be better employed as a directed alleyway spray treatment in wider spaced field crops.

Hardy nursery stock herbicide screen

Materials and methods

The hardy nursery stock (HNS) herbicide trial was set up at ADAS Boxworth, Cambridgeshire in June 2017. The trial consisted of 10 representative hardy nursery stock species (**Table 11**) that were obtained as 9 cm pot liners and potted up into 3 L pots using Levington M2 growing media including an appropriate level of controlled release fertilizer. The trial consisted of five treatments in the trial including an untreated control, Flexidor 500, Sunfire, Centurion Max and Defy (**Table 12**). The treatments were tested at one or two timings, either in June 2017 after potting or December 2017 when the plants are dormant (not yet applied at time of reporting). Two treatments; Centurion Max and Defy were applied at one timing only reflecting their likely season of use, June and December respectively.

The trial was set up as a randomised split block design with three replicates. Each plot contained 50 plants, five plants of each of 10 species. The treatments were applied to the plots using an OPS sprayer and a 1 m boom with 02f110 nozzles to achieve a medium spray quality at a water volume of 1000 L/ha. No attempt was made to wash off any treatments from the foliage. The June treatments were applied after potting on 6 June 2017. The next treatments will be applied in December 2017.

Phytotoxicity was assessed approximately 2, 6 and 12 weeks after the herbicide applications were made. Phytotoxicity assessments involved comparing the treated plots to the untreated controls and awarding plant quality scores on a scale of zero to nine where zero is dead, seven is commercially acceptable and nine is healthy and comparable with an untreated control.

Data were analysed by analysis of variance (ANOVA).

Table 11. Species list for hardy nursery stock trial, ADAS Boxworth, Cambridgeshire

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

Table 12. Treatment list for hardy nursery stock trial, ADAS Boxworth, Cambridgeshire

	Treatment	**Active ingredient**	**Rate**	**Treatment timing**
1	Untreated	untreated	N/A	N/A
2	Flexidor 500	isoxaben 500 g/L	0.25 L/ha	June
3	Sunfire	flufenacet 500 g/L	0.48 L/ha	June
4	Centurion Max	clethodim 120 g/L	2.0 L/ha	June
5	Flexidor 500	isoxaben 500 g/L	0.25 L/ha	December
6	Sunfire	flufenacet 500 g/L	0.48 L/ha	December
7	Defy	prosulfocarb 800 g/L	5.0 L/ha	December

Results

Results for the 2 WAT assessment are displayed in **Table 13** for the hardy nursery stock herbicide trial.

Treatment application at potting, 6 June 2017

Flexidor 500 applied in June 2017 seemed to scorch *Hydrangea macropylla* 'Forever (R)' and *Weigela florida* 'Wine and Roses (R)' 2 WAT, with scores of 6 and 6.7 respectively (**Table**

13). However, the scores were not significantly different to the scores of the untreated plots of these two species, which were 6.7 and 7.3 respectively as a result of drought stress due to exceptionally hot weather after potting. Flexidor 500 was found to be safe on all other species tested in the trial 2 WAT, with no scores below the commercially acceptable score of 7. After 6 weeks, *Hydrangea macropylla* 'Forever (R)' and *Weigela florida* 'Wine and Roses (R)' had recovered from initial scorching with scores of 8 and 9 respectively. All species that had been treated with Flexidor 500 in June 2017 appeared healthy 12 WAT.

Sunfire caused significant ($p<0.001$, 16df, L.S.D. 1.101) damage 2 WAT to *Buddleja davidii* 'Empire Blue', *Hydrangea macropylla* 'Forever (R)' and *Weigela florida* 'Wine and Roses' when applied in June 2017, scoring 5.5, 4.3, 4.7 respectively. Damage was in the form of curled and twisted leaves on *Buddleja,* and both *Hydrangea* and *Weigela* had scorched leaves (**Figures 11, 13**). By 6 WAT all species were considered commercially acceptable as no species had scores that were below 7. This remained the case at the 12 WAT assessment.

Figure 11. Sunfire damage to foliage of *Hydrangea* (21 July 2017)

Centurion Max applied in June 2017 caused some initial scorching to *Hydrangea* and *Spiraea japonica* 'Firelight' (**Figure 12**), with scores of 5.3 and 6.7 respectively. No significant adverse effects were noted on any other species at the 2 week assessment. By 6 WAT all species were considered commercially acceptable and both *Hydrangea* and *Spiraea* had recovered from the initial scorching.

Figure 12. Foliar damage to *Spiraea* (7 July 2017)

Table 13. Phytotoxicity results of hardy nursery stock trial 2 weeks after June treatments applied, 22 June 2017, ADAS Boxworth, Cambridge. Plant quality scores (scale of 0 - 9 where 9 is healthy, 0 is dead and 7 is commercially acceptable)

Species	**Trt 1 (Untreated control)**	**Trt 2 (Flexidor 500)**	**Trt 3 (Sunfire)**	**T4 (Centurion Max)**	**P value**	**LSD** (16df)
Azalea japonica 'Johanna'	9.0	8.3	8.0	7.3	NS	*
Buddleja davidii 'Empire Blue'	9.0	8.0	5.5	9.0	0.001	1.101
Euonymus fortune ' Blondy R'	9.0	8.3	8.7	8.3	NS	*
Hydrangea macropylla 'Forever (R)'	6.7	6.0	4.3	5.3	0.039	1.489
Hypericum x *moserianum*	9.0	8.7	8.0	8.3	NS	*
Lavandula stoechas 'Helmsdale'	9.0	9.0	9.0	9.0	NS	*
Spiraea japonica 'Firelight'	9.0	9.0	7.0	6.7	0.077	2.234
Viburnum tinus 'Gwenllian'	9.0	8.0	9.0	9.0	NS	*
Weigela florida ' Wine and Roses	7.3	6.7	4.7	6.7	0.010	1.290
Coreopsis verticillata 'Golden Grain'	9.0	9.0	9.0	9.0	NS	*

Figure 13. Sunfire caused slight foliar scorch to *Weigela*

Discussion

None of the treatments tested caused long term damage to any of the 10 species tested when applied after potting. However growers should be aware of the possibility of short term scorch from Flexidor 500 on *Hydrangea macropylla* 'Forever (R)' and *Weigela florida* 'Wine and Roses (R)', from Sunfire on *Buddleja davidii* 'Empire Blue', *Hydrangea macropylla* 'Forever (R)' and *Weigela florida* 'Wine and Roses' and from Centurion Max on *Hydrangea macropylla* 'Forever (R)' and *Spiraea japonica* 'Firelight'.

Conclusion

New products Sunfire and Centurion Max have shown potential for use over foliage on a range of 10 representative HNS subjects. Slight initial scorch on a few subjects suggests that growers should be prepared for some varietal susceptibility and the need for further testing before using on a wider scale.

Further tests will be carried out on Sunfire and Defy applied as a dormant season treatment.

Herbicide weed screens

Materials and methods

Herbicide weed screens were carried out at ADAS Boxworth, Cambridgeshire, on nine species of weeds that are commonly found in container grown HNS and included: annual meadow grass (*Poa annua*), wavy bittercress (*Cardamine flexuosa*), New Zealand bittercress (*Cardamine corymbosa*), common mouse ear chickweed (*Cerastium fontanum*), willowherb (*Epilobium ciliatum*), groundsel (*Senecio vulgaris*), pearlwort (*Sagina procumbens*) and common chickweed (*Stellaria media*). Screening tests were also attempted on hairy bittercress (*Cardamine hirsuta*) but despite several attempts the seed failed to germinate. Weed seeds were sown in small trays (210mm x 155mm) that were filled with a peat based growing media.

Each weed screen had four different treatments, including untreated and three different treatment timings; however, annual meadow grass had five different treatments and four different application timings (**Table 14**) in order to thoroughly test the efficacy of the post-emergence graminicide Centurion Max alongside the residual herbicides Sunfire and Defy.

Active ingredients can be found in **Table 15**. Each weed trial was set up as a randomised block design with four replicates and was grown under a poly tunnel at ADAS Boxworth. A plot consisted of a tray containing approximately 60 seeds of a particular weed species, however the number of weeds that germinated did vary.

Treatments were applied using an OPS knapsack sprayer and a 2m boom, at a water rate of 1000 L/ha. The pre-emergence applications (T1) were applied immediately after the weed seeds were sown in the trays. The T2 treatments were applied when 1 to 2 true leaves were present (GS 11-12) and the T3 treatments were applied when 3 to 4 true leaves were present (GS 13-14). T4 treatments were applied only to annual meadow grass.

For the pre-emergence assessments, phytotoxicity was assessed three times, once the seedlings had fully emerged in the untreated plots and then again approximately 2 and 6 weeks after the first assessment. For the T2, T3 and T4 treatment applications, phytotoxicity was assessed three times, approximately 2, 4 and 6 weeks after treatment (WAT). Plots were assessed for effects such as spotting, chlorosis, twisting or scorching of the foliage and effects on plant growth. Plots were scored for phytotoxicity on a 0-9 scale for plant health where 0 is plant death and 9 is a healthy plant and comparable to the untreated control.

For the pre-emergence assessments, seedling counts were carried out once the untreated plots had fully emerged and again approximately 2 and 6 weeks after the first assessment.

Seedling counts were carried out before each post-emergence application and 2, 4 and 6 weeks after T2, T3 and T4 were applied.

Table 14. Treatment list and timings for the weed screens at ADAS Boxworth, Cambridgeshire, 2017

Treatment	**Annual meadow**	**Wavy bittercress**	**NZ bittercress**	**Common mouse ear**	**Willowherb**	**Groundsel**	**Pearlwort**	**Common chickweed**
1. Untreated	T1 T2 T3 T4	T1 T2 T3	T1 T2 T3	T1 T2 T3	T1 T2 T3	T1 T2 T3	T1 T2 T3	T1 T2 T3
2. Flexidor 500 (0.5 L/ha)	T1 T2 T3 T4	T1 T2 T3	T1 T2 T3	T1 T2 T3	T1 T2 T3	T1 T2 T3	T1 T2 T3	T1 T2 T3
3. Sunfire (0.48 L/ha)	T1 T2 T3 T4	T1 T2 T3	T1 T2 T3	T1 T2 T3	T1 T2 T3	T1 T2 T3	T1 T2 T3	T1 T2 T3
4. Defy (5 L/ha)	T1 T2 T3 T4	T1 T2 T3	T1 T2 T3	T1 T2 T3	T1 T2 T3	T1 T2 T3	T1 T2 T3	T1 T2 T3
5. Centurion Max (2 L/ha)	T1 T2 T3 T4							

T1 is pre-emergence

T2 is GS11-12 (1-2 true leaves)

T3 is GS13-14 (3-4 true leaves)

T4 is 10 true leaves

Table 15. List of active ingredients for the weed screens at ADAS Boxworth, Cambridgeshire, 2017

Treatment		Active ingredient
1	Untreated	Untreated
2	Flexidor 500	isoxaben 500 g/L
3	Sunfire	flufenacet 500 g/L
4	Defy	prosulfocarb 800 g/L
5	Centurion Max	clethodim 120 g/L

Data were analysed by analysis of variance (ANOVA).

