Grower Summary

HNS PO 192a

Herbicides screening for Ornamental plant production (nursery stock, cut flowers and wallflowers)

Final 2016

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GROWER SUMMARY CUT FLOWER TRIALS

Headline

Herbicide trials carried out on China Aster, Larkspur, Sweet Williams, Peony and Wallflowers have indicated a number of herbicide treatments including combinations of Stomp Aqua, Goltix 70SC or Gamit 36 CS that can be used safely in these crops. Safe rates of use have been refined during the series of trials.

Background

There are few label recommended herbicides available for ornamental growers, which in many cases mean growers have to rely on hand weeding and cultivation, which is expensive and difficult in wet conditions, or on off-label herbicide usage through EAMUs. With the loss of key herbicide active ingredients such as oxadiazon (Ronstar Liquid), chlorthal-dimethyl (Dacthal-w75) and propachlor (Ramrod), it is necessary to find more options for cut flower growers. The increasing demand for British-grown cut flowers provides a significant business development opportunity for UK growers. However, the lack of technical information for the wide diversity of traditional and novel species being grown is a major factor limiting expansion of the sector. With improved knowledge, either the cost of ineffective treatments would be saved, or treatments that were effective would result in labour saving (reduced hand weeding) and a better quality crop.

During 2014, a range of herbicides were tested for crop safety on four key cut flower crops and wallflowers grown at the Cut Flower Centre (CFC), Holbeach St. Johns, as part of AHDB funded project HNS PO 192. Results from the work highlighted some promising new treatments, and so these products were further tested in 2015, both at the CFC and on grower holdings, to refine the treatments, examine rates of use and to see how well they worked in combination with other products.

Summary

Work was carried out between April and November 2015 to test a range of herbicides, either alone or in combination, for crop safety on four drilled flower species at the Cut Flower Centre (CFC); China aster (*Callistephus chinensis*; Compositae), Larkspur (*Delphinium consolida*; Ranunculaceae), Sweet Williams (*Dianthus barbartus*; Caryophyllacae) and Wallflowers (*Erysimum cheiri*; Cruciferae). Each flower species had a dedicated trial at the CFC and consisted of a total of 10 treatments, including an untreated control, replicated three times.

In addition to the trials held at the CFC, trials were also carried out during this period on growers' sites for transplanted China aster, newly planted Peony (*Paeonia* Hybrids; Paeonaciae) and drilled Sweet Williams. The purpose of these trials were to refine the rates of herbicides that had been tested at the CFC and to demonstrate promising treatments in larger plots. Two promising experimental treatments were compared with the growers' standard herbicide treatment in the China aster and Sweet Williams trials. In these trials the main treatments were applied post-drilling and Shark was applied post-emergence. In the Peony trial, there were 10 treatments, including an untreated control, with pre- and post-planting treatments.

The products used in the 2015 trial are listed in **Table 9,** along with their approval status.

Table 9. Products and rates used in the Cut Flower trials, 2015

			Rate kg/ha or L/ha				
Product	**Active**	**Approval status**	**China Aster**	**Larkspur**	**Peony**	**Sweet William**	**Wallflower**
Benfluralin	60% w/w benfluralin	Not approved	2	2	2	2	2
Butisan S	500 g/L metazachlor	Label[1]			1.5		1
Defy	800 g/L prosulfocarb	EAMU outdoor[2]		4		2 4	
Dual Gold	960 g/L s-metolachlor	EAMU outdoor[4]		0.78			
Flexidor 500	500 g/L isoxaben	Label[1]			0.5		
Gamit 36 CS	360 g/L clomazone	EAMU outdoor[3]	0.05 0.125 0.25	0.25	0.125		0.05 0.125 0.25 0.33
Goltix 70 SC	700 g/L metamitron	EAMU[2]				1.0 2.0	
HDC H24	confidential	Not approved		X	X		
Kerb Flo 400	400 g/L propyzamide	Not approved	3.75				
Nirvana	250 g/L pendimethalin + 16.7 g/L imazamox	EAMU outdoor	3 4.5				
Ronstar Liquid	25% oxadiazon	Not approved	4.0				
Shark	60 g/L carfentrazone ethyl	EAMU outdoor and protected	0.33 0.66			0.33 0.66	

