

Project title Hardy ornamentals: herbicide screening for herbaceous perennials and grasses

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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 FOR HNS166

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

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ADAS UK Ltd

Signature Date

Report authorised by:

Dr Tim O'Neill

Horticulture Research Manager

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Signature Date

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GROWER SUMMARY

Headline

A range of herbicide products have been assessed for crop safety when applied to newly potted and established container-grown herbaceous perennial nursery stock.

Background and expected deliverables

Good weed control continues to be important for hardy ornamentals growers to ensure that plant quality is maintained and that accreditation standards are achieved. Herbicides remain the most cost-effective weed control method although herbaceous subjects are particularly vulnerable to herbicide damage.

With the loss of herbicides and changes in weed populations on nurseries it is important to continue to assess new products to help combat resistant weed species and extend the range of subjects screened for which herbicides can be used.

The recently completed HDC project HNS 139 (Atwood, 2009) identified herbicides, new to the UK, which appear to have potential for use on herbaceous perennial and grass crops. The focus of HNS 139 was mainly on shrub species, so further screening work is required specifically on herbaceous perennial and grass crops.

This project is evaluating several new herbicides for efficacy and safety for use on a wide range of container-grown herbaceous subjects as well as extending the range of crop species phytotoxicity information for currently used herbicides

Summary of the project and main conclusions

In 2008, an experiment was done to investigate the phytotoxicity of six herbicide treatments on a range of container-grown herbaceous species in a commercial nursery situation. A summer experiment examined treatments applied immediately after potting. Results were reported in the 2009 annual report.

In 2009, two further experiments were done, similar to those conducted in 2008 but with a different range of herbaceous species. One experiment was set up at Howard Nurseries using newly potted 9 cm plants (Table 1), the other at Hawkesmill Nurseries using established 2 or 3 litre container plants (Table 2). Further experiments are planned for 2010 commencing in early spring with dormant potted plants.

Table 1. Plant species used in newly potted herbaceous plant experiments, 2009

<i>Artemisia</i> 'Lambrook Mist'	<i>Kniphofia</i> 'Tetbury Torch'
<i>Brunnera macrophylla</i>	<i>Leucanthemum</i> 'Agalia'
<i>Campanula glomerata</i> 'Superba'	<i>Lobelia</i> 'Russian Princess'
<i>Centaurea</i> 'Parham'	<i>Pulmonaria</i> 'Cotton Cool'
<i>Centranthus albus</i>	<i>Rudbeckia</i> 'Peamii'
<i>Crambe cordifolia</i>	<i>Salvia</i> 'East Friesland'
<i>Crocasmia</i> 'James Coey'	<i>Sisyrinchium striatum</i>
<i>Dicentra</i> 'Spring Morning'	<i>Stachys byzantium</i> 'Silver Carpet'
<i>Geranium striatum</i>	<i>Tradescantia</i> 'Zwanenborg Blue'
<i>Hemerocallis</i> 'Stella d'Or'	<i>Verbena bonariensis</i>

Table 2. Plant species used in the established herbaceous plant experiments, 2009

<i>Acanthus spinosus</i>	<i>Helleborus orientalis</i> (pink/white)
<i>Agapanthus</i> 'Headbourne Hybrids'	<i>Hemerocallis</i> 'Catherine Woodberry'
<i>Ajuga</i> 'Catlin's Giant'	<i>Heuchera</i> 'Chocolate Ruffles'
<i>Bergenia</i> 'Ergot'	<i>Liriope muscari</i> 'Blue'
<i>Brunnera macrophylla</i>	<i>Lobelia</i> 'Russian Princess'
<i>Coreopsis</i> 'Rum Punch'	<i>Ophiopogon</i>
<i>Crocasmia masoniorum</i>	<i>Phlox</i> 'Purple Eye Flame'
Ferns, one of each of the following species: <i>Dryopteris affinis</i> 'Crispa Congesta', <i>Matteuccia struthiopteris</i> , <i>Athyrium</i> 'Ghost', <i>Polypodium vulgare</i> , <i>Polystichum setiferum</i> 'Herrenhausen'.	<i>Teucrium</i> 'Purple Tails'
<i>Geranium</i> 'Brookside'	<i>Verbena rigida</i>
<i>Hakonechola macra</i> 'Aureola'	<i>Zantedeschia aethiopica</i> 'Crowborough'

Herbicide treatments were applied on 16 June 2009 (Howard Nursery) and 23 June 2009 (Hawkesmill Nursery) (Table 3).

Table 3. Treatments used in herbaceous plant nursery experiments, 2009

Product	Active ingredient	Product application rate	Approval status
Untreated control	-	-	-
Ronstar 2G	oxadiazon (2 % w/w)	200 kg/ha	Label
Teridox ¹	dimethachlor (500 g/L)	3.0 L/ha	Not in UK
Lenacil 80W ¹	lenacil (80 % w/w)	2.8 kg/ha	Label
Flexidor 125	isoxaben (125 g/L)	1.0 L/ha	Label
Springbok	metazachlor (200 g/L) + dimethenamid-p (200 g/L)	2.5 L/ha	SOLA requested
Dual Gold	s – metolachlor (960 g/L)	1.4 L/ha	Not in UK

¹Teridox was only used in the newly potted plant experiment, Lenacil was only used in the established plant experiment.