Results

Annual meadow grass

T1 application (pre-emergence), 2 June 2017

Sunfire and Defy applied pre-emergence both reduced the number of annual meadow grass seedlings emerging (**Figures 14 - 16**). At the emergence assessment the untreated plots contained 19 annual meadow grass seedlings, whereas the Sunfire plots contained no annual meadow grass and the Defy plots had less than one seedling on average. At 2 WAT and 7 WAT the Sunfire treated plots remained free of annual meadow grass and Defy treated plots had an average of one annual meadow grass seedling ($p<.001$, 8df, L.S.D. 4.372). Flexidor 500 plots had slightly lower numbers than the untreated plots 2 WAT and 7 WAT but this was not significant.

Figure 14. Sunfire applied pre-emergence to annual meadow grass (left) and Defy applied pre-emergence (right) – 5 July 2017

Figure 15. Untreated annual meadow grass – 5 July 2017

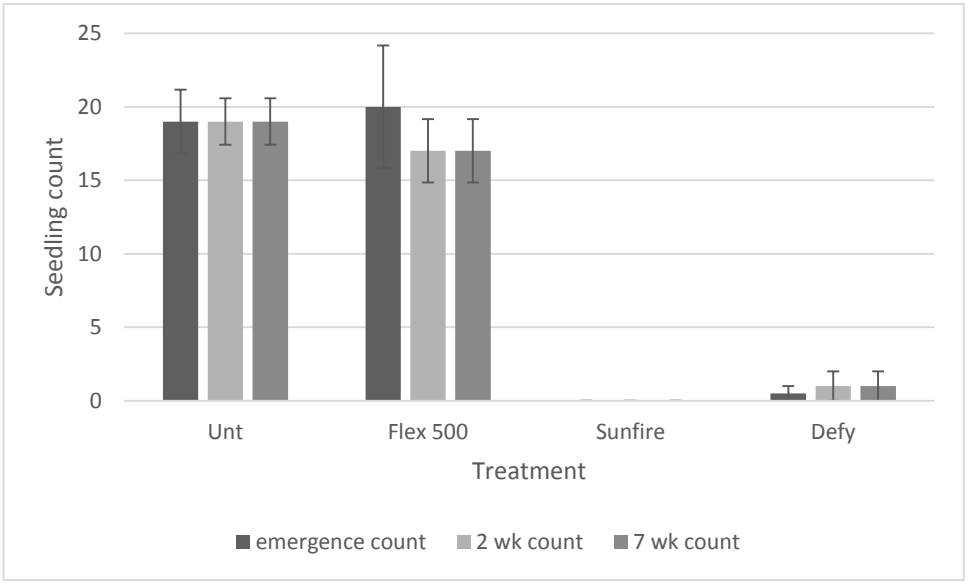

Figure 16. Annual meadow grass seedling counts following pre-emergence treatment application, assessed at emergence, and 2 and 7 weeks post-emergence – ADAS Boxworth, 2017

Defy applied pre-emergence caused significant scorching to the few emerging annual meadow grass, scoring 2.25 at 2 WAT and 0.75 at 7 WAT for seedling health compared with 9 for the untreated (**Table 17**). Plots that had been treated with Sunfire scored zero as no annual meadow grass seedlings emerged. Flexidor 500 had no significant phytotoxic effects on any emerged annual meadow grass seedlings when applied pre-emergence.

Table 17. Phytotoxicity - plant health scores for annual meadow grass after the pre-emergence treatments were applied – ADAS Boxworth, 2017. Score 0 is plant death and 9 is a healthy plant.

Trt. no.	Rate (Kg/ha or L/ha)	Score 2 wks after emergence (05.07.17)	Score 7 wks after emergence (07.08.17)
1. Untreated	N/A	9.0	9.0
2. Flexidor 500	0.5 L/ha	8.75	9.0
3. Sunfire	0.48 L/ha	0.0	0.0
4. Defy	5.0 L/ha	2.25	0.75
P Value		<0.001	<0.001
L.S.D. (9df)		3.577	0.766

T2 application (1-2 true leaves), 21 June 2017

Centurion Max reduced the number of emerged seedlings when applied at 1-2 true leaves (TL) to zero at the assessment carried out 4 WAT (**Figure 17**, p<.001, 12df, L.S.D. 6.799). These plots remained clean, with no annual meadow grass, 6 WAT (**Figure 17**). From the 4 WAT assessment onwards, Sunfire also slightly reduced the number of seedlings (**Figure 17**, p<0.001, 12df, L.S.D. 6.799). Defy and Flexidor 500 had no effect on the annual meadow grass when applied at the at 1-2 true leaves stage.

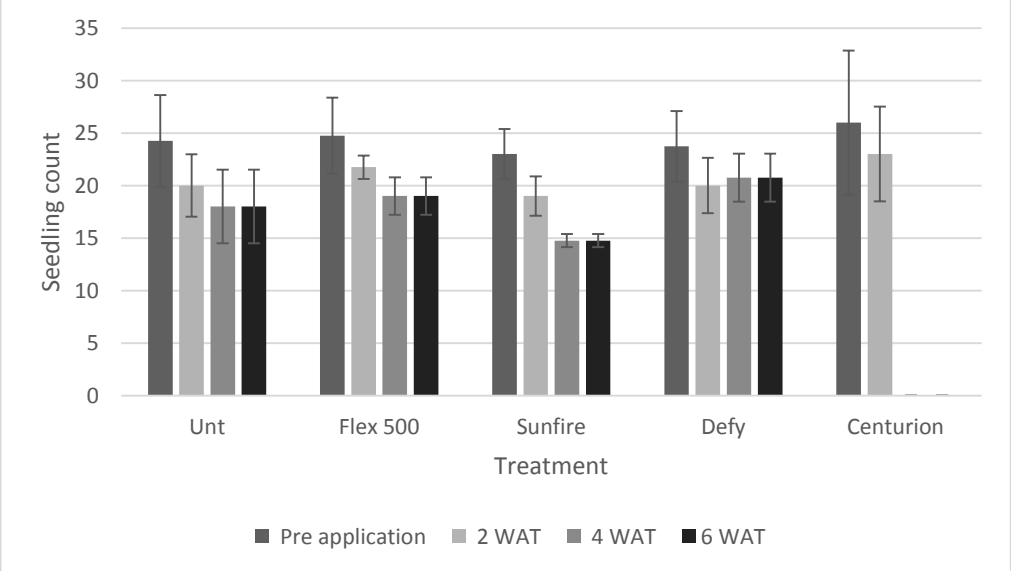

Figure 17. Annual meadow grass seedling counts for T2 (1-2 TL) treatment application. Assessed pre-treatment application, 2 weeks after treatment (WAT), 4 WAT and 6 WAT – ADAS Boxworth, 2017

Figure 18. Centurion Max applied to annual meadow grass at T2 (left) and untreated (right) – 26 July 2017

Centurion Max was the only herbicide applied to annual meadow grass at T2 to have a phytotoxic effect (**Table 18**). Centurion Max scorched the annual meadow grass at 2 WAT, scoring 2, and by the 4 WAT the annual meadow grass was dead (**Figure 18**). Sunfire also had a phytotoxic effect and caused some leaf curling on the annual meadow grass 2 WAT, however by 4 WAT the effects were much less obvious.

Table 18. Phytotoxicity - plant health scores for annual meadow grass after the T2 (1-2 true leaves) treatments were applied – ADAS Boxworth, 2017. Score 0 is plant death and 9 is a healthy plant.

Trt. no.	**Rate (Kg/ha or L/ha)**	**Score 2 WAT (05.07.17)**	**Score 4 WAT (20.07.17)**	**Score 6 WAT (03.08.17)**
1. Untreated	N/A	9.0	9.0	9.0
2. Flexidor 500	0.5 L/ha	9.0	8.5	9.0
3. Sunfire	0.48 L/ha	6.5	7.8	7.8
4. Defy	5.0 L/ha	8.0	8.8	8.3
5. Centurion Max	2.0 L/ha	2.0	0.0	0.0
P value		<.001	<.001	<.001

L.S.D. (12df)	1.087	1.098	0.878

T3 application (3-4 true leaves), 6 July 2017

Defy and Centurion Max reduced the number of annual meadow grass seedlings when applied at 3-4 true leaves (TL), (p<.001, 12df, L.S.D. 4.282). (**Figure 19).** Defy reduced the number of annual meadow grass seedlings from 21 pre-treatment application to nine at 3 WAT (p<.001, 12df, L.S.D. 4.282). Centurion Max reduced the number of seedlings from 23 pre-treatment application to 13 at 4 WAT. Flexidor 500 and Sunfire had no significant effect on the annual meadow grass when applied at this stage.

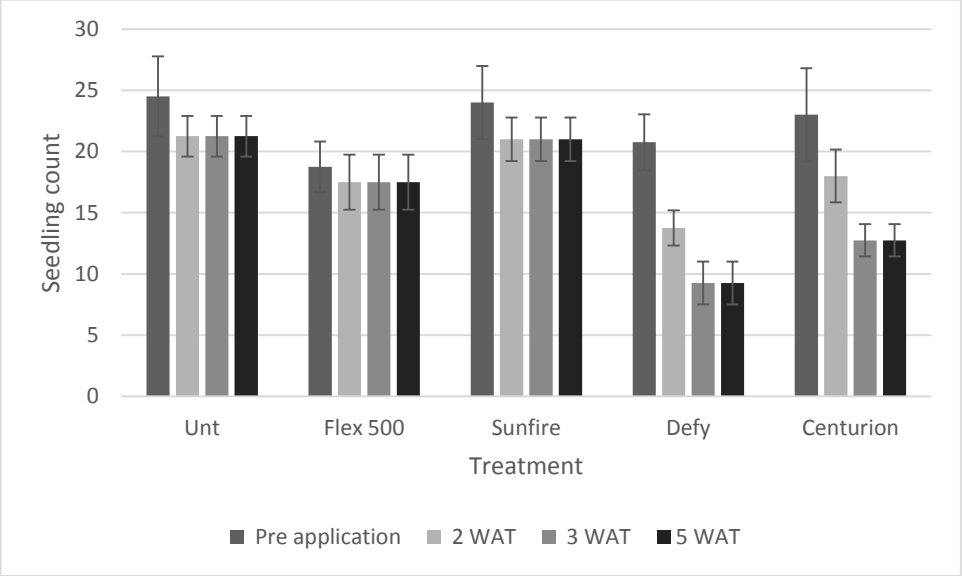

Figure 19. Annual meadow grass seedling counts for T3 (3-4 TL) treatment application. Assessed pre-treatment, 2 weeks after treatments (WAT), 3 WAT and 5 WAT – ADAS Boxworth 2017

The annual meadow grass that remained in both the Defy and Centurion Max plots was very scorched at each assessment (**Figure 20**). At 5 WAT, annual meadow grass treated with either Defy or Centurion Max scored 4 and 5 respectively compared with 9 untreated (**Table 19**). Flexidor 500 and Sunfire had no significant phytotoxic effects when applied at the 3 to 4 true leaves stage.