			Rate kg/ha or L/ha				
Product	**Active**	**Approval status**	**China Aster**	**Larkspur**	**Peony**	**Sweet William**	**Wallflower**
Stomp Aqua	455 g/L pendimethalin	EAMU outdoor	2	2	2.9	1.0 1.5 2.0	2 2.9
Successor	600 g/L pethoxamid	Not approved		2.0	2.0		
Venzar Flowable	440 g/L lenacil	LTAEU Outdoor			3		
Wing-P	250 g/L pendimethalin + 212.5 g/L dimethenamid-p	EAMU outdoor[2]		1.75	3.5		1.75 3.5

[1]Label only covers use on outdoor trees and shrubs but other ornamentals may be treated outdoors at grower's risk. Other formations of metazachlor can be used under protection providing the label does not specifically exclude such use.

[2]Pre-emergence only

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

[4]Use only permitted during May

X indicates an experimental treatment applied at an undisclosed rate

Trials were assessed for phytotoxic symptoms approximately 2, 6 and 10 weeks from sowing or transplanting. Drilled crops were also assessed for emergence and a weed assessment was carried out on each trial.

For each crop **Tables 10 – 17**, show the final phytotoxicity score for each treatment 10 weeks after treatment (WAT), the average number of emerged seedlings per plot for drilled crops, and the percentage weed cover, to give an overall summary for each treatment. NS = no significant differences between treatments ($P<0.05$), lsd is the least significant difference between treatments.

China aster (drilled)

For the drilled China aster crop (**Table 10**), Nirvana applied at a rate of 4.5 L/ha proved to be the most phytotoxic treatment, with yellowing to foliage and stunted plants. By 10 WAT, all other treatments were considered commercially acceptable for plant quality. When Shark was applied as a post-emergence treatment, this initially caused some damage to the crop, with leaf yellowing and scorching to leaf edges, but these plants were able to recover at both

application rates, so Shark could be considered for use as a herbicide in this crop, applied at a rate of 0.33 L/ha.

Plants treated with Stomp Aqua at 2 L/ha + Gamit at varying rates of 0.05-0.25 L/ha looked healthy and were commercially acceptable, but there was little difference in weed control and there was a tendency for emergence to be reduced in plots treated with the highest rate of Gamit at 0.25 L/ha. Therefore, Stomp Aqua 2 L/ha + Gamit 0.125 L/ha could be a suitable treatment applied to a crop post-drilling.

Table 10. Drilled China aster – Mean scores for phytotoxicity 10 weeks after treatment (WAT) (1 WAT), number of emerged seedlings and% weed cover – 2015 (scale of 0 - 9 where 9 is healthy, 0 is dead and 7 is commercially acceptable)

Treatment (rate kg or L)	**Phytotoxicity 10 WAT**	**Emergence (No.)**	**% weed cover**
1. Untreated	9.0	76.0	6.3
2. Benfluralin (2) / Gamit 36 CS (0.125)	8.3	101.7	6.0
3. Unt / Kerb Flo 400 (3.75)	8.7	96.7	5.0
4. Unt / Nirvana (3)	8.3	79.3	3.7
5. Unt / Nirvana (4.5)	6.3	82.7	1.7
6. Unt / Stomp Aqua + Gamit 36 CS (2 + 0.05)	9.0	85.0	3.7
7. Unt / Stomp Aqua + Gamit 36 CS (2 + 0.125)	9.0	86.7	3.7
8. Unt / Stomp Aqua + Gamit 36 CS (2 + 0.25)	8.7	69.7	4.0
9. Unt / Shark (post-em) (0.33)	5.7	N/A	N/A
10. Unt / Shark (post-em) (0.66)	6.0	N/A	N/A
F pr.	<.001		0.064
l.s.d (18 d.f)	1.587	NS	2.914

Note: plots treated with Shark were omitted from the emergence and weed cover assessment as this treatment went on at a later date.