Where a SOLA application has been requested products may be used in the same situations as currently approved. For example Springbok is approved for use on outdoor crops, such as oilseed rape, so may be used under the Long-Term Arrangements for Extension of Use on outdoor ornamentals.

Susceptibility to herbicide damage

Fifty two of the 63 species were tolerant of all the herbicides tested on them (Table 4). The exceptions are described below.

Brunnera were initially affected by Teridox, Flexidor 125 and Springbok causing stunting and necrosis (Figure 1) although all recovered. *Pulmonaria* can be susceptible to herbicides and Teridox and Springbok both caused a severe growth check (Figure 2) although they recovered later. *Campanula* was most severely damaged by herbicide treatments (Figure 3), only Flexidor 125 appeared safe although plants treated with Ronstar 2G or Dual Gold recovered quite well. *Geranium* was relatively unaffected by the treatments, only Teridox caused some initial stunting. Plants subsequently grew away normally. *Rudbeckia* was most affected by Teridox and Flexidor 125 with a significant loss of vigour, still noted at the second assessment. Dual Gold caused a more temporary growth check. *Stachys* has sometimes been suspected to be susceptible to Flexidor 125, but in this experiment there was no effect. Although Teridox and Dual Gold caused a slight

initial check, subsequently there was full recovery. It is interesting to note that the ferns all appeared tolerant of the herbicides tested. There was some foliage deterioration on *Matteuccia*, *Athyrium* and *Polypodium*, but the effect was not associated with any particular herbicide and could be attributable to end of season senescence.