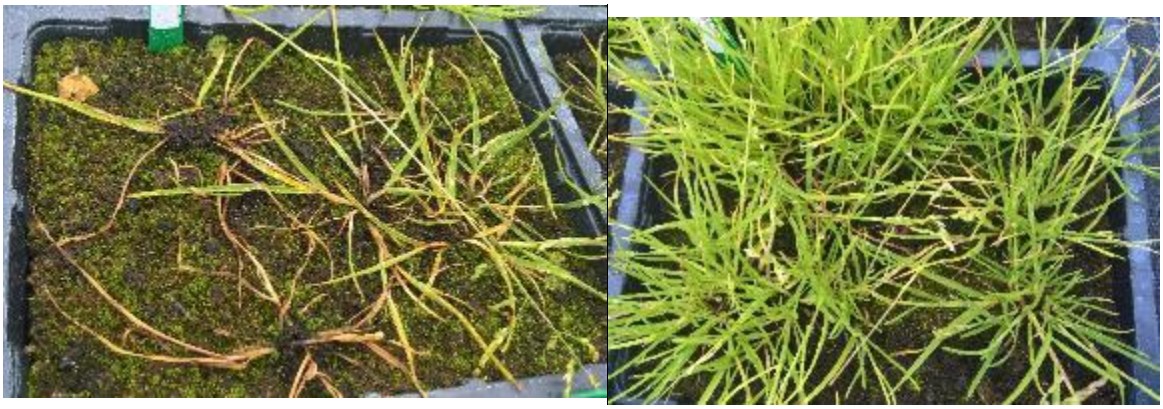

Figure 20. Annual meadow grass treated with Defy at T3 (left) and untreated (right) – 7 August 2017

Table 19. Phytotoxicity – plant health scores for annual meadow grass after the T3 (3-4 true leaves) treatments were applied – ADAS Boxworth, 2017. Score 0 is plant death and 9 is a healthy plant.

Trt. no.	**Rate (Kg/ha or L/ha)**	**Score 2 WAT (20.07.17)**	**Score 3 WAT (28.07.17)**	**Score 5 WAT (07.08.17)**
1. Untreated	N/A	9.0	9.0	9.0
2. Flexidor 500	0.5 L/ha	9.0	9.0	8.3
3. Sunfire	0.48 L/ha	8.0	8.0	8.7
4. Defy	5.0 L/ha	4.5	3.3	4.0
5. Centurion Max	2.0 L/ha	4.5	3.8	5.0
P value		<.001	<.001	<.001
L.S.D. (12df)		0.844	1.116	1.285

T4 application (10 true leaves), 24 July 2017

Centurion Max was the only treatment to reduce the number of annual meadow grass seedlings when applied at T4 (**Figure 21**). However, even though some scorching was observed it didn't seem to have an effect on numbers of Annual meadow grass seedlings until 4 WAT. At 6 WAT the number of seedlings in Annual meadow grass treated plots had significantly reduced to 2.5 (p<.001, 12df, L.S.D. 6.116).

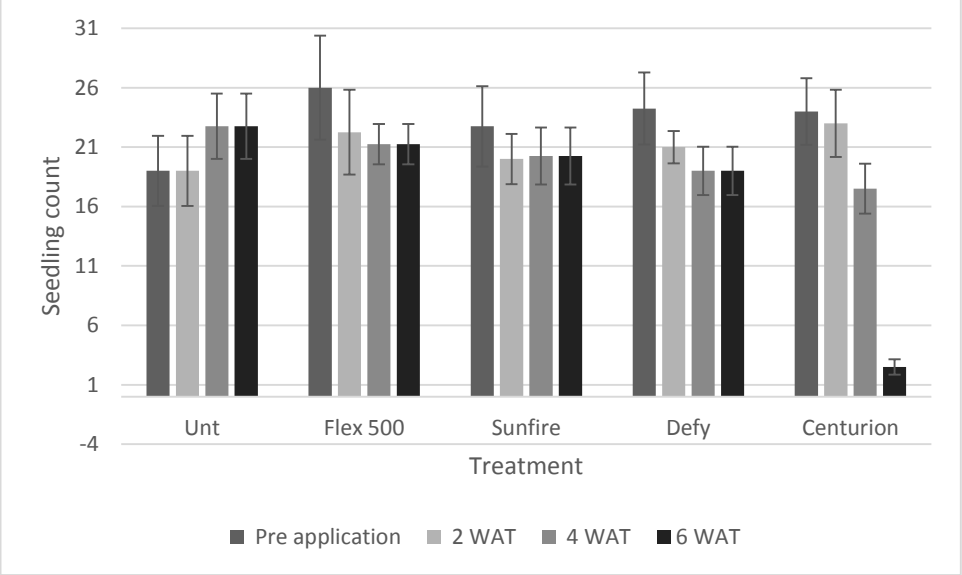

Figure 21 Annual meadow grass seedling counts for T4 (10 TL) treatment applications. Assessed pre-treatments, 2 weeks after treatment (WAT), 4 WAT and 6 WAT – ADAS Boxworth 2017

Centurion Max was the only treatment to have any phytotoxic effects when applied to Annual meadow grass at T4, scoring 6 for phytotoxicity 4 weeks after the treatments were applied (**Table 20**). However, even though some scorching was observed, it didn't seem to have an effect on numbers of annual meadow grass seedlings.

Table 20. Phytotoxicity – plant health scores for annual meadow grass after the T4 (10 true leaves) treatments were applied – ADAS Boxworth, 2017. Score 0 is plant death and 9 is a healthy plant.

Trt. no.	**Rate (Kg/ha or L/ha)**	**Score 2 WAT (11.08.17)**	**Score 4 WAT (23.08.17)**	**Score 6 WAT (06.09.17)**
1. Untreated	N/A	8.50	9.00	9.00
2. Flexidor 500	0.5 L/ha	8.25	8.00	9.00
3. Sunfire	0.48 L/ha	8.00	7.75	8.00
4. Defy	5.0 L/ha	7.75	8.25	7.25

5. Centurion Max	2.0 L/ha	6.75	6.00	1.75
P value		0.017	0.004	<.001
L.S.D. (12df)		0.964	1.312	1.482

Wavy bittercress

T1 application (pre-emergence), 2 June 2017

Flexidor 500 applied pre-emergence gave good control of wavy bittercress (**Figure 22).** There were no wavy bittercress seedlings in the plots that had received Flexidor 500 at pre-emergence at the assessment carried out two weeks after the untreated plots had fully emerged (p<.001, 9df, L.S.D. 17.44). This remained the case at the five week assessment. The pre-emergence application of Defy caused a significant reduction in the emergence rate of wavy bittercress seedlings (p<0.001, 9df, 15.06), though subsequent assessment showed no significant difference between Defy and untreated seedling counts. No significant difference between the seedling count of the Sunfire and untreated plots was found at the 2 or 5 WAT assessments.

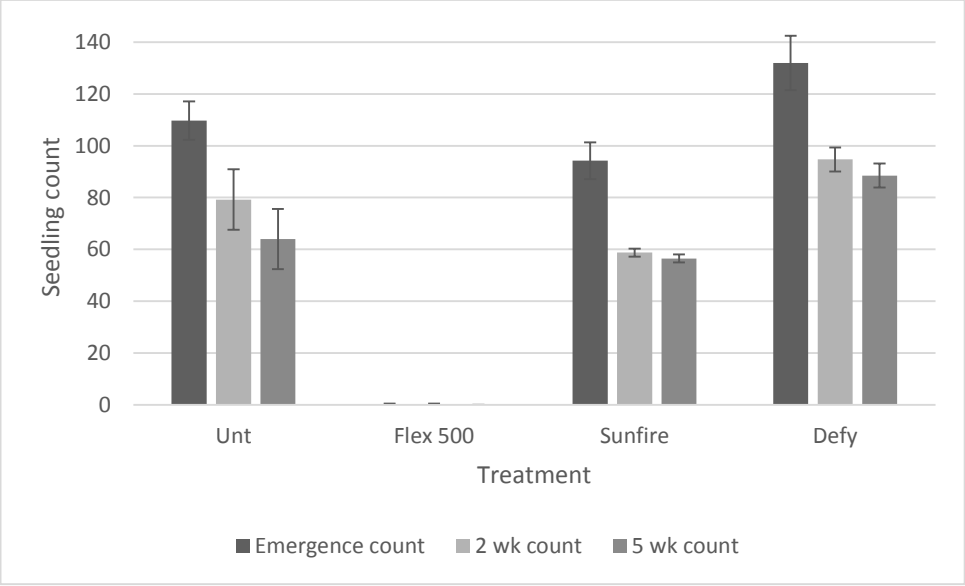

Figure 22. Wavy bittercress seedling counts following pre-emergence treatment application, assessed at emergence, and 2 and 5 weeks post-emergence – ADAS Boxworth, 2017

Flexidor 500 severely scorched any wavy bittercress seedlings that did germinate, scoring 1.5 compared with 9 for the untreated two weeks after emergence (**Table 21**). By five weeks after emergence, the wavy bittercress seedlings that had been treated with Flexidor 500 pre-

emergence were dead. Defy applied pre-emergence scored 4.8 compared with 9 for the untreated two weeks after emergence of the wavy bittercress due to stunting (**Figure 22**) of the seedlings, however by 5 weeks after emergence the seedlings had mainly recovered, scoring 7.8. Sunfire applied as a pre-emergence treatment didn't cause any significant phytotoxicity to the emerged wavy bittercress seedlings.

Table 21. Phytotoxicity – plant health scores for wavy bittercress after the pre-emergence treatments were applied – ADAS Boxworth, 2017. Score 0 is plant death and 9 is a healthy plant.

Trt. no.	**Rate (Kg/ha or L/ha)**	**Phytotoxicity score 2 wks after emergence (03.07.17)**	**Phytotoxicity score 5 wks after emergence (24.07.17)**
1. Untreated	N/A	9.0	9.0
2. Flexidor 500	0.5 L/ha	1.5	0.0
3. Sunfire	0.48 L/ha	8.3	9.0
4. Defy	2.0 L/ha	4.8	7.8
P value		0.004	<.001
L.S.D. (9df)		3.587	1.514

Figure 22. Defy applied pre-emergence to wavy bittercress (left) and untreated (right) – 5 July 2017

T2 application (1-2 true leaves), 21 June 2017

Flexidor 500 was the only treatment applied at 1-2 true leaves to reduce the number of wavy bittercress seedlings (**Figure 23**). Flexidor 500 reduced the number of wavy bittercress seedlings from 97 pre-treatment application to 29 at 4 WAT (p 0.002, 9df, L.S.D. 24.12).

Neither Sunfire nor Defy had a significant effect on controlling wavy bittercress when applied at 1-2 true leaves.

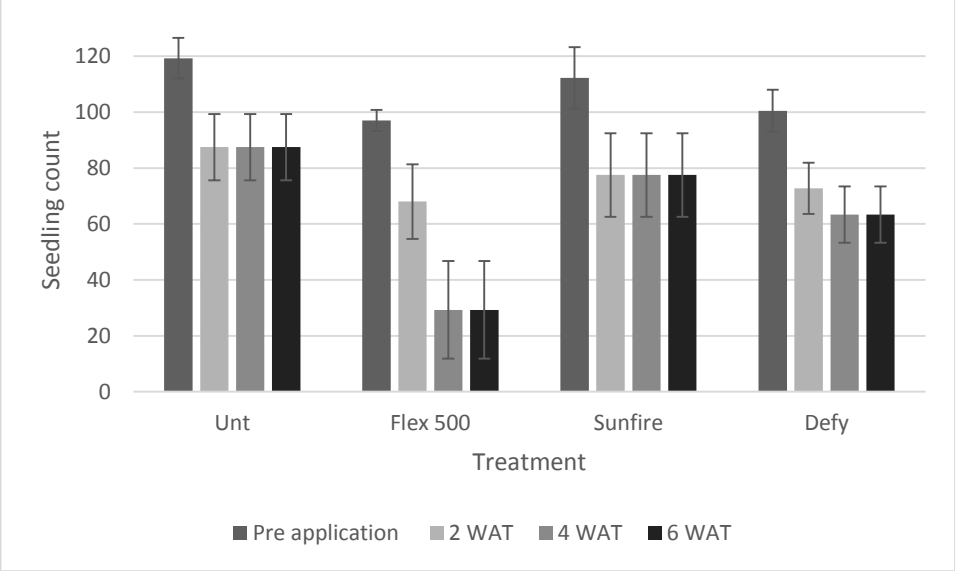

Figure 23. Wavy bittercress seedling counts for T2 (1-2 TL) treatment application. Assessed pre-treatment application, 2 weeks after treatment (WAT), 4 WAT and 6 WAT – ADAS Boxworth, 2017

Flexidor 500 applied at 1-2 true leaves caused severe scorch to the wavy bittercress (**Table 22**), scoring 2.8 for plant health at 2 WAT (**Figure 24**). Sunfire and Defy didn't cause significant damage to the wavy bittercress when applied at T2.