China aster (transplanted)

Shark caused initial scorching on the leaves of the China asters which had been treated with Stomp Aqua + Gamit 36 CS pre-planting and Shark post-planting (T1.b). However, 4 weeks after the Shark had been applied (10 weeks after the main treatments had been applied) the asters had fully recovered with the new growth coming through unaffected (**Table 11**). None of the main treatments (T1.a, T2 or T3) caused any phytotoxic damage to the China asters throughout the trial. The best weed control was achieved by using Stomp Aqua + Gamit 36 CS. The Stomp Aqua + Dual Gold treatment was less effective.

Table 11. Transplanted China aster - Mean scores for phytotoxicity 10 weeks after treatment (WAT) and% weed cover – 2015 (scale of 0 - 9 where 9 is healthy, 0 is dead and 7 is commercially acceptable)

Treatment (rate kg or L)	Phytotoxicity 10 WAT	% weed cover
1.a Stomp Aqua (2) + Gamit 36 CS (0.25)	9.0	5.5
1.b Stomp Aqua (2) + Gamit 36 CS (0.25) / Shark (0.33) (post-emergence)	9.0	7.0
2. Stomp Aqua (2) + Dual Gold (0.78)	9.0	**16.0**
3. Ronstar Liquid (4)	9.0	11.7

Figures in **bold** show statistical significance at the 95% level compared with the grower's standard treatment of Ronstar Liquid.

Larkspur

Emergence of the Larkspur was still variable 11 WAT (**Table 12**) and some phytotoxicity was seen throughout the trial in the form of stunting and distortion to foliage.The variable emergence made it difficult to draw firm conclusions, but some treatments were identified with potential for further investigation, and some that can be ruled out. Stomp 2 L/ha + Dual Gold 0.78 L/ha, Wing-P 1.75 L/ha and Successor 2 L/ha all appear to be particularly phytotoxic to the crop, with the latter two treatments also tending to reduce emergence. Stomp Aqua 2 L/ha + Defy 4 L/ha was less phytotoxic but appeared to affect emergence. Overall, Stomp 2 L/ha + Gamit 0.25 L/ha appears to have the best potential both for weed control and crop safety.

Table 12. Drilled Larkspur – Mean scores for phytotoxicity 11 weeks after treatment (WAT), number of emerged seedlings and% weed cover - 2015 (scale of 0 - 9 where 9 is healthy, 0 is dead and 7 is commercially acceptable)

Treatment (rate kg or L)	Phytotoxicity 11 WAT	Emergence (No.)	% weed cover
1. Untreated	9.0	46.0	21.7
2. Benfluralin (2) / Defy (4)	6.0	58.7	18.3
3. Benfluralin (4) / Gamit 36 CS (0.25)	5.7	36.3	15.0
4. Unt / Stomp Aqua (2) + Gamit 36 CS (0.25)	6.3	50.3	6.7
5. Unt / Stomp Aqua (2) + Defy (4)	6.7	29.3	20.0
6. Unt / Stomp Aqua (2) + Dual Gold (0.78)	4.0	39.0	11.7
7. Unt / Wing-P (1.75)	5.3	30.7	10.0
8. Unt / Dual Gold (0.78) + Gamit 36 CS (0.25)	8.0	46.0	16.7
9. Unt / Successor (2)	4.0	31.3	13.3
10. Unt / H24	6.0	51.3	18.3
F pr.	0.008		
l.s.d (18 d.f)	2.394	NS	NS

Sweet Williams (CFC)

In the Sweet Williams trial (**Table 13**) Defy at a higher rate of 2 L/ha was unsafe when mixed with Stomp Aqua. Although crop emergence was not reduced, the seedlings that did come through showed some chlorosis and were scored down for phytotoxicity at 10 WAT. When used at the lower rate 1 L/ha and mixed with Stomp Aqua at 0.75 L/ha, plants showed little sign of phytotoxicity.