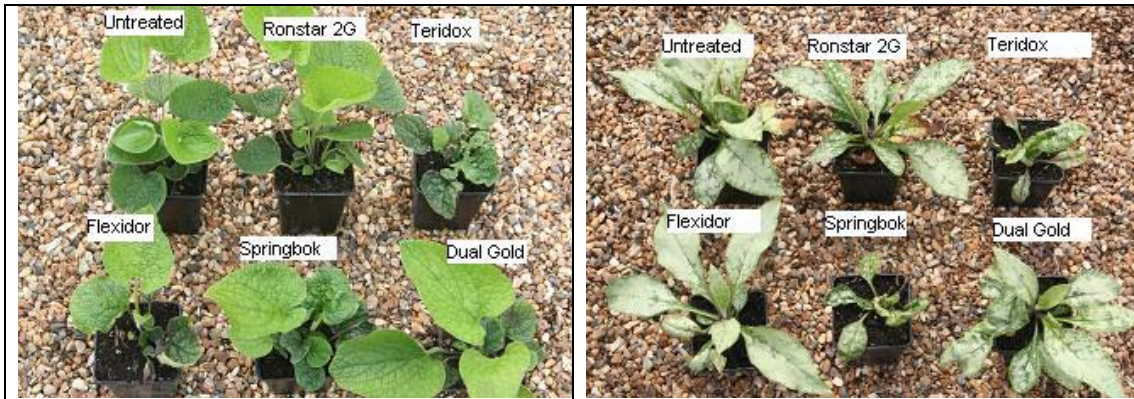


Figure 1. *Brunnera* 4 weeks after treatment

Figure 2. *Pulmonaria* 4 weeks after treatment

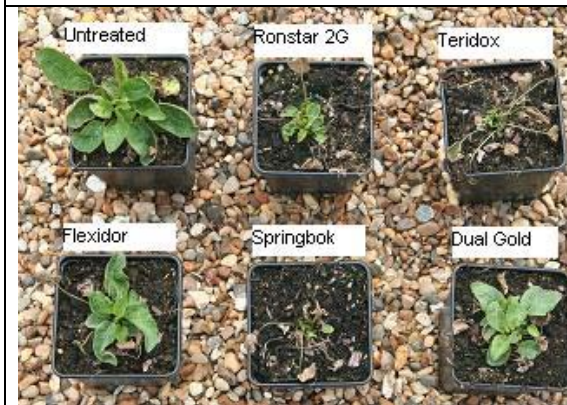


Figure 3. *Campanula* 4 weeks after treatment

Table 4. Herbicide tolerance summary for project Year One and Two,

Plant species	Dual Gold	Flexidor 125	Lenacil 80 W	Ronstar 2G	Springbok	Teridox
<i>Acanthus spinosus</i> *	T	T	T	T	T	
<i>Achillea</i> 'Salmon Beauty'	T	T		T	T	T
<i>Agapanthus</i> 'Headbourne Hybrids'	T	T	T	T	T	
<i>Ajuga</i> 'Catlin's Giant'	T	T	T	T	T	
<i>Alstromeria lutea</i>	T	T		T	T	T
<i>Artemisia</i> 'Lambrook Mist'	T	T		T	T	T
<i>Bergenia</i> 'Baby Doll'	T	T		T	S	T
<i>Bergenia</i> 'Ergot'	T	T	T	T	T	
<i>Brunnera macrophylla</i>	T	mS			S	S
<i>Brunnera macrophylla</i> *	T	T	T	T	S	
<i>Campanula glomerata</i> 'Superba'	mS	T		S	S	S
<i>Centaurea</i> 'Parham'	T	T		T	T	T
<i>Centranthus albus</i>	T	T		T	T	T
<i>Coreopsis</i> 'Rum Punch'	T	T	T	T	T	
<i>Coreopsis</i> 'Zagreb'	T	T		T	T	T
<i>Crambe cordifolia</i>	T	T		T	T	T
<i>Crocosmia</i> 'James Coey'	T	T		T	T	T
<i>Crocosmia</i> 'Kathleen'	T	T		mS	T	T
<i>Crocosmia masoniorum</i> *	T	T	T	T	T	
<i>Dicentra</i> 'Spring Morning'	T	T		T	T	T
<i>Dryopteris affinis</i> 'Crispa Congesta'	T	T	T	T	T	
<i>Dryopteris goldinia</i>	T	T		T	T	T
<i>Fragaria</i> 'Pink Panda'	T	T		T	T	T
<i>Geranium</i> 'Brookside'	T	T	T	T	T	
<i>Geranium nodosum</i>	T	T		T	T	T
<i>Geranium striatum</i>	T	T		T	T	mS
<i>Hakonechola macra</i> 'Aureola'	T	T	T	T	T	
<i>Helenium</i> 'Bruno'	T	T		T	T	T

Plant species	Dual Gold	Flexidor 125	Lenacil 80 W	Ronstar 2G	Springbok	Teridox
<i>Helleborus orientalis</i> (pink/white)*	T	T	T	T	T	
<i>Hemerocallis</i> 'Catherine Woodbery'*	T	T	T	T	T	
<i>Hemerocallis</i> 'Stafford'	T	T		T	T	S
<i>Hemerocallis</i> 'Stella d'Or'	T	T		T	T	T
<i>Heuchera</i> 'Chocolate Ruffles'*	T	T	T	T	T	
<i>Hosta albo marginata</i>	T	T		T	T	T
<i>Iris germanica</i> 'Jane Philips'	T	T		T	T	T
<i>Kniphofia</i> 'Tetbury Torch'	T	T		T	T	T
<i>Leucanthemum</i> 'Agalia'	T	T		T	T	T
<i>Leymus arenaria</i>	T	T		T	T	T
<i>Liriope muscari</i> 'Blue'*	T	T	T	T	T	
<i>Lobelia</i> 'Queen Victoria'	T	T		T	T	T
<i>Lobelia</i> 'Russian Princess'	T	T		T	T	T
<i>Lobelia</i> 'Russian Princess'*	T	T	T	T	T	
<i>Lupinus</i> 'Galaxy mixed'	T	T		T	T	T
<i>Matteuccia struthiopteris</i> , <i>Athyrium</i> 'Ghost'*	T	T	T	T	T	
<i>Ophiopogon</i> *	T	T	T	T	T	
<i>Penstemon</i> 'Sour Grapes'	T	S		S	T	T
<i>Peonia</i> 'Prima Verde'	T	T		T	T	T
<i>Phlox</i> 'Purple Eye Flame'*	T	T	T	T	T	
<i>Polypodium vulgare</i> *	T	T	T	T	T	
<i>Polystichum setiferum</i> 'Herrenhausen'*	T	T	T	T	T	
<i>Pulmonaria</i> 'Cotton Cool'	T	T		T	S	S
<i>Rudbeckia</i> 'Peamii'	mS	mS		T	S	S
<i>Salvia</i> 'East Friesland'	T	T		T	T	T
<i>Schizostylis</i> 'Sunrise'	T	T		T	T	T
<i>Sedum</i> 'Autumn Joy'	T	T		T	T	T
<i>Sisyrinchium striatum</i>	T	T		T	T	T

Plant species	Dual Gold	Flexidor 125	Lenacil 80 W	Ronstar 2G	Springbok	Teridox
<i>Stachys byzantium</i> 'Silver Carpet'	mS	T		T	T	mS
<i>Symphytum</i> 'Wisley Silver'	T	T		T	T	T
<i>Teucrium</i> 'Purple Tails'*	T	T	T	T	T	
<i>Tradescantia</i> 'Zwanenborg Blue'	T	T		T	T	T
<i>Verbena bonariensis</i>	T	T		T	T	T
<i>Verbena rigida</i> *	T	T	T	T	T	
<i>Zantedeschia aethiopica</i> 'Crowborough'*	T	T	T	T	T	

*Established plants - all others were newly potted.

T = Tolerant, mS = Moderately susceptible, S = Susceptible. Where no indication is given the treatment was not tested on that subject.

Key features of the herbicides tested

Dual Gold was safe to most of the subjects tested. Only *Campanula*, *Rudbeckia* and *Stachys* suffered a temporary growth check following treatment. Dual Gold in particular could be a useful herbicide for herbaceous growers. Although there are gaps in the weed control spectrum – notably bittercress – results from HNS 139 showed that it does give good control of willowherb and grasses and some control of groundsel so could be a useful supplement to Flexidor 125 which gives poor control of these weeds.

Springbok was damaging to more subjects, particularly the newly potted plants of *Brunnera*, *Campanula*, *Pulmonaria* and *Rudbeckia*. There were some indications of damage to *Leucanthemum*, and *Bergenia* was damaged in 2008 but not in 2009. One of the active ingredients in Springbok (metazachlor) has been associated with damage to container-grown herbaceous plants in the past when used as Butisan S.