Table 22. Phytotoxicity – plant health scores for wavy bittercress after the T2 (1-2 true leaves) treatments were applied – ADAS Boxworth, 2017. Score 0 is plant death and 9 is a healthy plant.

Trt. no.	**Rate (Kg/ha or L/ha)**	**Score 2 WAT (06.07.17)**	**Score 4 WAT (21.07.17)**	**Score 6 WAT (03.08.17)**
1. Untreated	N/A	9.0	9.0	9.0
2. Flexidor 500	0.5 L/ha	2.8	3.0	3.0
3. Sunfire	0.48 L/ha	8.0	8.5	8.5
4. Defy	2.0 L/ha	7.8	7.0	7.0
P value		<.001	<.001	<.001
L.S.D. (9df)		1.577	2.048	1.922

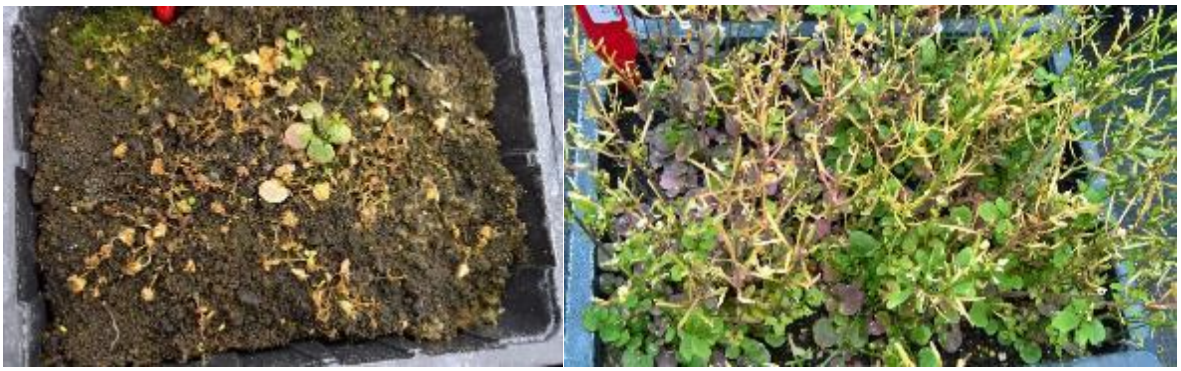

Figure 24. Flexidor 500 applied at T2 to wavy bittercress (left) and untreated (right) – 26 July 2017

T3 application (3-4 true leaves), 6 July 2017

No reductions in wavy bittercress numbers were seen after Flexidor 500, Sunfire or Defy were applied at 3 to 4 true leaves.

Flexidor 500 and Sunfire applied at 3-4 true leaves did cause scorching to wavy bittercress, scoring 5.3 and 5.5 compared with 9 untreated respectively at 2 WAT (**Table 23**). However, by 5 WAT wavy bittercress treated with either Flexidor 500 or Sunfire had started to recover, scoring 6 and 7.3 respectively. Defy didn't cause any significant phytotoxicity to the wavy bittercress when applied at 3-4 true leaves.

Table 23. Phytotoxicity – plant health scores for wavy bittercress after the T3 (3-4 true leaves) treatments were applied – ADAS Boxworth, 2017. Score 0 is plant death and 9 is a healthy plant.

Trt. no.	**Rate (Kg/ha or L/ha)**	**Phytotoxicity score 2 WAT (21.07.17)**	**Phytotoxicity score 3 WAT (28.07.17)**	**Phytotoxicity score 5 WAT (07.08.17)**
1. Untreated	N/A	9.0	9.0	9.0
2. Flexidor 500	0.5 L/ha	5.3	5.5	6.0
3. Sunfire	0.48 L/ha	5.5	5.5	7.3
4. Defy	2.0 L/ha	7.8	7.0	7.3
P value		<.001	<.001	0.004
L.S.D. (9df)		0.800	0.924	0.859

New Zealand bittercress

T1 application (pre-emergence), 2 June 2017

Flexidor 500 was the only treatment to reduce the number of New Zealand bittercress seedlings germinating when applied pre-emergence (**Figure 25**). At 5 weeks after emergence there were an average of 14 New Zealand bittercress seedlings that had germinated in plots treated with Flexidor 500, compared to 84 seedlings in untreated plots (p 0.010, 8df, L.S.D. 69.7 **Figure 25**).

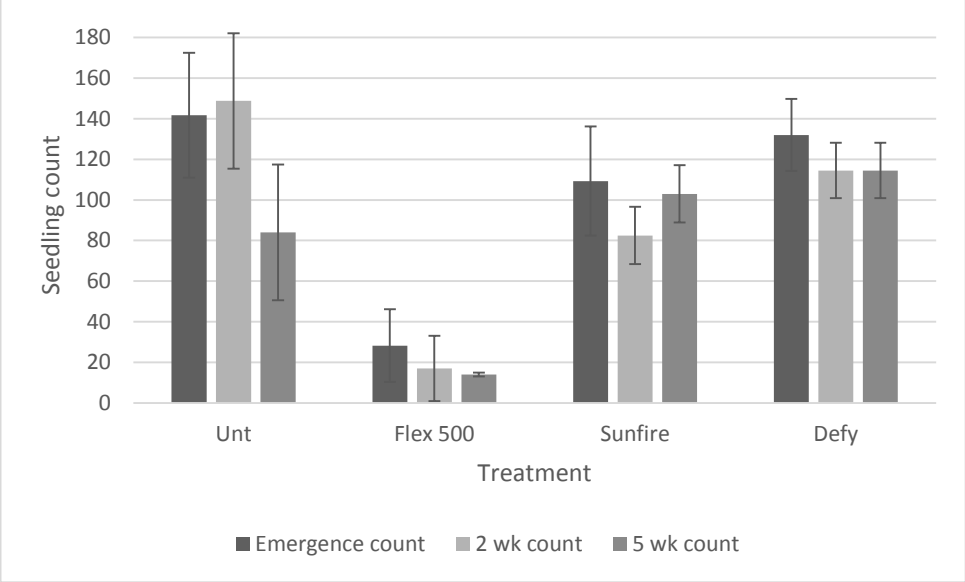

Figure 25. New Zealand bittercress seedling counts following pre-emergence treatment application, assessed at emergence, and 2 and 5 weeks post-emergence – ADAS Boxworth, 2017

Figure 26. Flexidor 500 applied pre-emergence to New Zealand bittercress (left) and untreated (right) – 26 July 2017

Flexidor 500 applied pre-emergence to New Zealand bittercress caused severe scorching to the few seedlings that did emerge two weeks after emergence, scoring 2.3 compared with 9 for the untreated (**Table 24, Figure 26**). After 5 weeks there was some recovery of the seedlings, scoring 4.3, however there were very few seedlings at this stage. .Sunfire and Defy caused some slight phytotoxic damage to New Zealand bittercress two weeks after emergence when applied pre-emergence. However, by five weeks after emergence these plants had recovered scoring 8.3 and 7.8 respectively.

Table 24. Phytotoxicity – plant health scores for New Zealand bittercress after the pre-emergence treatments were applied – ADAS Boxworth, 2017. Score 0 is plant death and 9 is a healthy plant.

Trt. no.	**Rate (Kg/ha or L/ha)**	**Score 2 wks after emergence (03.07.17)**	**Score 5 wks after emergence (24.07.17)**
1. Untreated	N/A	9.0	9.0
2. Flexidor 500	0.5 L/ha	2.3	4.3
3. Sunfire	0.48 L/ha	6.8	8.3
4. Defy	2.0 L/ha	6.0	7.8
P value		0.096	0.004
L.S.D. (9df)		5.305	2.234

T2 application (1-2 true leaves), 21 June 2017

None of the treatments (Flexidor 500, Sunfire or Defy) applied at 1-2 true leaves to the New Zealand bittercress significantly reduced the number of seedlings.

T3 application, (3-4 true leaves), 6 July 2017

None of the treatments (Flexidor 500, Sunfire or Defy) applied at 3-4 true leaves to the New Zealand bittercress reduced the number of seedlings.

Flexidor 500 applied at 3-4 true leaves scorched the New Zealand bittercress (**Table 25**). Defy applied at 3-4 true leaves slowed down the growth of the New Zealand bittercress as seed heads were not present in these plots on 26 July, whereas they were in the untreated plots (**Figure 27**). Sunfire had no effect when applied to New Zealand bittercress at the 3-4 true leaf stage.

Table 25. Phytotoxicity – plant health scores for New Zealand bittercress after the T3 (3-4 true leaves) treatments were applied – ADAS Boxworth, 2017. Score 0 is plant death and 9 is a healthy plant.

Trt. no.	**Rate (Kg/ha or L/ha)**	**Score 2 WAT (21.07.17)**	**Score 3 WAT (28.07.17)**	**Score 5 WAT (07.08.17)**
1. Untreated	N/A	8.8	9.0	8.0
2. Flexidor 500	0.5 L/ha	6.8	6.3	8.5
3. Sunfire	0.48 L/ha	7.8	7.0	7.5
4. Defy	2.0 L/ha	6.8	6.3	6.5
P value		NS	0.094	NS
L.S.D. (8df)		NS	2.461	NS

Figure 27. Defy applied at T3 (3-4 true leaves) to New Zealand bittercress (left), untreated (right) – 26 July 2017

Common mouse ear chickweed

T1 application (pre-emergence), 2 June 2017

Flexidor 500 applied at T1 significantly reduced the number of common mouse ear chickweed seedlings that emerged in the trial (p=0.005, 8df, L.S.D. 33.96) (**Figure 28**). Flexidor 500 reduced the number of chickweed seedlings to 48 on average compared to 117 in the untreated plots. Neither Sunfire nor Defy applied at pre-emergence to common mouse ear chickweed significantly reduced the number of seedlings.