Goltix either on its own at 2 L/ha or tank mixed with Stomp Aqua showed little phytotoxicity. However, when Goltix was applied at the higher 2 L/ha rate mixed with Stomp Aqua, crop emergence appeared slightly reduced although it was not significantly different from the untreated control.

Benfluralin incorporated followed by Defy caused little phytotoxicity, but crop emergence was reduced. Weed control was also rather poor with this treatment.

Shark applied as a post-emergence treatment did cause some severe scorch and bleaching to leaves on the plants initially. However, the plants did recover from this and five weeks after treatment there was no damage to the new growth. Weed control was also much better with this treatment compared with the pre-emergence treatments.

Table 13. Drilled Sweet Williams - Mean scores for phytotoxicity 10 weeks after treatment (WAT) (5 WAT for Shark), number of emerged seedlings and% weed cover – 2015 (scale of 0 - 9 where 9 is healthy, 0 is dead and 7 is commercially acceptable)

Treatment (kg or L)	Phytotoxicity 10 WAT	Emergence (No.)	% weed cover
1. Untreated	9.0	283	65.0
2. Benfluralin (2) / Defy (2)	8.0	176	60.0
3. Unt / Stomp Aqua + Goltix (0.75 + 1)	8.3	343	36.7
4. Unt / Stomp Aqua + Goltix (0.75 + 2)	8.0	291	11.7
5. Unt / Stomp Aqua + Defy (0.75 + 1)	8.0	231	45.0
6. Unt / Stomp Aqua + Defy (0.75 + 2)	6.0	182	46.7
7. Unt / Stomp Aqua + Defy (1 + 1)	6.7	227	36.7
8. Unt / Stomp Aqua + Defy (1 + 2)	6.3	314	43.3
9. Unt / Goltix (2)	8.0	343	43.3
10. Unt / Shark (0.33)(post-em)	9.0	N/A	23.3
F pr.	0.072	0.021	
l.s.d (18 d.f)	2.098	118.4	NS

Note: plots treated with Shark were omitted from the emergence assessment as this treatment went on at a later date

Sweet Williams (Grower sites)

The rates of Stomp Aqua and Defy that were tested in the first Sweet Williams grower trial were too high with both of the treatments resulting in poor crop emergence (**Table 14**). All treatments, except the grower's standard treatment of Ronstar (T3), caused phytotoxic damage to the Sweet Williams which was seen as scorched leaves. Both rates of Stomp Aqua and Defy provided better weed control than the grower's standard treatment of Ronstar, however due to the poor crop emergence, were considered unacceptable.

Table 14. Sweet Williams – Mean scores for phytotoxicity 8 weeks after treatment (WAT), crop emergence and% weed cover– 2015 (grower site in Norfolk)

Treatment (rate kg or L)	Crop emergence per m² 8 WAT	Phytotoxicity 8 WAT	% weed cover
1.a Stomp Aqua (1.5) + Defy (2)	**2.3**	**7.8**	**4.5**
1.b Stomp Aqua (1.5) + Defy (2) / Shark (0.33)(post-em)	**2.7**	**6.5**	**4.0**
2.a Stomp Aqua (1) + Defy (2)	**7.4**	**7.8**	**6.3**

Treatment (rate kg or L)	Crop emergence per m² 8 WAT	Phytotoxicity 8 WAT	% weed cover
2.b Stomp Aqua (1) + Defy 2) / Shark (0.33)(post-em)	**7.0**	**6.5**	**5.0**
3. Ronstar Liquid (3)	28.0	9.0	12.5

Figures in **bold** show statistical significance at the 95% level compared with the grower's standard treatment of Ronstar.