Flexidor 125 was safe to use on all species except for *Brunnera* and *Rudbeckia* and in 2008 *Hemerocallis* and *Penstemon* were damaged. Flexidor 125 is already widely used on herbaceous crops particularly for good control of bittercress. A

number of species are highly susceptible to damage from Flexidor 125 however. The results reported here indicate a further range of species that can be safely treated.

Teridox is relatively unknown as a herbicide for ornamentals. Initial crop safety results from 2008 were encouraging but more damage occurred in 2009 indicating that it may have more limited application.

Ronstar 2G is widely used on herbaceous crops particularly after potting. Some species suffer temporary foliage damage from Ronstar 2G however. Ronstar 2G was safe to use on all but *Penstemon* and *Crocsmia* in 2008 and *Campanula* in 2009. The results reported here indicate a further range of species that can be safely treated.

Financial benefits

It is difficult to establish the full financial benefit from the project at this stage because one of the key new herbicides identified is not yet available on the UK market. However the benefits from extending the range of crops to which Ronstar 2G and Flexidor 125 can be applied can be estimated to save around £2,500/ha in hand-weeding costs for those crops less the cost of herbicide at £54/ha for Flexidor 125 or £1,000/ha for Ronstar 2G.

Action points for growers

- When available in the UK, Dual Gold shows promise for use in container-grown herbaceous perennial nursery stock during the growing season but would require a SOLA for use on ornamentals.
- Dual Gold could be a useful supplement to Flexidor 125 to improve control of groundsel, grasses and willowherb.
- Springbok appears safe to a limited range of herbaceous perennials. It is currently available in the UK and can be used under LTAEU on ornamentals as a SOLA application has been requested.
- Further crop safety information is available to extend the use of Ronstar 2G, Lenacil 80W and Flexidor 125 to a wider range of species.

SCIENCE SECTION

Introduction

Good weed control continues to be important for hardy ornamentals growers to ensure that plant quality is maintained and that accreditation standards are achieved. Herbicides remain the most cost-effective weed control method, although herbaceous subjects are particularly vulnerable to herbicide damage. The most recent herbaceous weed control project carried out for the HDC was HNS 35e (Atwood 1995). Information from this project forms the basis for current recommendations in Great Britain.

In recent years a number of weed species have proved difficult to control and are increasing in distribution and importance. In addition some familiar herbicides are being lost due to the EC review process for pesticide approval (revision/replacement of Council Directive 91/414/EEC). It is therefore important to continue to assess new products to help combat resistant weed species and extend the range of subjects screened for which herbicides can be used.

The recently completed HDC project HNS 139 (Atwood, 2009) identified herbicides, new to the UK, which appear to have potential for use on herbaceous perennial and grass crops. The focus of HNS 139 was mainly on shrub species, so further screening work is required specifically on herbaceous perennial and grass crops.

This project aims to evaluate several new herbicides for efficacy and safety for use on a wide range of container-grown herbaceous subjects as well as extending the range of crop species phytotoxicity information for currently used herbicides

Materials and methods

In 2008, an experiment was done to investigate the phytotoxicity of six herbicide treatments on a range of container-grown herbaceous species in a commercial nursery situation. A summer experiment examined treatments applied immediately after potting. Results were reported in the 2009 annual report.

In 2009, two further experiments were set up, similar to those conducted in 2008 but with a different range of herbaceous species. One experiment was set up at Howard Nurseries using newly potted 9 cm plants. The other was set up at Hawkesmill Nurseries using established 2 or 3 litre plants.

Newly potted 9 cm pot experiment

Twenty herbaceous species were used (Table 5). All plants were supplied from Howard Nurseries own stock. Plants were supplied as plugs potted into 9 cm pots.

Table 5. Plant species used in newly potted herbaceous plant experiments, 2009

<i>Artemisia</i> 'Lambrook Mist'	<i>Kniphofia</i> 'Tetbury Torch'
<i>Brunnera macrophylla</i>	<i>Leucanthemum</i> 'Agalia'
<i>Campanula glomerata</i> 'Superba'	<i>Lobelia</i> 'Russian Princess'
<i>Centaurea</i> 'Parham'	<i>Pulmonaria</i> 'Cotton Cool'
<i>Centranthus albus</i>	<i>Rudbeckia</i> 'Peamii'
<i>Crambe cordifolia</i>	<i>Salvia</i> 'East Friesland'
<i>Crocasmia</i> 'James Coey'	<i>Sisyrinchium striatum</i>
<i>Dicentra</i> 'Spring Morning'	<i>Stachys byzantium</i> 'Silver Carpet'
<i>Geranium striatum</i>	<i>Tradescantia</i> 'Zwanenborg Blue'
<i>Hemerocallis</i> 'Stella d'Or'	<i>Verbena bonariensis</i>

Potting Mix:

Scotts M2 pre-mixed compost including 22% bark

3.5 kg/m³ Osmocote Exact Standard 8-9 month

0.3 kg/m³ Excemptor (thiacloprid 10 % w/w)

Experimental design

The experiment was a split plot design (Appendix 1). There were six treatments (including one control) replicated three times (18 main plots for herbicide treatments, 20 HNS species sub-plots x 5 plants). The pots were placed on gravel container beds with overhead irrigation. Overhead irrigation was used to settle the plants in.