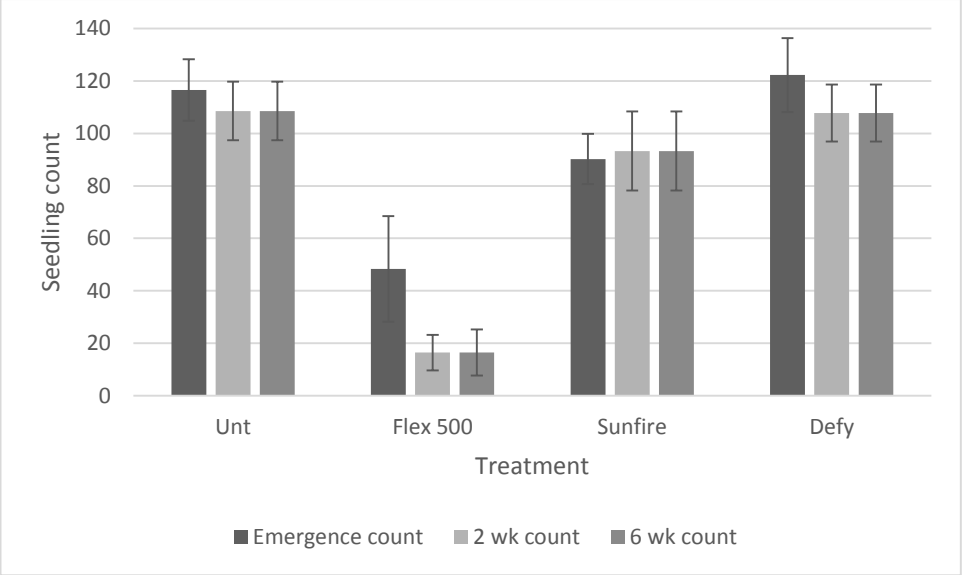

Figure 28. Common mouse ear chickweed seedling counts following pre-emergence treatment application, assessed at emergence, and 2 and 6 weeks post-emergence – ADAS Boxworth, 2017

The seedlings that did emerge however did not show significant phytotoxicity from any of the treatments apart from a transient effect of Sunfire at 2 WAT (**Table 26**)

Table 26. Phytotoxicity – plant health scores for common mouse ear chickweed after the pre-emergence treatments were applied – ADAS Boxworth, 2017. Score 0 is plant death and 9 is a healthy plant.

Trt. no.	**Rate (Kg/ha or L/ha)**	**Score 2 wks after emergence (26.06.17)**	**Score 6 wks after emergence (24.07.17)**
1. Untreated	N/A	9.0	9.0
2. Flexidor 500	0.5 L/ha	9.0	8.3
3. Sunfire	0.48 L/ha	7.8	9.0
4. Defy	2.0 L/A	9.0	9.0
P value		0.504	0.005
L.S.D. (9df)		2.515	0.3999

T2 application (1-2 true leaves), 21 June 2017

None of the treatments reduced the number of common mouse ear chickweed seedlings or caused significant phytotoxicity when applied at the 1-2 true leaves stage.

T3 application (3-4 true leaves), 6 July 2017

None of the treatments reduced the number of common mouse ear chickweed seedlings or caused significant phytotoxicity when applied at the 3 to 4 true leaf stage.

American willowherb

T1 application (pre-emergence), 27 July 2017

The post-emergence trial assessment showed Defy to be the only treatment to significantly reduce the emergence of willowherb seedlings when applied pre-emergence (**Figure 29**). At 6 weeks after emergence there were an average of 6 willowherb seedlings that had germinated in plots treated with Defy, compared to 19 seedlings in untreated plots ($p < 0.001$, 9df, L.S.D. 6.197; **Figure 29**).

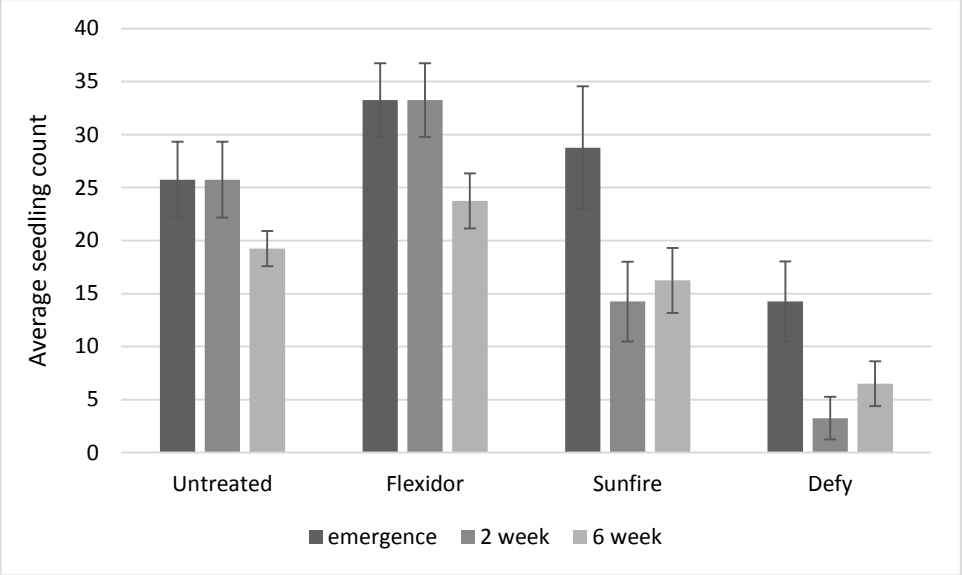

Figure 29. American willowherb seedling counts following pre-emergence treatment application, assessed at emergence, and 2 and 6 weeks post-emergence – ADAS Boxworth, 2017

Sunfire and Defy caused significant phytotoxic effects when applied at T1 (pre-emergence) to willowherb, with both treatments causing severe stunting and Sunfire shrivelling leaves. At 6 weeks post-emergence, phytotoxic effects persisted, with the distorted growth and stunting of Defy treated seedlings most notable (**Figure 30**). Of the treatments, only Defy differed significantly from the untreated, with a mean seedling phytotoxicity score of 3.5, compared to the untreated average phytotoxicity score of 7.75 (**Table 27**).

Figure 30. Defy applied at T1 (pre-emergence) to American willowherb, 6 WAT (left), untreated (right) – 3 October 2017

Table 27. Phytotoxicity – plant health scores for American willowherb after the pre-emergence treatments were applied – ADAS Boxworth, 2017. Score 0 is plant death and 9 is a healthy plant.

Trt. no.	**Rate (Kg/ha or L/ha)**	**Score 2 wks after emergence (08.09.17)**	**Score 6 wks after emergence (03.10.17)**
1. Untreated	N/A	9.00	7.75
2. Flexidor 500	0.5 L/ha	8.75	7.75
3. Sunfire	0.48 L/ha	5.75	7.00
4. Defy	5.0 L/A	1.50	3.50
P value		<0.001	0.014
L.S.D. (9df)		0.924	2.585

T2 application (1-2 true leaf), 21 August 2017

None of the herbicide treatments applied at T2 Growth Stage, 1-2 true leaf (GS) 11-12 significantly reduced willowherb seedling numbers.

There was no initial difference in the phytotoxic effect of the treatments when applied at GS 11-12. At 2 WAT, assessments showed Defy and Sunfire had caused significant phytotoxic effects, though at 4 and 6 WAT these effects only persisted in Defy treated seedlings (**Figure 31**, **Table 28**).

Figure 31. Defy applied at T2 1-2 true leaf (GS 11-12) to American willowherb, 4 WAT (left), untreated (right) – 22 September 2017

Table 28. Phytotoxicity – plant health scores for American willowherb after the GS 11-12 treatments were applied – ADAS Boxworth, 2017. Score 0 is plant death and 9 is a healthy plant.

Trt. no.	**Rate (Kg/ha or L/ha)**	**Score 2 wks post-application (08.09.17)**	**Score 4 wks post-application (22.09.17)**	**Score 6 wks post-application (03.10.17)**
1. Untreated	N/A	9.00	8.75	7.445
2. Flexidor 500	0.5 L/ha	8.50	8.25	8.333
3. Sunfire	0.48 L/ha	7.75	7.25	7.250
4. Defy	5.0 L/A	5.00	5.0	6.750
P value		<0.001	<0.001	0.038
L.S.D. (9df)		0.766	1.313	1.134

T3 application (3-4 true leaf), 1 September 2017

None of the herbicide treatments applied at T3 Growth Stage, 1-2 true leaf (GS) 13-14 significantly reduced willowherb seedling numbers.

At 4 WAT, Defy and Sunfire were shown to have significant phytotoxic effects to the willowherb seedlings. Symptoms persisted to 6 WAT for Defy and Sunfire treatments, with foliar discoloration and distorted growth (**Figure 32**). Both Defy and Sunfire differed significantly in phytotoxicity score from the untreated, with these treatments scoring 6.00, 6.25 and 8.25 respectively (**Table 29**).

Figure 32. 6 weeks after T3 (GS 13-14) treatment application to American willowherb; Defy (top left), Sunfire (top right), untreated (bottom left) – 12 October 2017

Table 29. Phytotoxicity – plant health scores for American willowherb after the GS 13-14 treatments were applied – ADAS Boxworth, 2017. Score 0 is plant death and 9 is a healthy plant.

Trt. no.	**Rate (Kg/ha or L/ha)**	**Score 4 wks post-application (28.09.17)**	**Score 6 wks post-application (12.10.17)**
1. Untreated	N/A	8.25	8.25
2. Flexidor 500	0.5 L/ha	7.00	7.25
3. Sunfire	0.48 L/ha	6.25	6.25
4. Defy	5.0 L/A	5.75	6.00
P value		<0.001	0.011
L.S.D. (9df)		0.666	1.258

Common chickweed

T1 application (pre-emergence), 22 September 2017

The post-emergence assessments showed Flexidor 500 was the only treatment to significantly reduce the emergence of chickweed seedlings when applied pre-emergence (**Figure 33**). At 6 weeks after emergence there were an average of 16.5 chickweed seedlings in plots treated with Flexidor, compared to 40.25 seedlings in untreated plots ($p < 0.001$, 9df, L.S.D. 12.35; **Figure 33**).

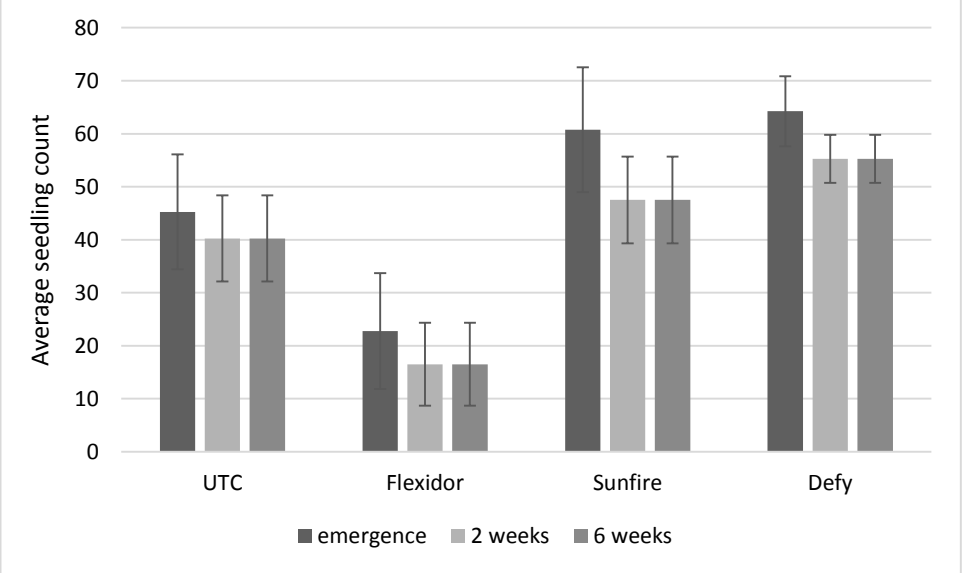

Figure 33. Common chickweed seedling counts following pre-emergence treatment application, assessed at emergence, and 2 and 6 weeks post-emergence – ADAS Boxworth, 2017

When applied pre-emergence, none of the treatments (Flexidor 500, Sunfire or Defy) were observed to have a phytotoxic effect on the seedlings that had emerged.