A second Sweet Williams trial was carried out to test reduced rates of herbicides compared with the first grower site trial, and the opportunity was taken to test an alternative treatment of Stomp Aqua + Goltix. Crop emergence was poor across the whole trial, including the untreated plots (**Table 15**). Some initial slight herbicide damage was seen throughout the entire trial in the form of chlorotic spots on the Sweet Williams' leaves, even in the untreated plots. It is thought that this damage was caused from a herbicide that had been applied to a previous crop in the field. However, the only trial treatment to cause significant phytotoxic damage was the post-emergence application of Shark (T2.b and T3.b). Shark caused scorching to the leaves of the Sweet Williams, however the Sweet Williams had almost fully recovered by the final assessment that was carried out 12 weeks after the main treatments had been applied (3 weeks after the Shark was applied). Weed coverage of plots was lowest in the plots that had received an application of Stomp Aqua + Goltix with a post emergence application of Shark (T3.b).

Table 15. Sweet William – Mean scores for phytotoxicity 12 weeks after treatment (WAT), crop emergence and% weed cover– 2015 (grower site in Lincolnshire) (scale of 0 - 9 where 9 is healthy, 0 is dead and 7 is commercially acceptable)

Treatment	Crop emergence per m² 12 WAT	Phytotoxicity 12 WAT	% weed cover
1.Untreated	4.4	9.0	77.0
2.a Stomp Aqua (0.75) + Defy (1)	**1.0**	**8.5**	**38.1**
2.b Stomp Aqua (0.75) + Defy (1) / Shark (0.33) (post-em)	**6.0**	**8.0**	**18.8**
3.a Stomp Aqua (0.75) + Goltix (1)	**8.0**	8.8	50.6
3.b Stomp Aqua (0.75) + Goltix (1) / Shark (0.33) (post-em)	**14.0**	**8.0**	**6.3**

Figures in **bold** show statistical significance at the 95% level compared with the untreated control.

Wallflower

In the drilled Wallflower crop (**Table 16**), all treatments were safe in terms of foliar phytotoxicity. However, there was a tendency for emergence to be slightly reduced by some

of the treatments, notably Stomp Aqua + Gamit 36 CS at both 2 L/ha + 0.25 L/ha and 2.9 L/ha + 0.33 L/ha (T5 and T6), Wing-P 3.5 L/ha (T8) and Wing-P 3.5 L/ha + Gamit 36 CS 0.125 L/ha (T10).

Benfluralin as a pre-drilling treatment followed by Gamit 36 CS (T4), Wing-P 1.75 L/ha (T7) and Wing-P 1.75 L/ha + Gamit 36 CS 0.125 L/ha (T9), all had good emergence.

In terms of weed control, all products achieved sufficient weed control, although Benfluralin / Gamit 36 CS (T4) was slightly poorer. There was little difference between T7 and T9, Wing-P 1.75 L/ha and Wing-P 1.75 L/ha + Gamit 36 CS 0.125 L/ha, which suggests that for the weed population at this site there was no benefit to mixing Wing-P with Gamit.

Table 16. Drilled Wallflowers - Mean scores for phytotoxicity 10 weeks after treatment (WAT), number of emerged seedlings and% weed cover – 2015 (scale of 0 - 9 where 9 is healthy, 0 is dead and 7 is commercially acceptable)

Treatment	**Phytotoxicity 10 WAT**	**Emergence (No. per m²)**	**% weed cover**
1. Untreated	9.0	108.0	50.0
2. Benfluralin / Butisan S	8.0	95.3	5.7
3. Benfluralin / Butisan S + Gamit 36 CS	8.0	110.7	13.3
4. Benfluralin / Gamit 36 CS	8.0	102.7	20.0
5. Unt / Stomp Aqua + Gamit (2 + 0.25)	8.0	84.0	13.3
6. Unt / Stomp Aqua + Gamit (2.9 + 0.33)	8.0	87.3	8.3
7. Unt / Wing-P (1.75)	8.0	110.0	8.3
8. Unt / Wing-P (3.5)	8.0	86.0	13.3
9. Unt / Wing-P + Gamit (1.75 + 0.125)	8.0	112.7	10.0
10. Unt / Wing-P + Gamit (3.5 + 0.125)	8.3	72.0	5.0
F pr.	<.001	NS	0.002
l.s.d (18 d.f)	0.313	NS	17.24