Herbicide treatments

The herbicide treatments used are given in Table 6. Treatments were applied on 16 June 2009 as a single application. All treatments were applied in 1,000 L/ha water at 2 bar pressure using a CO₂-pressurised Oxford Precision Sprayer with a 1 m boom and F03-110 spray nozzles, except treatment 2, Ronstar 2G granules which were applied with a pepper pot shaker.

Table 6. Treatments used in the newly potted herbaceous plant nursery experiments

Treatment	Product	Active ingredient	Product application rate	Approval status
1.	Untreated control			
2.	Ronstar 2G	oxadiazon (2 % w/w)	200 kg/ha	Label
3.	Teridox	Dimethachlor (500 g/L)	3.0 L/ha	Not in UK
4.	Flexidor 125	isoxaben (125 g/L)	1.0 L/ha	Label
5.	Springbok	metazachlor (200 g/L) + dimethenamid-p (200 g/L)	2.5 L/ha	SOLA requested
6.	Dual Gold	s – metolachlor (960 g/L)	1.4 L/ha	Not in UK

Where a SOLA application has been requested, products may be used in the same situations as currently approved. For example Springbok is approved for use on outdoor crops, such as oilseed rape, so may be used under the Long-Term Arrangements for Extension of Use on outdoor ornamentals.

No other pesticides were applied to the experimental area during the experiment.

Assessments

Observations on phytotoxicity symptoms were made on 16 July 2009, 13 August 2009 and 1 October 2009. Where significant damage was noted the symptoms were assessed using a scoring system (Table 7).

Table 7. Quality scoring system used to assess herbicide damage to plant subjects

Score	% Phytotoxicity
0	Complete kill – \geq 80% damage
1	\geq 60 – <80% damage
2	\geq 40 – <60% damage
3	\geq 20 – <40% damage (unacceptable damage but could recover)
4	\geq 5 – <20% damage (considered unlikely to cause a significant reduction in quality at marketing)
5	No damage (same appearance as untreated controls) - <5% damage

Statistical analysis

All data were subjected to analysis of variance (ANOVA). Where significant F tests were obtained, means were separated using the least significant difference (LSD) test.

Established 2 or 3 litre pot experiment

Twenty four herbaceous species were used (Table 8). All plants were supplied from Hawkesmill Nurseries own stock. Plants were supplied as established 2 or 3 litre plants that had been potted summer 2008.

Table 8. Plant species used in the established herbaceous plant experiments 2009

<i>Acanthus spinosus</i> *	<i>Helleborus orientalis</i> (pink/white)
<i>Agapanthus</i> 'Headbourne Hybrids'	<i>Hemerocallis</i> 'Catherine Woodberry'
<i>Ajuga</i> 'Catlin's Giant'	<i>Heuchera</i> 'Chocolate Ruffles'
<i>Bergenia</i> 'Ergot'	<i>Liriope muscari</i> 'Blue'
<i>Brunnera macrophylla</i> *	<i>Lobelia</i> 'Russian Princess'*
<i>Coreopsis</i> 'Rum Punch'*	<i>Ophiopogon</i>
<i>Crocasmia masoniorum</i> *	<i>Phlox</i> 'Purple Eye Flame'
Ferns*, one of each of the following species: <i>Dryopteris affinis</i> 'Crispa Congesta', <i>Matteuccia struthiopteris</i> , <i>Athyrium</i> 'Ghost', <i>Polypodium vulgare</i> , <i>Polystichum setiferum</i> 'Herrenhausen'.	<i>Teucrium</i> 'Purple Tails'
<i>Geranium</i> 'Brookside'	<i>Verbena rigida</i>
<i>Hakonechola macra</i> 'Aureola'	<i>Zantedeschia aethiopica</i> 'Crowborough'

2 litre plants except * 3 litre

Potting Mix:

80% 18mm screen grade peat

20% Forest Gold Plus bark

3.0 kg/m³ Osmocote 8-9 month (18-11-10)

320 kg/m³ Osmocote Exact Standard 5-6 month (15-8-9)

0.3 kg/m³ Nitrochalk

4.5 kg/m³ Magnesian limestone

1.5 kg/m³ 15:10:20 Compound fertiliser

1.0 kg/m³ Vi-Nil (fipronil 0.1% w/w)

Experimental design

The experiment was a split plot design (Appendix 1). There were six treatments (including one control) replicated three times (18 main plots for herbicide treatments, 20 HNS species sub-plots x 5 plants). For the ferns, sub plots were further divided with 5 different fern species, one plant of each. The pots were placed on woven plastic ground cover container beds with overhead irrigation.

Herbicide treatments

The herbicide treatments used are given in Table 9. Treatments were applied on 23 June 2009 as a single application. All treatments were applied in 1,000 L/ha water at 2 bar pressure using a CO₂-pressurised Oxford Precision Sprayer with a 1 m boom and F03-110 spray nozzles, except treatment 2, Ronstar 2G granules which were applied with a pepper pot shaker.