T2 application (1-2 true leaf), 13 October 2017

When applied at 1-2 true leaves, Flexidor 500 was the only treatment to significantly reduce the number of common chickweed seedlings, an effect observed at 4 and 6 WAT ($p < 0.028$, 9df, L.S.D. 15.69; **Figure 34**). At 6 WAT, there was an average of 20.8 seedlings in Flexidor treated plots, whereas the average seedling count in untreated plots was 45.2 (**Appendix 3 Table 49**).

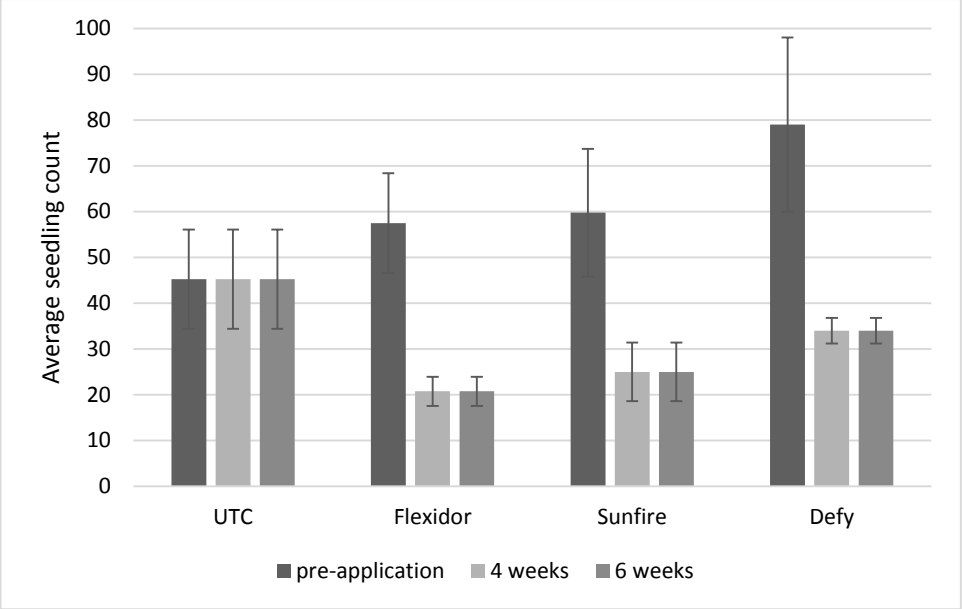

Figure 34. Common chickweed seedling counts for T2 (1-2 TL) treatment application. Assessed pre-treatment application, 4 WAT and 6 WAT – ADAS Boxworth, 2017

At 4 WAT, Flexidor 500 was shown to have a significant phytotoxic effects on the chickweed seedlings. This treatments differed significantly in phytotoxicity score from the untreated, scoring 2.75 and 6.25 respectively (**Table 30**). Symptoms did not persist to 6 WAT.

Table 30. Phytotoxicity – plant health scores for Common chickweed after the GS 11-12 treatments were applied – ADAS Boxworth, 2017. Score 0 is plant death and 9 is a healthy plant.

Trt. no.	**Rate (Kg/ha or L/ha)**	**Score 4 wks post-application (08.11.17)**	**Score 6 wks post-application (22.11.17)**
1. Untreated	N/A	6.25	6.25
2. Flexidor 500	0.5 L/ha	2.75	6.00
3. Sunfire	0.48 L/ha	6.5	6.75
4. Defy	5.0 L/A	6.25	6.50
P value		0.004	0.935
L.S.D. (9df)		1.890	2.783

T3 application (GS 13-14), 24 October 2017

None of the treatments applied at 3-4 true leaves significantly reduced the number of common chickweed seedlings.

However, when plots were assessed at both 2 and 4 WAT, some treatments were observed to have caused phytotoxic effects. At 2 WAT, the Defy and Flexidor treatments had average plant quality scores of 4.75 and 3.50 respectively, significantly lower than that of the untreated, with its average plant quality score of 7.00 ($p < 0.001$, 9df, L.S.D. 0.998; **Table 31**). The 4 WAT assessment gave similar results, with Defy and Flexidor scoring 4.75 and 2.00 respectively for plant quality ($p < 0.001$, 9df, L.S.D. 0.854; **Table 30**; **Figure 35**). Both treatments bleached plant foliage, with Flexidor browning and withering some leaves.

Table 31. Phytotoxicity – plant health scores for Common chickweed after the GS 13-14 treatments were applied – ADAS Boxworth, 2017. Score 0 is plant death and 9 is a healthy plant.

Trt. no.	**Rate (Kg/ha or L/ha)**	**Score 2 wks post-application (08.11.17)**	**Score 4 wks post-application (22.11.17)**
5. Untreated	N/A	7.00	7.75
6. Flexidor 500	0.5 L/ha	3.50	2.00
7. Sunfire	0.48 L/ha	6.75	7.25
8. Defy	5.0 L/A	4.75	4.75
P value		<0.001	<0.001
L.S.D. (9df)		0.998	0.854

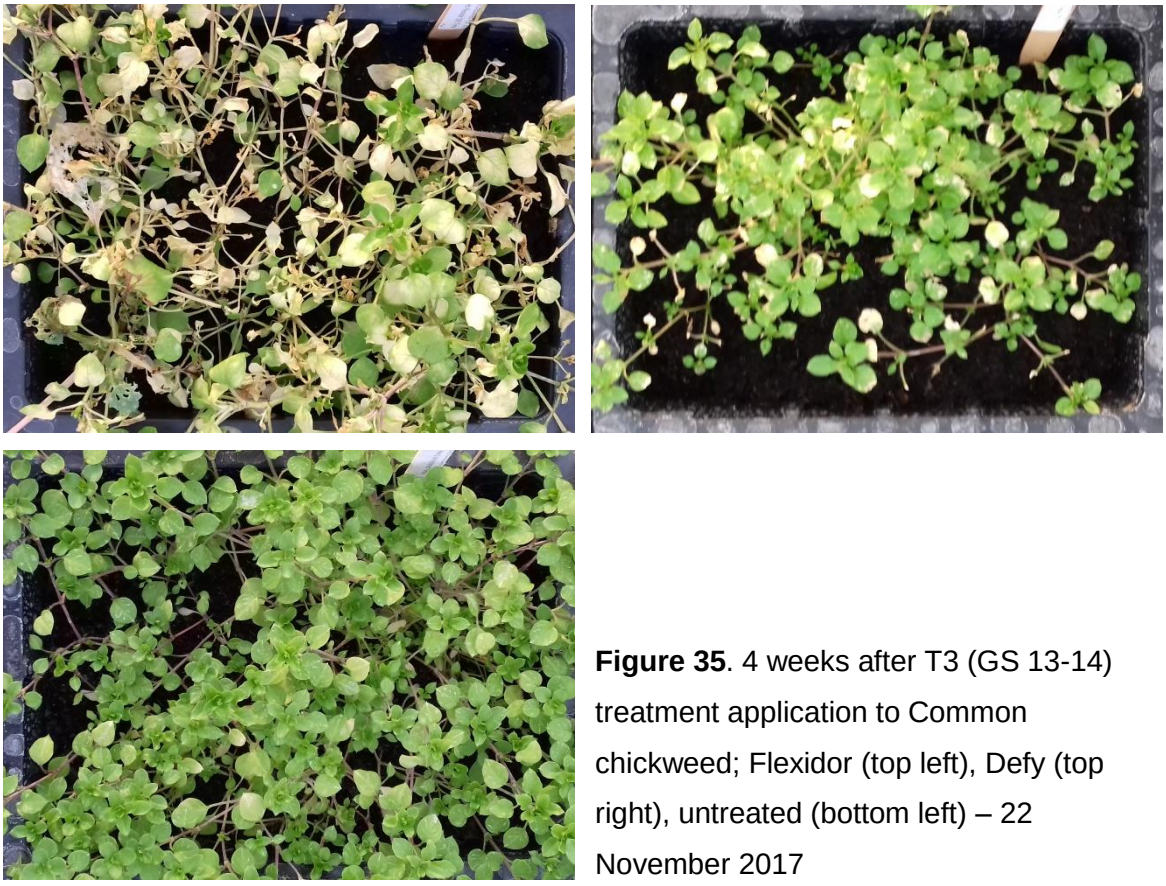

Figure 35. 4 weeks after T3 (GS 13-14) treatment application to Common chickweed; Flexidor (top left), Defy (top right), untreated (bottom left) – 22 November 2017

Groundsel

T1 application (pre-emergence), 22 September 2017

When applied pre-emergence, none of the treatments reduced the number of groundsel seedlings that emerged or caused significant phytotoxicity.

T2 application (GS 11-12), 13 October 2017

None of the treatments reduced the number of groundsel seedlings or caused significant phytotoxicity when applied at the 1-2 true leaves stage.

T3 application (GS 13-14), 24 October 2017

None of the treatments reduced the number of groundsel seedlings or caused significant phytotoxicity when applied at the 3-4 true leaves stage.

Procumbent pearlwort

T1 application (pre-emergence), 22 September 2017

The post-emergence trial assessment showed that Flexidor 500 and Sunfire significantly reduced the emergence of pearlwort seedlings when applied pre-emergence (**Figure 36**). At 6 weeks after emergence, an average of 7.2 and 28.5 pearlwort seedlings had germinated in Flexidor and Sunfire treated plots respectively, compared to an average of 61.8 seedlings in untreated plots (p 0.002, 9df, L.S.D. 22.78; **Figure 36**).

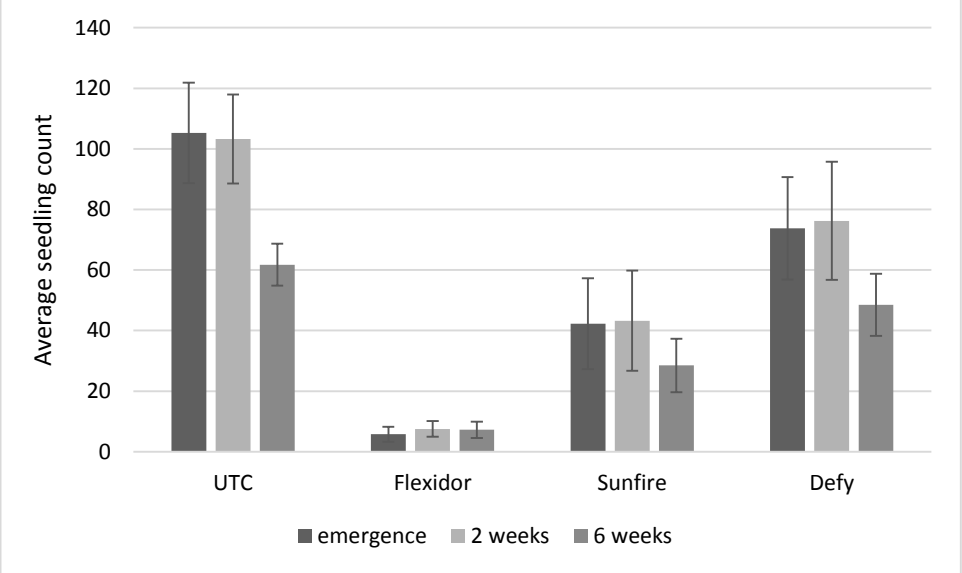

Figure 36. Procumbent pearlwort seedling counts following pre-emergence treatment application, assessed at emergence, and 2 and 6 weeks post-emergence – ADAS Boxworth, 2017

When applied pre-emergence, none of the treatments had significant phytotoxic effects on any emerged pearlwort seedlings.