Peony

Very little phytotoxicity was seen in the Peony herbicide trial except for a slight effect of Wing-P (3.5 L/ha) + Gamit 36 CS (0.125 L/ha) applied pre-planting (**Table 17**). This treatment combination initially stunted the crop but the plants recovered by the assessment that was carried out 10 WAT. Tank mixtures of Stomp Aqua (2.9 L/ha) with either HDC H24 or Butisan S (1.5 L/ha) gave the best weed control.

Table 17. Peony – Mean scores for phytotoxicity 10 weeks after treatment (WAT) and% weed cover– 2015 (grower site in Lincolnshire) (scale of 0 - 9 where 9 is healthy, 0 is dead and 7 is commercially acceptable)

Treatment	Phytotoxicity 10 WAT	% weed cover
1. Untreated	9.0	100.0
2. Benfluralin* / Butisan S + Flexidor 500	9.0	**21.7**
3. Unt / Stomp Aqua + Butisan S + Flexidor 500	9.0	**6.7**
4. Unt / Successor	9.0	93.3
5. Unt / Successor + Stomp Aqua	9.0	76.7
6. Unt / Successor + Flexidor 500	9.0	76.7
7.Unt / HDC H24 + Venzar Flowable	9.0	**8.3**
8. Unt / HDC H24 + Stomp Aqua	9.0	**5.0**
9. Unt / HDC H24 + Flexidor 500	9.0	78.3
10. Unt / Wing-P + Gamit 36 CS**	9.0	83.3

* Pre-planting treatment to be sprayed then incorporated into the soil using a rake

** Pre-planting treatment to be sprayed but not incorporated into soil

Figures in **bold** show statistical significance at the 95% level compared with the untreated control.

Financial Benefits

Hand or mechanical weeding costs are currently estimated at around £2000 per hectare, therefore an increase in the options available for weed control will allow growers to produce outdoor cut flowers at a lower cost. For example, an application of Stomp Aqua (2.9 L/ha) would cost approximately £28 per hectare. Gamit 36 CS at a rate of 0.25 L/ha would cost approximately £37 per hectare and an application of Goltix at a rate of 1 L/ha would cost approximately £23 per hectare. However, experience from the grower trial sites indicates that some hand weeding would still be required unless more persistent treatments can be found or follow up treatments applied. It is not currently commercial practice for growers to produce a crop from drilled China asters, however if there were herbicides available that allowed growers to grow in this way then this could save growers a considerable amount of money compared to producing a transplanted crop. Having more herbicides available for weed control would be beneficial to all cut flower growers as weed control is a continual hindrance across this industry.

Action Points

- Stomp Aqua + Gamit 36 CS was safe and provided the best weed control when applied pre-planting to transplanted China aster. Both Stomp Aqua and Gamit 36 CS have EAMUs that allow them to be used by growers in this way. However follow up herbicides will be desirable to prolong weed control.
- Stomp Aqua + Goltix was the safest treatment combination for Sweet Williams regarding crop emergence and also provided the best weed control when followed by a post-emergence application of Shark. Stomp Aqua, Goltix and Shark all have EAMUs for outdoor ornamental plant production and so can be adopted up by growers immediately.
- Tank mixtures of Stomp Aqua with either HDC H24 or Butisan S gave the best weed control and were safe to use on a crop of newly planted Peony. Stomp Aqua can be used as an EAMU on Peony and Butisan S has an on-label approval. HDC H24 is not yet available for use.
- For wallflowers, Wing-P with or without Gamit 36 SC as a tank mix gave the best results. The benefit from the addition of Gamit 36 SC would depend on the weed spectrum of the site.