Table 9. Treatments used in summer herbaceous plant nursery experiments

Treatment	Product	Active ingredient	Product application rate	Approval status
1.	Untreated control	-	-	-
2.	Ronstar 2G	oxadiazon (2 % w/w)	200 kg/ha	Label
3.	Lenacil 80W	lenacil (80 % w/w)	2.8 kg/ha	Label
4.	Flexidor 125	isoxaben (125 g/L)	1.0 L/ha	Label
5.	Springbok	metazachlor (200 g/L) + dimethenamid-p (200 g/L)	2.5 L/ha	SOLA requested
6.	Dual Gold	s – metolachlor (960 g/L)	1.4 L/ha	Not in UK

Where a SOLA application has been requested products may be used in the same situations as currently approved. For example Springbok is approved for use on outdoor crops, such as oilseed rape, so may be used under the Long-Term Arrangements for Extension of Use on outdoor ornamentals.

No other pesticides were applied to the experimental area during the experiment.

Results and Discussion

The results indicated that, apart from some initial damage to *Brunnera* (Table 10) none of the established crops tested at Hawkesmill Nursery were affected by any of the treatments. By the end of the season the *Brunnera* had fully recovered although the initial damage from Springbok would have reduced the marketability of the plants for 2 months after treatment. At the August and September assessments, there was some foliage deterioration on *Crocsmia*, and the ferns *Matteuccia*, *Athyrium* and *Polypodium*, but the effect was not associated with any particular herbicide and could be attributable to end of season senescence. In 2008, Ronstar 2G appeared to cause similar foliage yellowing earlier in the season. *Bergenia* were undamaged by any of the treatments in 2009 but in 2008 had shown some susceptibility to Springbok, causing veinal yellowing.

Table 10. Plant quality scores (0 – 5 index) for *Brunnera* established plants – Hawkesmill Nursery, 2009

<i>Treatment</i>	<i>Assessment date</i>		
	3 Jul 2009	4 Aug 2009	4 Sep 2009
1. Untreated control	5.0	5.0	5.0
2. Ronstar 2G	4.3	4.3	5.0
3. Lenacil 80W	5.0	4.7	5.0
4. Flexidor 125	4.0	4.0	5.0
5. Springbok	3.0	4.3	5.0
6. Dual Gold	4.7	4.7	5.0
<i>P</i> (ANOVA)	0.004	0.221	
df	10	10	
LSD (5%)	0.938	ns	

The newly potted plants at Howard Nursery proved to be more susceptible to herbicide damage (Table 11). This might be expected because of the more limited rooting system.

Brunnera were initially affected by Teridox, Flexidor 125 and Springbok causing stunting and necrosis (Figure 4), however by the final assessment in October all had recovered and were similar to the control. Ronstar 2G and Dual Gold were the safest treatments for *Brunnera*.

Pulmonaria is often considered to be somewhat susceptible to herbicide damage and is listed as moderately susceptible to Flexdor 125 (Atwood 2007), but the current results showed that Ronstar 2G, Flexidor 125 and Dual Gold were all safe. Teridox and Springbok both caused a severe growth check initially (Figure 5), but even so, plants recovered well by the August assessment, 6 weeks after treatment.

Campanula was the species to be most severely damaged by herbicide treatments (Figure 6), only Flexidor 125 appeared safe, many of the other treatments severely stunted or killed the plants. Plants treated with Ronstar 2G or Dual Gold recovered

quite well. Results from Flexidor 125 have been variable in earlier experiments on *Campanula* with considerable difference in varietal susceptibility (Atwood 1995).

Geranium was relatively unaffected by the treatments, only Teridox caused some initial stunting. Plants subsequently grew away normally.

Springbok, Teridox and Dual Gold appeared to cause initial stunting to *Leucanthemum* but results were variable and not statistically significant.