T2 application (GS 11-12), 13 October 2017

When applied at 1-2 true leaves, none of the treatments significantly reduced the number of pearlwort seedlings.

At both 4 and 6 WAT assessments, some treatments were observed to have caused phytotoxic effects. At 4 WAT, the average plant quality score for Flexidor was 3.0, significantly lower than that of the untreated, with its average plant quality score of 9.0 (p <0.001, 8df, L.S.D. 1.703; **Table 32**). The 6 WAT assessment gave similar results, with Flexidor and Defy scoring 1.25 and 6.25 respectively for plant quality (p <0.001, 9df, L.S.D. 1.2; **Table 32**). The lower scores for Flexidor and Defy was due to the foliar yellowing effect of these treatments.

Table 32. Phytotoxicity – plant health scores for pearlwort after the GS 11-12 treatments were applied – ADAS Boxworth, 2017. Score 0 is plant death and 9 is a healthy plant.

Trt. no.	**Rate (Kg/ha or L/ha)**	**Score 4 wks post-application (08.11.17)**	**Score 6 wks post-application (22.11.17)**
1. Untreated	N/A	9.0	9.0
2. Flexidor 500	0.5 L/ha	3.0	1.25
3. Sunfire	0.48 L/ha	8.81	8.25
4. Defy	5.0 L/A	6.75	6.25
P value		<0.001	<0.001
L.S.D. (9df)		1.703	1.2

T3 application (GS 13-14), 24 October 2017

None of the treatments applied at 3-4 true leaves significantly reduced the number of pearlwort seedlings.

When plots were assessed at 4 WAT, some treatments were observed to have caused phytotoxic effects, with leaves yellowed. At 4 WAT, the Defy and Flexidor treatments had average plant quality scores of 6.0 and 2.0 respectively, significantly lower than that of the untreated, with its average plant quality score of 9.0 ($p < 0.001$, 9df, L.S.D. 1.847; **Table 33**; **Figure 37**).

Table 33. Phytotoxicity – plant health scores for pearlwort after the GS 13-14 treatments were applied – ADAS Boxworth, 2017. Score 0 is plant death and 9 is a healthy plant.

Trt. no.	**Rate (Kg/ha or L/ha)**	**Score 2 wks post-application (08.11.17)**	**Score 4 wks post-application (22.11.17)**
5. Untreated	N/A	9.0	9.0
6. Flexidor 500	0.5 L/ha	7.5	2.0
7. Sunfire	0.48 L/ha	9.0	9.0
8. Defy	5.0 L/A	7.5	6.0
P value		0.141	<0.001
L.S.D. (9df)		1.808	1.847

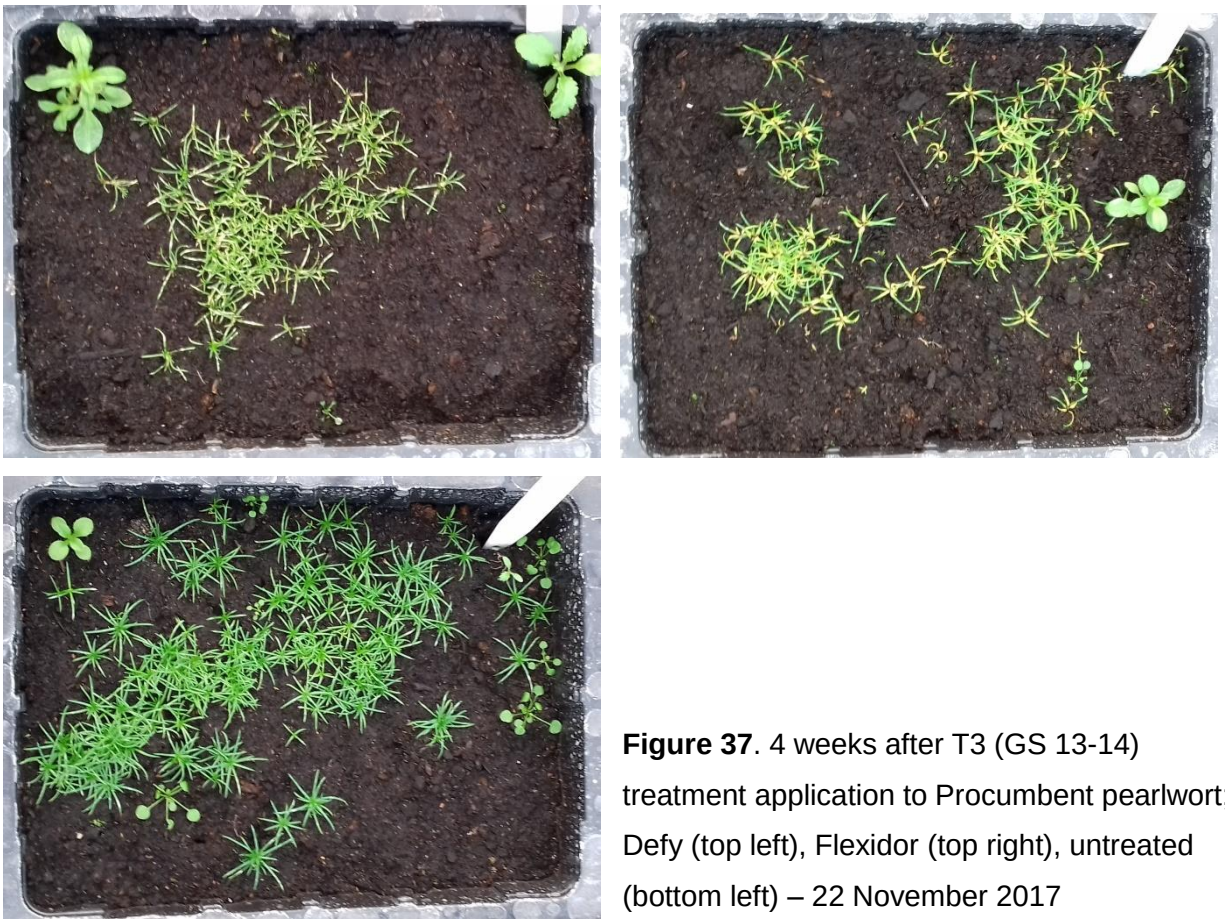

Figure 37. 4 weeks after T3 (GS 13-14) treatment application to Procumbent pearlwort; Defy (top left), Flexidor (top right), untreated (bottom left) – 22 November 2017

Discussion

Results of this comprehensive weed screen confirmed that the standard, Flexidor 500 continues to give good pre-emergence control of the majority of weeds of container grown nursery stock. The exceptions are annual meadow grass and American willowherb, results which confirm earlier findings (Atwood 2009). It is interesting that Flexidor 500 gave good control of early post-emergence (1-2 true leaf) and some stunting of 3-4 true leaf of wavy bittercress but no significant post-emergence control of New Zealand bittercress.

The new residual herbicides Sunfire and Defy only offered control of two of the key weeds tested. Both gave good pre-emergence control of annual meadow grass. Sunfire gave some suppression of emerged annual meadow grass at the 1-2 true leaf stage. Defy gave good suppression at the 3-4 true leaf stage but not at the earlier stage. Sunfire gave some pre-emergence control of pearlwort but inferior to Flexidor 500. Defy gave good control of American willowherb pre-emergence and marked stunting of emerged seedlings. However once emerged the seedlings were not completely eliminated so in practice weeding would still be required. Sunfire did not control American willowherb pre-emergence but caused some

stunting to emerge seedlings, although less severe than with Defy and again, weeding would be required in practice.

The selective contact grass herbicide Centurion Max performed well on emerged annual meadow grass, giving superior control to the other treatments and gave significant control up to the 10 true-leaf stage.

Conclusions

- Flexidor 500 was confirmed as giving good pre-emergence control of wavy bittercress, New Zealand bittercress, mouse ear chickweed, common chickweed and pearlwort. Annual meadow grass, groundsel and American willowherb were resistant.
- Defy gave good pre-emergence control of annual meadow grass and American willowherb and so could supplement Flexidor 500, but is only likely to be safe as a dormant season treatment.
- Defy could be a partial alternative to Devrinol (napropamide) as a winter treatment if an EAMU for the latter was not available, but if an authorisation for Devrinol on ornamentals was restored this would be preferred to Defy because of groundsel control.
- Sunfire gave good control of annual meadow grass and some control of pearlwort. Control of other weeds was disappointing. It may be useful as a supplement to Flexidor 500 but only where annual meadow grass and pearlwort is a problem.
- Centurion Max gave good control of emerged annual meadow grass including larger seedlings.

Knowledge and Technology Transfer

AHDB Grower magazine, Short note on Sencorex Flow EAMU. Submitted Sept 2017.

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Appendices

Appendix 1 – Budded rose trial (2016-17)

Table 34. Percentage weed cover of the budded rose trial 6 weeks after heading back treatments were applied – Pulham St Mary, 26 April 2017

Trt. no.	**Heading back**	**Rate (Kg/ha or L/ha)**	**Weed cover (%) 6 WAT (26.04.17)**
1	Untreated	N/A	0.875
2, 3, 9, 10	Stomp Aqua + Flexidor 500 + Springbok	2.0 + 0.5 + 1.25	0.219
4	Stomp Aqua + Flexidor 500 + HDC H43	2.0 + 0.5 + 2.0	0.125
5	Stomp Aqua + Flexidor 500 + HDC H42	2.0 + 0.5 + 1.5	0
6	Stomp Aqua + Venzar Flo + Sencorex Flow	2.0 + 2.0 + 0.44	0.125
7	Stomp Aqua + Flexidor 500 + Sencorex Flow	2.0 + 0.5 + 0.44	0.125
8	Stomp Aqua + Sencorex Flow + HDC H42	2.0 + 0.44 + 1.5	0.125
P value			**<0.001**
L.S.D. (25df)			**0.3081**

Table 35. Percentage weed cover of the budded rose trial 6 weeks after the follow up treatments were applied – Pulham St Mary, 30 June 2017

Trt. no.	Follow up	Rate (Kg/ha or L/ha)	Weed cover (%) 6 WAT (30.06.17)
1	Untreated	N/A	14.2
9, 10	Logo + Mero	0.78 + 20.90	9.6
P value			**0.079**
L.S.D. (33df)			**6.71**

Appendix 2 – Budded rose trial (2017-18)

Table 36. Percentage weed cover of budded rose plots 6 weeks after the planting treatments were applied – Pulham St Mary, 26 April 2017

Trt. no.	Planting	Rate (Kg/ha or L/ha)	Weed cover (%) 6 WAT (26.04.17)
1, 4	Untreated	N/A	5
2	Stomp Aqua + Flexidor 500 + Venzar Flo	2.9 + 0.5 + 3.0	0.75
3	Stomp Aqua + Flexidor 500 + HDC H43	2.9 + 0.5 + 2.0	1
5, 6, 7, 8	Stomp Aqua + Flexidor 500 + Sencorex Flow	2.9 + 0.5 + 0.73	0.25
9	Stomp Aqua + Venzar Flo + Sencorex Flow	2.9 + 3.0 + 0.73	0.25
P value			**<0.001**
L.S.D. (28df)			**0.4358**