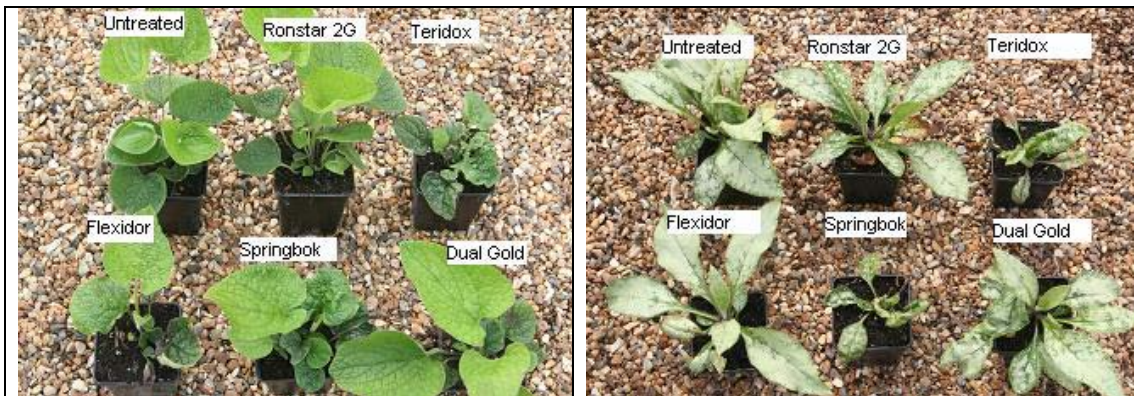


Figure 4. *Brunnera* 4 weeks after treatment

Figure 5. *Pulmonaria* 4 weeks after treatment

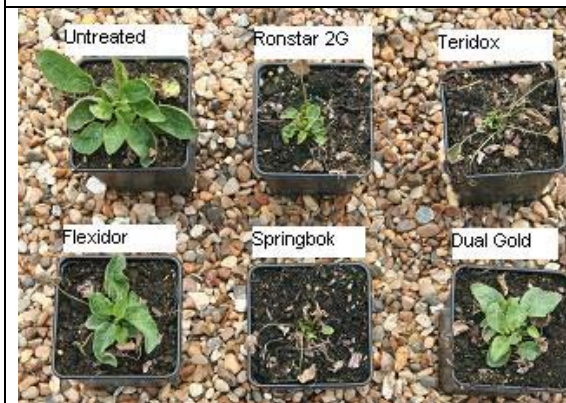


Figure 6. *Campanula* 4 weeks after treatment

Rudbeckia was most affected by Teridox and Flexidor 125 with a significant loss of vigour still noted at the second assessment. Dual Gold caused a more temporary growth check. By October there was virtually full recovery from all treatments, but Flexidor 125 and Teridox can be regarded as too damaging because of the initial effect. *Rudbeckia* has previously been listed as tolerant to Flexidor 125 (Atwood, 2007) so further testing would be beneficial.

Stachys has sometimes been suspected to be susceptible to Flexidor 125, but in this experiment there was no effect. Although Teridox and Dual Gold caused a slight initial check, subsequently there was full recovery.

The other species in the trial: *Artemisia*, *Centaurea*, *Centranthus*, *Crambe*, *Crocsmia*, *Dicentra*, *Hemerocallis*, *Kniphofia*, *Lobelia*, *Salvia*, *Sisyrinchium*, *Tradescantia* and *Verbena* were not affected by any of the herbicide treatments.

Overall, Dual Gold proved the safest of the new herbicides, confirming results from 2008. Teridox was much more damaging than in 2008 and may not be progressed further. Springbok was less safe than Dual Gold but could be acceptable on a more limited range of subjects.

Table 10. Plant quality score, (0 – 5 index) on seven herbaceous plant species newly potted – Howard Nursery, 2009

Treatment	<i>Brunnera</i>			<i>Campanula</i>			<i>Geranium</i>			<i>Leucanthemum</i>		
	16-Jul	13-Aug	6-Oct	16-Jul	13-Aug	6-Oct	16-Jul	13-Aug	6-Oct	16-Jul	13-Aug	6-Oct
1 Untreated	4.7	5.0	5.0	4.2	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
2 Ronstar 2G	4.7	4.7	5.0	2.1	4.0	4.5	4.8	5.0	5.0	4.2	4.4	4.7
3 Teridox	2.9	3.5	5.0	0.8	1.2	3.3	3.9	4.2	4.6	3.2	4.3	4.6
4 Flexidor 125	3.3	4.7	4.7	4.1	5.0	4.9	5.0	5.0	5.0	4.7	4.9	5.0
5 Springbok	3.2	3.9	5.0	1.3	2.6	3.6	5.0	5.0	5.0	3.1	3.8	4.3
6 Dual Gold	4.5	4.3	5.0	3.4	4.9	4.6	4.8	5.0	5.0	3.6	3.6	4.2
<i>P</i> (ANOVA)	0.058	0.040	0.465	<.001	0.003	0.493	0.084	0.037	0.465	0.167	0.205	0.178
df	10	10	10	10	10	10	10	10	10	10	10	10
LSD (5%)	ns	0.964	ns	1.310	1.777	ns	ns	0.536	ns	ns	ns	ns

Treatment	<i>Pulmonaria</i>			<i>Rudbeckia</i>			<i>Stachys</i>		
	16-Jul	13-Aug	6-Oct	16-Jul	13-Aug	6-Oct	16-Jul	13-Aug	6-Oct
1 Untreated	5.0	5.0	5.0	5.0	5.0	5.0	4.9	5.0	5.0
2 Ronstar 2G	4.2	4.8	5.0	4.1	5.0	5.0	5.0	5.0	5.0
3 Teridox	2.1	5.0	5.0	3.3	3.6	4.5	3.7	4.0	5.0
4 Flexidor 125	4.9	5.0	5.0	3.4	3.3	4.4	5.0	5.0	5.0
5 Springbok	2.8	4.9	5.0	3.3	4.7	5.0	4.3	4.3	4.9
6 Dual Gold	4.1	5.0	5.0	3.3	4.9	5.0	3.7	4.3	4.7
<i>P</i> (ANOVA)	<.001	0.556		0.404	<.001	0.050	<.001	0.007	0.326
df	10	10		10	10	10	10	10	10
LSD (5%)	1.802	0.279		2.037	0.594	0.491	0.585	0.575	0.304

Conclusions

Dual Gold was safe to most of the subjects tested. Only *Campanula*, *Rudbeckia* and *Stachys* suffered a temporary growth check following treatment. Dual Gold in particular could be a useful herbicide for herbaceous growers. Although there are gaps in the weed control spectrum – notably bittercress – results from HNS 139 showed that it does give good control of willowherb and grasses and some control of groundsel (Atwood, 2009) so could be a useful supplement to Flexidor 125 which gives poor control of these weeds.

Springbok was damaging to more subjects, particularly the newly potted plants of *Brunnera*, *Campanula*, *Pulmonaria* and *Rudbeckia*. There were some indications of damage to *Leucanthemum* and *Bergenia* was damaged in 2008 but not in 2009. One of the active ingredients in Springbok (metazachlor) has been associated with damage to container-grown herbaceous plants in the past when used as Butisan S.

Flexidor 125 was safe to use on all species except for *Brunnera* and *Rudbeckia* and in 2008 *Hemerocallis* and *Penstemon* were damaged. Flexidor 125 is already widely used on herbaceous crops particularly for good control of bittercress. A number of species are highly susceptible to damage from Flexidor 125 however. The results reported here indicate a further range of species that can be safely treated.

Teridox is relatively unknown as a herbicide for ornamentals. Initial crop safety results from 2008 were encouraging but more damage occurred in 2009 indicating that it may have more limited application.

Ronstar 2G is widely used on herbaceous crops particularly after potting. Some species suffer temporary foliage damage from Ronstar 2G however. Ronstar 2G was safe to use on all but *Penstemon* and *Crocsmia* in 2008 and *Campanula* in 2009. The results reported here indicate a further range of species that can be safely treated.

Technology transfer

A growers' walk was arranged to view the experiments at Howard Nursery for growers at the HDC herbaceous perennial technical discussion group on 30 July

2009. Interim results from the project were included in the three Weed Control in Nursery Stock Workshops held in Kent (25 August 2009), Norfolk (27 August 2009) and Worcestershire (2 September 2009).

References

Atwood, J., (1995). HDC report HNS 93e 'Chemical weed control in outdoor container-grown herbaceous perennial nursery stock

Atwood, J., (2007). HDC Handbook 'Practical weed control for nursery stock – An HDC growers' handbook

Atwood, J., (2009). HDC report HNS 139 'Control of problem weeds in hardy nursery stock'

Appendix 1: Experimental layouts

Layout: Established 2 or 3 litre pot experiment (Hawkesmill Nurseries)

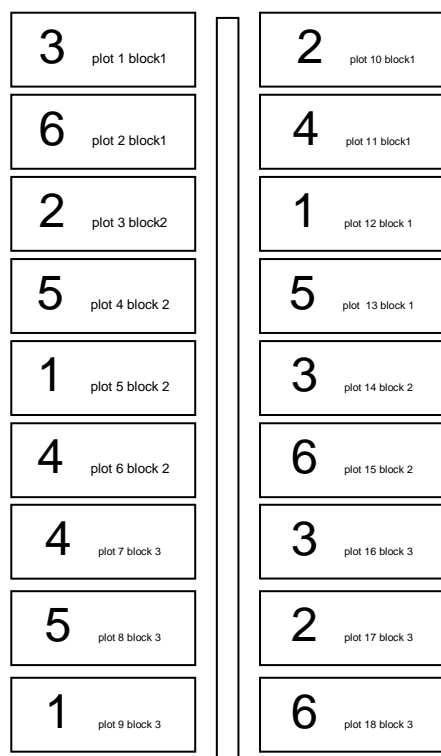


Table 11, Treatments for the established 2 or 3 litre pot experiment

<i>Treatment</i>	<i>Chemical</i>	<i>Rate</i>
1	Untreated control	-
2.	Ronstar 2G	200.0 kg/ha
3	Lenacil 80W	2.8 kg/ha
4	Flexidor 125	1.0 L/ha
5	Springbok	2.5 L/ha
6	Dual Gold	1.4 L/ha

Layout: Newly potted 9 cm pot experiment (Howards Nursery)

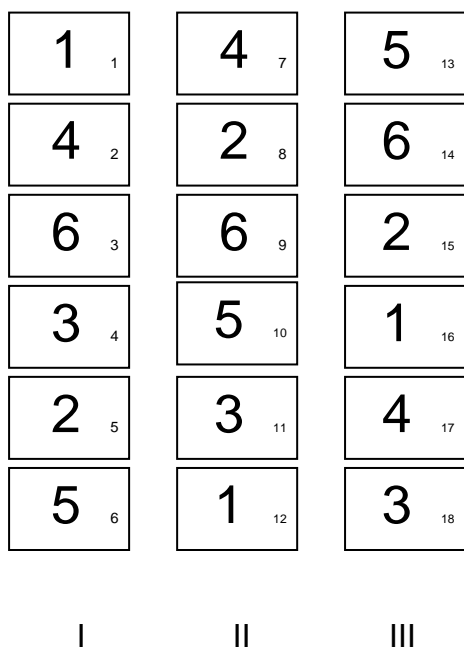


Table 12. Treatments for the newly potted 9 cm pot experiment.

<i>Treatment</i>	<i>Chemical</i>	<i>Rate</i>
1	Untreated control	-
2.	Ronstar 2G	200.0 kg/ha
3	Teridox 500EC	3.0 L/ha
4	Flexidor 125	1.0 L/ha
5	Springbok	2.5 L/ha
6	Dual Gold	1.4 L/ha