Table 37. Percentage weed cover of budded rose plots 9 weeks after the planting treatments were applied – Pulham St Mary, 18 May 2017

Trt. no.	Planting	Rate (Kg/ha or L/ha)	Weed cover (%) 12 WAT (18.05.17)
1, 4	Untreated	N/A	30.625
2	Stomp Aqua + Flexidor 500 + Venzar Flo	2.9 + 0.5 + 3.0	2.5
3	Stomp Aqua + Flexidor 500 + HDC H43	2.9 + 0.5 + 2.0	3.75
5, 6, 7, 8	Stomp Aqua + Flexidor 500 + Sencorex Flow	2.9 + 0.5 + 0.73	0.733
9	Stomp Aqua + Venzar Flo + Sencorex Flow	2.9 + 3.0 + 0.73	0.75
P value			**<0.001**
L.S.D. (27df)			**4.914**

Table 38. Percentage weed cover of budded rose plots 6 weeks after the budding treatments were applied – Pulham St Mary, 10 August 2017

Trt. no.	Follow up	Rate (Kg/ha or L/ha)	Weed cover (%) 6 WAT (10.08.17)
1	Untreated	N/A	27.5
2, 4, 5, 6, 7, 8, 9	Flexidor 500 + Butisan S	0.5 + 1.5	1.3
3	Flexidor 500 + HDC H43	0.5 + 2.0	1
P value			**<0.001**
L.S.D. (30df)			**2.595**

Appendix 3 – Herbicide weed screens

Annual meadow grass

Table 39. Annual meadow grass seedling counts following pre-emergence treatment application, assessed at emergence, and 2 and 7 weeks post-emergence – ADAS Boxworth, 2017

Trt. no.	Pre-emergence	Rate (Kg/ha or L/ha)	Seedling count emergence (20.06.17)	Seedling count 2 WAT (05.07.17)	Seedling count 7 WAT (07.08.17)
1	Untreated	N/A	19	19	19
2	Flexidor 500	0.50	20	17	17
3	Sunfire	0.48	0	0	0
4	Defy	5.0	0.5	1	1
P value			**<0.001**	**<0.001**	**<0.001**
L.S.D. (8df)			**6.81**	**4.372**	**4.372**

Table 40. Annual meadow grass seedling counts for T2 (1-2 TL) treatment application. Assessed pre-treatment application, 2 weeks after treatment (WAT), 4 WAT and 6 WAT – ADAS Boxworth, 2017

Trt. no.	T2 (1-2 TL)	Rate (Kg/ha or L/ha)	Seedling count pre-application (20.06.17)	Seedling count 2 WAT (05.07.17)	Seedling count 4 WAT (20.07.17)	Seedling count 6 WAT (03.08.17)
1	Untreated	N/A	24.25	20	18	18
2	Flexidor 500	0.50	24.75	21.75	19	19
3	Sunfire	0.48	23	19	14.75	14.75
4	Defy	5.0	23.75	20	20.75	20.75
5	Centurion Max	2.0	26	23	0	0
P value			**0.992**	**0.396**	**<0.001**	**<0.001**
L.S.D. (12df)			**14.18**	**6.633**	**6.799**	**6.799**

Table 41. Annual meadow grass seedling counts for T3 (3-4 TL) treatment application. Assessed pre-treatment, 2 weeks after treatments (WAT), 3 WAT and 5 WAT – ADAS Boxworth 2017

Trt. no.	T3 (3-4 TL)	Rate (Kg/ha or L/ha)	Seedling count pre-application (05.07.17)	Seedling count 2 WAT (20.07.17)	Seedling count 3 WAT (28.07.17)	Seedling count 5 WAT (07.08.17)
1	Untreated	N/A	24.5	21.25	21.25	21.25
2	Flexidor 500	0.50	18.75	17.5	17.5	17.5
3	Sunfire	0.48	24	21	21	21
4	Defy	5.0	20.75	13.75	9.25	9.25
5	Centurion Max	2.0	23	18	12.75	12.75
P value			**0.138**	**0.002**	**<0.001**	**<0.001**
L.S.D. (12df)			**5.065**	**3.349**	**4.282**	**4.282**

Table 42. Annual meadow grass seedling counts for T4 (10 TL) treatment applications. Assessed pre-treatments, 2 weeks after treatment (WAT), 4 WAT and 6 WAT – ADAS Boxworth 2017

Trt. no.	T4 (10 TL)	Rate (Kg/ha or L/ha)	Seedling count pre-application (24.07.17)	Seedling count 2 WAT (11.08.17)	Seedling count 4 WAT (23.08.17)	Seedling count 6 WAT (06.09.17)
1	Untreated	N/A	19	19	22.75	22.75
2	Flexidor 500	0.50	26	22.25	21.25	21.25
3	Sunfire	0.48	22.75	20	20.25	20.25
4	Defy	5.0	24.25	21	19	19
5	Centurion Max	2.0	24	23	17.5	2.5
P value			**0.685**	**0.835**	**0.556**	**<0.001**
L.S.D. (12df)			**10.62**	**8.39**	**7.02**	**6.116**

Wavy bittercress

Table 43. Wavy bittercress seedling counts following pre-emergence treatment application, assessed at emergence, and 2 and 5 weeks post-emergence – ADAS Boxworth, 2017

Trt. no.	**Pre-emergence**	**Rate (Kg/ha or L/ha)**	**Seedling count emergence (14.06.17)**	**Seedling count 2 WAT (26.06.17)**	**Seedling count 5 WAT (24.07.17)**
1	Untreated	N/A	109.75	79.25	64
2	Flexidor 500	0.50	0.25	0.25	0
3	Sunfire	0.48	94.25	58.75	56.5
4	Defy	5.0	132	94.75	88.5
P value			**<0.001**	**<0.001**	**<0.001**
L.S.D. (9df)			**15.06**	**17.44**	**17.51**

Table 44. Wavy bittercress seedling counts for T2 (1-2 TL) treatment application. Assessed pre-treatment application, 2 weeks after treatment (WAT), 4 WAT and 6 WAT – ADAS Boxworth, 2017

Trt. no.	**T2 (1-2 TL)**	**Rate (Kg/ha or L/ha)**	**Seedling count pre-application (14.06.17)**	**Seedling count 2 WAT (06.07.17)**	**Seedling count 4 WAT (21.07.17)**	**Seedling count 6 WAT (06.09.17)**
1	Untreated	N/A	119.25	87.5	87.5	87.5
2	Flexidor 500	0.50	97	68	29.25	29.25
3	Sunfire	0.48	112.25	77.5	77.5	77.5
4	Defy	5.0	100.5	72.75	63.33333	63.33333
P value			**0.164**	**0.068**	**0.002**	**0.002**
L.S.D. (9df)			**22.53**	**14.49**	**24.12**	**24.12**

New Zealand bittercress

Table 45. New Zealand bittercress seedling counts following pre-emergence treatment application, assessed at emergence, and 2 and 5 weeks post-emergence – ADAS Boxworth, 2017

Trt. no.	Pre-emergence	Rate (Kg/ha or L/ha)	Seedling count emergence (14.06.17)	Seedling count 2 WAT (26.06.17)	Seedling count 5 WAT (24.07.17)
1	Untreated	N/A	141.75	148.75	84
2	Flexidor 500	0.50	28.25	17	14
3	Sunfire	0.48	109.25	82.5	103
4	Defy	5.0	132	114.5	114.5
P value			**0.017**	**0.017**	**0.010**
L.S.D. (9df)			**68.1**	**71.9**	**69.7**

Common mouse ear chickweed

Table 46. Common mouse ear chickweed seedling counts following pre-emergence treatment application, assessed at emergence, and 2 and 6 weeks post-emergence – ADAS Boxworth, 2017

Trt. no.	Pre-emergence	Rate (Kg/ha or L/ha)	Seedling count emergence (14.06.17)	Seedling count 2 WAT (26.06.17)	Seedling count 6 WAT (24.07.17)
1	Untreated	N/A	116.5	108.5	108.5
2	Flexidor 500	0.50	48.33	16.5	16.5
3	Sunfire	0.48	90.25	93.25	93.25
4	Defy	5.0	122.25	107.75	107.75
P value			**0.005**	**<0.001**	**<0.001**
L.S.D. (9df)			**33.96**	**29.79**	**29.59**

American willowherb

Table 47. American willowherb seedling counts following pre-emergence treatment application, assessed at emergence, and 2 and 6 weeks post-emergence – ADAS Boxworth, 2017

Trt. no.	Pre-emergence	Rate (Kg/ha or L/ha)	Seedling count emergence (21.08.17)	Seedling count 2 WAT (08.09.17)	Seedling count 6 WAT (03.10.17)
1	Untreated	N/A	25.75	25.75	19.25
2	Flexidor 500	0.50	33.25	33.25	23.75
3	Sunfire	0.48	28.75	14.25	16.25
4	Defy	5.0	14.25	3.25	6.5
P value			**<0.001**	**0.001**	**<0.001**
L.S.D. (9df)			**6.54**	**11.84**	**6.197**

Common chickweed

Table 48. Common chickweed seedling counts following pre-emergence treatment application, assessed at emergence, and 2 and 6 weeks post-emergence – ADAS Boxworth, 2017

Trt. no.	Pre-emergence	Rate (Kg/ha or L/ha)	Seedling count emergence (12.10.17)	Seedling count 2 WAT (23.10.17)	Seedling count 6 WAT (25.11.17)
1	Untreated	N/A	45.25	40.25	40.25
2	Flexidor 500	0.50	22.75	16.50	16.50
3	Sunfire	0.48	60.75	47.50	47.50
4	Defy	5.0	64.25	55.25	55.25
P value			**<0.001**	**<0.001**	**<0.001**
L.S.D. (9df)			**15.31**	**12.35**	**12.35**

Table 49. Common chickweed seedling counts for T2 (1-2 TL) treatment application. Assessed pre-treatment application, 4 and 6 WAT – ADAS Boxworth, 2017

1	Untreated	N/A	45.25	45.25	45.25
2	Flexidor 500	0.50	57.5	20.75	20.75
3	Sunfire	0.48	59.75	25	25
4	Defy	5.0	79	34	34
P value			**0.242**	**0.028**	**0.028**
L.S.D. (9df)			**34.54**	**15.69**	**15.69**
Trt. no.	**Pre-emergence**	**Rate (Kg/ha or L/ha)**	**Seedling count emergence (12.10.17)**	**Seedling count 4 WAT (08.11.17)**	**Seedling count 6 WAT (25.11.17)**

Procumbent pearlwort

Table 50. Procumbent pearlwort seedling counts following pre-emergence treatment application, assessed at emergence, and 2 and 6 weeks post-emergence – ADAS Boxworth, 2017

Trt. no.	**Pre-emergence**	**Rate (Kg/ha or L/ha)**	**Seedling count emergence (12.10.17)**	**Seedling count 2 WAT (23.10.17)**	**Seedling count 6 WAT (25.11.17)**
1	Untreated	N/A	105.25	103.25	61.75
2	Flexidor 500	0.50	5.75	7.5	7.25
3	Sunfire	0.48	42.25	43.25	28.5
4	Defy	5.0	73.75	76.25	48.5
P value			**0.004**	**0.005**	**0.002**
L.S.D. (9df)			**44.10**	**45.18**	**22.78**